Chapter 5: Sustainable Development, Poverty Eradication and Reducing Inequalities

Coordinating Lead Authors: Joyashree Roy (India), Petra Tschakert (Australia), Henri Waisman (France)

Lead Authors: Sharina Abdul Halim (Malaysia), Purnamita Dasgupta (India), Bronwyn Hayward (New Zealand), Markku Kanninen (Finland), Diana Liverman (United States of America), Patricia Fernanda Pinho (Brazil), Keywan Riahi (Austria), Avelino G. Suarez Rodriguez (Cuba)

Contributing Authors: Philip Antwi-Agyei (Ghana), Mook Bangalore (United States of America), Mustapha Babiker (Sudan), Bishwa Bhaskar Choudhary (India), Neville Ellis (Australia), Maria Figueroa (Venezuela/Denmark), Mukesh Gupta (India), Amaha Medhin Haileselassie (Ethiopia), Karen Henrique Paiva (Brazil), Daniel Huppmann (Austria), Omar Massera (Mexico), Chukwumerije Okereke (Nigeria/United Kingdom), Simon Parkinson (Canada), Wilfried Rickels (Germany), Diana Hinge Salili (Fiji), Lisa Schipper (Sweden/United States of America), Jörn Schmidt (Germany), Pete Smith (United Kingdom of Great Britain and Northern Ireland), Shreya Some (India), Nenenteiti Teariki-Ruatu (Kiribati), Penny Urquhart (South Africa)

Review Editors: Svitlana Krakovska (Ukraine), Ramon Pichs Madruga (Cuba), Roberto Sanchez (Mexico)

Chapter Scientist: Neville Ellis (Australia)

Date: 22 December2017

Notes: TSU compiled version

Table of Contents

Executive Summary **4**
5.1 Scope and Delineations **8**
5.1.1 Sustainable Development, Poverty, Equality, and Equity: Core Concepts and Trends 8
5.1.2 Sustainable Development Goals 9
Box 5.1: Climate and the Sustainable Development Goals (SDGs) **11**
5.1.3 Pathways to 1.5°C 12
5.1.4 Chapter Structure and Types of Evidence 12
5.2 Poverty, Equality, and Equity Implications of a 1.5°C Warmer World **13**
5.2.1 Future Impacts and Risks from Sub-regional to Sub-national Levels 13
5.2.2 Risks of a 1.5°C Warmer World 14
5.2.3 Avoided Impacts of 1.5°C versus 2°C Warming 15
5.2.4 Risks from 1.5°C Global Warming and the Sustainable Development Goals 16
5.3 Climate Adaptation and Sustainable Development **17**
5.3.1 Sustainable Development in Support of Climate Adaptation 17
5.3.2 Synergies and Trade-offs between Adaptation Response Options and Sustainable Development 19
5.3.3 Sustainable Development Implications of Adaptation Pathways toward a 1.5°C Warmer World 23
5.4 Mitigation and Sustainable Development **24**
5.4.1 Synergies and Trade offs between Mitigation Options and Sustainable Development 25
5.4.1.1 Accelerating Efficiency in Resource Use 25
5.4.1.2 Behavioural Options 25
5.4.1.3 Access to Modern and Reliable Energy and Fuel Switch 26
5.4.1.4 Cross-sector Response Options 29
5.4.1.5 Land-based Agriculture, Forestry and Ocean: Response Options 30
5.4.2 Temporal and Spatial Trade-offs and Distributional Impacts 33
5.4.3 Sustainable Development Implications of 1.5°C and 2°C Mitigation Pathways 34
5.4.3.1 Air Pollution and Health 35
5.4.3.2 Food Security and Hunger 35
5.4.3.3 Lack of Energy Access / Energy Poverty 36
5.4.3.4 Water Security 36
5.4.3.5 Biodiversity 37
5.5 Integrating Adaptation, Mitigation and Sustainable Development: Challenges and Enabling Conditions **39**
5.5.1 Coherent and Integrated Institutions and Governance 40
5.5.2 Participatory Processes to Address Issues of Power and Justice 41
5.5.3 Accounting for Local Circumstances and Unequal Opportunities 41

5.5.4 Towards a Systemic and Dynamic Approach for Integration 42
5.6 Sustainable Development Pathways to 1.5°C 43
5.6.1 Sustainable Development Pathways 43
5.6.2 Climate-resilient Development Pathways 46
5.6.2.1 Transformations, Well-being, and Equity 47
5.6.2.2 Development Trajectories, Responsibilities, and Capacities 48
5.6.3 Emerging Country and Community Experiences with Climate-Resilient Development Pathways 51
5.6.3.1 Regional and State-led Efforts Toward Climate-resilient Development Pathways: Green States, Low-carbon Economies, and National Planning and Partnerships 52
Box 5.2: Low-Carbon Pathways in Oil-Producing Countries 53
Box 5.3: Republic of Vanuatu–National Planning for Development and Climate Resilience 55
5.6.3.2 Community-led And Bottom-up Approaches to Climate-resilient Development Pathways ... 56
Box 5.4: Alternative Development Pathways and Transnational Movements 56
Box 5.5: Cases of Ecosystem- and Community-based Practices in Drylands 58
Cross-Chapter Box 5.1: Cities and Urban Transformation 59
5.6.4 Sustainable and Climate-resilient Development Pathways: Enabling Conditions and Lessons Learned 62
5.6.4.1 Inclusive Governance 62
5.6.4.2 Social Learning 63
5.6.4.3 Equity, Rights, and Justice 64
5.6.4.4 Indicators, Monitoring, and Evaluation 64
5.7 Synthesis and Research Gaps 65
Frequently Asked Questions 67
References 70

Executive Summary

The final chapter in this Special Report assesses the knowledge on connections between sustainable development, poverty eradication, reducing inequalities, and pathways to limit global warming to 1.5°C above-preindustrial times. The UN 2030 Agenda for Sustainable Development established a set of 17 Sustainable Development Goals (SDGs) that seek to end poverty and hunger; reduce inequalities; ensure health; education; sustainable energy; water and work for all; and foster sustainable cities, consumption, ecosystems. SDG13 focuses on urgent action to combat climate change and its impacts. This chapter assesses the many ways in which the impacts of a 1.5°C warmer world, and the impacts of possible adaptation and mitigation responses, interact with efforts to achieve sustainable development and the SDGs. The chapter also explores the impacts of pursuing the SDGs on limiting warming to 1.5°C and on adaptive capacities, particularly for the most vulnerable populations. Finally, the chapter also assesses sustainable development pathways to 1.5°C, including climate-resilient development pathways that maximise synergies and minimise trade-offs between climate responses of mitigation and adaptation with sustainable development, especially poverty alleviation and reducing inequality. More research is needed to increase the confidence and breadth of understanding the specific links between limiting global warming to 1.5°C and achieving sustainable development, especially at the regional level.

Without consideration for equity and fairness, and concerted efforts from all countries as well as individuals, communities, and organizations, the dual goal of limiting global warming by the end of the 21st Century to 1.5°C compared to pre-industrial times, including temperature overshoots along the way, and achieving the SDGs by 2030 and beyond, inclusive of poverty eradication, will be exceedingly difficult to reach (*high confidence*).

As risks increase with every level of additional warming, a higher number of potentially adverse future impacts can be avoided when global warming is limited to 1.5°C rather than 2°C, with important benefits for poor and disadvantaged people. The impacts of 1.5°C warming above pre-industrial times still pose significant challenges for human and ecosystem well-being, poverty eradication, and reducing inequalities (*medium evidence, high agreement*). Limiting global warming to 1.5°C versus 2°C will reduce the risks for livelihoods and for human, food, water, and ecosystem security through reduction of heat stress, more moderate impacts on agriculture and water, lower risks from extreme events, and reduced stress on unique and threatened systems, for instance those of high mountain areas, drylands, tropical coral reefs, and subsistence fisheries (*medium evidence, high agreement*) {5.2}. 1.5°C global warming will still have broad impacts and will disproportionately affect already disadvantaged and vulnerable populations, with more severe impacts expected in the case of temperature overshoot, particularly for indigenous people and systems in the Arctic, for agriculture- and coastal dependent livelihoods, and small-island developing states (SIDs) (*medium evidence, high agreement*) {5.2.1; 5.2.2}. Globally, the poorest people are projected to experience the impacts of 1.5°C global warming predominantly through increased food prices, food insecurity and hunger, income losses, lost livelihood opportunities, adverse health impacts and population displacements, for instance from increased heat stress and other extreme events such as coastal flooding, with more than 100 million additional people anticipated in poverty (*limited evidence, medium agreement*) {5.2.2}. Limits to adaptation and potential losses exist at every level of temperature increase (*medium confidence*), with place-specific implications, for example for Pacific Small Islands Developing States {5.2.3, 5.6.3}. Limiting global warming to 1.5°C is expected to make it easier to pursue sustainable development, with higher potential to eradicate poverty, reduce inequality, and foster equity than 2°C (*medium evidence, high agreement*). Limiting temperature to 1.5°C can reduce significantly the risks of failure in achieving certain SDGs, e.g. on poverty, health, and water and sanitation, although there will be differences between countries. Yet, the literature supporting this evidence remains scarce, particularly with respect to gender and inequalities (*limited evidence, medium agreement)* {5.2.4}.

Reducing climate vulnerability through adaptation is mostly consistent with achieving sustainable development in general, and the SDGs specifically (*high confidence*). Most adaptation strategies help meet the SDGs (known as synergies) but some generate negative consequences and make it more difficult to meet some SDGs (knowns as trade-offs) (*high confidence*). Transformative adaptation required to achieve sustainable development in a 1.5°C warmer world needs to address the root socio-

economic and cultural causes of vulnerability (*high confidence*).
Adaptation will be important in a 1.5°C warmer world to counter the anticipated impacts on human and natural systems around the world. Ensuring livelihood security, poverty alleviation, equity, and inclusion, support effectively the design of adaptation strategies that lead to the achievement of the SDGs, for climate-change affected communities but also more broadly (*high confidence*) {5.3.1, 5.3.2}. The extent of synergies between sustainable development and adaptation goals will vary by the development process adopted for a particular SDG (*high confidence*) {5.3.1}. There is a high potential for synergies between adaptation options and several sustainable development objectives, notably response options that reduce vulnerabilities in a way to support poverty reduction, elimination of hunger, clean water, and health (*very high confidence*) {5.3.2}. Negative outcomes (or trade-offs) can potentially occur either in the form of maladaptation or adverse consequences of particular adaptation strategy; this includes instances when the costs of adaptation increase poverty and debt, agricultural adaptation competes with protecting biodiversity or overlooks the poor and women, the expanded use air conditioning increases emissions, ecosystem-based adaptations conflicts with local rights, and migration increases cultural tensions (*high confidence*) {5.3.2}. Adaptation pathways that use a mix of adaptation options and maximise synergies and minimise trade-offs with sustainable development are successful when they follow inclusive, deliberative, and place-specific processes and procedural justice mechanisms; yet, persistent uneven power structures that dominate decision making reinforce existing social inequalities (*medium evidence, high agreement)* {5.3.3}.

Mitigation options compatible with 1.5°C warming can help meet sustainable development and the SDGs (synergies) but some generate negative consequences (trade-offs). Choices of mitigation options and policies will differentially affect people's lives and well-being, given different capacities and countries' positions on development trajectories. However, some of these risks can be reduced by policy designs and mechanisms at moderate cost (*high confidence*).
The choice of the portfolio of mitigation options and the policy instruments that are used for implementation will largely determine the overall synergies and trade-offs of 1.5°C mitigation pathways for sustainable development (*very high confidence*) {5.4.1,5.4.3, Figure 5.4.1, 5.4.2}. Mitigation actions in the energy demand sectors and behavioural response options with appropriate management of rebound effects can advance multiple SDGs simultaneously, more so than energy supply side mitigation actions (*very high confidence*) {5.4.1, Table 5.1 a-c, Figure 5.4.1}. Mitigation options that show higher synergies with SDGs are those that emerge from cross-sectoral efforts at city scale; new sectoral organisations based on the circular economy concept such as zero waste, decarbonisation and dematerialisation; and multi-policy interventions that follow systemic approaches. These synergies require governance coordination across sectors and nations, and collaboration and dialogue across scales (*medium evidence, high agreement*) {5.4.1.4}. A number of mitigation interventions in the AFOLU sector could help to deliver the SDGs, such as sustainable and climate-smart land/agricultural management, the shift toward sustainable healthy diets and reduction of food waste. Forestry mitigation options including reducing deforestation, afforestation, climate-smart sustainable forest management and multi-purpose systems for fibre, timber, and energy use- provide cost-effective measures and in many cases, negative emissions. Their appropriate design and implementation that take into account local people´s needs, biodiversity and other SD concerns can also provide large synergies with SDGs particularly within rural areas of developing countries (*high confidence*) {5.4.1.2, 5.4.1.5}. Mitigation pathways aiming at 1.5°C are in high synergies with health and air pollution. The nature of development patterns and the pursuit of sustainable development objectives affects the potential for ambitious mitigation and can reduce the social cost of reaching 1.5°C. Protection of oceans and marine ecosystems is a key enabler for ambitious mitigation, and the reduction of outdoor air pollution is a core motivation for public support for ambitious mitigation (*medium evidence, high agreement*) {5.4.1.5}. Economic growth and the reduction of inequalities can facilitate or hinder ambitious emission reductions depending on the strategy adopted to meet these sustainable development objectives (*medium evidence, medium agreement*) {5.4.1.4}. The rapid pace and magnitude of the required changes lead also to increased risks for trade-offs for a number of other sustainable development dimensions particularly risk of hunger, poverty, and basic needs, such as energy access. The negative impacts are more particularly for the poor populations without access to clean energy, employment and lead to overexploitation of some mineral resources required for renewable generation (medium confidence) {5.4.3, Figure 5.4.2}. Reducing these risks requires smart policy designs and mechanisms that shield the poor and redistribute the burden, so that the most vulnerable are not affected. Recent scenario analyses with focus on 1.5°C show that this is possible

at relatively modest costs (*high confidence*) {5.4.3, Figure 5.4.2}. For example, cash transfers, food subsidies and improvements in yields can reduce trade-offs of land-use change and bioenergy deployment which may threaten food and water security, cause biodiversity loss and competition for land, spikes in food prices, and lead to disproportionate consequences upon poor and indigenous populations (*high confidence*). Delaying actions to reduce GHGs increases risks of cost escalations, stranded assets, job loss, reduced flexibility in future response options in the medium to long-term. These may have trade-offs that increase uneven distributional impacts between countries at different stages of development (*medium evidence, high agreement*) {5.4.2}. 1.5°C pathways that feature very low energy demand show pronounced positive effects across multiple SDGs (*very high confidence*). Low-carbon and zero-carbon energy sources serve the dual goals of mitigation and improved access to modern and affordable energy, which is fundamental to human well-being and contributes to poverty reduction. But these transitions must be handled carefully to avoid trade-offs with sustainable development, notably upon poor and indigenous populations. They depend upon radical socio-cultural and organizational innovation, which can create challenges for social acceptability. For example, more electrification of transport sector can lead to rise in electricity prices and can adversely affect poor unless pro-poor redistributive policies are in place. Road infrastructure and city expansion can lead to eviction, bio energy can lead to land disputes unless appropriate strategies are built into the projects (*medium evidence, high agreement*) {5.4.1.3, 5.4.2.2, Table 5.1}. Economies dependent upon fossil fuel-based energy generation and/or export revenue will be disproportionally affected by restriction on the use of fossil fuels necessary for ambitious climate goal despite multiple other sustainable development benefits. There is a need for supplementary policies, including retraining, to ease job losses and the effects of higher energy prices, particularly in countries where the workforce is largely semi or unskilled (*very high confidence*) {5.4.1.3}.

While integrated approaches between mitigation, adaptation and sustainable development are possible, they will not be necessary, suitable or efficient for all situations. The efficiency of these integrated approaches to deliver triple-wins depends on the satisfaction of several enabling conditions (*medium evidence, high agreement*).

Comprehensive packages of adaptation and mitigation options supported by coordinated governance across sectors and nations can enhance sustainable development (*medium evidence, high agreement*) {5.3.1, 5.4.1}. Coherent and integrated institutions and governance, including on finance, is a key enabling condition for integrated approaches between mitigation, adaptation and sustainable development at the level of policies, programs and projects (*very high confidence*) {5.5.1}. The multi-level and multi-sector nature of integration inherently produce conflicting governing processes, actors and outcomes, raising issues of power, justice and political economy. The involvement of stakeholders though participatory mechanisms is a key condition for addressing these challenges in a way that ensures that the voices of the poor, disadvantaged and vulnerable populations are heard. Taking into account regional contexts and local knowledge is essential for maximizing the synergy potentials (*medium evidence, high agreement*) {5.5.2, 5.5.3}. Reconciling trade-offs between sustainable development, adaptation and mitigation towards a 1.5°C warmer world will require a dynamic view of the interlinkages between these three dimensions at different time horizons. This entails recognition of the ways in which development patterns shape the choices and effectiveness of interventions (*medium evidence, high agreement*) {5.5.4}.

Without strengthened contributions to decarbonization and commitment from countries, institutions, and communities to equity and fairness, pathways to 1.5°C will not allow to reach the Agenda 2030 objective to leave no one behind (*high confidence*). Sustainable development pathways, including climate-resilient development pathways, entail low-emissions trajectories that simultaneously promote fair and equitable climate resilience and effort sharing. These pathways take into account the following key aspects: the urgency of the 1.5°C target, the need to achieve global net zero emissions, the achievement of goals for sustainable development, the need to enhance capacity to adapt, the scale of societal transformation required, and the ethics, equity, and well-being implications of embarking on such substantial transformation {5.6.2}. The potential for such pathways differs between richer and poorer nations and regions (*very high confidence*), given different levels of development as well as differential responsibilities and capacities to cut emissions, eradicate poverty, and reduce inequalities and vulnerabilities. At the level of individuals, communities, and groups, emphasis on well-being, social inclusion, equity, and human rights helps to overcome limitations in capacity, as shown, for instance, in agrarian and social and climate justice movements in Latin America and Transition Towns predominantly in Europe and North America (*medium*

evidence, high agreement) {5.6.2; 5.6.3}. Initial evidence of partially successful pathways points toward significant possibilities as well as inherent difficulties to the achievement of sustainable, robust and equitable climate-resilient development, including considerable albeit incomplete efforts in so-called emerging green states in the Global South and oil-producing countries in the Middle East and North Africa. Even at 1.5°C global warming, challenges in some parts of the world—for example in the Small Island Development States in the Pacific, despite ambitious and inclusive planning processes for climate resilience—will not prevent limits to adaptation and residual impacts. With appropriate policy support, community-led and bottom-up approaches offer potentials for climate-resilient development pathways at scale – as shown in farmer managed cropland management across drylands in sub-Saharan Africa and countries in South and Southeast Asia (*medium evidence; high agreement*) {5.6.2; 5.6.3}. Participatory governance and iterative social learning constitute key aspects to enable transformative social change in a 1.5°C compatible development pathway. Yet, dominant pathways and entrenched power differentials continue to undermine the rights, values, and priorities of disadvantaged populations in decision making. Very limited indicators and monitoring and evaluation systems currently exist that track multi-level progress toward equitable, fair, and socially desirable low-carbon futures (*high confidence*) {5.6.4}.

Knowledge on the linkages between a 1.5°C warmer world, including climatic impacts and those from response options, and future development pathways that address poverty eradication, equality, and distributive justice is growing. However, several gaps in the current literature have been identified (*very high confidence*).

Limited evidence exists to date that explicitly examines the implications of a 1.5°C warmer world (and overshoots) for sustainable development, poverty eradication, and reducing equalities, and the near-term goals of SDGs. The assessments of avoided impacts and development implications of 1.5°C versus 2°C and higher warming often use proxies, which does not allow capturing the effects on inequalities that, in turn, shape vulnerabilities. Limited literature exists that empirically investigates the effectiveness of integrated policy frameworks to deliver triple-win (adaptation-mitigation-sustainable development) outcomes, the dynamics that produce such outcomes at the scale of implementation, and the anticipated winners and losers. More structured literature is needed on global trajectories compatible with 1.5°C warmer world and sustainable development that would emerge as a composite of local, regional, national pathways. Such studies would be directly policy-relevant at these scales of decision through quantification of the effects of different policy instruments on synergies and trade-offs, but would also inform on the related global trends characterizing the GHG emission objective and defining the global enabling conditions of change. Existing literature on development pathways that are sustainable and climate-resilient suggests inadequately demonstrate how governance structures enable or hinder different groups of people and countries at different levels of development, with different needs, rights, and capacities, to negotiate pathway options, values, and priorities, leaving significant ethical and moral questions unanswered. Methodologies of dialogues between different research communities, regarding processes of learning and deliberative decision making, and adequate and robust indicators, are needed to analyse the multiple dimensions of climate and development, overcoming persistent disciplinary knowledge fragmentation.

5.1 Scope and Delineations

This chapter assesses what is known about the connections between sustainable development and pathways to 1.5°C. It examines the impacts of keeping temperatures at 1.5°C global warming above preindustrial levels on sustainable development, compared to other scenarios, including 2°C, and examines the interactions between response measures of mitigation and adaptation and sustainable development. This chapter gives particular attention to synergies and trade-offs between 1.5°C and meeting the near term Sustainable Development Goals (SDGs) in the context of eradicating poverty and reducing inequality. The chapter builds on prior IPCC reports and assesses new literature. It offers insights into possible pathways and enabling conditions to achieve the 1.5°C goal and meet the SDGs with a particular focus on climate-resilient development pathways.

5.1.1 Sustainable Development, Poverty, Equality, and Equity: Core Concepts and Trends

Chapter 1 provides an introduction of the concepts of sustainable development, equity and poverty as used in this report, as well as an overview of ethical issues and the Sustainable Development Goals (Box 5.1). The UN General Assembly views sustainable development as recognizing "that eradicating poverty in all its forms and dimensions, combating inequality within and among countries, preserving the planet, creating sustained, inclusive and sustainable economic growth and fostering social inclusion are linked to each other and are interdependent" (United Nations, 2015c). The scientific literature and development organizations define sustainable development in a variety of ways and see it as difficult to measure precisely but commonly see it as meeting environmental, social and economic goals (Bebbington and Larrinaga, 2014; Redclift and Springett, 2015). For some authors, sustainable development can also be assessed in terms of "well-being"; a subjective measure of satisfaction that can include happiness, social relationships, life expectancy, perception of environmental quality, and health (Barrington-Leigh, 2016; Helliwell et al., 2013; Schmoker, 2011).

The AR5 reported with *high confidence* that sustainable development is strongly connected to climate change and that disruptive levels of climate change would preclude reducing poverty (Denton et al., 2014; Fleurbaey et al., 2014). It also identified synergies and trade-offs in solving climate and development challenges and assessed literature that showed that the responses to climate change – mitigation and adaptation – could have significant positive and negative impacts and distributional implications for development. The UN underlined this interconnection in the 2030 Agenda for Sustainable Development "Climate change is one of the greatest challenges of our time and its adverse impacts undermine the ability of all countries to achieve sustainable development" (United Nations 2015, p5). The World Bank finds that climate change is a key obstacle to eliminating poverty and that climate change can reverse or erase improvements in living conditions and decades of development (Hallegatte et al., 2016a).Chapter 1 of this Special Report briefly discusses definitions of poverty (see Section 1.4.2), highlighting its multiple dimensions beyond low incomes, such as hunger, illiteracy, poor housing, lack of access to services, social exclusion and powerlessness. Given that reducing and eliminating poverty is a primary goal of sustainable development and the SDGs, this chapter pays particular attention to the implications of the 1.5°C target for various measures of poverty.

Chapter 1 highlights the importance of equity and ethics in the analysis of climate and sustainable development (see Section 1.4.1), noting the mention of equity in the Paris agreement and other documents, especially in relation to fairness and justice. It also makes the connection between the 1.5°C target and human rights (see Section 1.4.1). A principle of *equality* sees every human being as of equal worth, and argues that everyone should have the same opportunity and rights irrespective of origins. Climate change and climate policies can have unequal causes and consequences as a result of social and economic inequalities such as those in income or health. As noted in Chapter 1 (see Section 1.4.1), *equity* generally means treating everyone fairly and impartially, both in the distribution of responsibilities (distributive equity) and resources and in participation in decision making (procedural equity), and is often associated with concepts of justice (Fleurbaey et al., 2014). Equity and equality are discussed in the literature on climate justice which highlights the importance of structural and other inequalities between countries, communities, and people,

the role of climate change in increasing inequality, the balance of co-benefits and trade-offs, and the need for equitable solutions to climate change (Holland, 2017; Okereke and Coventry, 2016; Klinsky et al., 2017; Lahn, 2017; Robiou et al., 2017; Caney, 2016; de Loma-Osorio, 2016; Moss, 2015; Caney, 2014; Gupta and Arts, 2017).

There is high agreement that individuals (and societies) often experience inequality and inequity through the intersection of multiple axes that include their gender, class, ethnicity, age, race, ability, and their relation to vulnerability and risk (Kaijser and Kronsell, 2014; Nightingale, 2011; Olsson et al., 2014; Thompson-Hall et al., 2016; Van Aelst and Holvoet, 2016; Vinyeta, Kirsten; Whyte, Kyle Powys; Lynn, 2015; Vinyeta et al., 2015). The UN Sustainable Development Goals (see below and Box 5.1) have a strong focus on reducing poverty and inequality: Goal 1 is to end poverty in all its forms everywhere, Goal 4 ensures equitable access to education, Goal 5 seeks gender equality, Goal 10 seeks to reduce inequality within and among countries, and other goals seek sanitation, water, healthy lives, energy, economic growth, and decent work "for all" (United Nations, 2016).

The AR5 concluded that risks from climate change are 'unevenly distributed and generally greater for disadvantaged people and communities in countries at all level of development'(IPCC 2014a: *ref*) and that multidimensional inequalities, often produced by uneven development processes, shape differential vulnerabilities to and risks from climate change (IPCC, 2014b).

Research shows that the responses to climate change interact in complex ways with goals of poverty reduction and equity. As we discuss in Sections 5.3 and 5.4 below, the benefits of adaptation and mitigation projects and funding may accrue to some and not others, responses may be costly and unaffordable to some people and countries, and projects may disadvantage some individuals, groups and development initiatives (Casillas and Kammen, 2012; Chen et al., 2016; Newell and Mulvaney, 2013; Schroeder and McDermott, 2014). One of the more challenging equity concerns arises if limits to adaptation produce significant residual impacts to some countries (Barnett et al., 2016a; Klein et al., 2014). The issue of loss and damage is addressed in the UNFCCC Warsaw International Mechanism and the Paris Agreement (Boyd et al., 2017; Mathew and Akter, 2017; Page and Heyward, 2017; Vanhala and Hestbaek, 2016) (see also Cross-Chapter Box 4.4).

5.1.2 Sustainable Development Goals

The 2000 UN Millennium Declaration prioritised global reductions in poverty and hunger, improvements in health, education, and gender equity, debt reduction, and improved access to water and sanitation between 1990 and 2015. Considerable success was claimed in reaching many of the targets of the *Millennium Development Goals* (MDGs), including halving poverty, reducing hunger, and increasing water security. Improvements in water security, slums and health may have reduced some aspects of climate vulnerability; yet, increases in incomes have been linked to rising greenhouse gas (GHG) emissions and thus to a trade-off between development and climate change (Janetos et al., 2012; United Nations, 2015b). Critics argued that the MDGs failed to address within country disparities and human rights, focused only on developing countries, did not address key environmental concerns, and had numerous measurement and attribution problems (Fukuda-Parr, Yamin, and Greenstein 2014; Langford, Sumner, and Yamin 2013).

The articulation of this new set of UN *Sustainable Development Goals* (see Chapter 1Box 1.2) raises the ambition for eliminating poverty and other deprivations while protecting the environment and reducing the risks of climate change. The SDGs apply to all countries and include ending poverty (SDG1) and hunger (SDG2), ensuring health (SDG3), access to education (SDG4), achieving gender equality (SDG5), ensuring access to water and sanitation (SDG6) and energy (SDG7), promoting inclusive economic growth (SDG8), building resilient infrastructure and sustainable industrialisation (SDG9), reducing inequality (SDG10), making sustainable cities (SDG11) and ensuring sustainable consumption and production (SDG12), combating climate change (SDG13), conserving oceans and marine resources (SDG14) and protecting terrestrial ecosystems (SDG15), promoting peace and justice (SDG16), and strengthening partnerships (SDG17).

Figure 5.1 illustrates the current situation for a selection of development indicators for which comprehensive data is available. Several of these indicators are measures for both the MDGs and SDGs. Several patterns and challenges to sustainable development are evident. Low-income countries are on average less well-nourished and have much less access to electricity and sanitation. Upper-middle income and high-income countries have less poverty, hunger, child mortality and better access to water, sanitation and electricity. Sub-Saharan Africa is disadvantaged on most indicators. However, South Asia has higher average incomes, child survival and nourishment compared to their lack of sanitation and access to electricity. These indicators for 2013 are the result of progress that was made in recent decades on many of the measured and widely available development indicators, but there are still millions of people in extreme poverty and hunger, where many children die before the age of five, and where millions are without access to clean water, sanitation or electricity.

[INSERT FIGURE 5.1 HERE]

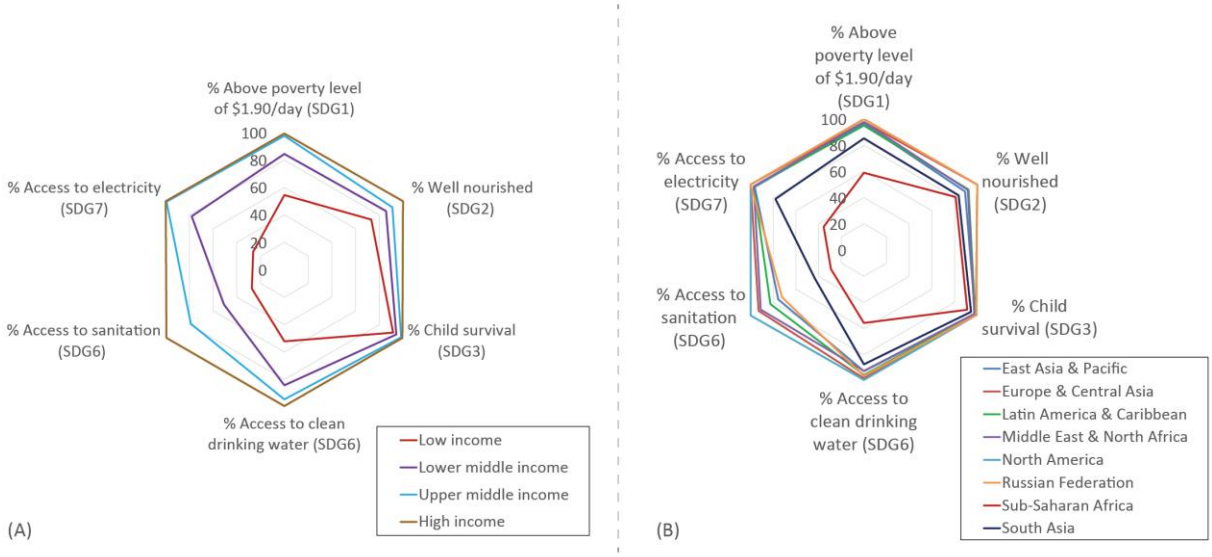


Figure 5.1: Sustainable Development indicators: Selected development indicators by (A) income group and by (B) world region for 2013. The income groups (low income, lower middle income, upper middle income and high income) are those used by the World Bank, as are the regional groupings. The indicators are associated with metrics used in the Sustainable Development Goals (SDGs) and include (i) the percent of the population living on more than $1.90/day at 2011 international prices (PPP), a poverty line defined by the World Bank and associated with SDG1 which seeks to eliminate poverty; (ii) the percent of population above the minimum level of dietary energy consumption (below which people are considered undernourished because their food intake is insufficient to meet dietary energy requirements) associated with SDG2 to eradicate hunger; (iii) the probability that a child will survive beyond the age of 5 measure as percent. It is based on the under-five mortality rate per 1000 babies born and is associated with SDG3 seeking healthy lives; (iv) the percentage of people using at least basic water services associated with SDG6 to ensure safe water. This indicator encompasses both people using basic water services as well as those using safely managed water services. Basic drinking water services is defined as drinking water from an improved source, provided collection time is not more than 30 minutes for a round trip. Improved water sources include piped water, boreholes or tube wells, protected dug wells, protected springs, and packaged or delivered water; (v) the percentage of the population using improved sanitation facilities. Improved sanitation facilities are likely to ensure hygienic separation of human excreta from human contact. They include flush/pour flush (to piped sewer system, septic tank, pit latrine), ventilated improved pit (VIP) latrine, pit latrine with slab, and composting toilet and are included in SDG6 to ensure safe water and sanitation; and (vi) the percentage of population with access to electricity. Electrification data are collected from industry, national surveys and international sources associated with MDG7 ensuring access to clean energy. All data is from the World Bank (http://databank.worldbank.org/).

Despite their ambitious and integrative vision, the 2030 Agenda has met with some scholarly criticism.

Some suggest the SDGs are too many and too complex, lack realistic targets, are focused on 2030 at the expense of longer term objectives, and may contradict each other (Death and Gabay, 2015; Horton, 2014). There are tensions between the progressive and normative aims of the SGDs and the means of implementation; because implementation may requires some fundamental economic transformations beyond global partnerships and international trade, and will need to address the inequalities that have long contributed to unsustainable development (UNRISD, 2016).

[START BOX 5.1 HERE]

Box 5.1: Climate and the Sustainable Development Goals (SDGs)

Sustainable Development Goal 13 commits to 'Take urgent action to combat climate change and its impacts'(United Nations, 2015c). This goal recognises that climate change is one of the major threats to development and to success on the other 16 goals. The specific targets under the goal include targets to:

13.1 Strengthen resilience and adaptive capacity to climate-related hazards and natural disasters in all countries
13.2 Integrate climate change measures into national policies, strategies and planning
13.3 Improve education, awareness-raising and human and institutional capacity on climate change mitigation, adaptation, impact reduction and early warning
13.4 Implement the commitment undertaken by developed-country parties to the United Nations Framework Convention on Climate Change to a goal of mobilizing jointly $100 billion annually by 2020 from all sources to address the needs of developing countries in the context of meaningful mitigation actions and transparency on implementation and fully operationalize the Green Climate Fund through its capitalization as soon as possible
13.5 Promote mechanisms for raising capacity for effective climate change-related planning and management in least developed countries and Small Island Developing States, including focusing on women, youth and local and marginalised communities

The targets acknowledge that the United Nations Framework Convention on Climate Change is the primary international, intergovernmental forum for negotiating the global response to climate change.

The indicators proposed so far (https://sustainabledevelopment.un.org/sdg13) include:
Indicator 13.1.1: Number of countries with national and local disaster risk reduction strategies
Indicator 13.1.2: Number of deaths, missing persons and persons affected by disaster per 100,000 people
Indicator 13.2.1: Number of countries that have communicated the establishment or operationalization of an integrated policy/strategy/plan which increases their ability to adapt to the adverse impacts of climate change, and foster climate resilience and low greenhouse gas emissions development in a manner that does not threaten food production (including a national adaptation plan, nationally determined contribution, national communication, biennial update report or other)
Indicator 13.3.1: Number of countries that have integrated mitigation, adaptation, impact reduction and early warning into primary, secondary and tertiary curricula
Indicator 13.3.2: Number of countries that have communicated the strengthening of institutional, systemic and individual capacity-building to implement adaptation, mitigation and technology transfer, and development actions
Indicator 13.a.1: Mobilised amount of United States dollars per year starting in 2020 accountable towards the $100 billion commitment
Indicator 13.b.1: Number of least developed countries and small island developing States that are receiving specialised support, and amount of support, including finance, technology and capacity-building, for mechanisms for raising capacities for effective climate change-related planning and management, including focusing on women, youth and local and marginalised communities

The goal will be reviewed at the UN High Level Political Forum in 2019. There is little research so far that explicitly assesses SDG 13, its progress or problems. The SDG Index and Dashboards report uses measures of CO_2 emissions per capita, imported CO2 emissions, climate change vulnerability, and effective carbon

rate (Sachs et al., 2017). It is important to note that the SDGs have the short-term target of 2030, whereas the Paris Agreement focuses on 2100, with stocktakes every five years from 2023. The Paris Agreement does not set a date for limiting temperatures to 2°C or 1.5°C, achieving a global goal on adaptation, or mobilizing the $100 billion for responses. It establishes the aim to reach global peaking of greenhouse gases "as soon as possible" (United Nations, 2015a).

[END BOX 5.1 HERE]

5.1.3 Pathways to 1.5°C

This chapter seeks to identify the pathways and strategies through which the world could limit warming to 1.5°C while also achieving sustainable development, including meeting the SDGs of the 2030 Agenda. Chapter 1 identifies several categories of pathways to global mean temperature of 1.5°C including temperature stabilization pathways where temperatures rise and stabilise at 1.5°C, overshoot pathways where temperatures rise above 1.5°C before peaking and declining to or below 1.5°C and a continued warming pathway where 1.5°C is just a stage on the way to warming temperatures. Box 1.2 (Chapter 1, Section 1.2.4) introduces the concepts of scenarios and pathways, including development pathways that are sustainable and climate resilient.

This chapter focuses on the sustainable development implications of stabilizing at 1.5°C rather than higher temperatures and on the ways in which sustainable development can enable and motivate climate action. There is very little literature on the implications of overshoot pathways for sustainable development. There are reports such as AR5 or the World Bank report on 4°C (World Bank, 2012) that examine what a 2°C or higher temperature would mean for development but they do not discuss how development would be affected by a rise and then fall in temperatures over a particular time span.

The AR5 introduced the notion of '*climate-resilient pathways*', as "development trajectories that combine adaptation and mitigation to realise the goal of sustainable development. They can be seen as iterative, continually evolving processes for managing change within complex systems" (IPCC, 2014b). Climate-resilient pathways are built on the concept of *resilience*, defined in the AR5 as 'the capacity of social, economic, and environmental systems to cope with a hazardous event or trend or disturbance, responding or reorganising in ways that maintain their essential function, identity, and structure, while also maintaining the capacity for adaptation, learning, and transformation'. Climate-resilient pathways rely on flexible, innovative, and participatory problem solving and may require transformational changes to reduce emissions and adapt to climate risks including transformation in social processes (Denton et al., 2014). The concept of *transformation* implies fundamental changes in natural and human systems including changes in values, institutions, technologies, and biological systems and can be contrasted with more incremental responses to climate change (Fazey et al., 2017; Pelling et al., 2015). Given the challenge of keeping temperatures under 1.5°C, in the context of sustainable development, and poverty eradication, and reducing inequalities, the pathways discussed in this report and this chapter demand greater emission reductions and more transformative changes and more attention to equity than those discussed in AR5.

The adoption of the SDGs and the efforts to achieve both sustainable development and the Paris Agreement, the word 'development' is combined with climate objectives through 'climate-resilient *development* pathways'. This implies understanding how development, transformation, and resilience go hand in hand with efforts to limit global warming, through simultaneous and conscious efforts to reduce vulnerabilities, enhance adaptation, and implement stringent emission reductions, in the context of equity, fairness, and justice (Section 5.6).

5.1.4 Chapter Structure and Types of Evidence

The chapter proceeds as follows: Section 5.2 describes future impacts and risks of a 1.5°C warmer world for sustainable development, poverty eradication, reducing inequalities, and equity, including avoided impacts

compared to a 2°C warmer world. It builds on the discussion of impacts in Chapter 3. Section 5.3 discusses evidence on how meeting the SDGs could enhance or limit the possibilities for adaptation, and assesses how adaptation response measures can have both synergies and trade-offs with sustainable development and the SDGs. Section 5.4 discusses connections between sustainable development and emissions reductions and examines the synergies and trade-offs between mitigation response measures and pathways and sustainable development. The sustainable development implications of Solar Radiation Management (SRM) are discussed in Cross-Chapter Box 4.2 (Chapter 4). Section 5.5 presents opportunities and challenges that result from the integration of adaptation, mitigation, and sustainable development, including distributional impacts. Section 5.6 summarises what is known about sustainable development pathways to 1.5°C and introduces climate-resilient development pathways. It examines emerging evidence of such pathways at different spatial scales, challenges encountered, and lessons learned. The chapter ends with a brief synthesis of findings and research gaps (Section 5.7), closing the arc of this Special Report opened in Chapter 1.

In this chapter, we use a variety of sources of evidence to assess the interactions of sustainable development broadly and the SDGs in particular with the causes, impacts, and responses to climate change of 1.5°C warming. We assess published literature, grey literature, and data that assess, measure, and model sustainable development–climate links from various angles and across scales as well as well documented case studies that illustrate connections, synergies, and trade-offs. While there is a scarcity of literature that explicitly links a 1.5°C target to sustainable development and the SDGs, we find relevant insights from many recent papers on climate and development, including work that examines trajectories to and beyond 1.5°C of warming. The chapter identifies a number of research gaps including the limited literature on a 1.5°C world and sustainable development, including the implications of overshoot scenarios, and the need for research on how integrated policy approaches, that include mitigation, adaptation and sustainable development, can be best developed.

5.2 Poverty, Equality, and Equity Implications of a 1.5°C Warmer World

5.2.1 Future Impacts and Risks from Sub-regional to Sub-national Levels

Climate change could lead to significant impacts on extreme poverty by 2030 (Hallegatte et al., 2016a; Hallegatte and Rozenberg, 2017). The AR5 concluded with high confidence that future impacts (risks) will be experienced differentially according to gender, caste, or ethnicity within and across societies (Olsson et al., 2014; Vincent et al., 2014). Some of these impacts can be easily detected and attributed to climate change (Cramer et al., 2014) while others are more difficult to measure, and identify, although not less real to the people who experience them. The latter include, for instance, loss of identity through displacement, culture, ecosystem security and migration (Adger et al., 2014; Barnett et al., 2016b; Serdeczny et al., 2017; Tschakert et al., 2017). Drawing attention to these less obvious impacts is compounded not only by scarce climate data and other observational records in the Global South poor countries (Hansen et al., 2016). It is also compounded by the fact that any global temperature target, including 1.5°C, is not experienced as such on the ground but will manifest itself in higher warming and/or extreme events mostly in countries in the Global South, with highly different patterns of societal vulnerability (Aitsi-Selmi and Murray, 2016). Temperature overshoot toward 1.5°C at the end of the century (see Chapter 3, Section 3.6.1) is expected to be even more detrimental for certain populations and places for instance for Arctic systems, agriculture-dependent livelihoods as well as coastal-dependent livelihoods (O'Neill et al., 2017b); yet the literature is exceedingly scarce on implications for poverty reduction, inequalities, and equity. Inequality in general, and the gender aspects of inequality, are seldom addressed sufficiently in case studies on climate change (Djoudi et al., 2016).

This section focuses on future impacts and risks of 1.5°C and higher warming on dimensions of poverty, inequality, and equity at sub-regional levels (at a spatial level below the IPCC regions), such as from countries or groups of countries to households), complementing the Chapter 3 assessment at the regional and global level. It does so through the lens of livelihood, human, food, water, and ecosystem security, building on key risks (Oppenheimer et al., 2014). We acknowledge the difficulty in making visible the future impacts and risks at these lower levels as they entail embodied experiences to emerge at the intersection of systemic

inequalities and multi-dimensional vulnerabilities along the axes of gender, class, ethnicity, age, race, and (dis)ability, marginalisation and deprivation, and social inclusion and exclusion that are exacerbated by uneven development patterns (e.g., Olsson et al. 2014; Brandi, 2015). The literature on such 1.5°C-specific risks is exceedingly scarce; yet, identifying and addressing inequality is at the core of staying within a safe and just space for humanity (Raworth, 2012). The literature on the links between poverty and inequality and climate change, however, is substantial and shows a detrimental relationship: the poor will experience climate change severely, and climate change will exacerbate poverty (Hallegatte et al., 2016b; O'Neill et al., 2017c; Olsson et al., 2014) (see also Chapter 3, Section 3.4.10) (*very high confidence*).

5.2.2 Risks of a 1.5°C Warmer World

Insights from the updated Reasons for Concern (RFC) suggest transitions from moderate to high risk, for instance, for indigenous Arctic people, their livelihoods, and their ecosystems within the range of ~1.1–1.6°C global warming (O'Neill et al., 2017a) (see Chapter 3, Section 3.4). Bottom-up approaches that start with household-level data and then overlay future demographic and socio-economic trajectories with climate change scenarios offer a promising methodological alternative. For instance, Hallegatte and Rozenberg (2017) project that, under ~1.5°C warming by 2030, up to 122 million additional people could be in poverty due to climate change under a 'poverty scenario', similar to SSP4 (Inequality) (see Chapter 1, Box 1.2; and Chapter 2, Section 2.5.1), mainly due to increased food prices and health impacts. The same study projects most detrimental income losses for the poorest 20%, modeled for household data sets across 92 countries, suggesting that the already poor will get poorer and the poverty headcount will increase as a result of climate change. Without redistributive policies, the impacts of climate mitigation measures on poor people, through increased food and energy prices, could be even more damaging, especially taking into account gender discrepancies and the high vulnerability of children (Hallegatte and Rozenberg 2017).

In terms of livelihood security, risks associated with labor productivity, economic losses, and loss of life are anticipated to have significant implications for poverty, inequality, and equity. Past empirical evidence on the impact of extreme temperatures on labor productivity from the US and India suggest that an increase of 1°C in warming could reduce productivity by 1 – 3% for people working outdoors or without air conditioning, typically the poorer segments of the workforce (Deryugina and Hsiang, 2014; Park et al., 2015; Sudarshan et al., 2015; Zivin and Neidell, 2010). Current productivity thus will likely be severely impacted by a higher global heat stress, projected to increase by 5.7 times with 1.5°C of warming, with cities such as Kolkata expected to experience record conditions every year (Matthews et al., 2017). By 2030, compared to 1961–1990 climate change could be responsible for an additional 38,000 annual deaths due to heat exposure among elderly people, 48,000 due to diarrhea, 60,000 due to malaria, and about 95,000 due to childhood undernutrition (WHO, 2014). There is an increased risk of undernutrition resulting from diminished food production in poor regions at warming greater than 1.5°C (see also Chapter 3, Section 3.4.7).

Health shocks and poor health already exacerbate poverty through income losses, health expenses, and care giver responsibilities (see also Chapter 3, Section 3.4.7); moreover, higher morbidity and mortality will slow down poverty reduction and increase inequality (Hallegatte et al., 2016a). Such loss estimates, however, may not adequately reflect welfare impacts for poor households; they often own relatively little (hence are underrepresented in loss statistics) but suffer much more in terms of loss of income, savings, and health (Hallegatte et al., 2017).

There is a very high risk of displacement attributed to extreme climate events (floods, hurricanes) and increased sea level rise (Chapter 3, Section 3.3 and Section3.4), with temperature warming greater than 1.5°C by 2050 in low income and least developed countries is expected to result in high levels of poverty and inequality and low institutional capacity to respond to hazards (Aitsi-Selmi and Murray, 2016). This includes all small island developing states (SIDSs) in the Caribbean and the Pacific, and projections for the Bahamas, for example suggest annual average of 5.9% of displacements by tropical cyclones by 2050 (Aitsi-Selmi and Murray, 2016).

For food security, heterogeneous effects are expected regarding risks for poor people from food production

and price fluctuations. Net consumers of food products are likely to be harmed while those depending on agricultural wages may experience mixed impacts (Hallegatte et al., 2016a). There is high confidence between the link of increased ocean acidification and temperature warming, and the reduction of coral reefs leading to reduced fish species and other resources important for livelihood security of around 500 million coastal people in tropical and subtropical regions (Gattuso et al., 2015; Cramer et al., 2014) (see also Chapter 3, Box 3.6). In Bangladesh, for example, projected loss of freshwater fish stocks by 2050 is expected to greatly impact livelihood and food security for poor households due to their lack of mobility, reduced access to land, and deep reliance on local ecosystems (Dasgupta et al., 2017). There is limited evidence but high agreement that the accelerated retreat of glaciers in high mountain regions such as the Tibetan plateau and countries like Bolivia will negatively impact the water and food security of the poor (Immerzeel et al., 2010). For instance, it is estimated that the food security of 4.5% of the total population in Asia river basins such as the Brahmaputra and Indus basins will be threatened as a result of reduced water availability and the Tibetan plateau retreat in these basins by 2050, with regional temperature increase greater than 1.5°C (Kraaijenbrink et al. 2017; Immerzeel et al. 2010) (see also Chapter 3, Section 3.4.5). Limited evidence but high agreement exists that impacts are likely to occur simultaneously across different levels of security, but the literature on interacting and cascading effects of climate change among multiple sectors and existing drivers of inequality remains scarce (Hallegatte et al., 2014; O'Neill et al., 2017b; Reyer et al., 2017b, a).

5.2.3 Avoided Impacts of 1.5°C versus 2°C Warming

As risks increase with every level of additional warming, avoided future impacts can be expected when global warming is limited to 1.5°C rather than 2°C (see Chapter 3, Section 3.4). Yet, limited literature exists that assesses such avoided impacts regarding poverty eradication, inequalities, and equities. There is *high confidence* that limiting warming to 1.5°C would reduce the risks for unique and threatened ecosystems and associated risks with extreme weather events from High to Moderate/High transition (O'Neill et al., 2017b) (see also Chapter 3, Figure 3.17). This has implications for reducing risks on livelihoods, human, water, food and ecosystem security (O'Neill et al., 2017b).

For instance, risks for food, water, and ecosystem security particularly in subtropical regions such as Central America, and countries such as South Africa and Australia can be reduced in 1.5°C compared to higher risks posed at 2°C (Schleussner et al., 2016). There is *limited evidence* but *high agreement* that limiting temperature warming below 1.5°C will significantly reduce the population exposed to poverty in African and Asian countries (Byers et al.; Clements, 2009). For most of the African countries, twelve million people could be at risk from hunger at 1.5°C temperature warming compared to an additional 55 million people in 2°C warming scenario (Clements, 2009). In warming scenarios above 1.5°C Africa and Asia regions have higher fractions of the global exposed and vulnerable population to poverty, ranging from 8 – 21% at 1.5°C warming, to 29 – 54% at 3°C (Byers et al.).

Limiting warming to 1.5°C will reduce the total population exposed to droughts and heat waves from 455 million people at 1.5°C to 781 million people at 2°C, mainly in subtropical and tropical regions to more than one extreme drought event per year (Lange et al. submitted).Specifically, it will reduce the number of people in India and Australia exposed to heat waves by half relative to ~ 3 – 4°C in RCP8.5 by the mid-21st century(Mishra et al. 2017; King et al. 2017; Lange et al. submitted). For instance, in Mexico City, limiting the global temperature at 1.5°C will lead to reduced precipitation decline compared to 2°C reducing crop failures (Sosa-Rodriguez, 2014) and in the Northwest of USA, an increase in drier summers can be avoided by limiting the temperature target of 1.5°C (Karmalkar et al., 2017).

There is *high confidence* that maintaining levels of global warming at 1.5°C will reduce coral reefs mortality and safeguard livelihoods with some limited potential for adaptation at the lower warming level (Tschakert, 2015; O'Neill et al., 2017b; Reyer et al., 2017b; Magrin et al., 2014; Nurse et al., 2014; Hoegh-Guldberg et al., 2014; Schleussner et al., 2016) (see Chapter 3, Box 3.6). Specifically, 1.5°C limiting in temperature will reduce by 40% the exposure of coral reefs in the coast of Guyana, Suriname, and French Guiana to annual bleaching events until 2050 (in comparison to 2°C of warming) with implications for subsistence fisheries, tourism and protection from coastal storm surges (Reyer et al., 2017a).

Another way of assessing avoided impacts between 2°C and 1.5°C is to use, as a proxy, the AR5 WGII risk tables that were based on expert judgment. These tables suggest near-term (2030–2014) risks roughly comparable to those expected under 1.5°C warming by the end of the century compared to long-term (2080-2100) risks associated with 2°C warming. Figure 5.2 shows three examples representing the range of avoided impacts relevant for poverty and inequality, with and without adaptation. For some areas (Figure 5.2a), the lower temperature target could result in risks reduced from very high (without adaptation) and high (with adaptation) under 2°C to low (with adaptation) under 1.5°C. For other areas (Figure 5.2c), no or very limited adaptation potential is anticipated, with the same negative impacts expected for both 1.5°C and 2°C (Figure 5.2c). The risk for other negative impacts to occur are projected to be medium under 2°C with further potential for reduction, especially with adaptation, to very low levels (Figure 5.2b). Context – and place – specific projections for the lives of poor and disadvantaged populations are not possible from these risk assessments.

[INSERT FIGURE 5.2 HERE]

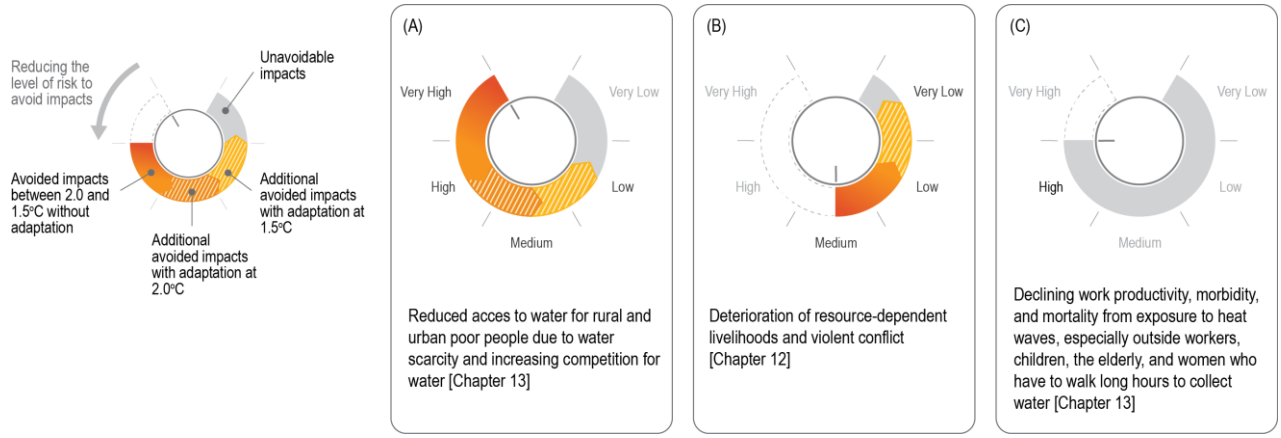


Figure 5.2: Reduced risk levels due to avoided impacts between 2°C and 1.5°C warming (in solid red-orange), additional avoided impacts with adaptation under 2°C (striped orange) and under 1.5°C (striped yellow), and unavoidable impacts with no or very limited potential for adaptation (grey), extracted from the AR5 WGII risk tables (Field et al., 2014, and underlying chapters). Risk levels for people and livelihoods associated with each of the two global warming levels range from very high to very low, with the potential for risk reduction through adaptation in addition to adaptation currently in place (expert judgement). The three examples (A-C, from left to right) illustrate the approximated range of possible avoided impacts (AR5 WGII chapter numbers in parenthesis).

5.2.4 Risks from 1.5°C Global Warming and the Sustainable Development Goals

Highlighting such fine-grained risks and avoided impacts, even if difficult to quantify, is important because it draws attention to the dynamics under which these risks undermine human capabilities and limit people's options to live dignified lives (Klinsky et al., 2017b), exacerbate inequalities, inhibit adaptive capacities and action, and ultimately curtail the potential for well-being and sustainable development (Section 5.5 and 5.6). Additional and avoided risks can be further exacerbated by negative impacts from adaptation and mitigation response options, especially when they disproportionally affect already disadvantaged populations (Section 5.4.2), hence constituting possibly double and triple injustices and losses (Section 5.5). As example, for health, there is no 'safe limit', as current impacts and risks from climate change and variability were already unacceptable, affecting people's health significantly and inequitably (Ebi and Bowen, 2016; Tschakert, 2015).

Global warming of 1.5°C compared to 2°C by the end of the century is expected to provide better chances to achieve the SDGs by 2030, with higher potentials to eradicate poverty, reduce inequality, and foster equity. Yet, the literature supporting this expectation remains scarce with the different timelines further

compounding the challenge of meaningful conclusions. Projections for ≤2°C (equivalent to RCPs 2.6 and 4.5) and 2.6–4.8°C (equivalent to RCP 8.5) suggest very low to low risk of failure for the former compared to very high risk of failure for the latter in terms of achieving SDG 1 (poverty), with poverty levels 80–140% lower for Asia and sub-Saharan Africa, as well as for SDGs 3 (health), 5 (gender equality), 6 (water and sanitation), and 10 (inequality), although there will be differences between countries (Ansuategi et al., 2015). In addition to direct implications, links between the individuals SDGs, particularly #1, 3, 5, and 10, indicate that delayed or diminished progress in one or several of the underlying targets also results in lower food security (OECD 2016) and hence further threats to human capabilities and well-being.

5.3 Climate Adaptation and Sustainable Development

Adaptation will be important in a 1.5°C warmer world since substantial impacts will be felt in various regions, human and natural systems (see Chapter 3, Section 3.3) (*robust evidence, high agreement*). Climate adaptation is the process of adjusting to actual or expected climate change (Agard et al., 2014) and adaptation options include structural, institutional, and social responses. Effective adaptation depends on the adaptive capacity of individuals and institutions including their ability to adjust to damage, seize opportunities and respond to consequences (Agard et al., 2014). Planning and policy implementation for adaptation includes enabling institutional action and financial investment (Betzold and Weiler, 2017; Sonwa et al., 2017; Sovacool et al., 2017b). Adaptation measures and options include structural and physical adaptations (coastal protection, water storage, plant breeding, transport and urban infrastructure, and ecosystem management), social adaptations (education, information, migration, social safety nets), and governance and institutional adaptations (insurance, land use regulation, water management, legal institutions and planning (see Chapter 4 and Table 14.1 in the WGII AR5 (Jha et al., 2017b; Maguire and McGee, 2017; Noble et al., 2014). Although engineering and technological measures currently dominate adaptation efforts, ecosystem-based, community-based, and institutional and social approaches are increasing (Chong, 2014; Munang et al., 2014; Reid, 2016).

This section investigates the interrelationships between adaptation response options and advancing sustainable development. Adaptation and development are to be best understood as having a two-way relationship. On the one hand, adaptation can assist in meeting long-term development goals (Klein et al., 2014). On the other hand, development affects the adaptive capacity of social and natural systems to cope with the negative impacts of climate change while reducing poverty and improving well-being (Castellanos-Navarrete and Jansen, 2015; Lee et al., 2014). This section assesses how prioritizing sustainable development enhances or impedes climate adaptation efforts (Section 5.3.1), and how climate adaptation measures create synergies and trade-offs with sustainable development and the SGDs, including poverty eradication and reducing inequalities (Section 5.3.2). Subsequently, the section discusses the sustainable development implications of adaptation pathways towards a 1.5°C warmer world (Section 5.3.3).

5.3.1 Sustainable Development in Support of Climate Adaptation

Making sustainable development a priority, and meeting the 2030 SDGs, is mostly consistent with efforts to adapt to climate change. Other international programs for sustainable development such as the UN Sendai Framework for Disaster Risk Reduction and the New Urban Agenda of UN Habitat highlight the importance of risk reduction and equitable, inclusive, and accountable approaches that are consistent with reducing climate vulnerabilities and adapting to climate change (Kelman, 2017; Roberts et al., 2015; Satterthwaite, 2017; Schlosberg et al., 2017).

Multiple lines of evidence confirm that sustainable development significantly influences vulnerability and adaptive capacity (Ayers et al., 2014; Forsyth, 2013; Reed et al., 2015). The process of development is more effective in supporting adaptive capacities if it considers not only major vulnerabilities and priority activities (hazard-based approaches) *per se*, but also the root causes of vulnerability, including insufficient information, social or institutional capacity, finance, or technology (Abel et al., 2016; Colloff et al., 2017; Mapfumo et al., 2017; Noble et al., 2014). Transformative adaptation, defined as ‘adaptation that changes the

fundamental attributes of a system in response to climate and its effects'(IPCC 2014d: *ref*) has the potential to be strongly impacted by the type of development pursued. Four significant dimensions by which sustainable development can lead to effective adaptation, transformative and incremental, are discussed below.

Firstly, the literature suggests that sustainable development will enable transformative adaptation when attention is paid to reducing poverty and promoting equity, social justice and fairness in climate adaptation decision making, rather than addressing current vulnerabilities as stand-alone climate problems (Antwi-Agyei et al., 2017b; Arthurson and Baum, 2015; Mathur et al., 2014a; Shackleton et al., 2015a). The overarching development goals of zero poverty, good health, and gender equality contribute to reducing climate vulnerabilities associated with low incomes, poor health, or gender differentials (Blau, 2017; Lemos et al., 2016).

Ending poverty in its multiple dimensions (SDG1) is a highly effective form of climate adaptation (Hallegatte and Rozenberg, 2017; Leichenko and Silva, 2014) with poor countries having less ability to adapt than richer countries (Fankhauser and McDermott, 2014). Addressing income inequality and poverty is a key precursor to reducing vulnerability in urban municipalities (Colenbrander et al., 2017; Rasch, 2017)and in agrarian communities (Eriksen and O'Brien, 2007; Hashemi et al., 2017). However, reducing poverty alone is not enough and complementary measures are needed to ensure that increased household wealth is channelled into risk reduction and risk management strategies enhancing adaptive capacities (Nelson et al., 2016).

Secondly, participation by local people is most effective for enabling effective adaptation when it addresses the wider socioeconomic and cultural processes that inhibit inclusive and equitable decision making (McCubbin et al., 2015; Nyantakyi-Frimpong and Bezner-Kerr, 2015).Sustainable development can also advance local participation in multi-scale planning strategies (Toole et al., 2016). It is particularly effective in advancing public engagement in planning when it is associated with peace building (Gupta and Arts, 2017b; Holden et al., 2016).The incorporation of local indigenous knowledge about, for example, weather, farming or seed resources, into decision making can also facilitate and significantly strengthen adaptive capacity (Nkomwa et al., 2014; Orlove et al., 2010; Slegers, 2008; Sutcliffe et al., 2016). Recent analyses of behaviour amongst high consumers in China (Wang, 2017), Finland (Ala-Mantila et al., 2016), the United Kingdom (Butler et al., 2016a) and the United States (Dickinson et al., 2016) highlight the complex way in which motivations, values and social norms, together with household structures, opportunities to participate in new practices and household incomes, reinforce, undermine or lock-in behaviours that strengthen climate adaptation over the short-, medium- and long-term (Dilling et al., 2015).

Thirdly, development is effective in promoting transformative adaptation when it addresses existing social exclusion and social inequalities (see also Section 5.6.2 and Section 5.6.4 for a discussion on equity and justice as enabling conditions for achieving climate resilient development pathways). Several goals for sustainable development, including access to education, gender equality and partnership, support values and behaviors that promote transformative adaptation (Fazey et al., 2017; O'Brien, 2016; O'Brien et al., 2015). For example, SDG 5 on gender equality and empowering women supports climate adaptation measures that include women's input, seek to reduce women's vulnerabilities and ensure that women benefit from adaptation actions (Bhattarai et al., 2015; Cohen, 2017; Mbow et al., 2015; Nilsson et al., 2016; Pearse, 2016; Van Aelst and Holvoet, 2016). This includes addressing the loss of women's rights to lands, as shown, for instance, in the case of women and migrant farmers in Ghana (Antwi-Agyei et al., 2015). Gender is particularly important given the disproportionate risk burden in climate adaptation which women and children continue to bear (Cutter, 2016). New gender responsive national adaption plans are being developed (Cutter, 2016; Doze and Dekens, 2017) but knowledge gaps in gender and climate research remain (Schipper et al., 2017). Emerging research suggests the Green Climate Fund may help bridge this gap (Ihalainen et al., 2017). SDG 4 seeks inclusiveness and equality in access to education. Highly educated individuals and societies have better preparedness and responses to disasters, suffer less negative impacts, and are able to recover faster (Frankenberg et al., 2013; Samir, 2013; Sharma et al., 2013). Investment in universal primary and secondary education levels around the world, and improving literacy is, therefore, an effective strategy for transforming and significantly strengthening adaptive capacities (Antwi-Agyei et al., 2012; Muttarak and

Lutz, 2014; Santos et al., 2016; Striessnig et al., 2013; Striessnig and Loichinger, 2015). Investment in equal and inclusive skills and increased access to finance can also reduce vulnerability to climate change (Bowen et al., 2012) as envisioned in SGD17 which seeks strong partnerships. For example, partnerships for climate finance alongside carbon taxation have been identified in the emerging literature as strategies to reduce inequalities (SDG 10) and advance climate mitigation and adaption (Chancel and Picketty, 2015). Local and national institutions for adaptation can be supported through the strong institutions sought under SDG 16 (Agrawal, 2010; Mubaya and Mafongoya, 2017). The role of institutions (SDG 16) and financial partnerships (SDG 17) is also key for diffusion of technological innovation and building resilience for example in agriculture (Chhetri et al., 2012; Halonen et al., 2017; Nhamo, 2016).

Fourth and finally, concrete actions on specific development goals are supportive of enhanced adaptive capacities. For example, SDG 11 seeks resilient and sustainable cities and settlements and is particularly important for the achievement of effective adaptation (Satterthwaite, 2017). The SDG targets of reducing disaster losses in cities and of increasing the number of cities implementing policies for climate adaptation are directly supportive of climate adaptation (Depietri and McPhearson, 2017; Klopp and Petretta, 2017; Parnell, 2017). Significant pressures on resource use and consumption created by rapid urbanisation can also outpace adaptive capacity if adaptation is based on an incremental vision (Bren d'Amour et al., 2016; Doll and Puppim de Oliveira, 2017; Thorne et al., 2017), for instance, in the case of rapid concentration of populations in dense urban areas exposed to floods (Neumann et al., 2015; Zougmore et al, 2016; Kelman, 2017). Ensuring water and sanitation for all (the goal of SDG 6) has strong synergies with climate adaptations that seek to increase water and health security. Developing reliable sources for safe drinking water is an important option for adapting households to drought, as are increases in water-use efficiency and cooperation in the management of transboundary water resources (Bhaduri et al., 2016; Olmstead, 2014; Rasul and Sharma, 2016a; Rouillard et al., 2014). Appropriate water management is crucial for ensuring water resource quantity and quality, and for tackling increase in urban wastewater production from population outburst and extreme weather conditions (Kumar et al., 2017; Ware, 2016; Zouboulis and Tolkou, 2015). For instance, wastewater reuse will be necessary as part of climate change adaptation measure (Hiremath et al., 2016; Trinh et al., 2013; Valipour and Singh, 2016). In water-stressed countries and in countries vulnerable to water-borne diseases, ensuring access to adequate and safe water is critical for health sector adaptation (Dasgupta, 2016; Ebi, 2016). SDG 2, which seeks zero hunger, has targets that include increasing agricultural productivity and incomes, implementing resilient agricultural practices, and maintaining genetic diversity – all strategies that are also those for adapting agricultural and food systems to climate change (Lipper et al., 2014). SDG3 for good health and well-being sets out to reduce maternal and infant mortality, reduce infectious disease, provide health cover, and increase health finance – also consistent with adaptation strategies to reduce the impacts of climate on health.

Reducing climate vulnerability through adaptation is mostly consistent with achieving sustainable development in general, and the SDGs specifically (*medium evidence, high agreement*).Amongst available mechanisms, those that preserve and ensure livelihood security are most effective for designing adaptation strategies that lead to achievement of the SDGs. This holds true for climate-change affected communities but also more broadly (*medium evidence, high agreement*). Transformative and context-specific adaptation, takes into consideration root socio-economic and cultural causes of vulnerability, including poverty and existing inequalities, and local specificities, including indigenous knowledge (*medium evidence, high agreement*). This constitutes an adaptation pathway that facilitates achievement of the SDGs in a 1.5°C warmer world (*medium evidence, high agreement*).

5.3.2 Synergies and Trade-offs between Adaptation Response Options and Sustainable Development

There are synergies and trade-offs between the dual goal of keeping temperatures below 1.5°C global warming and achieving sustainable development, in the short and the long term. The extent of synergies between development and adaptation goals will vary by the development process adopted for a particular SDG (*medium evidence, high agreement*). This section focuses on the implications of adaptation response options for sustainable development. It highlights synergies and trade-offs between adaptation and sustainable development for some key sectors and approaches to adaptation (see Figure SPM 2 and Table 1

in WGII AR5for details on the relevance of the risks arising in these sectors for different regions in the world). An assessment of evidence and agreement on these indicates that the impacts of adaptation measures on sustainable development, poverty alleviation, and equity in general, and the SDGs specifically, are expected to be largely positive, given that the inherent purpose of adaptation is to lower risks. Converging examples show that well integrated adaptation supports sustainable development (Adam, 2015; Aggarwal, 2013; Eakin et al., 2014; Smucker et al., 2015; Weisser et al., 2014). However, there are also trade-offs between adaptation measures and sustainable development across many adaptation measures. Most robust evidence of positive synergies stems from the agricultural and health sectors, and from ecosystem-based and cultural-based adaptation particularly among indigenous peoples.

Agricultural adaptation: In the agricultural sector, the most direct synergy is between SDG2 (eliminating hunger) and adaptation in cropping, livestock and food systems designed to maintain or increase production and SDG2 (eliminating hunger) (Rockström et al., 2017; Lipper et al., 2014; Neufeldt et al., 2013). Evidence indicates that farmers with adaptation strategies have higher food security levels and experience lower levels of poverty(Ali and Erenstein, 2017). Vermeulen et al. (2016) report strongly positive returns on investment across the world from agricultural adaptation with side benefits for environment and economic well-being. Well adapted agricultural systems contribute to safe drinking water, health, biodiversity and equity goals (DeClerck et al., 2016; Myers et al., 2017). Similar synergies were observed for water resources adaptation, specifically SDG6 on clean water and when attention is paid to local needs and governance (Bhaduri et al., 2016; Schoeman et al., 2014). Insurance and climate services are additional options that suggest synergies in terms of protecting incomes and livelihoods (Carter et al., 2016; Linnerooth-Bayer and Hochrainer-Stigler, 2015; Lourenço et al., 2015). Climate-smart agriculture (CSA) is a systematic approach to agricultural development intended to address synergies between food security and climate change adaptation and mitigation spanning from field management to national policy (see also Section 5.3.2, Section 5.4.2 and Section 5.5.2). While some scholars see CSA as an excellent option for adaptation, others are concerned that climate-smart agriculture is biased to technological solutions and may not be gender sensitive (Altieri and Nicholls, 2017; Lipper et al., 2014).

Agricultural response options increase risk for health, oceans, and access to water if fertiliser and pesticides are used without regulation or irrigation competes for water (Campbell et al., 2016; Lobell and Tebaldi, 2014; Shackleton et al., 2015a). Expanding farm land can have negative effects on biodiversity and on bioenergy production. Other adaptations such as crop insurance and climate services tend to overlook the poor and thereby increase inequality (Carr and Onzere, 2016; Carr and Owusu-Daaku, 2015; Dinku et al., 2014; Georgeson et al., 2017a). For example, agricultural insurance, can have ‘maladaptive’ outcomes. Although there is mixed evidence in the literature on whether insurance increases or decreases fertiliser and pesticide use, but in the cases where it does increase the usage of such agrochemical inputs, it has negative effects on ground water (SDG 6), biodiversity SDG 15 and human health (SDG 3) under certain conditions (Müller, Johnson, & Kreuer, 2017).

Changes in cropping patterns and timing may increase workloads, especially for women, and changes in crop mix can result in loss of income or culturally appropriate food (Bryan et al., 2017; Carr and Thompson, 2014; Thompson-Hall et al., 2016). Cradle-to-grave evaluations help delineate trade-offs and complementarities between agricultural yields, biodiversity protection, and human nutrition (Kanter et al., 2016). Transformational agricultural adaptation requires careful interactions with broader political and cultural environments as costs and benefits can extend far beyond the local farm system (Rickards and Howden, 2012).

Health adaptation: Adaptation responses in the health sector will reduce morbidity and mortality in countries at all stages of development (Arbuthnott et al., 2016; Ebi and Del Barrio, 2017). Early warning systems help lower injuries, illnesses, and deaths during heat waves and other extreme and weather events and during outbreaks of infectious diseases, with positive impacts for SDG3 (good health and well-being) and SDG13 (climate action). Better institutions for sharing information, additional indicators for detecting climate sensitive diseases, improved provision of basic health care services and coordination with other sectors also improve risk management, thus reducing adverse health outcomes (Dasgupta et al., 2016; Dovie et al., 2017).

In the health sector, trade-offs occur when, for example, increased use air conditioning to enhance resilience to heat stress leads to higher energy consumption and, depending on the energy source, higher greenhouse gas emissions (Petkova et al., 2017). This is a direct negative implication for SDG13. Adaptation responses in one sector can lead to negative impacts in another sector. An example is the creation of urban wetlands through flood control measures which can breed mosquitoes, adversely affecting SDG3 (Smith et al., 2014a; Woodward et al., 2011).

However, not all adaptation options produce just synergies, or trade-offs. In reality, two-way relationships are common, as in public health. On the one hand, effective adaptation measures for the near-term, in situations where basic needs are yet to be met, or resources are scarce, are programs that implement basic public health measures (Dasgupta, 2016; Hess et al., 2012; Smith et al., 2014a). Adaptation needs are linked with existing deficits in health systems and there are many examples of where measures to reduce current deficits are important for tackling future climate change impacts (Woodward et al., 2011). On the other hand, specific and planned adaptation efforts are required in parallel for climatic events, such as recurrent flooding. Such events can lead to erosion of household coping capacity over time (Webster and Jian, 2011), damage to infrastructure, undermining of long-term adaptive capacity, and increases in cumulative risk (Tapsell et al., 2002). In this case, more of the same is not sufficient.

Ecosystem-based adaptation (EBA): EBA includes ecological restoration (e.g., of wetlands and floodplains), afforestation, fire management, and green infrastructure, and is found to yield mostly positive benefits for sustainable development (Brink et al., 2016; Butt et al., 2016; Jones et al., 2012; Munang et al., 2013a; Ojea, 2015), although there are research and data gaps that make assessments difficult (Doswald et al., 2014). EBA with mangrove restoration has reduced coastal vulnerability while protecting marine and terrestrial ecosystems; river basin EBA has reduced flood risk and improved water quality; and wetland and mangrove restoration has increased local food security (Chong, 2014; Munang et al., 2013b). EBA may be more cost effective than other options, can be inclusive of local knowledge, and more easily accessed by the poor (Daigneault et al., 2016; Estrella et al., 2016; Ojea, 2015). The AR5 noted biodiversity, hazard reduction, and water protection co-benefits as well as economic benefits such as ecotourism through improving ecosystem services. Because ecosystems themselves are sensitive to temperatures and sea level, a 1.5°C global temperature increase, compared to 2°C or higher, is likely to enhance the success and reduce the costs of EBA.

As EBA has become mainstreamed into adaptation, more evaluations of synergies and trade-offs with sustainable development and agreements such as the Convention on Biological Diversity are available (Conservation International, 2016; Huq et al., 2017; Morita and Matsumoto, 2015; Szabo et al., 2015). Trade-offs include loss of other economic land use types and resource extraction, tensions between biodiversity and adaptation priorities, lack of respect for local knowledge, and conflicts over governance across scales and land rights (Mercer et al., 2012; Ojea, 2015; Wamsler et al., 2014). PES schemes that trade social outcomes for market-based business models risk perpetuating inequality and injustice (e.g., Fairhead et al., 2012; Muradian et al., 2013; Hahn et al., 2015; Calvet-Mir et al., 2015; Chan et al., 2017).

Coastal adaptation: Coastal adaptation to a range of global average temperatures and sea level rise has strong synergies with sustainable development objectives. Recent work indicates that adaptation to sea-level rise remains essential in coastal areas even under climate stabilization scenarios (1.5°C and 2°C) underlining the promotion of long-term adaptation and adaptation pathway approaches for coastal areas (Nicholls et al. In Press).Adaptation options that include building resilient infrastructure such as coastal defences are consistent with the SDGs on resilient infrastructure and sustainable cities as well as the Sendai framework for disaster risk reduction. Such so called ‘hard’ adaptation options may involve trade-offs when they have high costs and divert resources from other development priorities or if they impact on coastal ecosystems. Coastal adaptation options that are based on restoring ecosystems such as mangrove forests are more consistent with goals for life on land and in oceans (SDG 14) and can increase food security in sheltering fisheries. Coastal adaptation that involves land use control or relocation of coastal communities may be more or less consistent with development goals depending on whether decisions are participatory and the new settlements are designed for equity and sustainability (Chow, 2017; Dulal et al., 2009; Fletcher et al., 2016; Gibbs, 2016; Jobbins et al., 2013; Paprocki and Huq, 2017; Serrao-Neumann et al., 2014; Szabo et al., 2015;

Voorn et al., 2017).

Community-based adaptation: Community-based adaptation involves local people in a participatory and collaborative manner through the merging of scientific and local knowledge to improve resilience and ensure sustainability of adaptation plans (Fernandes-Jesus et al., 2017; Ford et al., 2016; Grantham and Rudd, 2017; Gustafson et al., 2016, 2017). However, community based adaptation has also been criticised for not always representing vulnerable people fairly or for failing to build long-term social resilience (Ensor, 2016; Forsyth, 2013; Taylor Aiken et al., 2017). Evidence from climate change-affected communities indicates that community based adaptation provides benefits by increasing local adaptive capacity in order to improve livelihood assets and security as well as addressing inequalities, gender biases, at the local level, in providing synergies with SDG 5 and SDG10 (Vardakoulias and Nicholles, 2014). Still, challenges of such adaptation are observed in mainstreaming into national and local planning, upholding principles of equity, justice and ensuring access to information that is fair for all, in a manner that enhances SDG 5 (gender equality), SDG10 (reducing inequality), SDG 16 (peace, justice and strong institutions) (Archer et al., 2014; Cutter, 2016; Kim et al., 2017; Reid and Huq, 2014).

Community based adaptation that is grounded on community values, coping strategies and decision-making structures cannot work in isolation at the community level since factors beyond the control of the community scale, such as governance and policy context, affect their vulnerability to climate change (Reid, 2016; Jeans et al., 2014; Tschakert et al., 2016). Adaptation responses induced by climate change interventions, such as global expansion of biofuels, where land is diverted from subsistence to commercial use due to nationally driven policies, could also have adverse negative impacts on achieving SDG10 (reducing inequality), for the local, indigenous as well as vulnerable groups, arising from the resultant dispossession of land, which affects their overall well-being physically, socially and culturally (Chambwera et al.; Dasgupta et al., 2014; Lunstrum et al., 2015). Other examples observed, moving the flood defenses inland as part of a managed realignment project resulted in taking agricultural land out of production, in which will affect farmers' livelihoods (Van de Noort, 2013). Focus on protection strategies in responding to coastal issues (i.e., dykes) lead to path dependencies and reduce local adaptive capacity for self-determinism in adaptation processes (Smith et al., 2013b).

Traditional knowledge-based adaptation: Long standing traditional knowledge systems have enabled indigenous people to sustain themselves against environmental change and uncertainty through generations (Armitage, 2015; Apgar et al., 2015;Whyte, 2015; Ford et al., 2016; Cobbinah and Anane, 2016; CTKW, 2015;Ani, 2013) (see also Chapter 4, Cross-Chapter Box 4.3). Building resilience through traditional knowledge and social cohesion enhances SDG2 (eliminating hunger), SDG6 (clean water and sanitation) and SDG10 (reduced inequalities), with evidence from initiatives that are community initiated and/or draw upon community knowledge or resources (Ayers et al., 2014; Berner et al., 2016; Chief et al., 2016; Chishakwe et al., 2012; Lasage et al., 2015; Murtinho, 2016; Regmi and Star, 2015; Reid, 2016). However, traditional knowledge is diminishing due to displacement and relocation of indigenous communities (Ensor, 2016; Maldonado et al., 2013; Villamizar et al., 2017; Warner, 2015; Williams and Hardison, 2013), thus multiple forms of knowledge should be incorporated to complement adaptation processes in achieving sustainable development (Ani, 2013; Ataur Rahman and Rahman, 2015; Enqvist et al., 2016; Tengö et al., 2014). The resilience of traditional knowledge is also threatened by a history of exploitation, a lack of recognition and respect for indigenous people values and rights, and a lack of safeguards for the control and proper use of their knowledge (Ensor, 2016; Villamizar et al., 2017; Williams and Hardison, 2013).

Migration as adaptation: Empirical evidence indicates that decisions about migration are inextricably linked to a host of socio-economic, political and institutional conditions (see for instance Waldinger and Frankhauser ,2015), including job availability, skill and educational levels, environmental changes, climate and health hazards (Suckall et al., 2017). However, the extent to which it succeeds as an adaptation option depends also on several factors, including prevailing differentials in income and socio-economic status and access to information among migrants. Temporary migration is a centuries old strategy for adapting to extreme events amongst pastoralists and seasonal agricultural workers (Keshri and Bhagat, 2013). Many climate change-affected communities have already been using migration as a means to adapt to and withstand the challenges to their livelihoods and security (Jha et al., 2017a; Marsh, 2015) and its success lies

in having appropriate adaptation measures in destination areas and strengthening existing protections for all migrants (Entzinger and Scholten, 2016; McNamara, 2015). There are sustainable development impacts in both the sending and receiving regions when migration is used as an adaptation option (Fatima et al., 2014). For example, those left behind may be vulnerable women and the elderly without sustainable livelihoods and migration can be culturally disruptive (Islam and Shamsuddoha, 2017; Wilkinson et al., 2016). When migrants end up in refugee camps. they may experience poor health and hunger and may increase pressure on water and energy resources at their destination (McMichael, 2015; Patrozou, 2015).

Payment for ecosystem services (PES), is an innovative means of facilitating adaptation and has been increasingly advocated for ecosystem based adaptation in particular. It provides incentives to land owners and natural resource managers to preserve environmental services and, when designed with a pro-poor focus, contributes to poverty reduction and livelihood security. Evidence from Costa Rica, with first experiences going back to the 1990s, indicates neutral or positive impacts on livelihood outcomes (Arriagada et al., 2015; Locatelli et al., 2008) and rates of deforestation (Arriagada et al., 2012; Sánchez-Azofeifa et al., 2007). Similar dual synergies have been reported for Brazil (see Section 5.6.3) and programs in other countries, although evidence of coupled adaptation-mitigation benefits remains scarce (Samii et al. 2014; Börner et al. 2016). Higher synergies are achieved when there is local participation in the design, implementation and monitoring of PES programs (Wegner, 2016) and when they are user-financed (voluntary) and locally-targeted and monitored (Wunder et al., 2008).

There is robust evidence of the potential for synergy between adaptation responses and several SDGs, such as poverty reduction, elimination of hunger, clean water, and health (*robustevidence, high agreement*). However, negative outcomes (or trade-offs) can also potentially occur across sectors either in the form of maladaptation or adverse consequences of particular development or adaptation strategies (*medium evidence, high agreement)*. Examples of such instances include conservation of biodiversity and agricultural expansion, resilience to heat stress and energy consumption, land rights and biofuel programs, high cost adaptation options in resource constrained situations. More research is required to understand how trade-offs and synergies will intensify or reduce, differentially across geographic regions and time, under a 1.5ºC world as compared to higher temperatures.

5.3.3 Sustainable Development Implications of Adaptation Pathways toward a 1.5°C Warmer World

In a 1.5°C warmer world, adaptation response options will need to be intensified, accelerated, and scaled up. To ensure desirable outcomes for sustainable development and achieving the SDGs, above all eradicating poverty and reducing vulnerabilities and inequalities, the long-term goal will be to enhance known synergies and minimise negative impacts. This entails not only the right ‘mix’ of options (asking ‘right for whom and for what?’) but also a forward-looking and dynamic understanding of adaptation pathways (see Chapter 1, Section 1.2.4, Box 1.2), best understood as decision-making processes over sets of potential action sequenced over time (Câmpeanu and Fazey, 2014; Wise et al., 2014). This challenge is compounded by the fact that responses to change, that is, adapting to the local realities of a 1.5°C global warming, create new and unknown conditions. Hence, multiple and often interrelated pathways become possible, at different scales and for different groups of people. Choices between possible pathways are shaped by uneven power structures and historical legacies and, in turn, create further change and the need for more or different responses (Fazey et al., 2016; Lin et al., 2017; Murphy et al., 2017; Bosomworth et al., 2017).

Pursuing a pathway approach to place-specific adaptation harbors the potential for significant positive outcomes, with synergies for well-being and dignified lives, and to ‘leap-frog the SDGs’ through inclusive adaptation planning (Butler et al., 2016b), in countries at all levels of development (*medium evidence, high agreement*). It allows for identifying socially-salient and place-specific tipping points before they are crossed, based on what people value and trade-offs that are acceptable to them (Barnett et al., 2014, 2016b; Gorddard et al., 2016a; Tschakert et al., 2017), sometimes contesting best science predictions and state adaption responses (Fincher et al., 2014; Fazey et al., 2016; Murphy et al., 2017). Yet, emerging evidence also suggests significant and often hidden trade-offs that reinforce rather than reduce existing social inequalities and hence may lead to poverty traps (Barnett et al., 2016; Nagoda, 2015; Godfrey-Wood and

Naess, 2016; Pelling et al., 2016; Butler et al., 2016b; Murphy et al., 2017) (*medium evidence, high agreement*).

Dominant or normative pathways tend to validate the practices, visions, and values of existing governance regimes and the more privileged members of a community, given their assets and long-standing power positions, while devaluing those of less well-off households, different ethnic groups, and other disenfranchised stakeholders, thereby exacerbating inequalities and pushing the most vulnerable toward lock-in situations with less and less capacity to navigate change, as shown in case studies from Romania, the Solomon Islands, and Australia (Fazey et al., 2016; Davies et al., 2014; Bosomworth et al., 2017). Tensions between values and worldviews that influence adaptation pathway decisions, for instance individual economic gains and prosperity versus community cohesion and solidarity, further erode collective adaptive action; moreover, innovative actions that deviate from the dominant path are discouraged (Fazey et al., 2016; Davies et al., 2014; Bosomworth et al., 2017). In the city of London, UK, the dominant adaptation and disaster risk management pathway adopts a discourse of resilience, albeit one embedded in national austerity measures; it increasingly emphasises self-reliance which, given the city's rising inequalities, intensifies the burden on low-income citizens and marginal populations such as the elderly and migrants and others who are unable to afford flood insurance or protect themselves against heat waves (Pelling et al., 2016). A climate adaptation and development pathway that enables subsistence farmers in the Bolivian Altiplano to become world-leading quinoa producers has led to reduced exposure and vulnerabilities and increased community resilience, but it has also triggered a series of new threats; these range from loss of ecosystem services to loss of social cohesion and traditional values to social exclusion and dispossession (Chelleri et al., 2016). A narrow view of decision making, for example focused on technical feasibility and cost-benefit analyses, tends to crowd out more participatory and inclusive processes that foreground collective learning and wider consultation (Lawrence and Haasnoot, 2017; Lin et al., 2017) and obscure contested values and power asymmetries in governance (Bosomworth et al., 2017).

A situated and context-specific understanding of place that brings to the fore multiple knowledges, values, and contested politics helps to overcome dominant path dependencies, challenge scientific options detached from place, and advance joint place making (Murphy et al., 2017; Wyborn et al., 2015). These insights suggest that win-win outcomes, even via socially-inclusive adaptation pathway approaches to plan and prepare for 1.5°C global warming and higher local warming, will be exceedingly difficult to achieve without a commitment to inclusiveness, place-specific trade-off deliberations, redistributive measures, and procedural justice mechanisms to facilitate equitable transformation while meeting the SDGs, particularly poverty eradiation and reducing inequalities (*medium evidence, high agreement*).

5.4 Mitigation and Sustainable Development

Mitigation response options and mitigation pathways are expected to have synergies and trade-offs for sustainable development, poverty eradication, and inequalities, and the SDGs, across sectoral and regional contexts. The literature assessed in this section, although each one of them does not always directly refer to 1.5°C, but writes about the mitigation options that are crucially needed to accelerate the reductions of emission and to deepen them and are critical for 1.5°C pathways (see also Chapter 2, Section 2.3, and Chapter 4, Section 4.3). Aligning mitigation actions to sustainable development objectives can ensure public acceptance (IPCC, 2014c) since development can be an important motivation for pro-environmental change, across diverse publics (Bain et al., 2016;Roy et al,. 2016). Attention to development is particularly important in the context of 1.5°C global warming as such an ambitious climate goal will require a radical shift from business-as-usual development (Boucher et al., 2016; Griggs et al., 2013). Maximizing the synergies between mitigation and sustainable development enables policy design for fast actions (Lechtenboehmer and Knoop, 2017) and advance debate about ways and means to achieve just and fair approaches to achieving the 1.5°C degree target, (Mary Robinson Foundation, 2015; Gupta and Arts, 2017; Holz et al., 2017; Winkler et al., 2017, UNEP, 2017) . Section 5.4.1 assesses such synergies and trade-offs between mitigation options and sustainable development goals. It also presents how a sustainable development approach can help in accelerating mitigation actions. Section 5.4.2 presents short assessment of what are the distributional impacts of delayed mitigation actions. Section 5.4.3 presents sustainable development implications of 1.5°C

and 2°C mitigation pathways and the corrective measures that can strengthen synergies.

5.4.1 Synergies and Trade offs between Mitigation Options and Sustainable Development

Past IPCC assessment reports have examined mitigation strategies for specific sectors (energy supply, industry, buildings, transport, and agriculture, forestry and land use (AFOLU)). In this section, the focus is on comprehensive assesment of the interaction of diverse mitigation option categories for sustainable development including dimensions of poverty and inequality. *There is very high agreement* in the literature that pursuing stringent climate mitigation options generates multiple positive non-climate co-benefits that have the potential of reducing costs of achieving several sustainable development dimensions (IPCC, 2014c; Schaeffer et al., 2015b; Singh et al., 2010; Ürge-Vorsatz et al., 2014, 2016; von Stechow et al., 2015) (see also Table 5.1 and Figure 5.3) and advancing multiple short-term tragets under the SDGs. However, the literature also suggests potential trade-offs (Table 5.1 and Figure 5.3). Understanding of this two way interaction is key for selecting mitigation options that are not necessarily cost-effective from a narrow GHG emission mitigation perspective, but maximise the synergies between mitigation and development (Delponte et al., 2017; Hildingsson and Johansson, 2015; van Vuuren et al., 2017).

5.4.1.1 Accelerating Efficiency in Resource Use

There is very high confidence in the literature that accelerating energy efficiency improvement in all end use energy demand sectors has strong synergies with large number of SDGs (Figure 5.3, Table 5.1). The residential sector accounts for roughly one-third of total global final energy use (Lucon et al., 2014). A study in Canada shows that efficient lighting, efficient furnaces, and high efficiency appliances can be achieved at the lowest cost (Subramanyam et al., 2017). Accelerating energy efficiency improvement by removal of local barriers (Lucon et al., 2014; Mata et al., under review) in buildings across various countries has positive impacts on sustainable development and connects with large number of SDGs (Table 5.1, Figure 5.3). *There are robust evidence* that they generate health benefits, reduction in morbidity, cost savings, local employment, food security, women empowerment, reduced school absences, improved appearance, thermal comfort, pride in place and enhanced social status, improved indoor air quality, and energy savings, local sourcing of materials (Berrueta et al., 2017; Cameron et al., 2015; Casillas and Kammen, 2012; Derbez et al., 2014; Fay et al., 2015; Hallegatte et al., 2016a; Hirth and Ueckerdt, 2013; Kusumaningtyas and Aldrian, 2016; Liddell and Guiney, 2015; Maidment et al., 2014; McCollum et al., 2017; Scott et al., 2014; Sharpe et al., 2015; Wells et al., 2015; Willand et al., 2015). The industrial sector generate synergies with all the economic dimensions of sustainable developmental goals by accelerating energy efficiency improvements through removal of barriers especially in many developing countries (Apeaning and Thollander, 2013; Fischedick et al., 2014). It creates decent jobs, training of youths and technical and managerial skills, which in turn help in sustaining the efficient manufacturing practice management, help in reducing poverty, lead to water savings. Energy efficiency of tourism transport can help in reducing rising energy consumption and emission from tourism transport (Shuxin et al., 2016).

There is *high agreement* in literature that to actualize the full potential of energy savings, the managing rebound effect must be managed strategically (Altieri et al., 2016; Chakravarty and Tavoni, 2013; IPCC, 2014c; Karner et al., 2015; Zhang et al., 2015). Residing in energy efficient homes without adequate heating and ventilation strategies to minimise indoor dampness, for example, may increase the risk of adult asthma (Sharpe et al., 2015). In the extractive industries, water and energy efficiency targets are not always synergistic. These efficiency targets need to be addressed in a strategic and integrated way over the next decade to avoid industry level shortfalls (Nguyen et al., 2014).

5.4.1.2 Behavioural Options

Consumption perspective strengthens the environmental justice discourse while possibly increasing an individualised environmental discourse (Hult and Larsson, 2016). Behavioural responses and right incentive design help realising the full potential of intermittent renewable energy (Nyholm et al., 2016) and energy efficiency improvements (Chakravarty and Roy, 2016). Complex interactions exist between resident

behaviours and the built environment. Building technology and occupant behaviours interact to affect home energy consumption (Zhao et al., 2017). Echegaray (2016) discusses, based on urban sample survey in Brazil, subjective preference for new products. Declaration of premature obsolescence for appliances act as barrier to sustainability. Longer life for goods and services is important to reduce demand and industrial emission (Fischedick et al., 2014).At the same time Liu et al. (2016b) suggest that there is need to go beyond individualist and structuralist perspectives to analyse sustainable consumption. Inertia in the occupant behaviour to change habits quickly sometimes cannot take advantage of more than 50% of energy efficiency potential of an efficient building (Zhao et al., 2017).

There is high agreement in literature that synergies between efficiency improvement and changes in behavioural responses in residential sector can help achieve multiple SDGs across all three dimensions of sustainable development (Aydin et al., 2015; Berrueta et al., 2017; Cameron et al., 2016; Fay et al., 2015; Hallegatte et al., 2016c; Ismailos and Touchie, 2017; Jakob and Steckel, 2014; Maidment et al., 2014; McCollum et al., 2017; Scott et al., 2014) and also to large extent SDG 7 if rebound effect can be managed appropriately. Behaviour to adjust thermostat help in energy saving, building survey and monitoring also have positive impact (Song et al., 2016). Adoption behaviour of smart meters and smart grids which can happen through community based social marketing, participatory behaviour change programmes and help in reduction in peak demand, expansion of innovation and infrastructure for energy savings (Anda and Temmen, 2014). Promoting low-emission options for households requires taking account of the cultural and social needs of users, such as recognising that stoves often serve as a gathering point for families (Bielecki and Wingenbach, 2014). It also depends upon the articulation of new technology diffusion with other dimensions, like behaviour and lifestyle change (Jensen et al., 2016; Quam et al., 2017). Profound changes in energy uses, like the ones required to take people out of poverty, provide energy access and reduce GHG emissions, require a combination of changes in technologies and consumption patterns which in turn depend upon radical socio-cultural, technological and organisational innovation (Doyle and Davies, 2013; Mont, 2014; Rourke and Lollo, 2015). User behaviour plays a much more important role toward decarbonization in transport sector (Mattauch, Ridgway, & Creutzig, 2016). Individual behaviour change towards increased physical activity in short distances in non-motorised modes, public transport, two wheelers, car model choice and use patterns generate health benefits (Chakrabarti and Shin, 2017; Shaw et al., 2014b) help reducing inequality in access (Kagawa et al., 2015; Lucas and Pangbourne, 2014), sustainable infrastructure growth in human settlements (Kagawa et al., 2015; Lin et al., 2015) but public policy intervention is needed to reduce risks of road accidents for pedestrians (Hwang et al., 2017; Khreis et al., 2017) and increase safety on the road (SDG 16)Partnership on Sustainable Low Carbon Transport, 2017). Individual automobile use behaviour change with appropriate incentives and awareness programs, policy interventions targeting restrictions on driving behaviour enhance SDG12, choice of sustainable lifestyle (Creutzig et al., 2016; Kagawa et al., 2015; Lin et al., 2015).

There is robust evidence and high agreement that in the AFOLU sector, behavioural change leading to dietary change toward global healthy diets and waste reduction could reduce emissions (Bajželj et al., 2014; Garnett, 2011; Hiç et al., 2016; Kummu et al., 2012; Tilman and Clark, 2014), whilst also contributing predominantly to SDGs 2, 3 and 13, with additional contributions to SDGs 6, 12, 14 and 15. Encouraging responsible sourcing of forest products enhances economic benefits by creating decent jobs, helps innovation and upgrading of technology, encourages responsible decision making and enhances trade (Bartley, 2010; Hejazi et al., 2015; Huang et al., 2013).

5.4.1.3 Access to Modern and Reliable Energy and Fuel Switch

There is *robust evidence and agreement* that millions of people in the global south are escaping poverty by accessing modern energy forms (Lloyd et al., 2017) which are fundamental to human development (Anenberg et al., 2013; Bonan et al., 2014; Burlig and Preonas, 2016; Casillas and Kammen, 2010; Chowdhury, 2010; Clancy et al., 2012; Cook, 2011; Dinkelman, 2011; Haves, 2012; Kaygusuz, 2011; Kirubi et al., 2009; Köhlin et al., 2011; Matinga, 2012; McCollum et al., 2017; Pachauri et al., 2012; Pode, 2013; Pueyo et al., 2013; Rao et al., 2014; Zulu and Richardson, 2013). Aggressive efficiency improvement with low carbon generation sources has potential to offset increased demand in residential sector (Reyna and Chester, 2017). The systems that are less carbon intensive and vital for advancing human development,

resolve energy access and energy poverty issues in rapidly growing countries like Vietnam, Brazil, India, South Africa, and poorest countries transitioning from agrarian to industrial societies (Dasgupta and Roy, 2017; Mark et al., 2017). In Africa in crowded cities informal transport, high cost of commuting limits access to jobs (Lall et al., 2017). In Latin American cities, triple informality (transport, jobs, housing) is leading to low productivity and living standards (CAF Corporacion Andina de Fomento, 2017), poor road infrastructure reduces safety in cities and by increasing risks of road accidents (Vasconcellos and Mendonça, 2016). However, in cities such infrastructure expansion need to include pro-poor strategies into construction and operation as sometimes such constructions lead to eviction from informal settlements (Colenbrander et al., 2016). Electric vehicles using electricity from renewables or low carbon sources need to be combined with e-mobility options such as trolley buses, metros, trams and electro buses, as well as promote walking and biking, especially for short distances (Ajanovic, 2015).

Effective regional cooperation in renewable energy is key to promoting a synergetic approach between enhanced access to electricity, cooking energy, and emission reductions (Uddin and Taplin, 2015).The deployment of small-scale renewables (Sovacool and Drupady, 2012), or off-grid solutions for people in remote areas (Sanchez and Izzo, 2017; Sovacool, 2012) has strong potential for synergies with access to energy but requires adopting measures to overcome technology and reliability risks associated with large-scale deployment of renewables (Giwa et al., 2017; Heard et al., 2017). Development of baseload energy sources from renewable like geothermal, biomass or hydro power ensure reliability of energy supply with low-carbon options (Matek, 2015; Matek and Gawell, 2015). Renewable energies could potentially serve as the main source of meeting energy demand in rapidly growing cities of the Global South with multiple sustainable development benefits. Ali et al. (2015) estimated the potential of solar, wind and biomass renewable energy options to meet parts of the electrical demand in Karachi, Pakistan. Switching to low-carbon fuels in the residential sector enhances SDGs 3, 7, 11, and 13. Low-income populations in the Global North are often left out of renewable energy generation schemes, either because of high start-up costs or lack of home ownership (UNRISD, 2016).

Incentive design to addressing the behaviourial response through rebound effect need to keep in view the differential magnitudes and welfare implications in the context of developed and developing countries especially in the latter where energy access is limited and unmet demand is high (Aydin et al., 2015; Chakravarty et al., 2013; Santarius et al., 2016). In developing countries higher rebound effect help in achieving affordable access to energy (SDG 7.1) faster, so rebound supressing policies such as carbon price/carbon tax can harm disproportionately consumers with energy poverty and need to be regionally differentiated (Kriegler et al., under review) and be made revenue neutral to avoid trade off even in developing country context (Saunders, 2011;Combet, 2013; Grottera et al., 2015;Winkler 2017). In cases where higher energy costs make the shift towards clean-burning cooking fuels less acceptable (Cameron et al., 2016) synergies in policies for energy access, air pollution and climate change are required (Rao et al., 2013).

In the transport sector, fuel use such as use of sustainable biodiesel, natural gas, electric vehicles (EVs) are considered for deep decarbonised transport system and climate benefits with benefits for local air pollution (Alahakoon, 2017; Nanaki and Koroneos, 2016; Sundseth et al., 2015) but for electric vehicles environmental benignity will depend on electricity generation mix (Ajanovic, 2015; Wolfram and Wiedmann, 2017; Xylia and Silveira, 2017) to be consistent with SDG7. Social acceptance is a determining factor for the large-scale deployment of bioenergy solutions in a way that maximises the synergies with sustainable development objectives, in turn depending upon a complex set of socioeconomic, local and market dimensions (Fytili and Zabaniotou, 2017). With more electrification of transport sector electricity price can go up and adversely affect poor unless pro-poor redistributive policies are in place (Klausbruckner et al., 2016). Improving and Promoting public transport system makes cities sustainable (Song et al., 2016).

Outdoor air quality improves due to reduction of pollutants from fossil fuel combustion (West et al., 2013; Yang et al., 2016). The health benefits can motivate public support for ambitious actions that also have the benefit fo reducing GHG emissions (Thurston, 2013). This is for example the case of transport solutions improving air quality at street and pedestrian level in cities and contributing to lower emission intensity of transport activities, through inter-city passenger transport management (Ren et al., 2016) or actions on urban

transport (Creutzig et al., 2015a).

For energy intensive processing industries (EPI), which account for most of the 30% global emissions share of the total industry sector, have an urgent need for zero carbon energy sources (Åhman et al., 2017; Denis-Ryan et al., 2016). This calls for a change in user behaviour, culture, policy, corporate innovation strategy, infrastructure besides radical technology change along with ongoing energy efficiency improvements and low carbon fuel transitions (Lechtenboehmer and Knoop, 2017; Wesseling et al., 2017). Study in EU energy intensive processing industries (EPI) shows need for radical technology innovation through maximum electrification, hydrogen use or biomass, integration of CCS and innovations for CCU. However, strong synergies with multiple SDGs due to progressing decoupling , innovation, scope of cross sectoral, supranational partnership, scope for sustainable production need to be strengthened by attending to the trade off due to risks of CCS based carbon leakage, higher need electricity and price impacts through careful regulatory mechanisms (Wesseling et al., 2017).

Phasing out of coal and fast deployment of renewables like solar and wind, hydro, modern biomass in energy supply sector do enhance health goal by reducing air pollution. It also advances SDGs 1 and 10, 11,12(Chaturvedi and Shukla, 2014; Haines et al., 2007; IEA, 2016; McCollum et al., 2017; Riahi et al., 2015, 2017; Rose et al., 2014a; Smith and Sagar, 2014; West et al., 2013) Rao et al (2016). However, some conflict with SDGs can emerge from offshore installations with SDG 14 based on local context (Inger et al., 2009; McCollum et al., 2017; Michler-Cieluch et al., 2009; WBGU, 2013) Buck and Krause (2012); and also with SDG 15 due to landscape and wild life from wind, large hydro and large biomass installations (Wiser et al. (2011); Lovich and Ennen (2013); Garvin et al. (2011); Grodsky et al. (2011); Dahl et al. (2012); de Lucas et al. (2012); Dahl et al. (Dahl et al., 2012); Jain et al. (2011), and habitat impact (Smith et al. 2014). But, trade-offs between renewable energy production and other environmental objectives need to be scrutinised for negative social outcomes. Shifts towards domestically-produced renewable energy enhance energy security in fossil-importing economies (Oshiro et al., 2016).

Achieving deep cut in emissions through CCS and nuclear options can also have significant adverse implications for health and water security (SDGs 3, 6) and increase the societal costs and risks associated with the handling of waste and abandoned reactors (see SDG8) (see Table 5.1a and d and Figure 5.3).

Deep cuts to emissions could impede development for certain regions, countries, and populations unless low carbon pathways and low cost energy are rapidly made available and implemented (Colenbrander et al., 2016). Phasing out of coal reduces adverse impacts of upstream supply-chain activities, in particular local air pollution, and coal mining accidents and risks for terrestrial ecosystems (UNEP 2017). Switching to natural gas to replace coal is also expected to bring water benefits due to increasing power generation efficiency and reduced cooling water demands.Combining air pollution control and non-fossil energy targets lowers the total cost of the coal-control policy (Wang et al., 2016). Literature also suggests that ambitious emission reduction targets can unlock very strong decoupling potentials in industrialised fossil exporting economies (Hatfield-Dodds et al. 2015).

There is *high agreement* in the literature based on *robust evidence* that economies dependent upon fossil fuel-based energy generation and/or export revenue will be disproportionally affected by future needs to restrict the use of fossil fuels via stranded assets, unusable resources under the ground, lower capacity use, early phase out of large infrastructure already under construction under stringent cimate goals and higher carbon prices (Johnson et al. 2015; McGlade and Ekins 2015, UNEP 2017) (see Section 5.1, Box 5.2). Despite global climate goals investment in coal continues to be attractive in many countries as it is a mature technology, provides cheap energy supply, access and energy security (Jakob and Steckel, 2016) which make it politically attractive (Vogt-Schilb and Hallegatte, 2017) under such circusmtances there is *high agreement* in literature that besides sustainable development benefits there is need for supplementary policies to ease job losses, relatively higher prices of alterantive energy, (Garg et al., 2017; High-Level Commission on Carbon Prices, 2017; Jordaan et al., 2017; OECD, 2017; Oei and Mendelevitch, 2016; Oosterhuis and ten Brink, 2014; UNEP, 2017). Research on historical transitions shows that managing the impacts on workers through retraining programs are a key condition to align the phase down of mining industry, required for meeting ambitious climate targets, and the objectives of a ‘just transition’ (Caldecott et al., 2017; Galgóczi,

2014; Healy and Barry, 2017). This aspect is even more important in developing countries where the mining workforce is largely semi or unskilled (Altieri et al., 2016; Tung, 2016).

5.4.1.4 Cross-sector Response Options

Mitigation efforts that emerge from cross-sectoral efforts at city scale, new sectoral organisations based on the circular economy concept (Preston and Lehne, 2017) and multi-policy interventions that follow systemic approaches are showing higher synergies with SDGs.

The UNFCCC recognises that equitable development requires enabling developing countries to pursue economic growth to achieve higher standards of living and well-being and reduced inequalities (Barroso et al., 2016; dos Santos Gaspar et al., 2017). The compatibility between this and ambitious emission reductions depends on the capacity to decouple economic growth and GHG emissions (Holden et al., 2016; Stern et al., 2016) and on the promotion of measures addressing inequality while enhancing climate change mitigation efforts (Chakravarty and Tavoni, 2013; Jorgenson, 2015; Ley, 2017b). The potential for decoupling economic growth and GHG emissions is highly debated. The literature on de-growth argues that reliance on decoupling alone is not realistic and that ambitious climate goals also require a radical cut to energy demand and GDP growth, especially amongst developed states (Antal and Van Den Bergh, 2016; Jackson and Senker, 2011; Weiss and Cattaneo, 2017; Wiseman, 2017; Zhang et al., 2016).Others argue that economic growth can be compatible with decarbonisation and dematerialisation under specific conditions and well-designed policy settings which reorient growth patterns towards more efficient resources and energy use (Liu et al., 2017; Schandl et al., 2016; Sheng and Lu, 2015).Creutzig et al. (2014) find that the European energy transition with a high-level of renewable energy installations in the periphery could act as an economic stimulus, decrease trade deficits, and possibly have positive employment effects.

Achieving inclusive, low-carbon growth depends on the capacity to mobilise finance for sustainable infrastructure, and the ability of carbon pricing schemes to close infrastructure access gaps (Bak et al., 2017; Bhattacharyya et al., 2016; Jakob et al., 2016). A major challenge in developing economies is to attain and sustain economic development without increasing GHG emissions, calling for specific strategies maximising the opportunities of the domestic context (Elum et al., 2017; Emodi and Boo, 2015). This also calls for specific measures to manage the transitioning to low-carbon growth through progressive implementation measures to avoid serious immediate unemployment issues (Yuan et al., 2015), direct investment in key sectors for mitigation (Waisman et al., 2013). Adopting adequate economic incentives, particularly fossil fuel subsidy reforms, can also be a key driver of this shift to low-carbon energy for taking people out of poverty (Jakob et al., 2015; Ouyang and Lin, 2014; Rentschler and Bazilian, 2016).

Development policies, can enhance synergies with energy efficiency and deployment of decentralised renewable energy, sustainable consumption and production practices (Alstone et al., 2015; Creutzig et al., 2016; Druckman and Jackson, 2016; Geels et al., 2015; von Stechow et al., 2015)and reduce the social cost of carbon compared to a narrowly focused climate-centric approach (Shukla et al., 2015)

In many newly industrialising countries, the dual problem of resource scarcity and environmental impacts of manufacturing processes can be addressed through adoption of operations that follow industrial symbiosis, industrial park/clusters or the circular economy concept. Such industrial operations improve the sustainable development ability by reducing non-renewable inputs, imported resource inputs, and associated services and the ratio of savings to the total GDP of the industrial park is also positive. It helps in reducing the need for raw materials and energy consumption and improves the overall sustainability (Fan et al., 2017). Other benefits accruing through industrial parks in China are water savings, waste reduction and conversion to resources, resource savings through regenerative use of resources, sustenance of profitability, sustainable supply chain management, enhancing capability, ecosystem service value enhancement (Zeng et al., 2017). Industries are becoming energy supplier for neighbouring towns. The use of waste heat, waste water, and industry roof-tops for solar help meet neighbourhood urban energy demands. It creates a new opportunity for energy enhancing independency of specific regions, total energy demand reductions by towns, primary energy demand reduction and heating energy demand for towns beings met (Karner et al., 2015).

In the transport sector, the EU policy package of taxing fuels for private transportation, reducing taxes on electricity and increase in subsidies to renewable sources of electricity has been successful in simultaneously addressing SDGs 7 and 8 (Bartocci and Pisani, 2013). Systemic policy targeting of mass transit systems, energy-efficient vehicles, stringent emission standards, and biofuel can have synergies with SDGs 3 and 12 (Aggarwal, 2017). Integrated climate and air pollution target-oriented policies can enhance multiple SDGs (1,3,8,10,11, and 12) (Klausbruckner et al., 2016). However, elctrification of transport sector unless supplemented by increasing deacrbonisation of electricity cannot deliver desired climate goal (Ajanovic, 2015; Wolfram and Wiedmann, 2017).

Despite multiple benefits of industrial parks, industrial symbiosis may result in loss of regulating and supporting services of the surrounding area and decrease the indirect economic value of these services in some cases (Shi et al., 2017).

It is unclear whether private finance can deliver the full range of actions required for a low carbon transition, or what role the public sector can and should play to mobilise these resources. Case of Kolkata shows that governments in developing countries can lay the foundations for compact, connected low-carbon cities (Colenbrander et al., 2016). Identification of mitigation options with positive impacts on sustainable development may not be sufficient to deliver desired sustainable development objectives unless they are rightly valued and integrated into policy packages, supplemented by governance coordination across sectors and nations (von Stechow et al., 2015), and ensure collaboration and dialogue between local communities and municipal bodies (Colenbrander et al., 2016; Ghosh et al., 2016). In rapidly devloping countries, efforts need to go beyond green growth indicators (Roy et al., 2016). Institutions that are effective, accountable, and transparent are needed at all levels of government to improve energy access, promote modern renewables, and boost energy efficiency.

In the AR5, assessments of the Clean Development Mechanism (CDM) as an instrument for emission trading and sustainable development benefits are given. While some literature criticises the CDM for limited sustainable development benefits (Crowe, 2012; Olsson et al., 2014), the bulk of the literature finds that the CDM has been instrumental in mobilizing mitigation in developing countries, especially from renewable energy (see overview of CDM-related literature in(Michaelowa, 2015; Stavins et al., 2014). While initially, CDM activities focused on Asia and Latin America, the programmatic approach introduced from 2007 onwards led to Africa having a share of 30% in such programmatic activities (Michaelowa et al., 2015). If demand of emission credits increased in the future, market mechanisms like the CDM could play an important role in reducing mitigation cost, thus leading to higer ambition and an increased likelihood to reach the 1.5°C target of the Paris Agreement (Bodnar et al., In Press)

Mitigation responses are likely to produce differentiated opportunities and risks in the context of sustainable development when descaled to the regional/nation/local level. This is because social, economic, environmental and political contexts shape how mitigation opportunities, risks and costs manifest in specific places. For instance, the costs of mitigation vary significantly between regions, with aggregate relative costs typically lower in OECD and Latin American countries and higher in other regions (Clarke et al., 2014). Emission reduction costs associated with Nationally Determined Contributions (NDCs) also differ significantly between countries as a percentage of GDP (Akimoto et al., 2016). Fujimori et al. (2016a) also show that NDC cost differs across countries. At the same time, the emissions trading system can reduce the mitigaion cost largely by 80%.

5.4.1.5 Land-based Agriculture, Forestry and Ocean: Response Options

The land sector also offers a variety of cost-competitive mitigation options, and sustainability criteria are needed to guide development and implementation of AFOLU mitigation measures with context-specific application (Bustamante et al., 2014). Land-use options, and especially forestry, plays a key role for emission reductions proposed by many countries to fulfil their NDCs and will be critical in longer-term strategies towards 1.5°C (Smith et al., 2014b). For forestry, key mitigation options include avoiding deforestation, afforestation and reforestation, climate-smart forest management, as well as integrated systems such as agroforestry, biochar and sustainable use of wood products for long-term use and wood residues for energy

(Griscom et al., 2017; Siagian et al., 2016). Negative emissions (i.e., a carbon sink) can be achieved with afforestation programs, sustainable forest management that increases biomass productivity and carbon in soils, and by using wood products for energy that substitutes fossil fuels. Implementation of mitigation in forest sector through REDD+ (Reducing Emissions from Deforestation and Forest Degradation) not only contributes to emissions reductions, but also contributes to biodiversity conservation and climate change adaptation (Bustamante et al., 2014; Morita and Matsumoto, 2018). Research on the sustainable development implications of both REDD+ and other land use measures has expanded considerably since the AR5. An analysis of first generation REDD+ pilot and demonstration activities by estimating smallholder opportunity costs of REDD+ in 17 sites in six countries (Brazil, Peru, Cameroon, Tanzania, Indonesia, and Vietnam) shows that in the case of flat payments, the poorest households would be the ones generating most of the emission reductions, with significant consequences on both equity and efficiency of REDD+ initiatives (Ickowitz et al., 2017). There are significant differences between countries and locations in terms of implementation of REDD+ policies due to biophysical conditions (e.g., carbon density per unit area), livelihood strategies, governance structures, and the integration of climate change mitigation into land use policies (Luttrell et al., 2013; Ravikumar et al., 2015; Nobre et al., 2016, Di Gregorio et al., 2017a; Ickowitz et al., 2017; Loft et al., 2017). Studies on gender in first generation REDD+ pilots and demonstration activities show that women have been less involved in REDD+ initiative design decisions and processes than men (Brown, 2011; Larson et al., 2014), and that implementation of REDD+ can perpetuate gendered divisions of labour (Westholm and Arora-Jonsson, 2015). REDD+ projects have also been shown to negatively affect indigenous groups in some cases. Promoting land-use changes through planting monocultures on biodiversity hot spots can have adverse side-effects for biodiversity and local food security (IPCC, 2014c). Conservation efforts to enhance land and forest carbon sinks have excluded traditional owners and indigenous populations from efforts to manage natural resources, as in the case of Australia (Winer et al., 2012).

Supply side actions reduce GHG emissions per unit of land per animal, or per unit of product while demand-side actions cover changing consumption patterns (Bajželj et al., 2014; Bellarby et al., 2013; Garnett, 2011)of food and other products, by reducing waste, and so on (Fuss et al., 2014; Ingram, 2011; Siagian et al., 2016). Climate-smart agriculture mitigates GHGs through soil management, sustainable agricultural intensification, and waste reduction (Bennetzen et al., 2016; Branca et al., 2011; Lipper et al., 2014), though measures require close scrutiny (Frank et al., 2017; Neufeldt et al., 2013). Sustainable intensification (Smith, 2013) can promote conservation of biological diversity by reducing deforestation by rehabilitation and restoration of biodiverse communities on previously developed crop or pasture land (Lamb et al., 2016), though rebound effects need to be considered, and land spared may not be of equivalent status for delivering the SDGs. Reduction of waste in the food system generally benefits sustainable development (Kummu et al., 2012). On the demand side, proposals to reduce methane and other GHG emissions by cutting livestock consumption can increase food security for some, if land grows food not feed (Schader et al., 2015; Muller et al., in press).Mitigation policies implemented through a uniform global carbon price may also have negative effects on the agricultural sector. Poorer populations are more sensitive to price fluctuations, and the strongest decrease would occur for livestock product consumption in sub-Saharan Africa (Havlík et al., 2015). Proposals to reduce methane and other GHG emissions by cutting livestock consumption could also undermine livelihoods and the cultural identity of poor farming populations (Herrero et al., 2016), if implemented without due consideration of these issues. Many Short-Lived Climate Pollutant mitigation measures (SLCP) like provision of cleaner fuel and devices for rural households are synergistic to SDGs 3,4,5,15 (Griggs et al., 2014), transport fuel and small industrial fuels, banning the open burning of biomass and waste in urban areas are synergistic to multiple SDGs, 2,3,7,11,12 (UNEP 2017).

Deep emission reductions through biofuel/biodiesel based transformations, if not managed carefully, can exacerbate food security and land use disputes with disproportionate negative impacts upon rural poor and indigenous populations (Aha and Ayitey, 2017; Johansson et al., 2016; Olsson et al., 2014; Shi et al., 2017)(Zhang and Chen, 2015). Unjust and adverse outcomes have been documented amongst biofuel and large hydropower projects in various developing countries, predominantly via the displacement and replacement of subsistence food economies, resulting in increased food insecurity and reduced access to fuel for the rural poor (Table 5.1, Figure 5.3, Grill et al., 2015; Grubert et al., 2014; Fricko et al., 2016; De Stefano et al., 2017). Dedicated crop for bioenergy may also increase irrigation needs and exacerbate water

stress with negative associated impacts on multiple SDGs (e.g., 1, 6, 7, and 10).

Large-scale mitigation efforts may also produce negative spillovers that inhibit the capacity of poor and vulnerable groups to produce triple wins. A large body of literature now exists documenting the negative impacts of bio-carbon sequestration and other mitigation measures upon vulnerable groups via processes of land appropriation and dispossession (Cavanagh and Benjaminsen, 2014; Corbera et al., 2017; Fairhead et al., 2012; Hunsberger et al., 2014; Work, 2015). Emerging evidence indicates that future mitigation efforts required to reach stringent climate targets, particularly those associated with Carbon Dioxide Removal (e.g., BECCS and afforestation and reforestation), may also impose significant constraints upon poor and vulnerable communities via increased food prices and competition for arable land (Burns and Nicholson, 2017; Muratori et al., 2016; Smith et al., 2016) and the adoption of policy frameworks for the management of the supply chain (Fajardy and Mac Dowell, 2017).

Ocean Iron Fertilisation (OIF) can increase food availability for fish stocks leading to increased yields but potentially at the cost of reducing the yields of fisheries outside the enhancement region by depleting other nutrients Maintaining mangrove, Seaweed aquaculture, greening of aquaculture can not only help sequestration but also employment generation (Table 5.1, Figure 5.3).

Protecting oceans and strengthening the health of coastal and marine ecosystems, including preserving ocean fauna, consistently appears to be a key enabler for strong emission reductions by enhancing carbon sinks (Atwood et al., 2015; Gattuso et al., 2015; Magnan et al., 2016a; Singh et al., 2017b). Despite uncertainties, richness of seagrasses, tidal marshes and mangroves are recognised as dense carbon sinks (Fourqurean et al., 2012; Johannessen and Macdonald, 2016; Lavery et al., 2013; Lovelock et al., 2017). Valuing ‘Blue carbon’ ecosystems can link local coastal management to the global debate on climate change (Huxham et al., 2015). Traditional knowledge and management systems from local communities also has a key role to play in preserving the long-term storage of blue carbon (Vierros, 2017). Only strong mitigation action can ensure a sustainable use of the ocean (Lubchenco et al., 2016) and protect key marine and coastal organisms, ecosystems from the high risks they would face even under 2°C-compatible scenarios, hence maintaining the carbon sink capacity of the ecosystem.

Detailed assement of synergies and trade-offs of mitigation options with SDGs (Table 5.1a–d, Figure 5.3) clearly reveals that synergies of mitigation response options in near term are far more than tradeoffs. Mitigation actions in energy demand sectors and behaviourial response options can advance multiple SDGs simultaneously far more compared to energy supply side mitigation actions. Corrective measures and choice of options in mitigation portfolio based on immediate synergies and in some instances sustainable development approach can overcome trade-offs to further strengthen the synergies (*robust evidence, high agreement*).

[INSERT FIGURE 5.3 HERE]

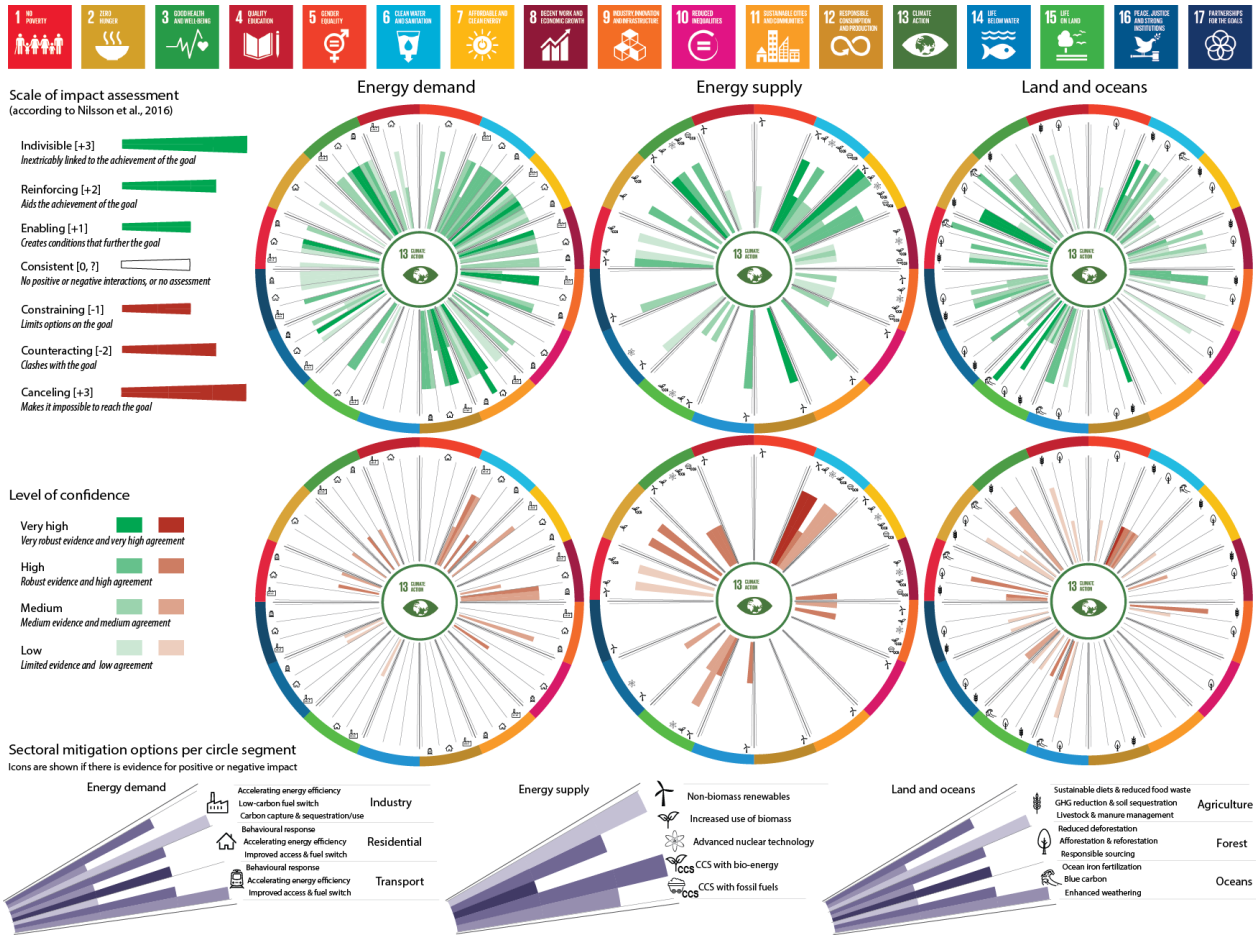


Figure 5.3: Synergies and trade-offs between mitigation options and SDGs. Top three wheels are representing synergies and bottom three wheels show trade -offs. Colours on the border of the wheels correspond to the SDGs listed above. Here SDG 13 climate action is at the centre because the figure shows if mitigation actions (climate action) in various sectors are taken then what do they interact with the 16 SDGs. Vertically starting from the first left side pair of wheels correspond to synergies (Top) and tradeoffs (Bottom) of three mitigation actions undertaken in each of the energy demand sectors (Industry, Residential and Transport sectors). Middle pair of wheels vertically shows the synergies (Top) and tradeoffs (Bottom) with SDGs of the five mitigation actions taken in the energy supply sector. Right most pair, shows synergies (top) and tradeoffs (bottom) with SDGs of three types of mitigation actions in each of the sectors Agriculure, Forestry and Oceans. Length of the coloured bars show the strength of the synergies or tradeoffs. Longer the bar higher is the strength. Shade of the color represent level of confidence based on evidence and agreement in the literature. Darker the shade higher is the confidence and lighter the shade confidence level is lower. White within wheels show no interaction between the corresponding mitigation action sand the SDG, Grey within the wheels show knowledge gap. Bottom panel shows various mitigation actions in each sector and corresponding symbols.

5.4.2 Temporal and Spatial Trade-offs and Distributional Impacts

Delaying action to reduce greenhouse gas emissions increases the risks associated with mitigation (*very high confidence);* however, these risks are not uniform for all mitigation options, or for different regions and groups (*medium evidence; medium agreement*). Weak mitigation targets in the short term necessitate significant and rapid up-scaling of mitigation efforts in the future if stringent climate targets are to be met (Gambhir et al., 2017; van Soest et al., 2017). The rapid scale-up of future mitigation efforts presents various potential risks, including increased mitigation costs (Luderer et al., 2013; Schaeffer et al., 2015a) stranded coal assets (Gambhir et al., 2017; Johnson et al., 2015), job losses (Rozenberg et al., 2014), risks associated

with grid integration of fluctuating renewable energy (von Stechow et al., 2016), and increased inter-generational and inter-regional inequities (Liu et al., 2016a; Mary Robinson Foundation: Climate Justice, 2015). Delayed mitigation is also likely to constrain flexibility of future response options (von Stechow et al., 2015) and necessitate wide-scale deployment of negative emission technologies (Fujimori et al., 2016b; Rogelj et al., 2015), thereby increasing the likelihood of negative trade-offs between energy, environmental and socio-economic objectives (Fujimori et al., 2015; Smith et al., 2016; von Stechow et al., 2016). Constraining technological options for mitigation requires significant up-scaling of other technological options, thereby increasing overall mitigation risks (Muratori et al., 2016; von Stechow et al., 2016). Restricted technological portfolios have also been shown to incur higher associated financial costs than unconstrained technological portfolios (Jakob and Steckel, 2016; Luderer et al., 2013).

Future climate response options are expected to impose differential regional impacts. For example, economies dependent upon fossil fuel-based energy generation and/or export revenue will be disproportionally affected by future efforts to restrict the use of fossil fuels via stranded assets and unusable resources (Johnson et al., 2015; McGlade and Ekins, 2015) (see Box 5.2). In turn, different climate response options will likely have regionally-differentiated implications for energy and food security. Cumulative oil imports as a percentage of oil consumption are projected to rise significantly for Asian and OECD nations under mitigation scenarios consistent with the 2°C warming target (Jakob and Steckel, 2016). Alternatively, technological constraints are projected to significantly alter global energy trade patterns out to 2100 under 'full technology' and 'no CCS' scenarios (Muratori et al., 2016). Under the latter scenario, fossil fuels have been projected to be largely phased out by 2100, resulting in many Middle Eastern and African energy exporters becoming net energy importers by the end of the century while many North American and Eastern European nations become net exporters.

[INSERT TABLE 5.1 HERE]

Table 5.1: Impacts of mitigation options on specific targets of the 17 SDGs, for social (a & b), economic (c), and environmental (d) dimensions.

[Due to size, Table 5.1.a–d is provided at the end of the chapter, page 114. A high resolution version of the table is available as a supplementary PDF (SR15_SOD_Chapter5_Table5_1.pdf) that can be downloaded with the chatper for review]

5.4.3 Sustainable Development Implications of 1.5°C and 2°C Mitigation Pathways

While previous sections have focused on individual mitigation options and their interaction with sustainable development and SDGs and distributional aspects, this section takes a systems perspective. Emphasis is on quantitative pathways depicting path depednent evolutions of the system over time. Specifically, the focus is on fundamental transformations and thus stringent mitigation policies consistent with 1.5°C and 2°C, and the differential synergies and trade-offs with respect to the various sustainable development dimensions.

As described in Chapter 2 (Section 2.3), achieving 1.5°C or 2°C targets require deep cuts in GHG emissions and large scale changes of energy supply and demand as well as agriculture and forestry systems. For the assessment of the sustainable development implications, we draw upon comparative and multi-model pathways studies, for example, (CD-LINKS 2017; Krey et al. submitted), which have assessed the aggregated impact of mitigation for multiple sustainable development dimensions and across multiple integrated assessment modelling (IAM) frameworks (eg, IMAGE, REMIND-Magpie, MESSAGE-GLOBIOM, AIM, WITCH, GCAM, E3MG, and others). Often these tools are linked to disciplinary models covering specific SDGs in more detail (see eg Cameron et al, 2015; Rao et al, 2017 or for multiple models Krey et al, submitted). Unsing multiple IAMs and disciplinary models are important for a robust assessment of the sustainable development implications of different pathways. The recent literature on 1.5°C mitigation pathways has begun to provide estimations of different sustainable development dimensions, including particularly air pollution and health, food security and hunger, energy access, biodiversity, water security, and poverty and equity (also see Sections 5.4.1 and 5.4.2). Furthermore, emphasis is on multi-regional

studies, which can be aggregated to the global scale, and wherever possible we discuss also near-term implications in terms of the NDCs and SDGs.

5.4.3.1 Air Pollution and Health

Greenhouse gases and air pollutants are typically emitted by the same sources, such as power plants, cars, factories, agriculture, forest and peatland fires. Hence, mitigation strategies that reduce GHGs or the use of fossil fuels typically also reduce emissions of pollutants, such as particulate matter (PM2.5 and PM20), black carbon (BC), sulphur dioxide (SO_2), nitrogen oxides (NO_x), and other harmful species (Clarke et al., 2014; see Figure 5.4), causing adverse health and ecosystem effects at various scales (Bollen et al., 2009; GEA, 2012; Kusumaningtyas and Aldrian, 2016; Markandya et al., 2009; Smith et al., 2009).

Mitigation pathways typically show that there are significant synergies for air pollution, and that the synergies increase with the stringency of the mitigation policies (Amann et al., 2011; Rao et al., 2016; Shindell et al., 2017, Klimont et al., 2017). Recent multi-model comparisons indicate that mitigation pathways consistent with 1.5°C would result in higher co-benefits for air pollution and health compared to pathways that stay below 2°C (see Figure 5.4, panel a and b), reducing the number of premature deaths by about 0.2 million by 2050 (Krey et al., submitted; and Chapter 2 Scenario Database). The co-benefits for air pollution are the biggest in the developing world, particularly in Asia. The currently pledged NDCs lead in most countries to limited structural changes and therefore the health co-benefits of NDCs are comparatively small, (Krey et al., submitted). While the quantitative modelling literature focuses primarily on air pollution, the systemic implications of joint mitigation and well-being strategies on health go beyond air pollution, with potentials to address both chronic lifestyle conditions and mental health issues through a re-orientation of values, beliefs and norms across societies (Bhaskar et al., 2010).

5.4.3.2 Food Security and Hunger

Stringent climate mitigation strategies in line with ‘well below 2°C’ or ‘1.5°C’ goals do rely often on the deployment of large-scale land-related measures, like afforestation and/or bioenergy production (Creutzig et al., 2015b; Popp et al., 2014; Rose et al., 2014b). These land-related measures can compete with food production and hence raise food security concerns (Smith et al., 2014b). Mitigation studies indicate that so-called ‘single-minded’ climate policy, aiming solely at limiting warming to 1.5°C or 2°C without concurrent measures in the food sector, can have negative impacts for global food security (Fujimori et al. submitted; Hasegawa et al. 2015; Krey et al. submitted). Impacts of 1.5°C mitigation pathways can be significantly higher than those of 2°C pathways (see Figure 5.4), particularly in Africa and parts of Asia. In these “single-minded” scenarios, mitigation policies worsen food security and may increase the number of people at risk of hunger significantly compared to a case without climate mitigation, between about 0.2 to 1.2 billion people at risk of hunger (Fujimori et al.; Hasegawa et al., 2015; Krey et al., submitted) (Figure 5.4, panels a and b).

An important driver of the food security impacts in these scenarios is the increase of food prices and the effect of mitigation on disposable income and wealth due to GHG pricing. On aggregate the price and income effects on food are found to be bigger than the effect due to competition over land between food and bioenergy (Hasegawa et al., 2015)(Fujimori et al., submitted). In this context, a recent study shows that on balance, limiting bioenergy may have a negative effect on food security, since the associated negative effects of the increased GHG prices (assuming that such prices are also applied to non-CO_2 emissions associated with food production) will more than offset the positive effects of reduced land competition (Hallegatte et al., 2016b).

(Grubler et al. submitted) show that 1.5°C pathways without reliance on BECCS can be achieved through a fundamental transformation of the service sectors which would significantly reduce energy and food demand. Such low energy demand (LED) pathways would result in significantly reduced pressure on food security, lower food prices, and less people at risk of hunger.

In order to fully eradicate food-security trade-offs, however, mitigation policies need to be designed in a way so that they shield the population at risk of hunger. Krey et al. (submitted) and Fujimori et al. (submitted)

find that relatively simple complementary measures, such as food price support, may entirely eradicate the identified trade-off between climate mitigation and food security. The costs measured by welfare changes for these complementary food security policies are found to be low globally and much smaller than the associated mitigation costs of 1.5°C pathways of 2– 6% of total GDP (Rogelj et al. forthcoming). Food subsidies are not the only measures that are available for eradicating food security concerns. Other measures may include, for example, direct cash transfers, improvements of agricultural productivity and yields (Frank et al., 2017; Valin et al., 2013), or programs focusing on forest land-use change (Havlík et al., 2014) to mention a few.

Importantly, the food security trade-offs will also be reduced by the avoided impacts in the agricultural sector due to the reduced climate change of the 1.5°C pathways (see Chapter 3, Section 3.5, and Section 3.6).

5.4.3.3 Lack of Energy Access / Energy Poverty

A lack of access to clean and affordable energy (especially for cooking) is a major policy concern in many countries, especially in South Asia where over 70% of the population relies primarily on solid fuels for cooking even today (GEA, 2012; WB and IEA, 2017). Scenario studies which quantify the interactions between climate mitigation and energy access, indicate that the increase of energy costs due to stringent climate policycould significantly slow down the transition to clean cooking fuels (Cameron et al. 2016; Krey et al. submitted).

Estimates across five different models (AIM, IMAGE, WITCH, REMIND, and MESSAGE-Globiom; Krey et al. submitted) indicate that in absence of compensatory measures the number of people without access to clean cooking may increase by 2050 from 1.6–3 billion in baseline scenarios to about 2.7–3.6 billion in 1.5°C pathways (Figure 5.4, panel a). Redistributional measures, such as subsidies on cleaner fuels and stoves, could fully offset the negative effects of mitigation on energy access. Costs of the redistributional measures are estimated to be modest, about an order of magnitude smaller than the mitigation costs of 1.5°C pathways (Krey et al. submitted). The recycling of revenues from climate policy might act as a means to help finance the costs for providing energy access to the poor (Cameron et al., 2016).

5.4.3.4 Water Security

Transformations towards low-carbon energy and agricultural systems can have major implications for freshwater demand as well as water pollution. The up-scaling of renewables and energy efficiency as depicted by low emissions pathways will, in most instances, lower water demands for thermal energy supply facilities (‘water-for-energy’) compared to fossil energy technologies, and thus reinforce targets related to water access and scarcity. However, some low-carbon options such as bioenergy, nuclear and hydropower technologies could, if not managed properly, have counteracting effects that compound existing water-related problems in a given locale (Byers et al., 2014; Davies et al., 2013; Fricko et al., 2016; Fujimori et al., 2017; Hanasaki et al., 2013; Hejazi et al., 2013; McCollum et al., 2017; PBL, 2012; Stewart et al., 2013; Vidic et al., 2013; Wang et al., 2017).

Under stringent mitigation efforts, the demand for bioenergy can result in a substantial increase of water demand for irrigation, thereby potentially contributing to water scarcity in water-stressed regions (Berger et al., 2015; Bonsch et al., 2016; Gerbens-Leenes et al., 2009, 2012; Jägermeyr et al., 2017) However, by prioritizing rain-fed production of bioenergy this risk can be limited (Bonsch et al., 2016; Hayashi et al., 2015).

Reducing energy demand emerges as a robust strategy for both water conservation and GHG emissions reductions (Von Stechow et al. 2015; Grubler et al. submitted). The results underscore the importance of an integrated approach when developing water, energy, and climate policy, especially in regions where rapid growth in both energy and water demands is anticipated (Parkinson et al. submitted).

Comparing estimates across different models (Krey et al. submitted), the overall signal in terms of water-related synergies and trade-offs of 1.5°C mitigation pathways are relatively ambiguous. Some pathways

show positive co-benefits while others indicate increases of water use due to mitigation (Figure 5.4, panels a and b). The signal depends on the adopted specific policy implementation or mitigation strategies and technology portfolio. Mitigation options in the electricity sector exist with potentially higher (e.g., nuclear, carbon capture and storage) or lower (solar PV, wind) water use than conventional fossil power options. A number of adaptation options exist (eg, dry cooling), which can effectively reduce electricity-related water trade-offs (Fricko et al., 2016). Similarly, irrigation water use will depend on the regions where crops are produced, whether they are irrigated, the sources of bioenergy (e.g., agriculture vs. forestry) and dietary change induced by climate policy.

5.4.3.5 Biodiversity

Stringent mitigation pathways reaching 2°C or 1.5°C are often associated with large-scale land-use changes due to afforestation and/or bioenergy deployment (Popp et al. 2017; Rogelj et al. submitted).

The bioenergy deployment in these scenarios may be confronted by substantial concerns for competition over land with potentially high biodiversity impacts (see Fuss et al. (2014) for a review and (Edenhofer et al., 2013; Haberi, 2015; Robledo-Abad et al., 2017; Smith et al., 2013a; Williamson, 2016). In addition, the reclamation of so-called marginal land for biomass for energy which is often associated with detrimental impact on biodiversity (Dale et al., 2010; Shaw et al., 2014a; Wiens et al., 2011). Specific options, however, allow for biodiversity preservation, or positive contribute to biodiversity (Fuss et al. submitted).

As summarised by (Fuss et al. submitted), comprehensive review of the effect of afforestation and reforestation on biodiversity is lacking at the moment. Nonetheless, afforestation using native species is generally regarded as superior compared to plantations (Hall et al 2012, McKinley et al 2011); and although they may perform less well in terms of carbon sequestration, diverse afforestation plots are less vulnerable also to climatic perturbations (Locatelli et al., 2015) and provide a greater variety of subsistence products and services, enhancing local management and acceptability (Locatelli et al., 2015) (Díaz et al 2009, Venter et al 2012).

Recent estimates across a range of different 1.5°C and 2°C pathways from six different IAM models (Krey et al. submitted) indicate that biodiversity loss of mitigation activities may be substantial (see Figure 5.4, panel b). Biodiversity loss in 1.5°C pathways is estimated to be 0.5–3% by 2050 (measured as the fraction of species whose future potential distribution area changes by more than 50%), which compares to 0.4–1.6% in 2°C pathways and 0.2–0.3% in the baseline (without new mitigation policies) (see Figure 5.4, panel a).

[INSERT FIGURE 5.4 HERE]

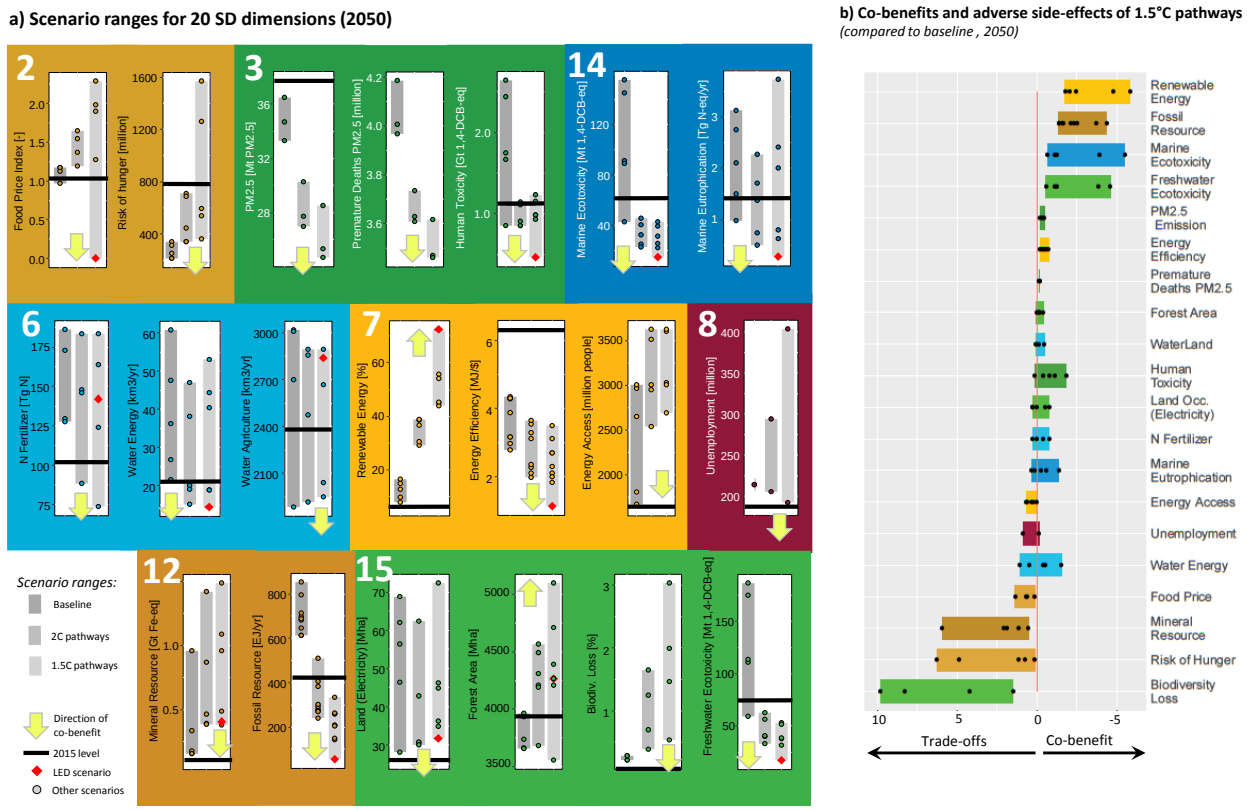


Figure 5.4: Sustainable development implications of 1.5°C pathways. Panel (a) shows ranges for 1.5°C pathways for 20 different sustainable development dimensions compared to ranges of 2°C pathways and baselines scenarios. The ranges depict quantifications of up to six different integrated assessment models, which were coupled to disciplinary models for the assessment of distributional and local effects for eg air pollution and health implications, biodiversity, employment, energy access and many other sustainable development implications (covering SDG 2, 3, 6, 7, 8, 12, 14, 15) Panel (b) presents the resulting co-benefits and trade-offs of 1.5°C pathways compared to middle-of-the-road baseline scenarios. Each figure in panel (a) shows the underlying data for one corresponding 1.5°C bar in panel (b). All estimates are for the year 2050. Note that sustainable development effects are estimated for the effect of mitigation and do not include benefits from avoided impacts (see Chapter 3, Section 3.5). Red dots denote estimates from a pathway with extremely low energy demand (LED) reaching 1.5°C without BECCS. Sources: (Fujimori et al.; CD-LINKS 2017; Krey et al. submitted), (Gruebler et al, submitted).

In summary, the assessment of mitigation pathways shows that, in order to meet the 1.5°C target, a wide range of technological options, including large-scale deployment of negative emission technologies (e.g., BECCS) will likely be required (see Chapter 2, Section 2.3 and Section 2.4). While pathways aiming at 1.5°Care associated with high co-benefits for some sustainable development dimensions (such as human health and air pollution, forest preservation, fossil resource use, and human-, marine-, and eco-toxicity; see Figure 5.4, panel a and b), the rapid pace and magnitude of the required changes lead also to increased risks for adverse side-effects for a number of other sustainable development dimensions (particularly risk of hunger, food security, biodiversity, and mineral resources for renewables; Figure 5.4, panel a and b) . Reducing these risks requires smart policy designs and mechanisms that shield the poor and redistribute the burden, so that the most vulnerable are not affected. Recent scenario analyses show that associated costs for eradicating the trade-offs for eg food and energy access to be modest and significantly lower than the costs of mitigation (see Krey et al, submitted; Fujimori et al., submitted). Fundamental transformation of demand, including efficiency and behavioural changes, can help to significantly reduce the reliance on risky technologies, such as BECCS, and thus reduce the risk of potential trade-offs between mitigation and other sustainable development dimensions (Grubler et al, 2015 and von Stechow et al., 2015). Reliance on demand-side measures only, however, will not be sufficient for meeting stringent targets, such as 1.5°C and 2°C (Clarke et al, 2014).

5.5 Integrating Adaptation, Mitigation and Sustainable Development: Challenges and Enabling Conditions

The purpose of this section is to assess integrated approaches to climate and development, outlining key enabling conditions and constraining factors affecting the integration of adaptation, mitigation and sustainable development at policy and community levels. Although little literature has examined integrated approaches in the context of 1.5°C global warming, the adoption of the Paris Agreement and the 2030 Agenda for Sustainable Development underscore the need for integrated responses to interlinked climate and development challenges given the close synergies between ambitious mitigation to 1.5°C, the feasibility of effective adaptation to the changes already locked into the climate system and poverty reduction (Boas et al., 2016; ICSU, 2017; Nilsson et al., 2016).

Climate response options for adaptation and mitigation interact with each other (see Chapter 4, Section 4.5) and with other development goals, producing separately a complex assemblage of synergies and trade-offs with attendant effects on poverty, equity and sustainable development (see Sections 5.3 and 5.4.). In practice, the three dimensions are closely interlinked such that concrete decision-making requires an integrated vision of mitigation, adaptation and sustainable development (Nunan, 2017). This integrated approach cannot be built by simply adding a development perspective on top of existing climate policy initiatives, but requires significant shifts in institutional approaches to environmental policies and regulation at all scales (Ficklin et al., 2017). The AR5 identified the integration of adaptation and mitigation response options within the broader context of sustainable development as an 'aspirational goal' for climate policy (Denton et al., 2014). In turn, analysis of the potential for policy frameworks and development strategies to deliver integrated outcomes is gaining prominence (Di Gregorio et al., 2017a; Duguma et al., 2014b; Few et al., 2017; Northrop et al., 2016; Stringer et al., 2014; Sugar et al., 2013; Tanner et al., 2017).

Climate Policy Integration (CPI), a variant of the Environmental Policy Integration (EPI) literature, proposes a conceptual framework for thinking about policy integration, which argues that climate concerns should be 'mainstreamed' into existing policy fields (Jordan and Lenschow, 2010). Recent literature has started to investigate what, beyond the conceptual discussion, can be learnt to inform policymakers striving to design policies that integrate climate objectives, notably when considering the relationship with sustainable development (Adelle and Russel, 2013). In the European Sustainable Development Strategy, four criteria are identified for climate legislation to contribute to sustainable development in a way that can be evaluated at the policy proposal stage: policy integration and coherence, environmental protection, social and economic development and justice/participation (Rietig, 2013). But, the basic factors that can make the promises of climate policy integration work in practice are still not clearly defined (Runhaar et al., 2014). Integrated strategies can be useful as policy documents, but they cannot replace more focused strategies that adopt a narrower, sectoral basis (Casado-Asensio and Steurer, 2014).

The climate-compatible development (CCD) literature adopts a donor perspective aimed at fostering 'triple wins' in individual project, that is, delivering synergies between simultaneously reaching low emissions, building resilience and promoting development (Bickersteth et al., 2017; Mitchell and Maxwell, 2010). The literature on CCD consists essentially of empirical analysis of how CCD has been operationalized, how triple-wins can be achieved (Ellis et al., 2013; Nunan, 2017; Stringer et al., 2014; Suckall et al., 2014a) and what are the potential missing links and challenges revealed by concrete implementation (Antwi-Agyei et al., 2017a; Kalafatis, 2017). Robust criteria to evaluate triple-wins do not exist (Suckall et al., 2015). The operationalization of CCD shows the existence of multi-level and multi-sector trade-offs with 'winners' and 'losers' across governance levels and (spatial and temporal) scales (Ficklin et al., 2017; Wood, 2017).

Integrated approaches are possible but are often difficult to achieve and not always ideal, and integration will not be necessary, suitable or efficient for all situations. For example, broad analyses of adaptation, mitigation and development interactions have been conducted for climate-smart agriculture and carbon-forestry projects highlighting the potential for integration (Bryan et al., 2013; Campbell et al., 2016; Dyer et al., 2012; Kaczan et al., 2013; Lipper, 2014; Stringer et al., 2012). But there is little empirical evidence of triple wins being achieved in climate-smart projects, and there is even risk that the search for triple wins leads to the adoption of less effective policies if they don't take into account the local and external constraints like skills,

knowledge or funding (Nunan, 2017) (see also Chapter 4).

A major challenge for governments, communities and other stakeholders, then, is to identify the enabling conditions that manage trade-offs and enhance synergies across adaptation, mitigation and sustainable development objectives at the level of policies, programs and projects in the pursuit of the 1.5°C target and the SDGs.

5.5.1 Coherent and Integrated Institutions and Governance

Strong institutions, effective cross-institutional partnerships, and multi-level governance are central for the development policy frameworks with high synergy potential at the national level (Di Gregorio et al., 2017a; Duguma et al., 2014b; Somorin et al., 2015) and at the scale of community and project interventions (Dyer et al., 2013; Kongsager et al., 2016; Sánchez and Izzo, 2017; Suckall et al., 2015). Low-carbon and adaptation objectives can be more easily aligned at the project level than at the aggregate and macroeconomic level where the consistency of low-carbon and climate resilient patterns of growth is less clear and vary on a geographical basis (Pye et al., 2010). This stresses the importance of internal and external climate policy coherence, of vertical policy integration to mainstream climate change into sectoral policies and of horizontal policy integration to ensure cross-sectoral coordination (Di Gregorio et al., 2017b; Rietig, 2013). The absence of strong institutions and weak institutional co-ordination can undermine integration potential, with 'institutional tussles' (Stringer et al., 2014), the reluctance of ministries to cede power (Di Gregorio et al., 2017a), and weak institutional oversight and corruption (Tanner et al., 2017) inhibiting integrative efforts.

Enhancing synergy potential remains challenging for many nations, particularly for those with weak and uncoordinated overarching governance for climate policy (Di Gregorio et al., 2017a; Stringer et al., 2014). Environmental governance is achieved between and among different levels of government, civil society and the private sector (Dyer et al., 2013). Significant challenges relate to limited coordination among institutions and agencies, limited institutional capacity and a lack of resources in ensuring coherence, which is particularly important for climate-sensitive sectors such as agriculture, energy, water, forest and wildlife (Antwi-Agyei et al., 2017a). The production, framing, communication and use of climate knowledge is also hampered by inadequate coordination that limit the capacity to inform complex multi-staged decision-making (Tàbara et al., 2017a).

Conventional funding mechanisms like CDM are shown to exacerbate existing inequalities and hence fail to fill the energy access gap in a number of LDCs like Tanzania, demonstrating the need for innovative energy funding schemes (Wood et al., 2016b). Access to external funding is often required to achieve triple wins (Sánchez and Izzo, 2017; Wood, 2017), but it can effective to reach this objective only if financing and implementing entities and the local governance structures in place ensure that projects meet the triple objective, as shown on the example of Decentralised renewable energy in Central America (Ley, 2017a). Even when integration between adaptation and mitigation is practical, effective or desirable, it can be facilitated or disabled by project financing structures (Locatelli et al., 2015), international donors who hold a lot of power over aid-dependent countries (Ficklin et al., 2017; Phillips et al., 2017; Schipper et al., 2017) by the national and international policy settings (Kongsager et al., 2016), by the nature of multilevel engagement with the private sector (Leventon et al., 2015). Lack of additionality and validation problems also constrains the capacity of programs to deliver triple wins (Kongsager and Corbera, 2015; Ley, 2017b). The case of micro-hydropower systems in the Dominican Republic shows that access to finance and education and alignment of community needs and national policy objectives are key enabling factors for synergistic adaptation, mitigation and sustainable development outcomes for local communities (Sanchez and Izzo, 2017). In developing countries, it is also essential to ensure that enough finance is directed towards the necessary capacity-building needs and enabling factors, which requires strong connections with national planning processes (Boyle et al., 2013).

5.5.2 Participatory Processes to Address Issues of Power and Justice

The multi-level and multi-sector nature of integration inherently produce conflicting governing processes, actors and outcomes (Ficklin et al., 2017). Issues of power and justice affect the pursuit of integrated adaptation, mitigation and sustainable development measures, which calls for accounting for political economy dimensions in the design of integrated approaches (Nunan, 2017). Evidence of actualising integration outcomes underscores the need to address power, justice and equity, acknowledging that integration of mitigation, adaptation and development can also create auxiliary benefits and negative side-effects on different stakeholders and local people an (Nunan, 2017; Wood, 2017). The plurality of values and interests that coexist and conflict mean that there is no universal standard of distributive justice, which should instead be negotiate between these interests (Fisher, 2015). In particular, given the objective to reduce the vulnerabilities of local people, their voices should be heard to avoid the risk of perpetuating local inequalities and providing least benefit to underprivileged households (Mathur et al., 2014b; Wood et al., 2017). These trade-offs should be considered within wider national policy contexts, as shown, for example, in Kenya, where renewable energy, such as grid connected geothermal power and off-grid solar home systems, is judged as a cost-competitive option for achieving triple wins, but trade-offs arise because of high interest in utilizing the country's fossil fuel reserves for energy security (Naess et al., 2015).

Analyses of carbon forestry in Mozambique (Quan et al., 2017), energy system transformation in Kenya (Newell et al., 2014b), and artisanal fisheries in Ghana (Tanner et al., 2017) show how powerful interests can inhibit synergistic policy implementation, and shape how triple-wins are defined and for whom they are delivered. Insights from Malawi reveal how visible, hidden, and invisible forms of power create barriers to procedural justice (Barrett, 2013; Wood et al., 2016a), which, in turn, perpetuate local inequalities (Wood, 2017). Power asymmetries and various forms of injustice may also exacerbate local inequalities, as discussed in the context of climate-smart agriculture (Neufeldt et al., 2013; Taylor, 2017a), carbon offsets (Cavanagh and Benjaminsen, 2014) and CCD (Ficklin et al., 2017; Phillips et al., 2017; Stringer et al., 2017). However, analyses may overlook or downplay trade-offs, value conflicts and power asymmetries (Chandra et al., 2017; Neufeldt et al., 2013; Taylor, 2017b). One of the principal areas of contestation around climate-smart agriculture relates to equity, including who wins and who loses, who is able to participate, and whose knowledge and perspectives count in the process (Karlsson et al., 2017).

The involvement of stakeholders though participatory mechanisms is a key condition for addressing these challenges to support sustainable climate policy integration (Rietig, 2013). For instance, participation of community members in the planning, multi-stakeholder partnerships, implementation and monitoring of integrated climate-development projects enhances local empowerment, trust and collaboration, and social capital (Dyer et al., 2013; Sanchez and Izzo, 2017). In contrast, contestations over land in community forestry projects have produced a range of social trade-offs that undermine livelihood resilience and exacerbate inequalities (Few et al., 2017; Kongsager and Corbera, 2015). Taking into account regional contexts and local knowledge is essential for maximizing the synergy potentials, in contrast to top-down approaches which may lead to undesired trade-offs, as shown in the example of the water–energy nexus of irrigation modernization in China (Cremades et al., 2016).

5.5.3 Accounting for Local Circumstances and Unequal Opportunities

Even when integration between adaptation, mitigation and development is effective and desirable, not all people and places have equal opportunities to achieve it, with least-developed countries demonstrating the least potential (Duguma et al., 2014b). Low-emission, climate-resilient development plans are still developed in a growing number of least developed economies with an emphasis on different aspects of the low-carbon resilient agenda, according to a country's circumstances (Fisher, 2013a). This is done by adopting an holistic vision of development (White, 2010) that goes beyond economic factors and carbon emissions to assess the tradeoffs in integrated approaches, and capture issues such as quality of life, cultural significance and social cohesion (Ficklin et al., 2017). Within a country, people and individuals have different opportunities to benefit from integrated approaches because the space available for synergies between adaptation, mitigation and sustainable development depends on their situation. Mitigation or adaptation interventions stand to

create multi-level patterns of both benefits and negative side-effects that may have diverse consequences for individuals and groups (Tompkins et al., 2013).

Climate change impacts will disproportionately undermine the capacities of poor and vulnerable populations to achieve triple wins by restricting development opportunities, economic growth and adaptive capacities (Hallegatte et al., 2016b; IMF, 2017; Olsson et al., 2014; Reyer et al., 2017b; UN-OHRLLS, 2009). Moreover, climate shocks and stressors have been shown to negatively affect some CCD projects by undermining the synergistic potential of planned interventions (Kongsager and Corbera, 2015) and producing negative side effects in some cases (Wood, 2017). Vulnerable and disadvantaged communities experiencing multiple stressors (including climate change) with few livelihood alternatives – women and the elderly in particular – may either not have the resources and skills to pursue integrated objectives (Sietz and Van Dijk, 2015), and this may not be the most effective way to address their most pressing concerns.Indigenous populations are disproportionately exposed to climate change impacts, which may cause an adaptation-mitigation disconnect hindering the benefits of integrated strategies for transformational changes when indigenous knowledge and adaptive capacities are ignored in adaptation planning (Thornton and Comberti, 2017).

5.5.4 Towards a Systemic and Dynamic Approach for Integration

The enabling conditions and challenges discussed in previous sections evolve over time and the capacity to implement integrated approaches to mitigation, adaptation and sustainable development feature path dependencies. Uneven starting conditions increase the risk of maladaptation (see Section 5.3.2) (Juhola et al., 2016; Magnan et al., 2016b), and the risk of negative effects of mitigation responses on the poor and vulnerable groups (see Section 5.4) (e.g., through processes of land appropriation and dispossession) (Cavanagh and Benjaminsen, 2014; Corbera et al., 2017; Fairhead et al., 2012; Hunsberger et al., 2014; Work, 2015) or increased food prices and competition for arable land (Burns and Nicholson, 2017; Muratori et al., 2016; Smith et al., 2016).

Furthermore, reinforcing mechanisms known as poverty traps (see Haider et al., 2017) may further erode the capabilities and capacities of already disadvantaged and marginalised groups. Vulnerable and disadvantaged communities experiencing multiple stressors (including climate change) with few livelihood alternatives may employ short-term maladaptive coping strategies that lock communities into high-carbon development pathways, in turn undermining their long-term socio-economic development and adaptive capacities (Ehara et al., 2016; Suckall et al., 2014b; Tanner et al., 2017; Thornton and Comberti, 2017), thus further entrenching poverty and community disadvantages.

Regions, nations and communities with weak or absent enabling conditions may be subject to vicious circles like poverty traps, and are likely to encounter worsening trade-offs between adaptation, mitigation and sustainable development over time. This is what happens when poorly designed and implemented development interventions impose significant costs and constrain alternative low-carbon and climate-resilient development trajectories for local communities over the longer-term.The Tropics is emerging as a region prone to such situation due to high vulnerability to climate risks (Harrington et al., 2016; Herold et al., 2017; Pecl et al., 2017), susceptibility to climate response spillovers (Muratori et al., 2016), prevalence of fragile states (Fund for Peace, 2017) and un-coordinated policy contexts (Duguma et al., 2014b).

Nonetheless, the improvements of enabling conditions can enhance the opportunities for integrated approaches. Balancing stakeholders' immediate needs with longer-term global climate objectives may produce synergies that enhance project effectiveness, development opportunities, and livelihood resilience (Sanchez and Izzo, 2017; Suckall et al., 2015). Pursuing big wins or 'low hanging fruit' options in the short-term might prioritise actions that are easier to measure and execute but prevent the search for longer-term projects with synergies or win-wins across climate and development objectives (Fisher, 2013a). This is notably true for community-based integrated policy might be more likely to trigger the transformational changes called by integrated strategies if it employs a longer time horizon, recognition of adaptability and feedbacks, integrated decision making, and systems thinking (Burch et al., 2014).

Ultimately, reconciling trade-offs between local development needs and global emission reductions towards a 1.5°C warmer world will require a more dynamic view of the interlinkages between adaptation, mitigation and sustainable development (Nunan, 2017). This entails recognition of the ways in which development contexts shape the choice and effectiveness of interventions, limit the range of responses afforded to communities and governments, and potentially impose injustices upon vulnerable groups (Thornton and Comberti, 2017; UNRISD, 2016). In situations where trade-offs appear intractable, for example where indigenous communities are exposed to extreme or rapid climate change, considering alternative development pathways that open up novel possibilities for equitable responses will become essential (Thornton and Comberti, 2017). Such climate-resilient development pathways are discussed in the next section.

5.6 Sustainable Development Pathways to 1.5°C

This final section assesses what is known in the literature on development pathways that are sustainable and climate resilient and relevant to a 1.5°C warmer world. It builds on insights from approaches that integrate adaptation, mitigation, and sustainable development (Section 5.5) but takes a more dynamic view, based on the notion of pathways. Box 1.2 (Chapter 1, Section 1.2.4) describes pathways in two broad ways: as temporal evolution of a set of scenario features, such as GHG emissions and socioeconomic development, largely quantitative; and as solution-oriented trajectories and decision-making processes about transitions from today's world to achieving a set of future goals, typically more qualitative. Both are relevant for understanding short-term actions that enable long-term transformations and are examined in Section 5.6.1 and Section 5.6.2, respectively.

Limiting global warming to 1.5°C above pre-industrial times and ensuring well-being among human populations and ecosystems in a 1.5°C warmer world require ambitious and well-integrated adaptation-mitigation-development pathways that deviate fundamentally from high-carbon, business-as-usual futures (Arts, 2017; Gupta and Arts, 2017a; Okereke and Coventry, 2016; Sealey-Huggins, 2017). Well-being for all is at the core of an ecologically safe and socially just space for humanity (Dearing et al., 2014; Raworth, 2012, 2017b; Rockström et al., 2009a), highlighting the relational and subjective dimensions of being and social interactions (White, 2010). These integrated pathways address the urgency and unprecedented scale of emission reductions necessary to remain within a 1.5°C target (Chapter 2, Section 2.4), the transformational changes needed to overcome the path dependencies that cause current unsustainable trajectories and undesirable lock-in patterns (Chapter 4, Section 4.5), and the ethics and equity dimensions associated with ambitious decarbonization and society-wide transformation across scales and regions (Chapter 5, Sections 5.6.1–5.6.4). These pathways also entail a collective, value-driven reflection about the desirable futures we want (Bai et al., 2016; Gillard et al., 2016; Tàbara et al., 2017b).

5.6.1 Sustainable Development Pathways

This section focuses on the growing body of literature on pathways exploring linkages between mitigation, adaptation and sustainable development. It presents, to a large extent, insights from systems approaches to development pathways relevant to a 1.5°C warmer world, and how to get there.

Identifying "enabling" conditions under which integration of sustainable development with adaptation and mitigation can be achieved is critical for the design of transformation strategies that maximise synergies and avoid potential trade-offs (see Section 5.5). Full integration across all sustainable development dimensions is, however, challenging, given the diversity of sustainable development dimensions and the need for high temporal, spatial, and social resolution to tackle local effects of sustainable development, including heterogeneity that is critically important for understanding poverty and equity implications (von Stechow et al. 2015; Johnson et al. submitted). While quantitative systems models can be helpful in identifying how to address these trade-offs, the analysis of sustainable development pathways often requires improved representation of sustainable development drivers as well as further integration through, for example,

bridging and linking of different analytical approaches that can complement each other (Rao et al., 2017; Johnson et al., submitted; Geels et al., 2016; Turnheim et al., 2015).

Generally, available research on long-term climate change mitigation and adaptation scenarios has covered individual SDGs to different degrees. An initial understanding of the interactions between climate and other SDGs has developed in the areas of health (SDG3), energy (SDG7), economic growth (SDG8) and, increasingly, hunger (SDG 2), as well as the sustainable use of water (SDG6), land (SDG15) and oceans (SDG14) (e.g., Vuuren et al. (2012); McCollum et al. (2013); Clarke et al. (2014); von Stechow et al. (2016); Krey et al.(submitted)). Key areas such as poverty (SDG1), inequality within and between countries (SDG10), the role of education (SDG4), gender (SDG5) sustainable communities and cities (SDG11) or institutions (SDG16) are largely underexplored territory for integrated long-term scenarios (see also Section 5.4.3).

Many pathways studies have focused predominantly on one-directional interactions across a limited set of sustainable development dimensions. Being more limited in scope, these studies often take one or more SDGs as an entry point for reaching broader societal objectives. For example, Abel et al. (2016) show how universal education (SDG 4) would fundamentally change the role of woman in society and by extension result in reduction of fertility in the developing world, ultimately reducing population growth significantly. A smaller population may lead to reduced emissions (O'Neill et al., 2010) and thus support reaching stringent climate targets such as 1.5°C. Higher income due to education may, at the same time, however, increase emissions. The balance of the two effects is not well understood. Another example for a sectoral study is the Global Energy Assessment (Riahi et al., 2012), illustrating how a fundamental energy transformation (SDG7), if managed appropriately, can result in multiple societal benefits for health, security, affordability, access and reliability of energy services.

Recent pathways studies exploring sustainable development have broadened their scope, given particularly the growing recognition of the many interactions inherent in the management of water, energy, and land-related SDGs and that these interdependencies could fundamentally alter the adopted transition strategies (Arent, 2014; Bierbaum and Matson, 2013). In this context,"nexus" refers to a sub-set of sustainable development dimensions that are investigated together because of their particularly close relationships. Examples of a "nexus" approach include (Parkinson et al., 2016; Conway et al., 2015; Welsch et al., 2014; Rasul and Sharma, 2016; Howarth and Monasterolo, 2017; Keairns et al., 2016). While such a nexus approach foregrounds interactions and feedbacks from a complex systems perspective (Howarth and Monasterolo, 2017), assemblage approaches focus on continuously changing relations between human and non-human actors and constructive tension as opportunities for change (Gillard et al., 2016). Given these interdependencies, the concept of nexus thinking (Fricko et al., 2016) has gained traction within the IAM community and work has begun to improve the representation of nexus linkages within individual models and to develop integrated nexus frameworks that endogenously consider the trade-offs and synergies among water, food, and energy supply systems (Johnson et al., submitted).

A key challenge of the nexus approach lies in the cross-sectoral nature and complex interlinkages between advancing sustainable development and addressing climate change (Boas et al., 2016; Dimitrov, 2016). Networked governance can assist complex climate decision making (Tosun and Schoenefeld, 2017).However a reductive focus on specific SDGs in isolation may undermine the long-term achievement of sustainable climate change mitigation (Holden et al., 2016).

Nexus assessments are particularly needed in the context of the Sustainable Development Goals (SDGs) where an integrated framework would be useful to identify strategies for addressing multiple goals while avoiding efforts that are counterproductive from a holistic perspective (van Vuuren et al., 2015; Weitz, 2015; Zhou and Moinuddin, 2017). In this context, an early pioneering study by PBL (Vuuren et al., 2012) extended the boundary conditions of pathways to explore also the sustainability of land use, and identify strategies for eradicating hunger and maintaining stable and sufficient food supply while conserving biodiversity. A more recent example of pathways of how water, energy and climate SDGs (6,7,13) interact (Parkinson et al, submitted) calls for integrated water-energy investment decisions in order to manage the transition of these strongly connected sectors. An important option in this context is the provision of

bioenergy, which can help mitigate climate change and alleviate energy security concerns, but can have negative impacts on food security, water use, and biodiversity (Bonsch et al., 2016; Chaturvedi et al., 2013; Lotze-Campen et al., 2014; Secretariat of the Convention on Biological Diversity, 2009).Despite these trade-offs, many synergies among solutions exist. Foremost,policies that improve the resource use efficiency of land, energy, and water may have synergistic benefits for the other supply systems given that each system relies on resources from the others (Bartos and Chester, 2014).

Importantly, there is an increasing body of literature exploring the effect of mitigation pathways (and SDG13 on climate) for sustainable development and other SDGs, going beyond the energy-water-land nexus (Krey et al.,; Bertram et al.; Grubler et al.,) (Humpenoeder et al., 2017). These studies take decarbonization as an entry point and try to understand implications for sustainable development. (Bertram et al. submitted) emphasise the importance of the mitigation portfolio, and show how choices of mitigation technologies can help in designing mitigation portfolios that would maximise synergies with sustainable development and help avoid trade-offs. (Krey et al. submitted) present a recent modeling comparison experiment on how mitigation affects 21 selected sustainability dimensions, ranging from ecosystem impacts (e.g., biodiversity and afforestation) to health implications, food security, water, employment, to name just a few. A keyconclusion from the study is that major synergies between 1.5°C pathways and sustainable development exist and that in most areas where trade-offs between mitigation and sustainable development can be avoided through appropriate policy design (see also Section 5.4.3). Regulation in specific areas may complement price-based instruments to avoid trade-offs due to high carbon pricing of 1.5°C pathways. Such combined policies generally lead also to more early action maximizing synergies and avoiding some of the adverse climate effects for sustainable development (Bertram et al., submitted).

A more comprehensive analysis of climate change in the context of sustainable development will be dependent on defining suitable reference scenarios that lend themselves to broader sustainable development considerations. The Shared Socioeconomic Pathways (SSPs) (O'Neill et al., 2017; Riahi et al., 2017) (see Chapter 1,Box 1.2) provide a tool-box for integrated assessment of climate-development linkages and constitute thus an important first step in this direction (Ebi et al., 2014). Their underlying narratives (O'Neill et al., 2017a) map well into some of the key SDG dimensions. For example, SSP4 describes a world with highly unequal investments in human capital across the world combined with increasing disparities in economic opportunity and political power leading to increasing inequality and stratification, both within and across countries. In contrast, SSP1 describes a reference world that shifts towards a more sustainable path of inclusive development that respects environmental boundaries compared to historical patterns (van Vuuren et al., 2017). Comparing transition dynamics from such very different reference worlds and studying the co-benefits and risks at the climate-SDG nexus is crucial and thus an important gap that the new scenario framework can fill. The SSPs will need to be linked also to non-SSP pathways approaches, like (Shukla and Chaturvedi, 2013) and other studies, exploring the sustainability implications on regional and global levels.

The narratives and quantifications of the SSPs have been used so far primarily around mitigation and adaptation. The global mitigation dimension has been assessed relatively comprehensively (Riahi et al., 2017; Rogelj et al., submitted; Bauer et al., 2017; Popp et al., 2017; van Vuuren et al., 2017). Recently, also SSP-based work focusing on adaptation and impacts and applying the framework to different other sustainable development dimensions has become more widespread (Byers et al. submitted; Parkinson et al. submitted; Blanco et al. 2017; Hasegawa et al. 2014; Ishida et al. 2014; Arnell et al. 2015; Bowyer et al. 2015; Burke et al. 2015; Hallegatte and Rozenberg 2017; Lemoine and Kapnick 2016; O'Neill et al. 2017; Rozenberg and Hallegatte 2016; Rutledge et al. 2017). So far these activities have resulted in an ensemble of mitigation scenarios, comprehensively covering the entire SSP-RCP matrix. An important finding of the SSP-based mitigation analyses is that the socioeconomic storyline (SSPs) affects mitigation costs almost as much as the choice of the forcing target (RCPs). Perhaps equally important, the mitigation scenarios clearly illustrate how specific socio-economic conditions (e.g., as described by SSP3) might render specific climate forcing targets unattainable (such as 2.6 or 1.9 W m^{-2}) (Riahi et al. 2017; Rogelj et al. submitted) (Fujimori et al, 2017). The multiple pathways of the SSP-RCP framework lend itself thus for the systematic exploration of uncertainties and the extent of development-climate synergies or possible trade-offs.

Harnessing the full potential of the SSP framework to inform sustainable development requires (1) further

elaboration and extension of the current SSPs to explicitly cover sustainable development objectives, and (2) the development of new or variants of current narratives that would facilitate more SDG-focused analyses with climate as one objective (among other SDGs) (Riahi et al., 2017). Initial work in this direction comprises the development of SSP-based inequality and poverty projections (Rao et al, submitted), which have been downscaled to sub-national rural and urban as well as spatially explicit levels (Gidden et al. submitted). The high granularity of the datasets has enabled advanced assessments of local vulnerabilities impacts, and sustainable development effects based on the SSPs (Byers et al. submitted). The explicit representation of poverty and inequality constitutes thus a major advancement of the SSPs compared to earlier community scenario sets, such as the RCPs (van Vuuren et al., 2011) or the SRES (Nakicenovic et al., 2000). A major conclusion from the SSP-based inequality assessments is that aggressive reductions in between-country inequality may decrease the emissions intensity of global economic growth (Rao and Min, In Press). This is due to the higher potential for decoupling of energy from income growth in lower income countries, which would be critically important for reaching 1.5°C climate targets in a socially and economically equitable world.

Scenarios in major international research collaborations, for example under the umbrella of IPBES (Intergovernmental Platform on Biodiversity and Ecosystem Services) or "The World in 2050" (www.TWI2050.org) increasingly build upon the SSPs as a starting point in order to explore conditions under which the SDGs can be achieved. Particularly the TWI2050 has been established to provide the framework for the scientific community to explore so-called Sustainable Development Pathways (SDPs). The TWI2050 framework is designed to allow modeling groups, using for example Integrated Assessment Models (IAM) and Earth system models (ESM), and other models, to identify and explore pathways to achieve all SDGs on a stable and resilient Earth system (Griggs et al., 2013; Rockström et al., 2009b; Steffen et al., 2015). In addition, the SDPs share some elements with the so-called CDRPs (see Section 5.6.2), going beyond modelling and including a narrative where required governance and institutional changes would help addressing critical societal goals related to, eg, poverty, vulnerability and inequality. The framing is set to explore pathways to reach the SDGs by 2030, continue to deliver on social and economic aspirations in an expanding world by 2050, and to do so within the biophysical safe operating space of a stable and resilient Earth system. Main components of TWI2050 framework includes the development processes for the SDP narrative which would expand beyond the SSP1 sustainability narrative (O'Neill et al., 2017a; van Vuuren et al., 2017); and two target spaces of indicators that provide the first step to allow modeling groups and other research communities to use backcasting approaches to analyse pathways from 2050 (and in some cases 2100) to the present. At the moment, the pathways are under development as part of the TWI2050 community process with a first report scheduled for 2019 to inform the High Level Political Forum on the SDGs.

5.6.2 Climate-resilient Development Pathways

This section assesses literature that adopts the second notion of pathways as solution-oriented trajectories and decision-making processes toward achieving a set of future goals to be considered for a 1.5°C warmer world. It introduces climate-resilient development pathways (CDRPs) as a conceptual and aspirational notion of pathways that are socially desirable, taking into account individual and collective values and socio-cultural, place-specific preferences, fair and equitable, and compatible with 1.5°C trajectories (Figure 5.5; FAQ 2). CRDPs are best understood as an extension to climate-resilient pathways (Denton et al., 2014) and transformation (emission reduction) pathways (Clarke et al., 2014), as defined in the AR5, as well as earlier advances in the domain of climate-compatible development (Maxwell, 2016; Mitchell and Maxwell, 2010; Stringer et al., 2014; Wood et al., 2016a, 2017) and triple-wins (see Section 5.5). They are based on a growing, yet dispersed literature following the 2015 Paris Agreement and the Agenda 2030 – Transforming our World, including the triple emphasis on development, resilience, and transformation as laid out in the latter.

[INSERT FIGURE 5.5 HERE]

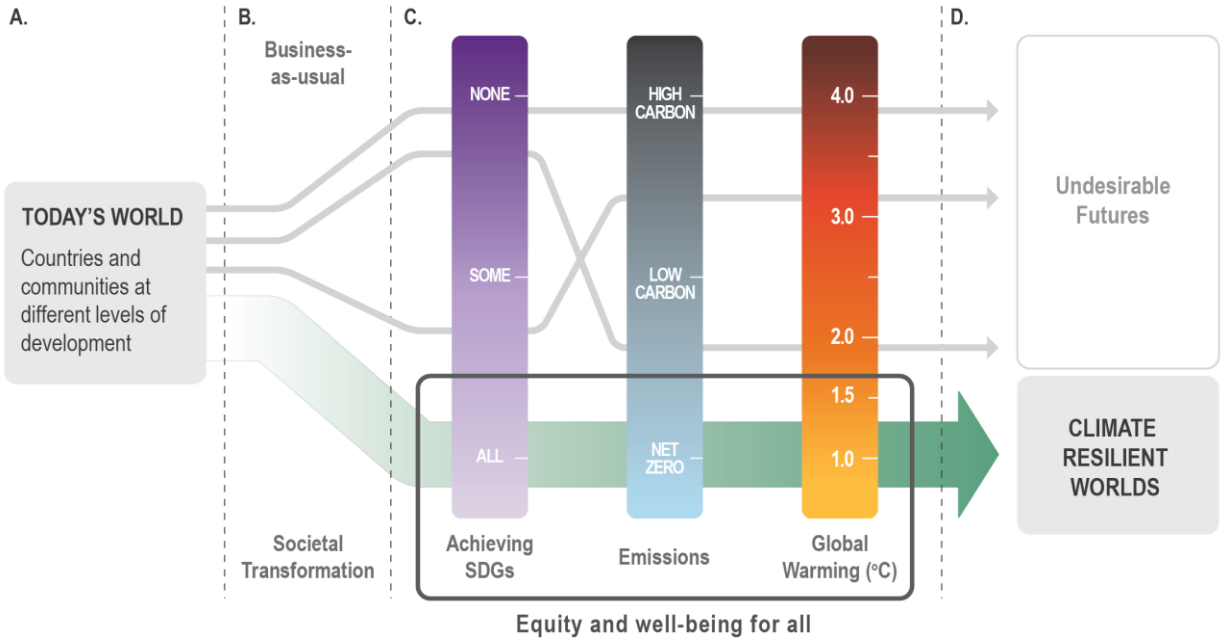


Figure 5.5: Climate-resilient development pathways (CRDPs) (green thick arrow) between our current world in which countries and communities exist at different levels of development, with various adaptation and mitigation measures available to them (A) and future worlds that are climate-resilient (bottom), undesirable (top), or somewhere in between (D). CRDPs emerge when aligned with societal transformation rather than business-as-usual policies and approaches (B). Pathways that achieve the SDGs by 2030 and beyond, strive for net zero emissions by mid- or later 21st century, and stay within the global 1.5°C warming target by the end of the 21st century, while ensuring equity and well-being for all, are considered as CRDPs (C).

5.6.2.1 Transformations, Well-being, and Equity

The notion of development pathways that are simultaneously climate resilient, as suggested by emerging literature, delineates a future in which easy wins, minor trade-offs, and space for inaction are waning while low-carbon trajectories are taken up across societies, in alignment with the UNFCCC premise of "common but differential responsibilities and respective capacities" (CBDR/RC). For CRDPs to attain the anticipated *transformations*, within a small window of time, all countries, independent of their income level or development status, as well as non-state actors, will need to strengthen their contributions, through bolder and more committed effort-sharing (Ekwurzel et al., 2017; Frumhoff et al., 2015; Holz et al., 2017; Millar et al., 2017; Rao, 2014; Shue, 2017) (*medium evidence, high agreement*). Sustaining decarbonization rates at a level compatible with the 1.5°C target would be 'historically unprecedented' (Millar et al. 2017: *ref*) and not possible without rapid transformations to a net-zero-emissions global economy by mid-century (Rockström et al., 2017a) or the later half of the century (Granoff et al., 2015). Such efforts would entail overcoming entrenched barriers such as technical, infrastructural, institutional, and behavioral carbon lock-in, within and across states and sectors (Pfeiffer et al., 2016; Seto et al., 2016), as well as defeating the path dependencies of poverty dynamics (so-called poverty traps) at the level of households, communities and nations (Boonstra et al., 2016; Enqvist et al., 2016; Haider et al., 2017; Lade et al., 2017) (*medium evidence, high agreement*).

Well-being for all(Dearing et al., 2014; Raworth, 2012, 2017b; Rockström et al., 2009a) appears as one of the core yardsticks for CRDPs. It includes peace and justice, social equity, gender equality, political voices, and networks, in addition to education, income and work, health, food, water, energy, and housing, as illustrated in the 'Doughnut" of social and planetary boundaries (Raworth, 2012). The fundamental social condition to enable well-being for all is to address entrenched inequalities within and between countries, especially those that show continuous shortfalls below the social foundations (e.g., peace and justice, gender equality, and political voice) while eliminating ecological overshoots (Raworth, 2017a, b), analogue to the

Agenda 2030 premise to 'leaving no one behind', including no place and no ecosystem. This entails transforming economies and overcoming uneven consumption and production patters to avoid critical human deprivation (Dearing et al., 2014; Häyhä et al., 2016; Raworth, 2017b) and moving toward development as well-being rather than growth (Gupta and Pouw, 2017).

Equity, fairness, and climate justice constitute the other essential yeardstick for these pathway endeavours (Caney, 2012; Klinsky et al., 2017a; Moellendorf, 2015; Roser and Seidel, 2017; Sealey-Huggins, 2017; Shue, 2014a; Thorp, 2014) (*medium evidence, high agreement*). Consideration for what is equitable and fair in the pursuit of 1.5°C suggests the need for stringent decarbonization that does not exacerbate social injustices, locally and at national levels (Okereke and Coventry, 2016), is 'socially desirable and acceptable' rather than merely economically and technically feasible (Rosenbloom, 2017; von Stechow et al., 2016), and makes visible vested interests implicated in defining what is considered feasible (Gardiner, 2013; Haasnoot et al., 2013; Meadowcroft, 2011; Normann, 2015; Patterson et al., 2016; Preston, 2013). Pathways compatible with 1.5°C warming are not merely 'possible futures' but their development, deliberation, and implementation entail societal values and a 'new politics of anticipation' (Beck and Mahony, 2017: *ref*), including attention to politics and power that perpetuate business-as-usual trajectories (O'Brien, 2016), the politics of the sustainability and capabilities of everyday life (Agyeman et al., 2016; Schlosberg et al., 2017), and the deep-seated inequities built into uneven development and uneven climate ambitions (CSO Review, 2015; Holz et al., 2017)(*medium evidence, high agreement*).

Identifying socially acceptable, inclusive, and equitable pathways for a 1.5°C warmer world that take into account differential responsibilities and capacities is a challenging yet essential endeavour, fraught with complex moral, practical, and political difficulties (*very high confidence*). It asks 'whose vision of a climate compatible [and resilient] future is being pursued and along which pathways?' (Gillard et al., 2016:*ref*). Hence, equity- and urgency-driven pathways toward livable, just, and low-carbon futures and conscious social transformation necessitate public deliberation and participatory processes, including from those most affected (Leach et al., 2010; O'Brien, 2016; Rosenbloom, 2017; Stirling, 2014; Tàbara et al., 2017a). Meeting the social and governance conditions that enable CRDPs is a prerequisite for their feasibility, yet how to do so remains insufficiently addressed in most pathways literature (see Chapter 1,Cross-chapter Box 1.1). Vital lessons emerge from lived experiences with and tensions within climate-compatible and climate-resilient development approaches (e.g., Baker et al., 2014; Archer and Dodman, 2015; Reed et al., 2015; Swilling et al., 2016; Arent et al., 2017; Brown et al., 2017) (see Section 5.5).

5.6.2.2 Development Trajectories, Responsibilities, and Capacities

The potential for embarking on and realistically pursuing development pathways that are sustainable and climate-resilient differs between nations at different levels of development (*very high confidence*). The associated equity challenges are made explicit through the 'Common but Differentiated Responsibilities and Respective Capacities' (CBDR-RC), as defined in the UNFCCC. There is a growing literature on various effort- or burden-sharing approaches to climate stabilization among all countries, predominantly at the level of nation states(Baer et al., 2008; Okereke and Dooley, 2010; Okereke and Coventry, 2016; Anand, 2017; du Pont et al., 2017; Bexell and Jönsson, 2017; van den Berg et al., under review). Different principles and methodologies result in different levels of responsibilities and capacities (Skeie et al., 2017), with some, however, systematically biased against poorer countries and those with low emissions (Kartha et al. forthcoming). The disparity between nations, their respective opportunities and challenges, and the position they occupy on current development trajectories, as highlighted in the 2017 SDG Dashboard, determine to a large extent the countries' uneven potential for pursuing CRDPs in a 1.5°C warmer world. For the developing world, achieving the 1.5°C goal also means potentially severely curtailed development prospects (Okereke and Coventry, 2016) while not meeting the 1.5°C will also have implications. Successfully navigating CRDPs will go hand in hand with countries' efforts to ensure inclusive societies, development as well-being, and green economies, and honour their obligations to human rights, as outlined in the SDGs and the Paris Agreement, in alignment with the Right to Promote Sustainable Development (Gupta and Arts, 2017a; Gupta and Pouw, 2017).

Recent advances in the scientific literature address notions of fair shares at the level of nation states in their

attempt to limit global warming to 1.5°C (CSO Review 2015;du Pont et al. 2017; Holz et al. 2017; Winkler et al. 2017). These efforts build on the AR5 'responsibility-capacity-need' assessment (Clarke et al., 2014), complement other proposed national-level metrics for capabilities, equity, and fairness (Fuglestvedt and Kallbekken, 2016; Heyward and Roser, 2016; Klinsky et al., 2017b) and fall under the wider umbrella of fair share debates on responsibility, capability, and right to development in climate policy (Fuglestvedt and Kallbekken, 2016). In the (I)NDCs, the large majority of nations (>90%), including Least Developed Countries (LDCs), Small Island States (SIDs) and other countries in the global South, considered fairness and equity largely through the lenses of a country's vulnerability and/or their small shares of global emissions, compared to OECD countries (<10%), with only limited reference to 1.5°C overall (Winkler et al., 2017). Such scientific literature contributes to the understanding of the ethical premises and consequences of the relative fairness in countries' pledges and actions, without being policy-prescriptive (Kartha et al., under review).

Recent literature suggests that a 'justice-centred implementation of 1.5°C compliant mitigation' (Holz et al. 2017:xx), based on a country's responsibility and capacity, requires both ambitious domestic emission reductions and committed international cooperation whereby wealthier countries support poorer ones, technically, financially, and otherwise, to mitigate their fair share (Okereke and Coventry, 2016). Such an approach also takes into account the differential costs of implementing mitigation (Akimoto et al., 2016; Clarke et al., 2014; Hof et al., 2017; Maljean-Dubois, 2016; Williams and Montes, 2016) (*medium evidence, medium agreement*). Figure 5.6 depicts these 'dual obligations' by highlighting high and low ambition fair share emission reductions. Data are extracted from the Climate Equity Reference Framework (CERF), the successor to the Greenhouse Development Rights framework (Baer et al., 2008), a well-known, justice-based effort-sharing scheme, and summarised by Holz et al. (2017): high-income countries are typically less vulnerable to climate change, externalise many of the costs of their domestic development (high international 'spill-overs'), and have pledged NDCs that, on average, are significantly lower than the fair share of emission reductions as assessed through the CERF. Poorer countries, by contrast, tend to be more vulnerable, generate low spillovers, and yet may have to do more than their fair share, conditional upon adequate external support (Holz et al., 2017).

[INSERT FIGURE 5.6 HERE]

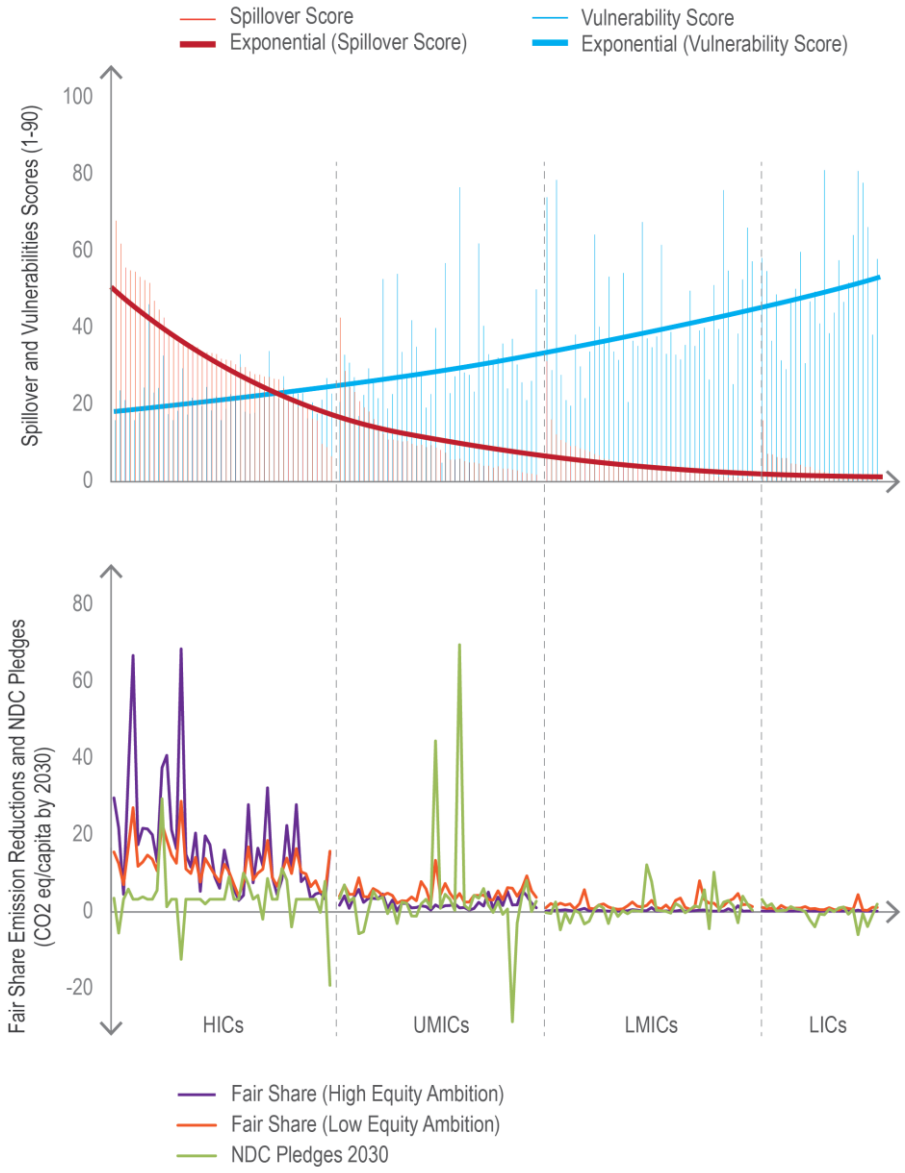


Figure 5.6: Common but Differentiated Responsibilities and Respective Capacities between high-, middle-, and low-income countries. The figure shows countries' vulnerability to climate change (blue), international spillovers (red), two 2030 'mitigation fair shares' for a 1.5°C consistent pathways (purple and orange line, respectively) and submitted Nationally Determined Contributed [NDC] pledges (lower ambition/unconditional) for 2030 (green line). Vulnerability and Spillover scores are shown along the left axis (0–90), with higher scores indicating higher vulnerability to climate change and higher international spillovers. The Vulnerability Score is a measure of a country's overall vulnerability to climate change, averaging the combined scores of the normalised Climate Change Vulnerability Index (Sachs et al., 2017), based upon HCSS, 2015) and the Notre Dame Global Adaptation Index (ND-GAIN, 2017). The Spillover Score is the degree to which development undertaken by one country negatively affects or forecloses development opportunities in other countries, that is, a measure of externalizing the costs of development, averaging nine normalised spillover indices grouped within three themes: environmental, finance and security (see Sachs et al., 2017). The blue and red dotted lines across the data set indicate trend lines (exponential) for the vulnerability score and spillover score, respectively, across the four income groupings. The Fair Share Emission Reduction Scores and NDC Pledges are shown on the right axis and are expressed in ktonnes CO_2 equivalent per capita ($ktCO_2$-eq/cap) against baseline, based on Holz et al. (2017) supplementary data, and the Climate Equity Reference Calculator (CERC, 2017). The 'high equity ambition' fair share score (most progressive) (purple line) is calculated using 1980 as the historical start

date, a development threshold of US$7,500, a luxury threshold of $50,000 (progressive between thresholds), and a 50:50 ratio between Responsibility and Capacity. The 'low equity ambition' fair share score (least progressive) (orange line) is calculated using 1990 as the historical start date, no development threshold and no luxury threshold, and a 50:50 ratio between Responsibility and Capacity. The NDC pledges for 2030 emission reductions (green line) are expressed in t/capita CO_2eq of mitigation below baseline, under the low ambition case Holz et al. (2017). Countries are grouped along the horizontal axis according to the World Bank 2017 income levels: High-Income Countries (HIC), Upper Middle-Income Countries (UMIC), Lower Middle-Income Countries (LMIC) and Low-Income Countries (LIC).

Recent literature suggests important contributions to climate change from non-state actors such as cities (Bulkeley et al., 2013, 2014b; Byrne et al., 2016), businesses (Frumhoff et al., 2015; Heede, 2014; Shue, 2017) and transnational initiatives (Andonova et al., 2017; Castro, 2016) and their responsibilities toward those affected by the damages (*medium evidence, medium agreement*). Strikingly, the contributions of 90 industrial carbon producers to the rise in atmospheric CO_2 (~57%), global mean surface temperature (~42–50%), and global sea level (~26–32%) over 1880–2010 (with two thirds of these during 1980–2010) has been highlighted (Shue, 2017; Heede, 2014; Ekwurzel et al., 2017). Hence, non-state actors, especially businesses, shape the potential of countries and citizens to pursue CRDP and, in turn, are shaped by the environment that determines their capacity to adopt low-carbon and climate-resilient trajectories and embark on transition pathways (see Chapter 4, Section 4.5).

At the level of groups and individuals, equity in pursuing low-carbon and climate-resilient development means deliberately focusing on well-being and strengthening the capabilities of people who are typically excluded, marginalised, and most vulnerable (Byrnes, 2014; Klinsky et al., 2017b; Tokar, 2014). Community-level CRDPs that focus on capabilities and capacities can provide an important complement to national trajectories, flagging potential negative impacts of state-level commitments on disadvantaged groups, such as low-income communities and communities of colour (Baer et al., 2008; Caney, 2009; Farrell, 2012; Rao et al., 2014). They underscore the crucial roles of social equity, participatory governance, social inclusion, and human rights, as well as innovation, experimentation, and collective learning (*medium evidence, high agreement*) (see emerging case studies and lessons learned in Section 5.6.3 and Section 5.6.4). This approach to CBDR-RC implies choosing climate actions that create opportunities and benefits and allow people to live a life in dignity (following Sen and Nussbaum) while avoiding actions that undermine capabilities and erode well-being (Klinsky et al. 2016). It is in alignment with transformative social development (UNRISD, 2016) and the 2030 Agenda of "leaving no one behind", aiming to preclude severe limitations in adaptive capacities while supporting transformation and strengthening resilience.

5.6.3 Emerging Country and Community Experiences with Climate-Resilient Development Pathways

Literaturedepicting different notions of sustainable development trajectories that are consistent with CRDPs as outlined above, degrees of global warming. Nonetheless, examples from case studies suggest four key aspects (outcomes), albeit not necessarily all at once: (i) enhanced adaptation and reduced vulnerabilities; (ii) stringent emission reduction; (iii) the promotion of equity, fairness and justice; and (iv) poverty eradication and improved well-being for people and ecosystems.

This section provides insights from regional-, national- and community-level policy and planning efforts and experiences consistent with CRDPs and their core dimensions. Through the case studies that follow, it is possible to identify context-specific ingredients for successes and challenges encountered, across a variety of scales, and hence provide invaluable lessons for a 1.5°C warmer world. None of these examples reveals win-win (or triple-win) trajectories but instead complex trade-offs along a continuum of 'socially acceptable' and 'market-oriented' pathways, highlighting the vital role of societal values, internal contestations, and political dynamics, all of which are not easily evaluated through scientifically and analytically rigorous analysis alone (Edenhofer and Minx, 2014; UNRISD, 2016; von Stechow et al., 2016).

5.6.3.1 *Regional and State-led Efforts Toward Climate-resilient Development Pathways: Green States, Low-carbon Economies, and National Planning and Partnerships*

Various development models and pathways exist, known under various lavels (e.g., green growth, inclusive growth, de-growth, post-growth, and developemt as well-being rather than growth) as well as region-speficic pathway planning and partnership approaches. States play an important role in reconciling low-carbon pathways with sustainable development and ecological sustainability. This section offers two examples.

Labels such as 'green economy', 'green growth', and 'green states' are increasingly used to describe nation-state strategies and policies for such dual commitment; yet, how states employ these concepts varies widely. Several typologies distinguish between green economy discourses and their potential for transformative change. Those discourses that align best with CRDPs are described as 'transformational' and 'strong' (Ferguson, 2015). Important insights stem from the 2011 UNEP report 'Towards a Green Economy: Pathways to Sustainable Development and Poverty Eradication' where a green economy is defined as 'low-carbon, resource efficient and socially inclusive', leading to 'improved well-being and social equity, while significantly reducing environmental risks and ecological scarcities' (UNEP 2011: 9); and the 2012 UNESCAP 'Green Growth, Resources and Resilience: Environmental Sustainability in Asia and the Pacific', with a strong focus on poverty reduction and resilience building (Georgeson et al., 2017b). Despite continuous reliance on market mechanisms and economic growth, and other criticism (Brockington and Ponte, 2015; Wanner, 2014), the UN approaches appear best suited to integrate green economy pathways with sustainable development and the SDGs (Brown et al., 2014; Georgeson et al., 2017b).

Nonetheless, in promoting poverty eradication, equity and social and environmental justice—core aspects of CRDPs—existing discourses fall short of their potential. An overemphasis on market and profit opportunities tend to trump environmental justice legislation and enforcement, and procedural justice policies appear more preoccupied with managing risks and controlling people and resistance rather than including and empowering affected citizens (Bell, 2015). States from the Global North, especially the Scandinavian countries that rank top in the Global Green Economy Index/Social Progress Index (2016), have embraced the concept of 'green states' earlier on (Tienhaara, 2014; Ferguson, 2015; Duit et al., 2016; Bäckstrand and Kronsell, 2015; Han, 2015; Bell, 2015; Kim and Thurbon, 2015; Bell, 2016), yet several high-income countries also show high spill-over effects due to the out-sourcing of their emissions (Holz et al., 2017) (see Figure 5.6). An alternative is a 'thick green' perspective that emphasises equitable de-growth beyond GDP reduction, democracy and empowerment of civil society, including marginalised groups, and justice that alters the global economy's very structure (Buch-Hansen, 2018; Ehresman and Okereke, 2015; Lorek and Spangenberg, 2014; Schneider et al., 2010) (see also Chapter 4, Section 4.5).

Several countries from the Global South, including China, India, Brazil, and South Africa, have been described as 'emerging green states' (Death 2014; Death 2015), despite concerns over lacking budgets, high unemployment or repressive regimes, and more urgent development priorities (Chandrashekeran et al., 2017; Brockington and Ponte, 2015; Cock, 2014). Brazil, for instance,has emphasised its leading role in ambitious climate action, based on low per-capita energy-driven GHG emissions, clean energy sources, and slowing rates of deforestation, coupled with the creation of green jobs, a boost in renewables and sustainable transportation (Brown et al., 2014; La Rovere, 2017) and social welfare programs tied to payment for ecosystem services (e.g., the now discontinued *Bolsa Verde*). The latter demonstrated success in poverty reduction, sustainable forest use practices, and more equitable decision making with community participation (Cook et al., 2012; Coudel et al., 2015; OECD, 2015; Schwarzer et al., 2016; Pinho et al., 2014; Börner et al., 2013; Gebara, 2013). Yet, wider concerns remain relating to Brazil's persistent inequalities, large-scale hydroelectric projects, monetisation of ecosystems, and lack of participation in green-style projects (Brown et al., 2014) as well as the labour conditions in the country's Brazil's growing sugarcane ethanol sector and associated potentials for displacement (McKay et al., 2016).

Such openings for low-carbon transitions in non-OECD countries, even if contradictory and incomplete, may boost stronger efforts (Stern, 2015) and provide vital lessons for CRDPs. Most national strategies are distinctly state-driven, ranging from Ethiopia's 'Climate-resilient Green Economy Strategy' and Mozambique's Green Economy Action Plan' to ecosystem- and conservation-driven green transition paths adopted in Costa Rica and other Latin American countries to China's and India's technology and renewables

pathways (Brown et al., 2014; Chen et al., 2015; Death, 2014, 2015, 2016; Khanna et al., 2014; Kim and Thurbon, 2015; Wang et al., 2015; Weng et al., 2015). Reconciling low-carbon pathways with inclusive development in oil-producing countries provides complex economic and ethical challenges, due to stranded assets (e.g., Caney, 2016; Bos and Gupta, 2017)(see Box 5.2). Experiences with low-carbon resilient development approaches in Least Development Countries (LDCs) highlight the crucial role of identifying synergies across scale, removing institutional barriers, and ensuring equity and fairness in distributing benefits as part of the right to development (see also Section 5.5) (Fisher, 2013b; Rai and Fisher, 2017).

[START BOX 5.2 HERE]

Box 5.2: Low-Carbon Pathways in Oil-Producing Countries

The Gulf Cooperative Council (GCC) region is characterised by high aridity, vast low costal lands, and fragile ecosystems as well as high dependency on hydrocarbon resources (natural oil and gas), which together make the region vulnerable to both the physical impacts of climate change and the socioeconomic impacts of policies and response measures to address climate change. The region is vulnerable to water stress (Evans et al., 2004; Shaffrey et al., 2009), desertification (Bayram and Öztürk, 2014), sea level rise, and high temperature and humidity with future levels potentially beyond human adaptability (Pal and Eltahir, 2016). Economically, the region is vulnerable to the negative impacts of climate change response measures on the global demand and price of hydrocarbons, given that oil and gas revenues accounted for ~70% of government budgets and contributed > 35% to the region's GDP in 2010 (Callen et al., 2014). The region is projected to face the highest costs from global GHG emission reduction pathways consistent with 2°C stabilization, regardless of the policy design, with average loss > 10% in present value consumption from business-as-usual scenarios compared to a world average cost of 1.5% (Leimbach et al., 2010; Massetti and Tavoni, 2011), with even higher losses expected under a 1.5°C compatible trajectory.

A low-carbon pathway that manages climate-related risks within the context of sustainable development and 1.5°C warming requires an adaptation approach that jointly addresses both types of vulnerabilities (Al Ansari, 2013; Babiker, 2016; Griffiths, 2017; Lilliestam and Patt, 2015). Rising per-capita GDP, energy and CO_2 intensities, and large carbon footprints (Babiker, 2010; Babiker and Fehaid, 2011) suggest difficult trade-offs between mitigation measures and economic development. Yet, there are emergent opportunities for energy price reforms, energy efficiency, turning emissions in valuable products, and deployment of renewables and other clean technologies, if accompanied with appropriate policies and in the context of economic diversification (Atalay et al., 2016; Luomi, 2014; Griffiths, 2017a; Griffiths, 2017b). The offered INDCs for GCC countries identified energy efficiency, deployment of renewables, and technology transfer to enhance agriculture, food security, protection of marine, and management of water and costal zones (Babiker, 2016). The renewables deployment potentials in the region are large, including the "Estidama" Initiative and Abu Dhabi'2 Plan 2030, and UAE 2050 Strategy for UAE; and Vision 2030 for Saudi Arabia (IRENA, 2016), yet their exploitation is currently limited by economics and structural challenges (Griffiths, 2017; Lilliestam and Patt, 2015). The deployment of renewables in planned mostly for electricity generation, ranging from 5% by 2030 for Bahrainto 25% by 2030 and 75% by 2050 for UAE (Griffiths, 2017).

The United Arab Emirates (UAE) is at the forefront among the GCC and Middle East and North African (MENA) countries in the development and deployment of renewable energy. UAE hosts the flagship renewables development project "Masdar" intended to be "The world's most sustainable eco-city" featuring a global clean technology hub, the world's first carbon-neutral zero waste city, and recently became the headquarter of the International Renewable Energy Agency (Angelidou, 2017; Cugurullo, 2016; IRENA, 2016). Masdar, inspired by the UAE Vision 2030, is a commercially driven, international renewable energy and sustainability company that advances solutions in energy, water, urban development and clean technologies in and outside the UAE (Cugurullo, 2013, 2016). Masdar city is a $20 billion emerging global clean-technology cluster that places its resident companies in the heart of the global renewable energy industry (Cugurullo, 2016). "Mubadala", a renewables company under Masdar, is advancing the development, commercialization and deployment of renewable energy solutions and clean technologies, establishing Abu Dhabi as a global centre of excellence in the renewable energy and clean technology sector

(Masdar, 2017). Under Masdar, "Shams1" is the largest concentrated solar power (CSP) plant in the region with a capacity of 100 MW developed through a BOO (Build Operate and Own) contract to feed the emirate of Abu Dhabi (Cugurullo, 2013; Masdar, 2017). UAE has the best frameworks in place for renewable energy deployment in the GCC and MENA context (Mondal et al., 2016) and is known for innovative pricing and methods of financing, for instance power auctioning, with Dubai leading in utility-scale solar PV auctions (Griffiths, 2017). The Power Purchase Agreement (PPA) for Dubai's first phase of renewable energy solar park of 200 MW was auctioned at a record low price of $0.0584 per kWh in March 2015. The auction for the third phase of the park in 2016 resulted in the lowest ever bid for solar PV of $0.0299 per kWh (Griffiths, 2017).

[END BOX 5.2 HERE]

The example of Small Pacific Island Development States (PSIDS) highlights other vital aspects of regional- and state-level planning and partnership efforts consistent with core dimensions of CRDPs. For most PSIDS, climate change poses a severe risk to sustainable development (*medium evidence, high agreement*). Since the AR5 – IPCC (2014), emerging literature has examined opportunities for PSIDS to coordinate national adaptation planning to advance the 2030 Agenda for Sustainable Development, respond to global climate change objectives of Paris and reduce the risk of disasters in line with the Sendai targets (FRDP, 2016; McCubbin et al., 2015; Nunn and Kumar, 2017; Shultz et al., 2016).

The SAMOA Pathway: SIDS Accelerated Modalities of Action (United Nations, 2014a) prioritised partnerships for adaptation to climate change as the immediate and urgent global priority for SIDS, considering their special needs and vulnerabilities to climate change, complex risks and the potential of climate change to adversely affect their efforts to achieve sustainable development (Steering Committee on Partnerships for SIDS and UNDESA, 2016). There is agreement that developing and enhancing the resilience of national economies and communities to climate change is a priority for most Pacific Island Countries (PIC) (Government of Kiribati, 2012, 2016; Lefale et al., 2017; MELAD, 2012).

However, PSIDS have varied access to human, institutional, social and financial resources at the national, island/provincial, and village/local community, particularly in small states like Kiribati, Nauru, and Tuvalu, to meet obligations under the UNFCC and achieve and maintain sustainable, resilient development (Barnett and Walters, 2016; Cvitanovic et al., 2016; Hemstock, 2017; Michalena and Hills, 2018).

Pacific Island communities have different approaches to the application and integration of 'resilience' and 'development' in national planning contexts as a result of differing social contexts and experiences of economic development and access to human, technical, institutional and financial resources including regional and international support (Aipira et al., 2017; Bell et al., 2016; Buggy and McNamara, 2016; Cabezon, 2015; Janif et al., 2016; McNamara and Buggy, 2017; Robinson and Dornan, 2017).

Climate resilience planning for the short to medium term may be insufficient to address increasingly complex, severe climatic impacts over time (Dilling et al., 2015). However. regionally related efforts to develop and implement climate-resilient community planning frameworks have been established in Papua New Guinea, Timor Leste, and Vietnam (Sterrett, 2015a). The Pacific Risk Resilience Programme (PRRP) also aims to provide guidance and advice to Fiji, Solomon Islands, Tonga and Vanuatu on ways to integrate planning to reduce vulnerability and enhance climate change and disaster risk management in routine national and subnational planning processes, in a gender- and socially-inclusive manner (UNDP, 2016). The Republic of Vanuatu is leading the PSIDS to develop a national plan coordinated across government departments and other sectors (MCCA, 2016)(see Box 5.3).

[START BOX 5.3 HERE]

Box 5.3: Republic of Vanuatu–National Planning for Development and Climate Resilience

The Republic of Vanuatu has developed a national response to climate-resilient development in the context of high exposure to hazard risk (UNU-EHS, 2016). Despite rapid urbanisation (ADB, 2013), an estimated 80% of the population still reside in rural areas and depend on 'subsistence, rain-fed agriculture' on coastal plains together with coastal fisheries for food security (Sovacool et al., 2017a). Sea level rise, increased risk of prolonged drought, water shortages, intense storms and cyclone events and degraded coral reef environments are predicted to erode human security (Aipira et al., 2017; Gov of Vanuatu, 2015).

While Vanuatu faces severely constrained adaptive capacity (Gov of Vanuatu, 2015; Kuruppu and Willie, 2015; Sovacool et al., 2017a), it has developed a national level sustainable development plan for 2016 to 2030, also referred to as the People's Plan (Republic of Vanuatu, 2016). This overarching national plan of action on economy, environment, and society aims to build adaptive capacity and resilience to climate change and disasters. It emphasises the importance of a single focal institutional point, coordinating an inclusive planning response that considers the rights of all Ni-Vanuatu including women, youth, the elderly and vulnerable groups are promoted in relevant institutions (Nalau et al., 2016). Vanuatu has also developed a Coastal Adaptation Plan (Republic of Vanuatu, 2016) and an integrated Climate Change and Disaster Risk Reduction Policy (2016–2030) that sets out directives for the implementation of CC and DRM initiatives. The first South Pacific national advisory board on Climate Change & Disaster Risk reduction (NAB) at a national level was established in Vanuatu in 2012 (UNDP, 2016). This is the policy making and advisory body for all disaster risk reduction and climate change programs, projects, initiatives and activities.

Vanuatu's National efforts aim to integrate planning at multiple scales, and increase climate resilience by supporting local coping capacities and iterative, inclusive processes of sustainable development and integrated risk assessment (Aipira et al., 2017; Eriksson et al., 2017; Granderson, 2017; Sovacool et al., 2017b). Climate resilient development is also supported by non-state partnerships for example the 'Yumi stap redi long climate change'– or the Vanuatu NGO Climate Change Adaptation Program, a climate-resilient policy approach, founded in 2012 by a consortium of local and international NGOs to increase the resilience of local communities to the impacts of climate change (Sovacool et al., 2017b). The focus has been on equitable governance, with particular attention to supporting women's voices in decision making through allied programs addressing domestic violence and participation, together with rights-based education; addressing structural constraints on adaptive capacity that exacerbate social marginalisation and exclusion; engaging in institutional reforms for greater transparency and accountability (Davies, 2015; Ensor, 2016; UN Women, 2016); and local participation in climate- smart agriculture (Ensor, 2016; Sterrett, 2015b). The aim is to limit external NGO influence to providing access to information so that communities are empowered to address structural and agency constraints, and local technical and decision making capacity is enhanced (Ensor, 2016; Maclellan, 2015).

Given Vanuatu's long history of disasters, local and traditional adaptive capacity is assessed as relatively high, despite barriers of knowledge, lack of access to technology; low literacy rates and barriers to women's participation (Aipira et al., 2017; Granderson, 2017; McNamara and Prasad, 2014). The experience of the low death toll after Cyclone Pam, despite significant infrastructure damage suggests absence of storm surge flooding combined with effective use of local knowledge in planning and early warning climate can support resilient development pathways in a 1.5°C warmer world (Handmer and Iveson, 2017). Yet, ongoing power imbalances embedded in the political economy of development and climate finance programs also tend to marginalise the priorities of local communities(Addinsall et al., 2017; Baldacchino, 2017; Sovacool et al., 2017b).

Relationships defined by power and cultural norms often continue to shape how local risks are understood, prioritised and managed (Kuruppu and Willie, 2015). However a focus on more equitable decision making has been identified as the basis for future adaptive actions that will benefit the whole community (Aipira et al., 2017; Ensor, 2016). Climate resilience is also supported when decision making integrates ecosystem, community and social planning in resource management (Sovacool et al., 2017a; Sterrett, 2015a). The

serious damage of Cyclone Pam 2015 highlights the benefits and limits of resilient development effort by individual SPIDS (Ensor; Handmer and Iveson, 2017) .

[END BOX 5.3 HERE]

5.6.3.2 Community-led And Bottom-up Approaches to Climate-resilient Development Pathways

Communities – both communities of practice and place-specific communities – also play an important role regarding pathways to low-carbon, sustainable development trajectories that simultaneously promote fair and equitable climate resilience. Their efforts reveal different angles to CRDPs, equally partial and incomplete, just as those at the level of countries and regions. The two case studies below depict examples from the perspective of alternative development pathways, with experiences from Latin America (Box 5.4), and community- and ecosystem-based practices in drylands, mainly from Africa (Box 5.5). A third case study on Transition Towns is presented in the Cross-Chapter Box 5.1.

[START BOX 5.4 HERE]

Box 5.4: Alternative Development Pathways and Transnational Movements

Agrarian movements and social and climate justice movements across the Global South and Global North have converged over food sovereignty and climate justice as linked priorities. This convergence stems not only from realising the disproportional climate change impacts on poor communities and advocating just climate solutions and transitions, but also from contesting the market-driven 'carbon complex' including REDD+, climate-smart agriculture, Blue Carbon, and green growth that perpetuate rather than reduce injustice (Claeys and Delgado Pugley, 2016; Tramel, 2016). Alternative ways of producing and delivering food, energy, and clean water are embedded in a vision of a better society that foregrounds redistribution, representation, and recognition of diverse identities (Scoones et al., 2017a), with roots in environmental and food justice (Agyeman et al., 2016; Alonso-Fradejas et al., 2015; Edelmann and Borras, 2016; Martinez-Alier et al., 2016) and social and solidarity economies (SSE) (Avelino et al., 2016; Chamorro and Utting, 2015; Grasseni et al., 2013; UNRISD, 2016; Utting, 2015). Peasants, indigenous peoples, hunters and gatherers, family farmers, rural workers, herders and pastoralists, fisher folk and urban people (Global Convergence of Land and Water Struggles, 2016) join efforts with movements such as *La Vía Campesina* and The World Forum of Fisher Folks (Tramel, 2016) to align socially-desirable adaptation and mitigation pathways with transnational solidarity and well-being and justice for all. Landless peasant movements, such as the *Movimento dos Trabalhadores Rurais Sem Terra* (MST) in Brazil, have also played a major role in addressing social and climate justice with a commitment to sustainability through agroecological transitions in the communities that are formed through the process of direct political action aimed at reclaiming land for small-scale peasant farmers and families (Meek, 2014, 2016; Pahnke, 2015).

Latin American countries have been at the forefront of alternative development pathways rooted in an appreciation for peasant and indigenous lifestyles and values. These development pathways address social shortcomings (Raworth, 2017a) and reveal culturally-appropriate opportunities to foster resilience to climate and other disturbances (Sietz and Feola, 2016), important prerequisites for CRDPs. *La Vía Campesina* is a transnational peasant movement that embraces a rights-based development approach centred on food sovereignty (largely self-reliance) and agroecology; it began in 1993, now counting >160 organisations in >70 countries and representing ~200 million small-scale producers (Claeys and Delgado Pugley, 2016)**.** The movement aims to restructure the global food system (Agarwal, 2014; Desmarais et al., 2014) and offer 'peasant solutions' to climate change to counter carbon trading, BECCS, and other 'false solutions' (Claeys and Delgado Pugley, 2016; McKeon, 2015)**.** *Buen Vivir*, translated as 'living well together', with origin in the world-view of Quechua peoples, encapsulates the principles of a 'good life' based ecological sustainability, local trade systems, simplicity, solidarity, food sovereignty, and multiple ways of knowing (Bell, 2016; Gupta and Pouw, 2017; McAfee, 2016; PWGAD, 2013). It also rejects fossil-fuel reliance, overemphasis on economic growth, and green growth pathways (McAfee, 2016), yet is not without critique

(e.g., Cochrane 2014; Calisto Friant and Langmore 2015). The recent boom of quinoa, a nutritious and climate-variable crop, illustrates the prospects and pitfalls of 'sustainable re-peasantisation' in the Bolivian Altiplano as global food networks become accessible while conflicts over land and identity with returning migrants challenge collective decision making and harmony as pillars of *Buen Vivir*(Kerssen, 2015)**.**

[END BOX 5.4 HERE]

The second example illustrates community-based drylands practices at scale, as an illustration of a transition toward CRDPs. Drylands, comprising heterogenous agroecological zones, are climate change hotspots (see Chapter 3, Section 3.3.15) where the protracted climate stress encountered is particularly challenging for building resilience (Fuller and Lain, 2017). Small-scale farmers in drylands are important agents of change in transforming food systems to efficiency and climate resilience (IRP, 2016); their role will be crucial in a 1.5°C development pathway. Cases of ecosystem- and community-based practices at scale that bring together adaptation, mitigation and development provide insights for achieving climate resilience in these vulnerability hotspots. Examples include: (i) farmer managed natural regeneration of trees in cropland (FMNR) in sub-Saharan Africa, and (ii) catchment rehabilitation using a range of sustainable land-water management practices in India and Ethiopia (see Box 5.5). With appropriate policy support, fostering enabling conditions, such as those which strengthen community land and forest rights farmer managed systems have the potential to spread (Stevens et al., 2014, Vermuelen et al., 2015), become pathways to resilience and serve as loci for transformation to CRDPs.

These cases embody enabling conditions required for CRDPs in including adaptive planning and management and ongoing learning (Gray et al., 2016); giving greater voice to women and to marginalised groups (Dumont et al., 2017); and the important role of social learning (Coe et al., 2014; Dumont et al., 2017; Epule et al., 2017; Isaac et al., 2007). Social learning is linked with building adaptive capacity (see Section 5.6.4), and is the primary mechanism for scaling up community-based successes and building a grassroots movement to focus on mindset change and agency (Binam et al., 2017; Dumont et al., 2017; Reij and Winterbottom, 2015).

An ongoing multi-institution project in East Africa and the Sahel (Ethiopia, Niger, Mali, Tanzania and Kenya), promotes nested communities of practice at different scales that include farmers, facilitators, extension, research, development and governance institutions, to facilitate an iterative co-learning cycle of action research (Coe et al., 2014; Sinclair, 2016). The role of social learning in FMNR indicates an evolution towards a promising CRDP, in which the politics of producing knowledge are opened up through the process of knowledge co-production. However, more evidence is needed on the impacts of FMNR on social equity, soils, water, non-economic livelihood benefits, microclimate, carbon sequestration, as well as on enabling governance frameworks (Francis et al., 2015; Weston et al., 2015).

The policy environment conditions the diffusion and scaling-up of the community-based approaches to climate-resilient development. Policy recognition and support to holistic agroforestry and farmer managed natural systems creates enabling conditions and provides the needed resources for the diffusion and spread of community based CRDPs. This is seen for some countries, such as in the case of Kenya's low carbon CRDP (Government of Kenya, 2012). In the case of MERET, its mainstreaming into the larger Sustainable Land Management Programme (SLMP) and other programs implies that MERET's community-driven triple-win approach has become the corner-stone of Ethiopia's ambitious drive for building a climate-resilient and a green middle-income economy within a decade, as envisioned in the country's NDC and national strategies. The National Mission for a Green India, as a mission under the National Action Plan on Climate Change, focuses on multiple ecosystem services along with carbon sequestration, and envisages a key role for local communities as it seeks to reach various targets such as social forestry/agroforestry over 3 million hectares and the NDC commitment of enhancing the carbon sink substantially by 2030 (Ministry of Environment and Forests).

Current constraints to these community-based practices at scale as the basis for CRDPs in different dryland

regions include inadequate attention to socio-technical processes of innovation, as well as to beyond-farm elements of the farming system (Grist et al., 2017; Scoones et al., 2017b), and contestations with the prevalent agricultural modernisation paradigm in Africa (Coe et al., 2017; Reij and Winterbottom, 2015); there remain also uncertainties about the impact of climate change on agroforestry systems; institutional inability to deal with long term climate risk at local scale by farmers (Singh et al., 2017a) and in case of MERET, matching of specific practices with agro-ecological conditions and complementary modern inputs (e.g., Kassie et al., 2015; Kato et al., 2011; Gebremedhin and Swinton, 2003). In general, the social, equity and governance dimensions and barriers of community-based practices at scale are not well documented and analysed. Policy support to overcome some of these constraints, creation of enabling conditions and support to research-in-development approaches to increase the evidence basis (Coe et al., 2014), would assist these community-based, large scale initiatives to transformation into climate-resilient development pathways in drylands.

[START BOX 5.5 HERE]

Box 5.5: Cases of Ecosystem- and Community-based Practices in Drylands

FMNR is practised in 18 countries across Sub-Saharan Africa, Southeast Asia, Timor-Leste, India and Haiti. Using community-based FMNR, farmers have restored over five million hectares of land in the Sahel (Bado et al., 2016; Haglund et al., 2011; Niang et al., 2014). In Ethiopia, the Managing Environmental Resources to Enable Transitions (MERET) programme entails community-based watershed rehabilitation to address the root causes of vulnerability and food insecurity, including soil and water conservation, afforestation and water harvesting – thus a 'triple win' approach of enhancing resilience, climate mitigation potential (e.g., through increased forest cover), and productivity of rural landscapes (Gebrehaweria et al., 2016; Haileslassie et al., 2008). During 2012–2015, MERET supported around 648,000 people, resulting in the rehabilitation of 400,000 hectares of land in 72 severely food insecure districts across Ethiopia.

In India, meta-analysis of 311 watershed case studies from different agro-ecological regions has revealed that watershed programmes have benefited farmers through enhanced irrigated areas by 33.5%, increased cropping intensity by 63%, reducing soil loss to 0.8 t/ha and runoff to 13%, and also improved groundwater availability. The watershed programmes were reported to be beneficial and viable with a benefit–cost ratio of 1: 2.14 and an internal rate of return of 22% (Joshi et al., 2005). In a recent study, (Agoramoorthy and Hsu, 2016) reported climate adaptive and mitigating outcomes of small check dams in some dryland districts in India, namely, Dahod in Gujarat and Jhalawar and Banswara in Rajasthan and opined that scaling up such interventions will be a win-win strategy for farming communities in terms of increase agricultural output and reduction in local climate change consequences. The adoption of conservation agriculture as a climate adaptation strategy in rainfed agroecosystems by farmers increased production by 200% in Central India's tribal belt (Pradhan et al., 2018).

These low-cost, flexible community-based practices at scale have been adopted by tens of thousands of resource-poor, risk-averse farmers, and positively assessed as low-regrets adaptation strategies (across the globe) (Francis et al., 2015; Niang et al., 2014; Weston et al., 2015). Evidence suggests that elements of supportive enabling environments include developing agroforestry value chains and markets (Reij and Winterbottom, 2015), and implementing sequenced integrated landscape management approaches (Gray et al., 2016).

Mitigation benefits have been quantified (Weston et al., 2015); in Niger, these include sequestration of an estimated 25–30 Mtonnes of carbon over the past 30 years by the 5 million hectares of still immature trees under FMNR (Stevens et al., 2014). In Ethiopia, an impact evaluation indicated that nearly two-thirds of all MERET households stated that they had successfully escaped from poverty during the previous ten years, while less than half of non-MERET households stated the same (WFP, 2012). While few scientific studies have directly evaluated the environmental impacts of MERET, studies assessing the program's core attributes, that is, soil and water conservation and other community-driven environmental rehabilitation efforts find significant impacts of MERET-related interventions on productivity and resilience (e.g., Kato et al., 2011; Kassie et al., 2015).

Social, economic and environmental benefits achieved through FMNR encompass a number of the attributes of emerging CRDPs, including strengthened ecosystem resilience and biodiversity, increased agricultural productivity and food security for poor households, a range of psycho-social benefits including joy and peace of mind, improved health, livelihood diversification and reduced poverty, enhanced agency and social capital through collaborative communities of practice, and reduced time spent by women in gathering firewood (Bado et al., 2016; Dumont et al., 2017; Francis et al., 2015; Mbow et al., 2015; Niang et al., 2014; Pye-Smith, 2013; Reij and Winterbottom, 2015; Weston et al., 2015).

[END BOX 5.5 HERE]

[START CROSS-CHAPTER BOX 5.1]

Cross-Chapter Box 5.1: Cities and Urban Transformation

Authors: W. Solecki, F. Aragon-Durand, P. Bertoldi, A. Cartwright, F. Engelbrecht, B. Hayward, D. Jacob, D. Ley, P. Marcotullio, S. Mehrotra, A. Revi, P. Newman, S. Schultz, P. Tschakert

Global Urbanisation in a 1.5°C Warmer World

Increasing urbanisation will be a key global trend in the next several decades as the world moves toward a 1.5°C increase in global temperature. It is estimated that there will be approximately 70 million additional urban residents every year through the mid part of this century (United Nations, 2014b). The vast major of the new urbanisation will be in small and medium sized cities in low- and middle-income countries that typically have limited capacity to adapt and mitigate climate change (Birkmann et al., 2016; Grubler et al., 2012a). Different regions of the world will experience different rates of increased urbanisation. The urbanisation rate in African countries will be especially high (Dodman et al., 2017; Gore, 2015). The new built environment and urban infrastructure being constructed, especially in the Global South, holds the potential to anticipate climate change but also raises significant questions of path dependency (Seto et al., 2014).

The process and character of urbanisation significantly influences cities' capacity to respond to climate change. Increase in urban population and urban land are associated with heightened resource demand driven by economic development (Huang et al., 2010). Resource demands on adjacent peri-urban areas and more distant locations (i.e., where critical resources are extracted and transported to cities) result in significant negative and positive impacts on rural economics, lifestyles, and territorial development (McGregor et al., 2006). Peri-urban zones, particularly those in low- and middle-income countries, will face the greatest demands given the simultaneous high rates of ongoing urbanisation(Dos Santos et al., 2017; Tian et al., 2017). The high level of people living under conditions of informality in these cities, limits the reach of formal governance and policy instruments. At the same time, growth in productivity driven by urbanisation and spatial development provides the economic and employment momentum to help finance climate resiliency and climate mitigation (Chu et al., 2017).

Multiple Interactions of Urbanisation and Environmental Change

Urbanisation is a significant driver of local, regional and global environmental change (Grimm et al., 2008; Marcotullio and McGranahan, 2007; Seto et al., 2014). At the local scale, urbanisation leads to a variety of ecological and environmental stresses and crises associated with environmental degradation and enhanced vulnerability, risk and impacts (Elmqvist et al., 2013). Urban and peri-urban dwellers most affected by environmental degradation often are vulnerable to climate change impacts, especially those living in informal settlements and conditions of informality (Revi et al., 2014). Conversely, urban densities present many opportunities for enhanced resource and energy use efficiency not available in lower-density population settings (Grubler et al., 2012b; Seto et al., 2014). Rural-to-urban migrants take advantage of these efficiencies as they adopt urban lifestyles (Nguyen et al., 2017; Shen et al., 2017).

The full complement of urban contexts including rural-to-urban linkages, through which migrants, resources and waste products flow and circulate, can be understood as a set of multiple, interlocking complex systems

(Dasgupta et al., 2014; Grimm et al., 2008; Revi et al., 2014). Urbanisation-focused systems include sociocultural-economic interactions (e.g., concerning class, gender [Chant et al. (2017)] race, ethnic and religious identities), governance structures (e.g., at the local, regional, and national scales – see Section 4.4.1 that deals with multi-level governance), urban infrastructure (e.g., the built environment including food, energy, waste, and water supply systems), and the interactions between the private and public, and formal and informal spheres.

Scalar Interactions of Governance, Resource and Waste Flow, and Economic Development

The structure and character of an individual city provide an urban metabolism and opportunities for reducing carbon and fostering resilience through adaptation (Carreón and Worrell, 2017). Rural-to-urban natural resource and waste flows connect higher density urban centres and extended metropolitan areas with their hinterlands bioregions. These links can enable opportunities for decarbonizing power and transport sectors, and creating adaptive responses to climate change (Newman et al., 2017). Governance of these resource and waste links also influence the rate of economic growth and equity, and how environmental stresses and risks are managed (Hughes et al., 2018).

At the international scale, the force of economic globalization significantly affects cities. These shifts result in changes in urban spatial development, income growth and inequities, and environmental stresses. Economic globalization is now continuing throughout much of the Global South and has implications for energy, transport, and water system infrastructure path dependency and the limiting of capacity to make mitigation and adaptation adjustments.

The Paris Climate Agreement NDCs will be promulgated at least in part through central governments to urban regions and local communities (Betsill et al., 2015). At the same time, the Agreement recognises the role of non-state actors in providing climate change solutions. Transnational coalitions of cities are at the forefront of climate solutions discussions and connect with national government policies and take part in international debates on climate change (Betsill et al., 2015; Bulkeley et al., 2014a; Hughes et al., 2018). Cities increasingly are connected with each other via bi-lateral or multi-lateral agreements and networks (Bouteligier, 2012). These linkages provide opportunities for advanced and accelerated collaborative learning and problem solving and emphasizing a city dimension in climate change negotiations (Johnson, 2018). Many networks have adopted or specifically focus on sustainability themes, and on climate adaptation and mitigation issues specifically (Fünfgeld, 2015).

Urban Transformations – Connections of Adaption and Mitigation and Emerging Climate-Resilient Development Pathways

City governments, non-governmental organizations, enterprises, and residents understand the effects climate change has on everyday life in their city (Bouteligier, 2015). At the same time, urban populations recognise the many other urban challenges, such as economic stagnation, social inequity, poverty, marginality, insecurity, and violence, and environmental pollution. Climate change interacts with and exacerbates many of the other stresses and crises in urban areas. For example, urban resource shortages (e.g., water), climate-triggered stress (e.g., extreme events) and social inequity are increasingly intertwined (Birkmann et al., 2016; Garschagen and Romero-Lankao, 2015). Conversely, climate mitigation including the advance of lower carbon-emitting transit options has immediate positive local impacts on urban air quality.

Cities have the potential for transformational adaptation and mitigation in part due to the concentration of economic activity and population, dense social networks, human resource capacity, high levels of investment in infrastructure and buildings, relatively nimble local governments, close connection to surrounding rural and natural environments, and a tradition of innovation. Local governments are closer to citizens and citizens' needs than central government. In addition, urban spaces offer a physical arena where local issues and solutions can be discussed and addressed (see case study on Transitions Towns below). The disruptive innovations of rooftop solar and other small-scale local technology for water and waste are happening in growing cities and can be used to leapfrog into a decarbonized, resilient and inclusive future, especially in slum renewal (see case study on Addis Ababa below). Electric vehicles and IT services are fast emerging solutions that contribute to city decarbonisation and enhanced air quality and life quality. Bringing financial and administrative resources from outside the city from regional, national and international sources also

provides advantages for cities (Colenbrander et al., 2016). Overall, cities are increasingly key sources of solution-based policy transitions required to address the global challenge of the Sustainable Development Goals (SDGs) and promote opportunities for the climate-resilient, sustainable development pathways.

Transition Towns (TTs) represent one example of how urban communities have begun to experiment with putting aspects of climate-resilient sustainable development pathways into practice. The grassroots TT movement (begun in the UK in 2005) combines adaptation, mitigation, and just transitions, mainly at the level of communities and towns. It now has >1,300 registered local initiatives in >40 countries (Grossmann and Creamer, 2017), although mostlyin the UK, the US, and other countries in the Global North. TTs exemplify 'progressive localism' (Cretney et al., 2016), aiming to foster a 'communitarian ecological citizenship' that goes beyond changes in consumption and lifestyle (Kenis, 2016). They promote equitable communities resilient to the impacts of climate change, peak oil, and unstable global markets; re-localisation of production and consumption; and transition pathways to a post-carbon future (Evans and Phelan, 2016; Feola and Nunes, 2014; Grossmann and Creamer, 2017).

TT initiatives typically pursue low-carbon living and economies, food self-sufficiency, energy efficiency through renewables, construction with locally-sourced material, and cottage industries, often in line with principles of de-growth (Barnes, 2015; North and Longhurst, 2013; Staggenborg and Ogrodnik, 2015; Taylor Aiken, 2016). Social and iterative learning through the collective involves dialogue, deliberation, capacity building, citizen science engagements, technical re-skilling to increase self-reliance, e.g. canning and preserving food and permaculture, future visioning, and emotional training to share difficulties and loss (Barnes, 2015; Taylor Aiken, 2015; Mehmood, 2016; Grossmann and Creamer, 2017; Kenis, 2016).

Enabling conditions for successful transition groups include flexibility, participatory democracy, inclusiveness and consensus-building, assuming bridging or brokering roles, and community alliances and partnerships (North and Longhurst, 2013; Feola and Nunes, 2014; Aiken, 2016; Mehmood, 2016; Grossmann and Creamer, 2017). Smaller scale rural initiatives allow for more experimentation (Cretney et al., 2016) while those in urban centres benefit from stronger networks and proximity to power structures (Nicolosi and Feola, 2016; North and Longhurst, 2013). Increasingly, TTs recognise the need to participate in policy making to overcome the 'post-political trap' (Barnes, 2015; Kenis and Mathijs, 2014).

Despite high self-ratings of success, some TT initiatives are too inwardly focused and geographically isolated (Feola and Nunes, 2014) while others have difficulties in engaging marginalised, non-white, non-middle-class community members (Evans and Phelan, 2016; Grossmann and Creamer, 2017; Nicolosi and Feola, 2016). In the UK, expectations of innovations growing in scale (Taylor Aiken, 2015) and carbon accounting methods required by funding bodies (Taylor Aiken, 2016) undermine local resilience building. Tension between explicit engagements with climate change action and efforts to appeal to more people have resulted in difficult trade-offs and strained member relations (Grossmann and Creamer, 2017). In the rapidly growing cities of South Asia and Africa, it is not yet clear that TTs are able to address the need for bulk infrastructure, shelter, clean energy and mobility that underpin climate change vulnerability (van Noorloos and Kloosterboer, 2017; Wachsmuth et al., 2016). Some of the coping strategies forged by citizens of developing countries, in the absence of public urban services, share attributes of flexibility, brokering, and partnership with TTs, and efforts have been able to harness low-carbon energy, sanitation and waste management technologies (Brown and McGranahan, 2016). There is no guarantee, however, that these strategies will evolve and cohere into the type of service delivery and climate governance system that prevails in many more developed cities (Jaglin 2014).

Transformations in informal settlements and urban slums illustrate a different set of opportunities and challenges, seen through the lens of contributions to the SDGs. Addis Ababa, for instance, like many developing country cities, has a high level of informal settlements (up to 80%) (Assefa and Newman, 2014). The question facing many such cities is how these informal settlements can be upgraded to achieve a reduction in GHG emissions (SDG 13) while enabling economic and social goals to be achieved as set out in the other SDGs (United Nations, 2015c).

Two approaches are at play in Addis Ababa. One is urban renewal based on slum clearance and transfer to

high rise dwellings; the other is urban regeneration based on in situ upgrading of infrastructure using solar energy and other community-based distributed infrastructure (OECD, 2011; Satterthwaite, 2016). Data from three existing slums have been compared to two urban renewal high-rise complexes in Addis Ababa, where residents were transferred from slums (Teferi submitted).

Communities in the informal settlements before in situ upgrade are exposed to physical, socio-economic, and health hazards because of poor quality housing, poor environmental sanitation, and inadequate social services. This situation is improved for relocated apartment dwellers who have better housing and living environments (SDG11), and better sanitation and water supply (SDG6). Yet, they have lost the all-important community cohesion that is a hallmark of informal settlements that provides the social safety net that underpins access to other SDGs, and the end of extreme poverty (SDG1).

Small-scale distributed infrastructure like roof-top solar PV not only enables access to clean and modern energy (SDG7) but also enables the achievement of climate goals (SDG13) and maintains the strength of informal community life (Teferi submitted). Governance of these informal settlements is currently maintained by *Idir*, a community-led self-help system. The *Idir* are elected by the residents and provide support for people in need through a local fund based on a monthly contribution. Giving *Idir* more responsibility to manage community-based infrastructure through training and job creation can not only improve the quality of life meeting several SDGs, but also facilitate required emission reduction that will contribute to 1.5°C agenda.

[END CROSS-CHAPTER BOX 5.1]

5.6.4 Sustainable and Climate-resilient Development Pathways: Enabling Conditions and Lessons Learned

The broader empirical evidence, including the above case studies (Boxes 5.2 – 5.5), shows that few resilience pathways initiatives exemplify all characteristics of CRDPs as described in Section 5.6.2, due to a number of factors: (a) the complexity of the task; (b) the initial stages of the learning curve for many actors; (c) climate change in general and the 1.5°C target specifically being only one of several objectives to be achieved; (d) the lure of succumbing to normative pathways that fortify rather than rectify privileged positions; and (e) the temptation of shorter-term economic gains and power relations over longer-term and more far-reaching social and environmental justice solutions. Thus, they are works-in-progress that embody aspects of resilience pathways, to be read within the context of treating interlinked adaptation-mitigation-development initiatives as ongoing processes and not outcomes (O'Brien et al., 2015). There is limited but growing evidence on how to transform development and societies while simultaneously addressing the climate change challenge and enhancing well-being for all.

Emerging evidence suggests that far reaching transformation to address climate change challenges and enhance well-being is more likely to be regarded as legitimate by local populations when it pays attention to just outcomes for those negatively affected by change (Cervigni and Morris, 2016; Dilling et al., 2015; Keohane and Victor, 2016; Naess et al., 2015; Newell et al., 2014a; Sovacool et al., 2015). However, it should be noted that there is not consensus on the direction of social transformation to address climate change. Lessons learned from the empirical evidence and emerging literature suggest four wider enabling conditions may advance CRDPs, these are: inclusive governance, social learning; equity and justice, and monitoring and evaluation.

5.6.4.1 Inclusive Governance

Emerging literature since AR5 and empirical evidence highlight the importance of inclusive governance in achieving CRDPs. Robust institutions, cross-institutional partnerships, and multi-scale communication can also help facilitate the development of policy pathways for transformation in complex decision making contexts (Di Gregorio et al., 2017a; Duguma et al., 2014a; Somorin et al., 2015). The growing role of citizens, cities, businesses, labour movements, governments, non-governmental organizations and international agencies in promoting climate policy transformation has also led to more co-production of policy, and a need for governance approaches at national, regional and international levels that can

coordinate, and monitor multi-scale policy actions and trade-offs in the course of implementing national goals for 1.5°C (Ayers et al., 2014; Clark et al., 2016; Gwimbi, 2017; Hale, 2016; Hayward, 2017; Maor et al., 2017; Roger et al., 2017; von Stechow et al., 2016; Webber, 2016). Local governments also play a pivotal role in linking climate change policies to other multi-scalar developmental priorities (Rescalvo et al., 2013; Wamsler et al., 2014).

At the national level, progress in developing key capacities for resilience (Väänänen et al., 2017) as well as building transparency and accountability through support for and tracking of impacts of climate finance (Governance of Climate Change Finance Team (UNDP Bangkok Regional Hub) and Adelante, 2015; Terpstra et al., 2015) can contribute to the equity and effectiveness of sustainable development pathways toward a 1.5°C warmer world and CRDPs. Inadequate monitoring and regulatory measures though may hamper more fundamental transformations (Chandrashekeran et al., 2017; Cock, 2014). Inclusive decision making can reduce compliance costs over time and enhance the ease of implementation, even in the absence of consensus or where decisions are controversial (DeCaro et al., 2017; Maor et al., 2017). At the same time, deliberative governance models that allow space for transformational agency, creative friction, and agitative actors may harbor greater potential for overcoming inertia and engendering far-reaching change (Evans and Reid, 2014; Gillard et al., 2016; Westley et al., 2013).

Solution-driven approaches rather than top-down steering have shown to reduce inequalities, advance well-being and distributive justice, and foster transformative change across the17 SDGs, operationalized best at regional levels (Hajer et al., 2015). Approaches with such transformative potential are expected to be successful when they adhere to strong social and right-based policies, particularly those that expand rights, increase equality and reduce power asymmetries, integrate economic objectives into social and environmental norms, and foster genuine participatory decision making (UNRISD 2016:10). Examples include social policies that adhere to principles of social and solidarity economy (SSE) and promote cooperation, solidarity, democratic governance, collective action, active citizenship, and environmental stewardship (Agarwal, 2015; Bauhardt, 2014; Laville, 2015; McMurtry, 2013; Utting, 2015; Wallimann, 2014) (see also Box 5.4).

5.6.4.2 Social Learning

Evidence across scales, from strategic new alliances in green states to Transition Towns re-skilling (Boxes 5.2–5.4) underscore the vital role of social learning for climate resilient development, including efforts to stay within the 1.5°C target and beyond. Given uncertainties in the rate, timing and scale of impacts, potential consequences of higher rates of warming (overshoot), and multiple possible pathways as well as path dependencies, social, collective, and iterative learning can facilitate accelerated adaptive management of adaptation-mitigation-development processes, and foster deliberate processes that incorporate values, world views, and different types of knowledges in a more inclusive decision space (Cundill et al., 2014; Butler et al., 2016b; Fazey et al., 2016; Gillard et al., 2016; Gorddard et al., 2016b; Fook, 2017). Knowledge co-production in climate resilience planning and implementation processes is a recognised mechanism for social learning, important in blending indigenous, local and scientific knowledge to support climate resilient development processes; extended learning cycles and iterative planning are necessary to address hidden, systemic drivers of transformation and uneven power dynamics (Ensor and Harvey, 2015; Butler et al., 2016b; Ziervogel et al., 2016; Tschakert et al., 2016; Delgado-Serrano et al., 2017; Fook, 2017; Harvey et al., 2017; Turnheim et al., 2015; Bataille et al., 2016). The link between social learning and building adaptive capacity is recognised in the literature, and studies increasingly explore tools for, monitoring of and the impact of social learning in complex inter-linked challenges such as climate resilient development processes; accomplished facilitation and recognising social difference to prevent co-option by more powerful actors are central to a successful outcome (Ensor and Harvey, 2015). (Lotz-Sisitka et al., 2015) highlight the potential for social learning to enable a transgressive approach to prevent resilience of unsustainable systems that could be maladaptive; such an approach could be important in enabling transformative social change in a 1.5°C pathway. Climate-resilient planning aims to address vulnerability as a multiple interconnected issue, interacting with the lives of differently situated community members and reflecting their differing perceptions of risk and access to sustainable livelihoods and economic opportunities (Aipira et al., 2017; Ensor, 2016).

5.6.4.3 Equity, Rights, and Justice

Procedural and distributive justice, human agency, and rights, including rights to development, and what is fair and acceptable to the least privileged are core elements of CRDPs (Tanner et al., 2014; Agyeman et al., 2016; Fook, 2017; Schlosberg et al., 2017). Yet, the large majority of case studies reveal wider dynamics can exacerbate existing vulnerabilities and inequalities and further undermine the rights and voices of the disadvantaged, often when market-based or development approaches marginalise local experiences of human well-being and equity, poverty eradication, empowerment, and access to resources (Boxes 5.2–-5.4). Power, knowledge, authority, and subjectivities all determine which pathways become dominant and normative and which get side-lined (AMCOW et al., 2012; Wise et al., 2014; Ensor et al., 2015; O'Brien et al., 2015; Fazey et al., 2016; Pelling et al., 2016; Tschakert et al., 2016), as well as which actors determine the meaning of transformational change (Winkler and Dubash, 2016). Failure to attend to underlying or new inequalities during times of change can reinforce the status quo or create new injustices rather than encouraging far reaching and equitable transformational change (Buggy and McNamara, 2016; Cervigni and Morris, 2016). Procedural justice dimensions skewed toward exclusive participation and decision making reinforce structural institutional barriers constraining the achievement of CRDPs (Barrett, 2013; Reed et al., 2015; Shackleton et al., 2015a; Simonet and Jobbins, 2016; Bedelian and Ogutu, 2017).

5.6.4.4 Indicators, Monitoring, and Evaluation

Strengthening the evidence base and improving monitoring for sustainable development pathways to 1.5°C and CRDPs will allow for greater effectiveness through enhanced adaptive management and will promote procedural and distributive justice, including gender equity (Bryan et al., 2017; Fuller and Lain, 2017; Wood et al., 2017)While very limited literature currently exists on evaluating emerging CRDPs, important lessons can be gleaned from growing M&E of existing resilience, adaptation and development and triple-win programs (e.g.,Fuller and Lain, 2017; Mukute et al., 2017). Pertinent issues are what criteria are used, how they are identified, by whom, how, and over which time frames, particularly with the aims of inclusiveness, iterative learning, and empowerment (Atteridge and Remling, 2017; Fuller and Lain, 2017). Some positive examples include context-specific, participatory and locally developed criteria for assessing climate-resilient livelihoods (Fuller and Lain, 2017; IFAD, 2016), impact evaluation given that long-term results need to be assured (Lain, 2017), and frameworks for structured experimentation targeted at decision makers and practitioners (e.g., USAID 2014). Lessons underscore the crucial role of empowered local participation in the design, implementation and monitoring of programs and longer-term trajectories for social change; they also stress sufficient timeframes to allow for diverse alliances to emerge and detect steps in resilience building, critical social thresholds, and learning loops rather than a single focus on narrow carbon accounting (Burch et al. 2014; Mercy Corps 2015; O'Brien et al. 2015; Southern Voices on Adaptation 2016; Taylor Aiken 2016; Wegner 2016; Mukute et al. 2017). Additionally, monitoring and evaluation programmes need to incorporate composite measures and coupled, non-linear effects of response diversity and connectivity as key resilience factors shaping sustainable development pathways for 1.5°C and CRDPs (Sietz and Feola, 2016; Speranza et al., 2014), to enhance the capacity of a socio-ecological system to withstand disturbance or to transform and enter a new, more sustainable development trajectory.

For a full understanding of equity and effectiveness of resilience pathways initiatives, qualitative as well as quantitative indicators are required, such as those tracking social and institutional capability (Fuller and Lain, 2017; Lain, 2017)agency and capacity for learning and knowledge sharing and management (Mukute et al., 2017; Speranza et al., 2014), and experimentation and innovation (Lain, 2017; Speranza et al., 2014); effective feedback loops are necessary between bottom-up and top-down monitoring and reporting frameworks (Fisher and Karani, 2015; Mukute et al., 2017; Speranza et al., 2014). At the municipal level, early insights from Transition Towns recommend a small set of measurable indicators, for example percentage of food grown and consumed locally (Haxeltine and Seyfang, 2009) while more recent experiences raise concerns about coercive and counterproductive requirements from funding bodies to measure and count (e.g., carbon saved through low-carbon lifestyles) that undermine local resilience building, social learning, and diverse ways of knowing (Taylor Aiken, 2016). In Mozambique and Uganda, participatory development of national standard climate indicators that were context- and gender-sensitive led to transformation of governance systems (Mukute et al., 2017). Meta-analyses have indicated that most M&E frameworks for adaptation do not adequately track maladaptation potential (Atteridge and Remling,

2017); this is an important gap that emerging monitoring and evaluation processes for climate-resilient development pathways will need to fill.

5.7 Synthesis and Research Gaps

This section concludes Chapter 5 as well as the entire Special Report. It summarises what is known about the sub-regional impacts of a 1.5°C warmer world, the positive and negative implications and distributional impacts of adaptation and mitigation response options and pathways toward this future reality, and the synergies and trade-offs between sustainable development, adaptation, and mitigation. It discusses the enabling conditions and challenges arising from the interactions between these factors over time for re-orienting global society towards sustainable and climate-resilient development pathways. These pathways harbour the potential for limiting the rise in global temperatures to 1.5°C above pre-industrial levels while achieving sustainable development objectives, poverty eradication and reducing inequalities, in countries of all levels of development. This section closes the narrative arc introduced by Chapter 1. It ends with discussing major research gaps.

Moving towards sustainable and equitable futures in a 1.5°C warmer world is possible, and an ethical imperative given the consequences of failing to do so, particularly with respect to inequalities and social, cultural, and biophysical losses. The two objectives of limiting temperature increases and associated negative impacts, and achieving development and the SDGs, poverty eradication and reduction of inequalities worldwide are mutually reinforcing. Reducing climate impacts through ambitious mitigation and effective adaptation is a key condition for meeting sustainable development objectives, and sustainable development patterns are the key enablers for effective actions for limiting climate impacts. Yet, it is also challenging as these alternative pathways, grounded in fairness and justice and embedded in integrated adaptation and mitigation approaches, go hand in hand with conscious social transformations.

The findings underscore the numerous ethical dilemmas emerging from business-as-usual approaches and an entrenched binary logic that pits climate-first against development-first solutions. The transformations towards the dual goal of sustainable development and 1.5°C involve profound changes of development patterns at all scales, and require taking into account the specific circumstances of each context and the articulation over time between short-term actions and longer-term objectives. This chapter and the preceding chapters have assessed the challenges of implementing these transformations and enabling conditions. Climate-resilient development pathways, as partial and incomplete they may be to date, open up routes towards socially-desirable and co-constructed futures that are ethical, liveable, equitable, and justifiable to generations to come.Emerging literature on development pathways that are sustainable and climate-resilient suggests key ingredients that meet both development, equity, and well-being priorities as well as ambitious climate action. Case studies from the level of nation states to communities reveal opportunities and significant challenges to enable and sustain such pathways, particularly within the mandate of the 2030 Agenda to ‘leave no one behind’.

Knowledge on the linkages between a 1.5°C warmer world, including climatic impacts and those from response options, and future development pathways that address poverty eradication, equality, and distributive justice is growing. However, several gaps in the current literature have been identified:

- Limited evidence exists to date that explicitly examines or measures the implications of a 1.5°C warmer world (and overshoots) for sustainable development, poverty eradication, and reducing equalities, and the near-term goals of SDGs. So far, few projections exist that indicate how any degree of additional global warming will affect populations at the level of households, livelihoods, and communities, particularly those who are already disadvantaged. Equally little is known about how differentiated impacts will map onto future structural inequalities and poverty dynamics, in countries of all levels of development.
- The same research gaps exist for assessments of avoided impacts and development implications of 1.5°C versus 2°C and higher warming. Although proxies can be used to project differential impacts

(e.g., the updated Reasons for Concern), these estimates are unable to reveal the embodied and emplaced implications of a 1.5°C warmer world in the context of pervasive power differentials that perpetuate or even exacerbate inequalities that, in turn, shape vulnerabilities, especially among the most marginalised.

- Some progress has been made in locating synergies and trade-offs associated with individual climate response options (adaptation and mitigation) and their implications for the SDGs, and vice versa. Yet, these positive and negative impacts need to be coupled with policy-relevant assessments. More studies are needed to investigate and quantify the synergies and trade-offs for a 1.5°C warmer world, specific to regional, national and sub-national levels. Quantitative assessments of policy instruments to enhance synergies on mitigation options and sustainable development dimensions in a cost-effective manner can inform decision makers more concretely to take action. Only limited literature has considered the dynamics of clustered response options and their configurations in multiple, often competing pathways, and their implications for the dual objective imposed by the 1.5°C target. More literature is needed to treat SDGs in general and as a nexus and consider their implications for climate change adaptation (and mitigation). In addition, the global level conclusion that adaptation will be lower in a 1.5°C world because higher levels of mitigation will have been achieved has no supporting literature and comes as a deductive reasoning which is insufficient to understand the interplay with sustainable development.
- Limited literature exists that empirically investigates the effectiveness of integrated policy frameworks to deliver triple-win (adaptation-mitigation-sustainable development) outcomes, the dynamics that produce such outcomes at the scale of implementation, and the anticipated winners. These include the combined effects of response measures and structural development deficiencies, including persistent poverty, across regions and sectors and among different groups of people.
- The question of sustainable development and 1.5°C climate goal poses an issue of multi-scale articulation. The implementation challenges of sustainable development, adaptation and mitigation measures are often more precisely understood at the local scale but the 1.5°C goal and several key enabling conditions of change (e.g., finance, technology) require a global-scale perspective. These two scales of analyses are largely investigated in disconnected bodies of literature. More structured literature is needed, that investigate the specificities of each local, regional, national context, to be directly policy-relevant at these scales of decision, but that allows also to build a global trajectory emerging as a composite of these local visions.
- Emerging literature suggests key ingredients of climate-resilient development pathways that meet both development and justice priorities and stringent climate action. It remains unclear how governance structures enable or hinder different groups of people and countries at different levels of development, with different needs, rights, and capacities, to negotiate pathway options, values, and priorities. There is also a significant knowledge gap regarding possible benefits and negative side-effects from a range of pathway choices and path dependencies along the spectrum of socially desirable to technically and economically feasible. These gaps in knowledge constitute significant ethical and moral questions that climate science alone is ill equipped to solve. There is an urgent need for adequate and robust monitoring and indicators of success for such development pathways that take into consideration diverse types of knowledge and experiences regarding a range of enabling conditions and challenges (geophysical and environmental-ecological, technological and economic, and cultural, social and institutional), in a way that enables exchanges between the different research communities to overcome disciplinary fragmentation.
- More research is needed to adequately capture the value of iterative learning, resilience building, and deliberative decision-making in climate-resilient development pathways and possibilities for scaling-up emerging success stories, as well as stringent outcomes of zero-emission trajectories that are compatible with a commitment to sustainable development and poverty eradication in a fair and equitable 1.5°C warmer world.

Frequently Asked Questions

FAQ 5.1: What are the interactions between sustainable development and limiting global warming to 1.5°C?

Summary:
The UN Sustainable Development Goals (SDGs) aim to enhance global development in ways that meet the needs of the present without compromising the needs of future generations. Sustainable development is closely linked with climate change. Limiting the world to 1.5°C warming will have impacts on sustainable development and, similarly, pursuing sustainable development will influence emissions and impacts. Responses to climate change in the form of adaptation and mitigation will also interact with sustainable development. These impacts may work together and be positive, resulting in a synergy, or work against each other in a negative way, known as a trade-off. Maximising synergies and limiting trade-offs is the goal when planning future actions to reduce climate change and to pursue sustainable development.

For more than 25 years, the United Nations (UN) and other international organizations have embraced the concept of sustainable development, understood as the ambition to meet the needs of the present without compromising future generations. This concept spans economic, social and environmental objectives including poverty and hunger alleviation, equitable economic growth and access to resources, and the protection of water, air and ecosystems.

Recent decades have seen big improvements in sustainable development. There have been reductions in poverty, hunger and child mortality, as well as greater access to clean water and sanitation. But more is needed to achieve sustainable development for all. The UN Sustainable Development Goals (SDGs), endorsed in 2015 as part of the 2030 Agenda for Sustainable Development, apply to all countries and cover ambition in seventeen key areas(*refer to FAQ Figure*). These are: to eliminate extreme poverty and hunger; to ensure health, education, peace, safe water and clean energy for all; to promote inclusive and sustainable cities, consumption, infrastructure and economic growth; to reduce inequality, including gender inequality; to combat climate change, and to protect the oceans and terrestrial ecosystems.

[***Figure Suggestion:*** *The official UN figure of 17 Sustainable Development Goals (SDGs)*]

The link between climate change and sustainable development is complex. Previous IPCC reports have found that climate change undermines sustainable development, and that well-designed responses to climate change in the form of both adaptation and mitigation can promote more sustainable and equitable societies.

Limiting global warming to 1.5°C requires international, national, community and individual adaptation and mitigation actions that are not just limited to technology and infrastructure, but that also cover policy design, implementation and behavioural changes. Most actions in these areas will have some impacts on sustainable development. This can happen in a positive way where sustainable development is strengthened, known as a *synergy*, or in a negative way, where sustainable development is hindered or reversed, known as a *trade-off*.

For example, sustainable forestry management illustrates the synergies between climate change mitigation and sustainable development. Well-managed and protected forests can prevent emissions from deforestation as well as absorb carbon, reducing warming at reasonable cost. Sustainable forests can take into account the needs of local people, protect watersheds and enhance biodiversity. Achieving synergies requires coordination across sectors and nations, as well as collaboration at local to international scales.

Pursuing climate mitigation compatible with a 1.5°C warmer world, if poorly designed or implemented, can lead to negative trade-offs with some dimensions of sustainability. An example of such trade-offs are the negative impacts of changing how land is used from natural forests, indigenous ownership, or agriculture to plantations for bioenergy production. This can threaten food and water security, create conflict over land rights, cause biodiversity loss, and increase food prices. Another trade-off can occur for some countries and workers if a switch is made from fossil fuels to other energy sources without adequate planning for a transition. Many trade-offs can be minimised if effectively managed, however. For example, maximising the

efficiency of bioenergy crops to reduce land-use change, or providing retraining for employees of sectors in transition.

In general, progress made to reduce poverty and gender inequalities, and to enhance food, health and water security will likely help adaptation and reduce vulnerability to climate change. Similarly, the protection of oceans, marine and coastal ecosystems can reduce the impacts of climate change on these systems. The sustainable development goal of affordable and clean energy recognises the need for better access to electricity and the role of renewable energy, behavioural change, and energy efficiency in reducing the carbon intensity of energy and meeting ambitious climate goals. The Sustainable Development Goals for peace, justice, strong institutions and partnerships can all contribute to limiting warming to 1.5°C. These are all supported explicitly within SDG 13, which targets climate action consistent with the Paris Agreement.

Yet, there are some risks that making sustainable development the priority can undermine climate adaptation and mitigation goals if, for example, people escaping from poverty and hunger consume more energy or land, or goals for economic growth and industrialization drive increased fossil fuel consumption. The challenge is to implement sustainable development policies that improve well-being, reduce deprivation, poverty and ecosystem degradation at the same time as reducing emissions, limiting climate impacts and facilitating adaptation.

Good governance and strong partnerships when planning climate change adaptation and mitigation actions can help strengthen synergies and minimise trade-offs. While it is unlikely that all trade-offs can be avoided or minimised, corrective measures in the near term could at least help to create conditions that enable sustainable development in the long term.

FAQ 5.2: What are the pathways to achieving poverty reduction and reducing inequalities while reaching the 1.5°C world?

Alternative suggestion: What role do equity and justice play in pathways to limit warming to 1.5°C?

Summary:
Issues of equity, fairness and justice have long been central to climate change and sustainable development. Climate-related risks are unevenly distributed and the impacts of 1.5°C global warming will disproportionately affect disadvantaged populations. A number of pathways exist that could limit warming to 1.5°C at the same time as promoting sustainable development. These are where a mix of adaptation and mitigation measures are designed in a way that reduces emissions and enables adaptation while contributing to poverty eradication and reducing inequalities. Such transformative trajectories include 'Climate-Resilient Development Pathways' (CRDPs). They will differ across regions, and flexible governance will be needed to ensure they are inclusive, fair, and successful. While challenges would remain in some parts of the world, 1.5°C-compatible development pathways generate more benefits than those that reach 2°C warming or higher.

Equity, like equality, aims to promote justness and fairness for all. This is not necessarily the same as treating everyone equally, since not everyone comes from the same starting point. Often used interchangeably with fairness and justice, equity implies implementing different actions in different places all with a view to creating an equal world that is fair for all and where no one is left behind.

These concepts are, and have always been, strongly intertwined with climate change and sustainable development. The text of the Paris Agreement states that it "will be implemented to reflect equity… in the light of different national circumstances" and calls for "rapid reductions" of greenhouse gases to be achieved "on the basis of equity, and in the context of sustainable development and efforts to eradicate poverty". Similarly, the Sustainable Development Goals (SDGs) include goals to reduce poverty and inequalities and ensure equitable and affordable access to health, water and energy for all.

These principles are important for considering pathways that limit warming to 1.5°C in a way that is liveable

for every person and species. These pathways recognise the uneven development status between richer and poorer nations, the unevenly distributed impacts from climate change including impacts on future generations, and the uneven capacity of different nations and people to respond to climate risks. This is particularly true for those who are highly vulnerable to climate change people such as indigenous communities in the Arctic, people whose livelihoods depend on agriculture, coastal and marine ecosystems, and inhabitants of small-island developing states. The poorest people will experience a world that is 1.5°C warmer than pre-industrial levels mainly through higher food prices and hunger, but also through loss of income and livelihood opportunities, adverse health effects, and displacement.

Well-planned adaptation and mitigation measures are essential to avoid exacerbating inequalities or creating new injustices. Pathways exist that limit global warming to 1.5°C and incorporate mitigation and adaptation that reduces inequalities in terms of who benefits, who pays the costs, and who is affected by synergies and trade-offs. Attention to equity ensures that disadvantaged peoples can secure their livelihoods and live in dignity and that those who experience costs for mitigation or adaptation have financial and technical support to enable fair transitions.

*Climate-resilient development pathways (CRDPs)*illustrate ways of limiting warming to 1.5°C that incorporate efforts towards strengthening sustainable development and eradicating poverty. These trajectories simultaneously promote fair and equitable climate resilience and responses, by taking into account the following key aspects: the potential to limit warming to 1.5°C, the need to achieve global net zero emissions, the achievement of goals for sustainable development, the scale of societal transformation required, the need to build resilience and capacity to adapt, and attention to ethics, equity, and well-being. Additionally, they emphasise the potential for, and commitment to, reducing societal vulnerabilities, addressing inequalities, and alleviating poverty (*refer to FAQ Figure*).

*[**Figure Suggestion:** Schematic showing the key aspects and goals of climate-resilient development pathways – based on Figure 5.5 in the chapter]*

The characteristics of CRDPs will differ across communities and nations, and each will have different implications, distributional consequences, and criteria for success. Flexible governance can help support iterative and continuous learning that creates equitable and robust pathways toward socially- desirable, just, and low-carbon futures. There will still be significant challenges in some parts of the world where residual impacts will occur, but 1.5°C-compatible CRDPs generate more benefits than those that reach 2°C warming or higher temperatures.

There are few examples so far that meet all the criteria for sustainable and climate-resilient development pathways that reduce poverty and inequality, but there are good examples that illustrate the potential for implementing CRDPs. For instance, some countries have fostered clean energy and sustainable transportation while creating green jobs and supporting social welfare programs to reduce domestic poverty. Yet, persistent inequalities, committed paths to high-carbon energy infrastructure, and weak institutions can hamper progress toward climate resilience. Other examples include development paradigms inspired by community values, such as *Buen Vivir* and the Transition Movement. *Buen Vivir* is a Latin American concept based on indigenous ideas of communities living in harmony with nature, aligned with peace, diversity, solidarity, rights to education, health, and safe food, water, and energy, and well-being and justice for all. The Transition Movement, with origins in Europe, promotes equitable and resilient communities through low-carbon living, food self-sufficiency, and citizen science albeit achieving inclusive participation can remain a challenge.

References

Abel, G. J., Barakat, B., KC, S., and Lutz, W. (2016). Meeting the Sustainable Development Goals leads to lower world population growth. *Proceedings of the National Academy of Sciences* 113, 14294–14299. doi:10.1073/pnas.1611386113.

Adam, H. N. (2015). Mainstreaming adaptation in India - the Mahatma Gandhi National Rural Employment Guarantee Act and climate change. *Climate and Development* 7, 142–152. doi:10.1080/17565529.2014.934772.

ADB (2013). *Moving from risk to resilience: Sustainable urban development in the Pacific*. Mandaluyong City, Philippines: Asian Development Bank.

Addinsall, C., Weiler, B., Scherrer, P., and Glencross, K. (2017). Agroecological tourism: bridging conservation, food security and tourism goals to enhance smallholders' livelihoods on South Pentecost, Vanuatu. *Journal of Sustainable Tourism* 25, 1100–1116. doi:10.1080/09669582.2016.1254221.

Adelle, C., and Russel, D. (2013). Climate policy integration: a case of déjà vu? *Environmental Policy and Governance* 23, 1–12. doi:10.1002/eet.1601.

Adger, W. N. N., Pulhin, J. M. J. J. M., Barnett, J., Dabelko, G. D. G. D., Hovelsrud, G. K. G. K., Levy, M., et al. (2014). Human Security. Cambridge University Press doi:10.1017/CBO9781107415379.017.

Agard, J., Schipper, E. L. F., Birkmann, J., Campos, M., Dubeux, C., Nojiri, Y., et al. (2014). "Annex II: Glossary," in *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*, eds. C. B. Field, V. R. Barros, D. J. Dokken, K. J. Mach, M. D. Mastrandrea, T. E. Bilir, et al. (Cambridge, UK and New York, NY, USA: Cambridge University Press), 1757–1776.

Agarwal, B. (2014). Food sovereignty, food security and democratic choice: critical contradictions, difficult conciliations. *Journal of Peasant Studies* 41, 1247–1268. doi:10.1080/03066150.2013.876996.

Agarwal, B. (2015). The power of numbers in gender dynamics: illustrations from community forestry groups. *The Journal of Peasant Studies* 42, 1–20. doi:10.1080/03066150.2014.936007.

Aggarwal, P. (2017). 2°C target, India's climate action plan and urban transport sector. *Travel Behaviour and Society* 6, 110–116. doi:10.1016/j.tbs.2016.11.001.

Aggarwal, R. M. (2013). Strategic bundling of development policies with adaptation: an examination of Delhi's climate change action plan. *International Journal of Urban and Regional Research* 37, 1902–1915. doi:10.1111/1468-2427.12032.

Agoramoorthy, G., and Hsu, M. J. (2016). Small dams revive dry rivers and mitigate local climate change in India's drylands. *International Journal of Climate Change Strategies and Management* 8, 271–285. doi:10.1108/IJCCSM-12-2014-0141.

Agrawal, A. (2010). "Local institutions and Adaptation to Climate Change," in *Social Dimensions of Climate Change: Equity and Vulnerability in a Warming World*, eds. R. Mearns and N. Norton (Washington, DC, USA: The World Bank), 173–197.

Agyeman, J., Schlosberg, D., Craven, L., and Matthews, C. (2016). Trends and directions in environmental justice: from inequity to everyday life, community, and just sustainabilities. *Annual Review of Environment and Resources* 41, 321–340. doi:10.1146/annurev-environ-110615-090052.

Aha, B., and Ayitey, J. Z. (2017). Biofuels and the hazards of land grabbing: tenure (in)security and indigenous farmers' investment decisions in Ghana. *Land Use Policy* 60, 48–59. doi:10.1016/j.landusepol.2016.10.012.

Åhman, M., Nilsson, L. J., and Johansson, B. (2017). Global climate policy and deep decarbonization of energy-intensive industries. *Climate Policy* 17, 634–649. doi:10.1080/14693062.2016.1167009.

Aipira, C., Kidd, A., and Morioka, K. (2017). "Climate change adaptation in Pacific countries: fostering resilience through gender equality," in *Climate Change Adaptation in Pacific Countries: Fostering Resilience and Improving the Quality of Life*, ed. W. Leal Filho (Cham, Switzerland: Springer International Publishing AG), 225–239.

Aitsi-Selmi, A., and Murray, V. (2016). Protecting the Health and Well-being of Populations from Disasters: Health and Health Care in The Sendai Framework for Disaster Risk Reduction 2015-2030. *Prehospital and Disaster Medicine* 31, 74–78. doi:10.1017/S1049023X15005531.

Ajanovic, A. (2015). The future of electric vehicles: prospects and impediments. *Wiley Interdisciplinary Reviews: Energy and Environment* 4, 521–536. doi:10.1002/wene.160.

Akimoto, K., Sano, F., and Tehrani, B. S. (2016). The analyses on the economic costs for achieving the nationally determined contributions and the expected global emission pathways. *Evolutionary and Institutional Economics Review* 14, 193–206. doi:10.1007/s40844-016-0049-y.

Ala-Mantila, S., Ottelin, J., Heinonen, J., and Junnila, S. (2016). To each their own? The greenhouse gas impacts of intra-household sharing in different urban zones. *Journal of Cleaner Production* 135, 356–367. doi:10.1016/j.jclepro.2016.05.156.

Al Ansari, M. S. (2013). Climate change policies and the potential for energy efficiency in the Gulf Cooperation Council (GCC) Economy. *Environment and Natural Resources Research* 3, 106–117.

doi:10.5539/enrr.v3n4p106.
Alahakoon, S. (2017). Significance of energy storages in future power networks. *Energy Procedia* 110, 14–19. doi:10.1016/j.egypro.2017.03.098.
Ali, A., and Erenstein, O. (2017). Assessing farmer use of climate change adaptation practices and impacts on food security and poverty in Pakistan. *Climate Risk Management*. doi:10.1016/j.crm.2016.12.001.
Ali, S. M. H., Zuberi, M. J. S., Tariq, M. A., Baker, D., and Mohiuddin, A. (2015). A study to incorporate renewable energy technologies into the power portfolio of Karachi, Pakistan. *Renewable and Sustainable Energy Reviews* 47, 14–22. doi:10.1016/j.rser.2015.03.009.
Alonso-Fradejas, A., Borras, S. M., Holmes, T., Holt-Giménez, E., and Robbins, M. J. (2015). Food sovereignty: convergence and contradictions, conditions and challenges. *Third World Quarterly* 36, 431–448. doi:10.1080/01436597.2015.1023567.
Alstone, P., Gershenson, D., and Kammen, D. M. (2015). Decentralized energy systems for clean electricity access. *Nature Climate Change* 5, 305–314. doi:10.1038/NCLIMATE2512.
Altieri, K. E., Trollip, H., Caetano, T., Hughes, A., Merven, B., and Winkler, H. (2016). Achieving development and mitigation objectives through a decarbonization development pathway in South Africa. *Climate Policy* 16, S78–S91. doi:10.1080/14693062.2016.1150250.
Altieri, M. A., and Nicholls, C. I. (2017). The adaptation and mitigation potential of traditional agriculture in a changing climate. *Climatic Change* 140, 33–45. doi:10.1007/s10584-013-0909-y.
Amann, M., Bertok, I., Borken-Kleefeld, J., Cofala, J., Heyes, C., Höglund-Isaksson, L., et al. (2011). Cost-effective control of air quality and greenhouse gases in Europe: Modeling and policy applications. *Environmental Modelling & Software* 26, 1489–1501. doi:http://dx.doi.org/10.1016/j.envsoft.2011.07.012.
AMCOW, CDKN, and GWP (2012). Water security and climate resilient development: strategic framework.
Amin, S. (2006). The Millennium Development Goals: a critique from the South. *Monthly Review* 57, 1–15.
Anand, R. (2017). *International environmental justice: a North-South dimension*. London, UK: Routledge.
Anda, M., and Temmen, J. (2014). Smart metering for residential energy efficiency: the use of community based social marketing for behavioural change and smart grid introduction. *Renewable Energy* 67, 119–127. doi:10.1016/j.renene.2013.11.020.
Andonova, L. B., Hale, T. N., and Roger, C. B. (2017). National policy and transnational governance of climate change: substitutes or complements? *International Studies Quarterly* 61, 253–268. doi:10.1093/isq/sqx014.
Anenberg, S. C., Balakrishnan, K., Jetter, J., Masera, O., Mehta, S., Moss, J., et al. (2013). Cleaner cooking solutions to achieve health, climate, and economic cobenefits. *Environmental Science & Technology* 47, 3944–3952. doi:10.1021/es304942e.
Angelidou, M. (2017). The role of Smart City characteristics in the plans of fifteen cities. *Journal of Urban Technology* 24, 3–28. doi:10.1080/10630732.2017.1348880.
Ani, C. (2013). Managing Climate Change In Africa: Challenges To Traditional Knowledge Systems And Human Values. *Fourth World Journal* 12, 29–44.
Ansuategi, A., Greno, P., Houlden, V., Markandya, A., Onofri, L., Picot, H., et al. (2015). The impact of climate change on the achievement of the post-2015 sustainable development goals.
Antal, M., and Van Den Bergh, J. C. J. M. (2016). Green growth and climate change: conceptual and empirical considerations. *Climate Policy* 16, 165–177. doi:10.1080/14693062.2014.992003.
Antwi-Agyei, P., Dougill, A. J., and Stringer, L. C. (2015). Impacts of land tenure arrangements on the adaptive capacity of marginalized groups: The case of Ghana's Ejura Sekyedumase and Bongo districts. *Land Use Policy* 49, 203–212. doi:10.1016/j.landusepol.2015.08.007.
Antwi-Agyei, P., Dougill, A., and Stringer, L. (2017a). Assessing Coherence between Sector Policies and Climate Compatible Development: Opportunities for Triple Wins. *Sustainability* 9, 2130. doi:10.3390/su9112130.
Antwi-Agyei, P., Fraser, E. D. G., Dougill, A. J., Stringer, L. C., and Simelton, E. (2012). Mapping the vulnerability of crop production to drought in Ghana using rainfall, yield and socioeconomic data. *Applied Geography* 32, 324–334. doi:10.1016/j.apgeog.2011.06.010.
Antwi-Agyei, P., Quinn, C. H., Adiku, S. G. K., Codjoe, S. N. A., Dougill, A. J., Lamboll, R., et al. (2017b). Perceived stressors of climate vulnerability across scales in the Savannah zone of Ghana: a participatory approach. *Regional Environmental Change* 17, 213–227. doi:10.1007/s10113-016-0993-4.
Apeaning, R. W., and Thollander, P. (2013). Barriers to and driving forces for industrial energy efficiency improvements in African industries: a case study of Ghana's largest industrial area. *Journal of Cleaner Production* 53, 204–213. doi:10.1016/j.jclepro.2013.04.003.
Apgar, M. J., Allen, W., Moore, K., and Ataria, J. (2015). Understanding adaptation and transformation through indigenous practice: the case of the Guna of Panama. *Ecology and Society* 20.
Arbuthnott, K., Hajat, S., Heaviside, C., and Vardoulakis, S. (2016). Changes in population susceptibility to heat and cold over time: assessing adaptation to climate change. *Environmental Health* 15, S33. doi:10.1186/s12940-016-0102-7.
Archer, D., Almansi, F., DiGregorio, M., Roberts, D., Sharma, D., and Syam, D. (2014). Moving towards inclusive

urban adaptation: approaches to integrating community-based adaptation to climate change at city and national scale. *Climate and Development* 6, 345–356. doi:10.1080/17565529.2014.918868.
Archer, D., and Dodman, D. (2015). Making capacity building critical: power and justice in building urban climate resilience in Indonesia and Thailand. *Urban Climate* 14, 68–78. doi:10.1016/j.uclim.2015.06.007.
Armitage, D. R. (2015). "Social-ecological change in Canada's Arctic: coping, adapting, learning for an uncertain future," in *Climate Chnage and the Coast: Building Resilient Communities*, eds. B. Glavovic, M. Kelly, R. Kay, and A. Travers (Boca Raton, FL, USA: CRC Press), 103–124.
Arnell, N. W., Brown, S., Hinkel, J., Lincke, D., Lloyd-Highes, B., Lowe, J. A., et al. (2015). The global impacts of climate change under pathways that reach 2°, 3° and 4°C above pre-industrial levels.
Arriagada, R. A., Ferraro, P. J., Sills, E. O., Pattanayak, S. K., and Cordero-Sancho, S. (2012). Do payments for environmental services affect forest cover? A farm-level evaluation from Costa Rica. *Land Economics* 88, 382–399. doi:10.3368/le.88.2.382.
Arriagada, R. A., Sills, E. O., Ferraro, P. J., and Pattanayak, S. K. (2015). Do payments pay off? Evidence from participation in Costa Rica's PES program. *PLOS ONE* 10, 1–17. doi:10.1371/journal.pone.0131544.
Arthurson, K., and Baum, S. (2015). Making space for social inclusion in conceptualising climate change vulnerability. *Local Environment* 20, 1–17. doi:10.1080/13549839.2013.818951.
Arts, K. (2017). Inclusive sustainable development: a human rights perspective. *Current Opinion in Environmental Sustainability* 24, 58–62. doi:10.1016/j.cosust.2017.02.001.
Assefa, Z., and Newman, P. (2014). Older slums in Addis Ababa, Ethiopia: how do they work? in *UN-Habitat Conference: responsive urbanism in Informal Areas* (Cairo, Egypt).
Atalay, Y., Biermann, F., and Kalfagianni, A. (2016). Adoption of renewable energy technologies in oil-rich countries: explaining policy variation in the Gulf Cooperation Council states. *Renewable Energy* 85, 206–214. doi:10.1016/j.renene.2015.06.045.
Ataur Rahman, M., and Rahman, S. (2015). Natural and traditional defense mechanisms to reduce climate risks in coastal zones of Bangladesh. *Weather and Climate Extremes* 7, 84–95. doi:10.1016/j.wace.2014.12.004.
Atteridge, A., and Remling, E. (2017). Is adaptation reducing vulnerability or redistributing it? *Wiley Interdisciplinary Reviews: Climate Change*, e500. doi:10.1002/wcc.500.
Atwood, T. B., Connolly, R. M., Ritchie, E. G., and Lovelock, C. E. (2015). Predators help protect carbon stocks in blue carbon ecosystems. *Nature Climate Change* 5, 1038–1045.
Avelino, F., Grin, J., Pel, B., and Jhagroe, S. (2016). The politics of sustainability transitions. *Journal of Environmental Policy & Planning* 7200, 1–9. doi:10.1080/1523908X.2016.1216782.
Aydin, E., Kok, N., and Brounen, D. (2015). Energy Effciency and Household Behavior: The Rebound Effect in the Residential Sector. *JEL Codes: D12, Q51, R21* 48, 749–782.
Ayers, J. M., Huq, S., Wright, H., Faisal, A. M., and Hussain, S. T. (2014). Mainstreaming climate change adaptation into development in Bangladesh. *Climate and Development* 6, 293–305. doi:10.1002/wcc.226.
Babiker, M. (2010). The potentials for energy savings in the GCC economies. *Journal of Development and Economic Policies* 12, 31–58.
Babiker, M., and Fehaid, M. (2011). Climate change policy in the MENA region: prospects, challenges, and the implication of market instruments. Cairo, Egypt.
Babiker, M. H. (2016). Options for climate change policy in MENA countries after Paris. Giza, Egypt.
Bäckstrand, K., and Kronsell, A. (2015). *Rethinking the Green State: Environmental Governance Towards Climate and Sustainability Transitions*. , eds. K. Bäckstrand and A. Kronsell Abingdon, UK and New York, NY, USA: Routledge.
Bado, B. V., Savadogo, P., and Manzo, M. L. S. (2016). Restoration of Degraded Lands in West Africa Sahel: Review of experiences in Burkina Faso and Niger.
Baer, P., Fieldman, G., Athanasiou, T., and Kartha, S. (2008). Greenhouse Development Rights: towards an equitable framework for global climate policy. *Cambridge Review of International Affairs* 21, 649–669. doi:10.1080/09557570802453050.
Bai, X., van der Leeuw, S., O'Brien, K., Berkhout, F., Biermann, F., Brondizio, E. S., et al. (2016). Plausible and desirable futures in the Anthropocene: A new research agenda. *Global Environmental Change* 39, 351–362. doi:10.1016/j.gloenvcha.2015.09.017.
Bain, P., and et al. (2016). Co-benefits of addressing climate change can motivate action around the world. *Nature Climate Change* 6, 154–157. doi:10.1038/NCLIMATE2814.
Bajželj, B., Richards, K. S., Allwood, J. M., Smith, P., Dennis, J. S., Curmi, E., et al. (2014). Importance of food-demand management for climate mitigation. *Nature Climate Change* 4, 924–929.
Bak, C., Bhattacharyya, A., Edenhofer, O., and Knopf, B. (2017). Toward a comprehensive approach to climate policy, sustainable infrastructure and finance.
Baldacchino, G. (2017). Seizing history: development and non-climate change in Small Island Developing States. *International Journal of Climate Change Strategies and Management*, IJCCSM-02-2017-0037. doi:10.1108/IJCCSM-02-2017-0037.

Barnes, P. (2015). The political economy of localization in the transition movement. *Community Development Journal* 50, 312–326. doi:10.1093/cdj/bsu042.
Barnett, J., Graham, S., Mortreux, C., Fincher, R., Waters, E., and Hurlimann, A. (2014). A local coastal adaptation pathway. *Nature Climate Change* 4, 1103–1108. doi:10.1038/nclimate2383.
Barnett, J., Tschakert, P., Head, L., and Adger, W. N. (2016a). A science of loss. *Nature Climate Change* 6, 976–978.
Barnett, J., Tschakert, P., Head, L., and Adger, W. N. (2016b). A science of loss. *Nature Climate Change* 6, 976–978. doi:10.1038/nclimate3140.
Barnett, J., and Walters, E. (2016). "Rethinking the vulnerability of small island states: Climate change and development in the Pacific Islands Research Book Chapters," in *The Palgrave Handbook of International Development* doi:10.1057/978-1-137-42724-3_40.
Barrett, S. (2013). Local level climate justice? Adaptation finance and vulnerability reduction. *Global Environmental Change* 23, 1819–1829. doi:10.1016/j.gloenvcha.2013.07.015.
Barrington-Leigh, C. (2016). Sustainability and Well-Being: A Happy Synergy. *Development* 59, 292–298. doi:10.1057/s41301-017-0113-x.
Barroso, Â., Chaves, C., Martins, F. V., and Branco, M. C. (2016). On the possibility of sustainable development with less economic growth: a research note. *Environment, Development and Sustainability* 18, 1399–1414. doi:10.1007/s10668-016-9802-y.
Bartley, T. (2010). Transnational Private Regulation in Practice: The Limits of Forest and Labor Standards Certification in Indonesia. *Business and Politics* 12, 1–34. doi:10.2202/1469-3569.1321.
Bartocci, A., and Pisani, M. (2013). "Green" fuel tax on private transportation services and subsidies to electric energy: a model-based assessment for the main European countries. *Energy Economics* 40, S32–S57. doi:10.1016/j.eneco.2013.09.019.
Bataille, C., Waisman, H., Colombier, M., Segafredo, L., Williams, J., and Jotzo, F. (2016). The need for national deep decarbonization pathways for effective climate policy. *Climate Policy* 16, 7–26. doi:10.1080/14693062.2016.1173005.
Bauer, N., Calvin, K., Emmerling, J., Fricko, O., Fujimori, S., Hilaire, J., et al. (2017). Shared Socio-Economic Pathways of the energy sector – quantifying the narratives. *Global Environmental Change* 42, 316–330. doi:10.1016/j.gloenvcha.2016.07.006.
Bauhardt, C. (2014). Solutions to the crisis? The Green New Deal, degrowth, and the solidarity economy: alternatives to the capitalist growth economy from an ecofeminist economics perspective. *Ecological Economics* 102, 60–68.
Bayram, H., and Öztürk, A. B. (2014). "Global climate change, desertification, and its consqeuencs in Turkey and the Middle East," in *Global climate change and public health*, eds. K. . Pinkerton and W. . Rom (New York, NY, USA: Springer), 293–305. doi:10.1007/978-1-4614-8417-2_17.
Bebbington, J., and Larrinaga, C. (2014). Accounting and sustainable development: an exploration. *Accounting, Organizations and Society* 39, 395–413. doi:10.1016/j.aos.2014.01.003.
Beck, S., and Mahony, M. (2017). The IPCC and the politics of anticipation. *Nature Climate Change* 7, 311–313. doi:10.1038/nclimate3264.
Bedelian, C., and Ogutu, J. O. (2017). Trade-offs for climate-resilient pastoral livelihoods in wildlife conservancies in the Mara ecosystem, Kenya. *Pastoralism: Research, Policy and Practice* 7, 125017. doi:10.1186/s13570-017-0085-1.
Bell, J., Taylor, M., Amos, M., and N, A. (2016). Climate change and Pacific Island food systems. Cophenhagen, Denmark and Wageningen, the Netherlands.
Bell, K. (2015). Can the capitalist economic system deliver environmental justice? *Environmental Research Letters* 10. doi:10.1088/1748-9326/10/12/125017.
Bell, K. (2016). Green economy or living well? Assessing divergent paradigms for equitable eco-social transition in South Korea and Bolivia. *Journal of Political Ecology* 23.
Bellarby, J., Tirado, R., Leip, A., Weiss, F., Lesschen, J. P., and Smith, P. (2013). Livestock greenhouse gas emissions and mitigation potential in Europe. *Glob Chang Biol* 19, 3–18. doi:10.1111/j.1365-2486.2012.02786.x.
Bennetzen, E. H., Smith, P., and Porter, J. R. (2016). Decoupling of greenhouse gas emissions from global agricultural production: 1970-2050. *Glob Chang Biol* 22, 763–781. doi:10.1111/gcb.13120.
Berger, M., Pfister, S., Bach, V., and Finkbeiner, M. (2015). Saving the planet's climate or water resources? The trade-off between carbon and water footprints of European biofuels. *Sustainability (Switzerland)* 7, 6665–6683. doi:10.3390/su7066665.
Berner, J., Brubaker, M., Revitch, B., Kreummel, E., Tcheripanoff, M., and Bell, J. (2016). Adaptation in Arctic circumpolar communities: food and water security in a changing climate. *International Journal of Circumpolar Health* 3982, 1–8. doi:10.3402/ijch.v75.33820.
Berrueta, V. M., Serrano-Medrano, M., Garcia-Bustamante, C., Astier, M., and Masera, O. R. (2017). Promoting sustainable local development of rural communities and mitigating climate change: the case of Mexico's Patsari improved cookstove project. *Climatic Change* 140, 63–77. doi:10.1007/s10584-015-1523-y.
Bertram, C., Luderer, G., Popp, A., Minx, J. C., Lamb, W., Stevanovic, M., et al. Targeted policies can compensate

most of the increased mitigation risks in 1.5°C scenarios.
Betsill, M., Dubash, N. K., Paterson, M., van Asselt, H., Vihma, A., and Winkler, H. (2015). Building productive links between the UNFCCC and the broader global climate governance landscape. *Global Environmental Politics* 15, 1–10.
Betzold, C., and Weiler, F. (2017). Allocation of aid for adaptation to climate change: do vulnerable countries receive more support? *International Environmental Agreements: Politics, Law and Economics* 17, 17–36.
Bexell, M., and Jönsson, K. (2017). Responsibility and the United Nations' Sustainable Development Goals. *Forum for Development Studies* 44, 13–29. doi:10.1080/08039410.2016.1252424.
Bhaduri, A., Bogardi, J., Siddiqi, A., Voigt, H., Vörösmarty, C., Pahl-Wostl, C., et al. (2016). Achieving Sustainable Development Goals from a water perspective. *Frontiers in Environmental Science* 4. doi:10.3389/fenvs.2016.00064.
Bhaskar, R., Frank, C., Hoyer, K. G., Naess, P., and Parker, J. (2010). *Interdisciplinarity and climate change: transforming knowledge and practice for our global future*. Abingdon, UK and New York, NY, USA: Routledge.
Bhattacharyya, A., Meltzer, J. P., Oppenheim, J., Qureshi, Z., and Stern, N. (2016). Delivering on better infrastructure for better development and better climate.
Bhattarai, B., Beilin, R., and Ford, R. (2015). Gender, agrobiodiversity, and climate change: a study of adaptation practices in the Nepal Himalayas. *World Development* 70, 122–132. doi:10.1016/j.worlddev.2015.01.003.
Bickersteth, S., Dupar, M., Espinosa, C., Huhtala, A., Maxwell, S., and Pacha, M. J. (2017). Mainstreaming climate compatible development INSIGHTS FROM CDKN'S FIRST SEVEN YEARS. London .
Bielecki, C., and Wingenbach, G. (2014). Rethinking improved cookstove diffusion programs : A case study of social perceptions and cooking choices in rural ... *Energy Policy* 66, 350–358. doi:10.1016/j.enpol.2013.10.082.
Binam, J. N., Place, F., Djalal, A. A., and Kalinganire, A. (2017). Effects of local institutions on the adoption of agroforestry innovations: evidence of farmer managed natural regeneration and its implications for rural livelihoods in the Sahel. *Agricultural and Food Economics* 5, 2. doi:10.1186/s40100-017-0072-2.
Birkmann, J., Welle, T., Solecki, W., Lwasa, S., and Garschagen, M. (2016). Boost resilience of small and mid-sized cities. *Nature* 537, 605–608. doi:10.1038/537605a.
Blanco, V., Brown, C., Holzhauer, S., Vulturius, G., and Rounsevell, M. D. A. (2017). The importance of socio-ecological system dynamics in understanding adaptation to global change in the forestry sector. *Journal of Environmental Management* 196, 36–47. doi:10.1016/j.jenvman.2017.02.066.
Blau, J. (2017). *The Context of Paris: The MDGs and the SDGs. In: The Paris Agreement.* Palgrave Macmillan, Cham doi:https://doi.org/10.1007/978-3-319-53541-8_8.
Boas, I., Biermann, F., and Kanie, N. (2016). Cross-sectoral strategies in global sustainability governance: towards a nexus approach. *International Environmental Agreements: Politics, Law and Economics* 16, 449–464. doi:10.1007/s10784-016-9321-1.
Bodnar, P., Edwards, R., Hoch, S., McGlynn, E., Ott, C., and Wagner, G. Underwriting 1.5C: competitive approaches to financing accerlerated climate change mitigation (In Press). *Climate Policy*.
Bollen, J., van der Zwaan, B., Brink, C., and Eerens, H. (2009). Local air pollution and global climate change: A combined cost-benefit analysis. *Resource and Energy Economics* 31, 161–181. doi:10.1016/j.reseneeco.2009.03.001.
Bonan, J., Pareglio, S., and Tavoni, M. (2014). Access to Modern Energy: A Review of Impact Evaluations. Milan, Italy.
Bonsch, M., Humpenöder, F., Popp, A., Bodirsky, B., Dietrich, J. P., Rolinski, S., et al. (2016). Trade-offs between land and water requirements for large-scale bioenergy production. *GCB Bioenergy* 8, 11–24.
Boonstra, W. J., Björkvik, E., Haider, L. J., and Masterson, V. (2016). Human responses to social-ecological traps. *Sustainability Science* 11, 877–889. doi:10.1007/s11625-016-0397-x.
Börner, J., Baylis, K., Corbera, E., Ezzine-de-Blas, D., Ferraro, P. J., Honey-Rosés, J., et al. (2016). Emerging evidence on the effectiveness of tropical forest conservation. *PLOS ONE* 11, 1–11. doi:10.1371/journal.pone.0159152.
Bos, K., and Gupta, J. (2017). Climate change: the risks of stranded fossil fuel assets and resources to the developing world. *Third World Quarterly* 6597, 1–18. doi:10.1080/01436597.2017.1387477.
Bosomworth, K., Leith, P., Harwood, A., and Wallis, P. J. (2017). What's the problem in adaptation pathways planning? The potential of a diagnostic problem-structuring approach. *Environmental Science and Policy* 76, 23–28. doi:10.1016/j.envsci.2017.06.007.
Boucher, O., Bellassen, V., Benveniste, H., Ciais, P., Criqui, P., Guivarch, C., et al. (2016). Opinion: in the wake of Paris Agreement, scientists must embrace new directions for climate change research. *Proceedings of the National Academy of Sciences* 113, 7287–7290. doi:10.1073/pnas.1607739113.
Bouteligier, S. (2012). *Cities, networks, and global environmental governance: Spaces of innovation, places of leadership*. New York and London: Routledge.
Bouteligier, S. (2015). "Multinational companies and urban climate governance: Market making or successful policy innovation?," in *The urban climate change: Rethinking the role of cities in the global climate regime*, eds. C. Johnson, N. Toly, and H. Schroeder (New York and London: Routledge), 82–100.

Bowen, A., Cochrane, S., Fankhauser, S., and Fankhauser, S. (2012). Climate change, adaptation and economic growth. *Climatic Change* 113, 95–106. doi:10.1007/s10584-011-0346-8.

Bowyer, P., Schaller, M., Bender, S., and Jacob, D. (2015). "Adaptation as climate risk management: methods and approaches," in *Handbook of Climate Change Adaptation*, ed. L. Filho (Berlin and Heidelberg, Germany: Springer), 71–92.

Boyd, E., James, R. A., Jones, R. G., Young, H. R., and Otto, F. E. L. (2017). A typology of loss and damage perspectives. *Nature Climate Change* 7, 723–729. doi:10.1038/nclimate3389.

Boyle, J., Harris, M., Bizikova, L., Parry, J., Hammill, A., and Dion, J. (2013). Exploring trends in low-carbon, climate-resilient development. Manitoba.

Branca, G., McCarthy, N., Lipper, L., and Jolejole, M. C. (2011). *Climate-smart agriculture: a synthesis of empirical evidence of food security and mitigation benefits from improved cropland management*. Rome, Italy: Food and Agriculture Organization of the United Nations (FAO).

Bren d'Amour, C., Reitsma, F., Baiocchi, G., Barthel, S., Güneralp, B., Erb, K.-H., et al. (2016). Future urban land expansion and implications for global croplands. *Proceedings of the National Academy of Sciences* 114, 201606036. doi:10.1073/pnas.1606036114.

Brink, E., Aalders, T., Adam, D., Feller, R., Henselek, Y., Hoffmann, A., et al. (2016). Cascades of green: A review of ecosystem-based adaptation in urban areas. *Global Environmental Change* 36, 111–123. doi:10.1016/j.gloenvcha.2015.11.003.

Brockington, D., and Ponte, S. (2015). The Green Economy in the global South: experiences, redistributions and resistance. *Third World Quarterly* 36, 2197–2206. doi:10.1080/01436597.2015.1086639.

Brown, D., and McGranahan, G. (2016). The urban informal economy, local inclusion and achieving a global green transformation. *Habitat International* 53, 97–105.

Brown, E., Cloke, J., Gent, D., Johnson, P. H., and Hill, C. (2014). Green growth or ecological commodification: debating the green economy in the global south. *Geografiska Annaler, Series B: Human Geography* 96, 245–259. doi:10.1111/geob.12049.

Brown, H. C. P. (2011). Gender, climate change and REDD+ in the Congo Basin forests of Central Africa. *International Forestry Review* 13, 163–176. doi:10.1505/146554811797406651.

Bryan, E., Bernier, Q., Espinal, M., and Ringler, C. (2017). Making climate change adaptation programmes in sub-Saharan Africa more gender responsive: insights from implementing organizations on the barriers and opportunities. *Climate and Development* 0, 1–15. doi:10.1080/17565529.2017.1301870.

Bryan, E., Ringler, C., Okoba, B., Koo, J., Herrero, M., Silvestri, S., et al. (2013). Can agriculture support climate change adaptation, greenhouse gas mitigation and rural livelihoods? Insights from Kenya. *Climatic Change* 118, 151–165. doi:10.1007/s10584-012-0640-0.

Buch-Hansen, H. (2018). The Prerequisites for a Degrowth Paradigm Shift: Insights from Critical Political Economy. *Ecological Economics* 146, 157–163. doi:10.1016/j.ecolecon.2017.10.021.

Buggy, L., and McNamara, K. E. (2016). The need to reinterpret "community" for climate change adaptation: a case study of Pele Island, Vanuatu. *Climate and Development* 8, 270–280. doi:10.1080/17565529.2015.1041445.

Bulkeley, H., Andonova, L. B., Betsill, M. M., Compagnon, D., Hale, T., Hoffmann, M. J., et al. (2014a). *Transnational climate change governance*. Cambridge: Cambridge University Press.

Bulkeley, H., Carmin, J. A., Castán Broto, V., Edwards, G. A. S., and Fuller, S. (2013). Climate justice and global cities: mapping the emerging discourses. *Global Environmental Change* 23, 914–925. doi:10.1016/j.gloenvcha.2013.05.010.

Bulkeley, H., Edwards, G. A. S., and Fuller, S. (2014b). Contesting climate justice in the city: examining politics and practice in urban climate change experiments. *Global Environmental Change* 25, 31–40. doi:10.1016/j.gloenvcha.2014.01.009.

Burch, S., Shaw, A., Dale, A., and Robinson, J. (2014). Triggering transformative change: a development path approach to climate change response in communities. *Climate Policy* 14, 467–487. doi:10.1080/14693062.2014.876342.

Burke, M., Hsiang, S. M., and Miguel, E. (2015). Global non-linear effect of temperature on economic production. *Nature* 527, 235–239. doi:10.1038/nature15725.

Burlig, F., and Preonas, L. (2016). Out of the darkness and into the light? Development effects of rural electrification. Berkeley, CA, USA.

Burns, W., and Nicholson, S. (2017). Bioenergy and carbon capture with storage (BECCS): the prospects and challenges of an emerging climate policy response. *Journal of Environmental Studies and Sciences* 7, 527–534. doi:10.1007/s13412-017-0445-6.

Bustamante, M., Robledo-Abad, C., Harper, R., Mbow, C., Ravindranath, N. H., Sperling, F., et al. (2014). Co-benefits, trade-offs, barriers and policies for greenhouse gas mitigation in the agriculture, forestry and other land use (AFOLU) sector. *Global Change Biology* 20, 3270–3290. doi:10.1111/gcb.12591.

Butler, C., Parkhill, K. A., and Pidgeon, N. F. (2016a). Energy consumption and everyday life: choice, values and agency through a practice theoretical lens. *Journal of Consumer Culture* 16, 887–907. doi:10.1177/1469540514553691.

Butler, J. R. A., Bohensky, E. L., Suadnya, W., Yanuartati, Y., Handayani, T., Habibi, P., et al. (2016b). Scenario planning to leap-frog the Sustainable Development Goals: an adaptation pathways approach. *Climate Risk Management* 12, 83–99. doi:10.1016/j.crm.2015.11.003.

Butt, N., Possingham, H. P., De Los Rios, C., Maggini, R., Fuller, R. A., Maxwell, S. L., et al. (2016). Challenges in assessing the vulnerability of species to climate change to inform conservation actions. *Biological Conservation* 199, 10–15. doi:10.1016/j.biocon.2016.04.020.

Byers, E. A., Hall, J. W., and Amezaga, J. M. (2014). Electricity generation and cooling water use: UK pathways to 2050. *Global Environmental Change* 25, 16–30. doi:10.1016/j.gloenvcha.2014.01.005.

Byers, E., Gidden, M., Burek, P., Ebi, K., Greve, P., Havlik, P., et al. Global exposure and vulnerability to multi-sector climate change hotspots. *Environmental Research Letters* submitted.

Byers, E., Gidden, M., Burek, P., Ebi, K., Greve, P., Havlik, P., et al. Global exposure and vulnerability to multi-sector climate change hotspots.

Byrne, J., Ambrey, C., Portanger, C., Lo, A., Matthews, T., Baker, D., et al. (2016). Could urban greening mitigate suburban thermal inequity?: the role of residents' dispositions and household practices. *Environmental Research Letters* 11, 95014. doi:10.1088/1748-9326/11/9/095014.

Byrnes, W. M. (2014). Climate justice, Hurricane Katrina, and African American environmentalism. *Journal of African American Studies* 18, 305–314. doi:10.1007/s12111-013-9270-5.

Cabezon, E. ; L. H. ; P. T. ; K. W. ; Y. W. (2015). Enhancing Macroeconomic Resilience to Natural Disasters and Climate Change in the Small States of the Pacific. doi:9781513525792/1018-5941.

CAF Corporacion Andina de Fomento (2017). Crecimiento Urbano y accesso a Oportunidades: un desafio para America Latina (Urban Growth and Access to Opportunities Challenges for Latin America). Bogotá, Colombia.

Caldecott, B., Sartor, O., and Spencer, T. (2017). Lessons from previous "COAL TRANSITIONS" HIGH-LEVEL SUMMARY FOR DECISION-MAKERS HIGH-LEVEL SUMMARY FOR DECISION-MAKERS.

Calisto Friant, M., and Langmore, J. (2015). The buen vivir: a policy to survive the Anthropocene? *Global Policy* 6, 64–71. doi:0.1111/1758-5899.12187.

Callen, T., Cherif, R., Hasanov, F., Hegazy, A., and Khandelwal, P. (2014). Economic diversification in the GCC: past, present, and future.

Calvet-Mir, L., Corbera, E., Martin, A., Fisher, J., and Gross-Camp, N. (2015). Payments for ecosystem services in the tropics: a closer look at effectiveness and equity. *Current Opinion in Environmental Sustainability* 14, 150–162. doi:10.1016/j.cosust.2015.06.001.

Cameron, C., Pachauri, S., Rao, N. D., McCollum, D., Rogelj, J., and Riahi, K. (2016). Policy trade-offs between climate mitigation and clean cook-stove access in South Asia. *Nature Energy* 1, 1–5. doi:10.1038/nenergy.2015.10.

Cameron, R. W. F., Taylor, J., and Emmett, M. (2015). A Hedera green facade - energy performance and saving under different maritime-temperate, winter weather conditions. *Building and Environment* 92, 111–121. doi:10.1016/j.buildenv.2015.04.011.

Campbell, B. M., Vermeulen, S. J., Aggarwal, P. K., Corner-Dolloff, C., Girvetz, E., Loboguerrero, A. M., et al. (2016). Reducing risks to food security from climate change. *Global Food Security* 11, 34–43. doi:10.1016/j.gfs.2016.06.002.

Câmpeanu, C. N., and Fazey, I. (2014). Adaptation and pathways of change and response: a case study from Eastern Europe. *Global Environmental Change* 28, 351–367. doi:10.1016/j.gloenvcha.2014.04.010.

Caney, S. (2009). Justice and the distribution of greenhouse gas emissions. *Journal of Global Ethics* 5, 125–146. doi:10.1080/17449620903110300.

Caney, S. (2012). Just emissions. *Philosophy and Public Affairs* 40, 255–300. doi:10.1111/papa.12005.

Caney, S. (2014). Two kinds of climate justice: avoiding harm and sharing burdens. *Journal of Political Philosophy* 22, 125–149. doi:10.1111/jopp.12030.

Caney, S. (2016a). Climate change, equity, and stranded assets.

Caney, S. (2016b). The struggle for climate justice in a non-ideal world. *Midwest Studies In Philosophy* 40, 9–26. doi:10.1111/misp.12044.

Carr, E. R., and Onzere, S. N. (2016). Really effective (for 15% of the men): lessons in understanding and addressing user needs in climate services from Mali. *Climate Risk Management*. doi:10.1016/j.crm.2017.03.002.

Carr, E. R., and Owusu-Daaku, K. N. (2015). The shifting epistemologies of vulnerability in climate services for development: The case of Mali's agrometeorological advisory programme. *Area*, 7–17. doi:10.1111/area.12179.

Carr, E. R., and Thompson, M. C. (2014). Gender and climate change adaptation in agrarian settings. *Geography Compass* 8/3, 182–197. doi:10.1111/gec3.12121.

Carreón, J. R., and Worrell, E. (2017). Urban energy systems within the transition to sustainable development. A research agenda for urban metabolism. *Resources, Conservation and Recycling*, 0–1. doi:10.1016/j.resconrec.2017.08.004.

Carter, M. R., Cheng, L., and Sarris, A. (2016). Where and how index insurance can boost the adoption of improved agricultural technologies. *Journal of Development Economics* 118, 59–71. doi:10.1016/j.jdeveco.2015.08.008.

Casado-Asensio, J., and Steurer, R. (2014). Integrated strategies on sustainable development, climate change mitigation and adaptation in Western Europe: communication rather than coordination. *Journal of Public Policy* 343, 437–473. doi:10.1017/S0143814X13000287.

Casillas, C. E., and Kammen, D. M. (2010). The Energy-Poverty-Climate Nexus. *Science* 330, 1181–1182. doi:10.1126/science.1197412.

Casillas, C. E., and Kammen, D. M. (2012). Quantifying the social equity of carbon mitigation strategies. *Climate Policy* 12, 690–703. doi:10.1080/14693062.2012.669097.

Castellanos-Navarrete, A., and Jansen, K. (2015). Oil palm expansion without enclosure: smallholders and environmental narratives. *The Journal of Peasant Studies* 42, 791–816. doi:10.1080/03066150.2015.1016920.

Castro, P. (2016). Common but differentiated responsibilities beyond the nation state: how is differential treatment addressed in transnational Climate governance initiatives? *Transnational Environmental Law* 5, 379–400. doi:10.1017/S2047102516000224.

Cavanagh, C., and Benjaminsen, T. A. (2014). Virtual nature, violent accumulation: The "spectacular failure" of carbon offsetting at a Ugandan National Park. *Geoforum* 56, 55–65. doi:10.1016/j.geoforum.2014.06.013.

CD-LINKS (2017). Modelling Protocol for Global low-carbon development pathways of Work Package 3 of CD-LINKS. *CD-LINKS Report*, 22.

CERC (2017). Climate Equity Reference Calculator.

Cervigni, R., and Morris, M. (2016). *Confronting drought in Africa's drylands: opportunities for enhancing resilience*. , eds. R. Cervigni and M. Morris Washington DC, USA: World Bank.

Chakrabarti, S., and Shin, E. J. (2017). Automobile dependence and physical inactivity: insights from the California Household Travel Survey. *Journal of Transport and Health* 6, 262–271. doi:10.1016/j.jth.2017.05.002.

Chakravarty, D., Dasgupta, S., and Roy, J. (2013). Rebound effect: how much to worry? *Current Opinion in Environmental Sustainability* 5, 216–228. doi:10.1016/j.cosust.2013.03.001.

Chakravarty, D., and Roy, J. (2016). "The Global South: new estimates and insights from urban India," in *Rethinking climate and energy policies: new perspectives on the rebound phenomenon*, eds. T. Santarius, H. J. Walnum, and A. Carlo (Springer), 55–72.

Chakravarty, D., and Tavoni, M. (2013). Energy poverty alleviation and climate change mitigation: Is there a trade off? *Energy Economics* 40, S67–S73.

Chambwera, M., Heal, G., Dubeux, C., Hallegatte, S., Leclerc, L., Markandya, A., et al. "Economics of adaptation," in *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel of Climate Change*, eds. C. B. Field, V. R. Barros, D. J. Dokken, K. J. Mach, M. D. Mastrandrea, T. E. Bilir, et al. (Cambridge, United Kingdom and New York, NY, USA: Cambridge University Press), 945–977.

Chamorro, A., and Utting, P. (2015). Políticas públicas y la economía social y solidaria: hacia un entorno favorable. El caso de Nicaragua. Turin, Italy: ILO/ILO-ITC.

Chancel, L., and Picketty, T. (2015). Carbon and inequality: from Kyoto to Paris. Trends in the global inequality of carbon emissions (1998-2013) & prospects for an equitable adaptation fund. Paris, France.

Chandra, A., McNamara, K. E., and Dargusch, P. (2017). Climate-smart agriculture: perspectives and framings. *Climate Policy* 0, 1–16. doi:10.1080/14693062.2017.1316968.

Chandrashekeran, S., Morgan, B., Coetzee, K., and Christoff, P. (2017). Rethinking the green state beyond the Global North: a South African climate change case study. *Wiley Interdisciplinary Reviews: Climate Change*, e473. doi:10.1002/wcc.473.

Chant, S., Klett-Davies, M., and Ramalho, J. (2017). Challenges and potential solutions for adolescent girls in urban settings: a rapid evidence review. London, UK.

Chaturvedi, V., and Shukla, P. R. (2014). Role of energy efficiency in climate change mitigation policy for India: assessment of co-benefits and opportunities within an integrated assessment modeling framework. *Climatic Change* 123, 597–609. doi:10.1007/s10584-013-0898-x.

Chelleri, L., Minucci, G., and Skrimizea, E. (2016). Does community resilience decrease social–ecological vulnerability? Adaptation pathways trade-off in the Bolivian Altiplano. *Regional Environmental Change* 16, 2229–2241. doi:10.1007/s10113-016-1046-8.

Chen, C., Hellmann, J., Berrang-Ford, L., Noble, I., and Regan, P. (2016). A global assessment of adaptation investment from the perspectives of equity and efficiency. *Mitigation and Adaptation Strategies for Global Change*, n/a-n/a. doi:10.1007/s11027-016-9731-y.

Chen, X., Liu, X., and Hu, D. (2015). Assessment of sustainable development: A case study of Wuhan as a pilot city in China. *Ecological Indicators* 50, 206–214. doi:10.1016/j.ecolind.2014.11.002.

Chhetri, N., Chaudhary, P., Tiwari, P. R., and Yadaw, R. B. (2012). Institutional and technological innovation: understanding agricultural adaptation to climate change in Nepal. *Applied Geography* 33, 142–150. doi:10.1016/j.apgeog.2011.10.006.

Chief, K., Meadow, A., and Whyte, K. (2016). Engaging southwestern tribes in sustainable water resources topics and management. *Water (Switzerland)* 8, 1–21. doi:10.3390/w8080350.

Chishakwe, N., Murray, L., and Chambwera, M. (2012). Building climate change adaptation on community experiences: lessons from community-based natural resource management in southern Africa. London, UK: International Institute for Environment and Development (IIED).
Chong, J. (2014). Ecosystem-based approaches to climate change adaptation: progress and challenges. *International Environmental Agreements: Politics, Law and Economics* 14, 391–405. doi:10.1007/s10784-014-9242-9.
Chow, J. (2017). Mangrove management for climate change adaptation and sustainable development in coastal zones. *Journal of Sustainable Forestry* 0, 1–18. doi:10.1080/10549811.2017.1339615.
Chowdhury, S. K. (2010). Impact of infrastructures on paid work opportunities and unpaid work burdens on rural women in Bangladesh. *Journal of International Development* 22, 997–1017. doi:10.1002/jid.1607.
Chu, A., Lin, Y. C., and Chiueh, P. Te (2017). Incorporating the effect of urbanization in measuring climate adaptive capacity. *Land Use Policy* 68, 28–38. doi:10.1016/j.landusepol.2017.07.019.
Claeys, P., and Delgado Pugley, D. (2016). Peasant and indigenous transnational social movements engaging with climate justice. *Canadian Journal of Development Studies / Revue canadienne d'études du développement* 5189, 1–16. doi:10.1080/02255189.2016.1235018.
Clancy, J. S., Winther, T., Matinga, M., and Oparaocha, S. (2012). Gender equity in access to and benefits from modern energy and improved energy technologies: world development report background paper.
Clark, W. C., Van Kerkhoff, L., Lebel, L., and Gallopin, G. C. (2016). Crafting usable knowledge for sustainable development. *Proceedings of the National Academy of Sciences of the United States of America* 113. doi:10.1073/pnas.1601266113.
Clarke, L. E., Jiang, K., Akimoto, K., Babiker, M., Blanford, G., Fisher-Vanden, K., et al. (2014). "Assessing transformation pathways," in *Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*, eds. O. Edenhofer, R. Pichs-Madruga, Y. Sokona, E. Farahani, S. Kadner, K. Seyboth, et al. (Cambridge, UK and New York, NY, USA.: Cambridge University Press), 413–510.
Clemens, M. A., Kenny, C. J., and Moss, T. J. (2007). The trouble with the MDGs: confronting expectations of aid and development success. *World Development* 35, 735–751. doi:10.1016/j.worlddev.2006.08.003.
Clements, R. (2009). The Economic Cost of Climate Change in Africa.
Cobbinah, P. B., and Anane, G. K. (2016). Climate change adaptation in rural Ghana: indigenous perceptions and strategies. *Climate and Development* 8, 169–178. doi:10.1080/17565529.2015.1034228.
Cochrane, R. (2014). Climate change, buen vivir, and the dialectic of enlightenment: toward a feminist critical philosophy of climate justice. *Hypatia* 29, 576–598. doi:10.1111/hypa.12099.
Cock, J. (2014). The "Green Economy": a just and sustainable development path or a "wolf in sheep"s clothing'? *Global Labour Journal* 5, 23–44. doi:http://dx.doi.org/10.15173/glj.v5i1.1146.
Coe, R., Njoloma, J., and Sinclair, F. (2017). To control or not to control: how do we learn more about how agronomic innovations perform on farms? *Experimental Agriculture*, 1–7. doi:10.1017/S0014479717000102.
Coe, R., Sinclair, F., and Barrios, E. (2014). Scaling up agroforestry requires research "in" rather than "for" development. *Current Opinion in Environmental Sustainability* 6, 73–77. doi:10.1016/j.cosust.2013.10.013.
Cohen, M. (2017). *Climate change and gender in rich countries: work, public policy and action*. , ed. M. Cohen Abingdon, UK and New York, NY, USA: Routledge.
Colenbrander, S., Dodman, D., and Mitlin, D. (2017). Using climate finance to advance climate justice: the politics and practice of channelling resources to the local level. *Climate Policy* 0, 1–14. doi:10.1080/14693062.2017.1388212.
Colenbrander, S., Gouldson, A., Roy, J., Kerr, N., Sarkar, S., Hall, S., et al. (2016). Can low-carbon urban development be pro-poor? The case of Kolkata, India. *Environment and Urbanization* 29, 139–158. doi:10.1177/0956247816677775.
Colloff, M. J., Martín-López, B., Lavorel, S., Locatelli, B., Gorddard, R., Longaretti, P. Y., et al. (2017). An integrative research framework for enabling transformative adaptation. *Environmental Science and Policy* 68, 87–96. doi:10.1016/j.envsci.2016.11.007.
Combet, E. (2013). Fiscalite carbone et progrès social. Application au cas francais. Paris, France.
Conservation International (2016). Ecosystem Based Adaptation: Essential for Achieving the Sustainable Development Goals. Arlington, VA, USA.
Conway, D., van Garderen, E. A., Deryng, D., Dorling, S., Krueger, T., Landman, W., et al. (2015). Climate and southern Africa's water-energy-food nexus. *Nature Climate Change* 5, 837–846. doi:10.1038/Nclimate2735.
Cook, P. (2011). Infrastructure, rural electrification and development. *Energy for Sustainable Development* 15, 304–313. doi:10.1016/j.esd.2011.07.008.
Cook, S., Smith, K., and Utting, P. (2012). Green Economy or Green Society? Contestation and Policies for a Fair Transition. Geneva, Switzerland.
Corbera, E., Hunsberger, C., and Vaddhanaphuti, C. (2017). Climate change policies, land grabbing and conflict: perspectives from Southeast Asia. *Canadian Journal of Development Studies* 38, 297–304. doi:10.1080/02255189.2017.1343413.
Coudel, E., Ferreira, J., de Carvalho Amazonas, M., Eloy, L., Hercowitz, M., Mattos, L., et al. (2015). "The rise of PES

in Brazil: from pilot projects to public policies," in *Handbook of Ecological Economics*, eds. J. Martinez-Alier and R. Muradian (Cheltenham, UK: Edward Elgar Publishing), 450–472.
Cramer, W., Yohe, G. W., Auffhammer, M., Huggel, C., and Molau, U. (2014). "Detection and attribution of observed impacts," in *Climate Change 2014: Impacts, Adaptation and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*, eds. C. B. Field, V. . Barros, D. J. Dokken, K. J. Mach, M. D. Mastrandrea, T. E. Bilir, et al. (Cambridge, UK and New York, NY, USA.: Cambridge University Press), 979–1037.
Cremades, R., G S A Rothausen, S., Conway, D., Zou, X., Wang, J., and Li, Y. (2016). Co-benefits and trade-offs in the water–energy nexus of irrigation modernization in China. *Environmental Research Letters* 11, 54007. doi:10.1088/1748-9326/11/5/054007.
Cretney, R. M., Thomas, A. C., and Bond, S. (2016). Maintaining grassroots activism: Transition Towns in Aotearoa New Zealand. *New Zealand Geographer* 72, 81–91.
Creutzig, F., Fernandez, B., Haberl, H., Khosla, R., Mulugetta, Y., and Seto, K. C. (2016). Beyond technology: demand-side solutions for climate change mitigation. *Annual Review of Environment and Resources* 41, 173–198. doi:10.1146/annurev-environ-110615-085428.
Creutzig, F., Goldschmidt, J. C., Lehmann, P., Schmid, E., Von Bl??cher, F., Breyer, C., et al. (2014). Catching two European birds with one renewable stone: mitigating climate change and Eurozone crisis by an energy transition. *Renewable and Sustainable Energy Reviews* 38, 1015–1028. doi:10.1016/j.rser.2014.07.028.
Creutzig, F., Jochem, P., Edelenbosch, O. Y., Mattauch, L., van Vuuren, D. P., McCollum, D., et al. (2015a). Transport a roadblock to climate mitigation? *Science* 350, 911–912.
Creutzig, F., Ravindranath, N. H., Berndes, G., Bolwig, S., Bright, R., Cherubini, F., et al. (2015b). Bioenergy and climate change mitigation: an assessment. *GCB Bioenergy* 7, 916–944. doi:10.1111/gcbb.12205.
Crowe, T. L. (2012). The potential of the CDM to deliver pro-poor benefits. *Climate Policy* 3062, 1–22. doi:10.1080/14693062.2012.709080.
CSO Review (2015). Fair shares: a civil society equity review of INDCs. Manilia, London, Cape Town, Washington, et al.
Cugurullo, F. (2013). How to build a sandcastle: an analysis of the genesis and development of Masdar City. *Journal of Urban Technology* 20, 23–37. doi:10.1080/10630732.2012.735105.
Cugurullo, F. (2016). Urban eco-modernisation and the policy context of new eco-city projects: Where Masdar City fails and why. *Urban Studies* 53, 2417–2433. doi:10.1177/0042098015588727.
Cundill, G., Shackleton, S., Sisitka, L., Ntshudu, M., Lotz-Sisitka, H., Kulundu, I., et al. (2014). Social learning for adaptation: a descriptive handbook for practitioners and action researchers.
Cutter, S. L. (2016). Resilience to What? Resilience for Whom? *Geographical Journal* 182, 110–113. doi:10.1111/geoj.12174.
Cvitanovic, C., Crimp, S., Fleming, A., Bell, J., Howden, M., Hobday, A. J., et al. (2016). Linking adaptation science to action to build food secure Pacific Island communities. *Climate Risk Management* 11, 53–62. doi:10.1016/j.crm.2016.01.003.
Daigneault, A., Brown, P., and Gawith, D. (2016). Dredging versus hedging: Comparing hard infrastructure to ecosystem-based adaptation to flooding. *Ecological Economics* 122, 25–35. doi:10.1016/j.ecolecon.2015.11.023.
Dale, V. H., Kline, K. L., Wiens, J., and Fargione, J. (2010). Biofuels: implications for land use and biodiversity.
Dasgupta, P. (2016). *Climate Sensitive Adaptation in Health: Imperatives for India in a Developing Economy Context*. Springer India.
Dasgupta, P., Ebi, K., and Sachdeva, I. (2016). Health sector preparedness for adaptation planning in India. *Climatic Change* 138, 551–566. doi:10.1007/s10584-016-1745-7.
Dasgupta, P., Morton, J. F., Dodman, D., Karapınar, B., Meza, F., Rivera-Ferre, M. G., et al. (2014). "Rural areas," in *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel of Climate Change*, eds. C. B. Field, V. R. Barros, D. J. Dokken, K. J. Mach, M. D. Mastrandrea, T. E. Bilir, et al. (Cambridge, United Kingdom and New York, NY, USA: Cambridge University Press), 613–657.
Dasgupta, S., Huq, M., Mustafa, M. G., Sobhan, M. I., and Wheeler, D. (2017). The Impact of Aquatic Salinization on Fish Habitats and Poor Communities in a Changing Climate: Evidence from Southwest Coastal Bangladesh. *Ecological Economics* 139, 128–139. doi:10.1016/j.ecolecon.2017.04.009.
Dasgupta, S., and Roy, J. (2017). Analysing energy intensity trends and decoupling of growth from energy use in Indian manufacturing industries during 1973-1974 to 2011-2012. *Energy Efficiency* 10, 925–943. doi:10.1007/s12053-016-9497-9.
Davies, E. G. R., Kyle, P., and Edmonds, J. A. (2013). An integrated assessment of global and regional water demands for electricity generation to 2095. *Advances in Water Resources* 52, 296–313. doi:10.1016/j.advwatres.2012.11.020.
Davies, K. (2015). "Kastom, climate change and intergenerational democracy: experiences from Vanuatu," in *Climate change in the Asia-Pacific region*, ed. W. Leal Filho (Springer), 49–66.

Davies, T. E., Pettorelli, N., Cresswill, W., and Fazey, I. R. (2014). Who are the poor? Measuring wealth inequality to aid understanding of socioeconomic contexts for conservation: a case-study from the Solomon Islands. *Environmental Conservation* 41, 357–366. doi:10.1017/S0376892914000058.

de Loma-Osorio, G. F. y (2016). The 2030 Agenda for Sustainable Development: Bringing Climate Justice to Climate Action. *Development* 59, 223–228. doi:10.1057/s41301-017-0122-9.

Dearing, J. A., Wang, R., Zhang, K., Dyke, J. G., Haberl, H., Hossain, M. S., et al. (2014). Safe and just operating spaces for regional social-ecological systems. *Global Environmental Change* 28, 227–238. doi:10.1016/j.gloenvcha.2014.06.012.

De Stefano, L., Petersen-Perlman, J. D., Sproles, E. A., Eynard, J., and Wolf, A. T. (2017). Assessment of transboundary river basins for potential hydro-political tensions. *Global Environmental Change* 45, 35–46.

Death, C. (2014). The Green Economy in South Africa: Global Discourses and Local Politics. *Politikon* 41, 1–22. doi:10.1080/02589346.2014.885668.

Death, C. (2015). Four discourses of the green economy in the global South. *Third World Quarterly* 36, 2207–2224. doi:10.1080/01436597.2015.1068110.

Death, C. (2016). Green states in Africa: beyond the usual suspects. *Environmental Politics* 25:1, 116–135. doi:10.1080/09644016.2015.1074380.

Death, C., and Gabay, C. (2015). Doing biopolitics differently? Radical potential in the post-2015 MDG and SDG debates. *Globalizations* 12, 597–612. doi:10.1080/14747731.2015.1033172.

DeCaro, D. A., Anthony, C., Arnold, T., Boamah, E. F., and Garmestani, A. S. (2017). Understanding and applying principles of social cognition and decision making in adaptive environmental governance. *Ecology and Society* 22, 33. doi:doi.org/10.5751/ES-09154-220133.

DeClerck, F. A. J., Jones, S. K., Attwood, S., Bossio, D., Girvetz, E., Chaplin-Kramer, B., et al. (2016). Agricultural ecosystems and their services: the vanguard of sustainability? *Current Opinion in Environmental Sustainability* 23, 92–99. doi:10.1016/j.cosust.2016.11.016.

Delgado-Serrano, M. del M., Mistry, M., Matzdorf, B., and Leclerc, G. (2017). Community-based management of environmental challenges in Latin America. *Ecology and Society* 22, 4. doi:10.5751/ES-08924-220104.

Delponte, I., Pittaluga, I., and Schenone, C. (2017). Monitoring and evaluation of Sustainable Energy Action Plan: practice and perspective. *Energy Policy* 100, 9–17. doi:10.1016/j.enpol.2016.10.003.

Denis-Ryan, A., Bataille, C., and Jotzo, F. (2016). Managing carbon-intensive materials in a decarbonizing world without a global price on carbon. *Climate Policy* 16, S110–S128.

Denton, F., Wilbanks, T. J., Abeysinghe, A. C., Burton, I., Gao, Q., Lemos, M. C., et al. (2014). "Climate-resilient pathways: adaptation, mitigation, and sustainable development," in *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel of Climate Change*, eds. C. B. Field, V. R. Barros, D. J. Dokken, K. J. Mach, M. D. Mastrandrea, T. E. Bilir, et al. (Cambridge, UK and New York, NY, USA: Cambridge University Press), 1101–1131.

Depietri, Y., and McPhearson, T. (2017). "Integrating the Grey, Green, and Blue in Cities: Nature-Based Solutions for Climate Change Adaptation and Risk Reduction," in, 91–109. doi:10.1007/978-3-319-56091-5_6.

Derbez, M., Berthineau, B., Cochet, V., Lethrosne, M., Pignon, C., Riberon, J., et al. (2014). Indoor air quality and comfort in seven newly built, energy-efficient houses in France. *Building and Environment* 72, 173–187. doi:10.1016/j.buildenv.2013.10.017.

Deryugina, T., and Hsiang, S. (2014). Does the Environment Still Matter? Daily Temperature and Income in the United States. Cambride, MA, USA and New York, NY, USA.

Desmarais, A. A., Rivera-Ferre, M. G., and Gasco, B. (2014). "Building Alliances for Food Sovereignty: La Vía Campesina, NGOs, and Social Movements," in *Alternative Agrifood Movements: Patterns of Convergence and Divergence*, eds. D. H. Constance, M.-C. Renard, and M. G. Rivera-Ferre (Bingley, UK: Emerald Group Publishing Ltd), 89–110.

Di Gregorio, M., Nurrochmat, D. R., Paavola, J., Sari, I. M., Fatorelli, L., Pramova, E., et al. (2017a). Climate policy integration in the land use sector: mitigation, adaptation and sustainable development linkages. *Environmental Science and Policy* 67, 35–43. doi:10.1016/j.envsci.2016.11.004.

Di Gregorio, M., Nurrochmat, D. R., Paavola, J., Sari, I. M., Fatorelli, L., Pramova, E., et al. (2017b). Climate policy integration in the land use sector: Mitigation, adaptation and sustainable development linkages. *Environmental Science and Policy* 67, 35–43. doi:10.1016/j.envsci.2016.11.004.

Dickinson, J. L., McLeod, P., Bloomfield, R., and Allred, S. (2016). Which moral foundations predict willingness to make lifestyle changes to avert climate change in the USA? *PLOS ONE* 11, 1–11. doi:10.1371/journal.pone.0163852.

Dilling, L., Daly, M. E., Travis, W. R., Wilhelmi, O. V., and Klein, R. A. (2015). The dynamics of vulnerability: why adapting to climate variability will not always prepare us for climate change. *Wiley Interdisciplinary Reviews: Climate Change* 6, 413–425. doi:10.1002/wcc.341.

Dimitrov, R. S. (2016). The Paris agreement on climate change: behind closed doors. *Global Environmental Politics* 16,

1–11. doi:10.1162/GLEP_a_00361.
Dinkelman, T. (2011). The Effects of Rural Electrification on Employment: New Evidence from South Africa. *The American Economic Review* 101, 3078–3108. doi:10.1257/aer.101.7.3078.
Dinku, T., Block, P., Sharoff, J., Hailemariam, K., Osgood, D., del Corral, J., et al. (2014). Bridging critical gaps in climate services and applications in Africa. *Earth Perspectives* 1, 15. doi:10.1186/2194-6434-1-15.
Djoudi, H., Locatelli, B., Vaast, C., Asher, K., Brockhaus, M., and Basnett Sijapati, B. (2016). Beyond dichotomies: Gender and intersecting inequalities in climate change studies. *Ambio* 45, 248–262. doi:10.1007/s13280-016-0825-2.
Dodman, D., Leck, H., Rusca, M., and Colenbrander, S. (2017). African urbanisation and urbanism: implications for risk accumulation and reduction. *International Journal of Disaster Risk Reduction* 26, 7–15. doi:10.1016/j.ijdrr.2017.06.029.
Doll, C. N. H., and Puppim de Oliveira, J. A. (2017). *Urbanization and climate co-benefits: Implementation of win-win interventions in cities.* , eds. C. N. H. Doll and J. A. Puppim de Oliveira Abingdon, UK and New York, NY, USA: Routledge.
Dos Santos, S., Adams, E. A., Neville, G., Wada, Y., de Sherbinin, A., Mullin Bernhardt, E., et al. (2017). Urban growth and water access in sub-Saharan Africa: Progress, challenges, and emerging research directions. *Science of the Total Environment* 607–608, 497–508. doi:10.1016/j.scitotenv.2017.06.157.
dos Santos Gaspar, J., Marques, A., and Funhas, J. A. (2017). The traditional energy-growth nexus: A comparison between sustainable development and economic growth approaches. *Ecological Indicators2* 75, 286–296.
Doswald, N., Munroe, R., Roe, D., Giuliani, A., Castelli, I., Stephens, J., et al. (2014). Effectiveness of ecosystem-based approaches for adaptation: review of the evidence-base. *Climate and Development* 6, 185–201. doi:10.1080/17565529.2013.867247.
Dovie, D. B. K., Dzodzomenyo, M., and Ogunseitan, O. A. (2017). Sensitivity of health sector indicators' response to climate change in Ghana. *Science of the Total Environment* 574, 837–846. doi:10.1016/j.scitotenv.2016.09.066.
Doyle, R., and Davies, A. R. (2013). Towards sustainable household consumption: exploring a practice oriented , participatory backcasting approach for sustainable home heating practices in Ireland. *Journal of Cleaner Production* 48, 260–271.
Doze, A., and Dekens, J. (2017). A framework for gender-responsive national adaptation plan (NAP) process.
Druckman, A., and Jackson, T. (2016). "Understanding Households as Drivers of Carbon Emissions," in *Taking Stock of Industrial Ecology*, eds. R. Clift and A. Druckman (Springer International Publishing), 181–203.
du Pont, Y. R., Jeffery, M. L., Gütschow, J., Rogelj, J., Christoff, P., and Meinshausen, M. (2017). Equitable mitigation to achieve the Paris Agreement goals. *Nature Climate Change* 7, 38–43. doi:10.1038/NCLIMATE3186.
Duguma, L. A., Minang, P. A., and Van Noordwijk, M. (2014a). Climate change mitigation and adaptation in the land use sector: from complementarity to synergy. *Environmental Management* 54, 420–432. doi:10.1007/s00267-014-0331-x.
Duguma, L. A., Wambugu, S. W., Minang, P. A., and van Noordwijk, M. (2014b). A systematic analysis of enabling conditions for synergy between climate change mitigation and adaptation measures in developing countries. *Environmental Science and Policy* 42, 138–148. doi:10.1016/j.envsci.2014.06.003.
Duit, A., Feindt, P. H., and Meadowcroft, J. (2016). Greening Leviathan: the rise of the environmental state? *Environmental Politics* 25, 1–23. doi:10.1080/09644016.2015.1085218.
Dulal, H. B., Shah, K. U., and Ahmad, N. (2009). Social equity considerations in the implementation of caribbean climate change adaptation policies. *Sustainability* 1, 363–383. doi:10.3390/su1030363.
Dumont, E. ., Bonhomme, S., Pagella, T. F., and Sinclair, F. L. (2017). Structured stakeholder engagement leads to development of more diverse and inclusive agroforestry options. *Experimental Agriculture*, 1–23. doi:10.1017/S0014479716000788.
Dyer, J. C., Stringer, L. C., and Dougill, A. J. (2012). Jatropha curcas: Sowing local seeds of success in Malawi? In response to Achten et al. (2010). *Journal of Arid Environments* 79, 107–110. doi:10.1016/j.jaridenv.2011.12.004.
Dyer, J., Leventon, J., Stringer, L., Dougill, A., Syampungani, S., Nshimbi, M., et al. (2013). Partnership models for climate compatible development: experiences from Zambia. *Resources* 2, 1–25. doi:10.3390/resources2010001.
Eakin, H. C., Lemos, M. C., and Nelson, D. R. (2014). Differentiating capacities as a means to sustainable climate change adaptation. *Global Environmental Change* 27, 1–8. doi:10.1016/j.gloenvcha.2014.04.013.
Ebi, K. L. (2016). Adaptation and resilience. *Public Health Reviews* 37, 1–6. doi:10.1186/s40985-016-0032-5.
Ebi, K. L., and Bowen, K. (2016). Extreme events as sources of health vulnerability: drought as an example. *Weather Clim Extremes* 11. doi:10.1016/j.wace.2015.10.001.
Ebi, K. L., and Del Barrio, M. O. (2017). Lessons learned on health adaptation to climate variability and change: Experiences across low- and middle-income countries. *Environmental Health Perspectives* 125. doi:10.1289/EHP405.
Ebi, K. L., Hallegatte, S., Kram, T., Arnell, N. W., Carter, T. R., Edmonds, J., et al. (2014). A new scenario framework for climate change research: background, process, and future directions. *Climatic Change* 122, 363–372. doi:10.1007/s10584-013-0912-3.

Echegaray, F. (2016). Consumers' reactions to product obsolescence in emerging markets: the case of Brazil. *Journal of Cleaner Production* 134, 191–203. doi:10.1016/j.jclepro.2015.08.119.
Edelmann, M., and Borras, S. M. (2016). *Political dynamics of transnational agrarian movements*. Canada: Fernwood Publishing.
Edenhofer, O., and Minx, J. (2014). Mapmakers and navigators, facts and values. *Science* 345, 37–38.
Edenhofer, O., Seyboth, K., Creutzig, F., and Schlömer, S. (2013). On the sustainability of renewable energy sources. *Annual Review of Environment and Resources* 38, 169–200. doi:10.1146/annurev-environ-051012-145344.
Ehara, M., Hyakumura, K., Nomura, H., Matsuura, T., Sokh, H., and Leng, C. (2016). Identifying characteristics of households affected by deforestation in their fuelwood and non-timber forest product collections: case study in Kampong Thom Province, Cambodia. *Land Use Policy* 52, 92–102. doi:10.1016/j.landusepol.2015.12.006.
Ehresman, T. G., and Okereke, C. (2015). Environmental justice and conceptions of the green economy. *International Environmental Agreements: Politics, Law and Economics* 15, 13–27. doi:10.1007/s10784-014-9265-2.
Ekwurzel, B., Boneham, J., Dalton, M. W., Heede, R., Mera, R. J., Allen, M. R., et al. (2017). The rise in global atmospheric CO2, surface temperature, and sea level from emissions traced to major carbon producers. *Climatic Change*, 1–12. doi:10.1007/s10584-017-1978-0.
Ellis, K., Cambray, A., and Lemma, A. (2013). Drivers and challenges for climate compatible development.
Elmqvist, T., Fragkias, M., Goodness, J., Guneralp, B., Marcotullio, P. J., McDonald, R. I., et al. eds. (2013). *Urbanization, biodiversity and ecosystem services: Challenges and opportunities*. Berlin: Springer.
Elum, Z. A., Modise, D. M., and Nhamo, G. (2017). Climate change mitigation: the potential of agriculture as a renewable energy source in Nigeria. *Environmental Science and Pollution Research* 24, 3260–3273. doi:10.1007/s11356-016-8187-7.
Emodi, N. V., and Boo, K.-J. (2015). Sustainable energy development in Nigeria: current status and policy options. *Renewable and Sustainable Energy Reviews* 51, 356–381. doi:10.1016/j.rser.2015.06.016.
Enqvist, J., Tengö, M., and Boonstra, W. J. (2016). Against the current: rewiring rigidity trap dynamics in urban water governance through civic engagement. *Sustainability Science* 11, 919–933. doi:10.1007/s11625-016-0377-1.
Ensor, J. (2016). Adapation and resilience in Vanuatu: Interpreting community perceptions of vulnerability, knowledge and power for community-based adaptation programming. Carlton, Australia.
Ensor, J. . Resilience realities: resilience and development practice in Vanuatu.
Ensor, J., Boyd, E., Juhola, S., and Broto, V. C. (2014). "Building Adaptive Capacity in the Informal Settlements of Maputo: Lessons for Development from a Resilience Perspective," in *Climate Change Adaptation and Development: Transforming Paradigms and Practices*, eds. T. H. Inderberg, S. Eriksen, K. O'Brien, and L. Sygna (Abingdon, UK and New York, USA: Routledge), 19–38.
Ensor, J., and Harvey, B. (2015). Social learning and climate change adaptation: evidence for international development practice. *Wiley Interdisciplinary Reviews: Climate Change* 6, 509–522. doi:10.1002/wcc.348.
Entzinger, H., and Scholten, P. (2016). Adapting to Climate Change through Migration. A case study of the Vitnamese Mekong River Delta.
Epule, T. E., Ford, J. D., Lwasa, S., and Lepage, L. (2017). Climate change adaptation in the Sahel. *Environmental Science & Policy* 75, 121–137. doi:10.1016/j.envsci.2017.05.018.
Eriksen, S. H., and O'Brien, K. (2007). Vulnerability, poverty and the need for sustainable adaptation measures. *Climate Policy* 7, 337–352. doi:10.1080/14693062.2007.9685660.
Eriksson, H., Albert, J., Albert, S., Warren, R., Pakoa, K., and Andrew, N. (2017). The role of fish and fisheries in recovering from natural hazards: lessons learned from Vanuatu. *Environmental Science & Policy* 76, 50–58. doi:10.1016/j.envsci.2017.06.012.
Estrella, M., Renaud, F. G., Sudmeier-Rieux, K., and Nehren, U. (2016). "Defining New Pathways for Ecosystem-Based Disaster Risk Reduction and Adaptation in the Post-2015 Sustainable Development Agenda," in *Ecosystem-Based Disaster Risk Reduction and Adaptation in Practice*, eds. F. G. Renaud, K. Sudmeier-Rieux, M. Estrella, and U. Nehren (Springer International Publishing Switzerland), 553–591. doi:10.1007/978-3-319-43633-3.
Evans, B., and Reid, J. (2014). *Resilient life: the art of living dangerously*. John Wiley and Sons.
Evans, G., and Phelan, L. (2016). Transition to a post-carbon society: linking environmental justice and just transition discourses. *Energy Policy* 99, 329–339. doi:10.1016/j.enpol.2016.05.003.
Evans, J. P., Smith, R. B., and Oglesby, R. J. (2004). Middle East climate simulation and dominant precipitation processes. *International Journal of Climatology* 24, 1671–1694. doi:10.1002/joc.1084.
Fairhead, J., Leach, M., and Scoones, I. (2012). Green grabbing: a new appropriation of nature? *Journal of Peasant Studies* 39, 237–261. doi:10.1080/03066150.2012.671770.
Fajardy, M., and Mac Dowell, N. (2017). Can BECCS deliver sustainable and resource efficient negative emissions? *Energy & Environmental Science* 10, 1389–1426. doi:10.1039/C7EE00465F.
Fan, Y., Qiao, Q., Fang, L., and Yao, Y. (2017). Energy analysis on industrial symbiosis of an industrial park: a case study of Hefei economic and technological development area. *Journal of Cleaner Production* 141, 791–798. doi:10.1016/j.jclepro.2016.09.159.

Fankhauser, S., and McDermott, T. K. J. (2014). Understanding the adaptation deficit: Why are poor countries more vulnerable to climate events than rich countries? *Global Environmental Change* 27, 9–18. doi:10.1016/j.gloenvcha.2014.04.014.

Farrell, C. (2012). A Just Transition: Lessons Learned from the Environmental Justice Movement. *Duke Forum for Law and Social Change* 4, 45–63. doi:10.1525/sp.2007.54.1.23.

Fatima, R., Wadud, A. J., and Coelho, S. (2014). Human rights, climate change, environmental degradation: a new paradigm. *IOM, MPI, Issue in Brief*.

Fay, M., Hallegatte, S., Vogt-Schilb, A., Rozenberg, J., Narloch, U., and Kerr, T. (2015). Decarbonizing Development: Three Steps to a Zero-Carbon Future. Washington, DC, USA: World Bank.

Fazey, I., Moug, P., Allen, S., Beckmann, K., Blackwood, D., Bonaventura, M., et al. (2017). Transformation in a changing climate: a research agenda. *Climate and Development*, 1–21. doi:10.1080/17565529.2017.1301864.

Fazey, I., Wise, R. M., Lyon, C., Câmpeanu, C., Moug, P., and Davies, T. E. (2016). Past and future adaptation pathways. *Climate and Development* 8, 26–44. doi:10.1080/17565529.2014.989192.

Feola, G., and Nunes, R. (2014). Success and failure of grassroots innovations for addressing climate change: the case of the Transition Movement. *Global Environmental Change* 24, 232–250.

Ferguson, P. (2015). The green economy agenda: business as usual or transformational discourse? *Environmental Politics* 24, 17–37. doi:10.1080/09644016.2014.919748.

Fernandes-Jesus, M., Carvalho, A., Fernandes, L., and Bento, S. (2017). Community engagement in the Transition movement: views and practices in Portuguese initiatives. *Local Environment* 22, 1546–1562. doi:10.1080/13549839.2017.1379477.

Few, R., Martin, A., and Gross-Camp, N. (2017). Trade-offs in linking adaptation and mitigation in the forests of the Congo Basin. *Regional Environmental Change* 17, 851–863. doi:10.1007/s10113-016-1080-6.

Ficklin, L., Stringer, L. C., Dougill, A. J., and Sallu, S. M. (2017). Climate compatible development reconsidered: calling for a critical perspective. *Climate and Development*. doi:10.1080/17565529.2017.1372260.

Field, C. B., Barros, V. R., Mach, K. J., Mastrandrea, M. D., Aalst, M. van, Adger, W. N., et al. (2014). "Technical Summary," in *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*, eds. C. B. Field, V. R. Barros, D. J. Dokken, K. J. Mach, M. D. Mastrandrea, T. E. Bilir, et al. (Cambridge, UK and New York, NY, USA: Cambridge University Press), 35–94.

Fincher, R., Barnett, J., Graham, S., and Hurlimann, A. (2014). Time stories: making sense of futures in anticipation of sea-level rise. *Geoforum* 56, 201–210. doi:10.1016/j.geoforum.2014.07.010.

Fischedick, M., Roy, J., Abdel-Aziz, A., Acquaye, A., Allwood, J. M., Ceron, J.-P., et al. (2014). *Industry*. , eds. C. B. Field, V. R. Barros, D. J. Dokken, K. J. Mach, M. D. Mastrandrea, T. E. Bilir, et al. Cambridge, United Kingdom and New York, NY, USA.: Cambridge University Press.

Fisher, S. (2013a). Low-carbon resilient development in the least developed countries : Emerging issues and areas of research. London.

Fisher, S. (2013b). Low-carbon resilient development in the least developed countries: emerging issues and areas of research. London.

Fisher, S. (2015). The emerging geographies of climate justice. *The Geographical Journal* 181, 73–82. doi:10.1111/geoj.12078.

Fisher, S., and Karani, I. (2015). Strengthening frameworks to monitor and evaluate climate adaptation in Uganda.

Fletcher, C., Rambaldi, A., and Lipkin, F. (2016). Economic, equitable, and affordable adaptations to protect coastal settlements against storm surge inundation. *Regional Environmental*.

Fleurbaey, M., Kartha, S., Bolwig, S., Chee, Y. L., Chen, Y., Corbera, E., et al. (2014). "Sustainable development and equity," in *Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*, eds. O. Edenhofer, R. Pichs-Madruga, Y. Sokona, E. Farahani, S. Kadner, K. Seyboth, et al. (Cambridge, UK and New York, NY, USA.: Cambridge University Press), 283–350.

Fook, T. C. T. (2017). Transformational processes for community-focused adaptation and social change: a synthesis. *Climate and Development* 5529, 1–17. doi:10.1080/17565529.2015.1086294.

Ford, J. D., Stephenson, E., Cunsolo Willox, A., Edge, V., Farahbakhsh, K., Furgal, C., et al. (2016). Community-based adaptation research in the Canadian Arctic. *Wiley Interdisciplinary Reviews: Climate Change* 7, 175–191. doi:10.1002/wcc.376.

Forsyth, T. (2013). Community-based adaptation: a review of past and future challenges. *Wiley Interdisciplinary Reviews: Climate Change* 4, 439–446. doi:10.1002/wcc.231.

Fourqurean, J. W., Duarte, C. M., Kennedy, H., Marbà, N., Holmer, M., Mateo, M. A., et al. (2012). Seagrass ecosystems as a globally significant carbon stock. *Nature Geoscience* 5, 506–509. doi:10.1038/NGEO1477.

Francis, R., Weston, P., and Birch, J. (2015). The social, environmental and economics benefits of Farmer Managed Natural Regeneration (FMNR).

Frank, S., Havlík, P., Soussana, J.-F., Levesque, A., Valin, H., Wollenberg, E., et al. (2017). Reducing greenhouse gas

emissions in agriculture without compromising food security? *Environmental Research Letters* 12. doi:10.1088/1748-9326/aa8c83.
Frankenberg, E., Sikoki, B., Sumantri, C., Suriastini, W., and Thomas, D. (2013). Education, vulnerability, and resilience after a natural disaster. *Ecology and Society* 18. doi:10.5751/ES-05377-180216.
FRDP (2016). Framework for resilient development in the Pacific: an integrated approach to address climate change and disaster risk management (FRDP) 2017-2030.
Fricko, O., Parkinson, S. C., Johnson, N., Strubegger, M., Van Vliet, T. H. M., and Riahi, K. (2016). Energy sector water use implications of a 2°C degree climate policy. *Environmental Research Letters* 11, 34011. doi:10.1088/1748-9326/11/3/034011.
Frumhoff, P. C., Heede, R., and Oreskes, N. (2015). The climate responsibilities of industrial carbon producers. *Climatic Change* 132, 157–171. doi:10.1007/s10584-015-1472-5.
Fuglestvedt, J. S., and Kallbekken, S. (2016). Climate responsibility: fair shares? *Nature Climate Change* 6, 19–20. doi:10.1038/nclimate2791.
Fujimori, S., Hanasaki, N., and Masui, T. (2017). Projections of industrial water withdrawal under shared socioeconomic pathways and climate mitigation scenarios. *Sustainability Science* 12, 275–292. doi:10.1007/s11625-016-0392-2.
Fujimori, S., Hasegawa, T., Rogelj, J., Xu, X., Havlik, P., Krey, V., et al. (2018). Smart mitigation policies to ensure food security under 1.5°C goal. submitted.
Fujimori, S., Kubota, I., Dai, H., Takahashi, K., Hasegawa, T., Liu, J. Y., et al. (2016a). Will international emissions trading help achieve the objectives of the Paris Agreement? *Environmental Research Letters* 11. doi:10.1088/1748-9326/11/10/104001.
Fujimori, S., Masui, T., and Matsuoka, Y. (2015). Gains from emission trading under multiple stabilization targets and technological constraints. *Energy Economics* 48, 306–315. doi:10.1016/j.eneco.2014.12.011.
Fujimori, S., Su, X., Liu, J.-Y., Hasegawa, T., Takahashi, K., Masui, T., et al. (2016b). "Implication of Paris Agreement in the context of long-term climate mitigation goals," in *Post-2020 Climate Action*, eds. S. Fujimori, M. Kainuma, and T. Masui (Springer), 11–29. doi:10.1186/s40064-016-3235-9.
Fukuda-Parr, S., Yamin, A. E., and Greenstein, J. (2014). The power of numbers: a critical review of Millennium Development Goal targets for human development and human rights. *Journal of Human Development and Capabilities* 15, 105–117. doi:10.1080/19452829.2013.864622.
Fuller, R., and Lain, J. (2017). Building resilience: a meta-analysis of Oxfam's resilience Effectiveness Reviews.
Fund for Peace (2017). Fragile states index 2017. Washington, DC, USA.
Fünfgeld, H. (2015). Facilitating local climate change adaptation through transnational municipal networks. *Current Opinion in Environmental Sustainability* 12, 67–73. doi:10.1016/j.cosust.2014.10.011.
Fuss, S., Canadell, J. G., Peters, G. P., Tavoni, M., Andrew, R. M., Ciais, P., et al. (2014). Betting on negative emissions. *Nature Clim. Change* 4, 850–853. doi:10.1038/nclimate2392.
Fuss, S., Lamb, W. F., Callaghan, M. W., Hilaire, J., Creutzig, F., Amann, T., et al. Negative emissions - part 2: costs, potentials and side effects. *Environmental Research Reviews* submitted.
Fytili, D., and Zabaniotou, A. (2017). Social acceptance of bioenergy in the context of climate change and sustainability – A review. *Current Opinion in Green and Sustainable Chemistry* 8, 5–9. doi:10.1016/j.cogsc.2017.07.006.
Galgóczi, B. (2014). The Long and Winding Road from Black to Green: Decades of Structural Change in the Ruhr Region. *International Journal of Labour Research* 6, 217–240.
Gambhir, A., Drouet, L., McCollum, D., Napp, T., Bernie, D., Hawkes, A., et al. (2017). Assessing the feasibility of global long-term mitigation scenarios. *Energies* 10, 89. doi:10.3390/en10010089.
Gardiner, S. M. (2013). Why geoengineering is not a "global public good", and why it is ethically misleading to frame it as one. *Climatic Change* 121, 513–525. doi:10.1007/s10584-013-0764-x.
Garg, A., Mohan, P., Shukla, S., Kankal, B., and Vishwanathan, S. S. (2017). High impact opportunities for energy efficiency in India. Copenhagen.
Garnett, T. (2011). Where are the best opportunities for reducing greenhouse gas emissions in the food system (including the food chain)? *Food Policy* 36, S23–S32. doi:10.1016/j.foodpol.2010.10.010.
Garschagen, M., and Romero-Lankao, P. (2015). Exploring the relationships between urbanization trends and climate change vulnerability. *Climatic Change* 133, 37–52. doi:10.1007/s10584-013-0812-6.
Gattuso, J. P., Magnan, A., Bille, R., Cheung, W. W. L., Howes, E. L., Joos, F., et al. (2015). Contrasting futures for ocean and society from different anthropogenic CO2 emissions scenarios. *Science* 349, aac4722. doi:10.1126/science.aac4722.
GEA (2012). *Global Energy Assessment - Toward a Sustainable Future*. , eds. T. B. Johansson, N. Nakicenovic, A. Patwardhan, and L. Gomez-Echeverri International Institute for Applied Systems Analysis, Vienna, Austria and Cambridge University Press, Cambridge, UK and New York, NY, USA.
Gebrehaweria, G., Dereje Assefa, A., Girmay, G., Giordano, M., and Simon, L. (2016). An assessment of integrated watershed management in Ethiopia. Colombo, Sri Lanka doi:10.5337/2016.214.
Gebremedhin, B., and Swinton, S. M. (2003). Land tenure security and public programs. *Agricultural Economics* 29,

69–84. doi:10.1016/S0169-5.
Geels, F. W., Kern, F., Fuchs, G., Hinderer, N., Kungl, G., Mylan, J., et al. (2016). The enactment of socio-technical transition pathways: a reformulated typology and a comparative multi-level analysis of the German and UK low-carbon electricity transitions (1990-2014). *Research Policy* 45, 896–913. doi:10.1016/j.respol.2016.01.015.
Geels, F. W., McMeekin, A., Mylan, J., and Southerton, D. (2015). A critical appraisal of Sustainable Consumption and Production research: The reformist, revolutionary and reconfiguration positions. *Global Environmental Change* 34, 1–12. doi:10.1016/j.gloenvcha.2015.04.013.
Georgeson, L., Maslin, M., and Poessinouw, M. (2017a). Global disparity in the supply of commercial weather and climate information services. *Science Advances* 3, e1602632.
Georgeson, L., Maslin, M., and Poessinouw, M. (2017b). The global green economy: a review of concepts, definitions, measurement methodologies and their interactions. *Geo: Geography and Environment* 4, e00036. doi:10.1002/geo2.36.
Gerbens-Leenes, P. W., van Lienden, A. R., Hoekstra, A. Y., and van der Meer, T. H. (2012). Biofuel scenarios in a water perspective: The global blue and green water footprint of road transport in 2030. *Global Environmental Change* 22, 764–775. doi:10.1016/j.gloenvcha.2012.04.001.
Gerbens-Leenes, W., Hoekstra, A. Y., and van der Meer, T. H. (2009). The water footprint of bioenergy. *Proceedings of the National Academy of Sciences* 106, 10219–10223. doi:10.1073/pnas.0812619106.
Ghosh, D., Sengers, F., Wieczorek, A. J., Ghosh, B., Roy, J., and Raven, R. (2016). "Urban mobility experiments in India and Thailand," in *The Experimental City*, eds. J. Evans, A. Karvonen, and R. Raven (Abingdon, UK and New York, USA: Routledge), 122–136.
Gibbs, M. (2016). Why is coastal retreat so hard to implement? Understanding the political risk of coastal adaptation pathways. *Ocean & Coastal Management*.
Gidden, M. J., Rao, N. D., Parkinson, S. C., and Riahi, K. Spatially explicit urban and rural poverty estimates under different global socioeconomic futures. *Nature Sustainability* submitted.
Gillard, R., Gouldson, A., Paavola, J., and Van Alstine, J. (2016). Transformational responses to climate change: beyond a systems perspective of social change in mitigation and adaptation. *Wiley Interdisciplinary Reviews: Climate Change* 7, 251–265. doi:10.1002/wcc.384.
Giwa, A., Alabi, A., Yusuf, A., and Olukan, T. (2017). A comprehensive review on biomass and solar energy for sustainable energy generation in Nigeria. *Renewable and Sustainable Energy Reviews* 69, 620–641. doi:10.1016/j.rser.2016.11.160.
Global Convergence of Land and Water Struggles (2016). Cooling the Planet: Frontline Communities lead the struggle. Amsterdam, Netherlands.
Godfrey-Wood, R., and Naess, L. O. (2016). Adapting to Climate Change: Transforming Development? *IDS Bulletin* 47. doi:10.19088/1968-2016.131.
Gorddard, R., Colloff, M. J., Wise, R. M., Ware, D., and Dunlop, M. (2016a). Values, rules and knowledge: adaptation as change in the decision context. *Environmental Science and Policy* 57, 60–69. doi:10.1016/j.envsci.2015.12.004.
Gorddard, R., Colloff, M. J., Wise, R. M., Ware, D., and Dunlop, M. (2016b). Values, rules and knowledge: Adaptation as change in the decision context. *Environmental Science and Policy* 57, 60–69. doi:10.1016/j.envsci.2015.12.004.
Gore, C. (2015). "Climate change adaptation and African cities: understanding the impact of government and governance on future action.," in *Rethinking the role of cities in the global climate regime*, eds. C. Johnson, N. Toly, and H. Schroeder (New York and London: Routledge), 205–226.
Gov of Vanuatu (2015). Vanuatu climate change and disaster risk reduction policy 2016-2030. Suva, Fiji.
Governance of Climate Change Finance Team (UNDP Bangkok Regional Hub) and Adelante (2015). Budgeting for climate change: how governments have used national budgets to articulate a response to climate change.
Government of Kenya (2012). Kenya's climate change action plan: low carbon climate resilient development pathway.
Government of Kiribati (2012). Kiribati development plan 2012-2015.
Government of Kiribati (2016). Kiribati development plan 2016-19.
Granderson, A. A. (2017). Value conflicts and the politics of risk: challenges in assessing climate change impacts and risk priorities in rural Vanuatu. *Climate and Development*, 1–14. doi:10.1080/17565529.2017.1318743.
Granoff, I., Eis, J., MacFarland, W., Hoy, C., Watson, C., Battista, G. de, et al. (2015). Zero poverty, zero emissions: Eradicating extreme poverty in the climate crisis. London, UK.
Grantham, R. W., and Rudd, M. A. (2017). Household susceptibility to hydrological change in the Lower Mekong Basin. *Natural Resources Forum* 41, 3–17. doi:10.1111/1477-8947.12113.
Grasseni, C., Forno, F., and Signori, S. (2013). Beyond alternative food networks: an agenda for comparative analysis of Italy's Solidarity Purchase Groups (GAS) and Districts of Solidarity Economy (DES) vis-à-vis US Community Economies. in *Potential and Limits of Social and Solidarity Economy, 6-8 May 2013, Geneva, Switzerland* (Geneva, Switzerland: United Nations Research Institute for Social Development (UNRISD)), 21.
Gray, E., Henninger, N., Reij, C., Winterbottom, R., and Agostini, P. (2016). Integrated landscape approaches for

Africa's drylands. Washington DC, USA doi:10.1596/978-1-4648-0826-5.
Griffiths, S. (2017). Renewable energy policy trends and recommendations for GCC countries. *Energy Transitions* 1, 3. doi:10.1007/s41825-017-0003-6.
Griggs, D., Stafford-Smith, M., Gaffney, O., Rockström, J., Ohman, M. C., Shyamsundar, P., et al. (2013). Policy: sustainable development goals for people and planet. *Nature* 495, 305–7. doi:10.1038/495305a.
Grill, G., Lehner, B., Lumsdon, A. E., MacDonald, G. K., Zarfl, C., and Liermann, C. R. (2015). An index-based framework for assessing patterns and trends in river fragmentation and flow regulation by global dams at multiple scales. *Environmental Research Letters* 10, 15001.
Grimm, N. B., Faeth, S. H., Golubiewski, N. E., Redman, C. L., Wu, J., Bai, X., et al. (2008). Global Change and the Ecology of Cities. *Science* 319, 756–760. doi:10.1126/science.1150195.
Griscom, B. W., Adams, J., Ellis, P. W., Houghton, R. A., Lomax, G., Miteva, D. A., et al. (2017). Natural climate solutions. *Proceedings of the National Academy of Sciences* 114, 11645–11650. doi:10.1073/pnas.1710465114.
Grist, N., Harvey, B., Lebidi, Z., SUR1M, BRICS, and PRESENCES (2017). Framing innovations for climate resilience for farmers in Sahel. *Resilience Intel* 9.
Grossmann, M., and Creamer, E. (2017). Assessing diversity and inclusivity within the Transition Movement: an urban case study. *Environmental Politics* 26, 161–182. doi:10.1080/09644016.2016.1232522.
Grottera, C., Pereira, A., and Lèbre La Rovere, E. (2015). Impacts of carbon pricing on income inequality in Brazil. *Climate and Development* 9, 80–93. doi:10.1080/17565529.2015.1067183.
Grubert, E. A., Stillwell, A. S., and Webber, M. E. (2014). Where does solar-aided seawater desalination make sense? A method for identifying sustainable sites. *Desalination* 339, 10–17.
Grubler, A., Bai, X., Buettner, T., Dhakal, S., Fisk, D., Ichinose, T., et al. (2012a). "Urban energy systems," in *Global Energy Assessment - Toward a Sustainable Future* (Cambride, MA, USA and New York, NY, USA: Cambridge University Press), 1307–1400.
Grubler, A., Bai, X., Buettner, T., Dhakal, S., Fisk, D. J., Ichinose, T., et al. (2012b). "Chapter 18: Urban energy systems," in *Global Energy Assessment - Toward a Sustainable Future* (Cambridge University Press, Cambridge, UK and New York, NY, USA and the International Institute for Applied Systems Analysis), 1307–1400.
Grubler, A., Wilson, C., Bento, N., Boza-Kiss, B., Krey, V., McCollum, D. 3, et al. A global scenario of low energy demand for sustainable development below 1.5°C without negative emission technologies. submitted.
Gupta, J., and Arts, K. (2017a). Achieving the 1.5 °C objective: just implementation through a right to (sustainable) development approach. *International Environmental Agreements: Politics, Law and Economics*. doi:10.1007/s10784-017-9376-7.
Gupta, J., and Arts, K. (2017b). Achieving the 1.5 °C objective: just implementation through a right to (sustainable) development approach. *International Environmental Agreements: Politics, Law and Economics*. doi:10.1007/s10784-017-9376-7.
Gupta, J., and Pouw, N. (2017). Towards a trans-disciplinary conceptualization of inclusive development. *Current Opinion in Environmental Sustainability* 24, 96–103. doi:10.1016/j.cosust.2017.03.004.
Gustafson, S., Joehl Cadena, A., and Hartman, P. (2016). Adaptation planning in the Lower Mekong Basin: merging scientific data with local perspective to improve community resilience to climate change. *Climate and Development*, 1–15. doi:10.1080/17565529.2016.1223593.
Gustafson, S., Joehl Cadena, A., Ngo, C. C., Kawash, A., Saenghkaew, I., and Hartman, P. (2017). Merging science into community adaptation planning processes: a cross-site comparison of four distinct areas of the Lower Mekong Basin. *Climatic Change*, 1–16. doi:10.1007/s10584-016-1887-7.
Gwimbi, P. (2017). Mainstreaming national adaptation programmes of action into national development plans in Lesotho: lessons and needs. *International Journal of Climate Change Strategies and Management* 9, 299–315. doi:10.1108/IJCCSM-11-2015-0164.
Haasnoot, M., Kwakkel, J. H., Walker, W. E., and ter Maat, J. (2013). Dynamic adaptive policy pathways: A method for crafting robust decisions for a deeply uncertain world. *Global Environmental Change* 23, 485–498. doi:10.1016/j.gloenvcha.2012.12.006.
Haberi, H. (2015). "The growing role of biomass for future resource supply: prospects and pitfalls," in *Sustainability assessment of renewables-based products: methods and case studies*, eds. J. Dewulf, S. De Meester, and R. A. F. Alvarenga (Chichester, West Sussex, UK: John Wiley & Sons Ltd). doi:0.1002/9781118933916.ch1.
Haglund, E., Ndjeunga, J., Snook, L., and Pasternak, D. (2011). Dry land tree management for improved household livelihoods: farmer managed natural regeneration in Niger. *Journal of Environmental Management* 92, 1696–1705. doi:10.1016/j.jenvman.2011.01.027.
Hahn, T., McDermott, C., Ituarte-Lima, C., Schultz, M., Green, T., and Tuvendal, M. (2015). Purposes and degrees of commodification: economic instruments for biodiversity and ecosystem services need not rely on markets or monetary valuation. *Ecosystem Services* 16, 74–82. doi:10.1016/j.ecoser.2015.10.012.
Haider, L. J., Boonstra, W. J., Peterson, G. D., and Schlüter, M. (2017). Traps and sustainable development in rural areas: a review. *World Development* xx. doi:10.1016/j.worlddev.2017.05.038.
Haileslassie, A., Hagos, F., Mapedza, E., Claudia, S., Awulachew, S. B., Gebreselassie, S., et al. (2008). Institutional

settings and livelihood strategies in the Blue Nile Basin: implications for upstream/downstream linkages. Colombo, Sri Lanka.
Haines, A., Smith, K. R., Anderson, D., Epstein, P. R., McMichael, A. J., Roberts, I., et al. (2007). Policies for accelerating access to clean energy, improving health, advancing development, and mitigating climate change. *The Lancet* 370, 1264–1281. doi:10.1016/S0140-6736(07)61257-4.
Hajer, M., Nilsson, M., Raworth, K., Bakker, P., Berkhout, F., de Boer, Y., et al. (2015). Beyond cockpit-ism: Four insights to enhance the transformative potential of the sustainable development goals. *Sustainability* 7. doi:10.3390/su7021651.
Hale, T. (2016). "All hands on deck": the Paris Agreements and nonstate climate action. *Global Environmental Politics* 16. doi:10.1162/GLEP_a_00362.
Hallegatte, S., Bangalore, M., Bonzanigo, L., Fay, M., Kane, T., Narloch, U., et al. (2016a). *Shock Waves: Managing the Impacts of Climate Change on Poverty*. Washington, DC, USA: The World Bank doi:10.1596/978-1-4648-0673-5.
Hallegatte, S., Bangalore, M., Bonzanigo, L., Fay, M., Kane, T., Narloch, U., et al. (2016b). *Shock Waves: Managing the Impacts of Climate Change on Poverty*. Washington, DC, USA: The World Bank.
Hallegatte, S., Bangalore, M., Bonzanigo, L., Fay, M., Kane, T., Narloch, U., et al. (2016c). *Shock Waves: Managing the Impacts of Climate Change on Poverty*. Washington, DC, USA: The World Bank doi:10.1596/978-1-4648-0673-5.
Hallegatte, S., Bangalore, M., Bonzanigo, L., Fay, M., Narloch, U., and Rozenberg, J. (2014). *Climate change and poverty: an analytical framework*. World Bank Group: Washington, D. C doi:10.1596/1813-9450-7126.
Hallegatte, S., and Rozenberg, J. (2017). Climate change through a poverty lens. *Nature Climate Change* 7, 250–256. doi:10.1038/nclimate3253.
Hallegatte, S., Vogt-Schilb, A., Bangalore, M., and Rozenberg, J. (2017). Unbreakable: Building the Resilience of the Poor in the Face of Natural Disasters. Washington, DC, USA.
Halonen, M., Illman, J., Klimscheffskij, M., and Sjoblom, H. (2017). *Mobilizing climate finance flows: Nordic approaches and opportunities*. Nordic Council of Ministers.
Hanasaki, N., Fujimori, S., Yamamoto, T., Yoshikawa, S., Masaki, Y., Hijioka, Y., et al. (2013). A global water scarcity assessment under Shared Socio-economic Pathways - Part 2: Water availability and scarcity. *Hydrol. Earth Syst. Sci.* 17, 2393–2413. doi:10.5194/hess-17-2393-2013.
Handmer, J., and Iveson, H. (2017). Cyclone Pam in Vanuatu: Leanring from the low death toll. *Australian Institute for Disaster Resilience* 22.
Hansen, G., Stone, D., Auffhammer, M., Huggel, C., and Cramer, W. (2016). Linking local impacts to changes in climate: a guide to attribution. *Regional Environmental Change* 16, 527–541. doi:10.1007/s10113-015-0760-y.
Harlan, S. L., Pellow, D. N., and Roberts, J. T. (2017). "Climate Justice and inequality," in *Climate Change and Society: Sociological Perspectives*, eds. R. E. Dunlap and R. J. Brulle (Oxford University Press).
Harrington, L. J., Frame, D. J., Fischer, E. M., Hawkins, E., Joshi, M., and Jones, C. D. (2016). Poorest countries experience earlier anthropogenic emergence of daily temperature extremes. *Environmental Research Letters* 11, 1–8. doi:10.1088/1748-9326/11/5/055007.
Hasegawa, T., Fujimori, S., Shin, Y., Takahashi, K., Masui, T., and Tanaka, A. (2014). Climate change impact and adaptation assessment on food consumption utilizing a new scenario framework. *Environmental Science and Technology* 48, 438–445. doi:10.1021/es4034149.
Hasegawa, T., Fujimori, S., Shin, Y., Tanaka, A., Takahashi, K., and Masui, T. (2015). Consequence of climate mitigation on the risk of hunger. *Environmental Science & Technology* 49, 7245–7253. doi:10.1021/es5051748.
Hashemi, S., Bagheri, A., and Marshall, N. (2017). Toward sustainable adaptation to future climate change: insights from vulnerability and resilience approaches analyzing agrarian system of Iran. *Environment, Development and Sustainability* 19, 1–25.
Hatfield-Dodds, S., Schandl, H., Adams, P. D., Baynes, T. M., Brinsmead, T. S., Bryan, B. A., et al. (2015). Australia is "free to choose" economic growth and falling environmental pressures. *Nature* 527, 49–53. doi:10.1038/nature16065.
Haves, E. (2012). Does energy access affect women? Beyond anecdotes: a review of the evidence. London.
Havlík, P., Valin, H., Gusty, M., Schmid, E., Leclère, D., Forsell, N., et al. (2015). Climate Change Impacts and Mitigation in the Developing World - An Integrated Assessment of the Agriculture and Forestry Sectors. doi:10.13140/RG.2.1.3470.2803.
Havlík, P., Valin, H., Herrero, M., Obersteiner, M., Schmid, E., Rufino, M. C., et al. (2014). Climate change mitigation through livestock system transitions. *Proceedings of the National Academy of Sciences of the United States of America* 111, 3709–14. doi:10.1073/pnas.1308044111.
Haxeltine, A., and Seyfang, G. (2009). Transitions for the people: theory and practice of "transition" and "resilience" in the UK's Transition Movement.
Hayashi, A., Akimoto, F., Sano, F., and Tomoda, T. (2015). Evaluation of global energy crop production potential up to 2100 under socioeconomic development and climate change scenarios. *Journal of the Japan Institute of Energy*

94, 548–554. doi:doi.org/10.3775/jie.94.548.
Häyhä, T., Lucas, P. L., van Vuuren, D. P., Cornell, S. E., and Hoff, H. (2016). From Planetary Boundaries to national fair shares of the global safe operating space — How can the scales be bridged? *Global Environmental Change* 40, 60–72. doi:10.1016/j.gloenvcha.2016.06.008.
Hayward, B. (2017). *Sea change: climate politics and New Zealand*. Wellington, NZ: Bridget Williams Books.
Healy, N., and Barry, J. (2017). Politicizing energy justice and energy system transitions: Fossil fuel divestment and a "just transition." *Energy Policy* 108, 451–459. doi:10.1016/j.enpol.2017.06.014.
Heard, B. P., Brook, B. W., Wigley, T. M. L., and Bradshaw, C. J. . (2017). Burden of proof: A comprehensive review of the feasibility of 100% renewable-electricity systems. *Renewable and Sustainable Energy Reviews* 76, 1122–1133. doi:10.1016/J.RSER.2017.03.114.
Heede, R. (2014). Tracing anthropogenic carbon dioxide and methane emissions to fossil fuel and cement producers, 1854-2010. *Climatic Change* 122, 229–241. doi:10.1007/s10584-013-0986-y.
Hejazi, M. I., Edmonds, J., Clarke, L., Kyle, P., Davies, E., Chaturvedi, V., et al. (2013). Integrated assessment of global water scarcity over the 21st century – Part 2: Climate change mitigation policies. *Hydrol. Earth Syst. Sci. Discuss.* 2013, 3383–3425. doi:10.5194/hessd-10-3383-2013.
Hejazi, M. I., Voisin, N., Liu, L., Bramer, L. M., Fortin, D. C., Hathaway, J. E., et al. (2015). 21st century United States emissions mitigation could increase water stress more than the climate change it is mitigating. *Proceedings of the National Academy of Sciences of the United States of America* 112. doi:10.1073/pnas.1421675112.
Helliwell, J. F., Layard, R., and Sachs, J. (2013). World Happiness Report 2013: Trends, Explanations, and Distribution. New York doi:10.1093/acprof:oso/978099732739.001.0001.
Heltberg, R., Gitay, H., and Prabhu, R. G. (2012). Community-based adaptation: lessons from a grant competition. *Climate Policy* 12, 143–163. doi:10.1080/14693062.2011.582344.
Hemstock, S. (2017). "A case for formal education in technical vocational education and training for climate change adapatation and disaster risk reduction in the Pacific Islands region," in *Climate Change Adapation in Pacific Countries : fostering Resilience and Improving the quality of life*, ed. W. Filho (Cham, Switzerland: Springer Nature), 309–324.
Herold, N., Alexander, L., Green, D., and Donat, M. (2017). Greater increases in temperature extremes in low versus high income countries. *Environmental Research Letters* 12, 34007. doi:10.1088/1748-9326/aa5c43.
Herrero, M., Henderson, B., Havlík, P., Thornton, P. K., Conant, R. T., Smith, P., et al. (2016). Greenhouse gas mitigation potentials in the livestock sector. *Nature Climate Change* 6, 452–461. doi:10.1038/nclimate2925.
Hess, J. J., Mcdowell, J. Z., and Luber, G. (2012). Integrating climate change adaptation into public health practice: using adaptive management to increase adaptive capacity and build resilience. *Environmental Health Perspectives* 120, 171–179.
Heyward, C., and Roser, D. (2016). *Climate justice in a non-ideal world*. Oxford UK: Oxford University Press.
Hiç, C., Pradhan, P., Rybski, D., and Kropp, J. P. (2016). Food Surplus and Its Climate Burdens. *Environmental Science and Technology* 50, 4269–4277. doi:10.1021/acs.est.5b05088.
High-Level Commission on Carbon Prices (2017). Report of the high-level commission on carbon prices. Washington DC.
Hildingsson, R., and Johansson, B. (2015). Governing low-carbon energy transitions in sustainable ways: potential synergies and conflicts between climate and environmental policy objectives. *Energy Policy*88, 245–252. doi:10.1016/j.enpol.2015.10.029.
Hiremath, R., Kumar, B., Bansode, S. S., Nulkar, G., Patil, S. S., and Murali, J. (2016). Industrial Wastewater Management in the Context of Climate Change Adaptation in Selected Cities of India: A Business Approach. *Reconsidering the Impact of Climate Change on Global Water Supply, Use, and Management*, 294.
Hirth, L., and Ueckerdt, F. (2013). Redistribution effects of energy and climate policy: The electricity market. *Energy Policy* 62, 934–947. doi:10.1016/j.enpol.2013.07.055.
Hoegh-Guldberg, O., Cai, R., Poloczanska, E. S., Brewer, P. G., Sundby, S., Hilmi, K., et al. (2014). "The Ocean," in *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel of Climate Change*, eds. V. R. Barros, C. B. Field, D. J. Dokken, M. D. Mastrandrea, K. J. Mach, T. E. Bilir, et al. (Cambridge, UK and New York, NY, USA: Cambridge University Press), 1655–1731.
Hof, A. F., den Elzen, M. G. J., Admiraal, A., Roelfsema, M., Gernaat, D. E. H. J., and van Vuuren, D. P. (2017). Global and regional abatement costs of Nationally Determined Contributions (NDCs) and of enhanced action to levels well below 2C and 1.5C. *Environmental Science and Policy* 71, 30–40. doi:10.1016/j.envsci.2017.02.008.
Holden, E., Linnerud, K., and Banister, D. (2016). The Imperatives of Sustainable Development. *Sustainable Development* 25, 213–226. doi:10.1002/sd.1647.
Holland, B. (2017). Procedural justice in local climate adaptation: political capabilities and transformational change. *Environmental Politics* 26, 391–412. doi:10.1080/09644016.2017.1287625.
Holz, C., Kartha, S., and Athanasiou, T. (2017). Fairly sharing 1.5: national fair shares of a 1.5 °C-compliant global mitigation effort. *International Environmental Agreements: Politics, Law and Economics*. doi:10.1007/s10784-

017-9371-z.
Horton, R. (2014). Why the sustainable development goals will fail. *The Lancet* 383, 2196. doi:10.1016/S0140-6736(14)61046-1.
Howarth, C., and Monasterolo, I. (2017). Opportunities for knowledge co-production across the energy-food-water nexus: making interdisciplinary approaches work for better climate decision making. *Environmental Science and Policy* 75, 103–110. doi:10.1016/j.envsci.2017.05.019.
Huang, S. L., Yeh, C. T., and Chang, L. F. (2010). The transition to an urbanizing world and the demand for natural resources. *Current Opinion in Environmental Sustainability* 2, 136–143. doi:10.1016/j.cosust.2010.06.004.
Huang, W., Wilkes, A., Sun, X., and Terheggen, A. (2013). Who is importing forest products from Africa to China? An analysis of implications for initiatives to enhance legality and sustainability. *Environment, Development and Sustainability* 15, 339–354. doi:10.1007/s10668-012-9413-1.
Hughes, S., Chu, E. K., and Mason, S. G. (2018). *Climate Change in Cities: Innovations in Multi-Level Governance*. Cham: Springer.
Hult, A., and Larsson, J. (2016). Possibilities and problems with applying a consumption perspective in local climate strategies - the case of Gothenburg, Sweden. *Journal of Cleaner Production* 134, 434–442. doi:10.1016/j.jclepro.2015.10.033.
Hunsberger, C., Bolwig, S., Corbera, E., and Creutzig, F. (2014). Livelihood impacts of biofuel crop production: implications for governance. *Geoforum* 54, 248–260. doi:10.1016/j.geoforum.2013.09.022.
Huq, N., Bruns, A., Ribbe, L., and Huq, S. (2017). Mainstreaming ecosystem services based climate change adaptation (EbA) in bangladesh: status, challenges and opportunities. *Sustainability* 9, 926. doi:10.3390/su9060926.
Huxham, M., Emerton, L., Kairo, J., Munyi, F., Abdirizak, H., Muriuki, T., et al. (2015). Applying Climate Compatible Development and economic valuation to coastal management: a case study of Kenya's mangrove forests. *Journal of Environmental Management* 157, 168–181. doi:10.1016/j.jenvman.2015.04.018.
Hwang, J., Joh, K., and Woo, A. (2017). Social inequalities in child pedestrian traffic injuries: Differences in neighborhood built environments near schools in Austin, TX, USA. *Journal of Transport and Health* 6, 40–49. doi:10.1016/j.jth.2017.05.003.
Ickowitz, A., Sills, E., and de Sassi, C. (2017). Estimating smallholder opportunity costs of REDD+: a pantropical analysis from households to carbon and back. *World Development* 95, 15–26. doi:https://doi.org/10.1016/j.worlddev.2017.02.022.
ICSU (2017). A Guide to SDG interactions: From Science to Implementation. doi:10.24948/2017.01.
IEA (2016). World Energy Outlook Special Report: Energy and Air Pollution. Paris, France.
IFAD (2016). Republic of Uganda: Project for the Restoration of Livelihoods in the Northern Region (PRELNOR). Rome, Italy.
Ihalainen, M., Basnett, B. S., Larson, A., Duchelle, A., Thuy, P. T., and Djoudi, H. (2017). What should be included in the Green Climate Fund ' s new Gender Policy and Action Plan? Lessons from CIFOR's research and analyses. doi:10.17528/cifor/006541.
IMF (2017). The effects of weather shocks on economic activity: how can low-income countries cope? International Monetary Fund.
Immerzeel, W. W., van Beek, L. P. H., and Bierkens, M. F. P. (2010). Climate Change Will Affect the Asian Water Towers. *Science* 328, 1382–1385. doi:10.1126/science.1183188.
Inger, R., Attrill, M. J., Bearhop, S., Broderick, A. C., James Grecian, W., Hodgson, D. J., et al. (2009). Marine renewable energy: potential benefits to biodiversity? An urgent call for research. *Journal of Applied Ecology* 46, 1145–1153. doi:10.1111/j.1365-2664.2009.01697.x.
Ingram, J. (2011). A food systems approach to researching food security and its interactions with global environmental change. *Food Security* 3, 417–431. doi:10.1007/s12571-011-0149-9.
IPCC (2014a). Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. , eds. Core Writing Team., R. K. Pachauri, and L. A. Meyer Geneva, Switzerland: IPCC doi:10.1017/CBO9781107415324.
IPCC (2014b). "Summary for Policymakers," in *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*, eds. C. B. Field, V. R. Barros, D. J. Dokken, K. J. Mach, M. D. Mastrandrea, T. E. Bilir, et al. (Cambridge, UK and New York, NY, USA: Cambridge University Press), 1–32.
IPCC (2014c). "Summary for Policymakers," in *Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*, eds. O. Edenhofer, R. Pichs-Madruga, Y. Sokona, E. Farahani, S. Kadner, K. Seyboth, et al. (Cambridge, UK and New York, NY, USA.: Cambridge University Press), 1–30.
IRENA (2016). Renewable energy market analysis: the GCC region. Abu Dhabi.
IRP (2016). Food systems and natural resources. A report of the Working Group of the International Resource Panel.
Isaac, M. E., Erickson, B. H., Quashie-sam, S. J., and Timmer, V. R. (2007). Transfer of knowledge on agroforestry management practices the structure of farmer advice networks. *Ecology and Society* 12, 32.

Ishida, H., Kobayashi, S., Kanae, S., Hasegawa, T., Fujimori, S., Shin, Y., et al. (2014). Global-scale projection and its sensitivity analysis of the health burden attributable to childhood undernutrition under the latest scenario framework for climate change research. *Environmental Research Letters* 9. doi:10.1088/1748-9326/9/6/064014.

Islam, M. R., and Shamsuddoha, M. (2017). Socioeconomic consequences of climate induced human displacement and migration in Bangladesh. *International Sociology* 32, 277–298. doi:10.1177/0268580917693173.

Ismailos, C., and Touchie, M. F. (2017). Achieving a low carbon housing stock : An analysis of low-rise residential carbon reduction measures for new construction in Ontario. *Building and Environment* 126, 176–183. doi:10.1016/j.buildenv.2017.09.034.

Jackson, T., and Senker, P. (2011). Prosperity without growth: Economics for a finite planet. *Energy & Environment* 22, 1013–1016.

Jägermeyr, J., Pastor, A., Biemans, H., and Gerten, D. (2017). Reconciling irrigated food production with environmental flows for Sustainable Development Goals implementation. *Nature Communications* 8, 1–9. doi:10.1038/ncomms15900.

Jaglin, S. (2014). "Regulating service delivery in southern cities: rethinking urban heterogeneity.," in *In Parnell, S.and Oldfield, S. (eds) The Routledge handbook on cities of the global South. London: Routledge*.

Jakob, M., Chen, C., Fuss, S., Marxen, A., and Edenhofer, O. (2015). Development incentives for fossil fuel subsidy reform. *Nature Climate Change* 5, 709–712.

Jakob, M., Chen, C., Fuss, S., Marxen, A., Rao, N. D., and Edenhofer, O. (2016). Carbon Pricing Revenues Could Close Infrastructure Access Gaps. *World Development* 84, 254–265. doi:10.1016/j.worlddev.2016.03.001.

Jakob, M., and Steckel, J. C. (2014). How climate change mitigation could harm development in poor countries. *Wiley Interdisciplinary Reviews: Climate Change* 5, 161–168. doi:10.1002/wcc.260.

Jakob, M., and Steckel, J. C. (2016). Implications of climate change mitigation for sustainable development. *Environmental Research Letters* 11. doi:10.1088/1748-9326/11/10/104010.

Jamieson, D. (2015). Two cheers for climate justice. *Social Research* 82, 791–809.

Janetos, A. C., Malone, E., Mastrangelo, E., Hardee, K., and de Bremond, A. (2012). Linking climate change and development goals: framing, integrating, and measuring. *Climate and Development* 4, 141–156. doi:10.1080/17565529.2012.726195.

Janif, S., Nunn, P., Geraghty, P., Aalbersberg, W., Thomas, F., and Camailakeba, M. (2016). Value of traditional oral narratives in building climate-change resilience: insights from rural communities in Fiji. *Ecology and Society* 21, 7 ff.

Jeans, H., Oglethorpe, J., Phillips, J., and Reid, H. (2014). "The role of ecosystems in climate change adaptation: Lessons for scaling up," in *Community-based adaptation to climate change: Scaling it up*, eds. J. Ayers, E. L. F. Schipper, H. Reid, S. Huq, and A. Rahman (Abingdon, UK and New York, USA: Routledge).

Jensen, T., Holtz, G., Baedeker, C., and Chappin, É. J. L. (2016). Energy-efficiency impacts of an air-quality feedback device in residential buildings : An agent-based modeling assessment. *Energy & Buildings* 116, 151–163. doi:10.1016/j.enbuild.2015.11.067.

Jha, C. K., Gupta, V., Chattopadhyay, U., and Amarayil Sreeraman, B. (2017a). Migration as adaptation strategy to cope with climate change. *International Journal of Climate Change Strategies and Management*, IJCCSM-03-2017-0059. doi:10.1108/IJCCSM-03-2017-0059.

Jha, S. K., Mishra, S., Sinha, B., Alatalo, J. M., and Pandey, R. (2017b). Rural development program in tribal region: A protocol for adaptation and addressing climate change vulnerability. *Journal of Rural Studies* 51, 151–157. doi:10.1016/j.jrurstud.2017.02.013.

Jobbins, G., Doczi, J., and Wilkinson, E. (2013). Climate adaptation and resilience in coastal zones resilience to disasters and.

Johannessen, S. C., and Macdonald, R. W. (2016). Geoengineering with seagrasses: is credit due where credit is given? *Environmental Research Letters* 11, 113001. doi:10.1088/1748-9326/11/11/113001.

Johansson, E. L., Fader, M., Seaquist, J. W., and Nicholas, K. A. (2016). Green and blue water demand from large-scale land acquisitions in Africa. *Proceedings of the National Academy of Sciences of the United States of America* 113, 11471–11476. doi:10.1073/pnas.1524741113.

Johnson, C. A. (2018). "Cities as Saviours? The Global Politics of Urban Climate Mitigation," in *The Power of Cities in Global Climate Politics* (London: Palgrave Macmillan), 49–90.

Johnson, N., Burek, P., Parkinson, S., Edward, B., Flörke, M., Havlik, P., et al. Integrated assessment of the land-energy-water nexus: status, challenges and research opportunities. *Environmental Research Letters* submitted.

Johnson, N., Krey, V., McCollum, D. L., Rao, S., Riahi, K., and Rogelj, J. (2015). Stranded on a low-carbon planet: implications of climate policy for the phase-out of coal-based power plants. *Technological Forecasting and Social Change* 90, 89–102. doi:10.1016/j.techfore.2014.02.028.

Jones, H. P., Hole, D. G., and Zavaleta, E. S. (2012). Harnessing nature to help people adapt to climate change. *Nature Climate Change* 2, 504–509. doi:10.1038/nclimate1463.

Jordaan, S. M., Romo-Rabago, E., McLeary, R., Reidy, L., Nazari, J., and Herremans, I. M. (2017). The role of energy technology innovation in reducing greenhouse gas emissions: a case study of Canada. *Renewable and Sustainable*

Energy Reviews 78, 1397–1409. doi:10.1016/j.rser.2017.05.162.
Jordan, A., and Lenschow, A. (2010). Environmental Policy Integration: a State of the Art Review. *Environmental Policy and Governance Env. Pol. Gov* 20, 147–158. doi:10.1002/eet.539.
Jorgenson, A. K. (2015). Inequality and the carbon intensity of human well-being. *Journal of Environmental Studies and Sciences* 5, 277–282. doi:10.1007/s13412-015-0234-z.
Joshi, P. K., Jha, A. K., Wani, S. P., Joshi, L., and Shiyani, R. L. (2005). Meta-analysis to assess impact of watershed program and people's participation. Colombo, Sri Lanka.
Juhola, S., Glaas, E., Linnér, B.-O., and Neset, T.-S. (2016). Redefining maladaptation. *Environmental Science & Policy* 55, 135–140. doi:10.1016/j.envsci.2015.09.014.
Kaczan, D., Arslan, A., and Lipper, L. (2013). Climate-smart agriculture? A review of current practice of agroforestry and conservation agriculture in Malawi and Zambia.
Kagawa, S., Suh, S., Hubacek, K., Wiedmann, T., Nansai, K., and Minx, J. (2015). CO2 emission clusters within global supply chain networks: Implications for climate change mitigation. *Global Environmental Change* 35, 486–496. doi:10.1016/j.gloenvcha.2015.04.003.
Kaijser, A., and Kronsell, A. (2014). Climate change through the lens of intersectionality. *Environmental Politics* 23, 417–433. doi:10.1080/09644016.2013.835203.
Kalafatis, S. (2017). Identifying the potential for Climate Compatible Development efforts and the missing links. *Sustainability* 9, 1642. doi:10.3390/su9091642.
Kanter, D. R., Musumba, M., Wood, S. L. R., Palm, C., Antle, J., Balvanera, P., et al. (2016). Evaluating agricultural trade-offs in the age of sustainable development. *Agricultural Systems*. doi:10.1016/j.agsy.2016.09.010.
Karlsson, L., Naess, L. O., Nightingale, A., and Thompson, J. (2017). "Triple wins" or "triple faults"? Analysing the equity implications of policy discourses on climate-smart agriculture (CSA). *The Journal of Peasant Studies*, 1–25. doi:10.1080/03066150.2017.1351433.
Karmalkar, A. V., Bradley, R. S., Vliet, J. van, Berg, M. van den, Schaeffer, M., Vuuren, D. van, et al. (2017). Consequences of Global Warming of 1.5 °C and 2 °C for Regional Temperature and Precipitation Changes in the Contiguous United States. *PLOS ONE* 12, e0168697. doi:10.1371/journal.pone.0168697.
Karner, K., Theissing, M., and Kienberger, T. (2015). Energy efficiency for industries through synergies with urban areas. *Journal of Cleaner Production* 2020, 1–11. doi:10.1016/j.jclepro.2016.02.010.
Kartha, S., Athanasiou, T., Caney, S., Cripps, E., Dooley, K., Dubash, N. K., et al. Inequitable mitigation: cascading biases against poorer countries. submitted.
Kassie, M., Teklewold, H., Jaleta, M., Marenya, P., and Erenstein, O. (2015). Understanding the adoption of a portfolio of sustainable intensification practices in eastern and southern Africa. *Land Use Policy* 42, 400–411. doi:10.1016/j.landusepol.2014.08.016.
Kato, E., Ringler, C., Yesuf, M., and Bryan, E. (2011). Soil and water conservation technologies: A buffer against production risk in the face of climate change? Insights from the Nile basin in Ethiopia. *Agricultural Economics* 42, 593–604. doi:10.1111/j.1574-0862.2011.00539.x.
Kaygusuz, K. (2011). Energy services and energy poverty for sustainable rural development. *Renewable and Sustainable Energy Reviews* 15, 936–947. doi:10.1016/j.rser.2010.11.003.
Keairns, D. L., Darton, R. C., and Irabien, A. (2016). The energy-water-food nexus. *Annual Review of Chemical and Biomolecular Engineering* 7, 239–262. doi:10.1146/annurev-chembioeng-080615-033539.
Kelman, I. (2017). Linking disaster risk reduction, climate change, and the sustainable development goals. *Disaster Prevention and Management: An International Journal* 26, 254–258. doi:10.1108/DPM-02-2017-0043.
Kenis, A. (2016). Ecological citizenship and democracy: Communitarian versus agonistic perspectives. *Environmental Politics* 4016, 1–22. doi:10.1080/09644016.2016.1203524.
Kenis, A., and Mathijs, E. (2014). (De)politicising the local: The case of the Transition Towns movement in Flanders (Belgium). *Journal of Rural Studies* 34, 172–183. doi:10.1016/j.jrurstud.2014.01.013.
Keohane, R. O., and Victor, D. G. (2016). Cooperation and discord in global climate policy. *Nature Climate Change* 6. doi:10.1038/nclimate2937.
Kerssen, T. M. (2015). Food sovereignty and the quinoa boom: challenges to sustainable re-peasantisation in the southern Altiplano of Bolivia. *Third World Quarterly* 36, 489–507. doi:10.1080/01436597.2015.1002992.
Keshri, K., and Bhagat, R. B. (2013). Socioeconomic determinants of temporary labour migration in India. *Asian Population Studies* 9, 175–195. doi:10.1080/17441730.2013.797294.
Khanna, N., Fridley, D., and Hong, L. (2014). China's pilot low-carbon city initiative: A comparative assessment of national goals and local plans. *Sustainable Cities and Society* 12, 110–121. doi:10.1016/j.scs.2014.03.005.
Khreis, H., May, A. D., and Nieuwenhuijsen, M. J. (2017). Health impacts of urban transport policy measures: a guidance note for practice. *Journal of Transport & Health* 6, 209–227. doi:10.1016/j.jth.2017.06.003.
Kim, S.-Y., and Thurbon, E. (2015). Developmental Environmentalism. *Politics & Society* 43, 213–240. doi:10.1177/0032329215571287.
Kim, Y., Smith, J. B., Mack, C., Cook, J., Furlow, J., Njinga, J.-L., et al. (2017). A perspective on climate-resilient development and national adaptation planning based on USAID's experience. *Climate and Development* 9, 141–

151. doi:10.1080/17565529.2015.1124037.
King, A. D., Karoly, D. J., and Henley, B. J. (2017). Australian climate extremes at 1.5 °C and 2 °C of global warming. *Nature Clim. Change* 7, 412–416. doi:10.1038/nclimate3296.
Kirubi, C., Jacobson, A., Kammen, D. M., and Mills, A. (2009). Community-Based Electric Micro-Grids Can Contribute to Rural Development: Evidence from Kenya. *World Development* 37, 1208–1221. doi:10.1016/j.worlddev.2008.11.005.
Klausbruckner, C., Annegarn, H., Henneman, L. R. F., and Rafaj, P. (2016). A policy review of synergies and trade-offs in South African climate change mitigation and air pollution control strategies. *Environmental Science & Policy* 57, 70–78. doi:10.1016/j.envsci.2015.12.001.
Klein, R. J. T., Midgley, G. F., Preston, B. L., Alam, M., Berkhout, F. G. H., Dow, K., et al. (2014). "Adaptation opportunities, constraints, and limits," in *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*, eds. S. M. Field, C.B., V.R. Barros, D.J. Dokken, K.J. Mach, M.D. Mastrandrea, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy and and L. L. W. P.R. Mastrandrea (Cambride, MA, USA and New York, NY, USA: Cambridge University Press), 899–943. doi:10.1017/CBO9780511807756.003.
Klinsky, S., Roberts, T., Huq, S., Okereke, C., Newell, P., Dauvergne, P., et al. (2017a). Why equity is fundamental in climate change policy research. *Global Environmental Change* 44, 170–173. doi:10.1016/j.gloenvcha.2016.08.002.
Klinsky, S., Waskow, D., Northrop, E., and Bevins, W. (2017b). Operationalizing equity and supporting ambition: identifying a more robust approach to "respective capabilities." *Climate and Development* 9, 1–11. doi:10.1080/17565529.2016.1146121.
Klopp, J. M., and Petretta, D. L. (2017). The urban sustainable development goal: Indicators, complexity and the politics of measuring cities. *Cities* 63, 92–97. doi:10.1016/J.CITIES.2016.12.019.
Köhlin, G., Sills, E. O., Pattanayak, S. K., and Wilfong, C. (2011). Energy, Gender and Development: What are the Linkages? Where is the Evidence? Washington, DC, USA.
Kongsager, R., and Corbera, E. (2015). Linking mitigation and adaptation in carbon forestry projects: Evidence from Belize. *World Development* 76, 132–146. doi:10.1016/j.worlddev.2015.07.003.
Kongsager, R., Locatelli, B., and Chazarin, F. (2016). Addressing climate change mitigation and adaptation together: a global assessment of agriculture and forestry projects. *Environmental Management* 57, 271–282. doi:10.1007/s00267-015-0605-y.
Kraaijenbrink, P. D. A., Bierkens, M. F. P., Lutz, A. F., and Immerzeel, W. W. (2017). Impact of a global temperature rise of 1.5 degrees Celsius on Asia's glaciers. *Nature* 549, 257–260. doi:10.1038/nature23878.
Krey, V., Riahi, K., Hasegawa, T., Luderer, G., Ohashi, H., Parkinson, S., et al. Implications of the Paris Agreement for achieving the Sustainable Development Goals. *Nature Climate Change* submitted.
Kriegler, E., Bertram, C., Kuramochi, T., Jakob, M., Pehl, M., Höhne, N., et al. Short term policies to keep the door open for Paris climate goals. *Nature Climate Change* submitted.
Kumar, P., Masago, Y., Mishra, B. K., Jalilov, S., Emam, A. R., Kefi, M., et al. (2017). Current assessment and future outlook for water resources considering climate change and a population burst: A case study of Ciliwung River, Jakarta City, Indonesia. *Water (Switzerland)* 9. doi:10.3390/w9060410.
Kummu, M., de Moel, H., Porkka, M., Siebert, S., Varis, O., and Ward, P. J. (2012). Lost food, wasted resources: global food supply chain losses and their impacts on freshwater, cropland, and fertiliser use. *Sci Total Environ* 438, 477–489. doi:10.1016/j.scitotenv.2012.08.092.
Kuruppu, N., and Willie, R. (2015). Barriers to reducing climate enhanced disaster risks in least developed country-small islands through anticipatory adaptation. *Weather and Climate Extremes* 7, 72–83. doi:10.1016/j.wace.2014.06.001.
Kusumaningtyas, S. D. A., and Aldrian, E. (2016). Impact of the June 2013 Riau province Sumatera smoke haze event on regional air pollution. *Environmental Research Letters* 11. doi:10.1088/1748-9326/11/7/075007.
La Rovere, E. L. (2017). Low-carbon development pathways in Brazil and "Climate Clubs." *Wiley Interdisciplinary Reviews: Climate Change* 8, 1–7. doi:10.1002/wcc.439.
Lade, S. J., Haider, L. J., Engström, G., and Schlüter, M. (2017). Resilience offers escape from trapped thinking on poverty alleviation. *Science Advances* 3, e1603043. doi:10.1126/sciadv.1603043.
Lahn, B. (2017). In the light of equity and science: scientific expertise and climate justice after Paris. *International Environmental Agreements: Politics, Law and Economics*. doi:10.1007/s10784-017-9375-8.
Lain, J. (2017). Resilience in Ethiopia and Somaliland: Impact evaluation of the reconstruction project "Development of Enabling Conditions for Pastoralist and Agro-Pastoralist Communities."
Lall, S. V., Henderson, J. V., and Venables, A. J. (2017). *Africa's cities: opening doors to the world*. Washington DC, USA: World Bank.
Lamb, A., Green, R., Bateman, I., Broadmeadow, M., Bruce, T., Burney, J., et al. (2016). The potential for land sparing to offset greenhouse gas emissions from agriculture. *Nature Climate Change* 6, 488–492.

doi:10.1038/nclimate2910.
Lange, S., Volkholz, J., Zhao, F., Valle, I. V. del, Veldkamp, T., Reyer, C. P. O., et al. The climate change signal in natural disasters.
Langford, M., Sumner, A., and Yamin, A. E. (2013). *The Millennium Development Goals and Human Rights: Past, Present and Future*. , eds. M. Langford, A. Sumner, and A. E. Yamin New York, NY, USA: Cambridge University Press.
Larson, A. M., Dokken, T., and Duchelle, A. E. (2014). The role of women in early REDD+ implementation. *REDD+ on the ground: A case book of subnational initiatives across the globe* 17, 440–441. doi:10.1505/146554815814725031.
Lasage, R., Muis, S., Sardella, C. S. E., van Drunen, M. A., Verburg, P. H., and Aerts, J. C. J. H. (2015). A Stepwise, participatory approach to design and implement community based adaptation to drought in the Peruvian Andes. *Sustainability* 7, 1742–1773. doi:10.3390/su7021742.
Lavery, P. S., Matea, M.-A., Serrano, O., and Rozaimi, M. (2013). Variability in the Carbon Storage of Seagrass Habitats and Its Implications for Global Estimates of Blue Carbon Ecosystem Service. *PLOS ONE* 8. doi:10.1371/journal.pone.0073748.
Laville, J.-L. (2015). "Social and solidarity economy in historical perspective," in *Social and Solidarity Economy: Beyond the Fringe?*, ed. P. Utting (London, UK: Zed Books), 41–56.
Lawrence, J., and Haasnoot, M. (2017). What it took to catalyse uptake of dynamic adaptive pathways planning to address climate change uncertainty. *Environmental Science and Policy* 68, 47–57. doi:10.1016/j.envsci.2016.12.003.
Leach, M., Scoones, I., and Stirling, A. (2010). Governing epidemics in an age of complexity: Narratives, politics and pathways to sustainability. *Global Environmental Change* 20, 369–377. doi:10.1016/j.gloenvcha.2009.11.008.
Lechtenboehmer, S., and Knoop, K. (2017). Realising long-term transitions towards low carbon societies. Impulses from the 8th Annual Meeting of the International Research Network for Low Carbon Societies. , eds. S. Lechtenboehmer and K. Knoop Wuppertal, Germany.
Lee, J. S. H., Abood, S., Ghazoul, J., Barus, B., Obidzinski, K., and Koh, L. P. (2014). Environmental impacts of large-scale oil palm enterprises exceed that of smallholdings in Indonesia. *Conservation Letters* 7, 25–33. doi:10.1111/conl.12039.
Lefale, P., Faiva, P., and C, A. (2017). Living with change: An Integrated national strategy for enhancing the resilience of Tokelau to climate change and related hazards 2017-2030. Apia, Soamoa.
Leichenko, R., and Silva, J. A. (2014). Climate change and poverty: vulnerability, impacts, and alleviation strategies. *Wiley Interdisciplinary Reviews: Climate Change* 5, 539–556. doi:10.1002/wcc.287.
Leimbach, M., Bauer, N., Baumstark, L., and Edenhofer, O. (2010). Mitigation costs in a globalized world: Climate policy analysis with REMIND-R. *Environmental Modeling and Assessment* 15, 155–173. doi:10.1007/s10666-009-9204-8.
Lemoine, D., and Kapnick, S. (2016). A top-down approach to projecting market impacts of climate change. *Nature Climate Change* 6, 51–55. doi:10.1038/nclimate2759.
Lemos, C. M., Lo, Y., Nelson, D. R., Eakin, H., and Bedran-Martins, A. M. (2016). Linking development to climate adaptation: Leveraging generic and specific capacities to reduce vulnerability to drought in NE Brazil. *Global Environmental Change* 39, 170–179. doi:10.1016/J.GLOENVCHA.2016.05.001.
Leventon, J., Dyer, J. C., and Van Alstine, J. (2015). The private sector in climate governance: opportunities for climate compatible development through multilevel industry-government engagement. *Journal of Cleaner Production* 102, 316–323.
Ley, D. (2017a). "Sustainable development, climate change, and renewable energy in rural Central America," in *Evaluating Climate Change Action for Sustainable Development*, eds. T. Schuetz, W. Forch, P. Thornton, and V. Ioannis (Cham, Switzerland: Springer), 52–79. doi:10.1007/978-3-319-43702-6.
Ley, D. (2017b). "Sustainable Development, Climate Change, and Renewable Energy in Rural Central America," in *Evaluating Climate Change Action for Sustainable Development*, eds. J. I. Uitto, J. Puri, and R. D. van den Berg (Cham, Switzerland: Springer Nature), 187–212. doi:10.1007/978-3-319-43702-6.
Liddell, C., and Guiney, C. (2015). Living in a cold and damp home: Frameworks for understanding impacts on mental well-being. *Public Health* 129, 191–199. doi:10.1016/j.puhe.2014.11.007.
Lilliestam, J., and Patt, A. (2015). Barriers, risks and policies for renewables in the Gulf states. *Energies* 8, 8263–8285. doi:10.3390/en8088263.
Lin, B. B., Capon, T., Langston, A., Taylor, B., Wise, R., Williams, R., et al. (2017). Adaptation Pathways in Coastal Case Studies: Lessons Learned and Future Directions. *Coastal Management* 45, 384–405. doi:10.1080/08920753.2017.1349564.
Lin, J., Hu, Y., Cui, S., Kang, J., and Ramaswami, A. (2015). Tracking urban carbon footprints from production and consumption perspectives. *Environmental Research Letters* 10, 54001. doi:10.1088/1748-9326/10/5/054001.
Linnerooth-Bayer, J., and Hochrainer-Stigler, S. (2015). Financial instruments for disaster risk management and climate change adaptation. *Climatic Change* 133, 85–100. doi:10.1007/s10584-013-1035-6.

Lipper, L. (2014). Climate-smart agriculture for food security. *Nature Climate Change* 4, 1068–1072. doi:10.1038/NCLIMATE2437.
Lipper, L., and Al., E. (2014). Climate-smart agriculture for food security. *Nature Climate Change* 4, 1068–1072. doi:10.1038/NCLIMATE2437.
Lipper, L., Al., E., Thornton, P., Campbell, B. M., Baedeker, T., Braimoh, A., et al. (2014). Climate-smart agriculture for food security. *Nature Climate Change* 4, 1068–1072. doi:10.1038/NCLIMATE2437.
Liu, J.-Y., Fujimori, S., and Masui, T. (2016a). Temporal and spatial distribution of global mitigation cost: INDCs and equity. *Environmental Research Letters* 11, 114004. doi:10.1088/1748-9326/11/11/114004.
Liu, Q., Gu, A., Teng, F., Song, R., and Chen, Y. (2017). Peaking China's CO2 emissions: trends to 2030 and mitigation potential. *Energies* 10, 209. doi:10.3390/en10020209.
Liu, W., Oosterveer, P., and Spaargaren, G. (2016b). Promoting sustainable consumption in China: a conceptual framework and research review. *Journal of Cleaner Production* 134, 13–21. doi:10.1016/j.jclepro.2015.10.124.
Lloyd, J., Nordhaus, T., Sarewitz, D., and Trembath, A. (2017). *The Rightful Place of Science: Climate Pragmatism*. , eds. J. Lloyd, T. Nordhaus, D. Sarewitz, and A. Trembath Charleston, SC, USA: Consortium for Science, Policy, & Outcomes.
Lobell, D. B., and Tebaldi, C. (2014). Getting caught with our plants down: the risks of a global crop yield slowdown from climate trends in the next two decades. *Environmental Research Letters* 9, 74003. doi:10.1088/1748-9326/9/7/074003.
Locatelli, B., Pavageau, C., Pramova, E., and Di Gregorio, M. (2015). Integrating climate change mitigation and adaptation in agriculture and forestry: opportunities and trade-offs. *Wiley Interdisciplinary Reviews: Climate Change* 6, 585–598. doi:10.1002/wcc.357.
Locatelli, B., Rojas, V., and Salinas, Z. (2008). Impacts of payments for environmental services on local development in northern Costa Rica: a fuzzy multi-criteria analysis. *Forest Policy and Economics* 10, 275–285. doi:10.1016/j.forpol.2007.11.007.
Loft, L., Pham, T. T., Wong, G. Y., Brockhaus, M., Le, D. N., Tjajadi, J. S., et al. (2017). Risks to REDD+: potential pitfalls for policy design and implementation. *Environmental Conservation* 44, 44–55. doi:10.1017/S0376892916000412.
Lorek, S., and Spangenberg, J. H. (2014). Sustainable consumption within a sustainable economy - Beyond green growth and green economies. *Journal of Cleaner Production* 63, 33–44. doi:10.1016/j.jclepro.2013.08.045.
Lotz-Sisitka, H., Wals, A. E. J., Kronlid, D., and McGarry, D. (2015). Transformative, transgressive social learning: rethinking higher education pedagogy in times of systemic global dysfunction. *Current Opinion in Environmental Sustainability* 16, 73–80. doi:10.1016/j.cosust.2015.07.018.
Lourenço, T. C., Swart, R., Goosen, H., and Street, R. (2015). The rise of demand-driven climate services. *Nature Climate Change* 6, 1–2. doi:10.1038/nclimate2836.
Lovelock, C., Atwood, T., Baldock, J., Duarte, C., Hickey, S., Lavery, P., et al. (2017). Assessing the risk of carbon dioxide emissions from blue carbon. *Frontiers in Ecology and the Environment* 15, 257–265. doi:10.1002/fee.1491.
Lubchenco, J., Cerny-Chipman, E. B., Reimer, J. N., and Levin, S. A. (2016). The right incentives enable ocean sustainability successes and provide hope for the future. *Proceedings of the National Academy of Sciences of the United States of America*, 201604982. doi:10.1073/pnas.1604982113.
Lucas, K., and Pangbourne, K. (2014). Assessing the equity of carbon mitigation policies for transport in Scotland. *Case Studies on Transport Policy* 2, 70–80. doi:10.1016/j.cstp.2014.05.003.
Lucon, O., Ürge-Vorsatz, D., Zain Ahmed, A., Akbari, H., Bertoldi, P., Cabeza, L. F., et al. (2014). "Buildings," in *Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*, eds. O. Edenhofer, R. Pichs-Madruga, Y. Sokona, E. Farahani, S. Kadner, K. Seyboth, et al. (Cambridge, UK and New York, NY, USA: Cambridge University Press), 671–738.
Luderer, G., Pietzcker, R. C., Bertram, C., Kriegler, E., Meinshausen, M., and Edenhofer, O. (2013). Economic mitigation challenges: how further delay closes the door for achieving climate targets. *Environmental Research Letters* 8, 34033. doi:10.1088/1748-9326/8/3/034033.
Lunstrum, E., Bose, P., and Zalik, A. (2015). Environmental displacement: The common ground of climate change, extraction and conservation. *Area* 48, 130–133. doi:10.1111/area.12193.
Luomi, M. (2014). Mainstreaming climate policy in the Gulf Cooperation Council States.
Luttrell, C., Loft, L., Fernanda Gebara, M., Kweka, D., Brockhaus, M., Angelsen, A., et al. (2013). Who Should Benefit from REDD+? Rationales and Realities. *Ecology and Society* 18. doi:10.5751/es-05834-180452.
Maclellan, N. (2015). Yumi stap redi long klaemet jenis: Lessons from the Vanuatu NGO Climate Change Adaptation Program.
Magnan, A. K., Colombier, M., Billé, R., Joos, F., Hoegh-Guldberg, O., Pörtner, H.-O., et al. (2016a). Implications of the Paris Agreement for the ocean. *Nature Climate Change* 6, 732–735. doi:10.1038/nclimate3038.
Magnan, A. K., Schipper, E. L. F., Burkett, M., Bharwani, S., Burton, I., Eriksen, S., et al. (2016b). Addressing the risk

of maladaptation to climate change. *Wiley Interdisciplinary Reviews: Climate Change* 7, 646–665. doi:10.1002/wcc.409.

Magrin, G. O., Marengo, J. A., Boulanger, J.-P., Buckeridge, M. S., Castellanos, E., Poveda, G., et al. (2014). "Central and South America," in *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel of Climate Change*, eds. V. R. Barros, C. B. Field, D. J. Dokken, M. D. Mastrandrea, K. J. Mach, T. E. Bilir, et al. (Cambridge, UK and New York, NY, USA: Cambridge University Press), 1499–1566.

Maguire, A., and McGee, J. (2017). A universal human right to shape responses to a global problem? The role of self-determination in guiding the international legal response to climate change. *Review of European, Comparative and International Environmental Law* 26, 54–68. doi:10.1111/reel.12193.

Maidment, C. D., Jones, C. R., Webb, T. L., Hathway, E. A., and Gilbertson, J. M. (2014). The impact of household energy efficiency measures on health: A meta-analysis. *Energy Policy* 65, 583–593. doi:10.1016/j.enpol.2013.10.054.

Maldonado, J. K., Shearer, C., Bronen, R., Peterson, K., and Lazrus, H. (2013). The impact of climate change on tribal communities in the US: displacement, relocation, and human rights. *Climatic Change* 120, 601–614. doi:10.1007/978-3-319-05266-3_8.

Maljean-Dubois, S. (2016). The Paris Agreement: a new step in the gradual evolution of differential treatment in the climate regime? *Review of European, Comparative and International Environmental Law* 25, 151–160. doi:10.1111/reel.12162.

Maor, M., Tosun, J., and Jordan, A. (2017). Proportionate and disproportionate policy responses to climate change: core concepts and empirical applications. *Journal of Environmental Policy and Planning*, 1–13. doi:10.1080/1523908X.2017.1281730.

Mapfumo, P., Onyango, M., Honkponou, S. K., El Mzouri, E. H., Githeko, A., Rabeharisoa, L., et al. (2017). Pathways to transformational change in the face of climate impacts: an analytical framework. *Climate and Development* 9, 439–451. doi:10.1080/17565529.2015.1040365.

Marcotullio, P., and McGranahan, G. (2007). *Scaling Urban Environmental Challenges: From Local to Global and Back*. London: Earthscan.

Mark, C., Lloyd, J., Luke, M., Margonelli, L., Moss, T., Nordhaus, T., et al. (2017). "A high-energy planet," in *The Rightful Place of Science: Climate Pragmatism*, eds. J. Lloyd, T. Nordhaus, D. Sarewitz, and A. Trembath (Tempe, AZ, USA: Consortium for Science, Policy, & Outcomes, Arizona State University), 27–32.

Markandya, A., Armstrong, B. G., Hales, S., Chiabai, A., Criqui, P., Mima, S., et al. (2009). Public health benefits of strategies to reduce greenhouse-gas emissions: low-carbon electricity generation. *The Lancet* 374, 2006–2015. doi:10.1016/s0140-6736(09)61715-3.

Marsh, J. (2015). Mixed motivations and complex causality in the Mekong. *Forced Migration Review*, 68–69.

Martinez-Alier, J., Temper, L., Del Bene, D., and Scheidel, A. (2016). Is there a global environmental justice movement? *The Journal of Peasant Studies* 43, 731–755. doi:10.1080/03066150.2016.1141198.

Mary Robinson Foundation: Climate Justice (2015). Zero carbon, zero poverty the climate justice way. Dublin, Ireland.

Mary Robinson Foundation Climate Justice (2015). Rights for action: putting people at the centre of action on climate change. Dublin, Ireland.

Masdar (2017). Masdar City. Available at: http://masdar.ae [Accessed December 6, 2017].

Massetti, E., and Tavoni, M. (2011). The cost of climate change mitigation policy in Eastern Europe and former Soviet Union. *Climate Change Economics* 2, 341–370. doi:10.1142/S2010007811000346.

Mata, E., Bergfors, L., and Wanemark, J. (2018). Dynamic modelling of renovation scenarios for the existing multifamily buildings in Gothenburg up to year 2050. Stockholm, Sweden (in prep).

Matek, B. (2015). Flexible Opportunities with Geothermal Technology: Barriers and Opportunities. *The Electricity Journal* 28, 45–51. doi:10.1016/J.TEJ.2015.09.020.

Matek, B., and Gawell, K. (2015). The Benefits of Baseload Renewables: A Misunderstood Energy Technology. *The Electricity Journal* 28, 101–112. doi:10.1016/j.tej.2015.02.001.

Mathew, L. M., and Akter, S. (2017). "Loss and Damage Associated with Climate Change Impacts," in *Handbook of Climate Change Mitigation and Adaptation* (Cham: Springer International Publishing), 17–45. doi:10.1007/978-3-319-14409-2_55.

Mathur, V. N., Afionis, S., Paavola, J., Dougill, A. J., and Stringer, L. C. (2014a). Experiences of host communities with carbon market projects: towards multi-level climate justice. *Climate Policy* 14, 42–62. doi:10.1080/14693062.2013.861728.

Mathur, V. N., Afionis, S., Paavola, J., Dougill, A. J., and Stringer, L. C. (2014b). Experiences of host communities with carbon market projects: towards multi-level climate justice. *Climate Policy* 14, 42–62. doi:10.1080/14693062.2013.861728.

Matinga, M. N. (2012). A socio-cultural perspective on transformation of gender roles and relations, and non-change in energy-health perceptions following electrification in rural South Africa (Case Study for World Development Report 2012). ETC/ENERGIA in association Nord/Sør-konsulentene.

Matthews, T. K. R., Wilby, R. L., and Murphy, C. (2017). Communicating the deadly consequences of global warming for human heat stress. *Proceedings of the National Academy of Sciences* 114, 3861–3866. doi:10.1073/pnas.1617526114.
Maxwell, B. S. (2016). Climate compatible development : pathway or pipe dream ? Centre for Policy Dialogue Anniversary Lecture , 2015.
Mbow, C., Neely, C., and Dobie, P. (2015). "How can an integrated landscape approach contribute to the implementation of the Sustainable Development Goals (SDGs) and advance climate-smart objectives?," in *Climate-Smart Landscapes: Multifunctionality in Practice*, eds. P. A. Minang, M. van Noordwijk, C. Mbow, J. de Leeuw, and D. Catacutan (Nairobi, Kenya: World Agroforestry Centre (ICRAF)), 103–117.
McAfee, K. (2016). Green economy and carbon markets for conservation and development: a critical view. *International Environmental Agreements: Politics, Law and Economics* 16, 333–353. doi:10.1007/s10784-015-9295-4.
MCCA (2016). Corporate Plan 2016-2018.
McCollum, D., Echeverri, L. G., Busch, S., Pachauri, S., Parkinson, S., Rogelj, J., et al. (2017). Connecting the Sustainable Development Goals by their energy inter-linkages. Laxenburg, Austria.
McCollum, D. L., Krey, V., Riahi, K., Kolp, P., Grubler, A., Makowski, M., et al. (2013). Climate policies can help resolve energy security and air pollution challenges. *Climatic Change* 119, 479–494. doi:10.1007/s10584-013-0710-y.
McCubbin, S., Smit, B., and Pearce, T. (2015). Where does climate fit? Vulnerability to climate change in the context of multiple stressors in Funafuti, Tuvalu. *Global Environmental Change* 30, 43–55. doi:10.1016/j.gloenvcha.2014.10.007.
McGlade, C., and Ekins, P. (2015). The geographical distribution of fossil fuels unused when limiting global warming to 2 °C. *Nature* 517, 187–190. doi:10.1038/nature14016.
McGregor, D., Simon, D., and Thompson, D. (2006). *The peri-urban interface: approaches to sustainable natural and human resouce use*. London: Earthscan/Routledge.
McKay, B., Sauer, S., Richardson, B., and Herre, R. (2016). The political economy of sugarcane flexing: initial insights from Brazil, Southern Africa and Cambodia. *The Journal of Peasant Studies* 43, 195–223. doi:10.1080/03066150.2014.992016.
McKeon, N. (2015). La Via Campesina: The "peasants" way' to changing the system, not the climate. *Journal of World-Systems Research* 21, 241–249.
McMichael, C. (2015). Climate change-related migration and infectious disease. *Virulence* 6, 548–553. doi:10.1080/21505594.2015.1021539.
McMurtry, J.-J. (2013). Prometheus, Trojan Horse or Frankenstein? The social and solidarity economy as community creation, market wedge, or state monster (Draft). Geneva, Switzerland: United Nations Research Institute for Social Development.
McNamara, E. (2015). Cross-border migration with dignity in Kiribati. *Forced Migration Review* 49, 2015.
McNamara, K. E., and Buggy, L. (2017). Community-based climate change adaptation: a review of academic literature. *Local Environment* 22, 443–460. doi:10.1080/13549839.2016.1216954.
McNamara, K. E., and Prasad, S. S. (2014). Coping with extreme weather: Communities in Fiji and Vanuatu share their experiences and knowledge. *Climatic Change* 123, 121–132. doi:10.1007/s10584-013-1047-2.
Meadowcroft, J. (2011). Engaging with the politics of sustainability transitions. *Environmental Innovation and Societal Transitions* 1, 70–75. doi:10.1016/j.eist.2011.02.003.
Meek, D. (2014). Agroecology and radical grassroots movements' evolving moral economies. *Environment and Society: Advances in Research* 5, 47–65. doi:10.3167/ares.2014.050104.
Meek, D. (2016). The cultural politics of the agroecological transition. *Agriculture and Human Values* 33, 275–290. doi:10.1007/s10460-015-9605-z.
Mehmood, A. (2016). Of resilient places: planning for urban resilience. *European Planning Studies* 24, 407–419.
MELAD (2012). Kiribati integrated environmental policy.
Mercer, J., Kelman, I., Alfthan, B., and Kurvits, T. (2012). Ecosystem-based adaptation to climate change in Caribbean small island developing states: integrating local and external knowledge. *Sustainability* 4, 1908–1932. doi:10.3390/su4081908.
Mercy Corps (2015). Experiences from Ethiopia and the Mercy Corps' PRIME program. Portland, OR, USA.
Michaelowa, A. (2015). Opportunities for and alternatives to global climate regimes post-Kyoto. *Annual Review of Environment and Resources* 40, 395–417. doi:10.1146/annurev-environ-102014-021112.
Michalena, E., and Hills, J. (2018). Paths of renewable energy development in small island developing states of the South Pacific. *Renewable and Sustainable Energy Reviews* 82, 343–352. doi:10.1016/J.RSER.2017.09.017.
Michler-Cieluch, T., Krause, G., and Buck, B. H. (2009). Reflections on integrating operation and maintenance activities of offshore wind farms and mariculture. *Ocean & Coastal Management* 52, 57–68. doi:10.1016/j.ocecoaman.2008.09.008.
Millar, R. J., Fuglestvedt, J. S., Friedlingstein, P., Rogelj, J., Grubb, M. J., Matthews, H. D., et al. (2017). Emission

budgets and pathways consistent with limiting warming to 1.5 °C. *Nature Geoscience*, 1–8. doi:10.1038/ngeo3031.
Ministry of Environment and Forests National mission for a green India (under the National Action Plan on Climate Change).
Mishra, V., Mukherjee, S., Kumar, R., and Stone, D. (2017). Heat wave exposure in India in current, 1.5ºC, and 2.0 ºC worlds. *Environmental Research Letters* 12, 124012. doi:10.1088/1748-9326/aa9388.
Mitchell, T., and Maxwell, S. (2010). Defining climate compatible development.
Moellendorf, D. (2015). Climate change justice. *Philosophy Compass* 10, 173–186. doi:10.3197/096327111X12997574391887.
Mondal, M. A. H., Hawila, D., Kennedy, S., and Mezher, T. (2016). The GCC countries RE-readiness: strengths and gaps for development of renewable energy technologies. *Renewable and Sustainable Energy Reviews* 54, 1114–1128. doi:10.1016/j.rser.2015.10.098.
Mont (2014). Sustainable lifestyles 2050: stakeholder visions, emerging practices and future research. *Journal of Cleaner Production* 63, 24–32.
Morita, K., and Matsumoto, K. (2015). "Enhancing Biodiversity Co-benefits of Adaptation to Climate Change," in *Handbook of Climate Change Adaptation*, ed. W. L. Filho (Springer-Verlag Berlin Heidelberg), 953–972.
Morita, K., and Matsumoto, K. (2018). Synergies among climate change and biodiversity conservation measures and policies in the forest sector: a case study of Southeast Asian countries. *Forest Policy and Economics* 87, 59–69. doi:10.1016/j.forpol.2017.10.013.
Moss, J. (2015). *Climate change and justice*. Cambridge University Press.
Mubaya, C. P., and Mafongoya, P. (2017). The role of institutions in managing local level climate change adaptation in semi-arid Zimbabwe. *Climate Risk Management* 16, 93–105. doi:10.1016/j.crm.2017.03.003.
Mukute, M., Colvin, J., and Baloi, A. (2017). Africa climate change resilience alliance: phase 2 sythesis evaluation.
Muller, A., Schader, C., El-Hage Scialabba, N., Hecht, J., Isensee, A., Erb, K. H., et al. Can organic agriculture feed the world in 2050: a critical assessment of the challenges and opportunities (In Press). *Nature Communications*. doi:NCOMMS-16-04864D.
Munang, R., Andrews, J., Alverson, K., and Mebratu, D. (2014). Harnessing Ecosystem-based Adaptation To Address the Social Dimensions of Climate Change. *Environment: Science and Policy for Sustainable Development* 56, 18–24. doi:10.1080/00139157.2014.861676.
Munang, R., Thiaw, I., Alverson, K., Goumandakoye, M., Mebratu, D., and Liu, J. (2013a). Using ecosystem-based adaptation actions to tackle food insecurity. *Environment: Science and Policy for Sustainable Development* 55, 29–35. doi:10.1080/00139157.2013.748395.
Munang, R., Thiaw, I., Alverson, K., Mumba, M., Liu, J., and Rivington, M. (2013b). Climate change and Ecosystem-based Adaptation: A new pragmatic approach to buffering climate change impacts. *Current Opinion in Environmental Sustainability* 5. doi:10.1016/j.cosust.2012.12.001.
Muradian, R., Arsel, M., Pellegrini, L., Adaman, F., Aguilar, B., Agarwal, B., et al. (2013). Payments for ecosystem services and the fatal attraction of win-win solutions. *Conservation letters* 6, 274–279.
Muratori, M., Calvin, K., Wise, M., Kyle, P., and Edmonds, J. (2016). Global economic consequences of deploying bioenergy with carbon capture and storage (BECCS). *Environmental Research Letters* 11, 1–9. doi:10.1088/1748-9326/11/9/095004.
Murphy, D. J., Yung, L., Wyborn, C., and Williams, D. R. (2017). Rethinking climate change adaptation and place through a situated pathways framework: a case study from the Big Hole Valley, USA. *Landscape and Urban Planning* 167, 441–450. doi:10.1016/j.landurbplan.2017.07.016.
Murtinho, F. (2016). What facilitates adaptation? An analysis of community-based adaptation to environmental change in the Andes. *International Journal of the Commons* 10, 119–141. doi:10.18352/ijc.585.
Muttarak, R., and Lutz, W. (2014). Is education a key to reducing vulnerability to natural disasters and hence unavoidable climate change? *Ecology and Society* 19. doi:10.5751/ES-06476-190142.
Myers, S. S., Smith, M. R., Guth, S., Golden, C. D., Vaitla, B., Mueller, N. D., et al. (2017). Climate Change and Global Food Systems : Potential Impacts on Food Security and Undernutrition. *Annual Review of Public Health*, 1–19. doi:10.1146/annurev-publhealth-031816-044356.
Naess, L. O., Newell, P., Newsham, A., Phillips, J., Quan, J., and Tanner, T. (2015). Climate policy meets national development contexts: insights from Kenya and Mozambique. *Global Environmental Change* 35, 534–544. doi:10.1016/j.gloenvcha.2015.08.015.
Nagoda, S. (2015). New discourses but same old development approaches? Climate change adaptation policies, chronic food insecurity and development interventions in northwestern Nepal. *Global Environmental Change* 35, 570–579. doi:10.1016/j.gloenvcha.2015.08.014.
Nakicenovic, N., Alcamo, J., Grubler, A., Riahi, K., Roehrl, R. A., Rogner, H. H., et al. (2000). Special Report on Emissions Scenarios (SRES), A Special Report of Working Group III of the Intergovernmental Panel on Climate Change. Cambridge, UK and New York, NY, USA.
Nalau, J., Handmer, J., Dalesa, M., Foster, H., Edwards, J., Kauhiona, H., et al. (2016). The practice of integrating

adaptation and disaster risk reduction in the south-west Pacific. *Climate and Development* 8, 365–375. doi:10.1080/17565529.2015.1064809.
Nanaki, E. A., and Koroneos, C. J. (2016). Climate change mitigation and deployment of electric vehicles in urban areas. *Renewable Energy* 99, 1153–1160. doi:10.1016/j.renene.2016.08.006.
ND-GAIN (2017). ND-GAIN Country Index. *Notre Dame Global Adaptation Index Initiative*.
Nelson, D. R., Lemos, M. C., Eakin, H., and Lo, Y.-J. (2016). The limits of poverty reduction in support of climate change adaptation. *Environmental Research Letters* 11, 94011. doi:10.1088/1748-9326/11/9/094011.
Neufeldt, H., Jahn, M., Campbell, B. M., Beddington, J. R., Declerck, F., Pinto, A. De, et al. (2013). Beyond climate-smart agriculture: toward safe operating spaces for global food systems. *Agriculture and Food Security* 2, 1–6.
Neumann, B., Vafeidis, A. T., Zimmermann, J., and Nicholls, R. J. (2015). Future Coastal Population Growth and Exposure to Sea-Level Rise and Coastal Flooding - A Global Assessment. *PLOS ONE* 10, e0118571. doi:10.1371/journal.pone.0118571.
Newell, P., and Mulvaney, D. (2013). The political economy of the "just transition." *Geographical Journal* 179, 132–140. doi:10.1111/geoj.12008.
Newell, P., Phillips, J., Pueyo, A., Kirumba, E., Ozor, N. N., and Urama, K. (2014a). The Political Economy of Low Carbon Energy in Kenya. Brighton, UK doi:10.1111/j.2040-0209.2014.00445.x.
Newell, P., Phillips, J., Pueyo, A., Kirumba, E., Ozor, N., and Urama, K. (2014b). The Political Economy of Low Carbon Energy in Kenya. Brighton, UK doi:10.1111/j.2040-0209.2014.00445.x.
Newman, P., Beatley, T., and Boyer, Heather (2017). *Resilient Cities: Overcoming Fossil Fuel Dependence*. Second Edi. Washington DC: Island Press.
Nguyen, L. D., Grote, U., and Sharma, R. (2017). Staying in the cities or returning home? An analysis of the rural-urban migration behavior in Vietnam. *IZA Journal of Development and Migration* 7, 3. doi:10.1186/s40176-017-0089-z.
Nguyen, M. T., Vink, S., Ziemski, M., and Barrett, D. J. (2014). Water and energy synergy and trade-off potentials in mine water management. *Journal of Cleaner Production* 84, 629–638. doi:10.1016/j.jclepro.2014.01.063.
Nhamo, G. (2016). New Global Sustainable Development Agenda: A Focus on Africa. *Sustainable Development* 25, 227–241. doi:10.1002/sd.1648.
Niang, I., Ruppel, O. C., Abdrabo, M. A., Essel, A., Lennard, C., Padgham, J., et al. (2014). "Africa," in *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel of Climate Change*, eds. V. R. Barros, C. B. Field, D. J. Dokken, M. D. Mastrandrea, K. J. Mach, T. E. Bilir, et al. (Cambridge, UK and New York, NY, USA: Cambridge University Press), 1199–1265.
Nicholls, R. J., Brown, S., Goodwin, P., Wahl, T., Lowe, J., Solan, M., et al. Stablisation of global temperatures at 1.5°C and 2.0°C: implications for coastal areas. *Philosophical Transactions of the Royal Soceity A*.
Nicolosi, E., and Feola, G. (2016). Transition in place: Dynamics, possibilities, and constraints. *Geoforum* 76, 153–163. doi:10.1016/j.geoforum.2016.09.017.
Nightingale, A. J. (2011). Bounding difference : Intersectionality and the material production of gender , caste , class and environment in Nepal. *Geoforum* 42, 153–162. doi:10.1016/j.geoforum.2010.03.004.
Nilsson, M., Griggs, D., and Visback, M. (2016). Map the interactions between Sustainable Development Goals. *Nature* 534, 320–322. doi:10.1038/534320a.
Nkomwa, E. C., Joshua, M. K., Ngongondo, C., Monjerezi, M., and Chipungu, F. (2014). Assessing indigenous knowledge systems and climate change adaptation strategies in agriculture: a case study of Chagaka Village, Chikhwawa, Southern Malawi. *Physics and Chemistry of the Earth, Parts A/B/C* 67–69, 164–172. doi:10.1016/j.pce.2013.10.002.
Noble, I., Huq, S., Anokhin, Y., Carmin, J., Goudou, D., Lansigan, F. P., et al. (2014). "Adaptation needs and options," in *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*, eds. C. B. Field, V. R. Barros, D. J. Dokken, K. J. Mach, M. D. Mastrandrea, T. E. Bilir, et al. (Cambridge, UK and New York, NY, USA: Cambridge University Press), 659–708.
Normann, H. E. (2015). The role of politics in sustainable transitions: The rise and decline of offshore wind in Norway. *Environmental Innovation and Societal Transitions* 15, 180–193. doi:10.1016/j.eist.2014.11.002.
North, P., and Longhurst, N. (2013). Grassroots localisation? The scalar potential of and limits of the "transition" approach to climate change and resource constraint. *Urban Studies* 50, 1423–1438. doi:10.1177/0042098013480966.
Northrop, E., Biru, H., Lima, S., Bouye, M., and Song, R. (2016). Examining the alignment between the intended nationally determined contributions and sustainable development goals. Washington DC.
Nunan, F. (2017). *Making climate compatible development happen*. , ed. F. Nunan Abingdon, UK and New York, NY, USA: Routledge.
Nunn, P., and Kumar, R. (2017). Understanding climate-human interactions in Small Island Developing States (SIDS): Implications for future livelihood sustainability. *International Journal of Climate Change Strategies and*

Management, 1756–8692. doi:doi.org/10.1108/IJCCSM-01-2017-0012.
Nurse, L. A., McLean, R. F., Agard, J., Briguglio, L. P., Duvat-Magnan, V., Pelesikoti, N., et al. (2014). "Small islands," in *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel of Climate Change*, eds. V. R. Barros, C. B. Field, D. J. Dokken, M. D. Mastrandrea, K. J. Mach, T. E. Bilir, et al. (Cambridge, UK and New York, NY, USA: Cambridge University Press), 1613–1654.
Nyantakyi-Frimpong, H., and Bezner-Kerr, R. (2015). The relative importance of climate change in the context of multiple stressors in semi-arid Ghana. *Global Environmental Change* 32, 40–56. doi:10.1016/j.gloenvcha.2015.03.003.
Nyholm, E., Puranik, S., Mata, É., Odenberger, M., and Johnsson, F. (2016). Demand response potential of electrical space heating in Swedish single-family dwellings. *Building and Environment* 96, 270–282. doi:10.1016/j.buildenv.2015.11.019.
O'Brien, K. (2016). "Climate change adaptation and social transformation," in *International Encyclopedia of Geography: People, the Earth, Environment and Technology* (John Wiley & Sons Ltd). doi:10.1002/9781118786352.wbieg0987.
O'Brien, K., Eriksen, S., Inderberg, T. H., and Sygna, L. (2015). "Climate change and development: adaptation through transformation," in *Climate Change Adaptation and Development: Transforming Paradigms and Practices*, eds. T. H. Inderberg, S. Eriksen, K. O'Brien, and L. Sygna (Abingdon, UK and New York, USA: Routledge).
O'Neill, B. C., Dalton, M., Fuchs, R., Jiang, L., Pachauri, S., and Zigova, K. (2010). Global demographic trends and future carbon emissions. *Proceedings of the National Academy of Sciences of the United States of America* 107, 17521–6. doi:10.1073/pnas.1004581107.
O'Neill, B. C., Kriegler, E., Ebi, K. L., Kemp-Benedict, E., Riahi, K., Rothman, D. S., et al. (2017a). The roads ahead: narratives for shared socioeconomic pathways describing world futures in the 21st century. *Global Environmental Change* 42, 169–180. doi:10.1016/j.gloenvcha.2015.01.004.
O'Neill, B. C., Oppenheimer, M., Warren, R., Hallegatte, S., Kopp, R. E., Pörtner, H. O., et al. (2017b). IPCC reasons for concern regarding climate change risks. *Nature Climate Change* 7, 28–37. doi:10.1038/nclimate3179.
O'Neill, B. C., Oppenheimer, M., Warren, R., Hallegatte, S., Kopp, R. E., Pörtner, H. O., et al. (2017c). IPCC reasons for concern regarding climate change risks. *Nature Climate Change* 7. doi:10.1038/nclimate3179.
OECD (2011). Invention and transfer of environmental technologies.
OECD (2015). OECD Environmental Performance Reviews: Brazil 2015. Paris, France doi:10.1787/9789264240094-en.
OECD (2016). Better Policies for Sustainable Development 2016: A New Framework for Policy Coherence. Paris, France doi:10.1787/9789264256996-en.
OECD (2017). Investing in green growth. Paris.
Oei, P., and Mendelevitch, R. (2016). European scenarios of CO2 infrastructure investment until 2050. *The Energy Journal* 37. doi:10.5547/01956574.37.SI3.poei.
Ojea, E. (2015). Challenges for mainstreaming Ecosystem-based Adaptation into the international climate agenda. *Current Opinion in Environmental Sustainability* 14, 41–48. doi:10.1016/j.cosust.2015.03.006.
Okereke, C., and Coventry, P. (2016). Climate justice and the international regime: before, during, and after Paris. *Wiley Interdisciplinary Reviews: Climate Change* 7, 834–851. doi:10.1002/wcc.419.
Okereke, C., and Dooley, K. (2010). Principles of justice in proposals and policy approaches to avoided deforestation: Towards a post-Kyoto climate agreement. *Global Environmental Change* 20, 82–95. doi:10.1016/j.gloenvcha.2009.08.004.
Olmstead, S. M. (2014). Climate change adaptation and water resource management: A review of the literature. *Energy Economics* 46, 500–509. doi:10.1016/j.eneco.2013.09.005.
Olsson, L., Opondo, M., Tschakert, P., Agrawal, A., Eriksen, S. H., Ma, S., et al. (2014). "Livelihoods and Poverty," in *Climate Change 2014: Impacts, Adaptation and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*, eds. C. B. Field, V. R. Barros, D. J. Dokken, K. J. Mach, M. D. Mastrandrea, T. E. Bilir, et al. (Cambridge, UK and New York, NY, USA.: Cambridge University Press), 793–832. doi:10.1017/CBO9781107415379.018.
Oosterhuis, F. H., and ten Brink, P. (2014). *Paying the polluter: environmentally harmful subsidies and their reform*. Cheltenham, UK ; Northampton, MA, USA: Edward Elgar Publishing.
Oppenheimer, M., Campos, M., and Warren, R. (2014). "Emergent risks and key vulnerabilities," in *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Field, C.B., V.R. Barros, D.J. Dokken, K.J.*, eds. C. B. Field, V. . Barros, D. J. Dokken, K. J. Mach, M. D. Mastrandrea, T. E. Bilir, et al. (Cambridge, UK and New York, NY, USA: Cambridge University Press), 659–708.
Orlove, B., Roncoli, C., Kabugo, M., and Majugu, A. (2010). Indigenous climate knowledge in southern Uganda: the multiple components of a dynamic regional system. *Climatic Change* 100, 243–265. doi:10.1007/s10584-009-9586-2.

Oshiro, K., Kainuma, M., and Masui, T. (2016). Assessing decarbonization pathways and their implications for energy security policies in Japan. *Climate Policy* 16, S63–S77. doi:10.1080/14693062.2016.1155042.

Ouyang, X., and Lin, B. (2014). Impacts of increasing renewable energy subsidies and phasing out fossil fuel subsidies in China. *Renewable and Sustainable Energy Reviews* 37, 933–942. doi:10.1016/j.rser.2014.05.013.

Pachauri, S., Brew-Hammond, A., Barnes, D. F., Bouille, D. H., Gitonga, S., Modi, V., et al. (2012). "Energy Access for Development," in *Global Energy Assessment - Toward a Sustainable Future*, eds. T. B. Johansson, N. Nakicenovic, A. Patwardhan, and L. Gomez-Echeverri (Cambridge University Press, Cambridge, UK and New York, NY, USA and the International Institute for Applied Systems Analysis (IIASA), Laxenburg, Austria), 1401–1458.

Page, E. A., and Heyward, C. (2017). Compensating for Climate Change Loss and Damage. *Political Studies* 65, 356–372. doi:10.1177/0032321716647401.

Pahnke, A. (2015). Institutionalizing economies of opposition: explaining and evaluating the success of the MST's cooperatives and agroecological repeasantization. *The Journal of Peasant Studies* 42, 1087–1107. doi:10.1080/03066150.2014.991720.

Pal, J. S., and Eltahir, E. A. B. (2016). Future temperature in southwest Asia projected to exceed a threshold for human adaptability. *Nature Climate Change* 18203, 1–4. doi:10.1038/nclimate2833.

Paprocki, K., and Huq, S. (2017). Shrimp and coastal adaptation: on the politics of climate justice. *Climate and Development*.

Park, J., Hallegatte, S., Bangalore, M., and Sandhoefner, E. (2015). Households and heat stress estimating the distributional consequences of climate change. Washington, DC, USA.

Parkinson, S., Krey, V., Huppmann, D., Kahil, T., McCollum, D., Fricko, O., et al. Quantifying interactions between SDG 6 and a 1.5°C climate policy. submitted.

Parnell, S. (2017). Africa's urban risk and resilience. *International Journal of Disaster Risk Reduction* 26, 1–6. doi:10.1016/J.IJDRR.2017.09.050.

Patrozou, E. (2015). Our changing world: Impacts on health and infectious diseases. *Virulence* 6, 533–534. doi:10.1080/21505594.2015.1062961.

Patterson, J., Schulz, K., Vervoort, J., van der Hel, S., Widerberg, O., Adler, C., et al. (2016). Exploring the governance and politics of transformations towards sustainability. *Environmental Innovation and Societal Transitions*, 1–16. doi:10.1016/j.eist.2016.09.001.

PBL (2012). Roads from Rio+20: Pathways to Achieve Global Sustainability Goals by 2050. The Hague, Netherlands: PBL Netherlands Environmental Assessment Agency.

Pearse, R. (2016). Moving targets: Carbon pricing, energy markets, and social movements in Australia. *Environmental Politics* 25, 1079–1101. doi:10.1080/09644016.2016.1196969.

Pecl, G. T., Araújo, M. B., Bell, J. D., Blanchard, J. L., Bonebrake, T. C., Chen, I.-C., et al. (2017). Biodiversity redistribution under climate change: impacts on ecosystems and human well-being. *Science* 355, 1–7. doi:10.1126/science.aai9214.

Pelling, M., Abeling, T., and Garschagen, M. (2016). Emergence and Transition in London's Climate Change Adaptation Pathways. *Journal of Extreme Events* 3, 1650012. doi:10.1142/S2345737616500123.

Pelling, M., O'Brien, K., and Matyas, D. (2015). Adaptation and transformation. *Climatic Change* 133, 113–127. doi:10.1007/s10584-014-1303-0.

Petkova, E. P., Vink, J. K., Horton, R. M., Gasparrini, A., Bader, D. A., Francis, J. D., et al. (2017). Towards more comprehensive projections of urban heat-related mortality: estimates for New York city under multiple population, adaptation, and climate scenarios. *Environmental Health Perspectives* 125, 47–55. doi:10.1289/EHP166.

Pfeiffer, A., Millar, R., Hepburn, C., and Beinhocker, E. (2016). The "2°C carbon stock" for electricity generation: cumulative committed carbon emissions from the electricity generation sector and the transition to a green economy. *Applied Energy* 179, 1395–1408. doi:10.1016/j.apenergy.2016.02.093.

Phillips, J., Newell, P., and Pueyo, A. (2017). "Triple wins? Propsects for pro-poor, low carbon, climate resilient energy services in Kenya," in *Making climate compatible development happen*, ed. F. Nunan (Abingdon, UK and New York, NY, USA: Routledge), 114–129.

Pode, R. (2013). Financing LED solar home systems in developing countries. *Renewable and Sustainable Energy Reviews* 25, 596–629. doi:10.1016/j.rser.2013.04.004.

Popp, A., Calvin, K., Fujimori, S., Havlik, P., Humpenöder, F., Stehfest, E., et al. (2017). Land-use futures in the shared socio-economic pathways. *Global Environmental Change* 42, 331–345. doi:10.1016/j.gloenvcha.2016.10.002.

Popp, A., Rose, S. K., Calvin, K., Van Vuuren, D. P., Dietrich, J. P., Wise, M., et al. (2014). Land-use transition for bioenergy and climate stabilization: Model comparison of drivers, impacts and interactions with other land use based mitigation options. *Climatic Change* 123, 495–509. doi:10.1007/s10584-013-0926-x.

Pradhan, A., Chan, C., Roul, P. K., Halbrendt, J., and Sipes, B. (2018). Potential of conservation agriculture (CA) for climate change adaptation and food security under rainfed uplands of India: a transdisciplinary approach (In Press/Corrected Proof). *Agricultural Systems* in press. doi:10.1016/j.agsy.2017.01.002.

Preston, C. J. (2013). Ethics and geoengineering: reviewing the moral issues raised by solar radiation management and carbon dioxide removal. *Wiley Interdisciplinary Reviews: Climate Change* 4, 23–37. doi:10.1002/wcc.198.
Preston, F., and Lehne, J. (2017). A wider circle? The circular economy in developing countries. London.
Pueyo, A., Gonzalez, F., Dent, C., and DeMartino, S. (2013). The Evidence of Benefits for Poor People of Increased Renewable Electricity Capacity: Literature Review (Evidence Report 31). Institute of Development Studies.
PWGAD (2013). *Beyond Development: Alternative visions from Latin America*. , eds. M. Lang and D. Mokrani Rosa Luxemburg Foundation, Quito, Ecuador and Transnational Institute, Amsterdam, Netherlands.
Pye-Smith, C. (2013). The Quiet Revolution: How Niger's farmers are re-greening the croplands of the Sahel. Nairobi, Kenya.
Pye, S., Watkiss, P., Savage, M., and Blyth, W. (2010). The Economics of Low Carbon, Climate Resilient Patterns of Growth in Developing Countries: A Review of the Evidence Submission to DFID.
Quam, V. G. M., Rocklöv, J., Quam, M. B. M., and Lucas, R. A. I. (2017). Assessing Greenhouse Gas Emissions and Health Co-Benefits : A Structured Review of Lifestyle-Related Climate Change Mitigation Strategies. *International Journal of Environmental Research and Public Health*, 1–19. doi:10.3390/ijerph14050468.
Quan, J., Naess, L. O., Newsham, A., Sitoe, A., and Fernandez, M. C. (2017). "Carbon forestry and climate compatible development in Mozambique: a political economy analysis," in *Making climate compatible development happen*, ed. F. Nunan (Abingdon, UK and New York, NY, USA), 151–181.
Rai, N., and Fisher, S. (2017). *The political economy of low carbon resilient development: planning and implementation*. Abingdon, UK and New York, NY, USA: Routledge.
Rao, N. D. (2014). International and intranational equity in sharing climate change mitigation burdens. *International Environmental Agreements: Politics, Law and Economics* 14, 129–146. doi:10.1007/s10784-013-9212-7.
Rao, N. D., and Min, J. (2018). Is less global inequality good for climate change. *Wiley Interdisciplinary Reviews: Climate Change* in press.
Rao, N. D., Riahi, K., and Grubler, A. (2014). Climate impacts of poverty eradication. *Nature Climate Change* 4. doi:10.1038/nclimate2340.
Rao, N. D., van Ruijven, B. J., Bosetti, V., and Riahi, K. (2017). Improving poverty and inequality modeling in climate research. *Nature Climate Change* 7, 857–862. doi:10.1038/s41558-017-0004-x.
Rao, S., Pachauri, S., Dentener, F., Kinney, P., Klimont, Z., Riahi, K., et al. (2013). Better air for better health: forging synergies in policies for energy access, climate change and air pollution. *Global Environmental Change* 23, 1122–1130. doi:10.1016/j.gloenvcha.2013.05.003.
Rao, S., Zbignew Klimont, Smith, S. J., Dingenen, R. Van, Dentener, F., Bouwman, L., et al. (2016). Future Air Pollution in the Shared Socio-Economic Pathways. *Global Environmental Change* 42, 346–358. doi:10.1016/j.gloenvcha.2016.05.012.
Rasch, R. (2017). Income Inequality and Urban Vulnerability to Flood Hazard in Brazil. *Social Science Quarterly* 98, 299–325. doi:10.1111/ssqu.12274.
Rasul, G., and Sharma, B. (2016a). The nexus approach to water–energy–food security: an option for adaptation to climate change. *Climate Policy* 16. doi:10.1080/14693062.2015.1029865.
Rasul, G., and Sharma, B. (2016b). The nexus approach to water–energy–food security: an option for adaptation to climate change. *Climate Policy* 16, 682–702. doi:10.1080/14693062.2015.1029865.
Ravikumar, A., Larson, A. M., Duchelle, A. E., Myers, R., and Tovar, J. G. (2015). Multilevel governance challenges in transitioning towards a national approach for REDD+: evidence from 23 subnational REDD+ initiatives. *International Journal of the Commons* 9, 909–931.
Raworth, K. (2012). A safe and just space for humanity: can we live within the doughnut? *Nature* 461, 1–26. doi:10.5822/978-1-61091-458-1.
Raworth, K. (2017a). A Doughnut for the Anthropocene: humanity's compass in the 21st century. *The Lancet Planetary Health* 1, e48–e49. doi:10.1016/S2542-5196(17)30028-1.
Raworth, K. (2017b). *Doughnut economics: seven ways to think like a 21st-century economist*. White River Junction, VT, USA: Chelsea Green Publishing.
Redclift, M., and Springett, D. (2015). *Routledge International Handbook of Sustainable Development*. , eds. M. Redclift and D. Springett Abingdon, UK and New York, NY, USA: Routledge.
Reed, S. O., Friend, R., Jarvie, J., Henceroth, J., Thinphanga, P., Singh, D., et al. (2015). Resilience projects as experiments: implementing climate change resilience in Asian cities. *Climate and Development* 7, 469–480. doi:10.1080/17565529.2014.989190.
Regmi, B. R., and Star, C. (2015). Exploring the policy environment for mainstreaming community-based adaptation (CBA) in Nepal. *International Journal of Climate Change Strategies and Management* 7, 423–441. doi:10.1108/IJCCSM-04-2014-0050.
Reid, H. (2016). Ecosystem- and community-based adaptation: learning from community-based natural resource management. *Climate and Development* 8, 4–9. doi:10.1080/17565529.2015.1034233.
Reid, H., and Huq, S. (2014). Mainstreaming community-based adaptation into national and local planning. *Climate and Development* 6, 291–292. doi:10.1080/17565529.2014.973720.

Reij, C., and Winterbottom, R. (2015). Scaling up Regreening: Six Steps to Success. A Practical Approach to Forest Landscape Restoration.

Ren, W., Xue, B., Geng, Y., Lu, C., Zhang, Y., Zhang, L., et al. (2016). Inter-city passenger transport in larger urban agglomeration area: Emissions and health impacts. *Journal of Cleaner Production* 114, 412–419. doi:10.1016/j.jclepro.2015.03.102.

Rentschler, J., and Bazilian, M. (2016). Reforming fossil fuel subsidies: drivers, barriers and the state of progress. *Climate Policy*, 1–24. doi:10.1080/14693062.2016.1169393.

Republic of Vanuatu (2016). Vanuatu 2030: the people's plan. Port Villa, Vanuatu.

Rescalvo, M., Lasa, M., D'Silva, N., Barrios, R., Sommaripa, L., Scholz, S., et al. (2013). "Low carbon city development" (LCCD) as a strategy for sustainable cities: the case of Rio de Janeiro, Brazil. *International Journal of Technology Management & Sustainable Development* 12, 261–280. doi:10.1386/tmsd.12.3.261_1.

Revi, A., Satterthwaite, D. E., Aragón-Durand, F. Corfee-Morlot, J., Kiunsi, R. B. R., Pelling, M., Roberts, D. C., et al. (2014). "Urban areas.," in *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*, eds. C. B. Field, V. R. Barros, D. J. Dokken, K. J. Mach, M. D. Mastrandrea, T. E. Bilir, et al. (Cambridge, UK, and New York, NY, USA: Cambridge University Press), 535–612.

Reyer, C. P. O., Adams, S., Albrecht, T., Baarsch, F., Boit, A., Canales Trujillo, N., et al. (2017a). Climate change impacts in Latin America and the Caribbean and their implications for development. *Regional Environmental Change* 17, 1601–1621. doi:10.1007/s10113-015-0854-6.

Reyer, C. P. O., Rigaud, K. K., Fernandes, E., Hare, W., Serdeczny, O., and Schellnhuber, H. J. (2017b). Turn down the heat: regional climate change impacts on development. *Regional Environmental Change* 17, 1563–1568. doi:10.1007/s10113-017-1187-4.

Reyna, J. L., and Chester, M. V. (2017). Energy efficiency to reduce residential electricity and natural gas use under climate change. *Nature Communications* 8, 1–12. doi:10.1038/ncomms14916.

Riahi, K., Dentener, F., Gielen, D., Grubler, A., Jewell, J., Klimont, Z., et al. (2012). "Energy Pathways for Sustainable Development," in *Global Energy Assessment - Toward a Sustainable Future*, eds. T. B. Johansson, N. Nakicenovic, A. Patwardhan, and L. Gomez-Echeverri (Cambridge University Press, Cambridge, UK and New York, NY, USA and the International Institute for Applied Systems Analysis (IIASA), Laxenburg, Austria), 1203–1306.

Riahi, K., Kriegler, E., Johnson, N., Bertram, C., den Elzen, M., Eom, J., et al. (2015). Locked into Copenhagen pledges — Implications of short-term emission targets for the cost and feasibility of long-term climate goals. *Technological Forecasting and Social Change* 90, 8–23. doi:10.1016/j.techfore.2013.09.016.

Riahi, K., van Vuuren, D. P., Kriegler, E., Edmonds, J., O'Neill, B. C., Fujimori, S., et al. (2017). The Shared Socioeconomic Pathways and their energy, land use, and greenhouse gas emissions implications: an overview. *Global Environmental Change* 42, 153–168. doi:10.1016/j.gloenvcha.2016.05.009.

Rickards, L., and Howden, S. M. (2012). Transformational adaptation: Agriculture and climate change. in *Crop and Pasture Science*, 240–250. doi:10.1071/CP11172.

Rietig, K. (2013). Sustainable climate policy integration in the European Union. *Environmental Policy and Governance* 23, 297–310. doi:10.1002/eet.1616.

Roberts, E., Andrei, S., Huq, S., and Flint, L. (2015). Resilience synergies in the post-2015 development agenda. *Nature Climate Change* 5, 1024–1025. doi:10.1038/nclimate2776.

Robinson, S., and Dornan, M. (2017). International financing for climate change adaptation in small island developing states. *Regional Environmental Change*, 17, 1103–1115.

Robledo-Abad, C., Althaus, H.-J., Berndes, G., Bolwig, S., Corbera, E., Creutzig, F., et al. (2017). Bioenergy production and sustainable development: science base for policymaking remains limited. *GCB Bioenergy* 9, 541–556. doi:10.1111/gcbb.12338.

Rockström, J., Gaffney, O., Rogelj, J., Meinshausen, M., Nakicenovic, N., and Schellnhuber, H. J. (2017a). A roadmap for rapid decarbonization. *Science* 355, 1269–1271.

Rockström, J., Steffen, W., Noone, K., Persson, Å., Chapin, F. S. I., Lambin, E., et al. (2009a). Planetary boundaries: exploring the safe operating space for humanity. *Ecology and Society* 14, art32. doi:10.5751/ES-03180-140232.

Rockström, J., Steffen, W., Noone, K., Persson, Å., Chapin, F. S., Lambin, E. F., et al. (2009b). A safe operating space for humanity. *Nature* 461, 472–475.

Rockström, J., Williams, J., Daily, G., Noble, A., Matthews, N., Gordon, L., et al. (2017b). Sustainable intensification of agriculture for human prosperity and global sustainability. *Ambio* 46, 4–17. doi:10.1007/s13280-016-0793-6.

Rogelj, J., Alexander, P., Katherine V., C., Gunnar, L., Johannes, E., David, G., et al. Transition pathways towards limiting climate change below 1.5°C (submitted). *Nature Clim. Change* submitted.

Rogelj, J., Luderer, G., Pietzcker, R. C., Kriegler, E., Schaeffer, M., Krey, V., et al. (2015). Energy system transformations for limiting end-of-century warming to below 1.5 °C. *Nature Climate Change* 5, 519–527. doi:10.1038/nclimate2572.

Roger, C., Hale, T., and Andonova, L. (2017). The comparative politics of transnational climate governance.

International Interactions 43, 1–25. doi:10.1080/03050629.2017.1252248.
Rose, S. K., Kriegler, E., Bibas, R., Calvin, K., Popp, A., Weyant, J., et al. (2014a). Bioenergy in energy transformation and climate management. *Climatic Change* 123, 477–493. doi:10.1007/s10584-013-0965-3.
Rose, S. K., Kriegler, E., Bibas, R., Calvin, K., Popp, A., and Weyant, J. (2014b). Bioenergy in energy transformation and climate management. *Climatic Change* 123, 477–493. doi:10.1007/s10584-013-0965-3.
Rosenbloom, D. (2017). Pathways: An emerging concept for the theory and governance of low-carbon transitions. *Global Environmental Change* 43, 37–50. doi:10.1016/j.gloenvcha.2016.12.011.
Roser, D., Huggel, C., Ohndorf, M., and Wallimann-Helmer, I. (2015). Advancing the interdisciplinary dialogue on climate justice. *Climatic Change* 133, 349–359. doi:10.1007/s10584-015-1556-2.
Roser, D., and Seidel, C. (2017). *Climate justice*. Abingdon, Oxon: Routledge.
Rouillard, J., Benson, D., and Gain, A. (2014). Evaluating IWRM implementation success: are water policies in Bangladesh enhancing adaptive capacity to climate change impacts? *International journal of water* 30, 515–527.
Rourke, D. O., and Lollo, N. (2015). Transforming Consumption: From Decoupling, to Behavior Change, to System Changes for Sustainable Consumption. *Annual Review of Environment and Resources* 40, 233–259. doi:10.1146/annurev-environ-102014-021224.
Roy, J., Ganguly, D., and Chakravarty, D. (2016). Low carbon green growth strategies and sustainable development for mega cities: a case study of Kolkata. *Amity Journal of Economics* 1, 73–86.
Rozenberg, J., and Hallegatte, S. (2016). Modeling the Impacts of Climate Change on Future Vietnamese Households: A Micro-Simulation Approach.
Rozenberg, J., Vogt-schilb, A., and Hallegatte, S. (2014). Transition to Clean Capital, Irreversible Investment and Stranded Assets. World Bank.
Runhaar, H., Driessen, P., and Uittenbroek, C. (2014). Towards a Systematic Framework for the Analysis of Environmental Policy Integration. *Environmental Policy and Governance* 24, 233–246. doi:10.1002/eet.1647.
Rutledge, D., Ausseil, A.-G., Baisden, T., Bodeker, G., Booker, D., Cameron, M., et al. (2017). Identifying feedbacks, understanding cumulative impacts and recognising limits: a national integrated assessment. Synethsis report RA3. Climate change Impacts and implications for New Zealand to 2100:
Sachs, J., Schmidt-Traub, G., Kroll, C., Durand-Delacre, D., and Teksoz, K. (2017). An SDG Index and Dashboards - Global Report. New York, NY, USA.
Samii, C., Lisiecki, M., Kulkarni, P., and Chavis, L. (2014). Effects of Payment for Environmental Services (PES) on Deforestation and Poverty in Low and Middle Income Countries: A Systematic Review. *Campbell Systematic Reviews* 11, 95. doi:10.4073/csr.2014.11.
Samir, K. C. (2013). Community vulnerability to floods and landslides in Nepal. *Ecology and Society* 18. doi:10.5751/ES-05095-180108.
Sánchez-Azofeifa, G. A., Pfaff, A., Robalino, J. A., and Boomhower, J. P. (2007). Costa Rica's payment for environmental services program: intention, implementation, and impact. *Conservation Biology* 21, 1165–1173. doi:10.1111/j.1523-1739.2007.00751.x.
Sanchez, A., and Izzo, M. (2017). Micro hydropower: an alternative for climate change mitigation, adaptation, and development of marginalized local communities in Hispaniola Island. *Climatic Change* 140, 79–87. doi:10.1007/s10584-016-1865-0.
Sánchez, A., and Izzo, M. (2017). Micro hydropower: an alternative for climate change mitigation, adaptation, and development of marginalized local communities in Hispaniola Island. *Climatic Change* 140, 79–87.
Santarius, T., Walnum, H. J., and Aall, C. (2016). *Rethinking climate and energy policies: new perspectives on the rebound phenomenon*. , eds. T. Santarius, H. J. Walnum, and C. Aall Springer doi:10.1007/978-3-319-38807-6.
Santos, P., Bacelar-Nicolau, P., Pardal, M. A., Bacelar-Nicolau, L., and Azeiteiro, U. . (2016). "Assessing Student Perceptions and Comprehension of Climate Change in Portuguese Higher Education Institutions in"Implementing Climate Change Adaptation in Cities and Communities Integrating Strategies and Educational Approaches," in *Implementing Climate Change Adaptation in Cities and Communities Integrating Strategies and Educational Approaches*.
Satterthwaite, D. (2016). Missing the Millennium Development Goal targets for water and sanitation in urban areas. *Environment and Urbanization* 28, 99–118. doi:10.1177/0956247816628435.
Satterthwaite, D. (2017). Successful, safe and sustainable cities: towards a New Urban Agenda. *Commonwealth Journal of Local Governance* 0, 3. doi:10.5130/cjlg.v0i19.5446.
Schader, C., Muller, A., Scialabba Nel, H., Hecht, J., Isensee, A., Erb, K. H., et al. (2015). Impacts of feeding less food-competing feedstuffs to livestock on global food system sustainability. *Journal of the Royal Society Interface* 12, 20150891. doi:10.1098/rsif.2015.0891.
Schaeffer, M., Gohar, L., Kriegler, E., Lowe, J., Riahi, K., and van Vuuren, D. (2015a). Mid- and long-term climate projections for fragmented and delayed-action scenarios. *Technological Forecasting and Social Change* 90, 257–268. doi:10.1016/j.techfore.2013.09.013.
Schaeffer, M., Rogelj, J., Roming, N., Sferra, F., Hare, B., and Serdeczny, O. (2015b). Feasibility of limiting warming to 1.5 and 2°C. Berlin, Germany.

Schandl, H., Hatfield-Dodds, S., Wiedmann, T., Geschke, A., Cai, Y., West, J., et al. (2016). Decoupling global environmental pressure and economic growth: scenarios for energy use, materials use and carbon emissions. *Journal of Cleaner Production* 132, 45–56. doi:10.1016/j.jclepro.2015.06.100.

Schipper, L. E., Le Masson, V., Langston, L., Kratzer, S., Sogani, R., Nyukuri, E., et al. (2017). "Closing the knowledge gaps on gender and climate change CCD," in *Making climate compatible development happen development happen*, ed. F. Nunan (Abingdon, UK and New York, NY, USA: Routledge), 44–65.

Schleussner, C.-F., Rogelj, J., Schaeffer, M., Lissner, T., Licker, R., Fischer, E. M., et al. (2016). Science and policy characteristics of the Paris Agreement temperature goal. 6, 827.

Schlosberg, D., and Collins, L. B. (2014). From environmental to climate justice: climate change and the discourse of environmental justice. *Wiley Interdisciplinary Reviews: Climate Change* 5, 359–374. doi:10.1002/wcc.275.

Schlosberg, D., Collins, L. B., and Niemeyer, S. (2017). Adaptation policy and community discourse: risk, vulnerability, and just transformation. *Environmental Politics* 26, 1–25. doi:10.1080/09644016.2017.1287628.

Schmoker, M. (2011). Measuring What Matters: National Statistician's reflections on the National Debate on Measuring National Well-being. London.

Schneider, F., Kallis, G., and Martinez-Alier, J. (2010). Crisis or opportunity? Economic degrowth for social equity and ecological sustainability. Introduction to this special issue. *Journal of Cleaner Production* 18, 511–518. doi:10.1016/j.jclepro.2010.01.014.

Schoeman, J., Allan, C., and Finlayson, C. M. (2014). A new paradigm for water? A comparative review of integrated, adaptive and ecosystem-based water management in the Anthropocene. *International Journal of Water Resources Development* 627, 1–14. doi:10.1080/07900627.2014.907087.

Schroeder, H., and McDermott, C. (2014). Beyond carbon: Enabling justice and equity in REDD+ across levels of governance. *Ecology and Society* 19, 2–4. doi:10.5751/ES-06537-190131.

Schwarzer, H., Van Panhuys, C., and Diekmann, K. (2016). Protecting people and the environment: lessons learnt from Brazil's Bolsa Verde, China, Costa Rica, Ecuador, Mexico, South Africa and 56 other experiences. Geneva, Switzerland.

Scoones, I., Edelman, M., Borras, S. M., Hall, R., Wolford, W., and White, B. (2017a). Emancipatory rural politics: confronting authoritarian populism. *The Journal of Peasant Studies* 6150, 1–20. doi:10.1080/03066150.2017.1339693.

Scoones, I., Whitfield, S., Sumberg, J., Thompson, J., Brooks, S., Van Zwanenberg, P., et al. (2017b). *Pathways to Sustainable Agriculture*. Routledge.

Scott, F. L., Jones, C. R., and Webb, T. L. (2014). What do people living in deprived communities in the UK think about household energy efficiency interventions?? *Energy Policy* 66, 335–349. doi:10.1016/j.enpol.2013.10.084.

Sealey-Huggins, L. (2017). "1.5°C to stay alive": climate change, imperialism and justice for the Caribbean. *Third World Quarterly* 6597, 1–20. doi:10.1080/01436597.2017.1368013.

Serdeczny, O. M., Bauer, S., and Huq, S. (2017). Non-economic losses from climate change: opportunities for policy-oriented research. *Climate and Development*, 1–5. doi:10.1080/17565529.2017.1372268.

Serrao-Neumann, S., Crick, F., Harman, B., Sano, M., Sahin, O., van Staden, R., et al. (2014). Improving cross-sectoral climate change adaptation for coastal settlements: Insights from South East Queensland, Australia. *Regional Environmental Change* 14, 489–500. doi:10.1007/s10113-013-0442-6.

Seto, K. C., Davis, S. J., Mitchell, R. B., Stokes, E. C., Unruh, G., and Ürge-Vorsatz, D. (2016). Carbon Lock-In: Types, Causes, and Policy Implications. *Annual Review of Environment and Resources* 41, 425–452. doi:10.1146/annurev-environ-110615-085934.

Seto, K., Dhakal, S., Bigio, A., Blanco, H., Delgado, G., Dewar, D., et al. (2014). "Human settlements, infrastructure and spatial planning," in *Climate Change 2014: Mitigation of Climate Change Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*, eds. O. Edenhofer and T. Z. and J. C. M. R Pichs-Madruga, Y Sokona, E Farahani, S Kadner, K Seyboth, A Adler, I Baum, S Brunner, P Eickemeier, B Kriemann, J Savolainen, S Schlömer, C von Stechow (Cambridge, United Kingdom and New York, NY, USA: Cambridge University Press).

Shackleton, S., Ziervogel, G., Sallu, S., Gill, T., and Tschakert, P. (2015a). Why is socially-just climate change adaptation in sub-Saharan Africa so challenging? A review of barriers identified from empirical cases. 6. doi:10.1002/wcc.335.

Shackleton, S., Ziervogel, G., Sallu, S., Gill, T., and Tschakert, P. (2015b). Why is socially-just climate change adaptation in sub-Saharan Africa so challenging? A review of barriers identified from empirical cases. *Wiley Interdisciplinary Reviews: Climate Change* 6, 321–344. doi:10.1002/wcc.335.

Shaffrey, L. C., Stevens, I., Norton, W. A., Roberts, M. J., Vidale, P. L., Harle, J. D., et al. (2009). U.K. HiGEM: the new U.K. high-resolution global environment model - model description and basic evaluation. *Journal of Climate* 22, 1861–1896. doi:10.1175/2008JCLI2508.1.

Sharma, U., Patwardhan, A., and Patt, A. G. (2013). Education as a determinant of response to cyclone warnings: evidence from coastal zones in India. *Ecology and Society* 18. doi:10.5751/ES-05439-180218.

Sharpe, R. A., Thornton, C. R., Nikolaou, V., and Osborne, N. J. (2015). Higher energy efficient homes are associated

with increased risk of doctor diagnosed asthma in a UK subpopulation. *Environment International* 75, 234–244. doi:10.1016/j.envint.2014.11.017.
Shaw, A., Burch, S., Kristensen, F., Robinson, J., and Dale, A. (2014a). Accelerating the sustainability transition: exploring synergies between adaptation and mitigation in British Columbian communities. *Global Environmental Change* 25, 41–51. doi:10.1016/j.gloenvcha.2014.01.002.
Shaw, C., Hales, S., Howden-Chapman, P., and Edwards, R. (2014b). Health co-benefits of climate change mitigation policies in the transport sector. *Nature Clim. Change* 4, 427–433. doi:10.1038/nclimate2247.
Shen, H., Tao, S., Chen, Y., Ciais, P., Güneralp, B., Ru, M., et al. (2017). Urbanization-induced population migration has reduced ambient PM 2.5 concentrations in China. *Science Advances* 3, e1700300. doi:10.1126/sciadv.1700300.
Sheng, P., and Lu, D. (2015). Low-carbon development and carbon reduction in China. *Climate and Development* 8, 472–479. doi:10.1080/17565529.2015.1064812.
Shi, Y., Liu, J., Shi, H., Li, H., and Li, Q. (2017). The ecosystem service value as a new eco-efficiency indicator for industrial parks. *Journal of Cleaner Production* 164, 597–605. doi:10.1016/j.jclepro.2017.06.187.
Shue, H. (2014a). *Climate justice: vulnerability and protection*. Oxford UK: Oxford University Press.
Shue, H. (2014b). *Climate Justice: Vulnerability and Protection*. Oxford University Press.
Shue, H. (2017). Responsible for what? Carbon producer CO2 contributions and the energy transition. *Climatic Change*, 1–6. doi:10.1007/s10584-017-2042-9.
Shukla, P., Dhar, S., Pathakb, M., Mahadeviab, D., and Garg, A. (2015). Pathways to deep decarbonization in India.
Shukla, P. R., and Chaturvedi, V. (2013). Sustainable energy transformations in India under climate policy. *Sustainable Development* 21, 48–59. doi:10.1002/sd.516.
Shultz, J., Cohen, M., Hermosilla, S., Espinel, Z., and Maclean, A. (2016). Disaster risk reduction and sustainable development for small island developing states. *Disaster Health* 3, 32–44. doi:10.1080/21665044.2016.1173443.
Shuxin, W., Genxu, W., and Yiping, F. (2016). Factors Influencing the Energy Efficiency of Tourism Transport in China. 7, 246–253. doi:10.5814/j.issn.1674-764x.2016.04.002.
Siagian, U. W. R., Dewi, R. G., Boer, R., Hendrawan, I., Yuwono, B. B., and Ginting, G. E. (2016). Pathways to deep decarbonizing agriculture, forest and other land uses sector in Indonesia.
Sietz, D., and Feola, G. (2016). Resilience in the rural Andes: critical dynamics, constraints and emerging opportunities. *Regional Environmental Change* 16, 2163–2169. doi:10.1007/s10113-016-1053-9.
Sietz, D., and Van Dijk, H. (2015). Land-based adaptation to global change: What drives soil and water conservation in western Africa? *Global Environmental Change* 33, 131–141. doi:10.1016/j.gloenvcha.2015.05.001.
Simonet, C., and Jobbins, G. (2016). Understanding patterns of climate-resilient development - the case of Senegal. London, UK.
Sinclair, F. L. (2016). "Systems science at the scale of impact: reconciling bottom-up participation with the production of widely applicable research outputs.," in *Sustainable Intensification in Smallholder Agriculture: An Integrated Systems Research Approach*, ed. W. B. and K. A.-K. I. Oborn, B. Vanlauwe, M. Phillips, R. Thomas (London, UK: Earthscan), 43–57.
Singh, A., Syal, M., Grady, S. C., and Korkmaz, S. (2010). Effects of green buildings on employee health and productivity. *American Journal of Public Health* 100, 1665–1668. doi:10.2105/AJPH.2009.180687.
Singh, C., Daron, J., Bazaz, A., Ziervogel, G., Spear, D., Krishnaswamy, J., et al. (2017a). The utility of weather and climate information for adaptation decision-making: current uses and future prospects in Africa and India. *Climate and Development*, 1–17. doi:10.1080/17565529.2017.1318744.
Singh, G. G., Cisneros-montemayor, A. M., Swartz, W., Cheung, W., Guy, J. A., Mcowen, C. J., et al. (2017b). A rapid assessment of co-bene fi ts and trade-offs among Sustainable Development Goals. *Marine Policy* in press. doi:10.1016/j.marpol.2017.05.030.
Skeie, R. B., Fuglestvedt, J., Berntsen, T., Peters, G. P., Andrew, R., Allen, M., et al. (2017). Perspective has a strong effect on the calculation of historical contributions to global warming. *Environmental Research Letters* 12. doi:10.1088/1748-9326/aa5b0a.
Slegers, M. F. W. (2008). "If only it would rai": Farmers' perceptions of rainfall and drought in semi-arid central Tanzania. *Journal of Arid Environments* 72, 2106–2123. doi:10.1016/j.jaridenv.2008.06.011.
Smith, K. R., Jerrett, M., Anderson, H. R., Burnett, R. T., Stone, V., Derwent, R., et al. (2009). Public health benefits of strategies to reduce greenhouse-gas emissions: health implications of short-lived greenhouse pollutants. *The Lancet* 374, 2091–2103. doi:http://dx.doi.org/10.1016/S0140-6736(09)61716-5.
Smith, K. R., and Sagar, A. (2014). Making the clean available: Escaping India's Chulha Trap. *Energy Policy* 75, 410–414. doi:10.1016/j.enpol.2014.09.024.
Smith, K. R., Woodward, A., Campbell-Lendrum, D., Chadee, D. D., Honda, Y., Liu, Q., et al. (2014a). "Human health: impacts, adaptation, and co-benefits," in *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel of Climate Change*, eds. C. B. Field, V. R. Barros, D. J. Dokken, K. J. Mach, M. D. Mastrandrea, T. E. Bilir, et al. (Cambridge, UK and New York, NY, USA: Cambridge University Press), 709–

754.
Smith, P. (2013). Delivering food security without increasing pressure on land. *Global Food Security* 2, 18–23. doi:10.1016/j.gfs.2012.11.008.
Smith, P., Bustamante, M., Ahammad, H., Clark, H., Dong, H., Elsiddig, E. A., et al. (2014b). "Agriculture, Forestry and Other Land Use (AFOLU)," in *Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*, eds. O. Edenhofer, R. Pichs-Madruga, Y. Sokona, E. Farahani, S. Kadner, K. Seyboth, et al. (Cambridge, UK and New York, NY, USA.: Cambridge University Press), 811–922.
Smith, P., Davis, S. J., Creutzig, F., Fuss, S., Minx, J., Gabrielle, B., et al. (2016). Biophysical and economic limits to negative CO2 emissions. *Nature Clim. Change* 6, 42–50. doi:10.1038/nclimate2870\rhttp://www.nature.com/nclimate/journal/v6/n1/abs/nclimate2870.html#supplementary-information.
Smith, P., Haberl, H., Popp, A., Erb, K. H., Lauk, C., Harper, R., et al. (2013a). How much land-based greenhouse gas mitigation can be achieved without compromising food security and environmental goals? *Glob Chang Biol* 19, 2285–2302. doi:10.1111/gcb.12160.
Smith, T. F., Thomsen, D. C., Gould, S., Schmitt, K., and Schlegel, B. (2013b). Cumulative pressures on sustainable livelihoods: Coastal adaptation in the mekong delta. *Sustainability (Switzerland)* 5, 228–241. doi:10.3390/su5010228.
Smucker, T. A., Wisner, B., Mascarenhas, A., Munishi, P., Wangui, E. E., Sinha, G., et al. (2015). Differentiated livelihoods, local institutions, and the adaptation imperative: Assessing climate change adaptation policy in Tanzania. *Geoforum* 59, 39–50. doi:10.1016/j.geoforum.2014.11.018.
Somorin, O. A., Visseren-Hamakers, I. J., Arts, B., Tiani, A. M., and Sonwa, D. J. (2015). Integration through interaction? Synergy between adaptation and mitigation (REDD+) in Cameroon. *Environment and Planning C: Government and Policy* 34, 415–432. doi:10.1177/0263774X16645341.
Song, Y., Cervarich, M., Jain, A. K., Kheshgi, H. S., Landuyt, W., and Cai, X. (2016). The Interplay Between Bioenergy Grass Production and Water Resources in the United States of America. *Environmental science & technology* 50, 3010–3019.
Sonwa, D. J., Amadou, D., Mzouri, E.-H. El, Amos, M., T, F., and Mugabe, N. O. (2017). Drivers of climate risk in African agriculture. *Climate and Development* 9, 383–398.
Sosa-Rodriguez, F. S. (2014). From federal to city mitigation and adaptation: climate change policy in Mexico City. *Mitigation and Adaptation Strategies for Global Change* 19, 969–996. doi:10.1007/s11027-013-9455-1.
Southern Voices (2016). Putting principles into practice: civil society experiences from across the world of using the Joint Principles for Adaptation.
Sovacool, B. (2012). Deploying off-grid technology to Eradicate Energy Poverty. *Science*, 2–4. doi:10.1126/science.1222307.
Sovacool, B. K., and Drupady, I. (2012). *Energy Access, Poverty, and Development: The Governance of Small-Scale Renewable Energy in Developing Asia*. Abingdon, UK and New York, NY, USA: Routledge.
Sovacool, B. K., Linnér, B.-O., and Goodsite, M. E. (2015). The political economy of climate adaptation. *Nature Climate Change* 5, 616–618. doi:10.1038/nclimate2665.
Sovacool, B. K., Linner, B. O., and Klein, R. J. T. (2017a). Climate change adaptation and the Least Developed Countries Fund (LDCF): qualitative insights from policy implementation in the Asia-Pacific. *Climatic Change* 140, 209–226. doi:10.1007/s10584-016-1839-2.
Sovacool, B. K., Tan Mullins, M., Ockwell, D., and Newell, P. (2017b). Political economy, poverty, and polycentrism in the Global Environment Facility's Least Developed Countries Fund (LDCF) for Climate Change Adaptation. *Third World Quarterly* 6597, 1–23. doi:10.1080/01436597.2017.1282816.
Speranza, C. I., Wiesmann, U., and Rist, S. (2014). An indicator framework for assessing livelihood resilience in the context of social-ecological dynamics. *Global Environmental Change* 28, 109–119. doi:10.1016/j.gloenvcha.2014.06.005.
Staggenborg, S., and Ogrodnik, C. (2015). New environmentalism and Transition Pittsburgh. *Environmental Politics* 24, 723–741. doi:10.1080/09644016.2015.1027059.
Stavins, R., Zou, J., Brewer, T., Conte Grand, M., den Elzen, M., Finus, M., et al. (2014). "International Cooperation: Agreements and Instruments," in *Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*, ed. T. Z. and J. C. M. Edenhofer, O., R. Pichs-Madruga, Y. Sokona, E. Farahani, S. Kadner, K. Seyboth, A. Adler, I. Baum, S. Brunner, P. Eickemeier, B. Kriemann, J. Savolainen, S. Schlömer, C. von Stechow (Cambridge, United Kingdom and New York, NY, USA.: Cambridge University Press).
Steering Committee on Partnerships for SIDS and UNDESA (2016). Partnerships for small island developing states, Samoa.
Steffen, W., Richardson, K., Rockström, J., Cornell, S., Fetzer, I., Bennett, E., et al. (2015). Planetary boundaries: guiding human development on a changing planet. *Science* 348, 1217. doi:10.1126/science.aaa9629.

Stern, N. (2015). Growth, climate and collaboration: towards agreement in Paris 2015.
Stern, P. C., Sovacool, B. K., and Dietz, T. (2016). Towards a science of climate and energy choices. *Nature Climate Change* 6, 547–555.
Sterrett, C. (2015a). Final evaluation of the Vanuatu NGO Climate Change Adaptation Program.
Sterrett, C. L. (2015b). Final evaluation of the Vanuatu NGO Climate Change Adaptation Program.
Stevens, C., Winterbottom, R., Springer, J., and Reytar, K. (2014). Securing rights, combating climate change: how strengthening community forests rights mitigates climate change. Washington DC, USA.
Stewart, R. J., Wollheim, W. M., Miara, A., Vörösmarty, C. J., Fekete, B., Lammers, R. B., et al. (2013). Horizontal cooling towers: riverine ecosystem services and the fate of thermoelectric heat in the contemporary Northeast US. *Environmental Research Letters* 8, 25010.
Stirling, A. (2014). Emancipating Transformations: From controlling "the transition" to culturing plural radical progress. Brighton, UK.
Striessnig, E., and Loichinger, E. (2015). Future differential vulnerability to natural disasters by level of education. *Vienna Yearbook of Population Research* 13, 221–240.
Striessnig, E., Lutz, W., and Patt, A. G. (2013). Effects of educational attainment on climate risk vulnerability. *Ecology and Society* 18. doi:10.5751/ES-05252-180116.
Stringer, L. C., Dougill, A. J., Dyer, J. C., Vincent, K., Fritzsche, F., Leventon, J., et al. (2014). Advancing climate compatible development: Lessons from southern Africa. *Regional Environmental Change* 14, 713–725. doi:10.1007/s10113-013-0533-4.
Stringer, L. C., Dougill, A. J., Mkwambisi, D., Dyer, J., F, K., and Mngoli, M. (2012). Challenges and opportunities for carbon management in Malawi and Zambia. *Carbon Management* 3, 159–173.
Stringer, L. C., Sallu, S. ., Dougill, A. J., Wood, B. T., and Ficklin, L. (2017). "Reconsidering climate compatible development as a new development landscape in southern Africa," in *Making climate compatible development happen*, ed. F. Nunan (Abingdon, UK and New York, NY, USA: Routledge), 22–43.
Subramanyam, V., Kumar, A., Talaei, A., and Mondal, M. A. H. (2017). Energy efficiency improvement opportunities and associated greenhouse gas abatement costs for the residential sector. *Energy* 118, 795–807. doi:10.1016/j.energy.2016.10.115.
Suckall, N., Fraser, E., and Forster, P. (2017). Reduced migration under climate change: evidence from Malawi using an aspirations and capabilities framework. *Climate and Development* 9, 298–312. doi:10.1080/17565529.2016.1149441.
Suckall, N., Stringer, L. C., and Tompkins, E. L. (2014a). Presenting triple-wins? Assessing projects that deliver adaptation, mitigation and development co-benefits in rural Sub-Saharan Africa. *Ambio* 44, 34–41. doi:10.1007/s13280-014-0520-0.
Suckall, N., Stringer, L. C., and Tompkins, E. L. (2015). Presenting triple-wins? Assessing projects that deliver adaptation, mitigation and development co-benefits in rural Sub-Saharan Africa. *Ambio* 44, 34–41. doi:10.1007/s13280-014-0520-0.
Suckall, N., Tompkins, E., and Stringer, L. (2014b). Identifying trade-offs between adaptation, mitigation and development in community responses to climate and socio-economic stresses: Evidence from Zanzibar, Tanzania. *Applied Geography* 46, 111–121. doi:10.1016/j.apgeog.2013.11.005.
Sudarshan, A., Somanathan, E., Somanathan, R., and Tewari, M. (2015). The Impact of temperature on productivity and labor supply: evidence from Indian manufacturing. Delhi, India.
Sugar, L., Kennedy, C., and Hoornweg, D. (2013). Synergies between climate change adaptation and mitigation in development: case studies of Amman, Jakarta, and Dar es Salaam. *International Journal of Climate Change Strategies and Management* 5, 95–111.
Sundseth, K., Lopez-Aparicio, S., and Sundvor, I. (2015). Bioethanol vehicle transport in Oslo as climate policy: what are the social economic costs resulting from acetaldehyde pollution effects? *Journal of Cleaner Production* 108, 1157–1167. doi:10.1016/j.jclepro.2015.06.048.
Sutcliffe, C., Dougill, A. J., and Quinn, C. H. (2016). Evidence and perceptions of rainfall change in Malawi: do maize cultivar choices enhance climate change adaptation in sub-Saharan Africa? *Regional Environmental Change* 16, 1215–1224. doi:10.1007/s10113-015-0842-x.
Szabo, S., Matthews, Z., Renaud, F. G., Sebesvári, Z., Hossain, M. S., Foufoula-Georgiou, E., et al. (2015). Sustainable Development Goals Offer New Opportunities for Tropical Delta Regions. *Environment* 57, 16–23. doi:10.1080/00139157.2015.1048142.
Tàbara, J. D., St. Clair, A. L., and Hermansen, E. A. T. (2017a). Transforming communication and knowledge production processes to address high-end climate change. *Environmental Science & Policy* 70, 31–37. doi:10.1016/J.ENVSCI.2017.01.004.
Tàbara, J. D., St. Clair, A. L., and Hermansen, E. A. T. (2017b). Transforming communication and knowledge production processes to address high-end climate change. *Environmental Science and Policy* 70, 31–37. doi:10.1016/j.envsci.2017.01.004.
Tanner, T., Mensah, A., Lawson, E. T., Gordon, C., Godfrey-Wood, R., and Cannon, T. (2017). "Political economy of

climate compatible development: artisanal fisheries and climate change in Ghana," in *Making climate compatible development happen*, ed. F. Nunan (Abingdon, UK and New York, NY, USA: Routledge), 223–241. doi:10.1111/j.2040-0209.2014.00446.x.
Tapsell, S. M., Penning-Rowsell, E., Tunstall, S., and Wilson, T. (2002). Vulnerability to flooding: health and social dimensions. *Phil. Trans. R. Soc. Lond. A* 360, 1511–1525.
Taylor, M. (2017a). Climate-smart agriculture: what is it good for? *Journal of Peasant Studies* 0, 1–19. doi:10.1080/03066150.2017.1312355.
Taylor, M. (2017b). Climate-smart agriculture: what is it good for? *The Journal of Peasant Studies*, 1–19. doi:10.1080/03066150.2017.1312355.
Taylor Aiken, G. (2015). (Local-) community for global challenges: carbon conversations, transition towns and governmental elisions. *Local Environment* 20, 764–781. doi:10.1080/13549839.2013.870142.
Taylor Aiken, G. (2016). Prosaic state governance of community low carbon transitions. *Political Geography* 55, 20–29. doi:10.1016/j.polgeo.2016.04.002.
Taylor Aiken, G., Middlemiss, L., Sallu, S., and Hauxwell-Baldwin, R. (2017). Researching climate change and community in neoliberal contexts: an emerging critical approach. *Wiley Interdisciplinary Reviews: Climate Change* 8, n/a-n/a. doi:10.1002/wcc.463.
Teferi, Z. Improvement of slums in Addis Ababa: Moving towards community-sensitive distributed infrastructure? *Environment and Urbanization* submitted.
Tengö, M., Brondizio, E. S., Elmqvist, T., Malmer, P., and Spierenburg, M. (2014). Connecting diverse knowledge systems for enhanced ecosystem governance: The multiple evidence base approach. *Ambio* 43, 579–591. doi:10.1007/s13280-014-0501-3.
Terpstra, P., Peterson Carvalho, A., and Wilkinson, E. (2015). From Tracking to Action: Promoting Social Accountability in Adaptation Finance. Oxfam and World Resource Institute.
Thompson-Hall, M., Carr, E. R., and Pascual, U. (2016). Enhancing and expanding intersectional research for climate change adaptation in agrarian settings. *Ambio* 45, 373–382. doi:10.1007/s13280-016-0827-0.
Thorne, J. H., Santos, M. J., Bjorkman, J., Soong, O., Ikegami, M., Seo, C., et al. (2017). Does infill outperform climate-adaptive growth policies in meeting sustainable urbanization goals? A scenario-based study in California, USA. *Landscape and Urban Planning* 157, 483–492. doi:10.1016/j.landurbplan.2016.08.013.
Thornton, T. F., and Comberti, C. (2017). Synergies and trade-offs between adaptation, mitigation and development. *Climatic Change*, 1–14. doi:10.1007/s10584-013-0884-3.
Thorp, T. M. (2014). *Climate justice: a voice for the future*. New York: Palgrave Macmillan.
Thurston, G. D. (2013). Mitigation policy - Health co-benefits. *Nature Climate Change* 3, 863–864. doi:10.1038/nclimate2013.
Tian, L., Ge, B., and Li, Y. (2017). Impacts of state-led and bottom-up urbanization on land use change in the peri-urban areas of Shanghai: planned growth or uncontrolled sprawl? *Cities* 60, 476–486. doi:10.1016/j.cities.2016.01.002.
Tienhaara, K. (2014). Varieties of green capitalism: economy and environment in the wake of the global financial crisis. *Environmental Politics* 23, 187–204. doi:10.1080/09644016.2013.821828.
Tilman, D., and Clark, M. (2014). Global diets link environmental sustainability and human health. *Nature* 515, 518–522. doi:10.1038/nature13959.
Tokar, B. (2014). *Toward climate justice: perspectives on the climate crisis and social change*. Second. Porsgrunn, Norway: New Compass Press.
Tompkins, E. L., Mensah, G. A., King, L., Long, T., Lawson, E., Hutton, C., et al. (2013). An investigation of the evidence of benefits from climate compatible development.
Toole, S., Klocker, N., and Head, L. (2016). Re-thinking climate change adaptation and capacities at the household scale. *Climatic Change* 135, 203–209. doi:10.1007/s10584-015-1577-x.
Tosun, J., and Schoenefeld, J. J. (2017). Collective climate action and networked climate governance. *Wiley Interdisciplinary Reviews: Climate Change* 8. doi:10.1002/wcc.440.
Tramel, S. (2016). The Road Through Paris: Climate Change, Carbon, and the Political Dynamics of Convergence. *Globalizations* 13, 960–969. doi:10.1080/14747731.2016.1173376.
Trinh, L. T., Duong, C. C., Van Der Steen, P., and Lens, P. N. L. (2013). Exploring the potential for wastewater reuse in agriculture as a climate change adaptation measure for Can Tho City, Vietnam. *Agricultural Water Management* 128, 43–54. doi:https://doi.org/10.1016/j.agwat.2013.06.003.
Tschakert, P. (2015). 1.5°C or 2°C: a conduit's view from the science-policy interface at COP20 in Lima, Peru. *Climate Change Responses* 2, 3. doi:10.1186/s40665-015-0010-z.
Tschakert, P., Barnett, J., Ellis, N., Lawrence, C., Tuana, N., New, M., et al. (2017). Climate change and loss, as if people mattered: Values, places, and experiences. *Wiley Interdisciplinary Reviews: Climate Change* 8, e476. doi:10.1002/wcc.476.
Tschakert, P., Das, P. J., Shrestha Pradhan, N., Machado, M., Lamadrid, A., Buragohain, M., et al. (2016). Micropolitics in collective learning spaces for adaptive decision making. *Global Environmental Change* 40, 182–

194. doi:10.1016/j.gloenvcha.2016.07.004.
Tung, R. L. (2016). Opportunities and Challenges Ahead of China's "New Normal." *Long Range Planning*49, 632–640. doi:10.1016/j.lrp.2016.05.001.
Turnheim, B., Berkhout, F., Geels, F., Hof, A., McMeekin, A., Nykvist, B., et al. (2015). Evaluating sustainability transitions pathways: bridging analytical approaches to address governance challenges. *Global Environmental Change* 35, 239–253. doi:10.1016/j.gloenvcha.2015.08.010.
Uddin, N., and Taplin, R. (2015). Regional cooperation in widening energy access and also mitigating climate change: Current programs and future potential. *Global Environmental Change* 35, 497–504. doi:10.1016/j.gloenvcha.2015.05.006.
UN-OHRLLS (2009). The impact of climate change on the development prospects of the least developed countries and small island developing states. doi:10.1007/s10584-012-0510-9.
UN Women (2016). Time to Act on Gender, Climate Change and Disaster Risk Reduction: An overview of progress in the Pacific region with evidence from The Republic of Marshall Islands, Vanuatu and Samoa. Bangkok, Thailand doi:10.1038/ngeo275.
UNDP (2013). Human Development Report 2013 - The Rise of the South: Human Progress in a Diverse World. New York, NY, USA.
UNDP (2016). Risk governance: Building blocks for resilient development in the Pacific. Suva, Fiji.
UNEP (2011). Towards a green economy: pathways to sustainable development and poverty eradication - a synthesis for policy makers.
UNEP (2017). The emissions gap report 2017. Nairobi, Kenya.
United Nations (2014a). Resolution adopted by the General Assembly on 14 November 2014: SIDS accelerated modalities of action (SAMOA) pathway.
United Nations (2014b). World urbanisation prospects, 2014 revisions. New York, NY, USA.
United Nations (2015a). Paris Agreement.
United Nations (2015b). The Millennium Development Goals Report 2015. New York, NY, USA.
United Nations (2015c). Transforming Our World: The 2030 Agenda for Sustainable Development (A/RES/70/1). New York.
United Nations (2016). The Sustainable Development Goals Report 2016. New York, NY, USA: United Nations.
UNRISD (2016). Policy Innovations for Transformative Change: Implementing the 2030 Agenda for Sustainable Development. Geneva, Switzerland.
UNU-EHS (2016). World Risk Report 2016 - Logistics and infrastructure. doi:9783946785026.
Ürge-Vorsatz, D., Herrero, S. T., Dubash, N. K., and Lecocq, F. (2014). Measuring the co-benefits of climate change mitigation. *Annual Review of Environment and Resources* 39, 549–582. doi:10.1146/annurev-environ-031312-125456.
Ürge-Vorsatz, D., Kelemen, A., Tirado-Herrero, S., Thomas, S., Thema, J., Mzavanadze, N., et al. (2016). Measuring multiple impacts of low-carbon energy options in a green economy context. *Applied Energy* 179, 1409–1426. doi:10.1016/j.apenergy.2016.07.027.
USAID (2014). Climate-resilient development: a framework for understanding and addressing climate change. Washington, DC, USA.
Utting, P. (2015). *Social and Solidarity Economy: Beyond the Fringe*. , ed. P. Utting London, UK: Zed Books Ltd.
Väänänen, E., Dale, L., and Dickson, B. (2017). Anticipate, Absorb, Reshape: Current Progress on Three Key Capacities for Climate Resilience.
Valin, H., Havlík, P., Mosnier, A., Herrero, M., Schmid, E., and Obersteiner, M. (2013). Agricultural productivity and greenhouse gas emissions: trade-offs or synergies between mitigation and food security? *Environmental Research Letters* 8. doi:10.1088/1748-9326/8/3/035019.
Valipour, M., and Singh, V. P. (2016). "Global Experiences on Wastewater Irrigation: Challenges and Prospects BT - Balanced Urban Development: Options and Strategies for Liveable Cities," in, eds. B. Maheshwari, V. P. Singh, and B. Thoradeniya (Cham: Springer International Publishing), 289–327. doi:10.1007/978-3-319-28112-4_18.
Van Aelst, K., and Holvoet, N. (2016). Intersections of gender and marital status in accessing climate change adaptation: evidence from rural Tanzania. *World Development* 79, 40–50. doi:10.1016/j.worlddev.2015.11.003.
Van de Noort, R. (2013). *Climate Change Archaeology*. Oxford University Press doi:10.1093/acprof:osobl/9780199699551.001.0001.
van den Berg, N. J., van Soest, H. L., Hof, A. F., den Elzen, M. G. J., van den Vuuren, D. P., Chen, W., et al. Implications of various effort-sharing approaches for national carbon budgets and emission pathways. *Climatic Change* submitted.
van Noorloos, F., and Kloosterboer, M. (2017). Africa's new cities: The contested future of urbanisation. *Urban Studies*, 1–19. doi:0.1177/0042098017700574.
van Soest, H. L., de Boer, H. S., Roelfsema, M., den Elzen, M. G. J., Admiraal, A., van Vuuren, D. P., et al. (2017). Early action on Paris Agreement allows for more time to change energy systems. *Climatic Change* 144, 165–179. doi:10.1007/s10584-017-2027-8.

van Vuuren, D. P., Edmonds, J., Kainuma, M., Riahi, K., Thomson, A., Hibbard, K., et al. (2011). The representative concentration pathways: an overview. *Climatic Change* 109, 5–31. doi:10.1007/s10584-011-0148-z.
van Vuuren, D. P., Stehfest, E., Gernaat, D. E. H. J., Doelman, J. C., van den Berg, M., Harmsen, M., et al. (2017). Energy, land-use and greenhouse gas emissions trajectories under a green growth paradigm. *Global Environmental Change* 42, 237–250. doi:10.1016/j.gloenvcha.2016.05.008.
Vanhala, L., and Hestbaek, C. (2016). Framing Climate Change Loss and Damage in UNFCCC Negotiations. *Global Environmental Politics* 16, 111–129. doi:10.1162/GLEP_a_00379.
Vardakoulias, O., and Nicholles, N. (2014). Managing uncertainty: An economic evaluation of community-based adaptation in Dakoro, Niger. 54.
Vasconcellos, E. A., and Mendonça, A. (2016). Observatorio de Movilidad Urbana. Informe final 2015-2016.
Vermeulen, S., Richards, M., Pinto, A. De, Ferrarese, D., Läderach, P., Lan, L., et al. (2016). The Economic Advantage: Assessing the value of climate change actions in agriculture.
Vidic, R. D., Brantley, S. L., Vandenbossche, J. M., Yoxtheimer, D., and Abad, J. D. (2013). Impact of Shale Gas Development on Regional Water Quality. *Science* 340. doi:10.1126/science.1235009.
Vierros, M. (2017). Communities and blue carbon: the role of traditional management systems in providing benefits for carbon storage, biodiversity conservation and livelihoods. *Climatic Change* 140, 89–100. doi:10.1007/s10584-013-0920-3.
Villamizar, A., Gutiérrez, M. E., Nagy, G. J., Caffera, R. M., and Leal Filho, W. (2017). Climate adaptation in South America with emphasis in coastal areas: the state-of-the-art and case studies from Venezuela and Uruguay. *Climate and Development* 9, 364–382. doi:10.1080/17565529.2016.1146120.
Vinyeta, Kirsten; Whyte, Kyle Powys; Lynn, K. (2015). Climate Change Through an Intersectional Lens: Gendered Vulnerability and Resilience in Indigenous Communities in the United States. *Usda*.
Vinyeta, K., Whyte, K., and Lynn, K. (2015). Climate Change Through an Intersectional Lens: Gendered Vulnerability and Resilience in Indigenous Communities in the United States.
Vogt-Schilb, A., and Hallegatte, S. (2017). Climate policies and NDCs: reconciling the needed ambition with the political economy.
von Stechow, C., McCollum, D., Riahi, K., Minx, J. C., Kriegler, E., van Vuuren, D. P., et al. (2015). Integrating global climate change mitigation goals with other sustainability objectives: a synthesis. *Annual Review of Environment and Resources* 40, 363–394. doi:10.1146/annurev-environ-021113-095626.
Von Stechow, C., Mccollum, D., Riahi, K., Minx, J. C., Kriegler, E., Vuuren, D. P. Van, et al. (2015). Integrating Global Climate Change Mitigation Goals with Other Sustainability Objectives: A Synthesis. *Annual Review of Environment and Resources* 40, 363–394. doi:10.1146/annurev-environ-021113-095626.
von Stechow, C., Minx, J. C., Riahi, K., Jewell, J., McCollum, D. L., Callaghan, M. W., et al. (2016). 2°C and SDGs: United they stand, divided they fall? *Environmental Research Letters* 11. doi:10.1088/1748-9326/11/3/034022.
Voorn, T. van der, Quist, J., and Pahl-Wostl, C. (2017). Envisioning robust climate change adaptation futures for coastal regions: a comparative evaluation of cases in three continents. *Mitigation and Adaptation*.
Vuuren, D. P. van, Kok, M., Esch, S. van der, Jeuken, M., Lucas, P., Prins, A. G., et al. (2012). Roads from Rio+20: pathways to achieve global sustainability goals by 2050.
Wachsmuth, D., Cohen, D., and Angelo, H. (2016). Expand the frontiers of urban sustainability. *Nature* 536, 391–393.
Waisman, H.-D., Guivarch, C., and Lecocq, F. (2013). The transportation sector and low-carbon growth pathways: modelling urban, infrastructure, and spatial determinants of mobility. *Climate Policy* 13, 106–129. doi:10.1080/14693062.2012.735916.
Waldinger, M., and Frankhauser, S. (2015). Climate change and migration in developing countries: evidence and implications for PRISE countries. *Policy paper - ESRC Centre for Climate Change Economics and Policy, Grantham Research Institute on Climate Change and the Environmentalist*.
Wallimann, I. (2014). Social and solidarity economy for sustainable development: its premises and the Social Economy Basel example of practice. *International Review of Sociology* 24, 48–58.
Wamsler, C., Luederitz, C., Brink, E., Wamsler, C., and Luederitz, C. (2014). Local levers for change: mainstreaming ecosystem-based adaptation into municipal planning to foster sustainability transitions. *Global Environmental Change* 29, 189–201. doi:10.1016/j.gloenvcha.2014.09.008.
Wang, L., Patel, P. L., Yu, S., Liu, B., McLeod, J., Clarke, L. E., et al. (2016). Win-win strategies to promote air pollutant control policies and non-fossil energy target regulation in China. *Applied Energy* 163, 244–253. doi:10.1016/j.apenergy.2015.10.189.
Wang, X. (2017). The role of attitudinal motivations and collective efficacy on Chinese consumers' intentions to engage in personal behaviors to mitigate climate change. *The Journal of Social Psychology*, 1–13. doi:10.1080/00224545.2017.1302401.
Wang, X., Zhang, J., Shamsuddin, S., Oyang, R., Guan, T., Xue, J., et al. (2017). Impacts of climate variability and changes on domestic water use in the Yellow River Basin of China. *Mitigation and Adaptation Strategies for Global Change* 22, 595–608. doi:10.1007/s11027-015-9689-1.
Wang, Y., Song, Q., He, J., and Qi, Y. (2015). Developing low-carbon cities through pilots. *Climate Policy* 15, 81–103.

doi:10.1080/14693062.2015.1050347.
Wanner, T. (2014). The new "Passive Revolution" of the green economy and growth discourse: Maintaining the "Sustainable Development" of Neoliberal capitalism. *New Political Economy* 20, 1–21. doi:10.1080/13563467.2013.866081.
Ware, D. (2016). Climate change impacts on coastal water supply and waste water management. Gold Coast, Australia.
Warner, E. A. K. (2015). Indigenous adaptation in the face of climate change. *Journal of Environmental Sustainability Law* 21, 129–168.
WB, and IEA (2017). *Global Tracking Framework*. Washington, DC: International Bank for Reconstruction and Development / The World Bank and the International Energy Agency.
WBGU (2013). World in Transition: Governing the Marine Heritage. Berlin, Germany.
Webber, S. (2016). Climate change adaptation as a growing development priority: towards critical adaptation scholarship. *Geography Compass* 10, 401–413. doi:10.1111/gec3.12278.
Webster, P. J., and Jian, J. (2011). Environmental prediction, risk assessment and extreme events: adaptation strategies for the developing world. *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences* 369, 4768–4797. doi:10.1098/rsta.2011.0160.
Wegner, G. I. (2016). Payments for ecosystem services (PES): a flexible, participatory, and integrated approach for improved conservation and equity outcomes. *Environment, Development and Sustainability* 18, 617–644. doi:10.1007/s10668-015-9673-7.
Weiss, M., and Cattaneo, C. (2017). Degrowth - taking stock and reviewing an emerging academic paradigm. *Ecological Economics* 137, 220–230. doi:10.1016/j.ecolecon.2017.01.014.
Weisser, F., Bollig, M., Doevenspeck, M., and Müller-Mahn, D. (2014). Translating the "adaptation to climate change" paradigm: the politics of a travelling idea in Africa. *The Geographical Journal* 180, 111–119. doi:10.1111/geoj.12037.
Wells, E. M., Berges, M., Metcalf, M., Kinsella, A., Foreman, K., Dearborn, D. G., et al. (2015). Indoor air quality and occupant comfort in homes with deep versus conventional energy efficiency renovations. *Building and Environment* 93, 331–338. doi:10.1016/j.buildenv.2015.06.021.
Welsch, M., Hermann, S., Howells, M., Rogner, H. H., Young, C., Ramma, I., et al. (2014). Adding value with CLEWS - Modelling the energy system and its interdependencies for Mauritius. *Applied Energy* 113, 1434–1445. doi:10.1016/j.apenergy.2013.08.083.
Weng, X., Dong, Z., Wu, Q., and Qin, Y. (2015). China's path to a green economy: decoding China's green economy concepts and policies, IIED Country Report. London, UK.
Wesseling, J. H., Lechtenböhmer, S., Åhman, M., Nilsson, L. J., Worrell, E., and Coenen, L. (2017). The transition of energy intensive processing industries towards deep decarbonization: characteristics and implications for future research. *Renewable and Sustainable Energy Reviews* 79, 1303–1313. doi:10.1016/j.rser.2017.05.156.
West, J. J., Smith, S. J., Silva, R. A., Naik, V., Zhang, Y., Adelman, Z., et al. (2013). Co-benefits of mitigating global greenhouse gas emissions for future air quality and human health. *Nature Clim. Change* 3, 885–889. doi:10.1038/nclimate2009.
Westholm, L., and Arora-Jonsson, S. (2015). Defining Solutions, Finding Problems: Deforestation, Gender, and REDD+ in Burkina Faso. *Conservation and Society* 13, 189. doi:10.4103/0972-4923.164203.
Westley, F. R., Tjornbo, O., Schultz, L., Olsson, P., Folke, C., Crona, B., et al. (2013). A theory of transformative agency in linked social-ecological systems. *Ecology and Society* 18. doi:10.5751/ES-05072-180327.
Weston, P., Hong, R., Kaboré, C., and Kull, C. A. (2015). Farmer-managed natural regeneration enhances rural livelihoods in dryland West Africa. *Environmental Management* 55, 1402–1417. doi:10.1007/s00267-015-0469-1.
WFP (2012). MERET impact evaluation.
White, S. C. (2010). Analysing wellbeing: a framework for development practice. *Development in Practice* 20, 158–172. doi:10.2307/27806684.
WHO (2014). Quantitative risk assessment of the effects of climate change on selected causes of death, 2030s and 2050s. , eds. S. Hales, S. Kovats, S. Lloyd, and D. Campbell-Lendrum Geneva, Switzerland: World Health Organization (WHO).
Wiens, J., Fargione, J., and Hill, J. (2011). Biofuels and biodiversity. *Ecological Applications* 21, 1085–1095. doi:10.1890/09-0673.1.
Wilkinson, E., Kirbyshire, A., Mayhew, L., Batra, P., and Milan, A. (2016). Climate-induced migration and displacement: closing the policy gap.
Willand, N., Ridley, I., and Maller, C. (2015). Towards explaining the health impacts of residential energy efficiency interventions - A realist review. Part 1: Pathways. *Social Science and Medicine* 133, 191–201. doi:10.1016/j.socscimed.2015.02.005.
Williams, M., and Montes, M. F. (2016). Common but differentiated responsibilities: which way forward? *Development* 59, 114–120. doi:10.1057/s41301-017-0097-6.
Williams, T., and Hardison, P. (2013). Culture, law, risk and governance: contexts of traditional knowledge in climate

change adaptation. *Climatic Change* 120, 531–544. doi:10.1007/978-3-319-05266-3_3.
Williamson, P. (2016). Emissions reduction: scrutinize CO2 removal methods. *Nature* 530, 153–155. doi:10.1038/530153a.
Winer, M., Murphy, H., and Ludwig, H. (2012). Payment for Ecosystem Services Markets on Aboriginal Land in Cape York Pensinsula: Potential and Constraints. Geneva, Switzerland: United Nations Research Institute for Social Development (UNRISD).
Winkler, H., and Dubash, N. K. (2016). Who determines transformational change in development and climate finance? *Climate Policy* 16, 783–791. doi:10.1080/14693062.2015.1033674.
Winkler, H., Höhne, N., Cunliffe, G., Kuramochi, T., April, A., and de Villafranca Casas, M. J. (2017). Countries start to explain how their climate contributions are fair: more rigour needed. *International Environmental Agreements: Politics, Law and Economics*, 1–17. doi:10.1007/s10784-017-9381-x.
Wise, R. M., Fazey, I., Stafford Smith, M., Park, S. E., Eakin, H. C., Archer Van Garderen, E. R. M., et al. (2014). Reconceptualising adaptation to climate change as part of pathways of change and response. *Global Environmental Change* 28, 325–336. doi:10.1016/j.gloenvcha.2013.12.002.
Wiseman, J. and S. A. (2017). "The degrowth imperative: reducing energy and resource consumption as an essentail component in achieving carbon budget targets," in *Transitioning to a Post-Carbon Society: Degrowth, Austerity and Wellbeing*, eds. E. Garcia, M. Martinez-Iglesias, and P. Kirby (Springer Nature), 87–108. doi:1057/978-1-349-95176-5_4.
Wolfram, P., and Wiedmann, T. (2017). Electrifying Australian transport: hybrid life cycle analysis of a transition to electric light-duty vehicles and renewable electricity. *Applied Energy* 206, 531–540. doi:10.1016/j.apenergy.2017.08.219.
Wood, B. T. (2017). Socially just triple-wins? An evaluation of projects that pursue climate compatible development goals in Malawi.
Wood, B. T., Dougill, A. J., Quinn, C. H., and Stringer, L. C. (2016a). Exploring Power and Procedural Justice Within Climate Compatible Development Project Design: Whose Priorities Are Being Considered? *The Journal of Environment & Development* 25, 363–395. doi:10.1177/1070496516664179.
Wood, B. T., Quinn, C. H., Stringer, L. C., and Dougill, A. J. (2017). Investigating Climate Compatible Development Outcomes and their Implications for Distributive Justice: Evidence from Malawi. *Environmental Management* 60, 436–453. doi:10.1007/s00267-017-0890-8.
Wood, B. T., Sallu, S. M., and Paavola, J. (2016b). Can CDM finance energy access in Least Developed Countries? Evidence from Tanzania. *Climate Policy* 16, 456–473. doi:10.1080/14693062.2015.1027166.
Woodward, A., Lindsay, G., and Singh, S. (2011). Adapting to climate change to sustain health. *Wiley Interdisciplinary Reviews: Climate Change* 2, 271–282. doi:10.1002/wcc.103.
Work, C. (2015). Intersections of climate change mitigation policies, land grabbing and conflict in a fragile state: insights from Cambodia.
World Bank (2012). Turn Down the Heat: Why a 4°C Warmer World Must be Avoided.
Wunder, S., Engel, S., and Pagiola, S. (2008). Taking stock: A comparative analysis of payments for environmental services programs in developed and developing countries. *Ecological Economics* 65, 834–852. doi:10.1016/j.ecolecon.2008.03.010.
Wyborn, C., Yung, L., Murphy, D., and Williams, D. R. (2015). Situating adaptation: how governance challenges and perceptions of uncertainty influence adaptation in the Rocky Mountains. *Regional Environmental Change* 15, 669–682. doi:10.1007/s10113-014-0663-3.
Xylia, M., and Silveira, S. (2017). On the road to fossil-free public transport: the case of Swedish bus fleets. *Energy Policy* 100, 397–412. doi:10.1016/j.enpol.2016.02.024.
Yang, S., Chen, B., and Ulgiati, S. (2016). Co-benefits of CO2 and PM2.5 Emission Reduction. *Energy Procedia* 104, 92–97. doi:10.1016/j.egypro.2016.12.017.
Yuan, C., Yang, Y., Liu, S., and Fang, Z. (2015). An investigation into the relationship between China's economic development and carbon dioxide emissions. *Climate and Development* 9, 66–79. doi:10.1080/17565529.2015.1067182.
Zeng, H., Chen, X., Xiao, X., and Zhou, Z. (2017). Institutional pressures, sustainable supply chain management, and circular economy capability: Empirical evidence from Chinese eco-industrial park firms. *Journal of Cleaner Production* 155, 54–65. doi:10.1016/j.jclepro.2016.10.093.
Zhang, H., and Chen, W. (2015). The role of biofuels in China's transport sector in carbon mitigation scenarios. *Energy Procedia* 75, 2700–2705. doi:10.1016/j.egypro.2015.07.682.
Zhang, S., Worrell, E., and Crijns-Graus, W. (2015). Cutting air pollution by improving energy efficiency of China's cement industry. *Energy Procedia* 83, 10–20. doi:10.1016/j.egypro.2015.12.191.
Zhang, Z., Xue, B., Pang, J., and Chen, X. (2016). The Decoupling of Resource Consumption and Environmental Impact from Economic Growth in China: Spatial Pattern and Temporal Trend. *Sustainability* 8, 222. doi:10.3390/su8030222.
Zhao, D., McCoy, A. P., Du, J., Agee, P., and Lu, Y. (2017). Interaction effects of building technology and resident

behavior on energy consumption in residential buildings. *Energy and Buildings* 134, 223–233. doi:10.1016/j.enbuild.2016.10.049.

Ziervogel, G., Archer Van Garderen, E., and Price, P. (2016). Strengthening the science-policy interface by co-producing an adaptation plan: leveraging opportunities in Bergrivier municipality, South Africa. *Environment and Urbanization* 28, 1–20. doi:10.1177/0956247816647340.

Zivin, J. G., and Neidell, M. J. (2010). Temperature and the allocation of time: implications for climate change. *Journal of Labor Economics* 32.

Zouboulis, A., and Tolkou, A. (2015). "Effect of Climate Change in Wastewater Treatment Plants: Reviewing the Problems and Solutions BT - Managing Water Resources under Climate Uncertainty: Examples from Asia, Europe, Latin America, and Australia," in, eds. S. Shrestha, A. K. Anal, P. A. Salam, and M. van der Valk (Cham: Springer International Publishing), 197–220. doi:10.1007/978-3-319-10467-6_10.

Zulu, L. C., and Richardson, R. B. (2013). Charcoal, livelihoods, and poverty reduction: Evidence from sub-Saharan Africa. *Energy for Sustainable Development* 17, 127–137. doi:10.1016/j.esd.2012.07.007.

[Due to size, Table 5.1.a–d is provided here. A high resolution version of the table is available as a supplementary PDF (SR15_SOD_Chapter5_Table5_1.pdf) that can be downloaded with the chatper for review]

Chapter 5 Table 5.1

Table of Contents

Panel A Part 1: SDGs 1-4 – Industry, Residential, Transport

Panel A Part 2: SDGs 1-4 – Replacing Coal, Advanced Coal

Panel A Part 3: SDGs 1-4 – Agriculture & Livestock, Forest, Oceans

Panel B Part 1: SDGs 5, 10, 16, 17 – Industry, Residential, Transport

Panel B Part 2: SDGs 5, 10, 16, 17 – Replacing Coal, Advanced Coal

Panel B Part 3: SDGs 5, 10, 16, 17 – Agriculture & Livestock, Forest, Oceans

Panel C Part 1: SDGs 6, 12, 14, 15 – Industry, Residential, Transport

Panel C Part 2: SDGs 6, 12, 14, 15 – Replacing Coal, Advanced Coal

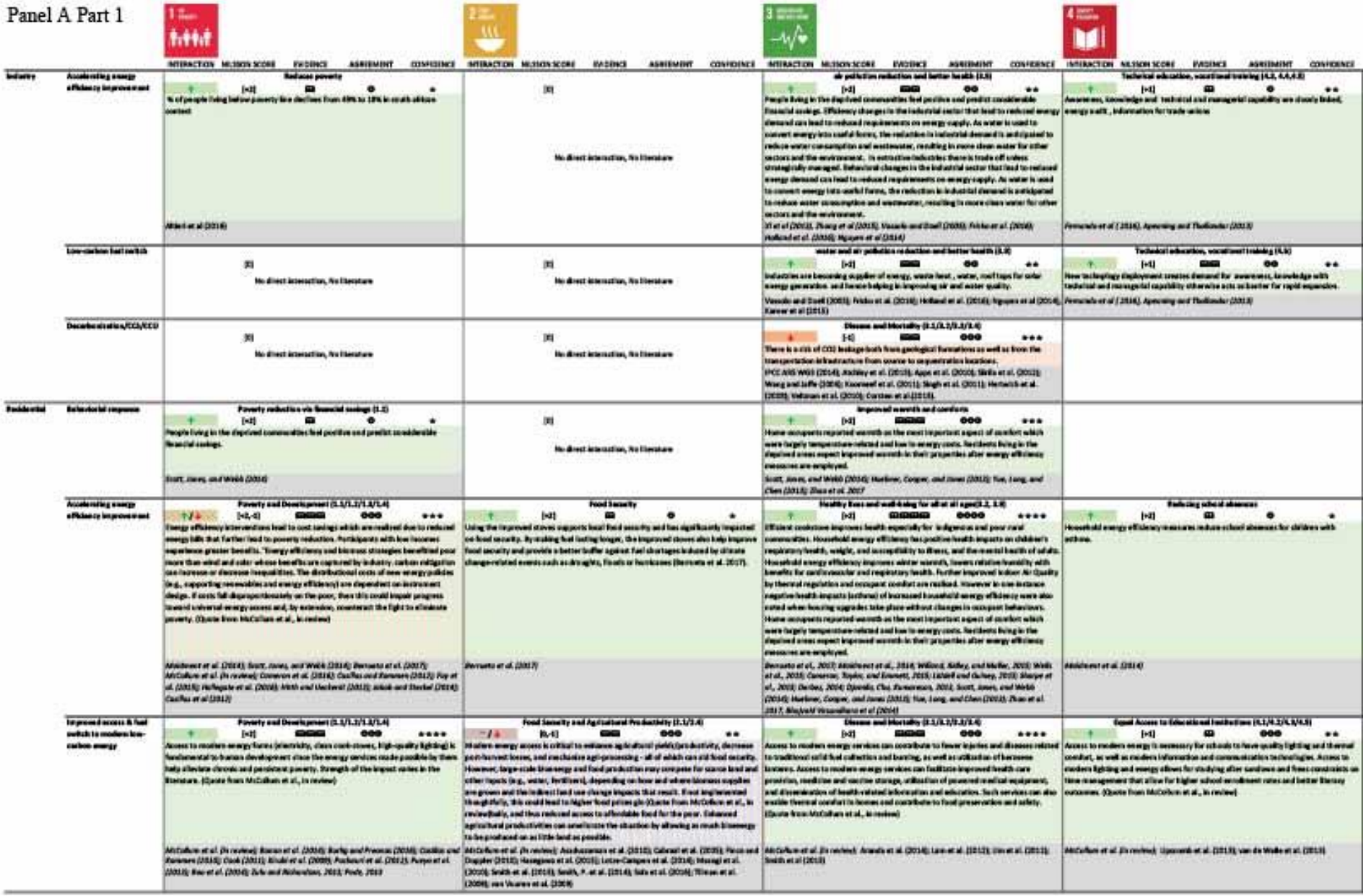
Panel C Part 3: SDGs 6, 12, 14, 15 – Agriculture & Livestock, Forest, Oceans

Panel D Part 1: SDGs 7, 8, 9, 11 – Industry, Residential, Transport

Panel D Part 2: SDGs 7, 8, 9, 11 – Replacing Coal, Advanced Coal

Panel D Part 3: SDGs 7, 8, 9, 11 – Agriculture & Livestock, Forest, Oceans

Panel A Part 1



		1					2					3					4				
		INTERACTION	NILSSON SCORE	EVIDENCE	AGREEMENT	CONFIDENCE	INTERACTION	NILSSON SCORE	EVIDENCE	AGREEMENT	CONFIDENCE	INTERACTION	NILSSON SCORE	EVIDENCE	AGREEMENT	CONFIDENCE	INTERACTION	NILSSON SCORE	EVIDENCE	AGREEMENT	CONFIDENCE
Industry	Accelerating energy efficiency improvement	Reduces poverty ↑ [+2] % of people living below poverty line declines from 49% to 18% in south african context Altieri et al (2018)					[0] No direct interaction, No literature					air pollution reduction and better health (3.9) ↑ [+2] People living in the deprived communities feel positive and predict considerable financial savings. Efficiency changes in the industrial sector that lead to reduced energy demand can lead to reduced requirements on energy supply. As water is used to convert energy into useful forms, the reduction in industrial demand is anticipated to reduce water consumption and wastewater, resulting in more clean water for other sectors and the environment. . In extractive industries there is trade off unless strategically managed. Behavioral changes in the industrial sector that lead to reduced energy demand can lead to reduced requirements on energy supply. As water is used to convert energy into useful forms, the reduction in industrial demand is anticipated to reduce water consumption and wastewater, resulting in more clean water for other sectors and the environment. Xi et al (2012), Zhang et al (2013), Vassolo and Doell (2005), Fthenakis et al. (2008); Holland et al. (2016); Nguyen et al (2014)					Technical education, vocational training (4.3, 4.4,4.5) ↑ [+1] Awareness, knowledge and technical and managerial capability are closely linked; energy audit , information for trade unions Fernando et al (2016), Apeaning and Thollander (2013)				
	Low-carbon fuel switch	[0] No direct interaction, No literature					[0] No direct interaction, No literature					water and air pollution reduction and better health (3.9) ↑ [+2] Industries are becoming supplier of energy, waste heat , water, roof tops for solar energy generation and hence helping in improving air and water quality. Vassolo and Doell (2005); Fthkis et al. (2008); Holland et al. (2016); Nguyen et al (2014), Xavier et al (2013)					Technical education, vocational training (4.3) ↑ [+1] How technology deployment creates demand for awareness, knowledge with technical and managerial capability otherwise acts as barrier for rapid expansion. Fernando et al (2016), Apeaning and Thollander (2013)				
	Decarbonization/CCS/CCU	[0] No direct interaction, No literature					[0] No direct interaction, No literature					Disease and Mortality (3.1/3.3/3.9) ↓ [-1] There is a risk of CO2 leakage both from geological formations as well as from the transportation infrastructure from source to sequestration locations. IPCC AR5 WG3 (2014); Atchley et al. (2013); Apps et al. (2010); Wells et al. (2012); Wang and Jaffe (2004); Koornneef et al. (2011); Singh et al. (2011); Herzog & et al. (2009); Viebahn et al. (2010); Corsten et al (2013).									
Residential	Behavioral response	Poverty reduction via financial savings (1.1) ↑ [+1] People living in the deprived communities feel positive and predict considerable financial savings. Scott, Jones, and Webb (2014)					[0] No direct interaction, No literature					Improved warmth and comfort ↑ [+1] Home occupants reported warmth as the most important aspect of comfort which were largely temperature-related and low in energy costs. Residents living in the deprived areas expect improved warmth in their properties after energy efficiency measures are employed. Scott, Jones, and Webb (2014); Huebner, Cooper, and Jones (2013); Yue, Long, and Chen (2013); Zhao et al. 2017									
	Accelerating energy efficiency improvement	Poverty and Development (1.1/1.2/1.3/1.4) ↑/↓ [+2,-1] Energy efficiency interventions lead to cost savings which are realized due to reduced energy bills that further lead to poverty reduction. Participants with low incomes experience greater benefits. "Energy efficiency and biomass strategies benefitted poor more than wind and solar whose benefits are captured by industry. carbon mitigation can increase or decrease inequalities. The distributional costs of new energy policies (e.g., supporting renewables and energy efficiency) are dependent on instrument design. If costs fall disproportionately on the poor, then this could impair progress toward universal energy access and, by extension, counteract the fight to eliminate poverty. (Quote from McCollum et al., In review) Adelekanet et al. (2014); Scott, Jones, and Webb (2014); Bennetta et al. (2017); McCollum et al. (In review); Cameron et al. (2016); Casillas and Kammen (2012); Fay et al. (2015); Hallegatte et al. (2016); Mirth and Steckel (2013); Jakob and Steckel (2014); Casillas et al (2012)	Food Security ↑ [+2] Using the improved stoves supports local food security and has significantly impacted on food security. By making fuel lasting longer, the improved stoves also help improve food security and provide a better buffer against fuel shortages induced by climate change-related events such as droughts, floods or hurricanes (Bennetta et al. 2017). Bennetta et al. (2017)	Healthy lives and well-being for all at ages(3.2, 3.8) ↑ [+2] Efficient cookstove improves health especially for indigenous and poor rural communities. Household energy efficiency has positive health impacts on children's respiratory health, weight, and susceptibility to illness, and the mental health of adults. Household energy efficiency improves winter warmth, lowers relative humidity with benefits for cardiovascular and respiratory health. Further improved Indoor Air Quality by thermal regulation and occupant comfort are realized. However in one instance negative health impacts (asthma) of increased household energy efficiency were also noted when housing upgrades take place without changes in occupant behaviours. Home occupants reported warmth as the most important aspect of comfort which were largely temperature-related and low in energy costs. Residents living in the deprived areas expect improved warmth in their properties after energy efficiency measures are employed. Bennetta et al., 2017; Abdelaziz et al., 2010; Willand, Ridley, and Moller, 2015; Wells et al., 2013; Cameron, Taylor, and Emmett, 2015; Liddell and Guiney, 2015; Sharpe et al., 2013; Davies, 2014; Ojunola, Cho, Purushotma, 2011; Scott, Jones, and Webb (2014); Huebner, Cooper, and Jones (2013); Yue, Long, and Chen (2013); Zhao et al. 2017, Wijayatunga Viswanathan et al (2014)	Reducing school absences ↑ [+2] Household energy efficiency measures reduce school absences for children with asthma. Abdelaziz et al. (2014)				
	Improved access & fuel switch to modern low-carbon energy	Poverty and Development (1.1/1.2/1.3/1.4) ↑ [+2] Access to modern energy forms (electricity, clean cook-stoves, high-quality lighting) is fundamental to human development since the energy services made possible by them help alleviate chronic and persistent poverty. Strength of the impact varies in the literature. (Quote from McCollum et al., In review) McCollum et al. (In review); Barnes et al. (2010); Barlig and Pinanas (2010); Casillas and Kammen (2010); Cook (2011); Khandker et al. (2009); Pachauri et al. (2012); Pueyo et al. (2013); Rao et al. (2014); Zulu and Richardson, 2013; Pode, 2010	Food Security and Agricultural Productivity (2.1/2.4) ~/↓ [0,-1] Modern energy access is critical to enhance agricultural yield/productivity, decrease post-harvest losses, and mechanize agri-processing - all of which can aid food security. However, large-scale bioenergy and food production may compete for scarce land and other inputs (e.g., water, fertilizer), depending on how and where biomass supplies are grown and the indirect land use change impacts that result. If not implemented thoughtfully, this could lead to higher food prices glo (Quote from McCollum et al., In review)bally, and thus reduced access to affordable food for the poor. Enhanced agricultural productivities can ameliorate the situation by allowing as much bioenergy to be produced on as little land as possible. McCollum et al. (In review); Asaduzzaman et al. (2010); Cabraal et al. (2005); Pacca and Duppler (2010); Hasegawa et al. (2015); Leon-Campos et al. (2014); Msangi et al. (2010); Smith et al. (2013); Smith, P. et al. (2014); Sala et al. (2014); Tilman et al. (2009); von Vicares et al. (2008)	Disease and Mortality (3.1/3.3/3.9/3.d) ↑ [+2] Access to modern energy services can contribute to fewer injuries and diseases related to traditional solid fuel collection and burning, as well as utilization of kerosene lanterns. Access to modern energy services can facilitate improved health care provision, medicine and vaccine storage, utilization of powered medical equipment, and dissemination of health-related information and education. Such services can also enable thermal comfort in homes and contribute to food preservation and safety. (Quote from McCollum et al., In review) McCollum et al. (In review); Amado et al. (2014); Lam et al. (2012); Lim et al. (2013); Smith et al (2013)	Equal Access to Educational Institutions (4.1/4.2/4.3/4.5) ↑ [+1] Access to modern energy is necessary for schools to have quality lighting and thermal comfort, as well as modern information and communication technologies. Access to modern lighting and energy allows for studying after sundown and frees constraints on time management that allow for higher school enrollment rates and better literacy outcomes. (Quote from McCollum et al., In review) McCollum et al. (In review); Lipscomb et al. (2013); van de Walle et al. (2013)				

D

Panel A Part 1

Transport	Behavioural response			**Road Traffic Accidents (3.4/3.6)** [+2,-1] Active travel modes' (such as walking and cycling) represent strategies not only for boosting energy efficiency but also, potentially, for improving health and well-being (e.g., lowering rates of diabetes, obesity, heart disease, dementia, and some cancers). However, a risk associated with these measures is that they could increase rates of road traffic accidents, if the provided infrastructure is unsatisfactory. Overall health effects will depend on the severity of the injuries sustained from these potential accidents relative to the health benefits accruing from increased exercise. (Quote from McCollum et al., in review) McCollum et al. (in review); Creutzig et al. (2012); Haines and Dora (2012); Saunders et al. (2013); Shaw et al. (2014); Woodcock et al. (2009); Shaw et al (2017);Chakraborti and Sila (2017); Hunag et al (2017)	
	Accelerating energy efficiency improvement			**Reduce illnesses from hazardous air, water and soil pollution (3.8)** [+2] Locally relevant policies targeting traffic reductions and ambitious diffusion of electric vehicles results in measured changes in non-climatic population exposure (indicated ambient air pollution, physical activity, and noise. The transition to low-carbon equitable and sustainable transport can be fostered by numerous short- and medium-term strategies that would benefit energy security, health, productivity, and sustainability. Evidence-based approach that takes into account greenhouse gas emissions, ambient air pollutants, economic factors (affordability, cost optimization), social factors (poverty alleviations, public health benefits), and political acceptability is needed tackle these challenges. (Schuckt et al., 2016);(Figueroa, Lah, Fulton, McKinnon, & Tiwari, 2014);(Peng, Yang, Wagner, & Mazzarelli, 2017); (Klaustrucker et al., 2016)	
	Improved access & fuel switch to modern low-carbon energy	**End Poverty in all its forms everywhere (1.1,1.4,1.a, 1.b)** [+2,-1] Climate change threatens to worsen poverty, therefor pro-poor mitigation policies are needed to reduce this threat; for example investing more and better in infrastructure by leveraging private resources and using designs that account for future climate change and the related uncertainty. Communities in poor areas cope with and adapt to multiple-stressors including climate change. Coping strategies provide short-term relief but in the long-term may negatively affect development goals. And responses generate a trade-off between adaptation, mitigation and development . African cities with dams and due to high commuting costs many walk to work places which limit access. In Latin america tripple informality leading to low productivity and living standards. In Sweden decarbonization of public bus is receiving attention more than efficiency improvement. With more electrification electricity price goes up and affordability can worsen for poor unless redistributive policies are in place. (Bellegate et al. 2015); (Suckall, Tompkins, & Stringer, 2014); Lall, Henderson, & Venables, 2017; (Corporación Andina de Fomento, 2017); Xylia et al (2017); Klaustrucker, Annegarn, Henneman, & Rafaj, 2018	**Ensure Access to Food Security (2.1, 2.3, 2.a, 2.b,2.c)** [3] 21 Projects aiming at resilient transport infrastructure development to improve access (e.g. C40 Cities Clean Bus Declaration, UITP Declaration on Climate Leadership, Cycling Delivers on the Global Goals, Global Sidewalk Challenge) do not substantially contribute to realizing the (indirect) transport targets with mostly a rural focus: Agricultural Productivity (SDG 2) and Access to Safe Drinking Water (SDG 6) Partnership on Sustainable Low-Carbon Transport, 2017	**Reduce illnesses from hazardous air pollution (3.8)** [+2] Projects aiming at resilient transport infrastructure development (e.g. C40 Cities Clean Bus Declaration, UITP Declaration on Climate Leadership, Cycling Delivers on the Global Goals, Global Sidewalk Challenge) are targeting at reducing airpollution. Electric vehicles using electricity from renewables or low carbon sources combined with e-mobility options such as trolleybuses, metros, trams and electro buses, as well as promote walking and biking, especially for short distances need consideration Partnership on Sustainable Low-Carbon Transport, 2017; Ajanovic (2015)	

Do N

Panel A Part 1

1

Panel A Part 2

		1				2				3				4			
		INTERACTION	MISSION SCORE	EVIDENCE	AGREEMENT	CONFIDENCE	INTERACTION	MISSION SCORE	EVIDENCE	AGREEMENT	CONFIDENCE	INTERACTION	MISSION SCORE	EVIDENCE	AGREEMENT	CONFIDENCE	INTERACTION	MISSION SCORE	EVIDENCE	AGREEMENT	CONFIDENCE
Replacing coal	Non-biomass renewables: solar, wind, hydro	+	[+2]	■■■■	●●●	●●●							Air Pollution (3.9)				+	[+1]	■	●	●
		Deployment of renewable energy and improvements in energy efficiency globally will aid climate change mitigation efforts, and this, in turn, can help to reduce the exposure of the world's poor to climate-related extreme events, negative health impacts, and other environmental shocks. (Quote from McCollum et al., in review)										+	[+2]	■■■■	●●●	●●●●	Decentralized renewable energy systems (e.g., home- or village-scale solar power) can support education and vocational training.				
		McCollum et al. (in review); Hallegatte et al. (2016); IPCC (2014); Riahi et al. (2012)										McCollum et al. (in review); Arvesberg et al. (2015); Chatzivasiloglou and Skalkos (2014); Haines et al. (2007); IEA (2016); Kiagiaova (2011); Nemet et al. (2010); Riahy et al. (2012); Rao et al. (2013); Rao et al. (2016); Riahi et al. (2012); Rose et al. (2014); Smith and Sagar (2014); van Vliet et al. (2012); West et al. (2013)					Anderson A., Leandro P., Crispino I., Hunter I., Saba S., Jenko S., Johnson N., Pedrono R., Lenaro R. (2017)
	Increased use of biomass	↑/↓	[+1,-1]	■■	●●	●	↑/↓	[+1,-1]	■■■■	●●●	●●●	+	[+2]	■■■■	●●●	●●●					
		Large-scale bioenergy production could lead to the creation of agricultural jobs, as well higher farm wages and more diversified income streams for farmers. Modern energy access can make marginal lands more cultivable, thus potentially generating on-farm jobs and incomes; on the other hand, greater farm mechanization can also displace labor. On the other hand, large-scale bioenergy production could alter the structure of global agricultural markets in a way that is, potentially, unfavorable to small-scale food producers. see SDG1 (Quote from McCollum et al., in review)					Farm Employment and Incomes (2.3) Large-scale bioenergy production could lead to the creation of agricultural jobs, as well higher farm wages and more diversified income streams for farmers. Modern energy access can make marginal lands more cultivable, thus potentially generating on-farm jobs and incomes; on the other hand, greater farm mechanization can also displace labor. On the other hand, large-scale bioenergy production could alter the structure of global agricultural markets in a way that is, potentially, unfavorable to small-scale food producers. The distributional effects of bioenergy production are underexplored in the literature. (Quote from McCollum et al., in review)					Disease and Mortality (3.1/3.2/3.3/3.4), Air Pollution (3.9) Replacing coal by biomass can reduce adverse impacts of upstream supply-chain activities, in particular local air and water pollution, and prevent coal mining accidents. Improvements in local air pollution in power generation compared to coal-fired power plants depend on the technology and fuel of biomass powerplants, but could be significant when switching from outdated coal-combustion technologies to state-of-the-art biogas power generation.					
		McCollum et al. (in review); Bolshtian et al. (1991); Creutzig et al. (2013); de Moraes et al. (2012); Gobin (1998); Rod (2012); Smith and Rasche (2013); van der Horst and Vermeylen (2011); Corbera and Pascual (2012); Creutzig et al. (2013); Davis et al. (2013); van der Horst and Vermeylen (2011); Muys et al. (2014); Erten F.C., Kappler B., Neubauer P. (2017)					McCollum et al. (in review); Bolshtian et al. (1991); Creutzig et al. (2013); de Moraes et al. (2012); Gobin (1998); Rod (2012); Smith and Rasche (2013); van der Horst and Vermeylen (2011); Corbera and Pascual (2012); Creutzig et al. (2013); Davis et al. (2013); van der Horst and Vermeylen (2011); Muys et al. (2014); Erten F.C., Kappler B., Neubauer P. (2017)					IPCC AR5 WGII (2014); Groenwolf et al. (2011); Singh et al. (2011); Hertwich et al. (2010); Vellinga et al. (2012); Gouten et al.(2013); Ashworth et al. (2011); Bleisdell et al. (2013); IPCC (2005); Miller et al. (2007); de Nazi-Melchbacher et al. (2009); Shackley et al. (2009); Wang-Pandkal and Kay (2009); Wabbajo'et al. (2009, 2010); Reliner and Hattell (2011); Epstein et al. (2010); Bugbeer et al. (2012); Chan et al. (2012); Chan and Griffiths (2010); Askar et al. (2013).					
	Nuclear/Advanced Nuclear													Disease and Mortality (3.1/3.2/3.3/3.4) In spite of the industry's overall safety track record, a non-negligible risk for accidents in nuclear power plants and waste treatment facilities remains. The long-term storage of nuclear waste is a politically fraught subject, with no large-scale long-term storage operational worldwide. Negative impacts from upstream uranium mining and milling are comparable to those of coal, hence replacing fossil fuel combustion by nuclear power would be neutral in that aspect. Increased occurrence of childhood leukaemia in populations living within 5 km of nuclear power plants was identified by some studies, even though a direct causal relation to ionizing radiation could not be established and other studies could not confirm any correlation (low evidence/agreement in this issue). IPCC AR5 WGII (2014); Cardis et al. (2006); Baliozian et al. (2011); Mwenisse et al. (2011a); WHO (2013); Abdelrasoul (2016); Al-Zoughool and Krewski (2009) cited in Sathaye et al. (2011a); Smith et al. (2013); Schneider et al. (2010); Trimarchi (2012); Brogge and Bushner (2011); Moller et al. (2012); Hiyama et al. (2013); Mwenisse and Moller (2013); Moller and Mousseau (2011); Moller et al. (2011); von Stedingk et al. (2014); Heinzelmann et al. (2010); Kaatsch et al. (2008); Sermage-Faure et al. (2012); Kleeve and Zeeuboer (2012).					
	CCS: Bio energy	↑/↓	[+1,-1]	■■■	●●	●	↑/↓	[+1,-1]	■■■■	●●●	●●●	↑/↓	[+1,-1]	■■■	●●●	●●●					
		See effects of increased bioenergy use.					See increased use of biomass effects. In addition, the concern that more bioenergy (for BECCS) necessarily leads to unacceptably high food prices is not founded on large agreement in the literature. ARS, for example, finds a significantly lower effect of large-scale bioenergy deployment on food prices by mid-century than the effect of climate change on crop yields. Also, Muratori et al. (2016) show that BECCS reduces the upward pressure on food crop prices by lowering carbon prices and lowering the total biomass demand in climate change mitigation scenarios. See literature on increased biomass use + Muratori et al. (2016); IPCC AR5 (2014)					See positive impacts of increased biomass use. On the other hand, there is a non-negligible risk of CO2 leakage both from geological formations as well as from the transportation infrastructure from source to sequestration locations. IPCC AR5 WGII (2014); Mulvey et al. (2013); Appa et al. (2010); Stiffa et al. (2012); Wang and Jaffe (2004); Vaonwolf et al. (2011); Singh et al. (2011); Hertwich et al. (2010); Vellinga et al. (2012); Gouten et al.(2013).					
Advanced coal	CCS: Fossil	No literature					No literature					The use of fossil CCS imply continued adverse impacts of upstream supply-chain activities in the coal sector, and because of lower efficiency of CCS coal power plants, upstream impacts and local air pollution are likely to be exacerbated. Furthermore, there is a non-negligible risk of CO2 leakage from geological storage the CO2 transport infrastructure from source to sequestration location. IPCC AR5 WGII (2014); Mulvey et al. (2013); Appa et al. (2010); Stiffa et al. (2012); Wang and Jaffe (2004); Vaonwolf et al. (2011); Singh et al. (2011); Hertwich et al. (2010); Vellinga et al. (2012); Gouten et al.(2013).					No literature				

Do N

Panel A Part 2

Panel A Part 3

		INTERACTION	MEDIAN SCORE	EVIDENCE	AGREEMENT	CONFIDENCE	INTERACTION	MEDIAN SCORE	EVIDENCE	AGREEMENT	CONFIDENCE	INTERACTION	MEDIAN SCORE	EVIDENCE	AGREEMENT	CONFIDENCE	INTERACTION	MEDIAN SCORE	EVIDENCE	AGREEMENT	CONFIDENCE
Agriculture & Livestock	Behavioural responses: Sustainable healthy diets and reduced food waste	Poverty and Development (1.1/1.2/1.3/1.4)					Food Security and promotion of Sustainable Agriculture(2.1/2.4/2a)					Tobacco Control (3.a/ 3.a.1)					No literature				
		↑/↓	[0,-1]				↑	[+2]				↑	[+1]								
		Cutting livestock consumption can increase food security for some if land grows feed not food, but can also undermine livelihoods and culture where livestock has long been the best use of land such as in parts of SSA					Cutting consumer waste of major food crops (i.e., wheat, rice, and vegetables) and meats (i.e., beef, pork, and poultry) in China , USA and India alone could feed ~410 million people per year . (Quoted from West et al.(2014)) One billion extra people could be fed if food crop losses could be halved. (Quoted from Kummu et al. (2012)) Reducing waste, especially from meat and dairy could play a role in delivering food security and reduce the need for sustainable intensification. (Quoted from Smith, P. (2013)). Dietary change toward global healthy diets could improve nutritional health, food security and reduce emissions					Consume fewer foods with low nutritional value e.g. Alcohol(These foods are not needed in our diet and need not be produced). (Quoted from Garnett, T. (2011)). Demand-side measures aimed at reducing the proportion of livestock products in human diets, where the consumption of animal products is higher than recommended, are associated with multiple health benefits, especially in industrialized countries (Quoted from Bustamante, M., et al. (2014))									
		IPCC WG II, 2014					West et al (2014), Kummu et al. (2012), Smith, P. (2013), Intergovernmental Panel on Climate Change. Working Group II. (2014), Garnett, T. (2011), Stehfest et al., 2014, Tilman & Clark, 2014)					Garnett, T. (2011), Bustamante, M., et al. (2014)									
	Land based greenhouse gas reduction and soil carbon sequestration						Food Security, sustainable agriculture and improved nutrition					Ensure healthy lives (3.c)					Ensure inclusive and quality education(4.4/4.7)				
							↑	[+2]				↑/↓	[+2,-2]				↑/↓	[+2,-2]			
							Site application of biotechnology, both conventional and modern methods can help to improve agricultural productivity,improving crops adaptability thereby catering to food security. Reducing tillage, alternating fallow and keeping the soil covered with residue, cover crops or perennial vegetation help prevent soil erosion so that the potential to maintain Soil Organic Matter (SOC) Efficient land management techniques can help in increasing crop yield and hence food security issues can be addressed. Yield projections are actually higher for developing countries than for developed countries, reflecting the fact that they have more "catch-up" potential (Quoted from Evenson, R. E. (1999)) Action is needed throughout the food system, such as shifting diets, reducing waste, improving governance and producing more food. (Quoted from Godfray, H. C. J., & Garnett, T. (2014)) Improving cropland management is the key to increase crop productivity without further degrading soil and water resources. (Quoted from Erenstein, O., et al. (2011)). Climate Smart Agriculture practices increases productivity and provides food security					Growing crops such as cassava, sorghum and millets even in harsh conditions are important to the diets of very poor people. The policy scenarios show that reduced research support, delayed trait introduction, delayed biotechnology, and climate change will delay progress in reducing malnutrition of children. The "global" effects are small, but local effects for some countries, e.g., Bangladesh and Nigeria, are significant. (Quoted from Evenson, R. E. (1999))					Science-based actions within CSA is required to integrate data sets and re-used models for testing hypotheses about feedback regarding climate, weather data products and agricultural productivity, such as the nonlinearity of temperature effects on crop yield and the assessment of trade-offs and synergies that arise from different agricultural intensification strategies. (Quoted from Steenwerth, K. L., (2014)). Low commodity prices have led to declining investment in research and development, farmer education, etc (Quoted from Lewis, A., et al. (2014))				
							Mbol, G. T. (2011),Harvey, C. A., et al. (2014), Campbell et al. (2014), West, T. O., & Post, W. M. (2002), Johnson et al. (2007),Harvey, C. A., et al. (2014), Evenson, R. E. (1999), Godfray, H. C. J., & Garnett, T. (2014),Erenstein, O., et al. (2011), McCarthy, N., Lipper, L., Branca, G. (2011), Tubiello, M., Rosenzweig, M., de Stefanis, R. (2014), Lipper, L., et al. (2014) Steenwerth, K. L., (2014))					Godfray, H. C. J., & Garnett, T. (2014), Evenson, R. E. (1999),					Steenwerth, K. L., (2014), Lewis, A., et al. (2014)				
	Greenhouse gas reduction from improved livestock production and manure management systems	Poverty reduction and resistance exposure to risk (1.5)					Food Security and promotion of Sustainable Agriculture(2.1/2.4/2a)					Ensure healthy lives (3.c)					No literature				
		↑	[+2]				↑	[+2]				↑/↓	[+2,-2]								
		Mixed-farming systems, can not only farmers mitigate risks by producing a multitude of commodities, but they can also increase the productivity of both crops and animals in a more profitable and sustainable way, (Quoted from Sarsaway, R. (1995))					Fostering transitions toward more productive livestock production systems targeting land-use change appears to be the most efficient lever to deliver food availability outcomes. (Quoted from Havlik, P., et al. (2014)) Genomic selection should be able to at least double the rate of genetic gain in the dairy industry (Quoted from Thornton, P. K. (2010)). Given the prevalence of mixed crop-livestock systems in many parts of the world, closer integration of crops and livestock in such systems can give rise to increased productivity and increased soil fertility. (Quoted from Thornton, P. K. (2010)). Managing the indirect effects of livestock systems intensification is critical for the sustainability of the global food system: like improving productivity and their close link to land sparing.(Quoted from Herrero, M., & Thornton, P. K. (2013)). In East Africa pastoralists have shifted from cows to camels, which are better adapted to survive periods of water scarcity and able to consistently provide more milk. (Steenwerth, K. L. et al. (2014)) Scenarios where zero human-edible concentrate feed is use for livestock: soil erosion potential reduces by 12%					Bio-digestion which has positive public health aspects, particularly where toilets are coupled with the bio-digester, and the anaerobic conditions kill pathogenic organisms as well as digest toxins. Preparation processes can improve or worsen health risks related to food crops or to livestock.									
		Sarsaway, R. (1995)					Havlik, P., et al. (2014), Steenwerth, K. L. (2014), Thornton, P. K. (2010), Herrero, M., & Thornton, P. K. (2013), Steenwerth, K. L. et al. (2014), Schader, C., et al. (2015)					Sarsaway, R. (1995), Burton, C. H. (2007).									

Do N

Panel A Part 3

Forest	Reduced deforestation, REDD+		Food Security and promotion of Sustainable Agriculture(2.1/2.4/2a) ↑ / ↓ [+1,-2] ▪▪▪ ● ▲ Food security, may lead to the conversation of productive land under forest, including community forests, into agricultural production. In a similar fashion, the production of biomass for energy purposes(SDG 7) may reduce food available for food production and/or for community forest activities (Quoted from Katila, P., et al. (2017)). Efforts by the Government of Zambia to reduce emissions by(REDD+, have contributed modern control, ecosystem and pollination valued at 2.5% of the country's GDP (Quoted from Katila, P., et al. (2017)), Nicolo, Nicol, & Ingram, (2015);Gnedeka, A. H., & Tsowou, S. L. H. (2017).		Secure inclusive and quality education(4.4/4.7) ↑ [+1] ▪▪ ● ▲ Local forest users learn to understand laws, regulations and policies which facilitate their participation in the society. Education and capacity building provide technical skill and knowledge. (Quoted from Katila, P., et al. (2017)) (Quoted from Katila, P., et al. (2017))
	Afforestation and reforestation	Poverty and Development (1.1/1.2/1.3/1.4) ↑ / ↓ [+2,-2] ▪▪▪ ●● ▲▲▲ CDM-AR can have different implications on local community livelihoods. Willingness to adopt afforestation is influenced in particular by Australian landholder's perceptions of its potential to provide a diversified income stream, and its impacts on flexibility of land management (Quoted from Feldman, Z., & Bull, L. (2014)). Land-owning stakeholders for reading implications for the CDM-compatible and non-CDM afforestation, land conservation (Quoted from Lewis et al. (2014)). Zomer, R. J., Trabucco, A., Bossio, D. A., & Verchot, L. V. (2008), Schirmer, J., & Bull, L. (2014), Lewis et al. (2014)	Food Security (2.1) ↑ / ↓ [+1,-1] ▪▪ ● ▲ CDM-AR can have different implications on local to regional food security and local community livelihoods. Zomer, R. J., Trabucco, A., Bossio, D. A., & Verchot, L. V. (2008).		Promote knowledge and skill to promote SD (4.7) ↓ [-1] ▪▪ ● ▲ Most landholders reported having low levels of knowledge about tree planting for carbon sequestration–particularly available programmes, prices and markets, and government rules and regulations (Quoted from Schirmer, J., & Bull, L. (2014)) Schirmer, J., & Bull, L. (2014)
	Reforestation (responsible sourcing)				
Oceans	Ocean Iron Fertilization		Food Security (2.1/2.2) ↑ / ↓ [+1,-1] ▪▪▪ ● ▲ OIF can have different implications on fish stocks and aquaculture, it might actually increase food availability for fish stocks (increasing yields) but potentially at the cost of reducing the yields of fisheries outside the enhancement region by depleting other nutrients. Strzepek and Harpp (2006), Lampitt et al. (2008), Williamson et al. (2012)		
	Blue carbon	Poverty and Development (1.1/1.2/1.3) ↑ [+3] ▪▪▪▪ ●●● ▲▲▲ avoiding loss of mangroves and maintaining the 2000 stock could save a value of ecosystem services from mangroves in Southeast Asia of approximately US$2.18 billion until 2050 (2007prices), with a 95% prediction interval of US$1.59–2.76 billion (case study area: South East Asia); Seaweed aquaculture will enhance carbon uptake and provide employment; traditional management systems provide benefits for blue carbon and support livelihoods for local communities; Greening of aquaculture can significantly enhance carbon storage; PES schemes could help capture the benefits derived from multiple ecosystem services beyond carbon sequestration; Zomer, R. J., Trabucco, A., Bossio, D. A., & Verchot, L. V. (2008), Schirmer, J., & Bull, L.	Food Production (2.1/2.4) ↑ [+3] ▪▪▪▪ ●●● ▲▲▲ avoiding loss of mangroves and maintaining the 2000 stock could save a value of ecosystem services from mangroves in Southeast Asia including fisheries; Seaweed aquaculture will provide employment; traditional management systems provide livelihoods for local communities; Greening of aquaculture can increase income and well being; Mariculture is a promising approach for China; Nellemann et al. (2012); Hasdiri et al. (2017); Vieros (2017); Ahmed et al. (2017a); Ahmed	
	Enhanced Weathering				

Do N

Panel A Part 3

Panel B Part 1

		5					10					16					17				
		INTERACTION	MUSEUM SCORE	EVIDENCE	AGREEMENT	CONFIDENCE	INTERACTION	MUSEUM SCORE	EVIDENCE	AGREEMENT	CONFIDENCE	INTERACTION	MUSEUM SCORE	EVIDENCE	AGREEMENT	CONFIDENCE	INTERACTION	MUSEUM SCORE	EVIDENCE	AGREEMENT	CONFIDENCE
Industry	Accelerating energy efficiency improvement	No literature					No literature					No literature									
	Low-carbon fuel switch	No literature					No literature														
	Decarbonisation/CCS/CCU																Environmental justice (17.6, 17.7 + |x2| ■ ●●● ★★★ EPI plants are capital intensive and are mostly operated by multinational with long investment cycles. In developed countries new innovation investments are happening in known fields . Such large innovation investments need strong collaboration among partners/competitors which can be facilitated by public fund, They happen at national /supra-national scale, across sectors, needs fresh model at IPR issues. Wesseling, J.H., S. Lechtenböhmer, M. Åhman, L.J. Nilsson, E. Worrell, L. Coenen (2017)				
Residential	Behavioral response											Environmental justice + |x2| ■ ● ▲ Hall et al. found that consumption-perspective strengthens the environmental justice discourse (as it claims to be a more just way of calculating global and local environmental effects) while possibly also increasing the environmental discourse. Hall and Lawson (2014)									
	Accelerating energy efficiency improvement	Gender equality and Women empowerment (5.1, 5.4) + |x2| ■ ●● ▲▲ Efficient cookstoves lead to empowerment of rural and indigenous women. Bennett et al. (2007), Bhojvaid Vasundhara et al (2014)					Improvement and inclusion (10.1/10.2/10.3/10.4) +/- |1,-1| ■■■■ ●●● ★★★ Energy efficiency measures and the provision of energy access can free up resources that can then be put towards other productive uses (e.g., educational and employment opportunities), especially for women and children in poor, rural areas. The distributional costs of new energy policies are dependent on instrument design. If costs fall disproportionately on the poor, then this could work against the promotion of social, economic and political equality for all. The impacts of energy efficiency measures and policies on inequality can be both positive (if they reduce energy costs) or negative (if mandatory standards increase the need for purchasing more expensive equipment and appliances). (Quote from McCollum et al., In review) McCollum et al. (In review); Cameron et al. (2016); Cuaillas and Reinaud (2011); Fay et al. (2015); Hallegatte et al. (2016); Hirth and Steckel (2016); Jakob and Steckel (2014); Casa and Dian (2016); Dobbelsteen (2011); Pachauri et al. (2012); Poyan et al. (2015)									
	Improved access & fuel switch to modern low-carbon energy	Women's Safety & Work (5.1/5.2/5.4) / Opportunities for Women (5.2/5.5) + |x1| ■■■ ●● ▲▲ Improved access to electric lighting can improve women's safety and girls' school enrollment. Cleaner cooking fuel and lighting access can reduce health risks and drudgery, which are disproportionately faced by women. Access to modern energy services has the potential to empower women by improving their income-earning and entrepreneurial opportunities and reducing drudgery. Participating in energy supply chains can increase women's opportunities and agency and improve business outcomes. (Quote from McCollum et al., In review) McCollum et al. (In review); Arensberg et al. (2010); Chowdhury (2010); Howes (2012); Hastings (2011); Pachauri and Rao (2013); Chowdhury (2010); Clancy et al (2012); Dobbelsteen (2011); Howes (2010); Kaygusuz (2011); Köhlin et al. (2011); Pachauri and Rao (2013); Ramey J., Akuffo H., Naylor R., Yanes D. (2017)										Institutional Capacity and Accountability (16.1/16.3/16.5/16.6/16.7/16.8) + |x2| ■■■■ ●●● ★★★★ Institutions that are effective, accountable, and transparent are needed at all levels of government (local to national to international) for providing energy access, promoting modern renewables, and boosting efficiency. Strengthening the participation of developing countries in international institutions (e.g., international energy agencies, United Nations organizations, World Trade Organization, regional development banks and beyond) will be important for issues related to energy trade, foreign direct investment, labor migration, and knowledge and technology transfer. Reducing corruption, where it exists, will help these bodies and related domestic institutions maximize their societal impacts. (Quote from McCollum et al., In review) Limiting armed conflict and violence will aid most efforts related to sustainable development, including progress in the energy dimension. McCollum et al. (In review); Acemoglu (2005); Acemoglu et al. (2014); ICRG; IEEC (2015); Tabellini (2010)					Promote transfer and diffusion of technology (17.6,17.7) + |x2| ■ ● ▲ Green building technology in Kazakhstan was based on transfer of knowledge among various parties Kim et al (2017)				
Transport	Behavioral response						Reduce inequality (10.2) + |x2| ■■■ ●● ▲▲ The equity impacts of climate change mitigation measures for transport, and indeed of transport policy intervention overall, are poorly understood by policymakers. This is in large part because standard assessment of these impacts is not a statutory requirement of current policy making. Managing transport energy demand growth will have to be advanced alongside efforts in passenger travel toward reducing the deep inequalities in access to transport services that currently affect the poor worldwide. Lucas & Pangbourne, 2014; Figueroa, Lah, Fulton, McKinnon, & Tiwari, 2014					Ensure safety on road (16.1) +/- |x1, -1| ■ ● ▲ With behavioral change towards walking for short distance pedestrian safety on the road might reduce serious public policy is appropriately formulated Partnership on Sustainable Low Carbon Transport, 2017					Help promote global partnership(17.1, 17.8,17.9,17.6,17.7) + |x2| ■ ● ▲ Projects aiming at resilient transport infrastructure development (e.g. C40 Cities Clean Bus Declaration, LSTP Declaration on Climate Leadership, Cycling Delivers on the Global Goals, Global Sidewalk Challenge) are happening through multistakeholder coalition Partnership on Sustainable Low Carbon Transport, 2017				
	Accelerating energy efficiency improvement											Ensure responsive, inclusive, participatory decision-making (16.7) + |x2| ■■■ ●● ▲▲ In transport mitigation is necessarily to conduct need assessment and stakeholder consultation to determine plausible challenges, prior to introducing a desired planning reforms. Further, the involved personnel should actively engage transport-based stakeholders during policy identification and to effective implementation to achieve desired results. User behaviour and stakeholder integration is key for successful transport policy implementation Appavoo, 2017, Attahough, Stu, Boeteneuwe, & Borrett, 2017					Help promote global partnership(17.1, 17.8,17.9,17.6,17.7) + |x2| ■ ● ▲ Projects aiming at resilient transport infrastructure development and technology adoption (e.g. C40 Cities Clean Bus Declaration, LSTP Declaration on Climate Leadership, Cycling Delivers on the Global Goals, Global Sidewalk Challenge) are happening through multistakeholder coalition Partnership on Sustainable Low Carbon Transport, 2017				
	Improved access & fuel switch to modern low-carbon energy						Reduce inequality (10.2) + |x2| ■■■ ●● ▲▲ The equity impacts of climate change mitigation measures for transport, and indeed of transport policy intervention overall, are poorly understood by policymakers. This is in large part because standard assessment of these impacts is not a statutory requirement of current policy making. Managing transport energy demand growth will have to be advanced alongside efforts in passenger travel toward reducing the deep inequalities in access to transport services that currently affect the poor worldwide. (Lucas & Pangbourne, 2014)(Figueroa, Lah, Fulton, McKinnon, & Tiwari, 2014)					Ensure responsive, inclusive, participatory decision-making (16.7) +/- |x1, -1| ■ ● ▲ Partial transport infrastructure improvement in many cities in developing countries lead to eviction from informal settlements which need appropriate redistributive policies and cooperation and partnership with all. Calenzaler et al 2017)					Help promote global partnership(17.1, 17.8,17.9,17.6,17.7) + |x2| ■ ● ▲ Projects aiming at resilient transport infrastructure development (e.g. C40 Cities Clean Bus Declaration, LSTP Declaration on Climate Leadership, Cycling Delivers on the Global Goals, Global Sidewalk Challenge) are happening through multistakeholder coalition Partnership on Sustainable Low Carbon Transport, 2017				

Do N

Panel B Part 2

		INTERACTION	NEXUS SCORE	EVIDENCE	AGREEMENT	CONFIDENCE	INTERACTION	NEXUS SCORE	EVIDENCE	AGREEMENT	CONFIDENCE	INTERACTION	NEXUS SCORE	EVIDENCE	AGREEMENT	CONFIDENCE	INTERACTION	NEXUS SCORE	EVIDENCE	AGREEMENT	CONFIDENCE
							Empowerment and Inclusion (10.1/10.2/10.3/10.4)					**Energy justice**									
Replacing coal	**Non-bio-mass renewables (solar, wind, hydro**	+	[+1]				+	[+1]				+	[+1]				+/-	[+2,0]			
		Decentralized renewable energy systems (e.g., home- or village-scale solar power) can reduce the burden on girl's and women of procuring traditional biomass.					Decentralized renewable energy systems (e.g., home- or village-scale solar power) can enable a more participatory, democratic process for managing energy-related decisions within communities. (Quote from McCollum et al., in review)					The energy justice framework serves as an important decision-making tool in order to understand how different principles of justice can inform energy systems and policies. Islar et al. (2017) states that off-grid and micro-scale energy development offers an alternative path to fossil-fuel use and top-down resource management as they democratize the grid and increase marginalized communities' access to renewable energy, education and health care.					International Cooperation (all goals)				
		Schwerhoff G., Sy M. (2017)					McCollum et al. (In review); Cass et al. (2010); Cumbers (2012); Kruse and Becker (2015); Walker and Devine-Wright (2008)					Mir et al. (2017)					McCollum et al. (In review); Clarke et al. (2009); Ru et al. (2014); Montreal Protocol (1989); New Climate Economy (2016); O'Neill et al. (2017); Ramaker et al. (2003); Riahi et al. (2012); Riahi et al. (2017)				
	Increased use of biomass																				
	Nuclear/Advanced Nuclear											**Reduce illicit arms trade (16.4)**									
												-	[-1]								
												Continued use of nuclear power poses a constant risk of proliferation. IPCC AR5 WG3 (2014); von Hippel et al. (2011, 2012); Sagan (2011); Yim and Li (2018); Adamantiades and Kessides (2009); Rogner (2012).									
	CCS: Bio-energy																				
							No literature														
Advanced coal	**CCS: Fossil**																				
		No literature					No literature					No literature									

Do N

Panel B Part 2

1

Panel B Part 3

		INTERACTION	MISSION SCORE	EVIDENCE	AGREEMENT	CONFIDENCE	INTERACTION	MISSION SCORE	EVIDENCE	AGREEMENT	CONFIDENCE	INTERACTION	MISSION SCORE	EVIDENCE	AGREEMENT	CONFIDENCE	INTERACTION	MISSION SCORE	EVIDENCE	AGREEMENT	CONFIDENCE
Agriculture & Livestock	Behavioural response: Sustainable healthy diets and reduced food waste	No literature					No literature					**Strong and effective institutions and responsive decision making (16.6/ 16.7 / 16.a)**	[+1,-1]				**Resource mobilization and Strengthen Partnership (17.1/17.14)**	[+1,-1]			
												Appropriate incentives to reduce food waste may require some policy innovation and experimentation, but a strong commitment for devising and monitoring them seems essential. (Quoted from Bajzel et al. (2014))					Decision makers should try to integrate agricultural, environmental and nutritional objectives through appropriate policy measures to achieve sustainable healthy diets coupled with reduction in food waste.				
												A financial incentive to reduce food waste could be created through effective taxation (e.g. by taxing foods with the highest manage rates, or by increasing taxes on waste disposal).					It is surprising that politicians and policy makers demonstrate little regarding the need of having strategies to reduce waste consumption and to encourage more sustainable eating practices in Netherlands.				
												Decision makers should try to integrate agricultural, environmental and nutritional objectives through appropriate policy measures to achieve sustainable healthy diets coupled with reduction in food waste.									
												It is surprising that politicians and policy makers demonstrate little regarding the need of having strategies to reduce waste consumption and to encourage more sustainable eating practices in Netherlands.									
												Bajzel et al (2014), Lavanchy (2013), Garnett, T. (2011), Dagevos, H., & Voordhuis, J. (2013).					Garnett, T. (2011), Dagevos, H., & Voordhuis, J. (2013).				
	Land based greenhouse gas reduction and soil carbon sequestration	No literature					No literature					**Build effective, accountable and inclusive institutions (16.6/ 16.7/16.8)**	[0,-1]				**Resource mobilization and Strengthen multi-stakeholder Partnership**	[+1]			
												Action is needed throughout the food system for improving governance and producing more					Climate Smart Agriculture requires more careful adjustment of agricultural practices to natural conditions, a knowledge-intensive approach, huge financial investment, and policy and institutional innovation, etc. Besides private investment quality of public investment is also important. (Quoted from Behnassi, M., Boussaid, M., Bikopichandran, R. (2014)).				
												Food. (Quoted from Godfray, H. C. J., & Garnett, T. (2014)).					Resource of climate finance for CSA in developing countries, including bilateral donors, multilateral financial institutions besides public sector finance.				
												CSA requires policy intervention for careful adjustment of agricultural practices to natural conditions, a knowledge-intensive approach, huge financial investment etc, as having strong institutional framework is very important.					CSA is considered to new ways of engaging in participatory research and partnerships with producers (Quoted from Steenwerth, E. L., (2010))				
												The main source of climate finance for CSA in developing countries is the public sector. Lack of institutional capacity (as a reason for ensuring creation of equal institutions amongst social groups and individuals) can reduce feasibility of NTCU mitigation measures in the near future, especially in areas where small-scale farmers or forest users are the stakeholders (Quoted from Radarsawa, M., (2014))									
												Godfray, H. C. J., & Garnett, T. (2014), Behnassi, M., Boussaid, M., Bikopichandran, R. (2014), Steenwerth, E. L., (2014), Lipper, L., et al. (2014), Radarsawa, M., (2014)					Behnassi, M., Boussaid, M., Bikopichandran, R. (2014), Lipper, L., et al. (2014), Steenwerth, E. L., (2014)				
	Greenhouse gas reduction from improved livestock production and manure management systems	No literature					No literature					**Responsible decision making (16.7)**	[+1]				**Improve domestic capacity for tax collection (17.1)**	[+1]			
												To maintain the economic and social cost, policies should target emissions at their source—on the supply side—rather than on the demand side as supply-side policies have lower calorie cost than demand-side policies. The role of livestock system transitions in emission reductions depends on the level of the carbon price and which emissions sector is targeted by the policies (Quoted from Havlík, P., et al. (2014))					The role of livestock system transitions in emission reductions depends on the level of the carbon price and which emissions sector is targeted by the policies (Quoted from Havlík, P., et al. (2014))				
												Havlík, P., et al. (2014)					Mechanisms for effecting behavioral change in livestock systems need to be better understood by implementing combinations of incentives and taxes distributionally in different parts of the world (Quoted from Herrero, M., & Thornton, P. K. (2013))				
												Havlík, P., et al. (2014)					Havlík, P., et al. (2014), Herrero, M., & Thornton, P. K. (2013)				

Do N

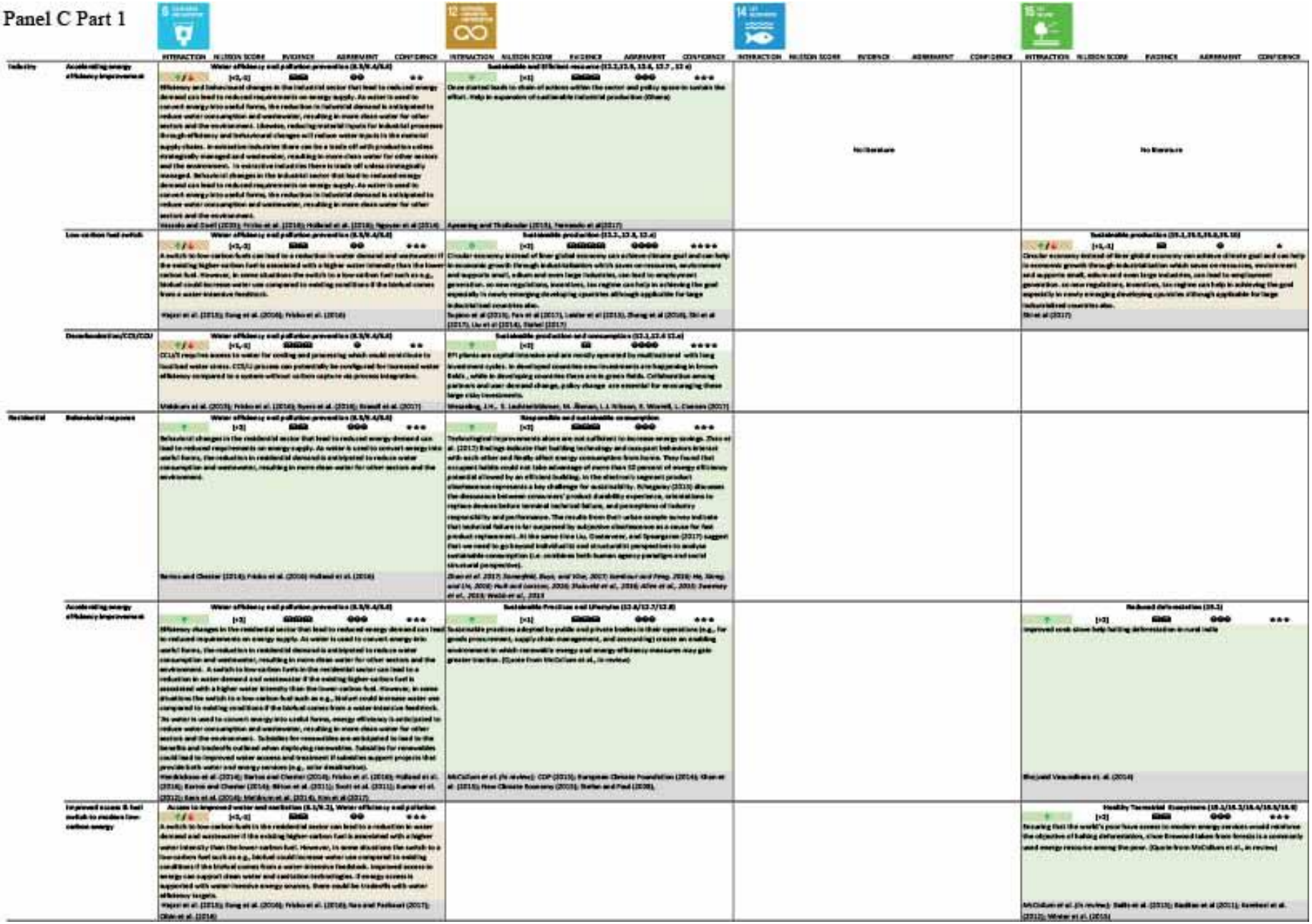
Panel B Part 3

Forest	Reduced deforestation, REDD+	**Opportunities for Women (5.1/5.5)** ↑/↓ [+/-1] ▣ ● ▲ Women have been less involved in REDD+ initiative (pilot project) design decisions and processes than men. Girls and women have an important role in forestry activities, related to fuel-wood, forest-food and medicines. Their empowerment could lead to sustainable forestry as well as reducing inequality ((Quoted from Katila, P., et al. (2017)) Brown 2011; Larson et al. 2015, ((Quoted from Katila, P., et al. (2017))	**Risks and inequality, empowerment and inclusion (10.1/10.2/10.3/10.4)** ↑ [+1] ▣ ● ▲ Urges developed country to support, through multilateral and bilateral channels, the development of REDD+ national strategies or action plans and implementation ((Quoted from Lima, M. G. B., Visseren-Hamakers, I. J., Braña-Varela, J., & Gupta, A. (2017)). Girls and women have an important role in forestry activities, related to fuel-wood, forest-food and medicines. Their empowerment could lead to sustainable forestry as well as reducing inequality ((Quoted from Katila, P., et al. (2017)) ((Quoted from Lima, M. G. B., Visseren-Hamakers, I. J., Braña-Varela, J., & Gupta, A. (2017)), ((Quoted from Katila, P., et al. (2017))	**Build effective, accountable and inclusive institutions, Responsible decision-making (16.6/ 16.7/16.8)** ↑ [+1] ▣▣ ●●● ▲▲▲ institutional building (National Forest Monitoring Systems, Safeguard Information Systems, etc.), with full and effective participation of all relevant countries ((Quoted from Lima, M. G. B., Visseren-Hamakers, I. J., Braña-Varela, J., & Gupta, A. (2017)). REDD+ actions also deliver non-carbon benefits (e.g. local socioeconomic benefits, governance improvements) ((Quoted from Lima, M. G., et al. (2016)) Forest governance is another central aspect in recent studies, including debate on decentralization of forest management, logging concessions in public owned commercially valuable forests, and timber certification, primarily in temperate forests. ((Quoted from Bustamante, M et al. (2014)) ((Quoted from Lima, M. G. B., Visseren-Hamakers, I. J., Braña-Varela, J., & Gupta, A. (2017)), Lima, M. G., et al. (2016)), Bustamante, M et al. (2014)	**Resource mobilization and Strengthen multi-stakeholder Partnership (13.1/ 13.2/13.3/17.17)** ↑/↓ [+1,-1] ▣ ● ▲ To provide finance and technology to developing countries to support ambitious reductions. Be supported by adequate and predictable financial and technology support, including support for capacity-building. ((Quoted from Lima, M. G. B., Visseren-Hamakers, I. J., Braña-Varela, J., & Gupta, A. (2017)) . Partnerships in the form of significant aid money from, e.g., Norway, other bilateral donors, and the World Bank's Forest Carbon Partnership Facility (FCPF) are forthcoming (quoted from Andrew, D. (2017)) Estimates of opportunity cost for REDD are very low. Lower costs action higher carbon prices could contribute to protect more forests, including those with lower carbon content. Conversely, where the cost of action is high, a large amount of additional funding would be required for the forest to be protected (Quoted from Miles, L., & Kapos, V. (2008)) Forest governance is another central aspect in recent studies, including debate on decentralization of forest management, logging concessions in public owned commercially valuable forests, and timber certification, primarily in temperate forests. ((Quoted from Bustamante, M et al. (2014)) ((Quoted from Lima, M. G. B., Visseren-Hamakers, I. J., Braña-Varela, J., & Gupta, A. (2017)), Andrew, D. (2017), Miles, L., & Kapos, V. (2008), Bustamante, M et al. (2014)
	Afforestation and reforestation			**Responsible decision-making (16.7)** ↑ [+1] ▣ ● ▲ Land-related mitigation, such as biofuel production, as well as conservation and reforestation action can increase competition for land and natural resources so these measures should be accompanied by complementary policies ((Quoted from Ilyasov, A. H., & Thwaer, S. L. H. (2017))	**Resource mobilization and Strengthen Partnership (17.1/17.14)** ↑ [+1] ▣▣ ●● ▲▲ Financing at the national and international level is required to grow more Seedlings/saplings, restore land, create awareness education factsheets, providing training of local communities regarding the benefits of afforestation and reforestation. Article 12 of the Kyoto Protocol further sets a Clean Development Mechanism through which countries in Annex I earn "certified emissions reductions" through projects implemented in developing countries ((Quoted from Montanarella, L., & Alva, J. L. (2015)). Afforestation and reforestation in India are being carried out under various programmes, namely social forestry initiated in the early 1980s, Joint Forest Management Programme initiated in 1990, afforestation under National Afforestation and Eco-development Board (NAEB) programmes since 1992, and private farmer and industry-initiated plantation forestry. The current rate of afforestation and reforestation is assessed to continue, the net tree stock could increase of 1.3% by 2030 ((Quoted from Ravindranath, N. H., Chakravarti, S. K., & Murthy, I. K. (2008)) Ilyasov, A. H., & Thwaer, S. L. H. (2017)	Kibria, G. (2015), Montanarella, L., & Alva, J. L. (2015), Ravindranath, N. H., Chakravarti, S. K., & Murthy, I. K. (2008))
	Reduction/ recycling (responsible sourcing)			**Responsible decision-making (16.7)** ↑ [+1] ▣▣ ●● ▲▲ Indonesian factories may seek advantages through corporate competition—perhaps by highlighting decent working conditions or the existence of a union—or to see trade associations or government agencies promoting the country as a responsible sourcing location ((Quoted from Burley, T. (2010)) In the absence of domestic legal instruments providing incentives to improve sustainability of sourcing, it appears that initiatives to engage the major importing enterprises in developing responsible sourcing practices and policies is a practical approach. Indeed initiatives involve all the major importers, they are unlikely to be successful since the high costs associated with accreditation would increase production costs for these firms relative to their competitors ((Quoted from Hoang, M., Miller, A., Sun, X., & Terheggen, A. (2015)). Burley, T. (2010), Hoang, M., Miller, A., Sun, X., & Terheggen, A. (2015)	**Finance and tools (17.1/17.13)** ↑ [+1] ▣▣ ●● ▲▲ Private certification initiatives for wood product and biomass sourcing may extend their schemes with criteria for "leakage" (external GHG effects). Also recycling of waste wood in pellets is not yet practiced, due to unclear rules in the EU Waste Directive about overseas shipping ((Quoted from Shikama, R., et al. (2014)) Engagement of Chinese government and private sector stakeholders in supply security sustainability initiatives may be the best way to support this gradual process of improvement. (quoted from Hoang, M., Miller, A., Sun, X., & Terheggen, A. (2015)). Although carrying out due diligence in timber sourcing can require considerable internal resources, it may be substantially less of a financial burden than the potential fines and reputational damage resulting from sourcing unknown or controversial timber. (quoted from Hoang, M., Miller, A., Sun, X., & Terheggen, A. (2015)) Shikama, R., et al. (2014), Hoang, M., Miller, A., Sun, X., & Terheggen, A. (2015)
Ocean	Ocean iron fertilization				
	Blue carbon				
	Enhanced Weathering				

Do N

Panel B Part 3

Panel C Part 1



		INTERACTION	NILSSON SCORE	EVIDENCE	AGREEMENT	CONFIDENCE	INTERACTION	NILSSON SCORE	EVIDENCE	AGREEMENT	CONFIDENCE	INTERACTION	NILSSON SCORE	EVIDENCE	AGREEMENT	CONFIDENCE	INTERACTION	NILSSON SCORE	EVIDENCE	AGREEMENT	CONFIDENCE
Industry	Accelerating energy efficiency improvement	Water efficiency and pollution prevention (6.3/6.4/6.6)					Sustainable and Efficient resource (12.2,12.5, 12.6, 12.7 , 12.a)					No literature					No literature				
		↑/↓	[+3,-3]		●●	●●	↑	[+3]		●●●	●●●										
		Efficiency and behavioural changes in the industrial sector that lead to reduced energy demand can lead to reduced requirements on energy supply. As water is used to convert energy into useful forms, the reduction in industrial demand is anticipated to reduce water consumption and wastewater, resulting in more clean water for other sectors and the environment. Likewise, reducing material inputs for industrial processes through efficiency and behavioural changes will reduce water inputs in the material supply chains. In extraction industries there can be a trade off with production unless strategically managed and wastewater, resulting in more clean water for other sectors and the environment. In extractive industries there is trade off unless strategically managed. Behavioral changes in the industrial sector that lead to reduced energy demand can lead to reduced requirements on energy supply. As water is used to convert energy into useful forms, the reduction in industrial demand is anticipated to reduce water consumption and wastewater, resulting in more clean water for other sectors and the environment.					One started leads to chain of actions within the sector and policy space to sustain the effort. Help in expansion of sustainable industrial production (Ghana)										
		Hussain and Dixit (2015); Priska et al. (2018); Holland et al. (2016); Nguyen et al (2014)					Ayeneng and Thalander (2015), Fernando et al(2017)														
	Low carbon fuel switch	Water efficiency and pollution prevention (6.3/6.4/6.6)					Sustainable production (12.2., 12.5, 12.a)										Sustainable production (09.2,09.5,09.b,09.4)				
		↑/↓	[+3,-3]		●●	●●●	↑	[+3]		●●●●	●●●●						↑	[+3,-3]		●	▲
		A switch to low carbon fuels can lead to a reduction in water demand and wastewater if the existing higher carbon fuel is associated with a higher water intensity than the lower carbon fuel. However, in some situations the switch to a low carbon fuel such as e.g., biofuel could increase water use compared to existing conditions if the biofuel comes from a water intensive feedstock.					Circular economy instead of liner global economy can achieve climate goal and can help in economic growth through industrialization which saves on resources, environment and supports small, reform and even large industries, can lead to employment generation. so new regulations, incentives, tax regime can help in achieving the goal especially in newly emerging developing countries although applicable for large industrialized countries also.										Circular economy instead of liner global economy can achieve climate goal and can help in economic growth through industrialization which saves on resources, environment and supports small, reform and even large industries, can lead to employment generation. so new regulations, incentives, tax regime can help in achieving the goal especially in newly emerging developing countries although applicable for large industrialized countries also.				
		Hejazi et al. (2015); Dang et al. (2016); Priska et al. (2018)					Tejasvi et al (2015), Pan et al (2017), Lester et al (2015), Zhang et al (2018), Shi et al (2017), Liu et al (2014), Stahel (2017)										Shi et al (2017)				
	Decarbonisation/CCS/CCU	Water efficiency and pollution prevention (6.3/6.4/6.6)					Sustainable production and consumption (12.2,12.4 12.a)														
		↑/↓	[+3,-3]		●	●●	↑	[+3]		●●●●	●●●●										
		CCS/U requires access to water for cooling and processing which could exist close to local/and water stress. CCS/U process can potentially be configured for increased water efficiency compared to a system without carbon capture via process integration.					EPI plants are capital intensive and are mostly operated by multinational with long investment cycles. In developed countries new investments are happening in known fields , while in developing countries there are in green fields. Collaboration among partners and user demand change, policy change are essential for encouraging these large risky investments.														
		Middleton et al. (2015); Priska et al. (2018); Byers et al. (2018); Kraxell et al. (2017)					Wassling, J.H., S. Lechtenböhmer, M. Åhman, L.J. Nilsson, K. Worrell, L. Claeson (2017)														
Residential	Behavioral response	Water efficiency and pollution prevention (6.3/6.4/6.6)					Responsible and sustainable consumption														
		↑	[+3]		●●●	●●●	↑	[+3]		●●●●	●●●										
		Behavioral changes in the residential sector that lead to reduced energy demand can lead to reduced requirements on energy supply. As water is used to convert energy into useful forms, the reduction in residential demand is anticipated to reduce water consumption and wastewater, resulting in more clean water for other sectors and the environment.					Technological improvements alone are not sufficient to increase energy savings. Zhou et al. (2012) findings indicate that building technology and occupant behaviors interact with each other and finally affect energy consumption from buses. They found that occupant habits could not take advantage of more than 50 percent of energy efficiency potential allowed by an efficient building. In the electronic segment product obsolescence represents a key challenge for sustainability. Ackerganey (2013) discusses the dissonance between consumers' product durability experience, orientations to replace devices before terminal technical failure, and perceptions of industry responsibility and performance. The results from their urban sample survey indicate that technical failure is far surpassed by subjective obsolescence as a cause for fast product replacement. At the same time Liu, Costanzevic, and Spangenberg (2017) suggest that we need to go beyond individualistic and structuralist perspectives to analyze sustainable consumption (i.e. combines both human agency paradigm and social structural perspective).														
		Barnes and Chester (2014); Priska et al. (2018); Holland et al. (2016)					Zhan et al. 2017; Stamfeld, Buys, and Khe, 2017; Sandnes and Feng, 2016; Ma, Wang, and Liu, 2016; Hult and Larsson, 2016; Stalvold et al., 2016; Allen et al., 2015; Sweeney et al., 2015; Webb et al., 2013														
	Accelerating energy efficiency improvement	Water efficiency and pollution prevention (6.3/6.4/6.6)					Sustainable Practices and Lifestyles (12.6/12.7/12.8)										Reduced deforestation (15.2)				
		↑	[+3]		●●●	●●●	↑	[+3]		●●●	●●●						↑	[+3]		●●●	●●●
		Efficiency changes in the residential sector that lead to reduced energy demand can lead to reduced requirements on energy supply. As water is used to convert energy into useful forms, the reduction in residential demand is anticipated to reduce water consumption and wastewater, resulting in more clean water for other sectors and the environment. A switch to low-carbon fuels in the residential sector can lead to a reduction in water demand and wastewater if the existing higher-carbon fuel is associated with a higher water intensity than the lower-carbon fuel. However, in some situations the switch to a low-carbon fuel such as e.g., biofuel could increase water use compared to existing conditions if the biofuel comes from a water intensive feedstock. As water is used to convert energy into useful forms, energy efficiency is anticipated to reduce water consumption and wastewater, resulting in more clean water for other sectors and the environment. Subsidies for renewables are anticipated to lead to the benefits and tradeoffs outlined when deploying renewables. Subsidies for renewables could lead to improved water access and treatment if subsidies support projects that provide both water and energy services (e.g., solar desalination).					Sustainable practices adopted by public and private bodies in their operations (e.g., for goods procurement, supply chain management, and accounting) create an enabling environment in which renewable energy and energy efficiency measures may gain greater traction. ([Quote from McCollum et al., in review)										Improved cook stove help halting deforestation in rural India				
		Hondalidson et al. (2014); Barnes and Chester (2014); Priska et al. (2018); Holland et al. (2016); Barnes and Chester (2014); Wilson et al. (2011); Scott et al. (2011); Kumar et al. (2012); Kern et al. (2014); Middleton et al. (2014); Kim et al (2017)					McCollum et al. (In review); CDP (2015); European Climate Foundation (2014); Khan et al. (2015); New Climate Economy (2015); Stefan and Paul (2008),										Bhojwani Vasudhara et. al. (2014)				
	Improved access & fuel switch to modern low-carbon energy	Access to improved water and sanitation (6.1/6.2), Water efficiency and pollution															Healthy Terrestrial Ecosystems (15.1/15.2/15.4/15.5/15.9)				
		↑/↓	[+3,-3]		●●	●●●											↑	[+3]		●●●	●●●
		A switch to low-carbon fuels in the residential sector can lead to a reduction in water demand and wastewater if the existing higher-carbon fuel is associated with a higher water intensity than the lower-carbon fuel. However, in some situations the switch to a low-carbon fuel such as e.g., biofuel could increase water use compared to existing conditions if the biofuel comes from a water intensive feedstock. Improved access to energy can support clean water and sanitation technologies. If energy access is supported with water intensive energy sources, there could be tradeoffs with water efficiency targets.															Recuring that the world's poor have access to modern energy services would reinforce the objective of halting deforestation, since firewood taken from forests is a commonly used energy resource among the poor. (Quote from McCollum et al., in review)				
		Hejazi et al. (2015); Dang et al. (2016); Priska et al. (2018); Rao and Pasbani (2017); Qian et al. (2014)															McCollum et al. (In review); Sathaye et al. (2010); Kaufman et al (2011); Kumboni et al. (2012); Winkler et al. (2016)				

Do N

Transport	Behavioural response	**Water efficiency and pollution prevention (8.3/5.4/6.8)** [+2] ●●● ●● Behavioral changes in the transport sector that lead to reduced transport demand can lead to reduced transport energy supply. As water is used to produce a number of important transport fuels, the reduction in transport demand is anticipated to reduce water consumption and wastewater, resulting in more clean water for other sectors and the environment. Villa et al. (2015); Tiedemann et al. (2016); Friko et al. (2016); Holland et al. (2016)	**Bonus Sustainable Consumption & Production patterns (12.3)** [+2] ●●● ●● Urban carbon mitigation must consider the supply chain management of imported goods, the production efficiency within the city, the consumption patterns of urban consumers, and the responsibility of the ultimate consumers outside the city. Important for climate policy of monitoring the CO2 clusters that dominate CO2 emissions in global supply chains because they offer insights on where climate policy can be effectively directed. (Liu, Hu, Cai, Song, & Seresinhe, 2015); (Sagawa et al., 2015); Felix et al (2016)		
	Accelerating energy efficiency improvement	**Water efficiency and pollution prevention (8.3/5.4/6.8)** [+2] ●●●● ●●● Similar to behavioral changes, efficiency measures in the transport sector that lead to reduced transport demand can lead to reduced transport energy supply. As water is used to produce a number of important transport fuels, the reduction in transport demand is anticipated to reduce water consumption and wastewater, resulting in more clean water for other sectors and the environment. Villa et al. (2015); Tiedemann et al. (2016); Friko et al. (2016); Holland et al. (2016)	**Sustainable Consumption (12.3/12.8)** [+2] ●●●● ●●● Relational complex transport behavior resulting in significant growth in energy-inefficient car choices, as well as differences in mobility patterns (distances driven, driving styles) and actual fuel consumption between different car segments all affect the core progress on transport decarbonization. Consumption choices, and individual lifestyles are situated tied to the form of the surrounding urbanization. Major behavioral changes and emissions reductions requires understanding of this relational complexity, consideration of potential interactions with other policies and the local context and implementation of both command and control as well as market-based measures. (Stanley, Hensher, & Loader, 2011);(Mahoney, Jeffe, Jamieson, Ale-Ahmadi, & Jamilla, 2011); (Gallego, Monteiro, & Sales, 2015); (Aamaas & Peters, 2017); (Ebeling & Metzler, 2017); Azevedo & Leal, 2017		
	Improved access & fuel switch to modern low-carbon energy	**Water efficiency and pollution prevention (8.3/5.4/6.8)** [+2,-1] ●●● ●●● A switch to low-carbon fuels in the transport sector can lead to a reduction in water demand and wastewater if the existing higher-carbon fuel is associated with a higher water intensity than the lower-carbon fuel. However, in some situations the switch to a low-carbon fuel such as e.g., biofuel could increase water use compared to existing conditions if the biofuel comes from a water-intensive feedstock. Transport electrification could lead to tradeoffs with water use if the electricity is provided with water-intensive power generation. Hejazi et al. (2015); Song et al. (2016); Friko et al. (2016)	**Bonus Sustainable Consumption & Production patterns (12.3)** [+2] ●●●● ●●● Due to persistent reliance on fossil fuels, it is posited that transport is more difficult to decarbonize than other sectors. This study partially confirms that transport is less reactive to a given carbon tax than the non-transport sectors. In the first half of the century, transport mitigation is delayed by 10-50 years compared to non-transport mitigation. The extent to which earlier mitigation is possible strongly depends on implemented technologies and model structure. (Kintzler et al., 2015); (Figueroa, Lee, Fulton, Mathiesen, & Tiwari, 2014); IPCC AR5 WG3 (2014); (Creutzig et al., 2015)		

Do N

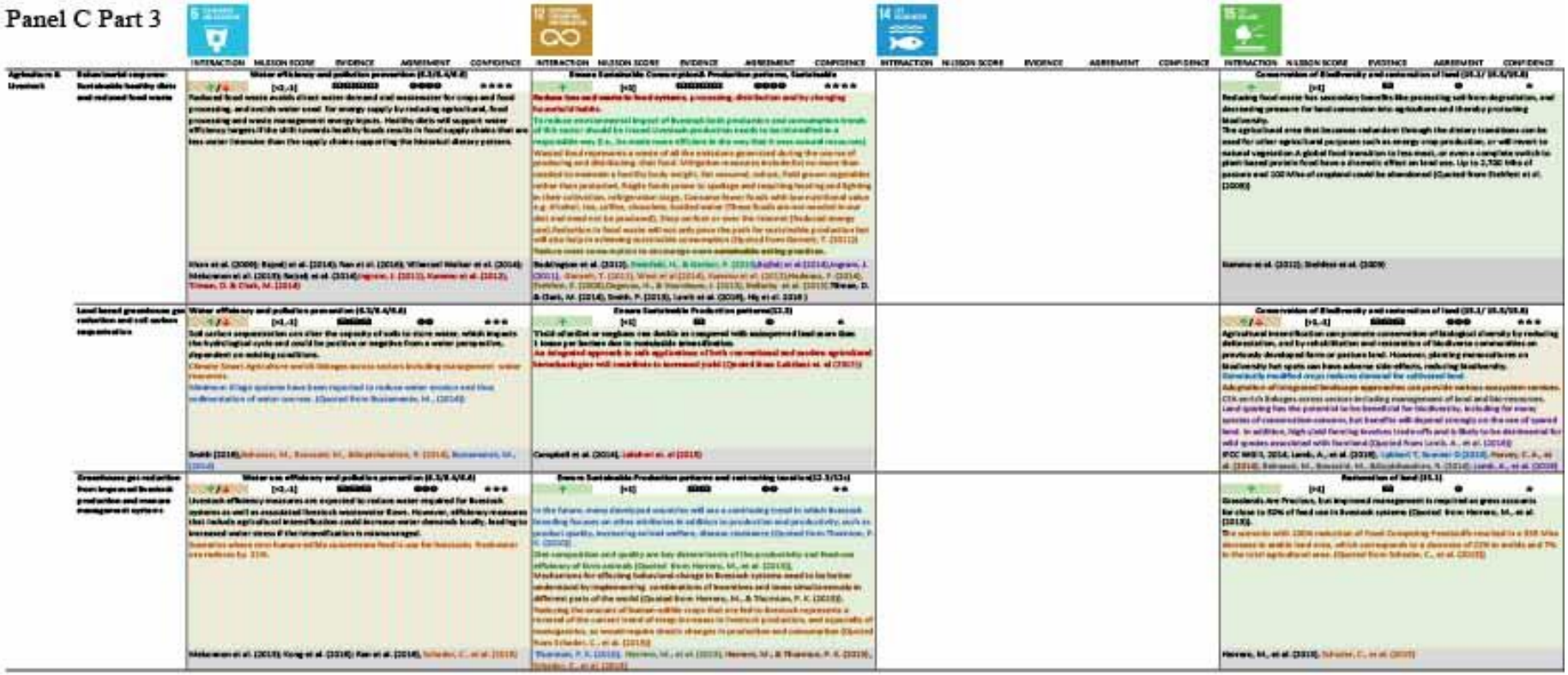
Panel C Part 1

Panel C Part 2

		6				12				14				15			
		INTERACTION	NLISSON SCORE	EVIDENCE	AGREEMENT	CONFIDENCE	INTERACTION	NLISSON SCORE	EVIDENCE	AGREEMENT	CONFIDENCE	INTERACTION	NLISSON SCORE	EVIDENCE	AGREEMENT	CONFIDENCE	INTERACTION	NLISSON SCORE	EVIDENCE	AGREEMENT	CONFIDENCE
Replacing coal	Non-biomass renewables solar, wind, hydro	Water efficiency and pollution prevention (6.3/6.4/6.6) / Access to improved water					Natural Resource Protection (12.2/12.3/12.4/12.5)					Marine Ecosystems (14.7) / Marine Protection (14.1/14.2/14.4/14.5)					Healthy Terrestrial Ecosystems (15.1/15.2/15.4/15.5/15.8)				
		↑/↓	[+1,-1]				↑	[+3]				↑/↓	[2,-1]				↓	[-1]			
		Wind/solar renewable energy technologies are associated with very low water requirements compared to existing thermal power plant technologies. Widespread deployment is therefore anticipated to lead to improved water efficiency and avoided thermal pollution. However, managing wind and solar variability can increase water use at thermal power plants and can cause poor water quality downstream from hydropower plants. Access to distributed renewables can provide power to improve water access, but could also lead to increased groundwater pumping and stress if mismanaged. Developing dams to support reliable hydropower production can fragment rivers and alter natural flows reducing water and ecosystem quality. Developing dams to support reliable hydropower production can result in disputes for water in basins with up- and downstream users. Storing water in reservoirs increases evaporation, which could offset water conservation targets and reduce availability of water downstream. However, hydropower plays an important role in energy access for water supply in developing regions, can support water security, and has the potential to reduce water demand if used without reservoir storage to displace other water intensive energy processes.					Renewable energy and energy efficiency show the depletion of several types of natural resources, namely coal, oil, natural gas, and uranium. In addition, the phasing-out of fossil fuel subsidies encourages less wasteful energy consumption; but if that is done, then the policies implemented must take care to minimize any counteracting adverse side-effects on the poor (e.g., fuel price rises). (Quote from McCollum et al., in review)					Ocean-based energy from renewable sources (e.g., offshore wind farms, wave and tidal power) are potentially significant energy resource bases for island countries and countries situated along coastlines. Multi-use platforms combining renewable energy generation, aqua-culture, transport services and leisure activities can lay the groundwork for more diversified marine economies. Depending on the local context and prevailing regulations, ocean-based energy installations could either reduce spatial competition with other marine activities, such as tourism, shipping, resources exploitation, and marine and coastal habitats and protected areas, or provide further grounds for protecting these exact habitats, therefore enabling marine protection. (Quote from McCollum et al., in review). Hydropower disrupts the integrity and connectivity of aquatic habitats and impact the productivity of inland waters and their fisheries					Land-use and wildlife impact for wind, habitat impact for hydropower				
		Bilton et al. (2011); Scott et al. (2011); Kumar et al. (2011); Kern et al. (2014); Meldrum et al. (2014); Fricko et al. (2016); Zhi et al. (2012); Grill et al. (2015); Deichert et al. (2016); Fricko et al. (2016); De Stefano et al. (2017)					McCollum et al. (in review); Banerjee et al. (2012); Bhattacharyya et al. (2016); Cameron et al. (2016); Kishi et al. (2011); Schwanitz et al. (2014)					McCollum et al. (in review); Buck and Krause (2012); Mühlen-Oelrich et al. (2008); WBGU (2010); Inger et al. (2009); Matthews N., Mccartney M. (2017); Cooke S.J., Allison E.H., Beard T.D., Jr., Arlinghaus R., Arthington A.H., Bartley D.M., Cowx I.G., Fuentevilla C., Leonard N.J., Lorenzen K., Lynch A.J., Nguyen V.M., Youn S.-J., Taylor W.W., Welcomme R.L. (2016)					Miser et al. (2011); Levish and Green (2013); Davies et al. (2011); Grodsky et al. (2011); Dahl et al. (2012); de Lucas et al. (2012); Dahl et al. (Dahl et al., 2012); Jain et al. (2011); Kumar et al. (2011); Aihe (2012); Kunz et al. (2011); Smith et al. (2013); Zhi et al. (2012); Matthews N., Mccartney M. (2017)				
	Increased use of bioenergy	Water efficiency and pollution prevention (6.3/6.4/6.6)															Healthy Terrestrial Ecosystems (15.1/15.2/15.4/15.5/15.8)				
		↑/↓	[+1,-1]														↑/↓	[+1,-1]			
		Biomass expansion could lead to increased water stress when irrigated feedstocks and water-intensive processing steps are used. Bioenergy crops can alter flow over land and through soils as well as require fertilizer and this can reduce water availability and quality. Planting bioenergy crops on marginal lands or in some situations to replace existing crops can lead to reductions in soil erosion and fertilizer inputs, improving water quality.															Protecting terrestrial ecosystems, sustainably managing forests, halting deforestation, preventing biodiversity loss and controlling invasive alien species could potentially clash with renewable energy expansion, if that would mean constraining large-scale cultivation of bioenergy or hydropower. Good governance, cross-jurisdictional coordination, and sound implementation practices are critical for minimizing trade-offs. (Quote from McCollum et al., in review)				
		Hejazi et al. (2015); Bonsch et al. (2016); Obia et al. (2016); Song et al. (2016); Kim et al. (2017); Tavoni et al. (2017); Woodbury et al. (2017); Griffiths et al. (2017); Yu et al. (2017)															McCollum et al. (in review); Smith et al. (2010); Smith et al. (2014); Ashworth-pong M., Green F.C., Gappler S., Neubauer P. (2017)				
	Nuclear (Advanced Nuclear	Water efficiency and pollution prevention (6.3/6.4/6.6)															Healthy Terrestrial Ecosystems (15.1/15.2/15.4/15.5/15.8)				
		↑/↓	[+1,-1]														↓	[-1]			
		Nuclear power generation requires water for cooling which can lead to localized water stress and the resulting cooling effluents can cause thermal pollution in rivers and oceans															Safety and waste concerns, uranium mining and milling				
		Webster et al. (2015); Fricko et al. (2016); Raptis et al. (2016); Hultkrantz et al. (2016)															IPCC AR5 WG3 (2014); Wuebbles and Jayaweera (2012); Greenberg (2016a); Kim et al.				
	CCS like energy	Water efficiency and pollution prevention (6.3/6.4/6.6)															Healthy Terrestrial Ecosystems (15.1/15.2/15.4/15.5/15.8)				
		↑/↓	[+1,-1]														↑/↓	[+1,-1]			
		CCUS requires access to water for cooling and processing which could contribute to localized water stress. However, CCS/U process can potentially be configured for increased water efficiency compared to a system without carbon capture via process integration. The bioenergy component adds the additional tradeoffs associated with bioenergy use.															Protecting terrestrial ecosystems, sustainably managing forests, halting deforestation, preventing biodiversity loss and controlling invasive alien species could potentially clash with renewable energy expansion, if that would mean constraining large-scale cultivation of bioenergy or hydropower. Good governance, cross-jurisdictional coordination, and sound implementation practices are critical for minimizing trade-offs. (Quote from McCollum et al., in review)				
		Meldrum et al. (2013); Fricko et al. (2016); Byers et al. (2016); Brandt et al. (2017)															McCollum et al. (in review); Smith et al. (2010); Smith et al. (2014); Ashworth-pong M., Green F.C., Gappler S., Neubauer P. (2017)				
Advanced coal	CCS Fossil	Water efficiency and pollution prevention (6.3/6.4/6.6)																			
		↑/↓	[+1,-1]																		
		CCUS requires access to water for cooling and processing which could contribute to localized water stress. However, CCS/U process can potentially be configured for increased water efficiency compared to a system without carbon capture via process integration. Coal mining to support clean coal CCS will negatively impact water resources due to the associated water demands, wastewater and land-use requirements.																			
		Meldrum et al. (2013); Fricko et al. (2016); Byers et al. (2016); Brandt et al. (2017)																			

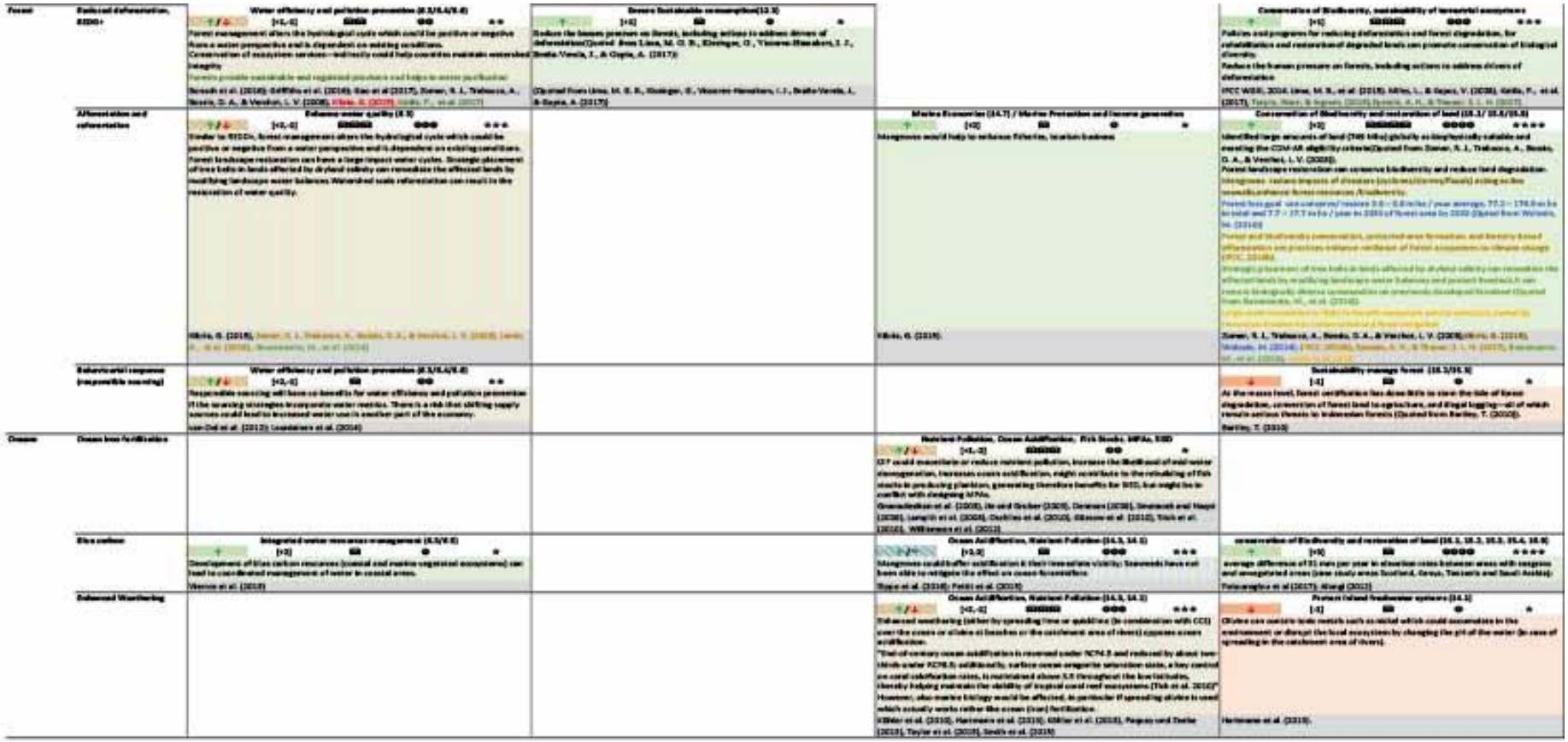
Do N

Panel C Part 2



Do N

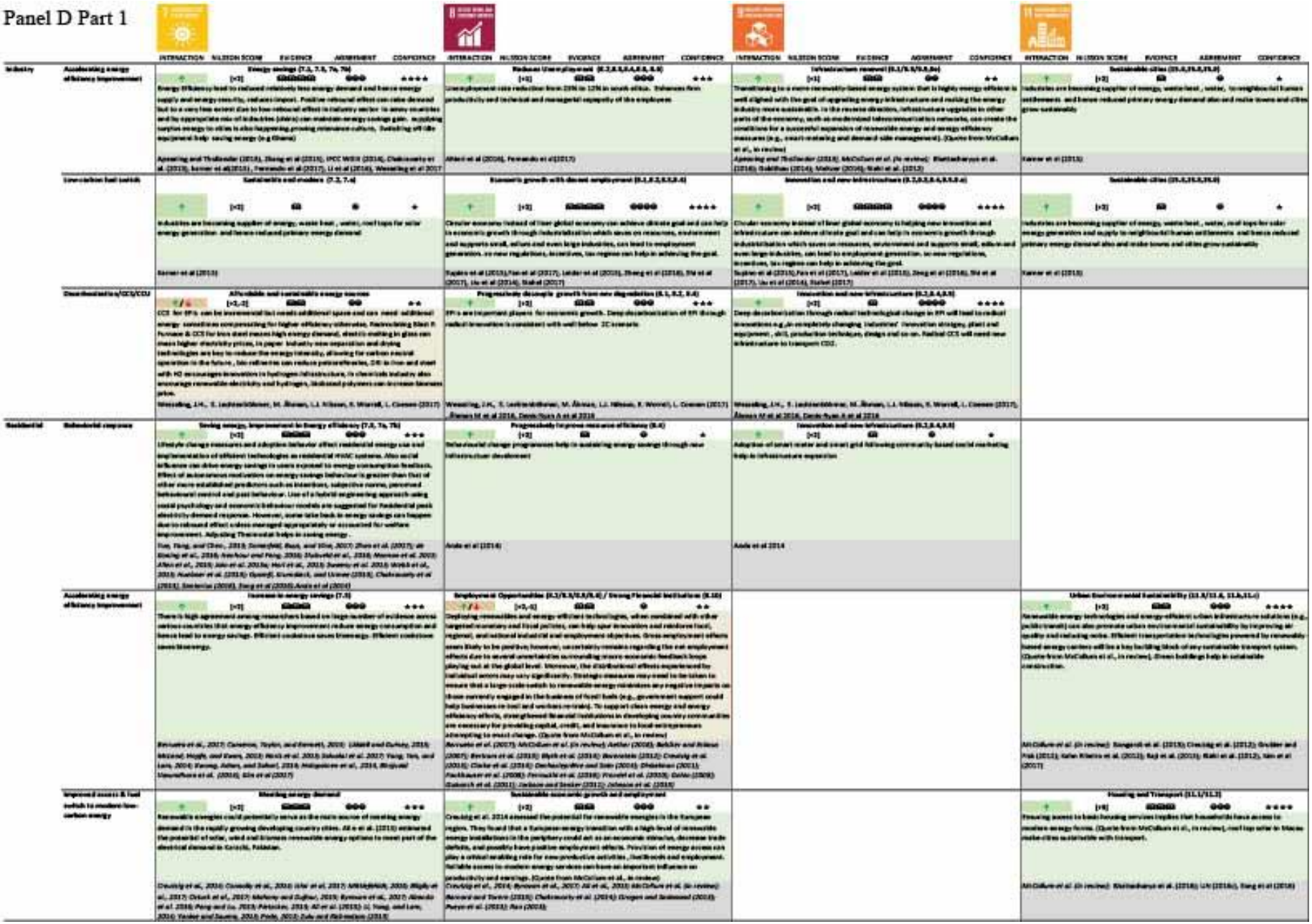
Panel C Part 3



Do N

Panel C Part 3

Panel D Part 1



		INTERACTION	NILSSON SCORE	EVIDENCE	AGREEMENT	CONFIDENCE	INTERACTION	NILSSON SCORE	EVIDENCE	AGREEMENT	CONFIDENCE	INTERACTION	NILSSON SCORE	EVIDENCE	AGREEMENT	CONFIDENCE	INTERACTION	NILSSON SCORE	EVIDENCE	AGREEMENT	CONFIDENCE
Industry	Accelerating energy efficiency improvement	Energy savings (7.3, 7.5, 7a, 7b)					Reduces Unemployment (8.2,8.5,8.4,8.6, 8.8)					Infrastructure renewal (9.1/9.5/9.5,9a)					Sustainable cities (11.5,11.5,11.5)				
		+	[+2]			●●●	+	[+1]			●●●	+	[+1]			●●	+	[+2]			●	+
		Energy Efficiency lead to reduced relatively less energy demand and hence energy supply and energy security, reduces import. Positive rebound effect can raise demand but to a very less extent due to low rebound effect in industry sector. In some countries and by appropriate mix of industries (Africa) can maintain energy savings gain. supplying surplus energy to cities is also happening, proving resistance culture. Switching off idle equipment help saving energy (e.g Ghana)					Unemployment rate reduction from 25% to 12% in south africa. Enhances firm productivity and technical and managerial capacity of the employees					Transitioning to a more renewably based energy system that is highly energy efficient is well aligned with the goal of upgrading energy infrastructure and making the energy industry more sustainable. In the reverse direction, infrastructure upgrades in other parts of the economy, such as modernized telecommunication networks, can create the conditions for a successful expansion of renewable energy and energy efficiency measures (e.g., smart metering and demand side management). (Quote from McCollum et al., in review)					Industries are becoming supplier of energy, waste heat, water, to neighbourhood human settlements and hence reduced primary energy demand also and make towns and cities grow sustainably				
		Apeaning and Thollander (2013), Zhang et al (2015), IPCC WEIR (2014), Chakravarty et al. (2013), Kanner et al(2013), Fernando et al (2017), Li et al (2016), Wesseling et al 2017					Ahlert et al (2016), Fernando et al(2017)					Apeaning and Thollander (2013), McCollum et al. (in review) Bhattacharyya et al. (2016), Goldthau (2014), Mathur (2016), Nakti et al. (2012)					Kanner et al (2013)				
	Low-carbon fuel switch	Sustainable and modern (7.2, 7.a)					Economic growth with decent employment (8.1,8.2,8.3,8.4)					Innovation and new infrastructure (9.2,9.3,9.4,9.5,9.a)					Sustainable cities (11.5,11.5,11.5)				
		+	[+2]		●	+	+	[+2]			●●●●	+	[+2]			●●●●	+	[+2]			●	+
		Industries are becoming supplier of energy, waste heat, water, roof tops for solar energy generation and hence reduced primary energy demand					Circular economy instead of linear global economy can achieve climate goal and can help in economic growth through industrialization which saves on resources, environment and supports small, culture and even large industries, can lead to employment generation. so new regulations, incentives, tax regime can help in achieving the goal.					Circular economy instead of linear global economy is helping new innovation and infrastructure can achieve climate goal and can help in economic growth through industrialization which saves on resources, environment and supports small, culture and even large industries, can lead to employment generation. so new regulations, incentives, tax regime can help in achieving the goal.					Industries are becoming supplier of energy, waste heat, water, roof tops for solar energy generation and supply to neighbourhood human settlements and hence reduced primary energy demand also and make towns and cities grow sustainably				
		Kanner et al (2013)					Tupiev et al (2015),Fan et al (2017), Lakder et al (2015), Zheng et al (2016), Shi et al (2017), Liu et al (2014), Stahel (2017)					Tupiev et al (2015),Fan et al (2017), Lakder et al (2015), Zheng et al (2016), Shi et al (2017), Liu et al (2014), Stahel (2017)					Kanner et al (2013)				
	Decarbonisation/CCS/CCU	Affordable and sustainable energy sources					Progressively decouple growth from new degradation (8.1, 8.2, 8.4)					Innovation and new infrastructure (9.2,9.4,9.5)									
		+ / ↓	[+2,-2]		●●	++	+	[+2]			●●●	+	[+2]			●●●●	++++					
		CCS for EPIs can be incremental but needs additional space and can need additional energy sometimes compensating for higher efficiency otherwise. Restructuring Blast Furnace & CCS for iron steel causes high energy demand, electric melting in glass can mean higher electricity prices, in paper industry new separation and drying technologies are key to reduce the energy intensity, allowing for carbon neutral operation in the future, bio refineries can reduce petroreferries, DRI in iron and steel with H2 encourages innovation in hydrogen infrastructure, in chemicals industry also encourage renewable electricity and hydrogen, biobased polymers can increase biomass price.					EPIs are important players for economic growth. Deep decarbonisation of EPI through radical innovation is consistent with well below 2C scenario					Deep decarbonisation through radical technological change in EPI will lead to radical innovations e.g.,in completely changing industries' innovation strategy, plant and equipment, skill, production technique, design and so on. Radical CCS will need new infrastructure to transport CO2.									
		Wesseling, J.H., S. Lechtenböhmer, M. Åhman, L.J. Nilsson, E. Worrell, L. Coenen (2017)					Wesseling, J.H., S. Lechtenböhmer, M. Åhman, L.J. Nilsson, E. Worrell, L. Coenen (2017), Åhman M et al 2016, Davis-Ryan A et al 2016					Wesseling, J.H., S. Lechtenböhmer, M. Åhman, L.J. Nilsson, E. Worrell, L. Coenen (2017), Åhman M et al 2016, Davis-Ryan A et al 2016									
Residential	Behavioral response	Saving energy, improvement in Energy efficiency (7.3, 7a, 7b)					Progressively improve resource efficiency (8.4)					Innovation and new infrastructure (9.2,9.4,9.5)									
		+	[+2]		●●●	+++	+	[+2]		●	+	+	[+2]		●	+					
		Lifestyle change measures and adoption behavior affect residential energy use and implementation of efficient technologies as residential HVAC systems. Also social influence can drive energy savings in users exposed to energy consumption feedback. Effect of autonomous motivation on energy savings behaviour is greater than that of other more established predictors such as intentions, subjective norms, perceived behavioural control and past behaviour. Use of a hybrid engineering approach using social psychology and economic behaviour models are suggested for residential peak electricity demand response. However, some take back in energy savings can happen due to rebound effect unless managed appropriately or accounted for welfare improvement. Adjusting Thermostat helps in saving energy.					Behavioural change programmes help in sustaining energy savings through new infrastructure development					Adoption of smart meter and smart grid following community based social marketing help in infrastructure expansion									
		Tue, Tang, and Chen, 2013; Somerfield, Bass, and Wise, 2017; Zhao et al. (2017); de Koning et al., 2016; Nachour and Feng, 2016; Dubuisson et al., 2016; Morrison et al. 2013; Allen et al., 2015; Jain et al. 2013a; Hart et al., 2013; Sweeney et al. 2013; Webb et al., 2013; Nuebner et al. (2013); Gyorgyi, Kiumdeck, and Unwin (2013); Chakravarty et al (2013); Sanderson (2016); Zhang et al (2016); Anda et al (2014)					Anda et al (2014)					Anda et al 2014									
	Accelerating energy efficiency improvement	Increase in energy savings (7.3)					Employment Opportunities (8.1/8.5/8.5/8.6) / Strong Financial Institutions (8.10)										Urban Environmental Sustainability (11.5/11.6, 11.6,11.c)				
		+	[+2]		●●●	+++	+ / ↓	[+2,-2]		●	++						+	[+2]			●●●	++++
		There is high agreement among researchers based on large number of evidence across various countries that energy efficiency improvement reduce energy consumption and hence lead to energy savings. Efficient cookstove saves Bioenergy. Efficient cookstove saves bioenergy.					Deploying renewables and energy efficient technologies, when combined with other targeted monetary and fiscal policies, can help spur innovation and reinforce local, regional, and national industrial and employment objectives. Gross employment effects seem likely to be positive; however, uncertainty remains regarding the net employment effects due to several uncertainties surrounding more economic feedback loops playing out at the global level. Moreover, the distributional effects experienced by individual actors may vary significantly. Strategic measures may need to be taken to ensure that a large scale switch to renewable energy minimizes any negative impacts on those currently engaged in the business of fossil fuels (e.g., government support could help businesses in fossil and workers re-train). To support clean energy and energy efficiency efforts, strengthened financial institutions in developing country communities are necessary for providing capital, credit, and insurance to local entrepreneurs attempting to enact change. (Quote from McCollum et al., in review)										Renewable energy technologies and energy efficient urban infrastructure solutions (e.g., public transit) can also promote urban environmental sustainability by improving air quality and reducing noise. Efficient transportation technologies powered by renewably based energy carriers will be a key building block of any sustainable transport system. (Quote from McCollum et al., in review). Green buildings help in sustainable construction.				
		Bernstein et al., 2017; Cameron, Taylor, and Emmett, 2015; Liddell and Guthrie, 2015; Mitchell, Hoggle, and Kwan, 2015; Rock et al. 2015; Sakuda et al. 2017; Yang, Yan, and Lam, 2014; Kwong, Adam, and Sohail, 2016; Malagueño et al., 2014; Bhojvaid Vasundhara et al. (2016); Kim et al (2017)					Bernstein et al. (2017); McCollum et al. (in review); Aether (2016); Bakker and Nilsson (2017); Bertram et al. (2015); Blyth et al. (2014); Bonnelein (2012); Creutzig et al. (2015); Clarke et al. (2014); Dechezleprêtre and Sato (2014); Dhakshinan (2011); Fischhauser et al. (2008); Fernandez et al. (2016); Fouquet et al. (2015); Gallo (2009); Gubrech et al. (2011); Jackson and Senker (2011); Johnson et al. (2015)										McCollum et al. (in review); Bangerak et al. (2013); Creutzig et al. (2012); Grubler and Fisk (2012); Kahn Ribeiro et al. (2012); Raji et al. (2013); Nakti et al. (2012); Nan et al (2017)				
	Improved access & fuel switch to modern low-carbon energy	Meeting energy demand					Sustainable economic growth and employment										Housing and Transport (11.1/11.2)				
		+	[+2]		●●●	+++	+	[+2]		●●●	++						+	[+2]			●●●	++++
		Renewable energies could potentially serve as the main source of meeting energy demand in the rapidly growing developing country cities. Ali et al. (2015) estimated the potential of solar, wind and biomass renewable energy options to meet part of the electrical demand in Karachi, Pakistan.					Creutzig et al. 2014 assessed the potential for renewable energies in the European region. They found that a European energy transition with a high level of renewable energy installations in the periphery could act as an economic stimulus, decrease trade deficits, and possibly have positive employment effects. Provision of energy access can play a critical enabling role for new productive activities, livelihoods and employment. Reliable access to modern energy services can have an important influence on productivity and earnings. (Quote from McCollum et al., in review)										Housing access to basic housing services implies that households have access to modern energy forms. (Quote from McCollum et al., in review), roof top solar in Macau make cities sustainable with transport.				
		Creutzig et al., 2014; Connolly et al., 2014; Ishai et al. 2017; Mikkelsen, 2015; Rigby et al., 2017; Ostack et al., 2017; Mahony and Sujhar, 2015; Bynsson et al., 2017; Abrado et al. 2016; Peng and Lu, 2013; Petrickis, 2015; Ali et al. (2015); Li, Yang, and Lam, 2014; Yankee and Swarra, 2015; Poole, 2013; Zulu and Richardson (2013)					Creutzig et al., 2014; Bynsson et al., 2017; Ali et al., 2015; McCollum et al. (in review); Ranzani and Torres (2015); Chakravarty et al. (2014); Grogan and Sadasivam (2013); Purya et al. (2013); Rao (2013)										McCollum et al. (in review); Bhattacharyya et al. (2016); Lin (2016a), Zheng et al (2016)				

Do N

1

Do N

Panel D Part 1

Panel D Part 2

		INTERACTION	NILSSON SCORE	EVIDENCE	AGREEMENT	CONFIDENCE	INTERACTION	NILSSON SCORE	EVIDENCE	AGREEMENT	CONFIDENCE	INTERACTION	NILSSON SCORE	EVIDENCE	AGREEMENT	CONFIDENCE	INTERACTION	NILSSON SCORE	EVIDENCE	AGREEMENT	CONFIDENCE
Replacing coal	Raw biomass renewables solar, wind, hydro	↑	[+8]	[illegible]	●●●	●●●●	Innovation and Growth (8.1/8.2/8.4)					Inclusive and Sustainable Industrialization (9.2/9.4)					Disaster Preparedness and Prevention (11.5)				
		Decarbonisation of the energy system through an up-scaling of renewables will greatly facilitate access to clean, affordable and reliable energy. Hydropower plays an increasingly important role for the global electricity supply. This mitigation option is in line with the targets of SDGT under the caveat of a transition to modern biomass. Cherian A. (2015); Ragel (2015); Cherian A. (2015); Jingura R.M., Kamusoko R.(2016)					↑	[3]	[illegible]	●●	●●	A rapid up-scaling of renewable energies could necessitate the early retirement of fossil energy infrastructure (e.g., power plants, refineries, pipelines) on a large scale. The implications of this could in some cases be negative, unless targeted policies can help alleviate the burden on industry. (Quote from McCollum et al., in review) McCollum et al. (in review); Bertram et al. (2015); Fankhauser et al. (2008); Guivarch et al. (2011); Johnson et al. (2015)					Deployment of renewable energy and improvements in energy efficiency globally will aid climate change mitigation efforts, and this, in turn, can help to reduce the exposure of people to certain types of disasters and extreme events. (Quote from McCollum et al., in review) McCollum et al. (in review); Duct et al. (2015); Hallegatte et al. (2016); IPCC (2014); Nahl et al. (2012); Tully (2006)				
	Increased use of biomass	↑	[+8]	[illegible]	●●●	●●●	↑	[+1]	[illegible]	●	●	↑	[+1]	[illegible]	●●●	●●					
		Increased use of modern biomass will facilitate access to clean, affordable and reliable energy. This mitigation option is in line with the targets of SDGT. Cherian A. (2015); Jingura R.M., Kamusoko R.(2016); Ragel (2015)					Decarbonisation of the energy system through an up-scaling of renewables will greatly facilitate access to clean, affordable and reliable energy. Jingura R.M., Kamusoko R. (2016)					Access to modern and sustainable energy will be critical to sustain economic growth. Jingura R.M., Kamusoko R. (2016); Shahbaz M., Rasool G., Ahmed K., Mahalik M.K. (2018)									
	Nuclear/Advanced Nuclear	↑	[1]	[illegible]	●	●●	↑	[1]	[illegible]	●	●●	Innovation and Growth (8.1/8.2/8.4)									
		Increased use of nuclear power can provide stable baseload power supply and reduce price volatility. IPCC AR5 WGS (2014)					Local employment impact and reduced price volatility IPCC AR5 WGS (2014)					↓	[-1]	[illegible]	●●●	●●●					
	CCS: Bio energy	↑	[+8]	[illegible]	●●●	●●●	↑	[+1]	[illegible]	●	●	↑	[+1]	[illegible]	●	●					
		Increased use of modern biomass will facilitate access to clean, affordable and reliable energy. IPCC AR5 WGS (2014)					See positive impacts of bio-energy use.					See positive impacts of bio-energy use and CCS/CCU in industrial demand.									
Advanced coal	CCS: Fossil	↑	[+8]	[illegible]	●●●	●●●	Innovation and Growth (8.1/8.2/8.4)					↑	[+1]	[illegible]	●	●					
		Advanced and cleaner fossil-fuel technology is in line with the targets of SDGT. IPCC AR5 WGS (2014)					↓	[-1]	[illegible]	●●●	●●●	See positive impacts of CCS/CCU in industrial demand.									

Do N

Panel D Part 2

Panel D Part 3

		INTERACTION	NILSSON SCORE	EVIDENCE	AGREEMENT	CONFIDENCE	INTERACTION	NILSSON SCORE	EVIDENCE	AGREEMENT	CONFIDENCE	INTERACTION	NILSSON SCORE	EVIDENCE	AGREEMENT	CONFIDENCE	INTERACTION	NILSSON SCORE	EVIDENCE	AGREEMENT	CONFIDENCE
Agriculture & Livestock	**Behavioural response: Sustainable healthy diets and reduced food waste**	**Energy Efficiency, universal access (7.1,7.3)** + [x1] ▣ ● ▲ Reducing global food supply chain losses have several important secondary benefits like conserving energy. Kuhnke et al. (2012),					**Sustained and inclusive economic growth (8.2)** + [x1] ▣▣▣ ●●● ▲▲▲ 25–28% of total cropland and fertilizers are used to produce losses. So reduction in food losses will help to diversify these valuable resources into other productive activities. Kuhnke et al. (2012);(Ali et al. 2016)				**Infrastructure building and promotion of inclusive industrialization (9.1/ 9.2)** + [x1] ▣▣▣ ●●● ▲▲▲ By targeting infrastructure,processing and distribution losses wastage in food systems can be minimized. 25–28% of total cropland and fertilizers are used to produce losses. So reduction in food losses will help to diversify these valuable resources into other productive activities. Reddington et al. (2011);Ingram, J. (2011);Lamb et al. (2016),					No literature
	Land based greenhouse gas reduction and soil carbon sequestration	**Sustainable and modern energy (7.A)** + [x1] ▣▣▣▣ ●●● ▲▲▲ Conventional agricultural biotechnology methods such as energy-efficient farming can help in sequestration of soil carbon. Modern biotechnologies like green energy, to efficient GM crops can also help in C-sequestration. Biotech crops allow farmers to use less and environmental friendly energy and practice soil carbon sequestration methods, both from traditional and GMO crops such as sugarcane, oilseed, rapeseed, and jatropha can be produced. Green energy programs through plantations of perennial non edible oil-seed producing plants and production of biodiesel for direct use in the energy sector, or blending biofuels with fossil fuels in certain proportions thereby promoting use of fossil fuels (Quoted from Lakshmi et. al (2015)). Genetically modified crops reduces demand fossil fuel based inputs. Mbow, H. P. (2015), Johnson et al. (2007), Lakshmi et. al (2015), Stern et al. (2007), Treasury (2009), Lee et al. (2009), Jain and Khanna (2018), Lybbert T, Sumner D (2012),					**Sustainable Growth (8.2)** +/- [<2,-1] ▣▣▣ ●● ▲▲ Many developing countries including Mali Stones will benefit from CSA given the central role of agriculture in their economic and social development (Quoted from Rahmani, M., Broussard,M., Bekoe,Hanselman, R. (2018)). Low commodity prices have reduced the incentive to invest in yield growth and have led to declining farm labour and farm capital investment.(Quoted from Lamb, A., et al. (2016)) Rahmani, M., Broussard,M., Bekoe,Hanselman, R. (2018), Lamb, A., et al. (2016)				**Infrastructure building, promotion of inclusive industrialization and innovation (9.1/** +/- [<2,-2] ▣▣▣▣ ●●● ▲▲▲ Reduced research support and delayed industrialization will have an adverse effect on food security and nourishment of children. Organic farming technologies utilizing bio-based fertilizers (composted manure and animal manure) are some of the conventional biotechnological options for reducing artificial fertilizer use (Quoted from Lakshmi et. al (2015)). CSA requires large financial investment and institutional innovation. CSA is committed to new ways of engaging in participatory research and partnerships with producers (Quoted from Steenwerth, K. L., (2014)). Technologies used on farms and during food processing to increase productivity which also helps in adaptation and/or mitigation are new, so assessing potential outcomes are difficult. Also Low awareness of CSA and inaccessible language, high costs, lack of verified impact of technologies, hard to reach and trans farmers, low crossover demand, unequal distribution of costs/benefits across supply chains are barriers of CSA technology adoption(Quoted from Long, T. B., Blok, V., &Coninx, I. (2016)) "evidence from the Netherlands, France, Switzerland and Italy. Low commodity prices have reduced the incentive to invest in yield growth and have led to declining investment to research and development ers (Quoted from Lamb, A., et al. (2016)) Ericsson, K. I. (1999), Lakshmi et. al (2015), Broussard, M., Bekoe,Hanselman, R. (2018),Steenwerth, K. L., et al. (2014),Long, T. B., Blok, V.,					No literature
	Greenhouse gas reduction from improved livestock production and manure management systems	**Energy Efficiency (7.3)** + [x1] ▣ ● ▲ Scenarios where zero human-edible concentrate feed is use for livestock non-renewable energy use reduces by 38% Schader, C., et al. (2015)					**Sustainable Economic Growth (8.4)** + [x1] ▣ ● ▲ Exploring the increasingly decoupled interactions between crops and livestock could be beneficial for promoting structural changes in the livestock sector and is a prerequisite for the sustainable growth of the sector. (Quoted from Herrero, M., & Thornton, P. K. (2013)) Herrero, M., & Thornton, P. K. (2013)				**Technological upgradation and innovation (9.2)** + [x2] ▣▣▣ ●●● ▲▲▲ Complete genome maps for poultry and cattle now exist, and these open up the way to possible advances in evolutionary biology, animal breeding and animal models for human diseases. Genomic selection should be able to at least double the rate of genetic gain in the dairy industry. (Quoted from Thornton, P. K. (2010)) Nanotechnology, biogas technology, separation technologies are a disruptive technology that enhance biogas production from anaerobic digesters or to reduce odours. Thornton, P. K. (2010), Sawayama, R. (1999), Burton, C. H. (2007)					No literature
Forest	**Reduced deforestation,**	**Energy Efficiency (7.3)** +/- [<1,-1] ▣ ● ▲ Consider the entire scale and resources of greenhouse gas while developing the nationally appropriate mitigations actions. For countries with a significant contribution of forest degradation (and GHG emissions)from wood fuels, this should be considered (Quoted from Lima, M. G. B., Visseren-Hamakers, I. J., Braña-Varela, J., & Gupta, A. (2017)). Biomass for energy is recognized as often being inefficient, and is often harvested in an unsustainable manner, but is a renewable energy source (Quoted from Lima, M. G. B., Visseren-Hamakers, I. J., Braña-Varela, J., & Gupta, A. (2017)), Lima, M. G. B., Visseren-Hamakers, I. J., Braña-Varela, J., & Gupta, A. (2017),					**Sustainable Economic Growth (8.4)** + [x1] ▣ ● ▲ Efforts by the Government of Zambia to reduce emissions by41CO2e, have contributed erosion control, economic and pollination valued at 2.5% of the country's GDP Turpie, Wait, & Ingram, (2013),Epstein, A. H., & Thaver, S. L. H. (2017),				**Infrastructure building, promotion of inclusive industrialization (9.1/ 9.2/9.5)** +/- [<1,-1] ▣ ● ▲ Expanding road net works are recognized as one of the main drivers of deforesting and forest degradation, diminishing forest benefits to communities, On the other hand, roads can enhance market access, thereby boosting local benefits (SDG 1) from the commercialization of forest products.(Quoted from Varela, P., et al. (2017)). Efforts by the Government of Zambia to reduce emissions by41CO2e, have contributed erosion control, economic and pollination valued at 2.5% of the country's GDP. (Quoted from Varela, P., et al. (2017)), Turpie, Wait, & Ingram, (2013),Epstein, A. H., & Thaver, S. L. H. (2017),					
	Afforestation and reforestation						**Decent job creation and Sustainable economic growth (8.1/8.4)** + [x1] ▣▣▣ ●● ▲▲ Many tree plantations worldwide have higher growth rates which can provide higher rates of returns for investors. Agroforestry initiatives that offer significant opportunities for projects to provide benefits to smallholder farmers can also help address land degradation through community based efforts in more marginal areas. Mangroves reduce impacts of disasters (cyclones/storms/floods) enhance water quality, fisheries, increase business, and livelihoods. Zomer, R. J., Trabucco, A., Bossio, D. A., & Verchot, L. V. (2008),									
	Behavioural response (responsible sourcing)	**Universal access (7.1)** + [x1] ▣ ● ▲ The trade of wood pellets from clean wood waste should be facilitated with less administrative barriers for the export by the EU, in order to have this new option seriously accounted for as a future resource for energy. (Quoted from Ikkema, K., et al. (2014)). Recommends further harmonization of legal harvesting, sustainable sourcing and cascaded use requirements for woody biomass for energy with the current requirements of voluntary SFM certification schemes (Quoted from Ikkema, K., et al. (2014)) Ikkema, K., et al. (2014)					**Decent job creation and Sustainable economic growth (8.1/8.4)** + [x1] ▣ ● ▲ Some standards seek primarily to coordinate global trade, many purport to promote ecological sustainability and social justice or to institutionalize "corporate social responsibility" (CSR) e.g. labour standards developed in the wake of sweatshop and child labour scandals. Environmental standards for pollution control etc. Indonesian factories may seek advantages through non-price competition—perhaps by highlighting decent working conditions or the existence of a sector—or to use trade associations or government promoting the country as a responsible sourcing location. Barclay, T. (2010)					**Technological upgradation and innovation, promotion of inclusive industrialization** + [x1] ▣▣▣ ●● ▲ Capacity for processing certified timber is often underutilized, due the limited supply available. As a result, manufacturing firms that are seeking to tap into green markets often turn to other sources of timber (Quoted from: Barclay, T. (2010)). Responsible sourcing, when integrated into business practices, can enable retailers to better manage brand value and reputation by avoiding negative public relations, as well as maintaining and enhancing brand integrity (Quoted from Hoang, M., Wilkes, A., Sun, F., & Yarlagadda, A. (2015)). Barclay, T. (2010), Hoang, M., Wilkes, A., Sun, F., & Yarlagadda, A. (2015),					
Oceans	**Ocean iron fertilization**																				
	Blue carbon																				
	Enhanced Weathering																				

Do N

1