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ACTION ON CLIMATE TODAY

LEARNING PAPER

Climate-Resilient Agriculture in South Asia: An analytical framework and insights from practice

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Oxford Policy Management

JUNE 2018

ACT (Action on Climate Today) is an initiative funded with UK aid from the UK government and managed by Oxford Policy Management. ACT brings together two UK Department for International Development programmes: the Climate Proofing Growth and Development Programme and the Climate Change Innovation Programme. The views expressed in this paper do not necessarily reflect the UK government's official policies.

Cover photo: Gathering fodder from communal land in northern India. Picture credit: Barry Pound.

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Acknowledgements

The authors would like to thank Rizwan Uz Zaman, Niramala Sanu, Naman Gupta, Pankaj Kumar, Rishu Garg, Arif Pervaiz, Azim Doosti, Jerin Thomas, Sunil Acharya and Soumik Biswas for providing the experience and learning necessary to inform this paper. Thanks are also owed to Vidya Soundarajan, Cristina Rumbaitis del Rio and Peter Reid, for reviewing drafts; Uma Pal, for providing research support; and Elizabeth Gogoi, for managing the research and production process.

Abbreviations and acronyms

AC	Adaptive Capacity
ACT	Action on Climate Today
ADB	Asian Development Bank
CA	Conservation Agriculture
CC	Climate Change
CCA	Climate Change Adaptation
CCAFS	CGIAR Climate Change, Agriculture and Food Security Research Program
CDKN	Climate and Development Knowledge Network
CIMMYT	International Maize and Wheat Improvement Center
CRA	Climate-Resilient Agriculture
CRiSTAL	Community-Based Risk Screening Tool – Adaptation and Livelihoods
CSA	Climate-Smart Agriculture
CSDRM	Climate-Smart Disaster Risk Management
Danida	Danish International Development Assistance
E	Exposure
FAO	Food and Agricultural Organization of the UN
FPC	Farmer Producer Company
GHG	Greenhouse Gas
GIZ	German International Cooperation
GoI	Government of India
GWP	Global Water Partnership
IBLI	Index-Based Livestock Insurance (Mongolia)
IFAD	International Fund for Agricultural Development
IPCC	Intergovernmental Panel on Climate Change
IRRI	International Rice Research Institute
ISET	Institute for Social and Environmental Transition
IWMI	International Water Management Institute
JSA	Jalayukt Shivar Abhiyan (Maharashtra)
M4P	Making Markets Work for the Poor
NAF	National Adaptation Fund (India)
NAP	National Adaptation Plan (Nepal)
NASA	National Aeronautics and Space Administration (US)
OECD	Organisation for Economic Co-operation and Development
PoCRA	Project on Climate-Resilient Agriculture (Maharashtra)
S	Sensitivity
SDG	Sustainable Development Goal
UNEP	UN Environment Programme
UNFCCC	UN Framework Convention on Climate Change
US	United States
VCA	Value Chain Analysis
WOTR	Watershed Organisation Trust
WRS	Warehouse Receipt System

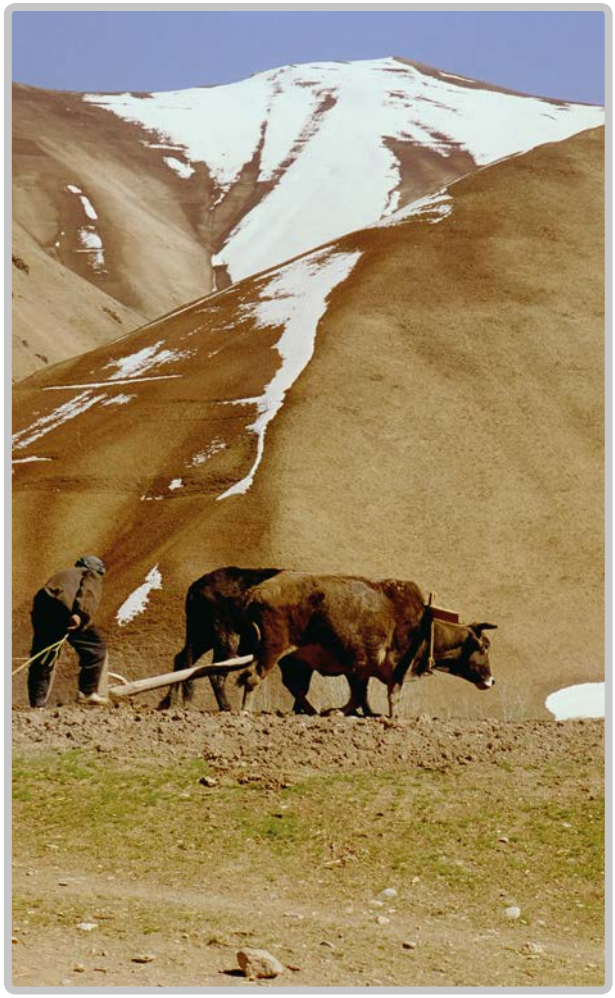
Executive summary

Agricultural systems are extremely vulnerable to climate change (CC), given their sensitivity to variations in temperature, precipitation and occurrence of natural events and disasters such as droughts and floods. Meanwhile, emissions from agricultural activities contribute considerably to global warming. This cause and effect relationship between agriculture and CC is rendered more complex by its impact on the economy, food security and development. This is especially so in South Asia, where majority of the population is dependent predominantly on agriculture as a source of livelihood.

The vulnerability of this region is exacerbated by existing conditions of poverty, malnutrition and increasing populations. This puts intense pressure on limited natural resources, especially land, water and energy – all of which are integral to agricultural systems. Given the scale of CC impacts, stand-alone measures for the sector to adapt to them will not suffice. Resilience needs to be mainstreamed and embedded into policies and programmes across scales of governance.

In this context, it becomes imperative to adopt Climate-Resilient Agriculture (CRA) measures at scale to address the impending impact of CC on agriculture. Hence, enabling CRA in the region constitutes one of the four fundamental pillars of Action on Climate Today (ACT), an initiative funded by the UK Department for International Development. The programme focuses on climate-proofing governance systems in five South Asian countries at the national and subnational levels and is designed to transform systems of planning and delivery for adaptation to CC. As a part of its interventions, ACT has been providing technical assistance to governments at the national and state level across South Asia to enable CRA.

CRA is a subset of Climate-Smart Agriculture (CSA) interventions with the specific objective of enhancing the resilience of agricultural systems and the social systems that depend on these. While CSA focuses on both mitigation and adaptation measures, CRA is concerned only with adaptation and resilience. The approach goes beyond on-farm activities and considers off-farm options such as livelihood diversification, when viable in the context of enhancing resilience. Similar to the Making Markets Work for the Poor (M4P) approach, it goes one step forward and looks at each link in the agriculture value chain through a much-needed CC lens.



Land preparation in Afghanistan.

The paper introduces a framework of practical entry points at the national and local level for addressing CC adaptation and resilience and maps them across the agriculture value chain and non-farming options. The entry points, which target exposure, sensitivity and adaptive capacity within the vulnerability framework, are as follows:

- **Policy and institutional entry points**, such as establishment of an enabling environment for climate-relevant policies, screening of existing agricultural policies, establishment of new institutions and approaches to ensure resilience and adaptation options reach a broader population, etc.
- **Financial entry points**, such as use of financial instruments to streamline farmer behaviour into ensuring enhanced resilience, enabling appropriate CC financial services for farmers,

providing safety nets against CC shocks and stresses, establishment of off-farm and non-farm income-generating activities, etc.

- **Information and social behaviour entry points**, such as conducting studies to provide information on CC causes, impacts, risks and options, enhancing social networks, cohesion and gender equality for resilience, developing information systems, increasing the efficiency of food use, etc.
- **Technical entry points**, such as identification of risks from actual and anticipated climate hazards, improvement of ecosystem health and buffering capacity, climate-proofing agricultural post-harvest infrastructure, development of emergency preparedness systems and procedures, etc.

The paper also identifies and discusses the critical challenges and knowledge gaps that currently exist in interacting and working with governments and organisations across these four main entry points.

The paper then goes on to explore the conceptual framework by presenting examples of CRA interventions developed and deployed across the four entry points by the ACT programme. This provides a high-resolution picture of how the programme has designed and operationalised its interventions across the four entry points, to demonstrate the effectiveness of the CRA framework.

Finally, the paper discusses a set of cross-cutting lessons derived from this review of the state of global practice on CRA and initiatives undertaken by the ACT programme. It concludes by highlighting the following:

- Moving beyond business as usual by addressing exposure and sensitivity to climate shocks, and increasing adaptive capacity in the context of agriculture systems and those dependent on them
- Engaging multiple stakeholders in processes to make agricultural practices more resilient to the impacts of CC
- Recognition of the political nature of the CRA approach and not looking at it as a set of isolated technical interventions
- Integration of initiatives with government priorities to generate political will for CRA to be sustainable and institutionalised
- The urgent need to scale up CRA across the region and ensure its uptake by policy-makers, civil society, the private sector, universities, banks and, most importantly, communities engaged in agriculture.

1. Introduction

Scientists have argued that one important way in which climate change (CC) will manifest itself globally is through its impact on agricultural systems. This is particularly problematic for South Asia, given the high dependence of its population on agriculture as a primary livelihood.

One of the four pillars of the Action on Climate Today (ACT) programme relates to enabling Climate-Resilient Agriculture (CRA) in the region. This five-year initiative funded by the UK Department for International Development provides direct technical assistance to national and subnational governments on mainstreaming climate change adaptation (CCA) in policies, plans, programmes and budgets. The initiative strengthens institutions to develop and deploy CCA policies, access and mainstream climate finance, promote CRA and enable Climate-Resilient Water Management.

This section sets the context for climate and development in South Asia. Section 2 outlines global responses to CC impacts and discusses how CRA overlaps with other existing paradigms of agricultural practice, such as Climate-Smart Agriculture (CSA). Section 3 outlines entry points for CRA and Section 4 common challenges. Section 5 illustrates how ACT is enabling CRA. The final section closes with cross-cutting reflections on lessons learnt by ACT in this domain of activity in the past four years.

1.1 South Asia: A context

South Asia has a total population of about 1.75 billion and covers over 5 million km^2, within which the climate varies from tropical monsoon in the south to temperate/alpine in the north. The region is characterised by geophysical, climatic and ecological diversity as well as immense differences in terms of demography and socio-economic development, both between and within countries.

South Asia accounts for less than 4% of the world's gross domestic product[1] and is home to one of its largest concentrations of rural poverty. High levels of economic inequality exacerbate a range of social, political and environmental challenges.

A total of 70% of the South Asian population lives in rural areas, and most, especially women, rely on agriculture for their livelihood. Even so, Afghanistan, Bangladesh and Nepal are net importers of food.

Farming systems vary with latitude, altitude and other factors. Smallholder rice-wheat, rice and rainfed mixed systems predominate (Dixon and Gulliver, 2001).

Increasing populations and economic growth are creating opportunities while putting intense pressure on natural resources. Land is subject to multiple demands, to provide food and environmental services. Food production in South Asia is projected to double by 2050, with over 80% of this expected to come from increased yields rather than an expansion of cultivated land (Alexandratos and Burinsma, 2012).

Around 25% of the population falls below the international poverty line[2] and in 2015, approximately 281 million people (one in six) were malnourished (FAO, 2015) – even though Asia contains some of the world's fastest-growing economies. Despite progress in reducing poverty, rapid population growth and limited resources means that the absolute number of undernourished people has continued to increase. Spikes and volatility in food prices affect all but add significantly to the vulnerability of the poor and marginalised, who spend up to 70% of their income on food items (ADB, 2012a).

Evidence (from Africa) shows that the least food-secure households are those that are least likely to take up new climate-smart practices (Kristjanson et al., 2012). Poor farmers are likely to have the lowest adaptive capacity (see Section 1.3) and are the most vulnerable to short-term shocks. They are also more vulnerable to longer-term changes, not having the resources to invest in the transition to new agricultural technology, new farming systems or non-farming livelihoods. There are implications in terms of explicit financing for poor groups, emergency food relief, safety nets,[3] reorientation of services to better cater to the needs of poor farmers and the need for careful consideration of trade-offs between food security and environmental protection or improvement.

1.2 Agriculture and its relationship to climate change

The Intergovernmental Panel on Climate Change (IPCC) defines CC as '*any change in climate over*

1 https://data.worldbank.org/indicator/NY.GDP.MKTP.KD
2 https://data.worldbank.org/region/south-asia
3 See Module 16 of FAO (2013).

time, whether due to natural variability or as a result of human activity' but it goes on to point to human activity as the main cause of the rise in CO_2 levels since the Industrial Revolution (UNFCCC, 2011). CC itself is not a new phenomenon, but the anticipated rate and scale of change are now projected to increase to levels that will make autonomous adaptation difficult (Lamboll et al., forthcoming).

Agriculture is a major contributor to global warming. The agriculture, forestry and other land use sectors are responsible for just under a quarter of total global anthropogenic greenhouse gas (GHG) emissions.

The main contributors are enteric fermentation (methane from livestock), organic fertilisers, synthetic fertilisers, burning biomass, swamp rice production, manure management, organic soils, and crop residues. This breakdown does not include land use change, forestry and peat draining/burning, which contribute about the same again to GHG emissions and have considerable implications for agriculture and the related social, physical and political sectors (Lamboll et al., forthcoming). The multiple causes and effects of CC, and the interrelatedness of many of these, imply that technical fixes are insufficient: social, economic, cultural, institutional and political responses are also required.

As well as contributing, agriculture is also highly affected by CC. Global warming exacerbates food security challenges through increased temperatures, rising sea levels, uncertain seasons and increased intensity and frequency of extreme weather events. In so doing, it threatens achievement of the Sustainable Development Goals (mainly SDG 1 No Poverty, SDG 2 Zero Hunger, SDG 3 Good Health and Well-Being, SDG 6 Clean Water and Sanitation, SDG 11 Sustainable Cities and Communities and SDG 13 Climate Action), that are key to the well-being of South Asia.

1.3 Impacts of climate change in South Asia

Impacts are already being felt in South Asia (IPCC, 2013), and further CC is inevitable in the coming decades. Warming trends and increasing temperature extremes have been observed across most of Asia over the past century. Global temperatures could rise by more than 2°C by the mid-21st century (IPCC, 2014a). There is insufficient data to draw clear conclusions about trends in annual rainfall over the past century in South Asia, except to say they are characterised by strong variability. The future trend is of greater rainfall at higher latitudes by the mid-21st century, and of more extreme rainfall events (IPCC, 2014b).

CC is expected to increase flooding of settlements, heat-related deaths and food and water shortages in South Asia (Bowen and Ebi, 2017). Changing precipitation patterns are also affecting water availability. Most of Asia's main cities are exposed to one or multiple hazards, with floods and cyclones being the most important ones (Adhikari et al., 2010). The risk of floods, and loss of life and property associated with floods, is highest in Bangladesh, India and Pakistan (Box 1).

Sea level rises in the Indian Ocean pose a threat to coastal communities, especially when linked to cyclones (IPCC, 2014b). Low-lying islands in the Sundarbans have already been submerged, with thousands of people displaced (Aalst et al., 2003). Sea level rises can also increase salinity in water and land in coastal areas, severely disrupting agricultural production.[4]

Many parts of South Asia are likely to experience a decline in crop productivity unless there is a shift to different crop varieties and management practices (Ban et al., 2008). CC may trigger pests and diseases, which have the potential to severely limit production (Chakraborty and Newton, 2011).

Crop production is likely to shift northwards, with cooler regions likely to benefit from warmer temperatures and an increase in their arable area (Altdorff et al., 2018). Rice is vulnerable to heat stress in parts of South Asia but warming may boost wheat production in upland Pakistan.

Box 1. The human and financial cost of climate change

Severe flooding in 2007 along the Ganges and Brahmaputra rivers affected over 13 million people in Bangladesh, while flooding in Pakistan in 2010 severely affected 20 million people. India has likewise suffered numerous events of extreme rainfall, flooding and droughts. The economic cost of the 2007 floods in Bangladesh was over $1 billion; in Pakistan it was nearly $10 billion.

Source: IWMI (2011)

4 http://ec.europa.eu/environment/integration/research/newsalert/pdf/sea_level_rise_and_the%20_impact_of_salinity_on_soil_invertebrates_442na3_en.pdf

One emerging pattern seems to be a shift of the monsoon to later in the year combined with longer dry spells within the monsoon period. The result is later harvest of the wet season (*kharif*) crop. This has a knock-on impact on sowing the following dry season (*rabi*) crop – now, because the *kharif* harvest is late, farmers are unable to sow when soil moisture is favourable.

A large number of the poorest land users in South Asia are share-croppers. Historically, the crop was fairly evenly divided between landlord and tenant. Now, as productivity drops, landlords demand a fixed amount of the harvest rather than a share, with adverse impacts on food security.

Climate-related declines in food productivity will affect livelihoods and exports, increasing poverty levels. For instance, in Bangladesh, these factors will lead to a net increase in poverty of 15% by 2030 (CDKN, 2014). The urban poor could experience rises in food prices if demand exceeds supply, as happened in 2007–2008, with urban wage labourers particularly vulnerable (IPCC, 2014b).

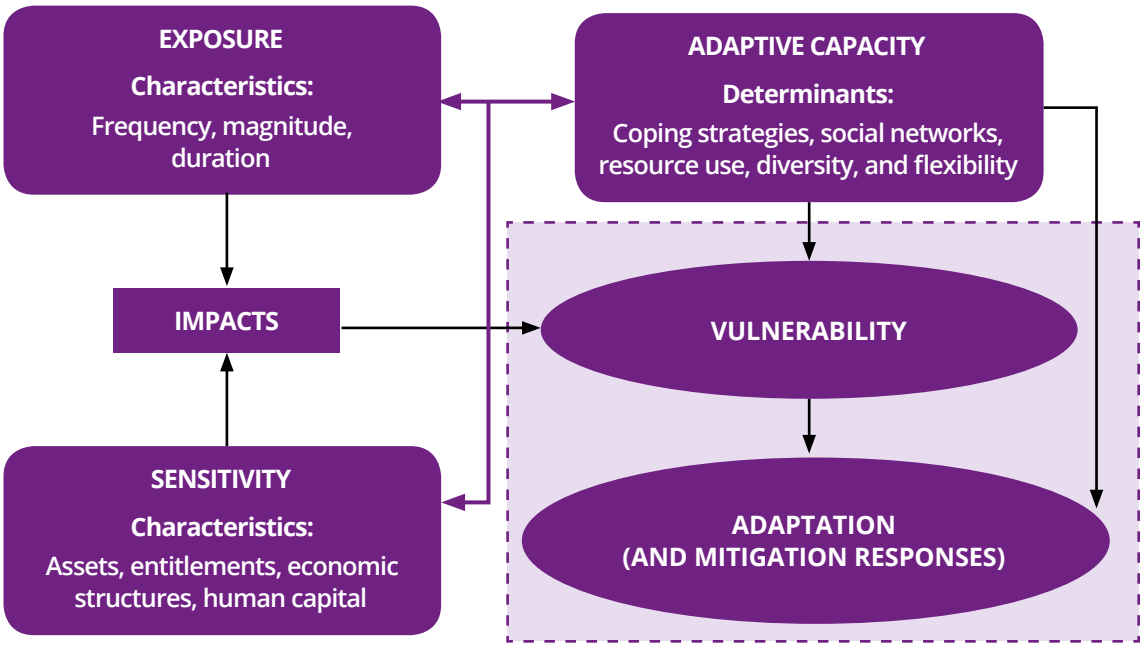
1.4 Addressing climate change

There are three interacting ways in which CC can be addressed: mitigation,[5] adaptation and resilience, as illustrated in Figure 1. ACT concentrates mostly on adaptation and resilience; this paper reflects this emphasis, albeit not ignoring mitigation. Adaptation and resilience both describe ways to improve the ability of households, communities and countries to cope with the impacts of CC. While adaptation engages with specific, anticipated risks to mitigate their impact; resilience deals with uncertainty, surprise and recovery from unexpected events.

Adaptation is the process of deliberate adjustment to actual or expected climate and its effects (IPCC, 2014). Adaptive change can be ***incremental*** (building on present practices and structures) or ***transformational*** (replacing present practices and structures with ones better adapted to the emerging circumstances), as illustrated in Table 1.

One criticism of adaptation measures is that they often fail to address persistent and intractable vulnerabilities, thus undermining their success and sustainability (Nelson et al., 2007). This has given rise to an interest in **resilience**, which can be defined as *'the capacity of a social-ecological system to cope with a hazardous event or disturbance, responding or reorganising in ways that maintain its essential function, identity, and structure, while also*

Figure 1. Vulnerability framework



Source: Gbetibouo and Ringler (2009)

5 Mitigation in agriculture refers to interventions that reduce the sources, or enhance the sinks, for GHG.

Table 1. Reducing vulnerability

Altering exposure	Reducing sensitivity	Increasing adaptive capacity
• Assess impacts and map hazards • Conduct land and water use planning • Protect watersheds and establish flood retention zones • Resettle exposed populations and restructure agriculture • Change cropping patterns	• Develop or adopt suitable crop and animal varieties • Improve irrigation and drainage systems • Enhance soil nutrition and water management • Diversify cropping • Adopt disaster prevention construction standards	• Develop adaptive strategies and action plans • Develop capacity to develop and implement plans that integrate across entry points • Diversify sources of income • Improve water and other infrastructure systems • Establish disaster and crop insurance schemes • Promote technical transfer and capacity-building

Note: Vulnerability refers to the degree to which a system is susceptible to, and unable to cope with, adverse effects of CC, including variability and extremes.

maintaining the capacity for adaptation, learning, and transformation' (IPCC, 2014b).

Resilience brings an understanding of how a system can be organised around multiple stable states, depending on the circumstances of the individuals involved (Nelson et al., 2007). For example, a rancher may prefer a system with a predominance of grasses that give better return per unit of labour, while a smallholder may prefer shrubs that give a better return per unit of land. Thresholds represent the boundaries around a system state, which, if crossed, represent the transition into another system state. Transformational change results from crossing ecological, social or policy thresholds – for example from tropical rainforest to ranching or biofuel production, or from farming to tourism. For decision-makers, a critical threshold is reached when CC renders current policy untenable and requires the formulation of alternative strategies.

This emphasises the wide variety of responses there may be to a change or event, even in the same community, made up of individuals and organisations with different agendas, assets and aspirations.

Even within a farming community, resilience cannot restrict itself to agricultural production; it must draw on the viability of the whole value chain for agricultural commodities *and* the multiple, non-farming coping mechanisms communities employ to ride out disasters or respond to change. It must exploit social networks (for shelter, cash loans, moral support, etc.) and commercial opportunities (paid labour, petty trading, sale of assets, etc.), as well as temporary or permanent migration.

The extent to which CC affects a community or household (their resilience and, conversely, their vulnerability (ADB, 2012b)) depends on their adaptive capacity, their sensitivity to particular aspects of CC and their exposure to the impacts (Lankao, 2005). These can be addressed through measures such as those shown in Table 1.

Resilience describes the ability of a system to accommodate CC. This capacity depends on the resources, information, relationships and assets the system can draw on to alter exposure, reduce sensitivity and increase adaptive capacity. These are unevenly distributed within a population, meaning individuals have different adaptive capacities, and some will need more support to cope than others.

2. Responding to the impacts of climate change on agriculture

The twin concepts of resilience and adaptation are incorporated in the umbrella CSA approach promoted by the Food and Agriculture Organization (FAO), the CGIAR Climate Change, Agriculture and Food Security (CCAFS) Research Program[6] and the World Bank.[7]

CSA is an approach to transforming and reorienting agricultural systems to support food security under the new realities of CC. It explicitly considers climatic risks and entails greater investment in managing these: this is what sets it apart from most other agricultural development approaches (Box 2).

Food security is at the heart of CSA and is described in four dimensions. Agricultural production determines both access to and ***availability*** of food supplies; agricultural markets and food chains affect food prices and ***access*** to food. Resilience in production systems and value chains is an essential determinant of ***stability***, and the nutritive quality, safety and waste associated with processing and food chains underlie ***utilisation***. CC can adversely affect all of these (Box 3).

Even in the absence of CC, the world faces major challenges in achieving success across all four dimensions of food security. CC magnifies and augments these (Wang, 2015).

CSA aspires to a triple-win: increased production; adaptation and resilience to CC; and the reduction of GHG emissions/sequestration of atmospheric carbon in soils and vegetation. There are some situations where this will be possible, such by as increasing soil organic matter, zero-grazing of goats and cattle and alternate wetting and drying for swamp rice.[8]

This paper focuses on **Climate-Resilient Agriculture**. CRA is a subset of CSA interventions with the specific aim of enhancing the resilience of agricultural systems and the social systems that depend on these. Looked at in another way, CRA is CSA excluding interventions to mitigate GHGs.

The paper presents entry points for CRA rooted in the agriculture value chain.[9] Importantly, CRA also considers off-farm options (e.g. livelihood

Box 2: The three pillars of Climate-Smart Agriculture

CSA integrates the three dimensions of sustainable development (economic, social and environmental) by jointly addressing food security and climate challenges. It is composed of three main pillars:

1. Sustainably increasing agricultural productivity, to support equitable increases in farm incomes, food security and development;
2. Adapting and building resilience of agricultural and food security systems to CC at multiple levels; and
3. Reducing GHG emissions from agriculture and increasing carbon sequestration.

Box 3. Climate change impacts on the four dimensions of food security

Availability of food may be reduced by a drop in production caused by extreme events, changes in the suitability/availability of arable land and water and unavailability/lack of access to suitable crops and livestock.

Access to food may be worsened by CC-intensified events that lead to damaged infrastructure and losses of livelihood assets and income.

Stability of food supply could be influenced by food price fluctuations and higher dependency on imports and food aid. High food prices affect access to nutrition by reducing purchasing power.

Utilisation of food can be affected indirectly by food safety hazards associated with pests and animal diseases.

Source: ADB (2012b)

6 https://ccafs.cgiar.org/climate-smart-agriculture-0#.V-ORTvWcHIU
7 http://www.worldbank.org/en/topic/climate-smart-agriculture
8 https://ccafs.cgiar.org/bigfacts
9 Starting from pre-production (e.g. access to land and input supply), going on to production (e.g. cultivation practices and soil and water management) then post-harvest (e.g. storage and marketing) and finally consumption (e.g. tweaking demand).

diversification) where these are viable, recognising that moving out of agriculture may, for some people in some circumstances, be the most rational adaptive response to changes in weather. This approach is not conceptually dissimilar to that of the well-known Making Markets Work for the Poor (M4P), which underlines the need for 'a holistic approach to development that offers the route needed to achieve systemic and sustainable change' to ensure agriculture systems benefit the poor and vulnerable (Darkoh et al., 2015). CRA adds a firm emphasis on dealing with the impacts of CC, which M4P lacks.

CSA and CRA have much in common with **sustainable agriculture**, which promotes farming in ways that do not deplete natural resource over the long term and is based on ecological principles.

Sustainable livelihoods is a holistic, household-centred approach that brings together the different assets (natural, physical, financial, social and human) available and the external influences acting on them. It is very relevant to vulnerability assessments (Box 4) and to understanding households' own livelihood strategies and how adaptation and resilience actions could improve these.

In **sustainable agricultural intensification**, 'yields are increased without adverse environmental impact and without the cultivation of more land' (Garnett and Godfray, 2012). There are strong parallels between sustainable intensification and climate adaptation. Both seek to improve ***efficiency*** in the use of natural resources.

None of these approaches is aimed exclusively at poor, vulnerable and socially marginalised groups, many of which are highly dependent on climate-sensitive resources (Sterrett, 2011) but have little control over them. Such groups need to be identified and given explicit attention in addressing the impacts of CC. The different rights, roles, responsibilities and representation of women and men must also be recognised and included (see Nelson and Huyer, 2016; World Bank et al., 2015).

Box 4. Vulnerability assessments

Vulnerability assessments are commonly distinguished as either top-down or bottom-up. Top-down approaches start with an analysis of CC and its impacts, whereas bottom-up approaches start with an analysis of the people affected. The former generally have a biophysical focus and the latter a social focus. The choice has important implications for the resources needed. Top-down approaches are usually preferred at global, national and regional levels, whereas bottom-up approaches start their analysis at the local level. There is no one-size-fits-all solution. Vulnerability cannot generally be assessed by taking a single, ready-made method. Rather, several methods should be combined uniquely for a given case.

Source: GIZ and GoI (nd)

Table 2. Comparison of approaches

	CRA	CSA	Sustainable agriculture	Sustainable livelihoods	Sustainable intensification
Main objectives	Food security and increased resilience along agriculture value chain	Food security, increased resilience and mitigation of GHG emissions	Maintaining natural resources for future generations	Holistic understanding of household strategies	Increased efficiency of resource use for improved production
Main focus	CC impacts	CC	Environment	Social well-being	Productivity
Geographic scale	Regional to local	Global to local	Global to local	Household/ community	Landscape to local
Incremental or transformative	Both	Both	Tends to be incremental	Both	Tends to be incremental
Main response covered	Adaptation and resilience	Mitigation, adaptation and resilience	Resilience	Vulnerability	Adaptation
When in vogue	Now	2000s till now	1970s–1990s but still relevant	1990s–2000s but still relevant	Now

3. Bringing CRA to life: Practical entry points

This section introduces a framework for addressing adaptation and resilience across the agriculture value chain and for mainstreaming CC into agricultural policies and practices.

The framework refers to national and local-level entry points. However, adaptation and resilience take place within an international enabling environment, which includes global and regional[10] agreements and commitments, international finance initiatives[11] and international research, analysis and technical support. There are also a number of major external influences, such as globalisation, financial and civil insecurity (Brock, 2012), transboundary issues such as river flows and plant quarantine, changing food consumption patterns, population increases, land fragmentation and natural resource degradation.

This framework is not simply an aid to thinking about CRA: it is useful for identifying practical ways to support and build climate resilience into any farming system and encourages thinking about adaptation that goes beyond on-farm technologies and generic policy prescriptions. Using the framework as a decision-making tool to support CRA requires an understanding of the specific vulnerabilities of a farming system: it does not replace a climate risk and vulnerability analysis as an initial step. However, it does provide a useful means of identifying interventions that will address risks at different points along the agriculture value chain. Section 5 categorises ACT's work on CRA across its programme locations to further illustrate the application and benefits of the approach

Before exploring the entry points for CRA, two points are important (see Bahadur et al., 2017). Engaging with political economy drivers and addressing factors that are part of the enabling environment are vital if the entry points discussed here are to prove effective.

First, all CRA interventions will be influenced by the political economy environment in which they are set. This includes the interests and incentives facing different groups, and how they exercise power and influence outcomes. Meanwhile, not just formal institutions but also informal social, political and cultural norms play a role. Multiple, often conflicting, values and ideas may affect how CC is tackled. For example, certain political parties favour market-based instruments for tackling CC, whereas others oppose them. Different cultural, religious and ethnic groups may have different beliefs about the process of, and responses to, CC. In addition, financial and civil insecurity; transboundary issues; population increases; consumption patterns; land fragmentation; and the state of natural resource degradation will all influence which entry points are selected as well how, when and by whom they are utilised.

Second, a range of enabling factors form the base for CRA interventions. These include the availability of relevant evidence on current and future climate risks and adaptation options as well as awareness and understanding of these across relevant stakeholder groups. They also include individual and institutional capacity to carry out CRA activities effectively. Crucially, availability of resources to undertake resilience-enhancing actions is another important factor in bringing CRA to life. Finance can come from existing domestic budgets of agriculture and allied sectors, or from additional exclusive streams of national and international climate finance.

Examples for each of the entry points from Table 6 are given in the paragraphs that follow. Section 1.4 (and Table 1) explained that making agriculture 'climate-resilient' is a function of reducing exposure (E) and sensitivity (S) to climate shocks and stressors and increasing the adaptive capacity (AC) of affected households and communities. Table 4 indicates which of these component(s) the entry points are targeting.

3.1 Policy and institutional entry points

Establish a favourable enabling environment for formulating and delivering CC policy for agriculture (targeting E, S and AC). This includes promoting an understanding of CC at all levels (partly by including CC in school, college and university curricula and within agricultural training institutes) and ensuring an evidence base for use in making policy decisions (Box 5). It also requires collaboration between relevant ministries (ADB, 2012b) and

10 E.g. the South Asian Association for Regional Cooperation Action Plan on Climate Change.

11 E.g. the UN Framework Convention on Climate Change Adaptation Fund has committed $354.9 million in 61 countries since 2010 to adaptation and resilience activities: http://unfccc.int/cooperation_and_support/financial_mechanism/adaptation_fund/items/3659.php

Table 3. Bringing CRA to life: practical entry points

Political economy environment and external influences: globalisation; financial and civil insecurity; transboundary issues; population increase; consumption patterns; land fragmentation; natural resource degradation; interests and incentives of different groups; the role of formal institutions and informal social, political and cultural norms; values and ideas circulating in a policy context

Enabling environment: CC policies and frameworks, awareness and understanding, evidence and research, institutional and individual capacity, finance

Entry point categories	Agriculture value chain phases and illustrative resilience-enhancing actions				Non-farming options
	Pre-production	Production	Post-harvest	Market	
Policy and institutions	• Establish favourable enabling environment for formulating and delivering CC policy for agriculture • Climate-proof existing agricultural policies and institutions • Design and deploy new policy instruments aimed at risk reduction for agricultural production through consultative processes • Establish new institutions and approaches to ensure resilience and adaptation options reach, and are adopted by, farming families • Review existing knowledge on CC risks to agriculture and fill knowledge gaps through research	• Develop climate-proofed food security strategies • Strengthen institutions providing services for agricultural adaptation and resilience	• Develop food storage and distribution capacities • Encourage farmers to move up value chain as part of risk-spreading	• Develop and deploy policy instruments to increase food access, quality and availability • Promote policies that encourage climate-resilient food choices	• Explore policy options for reducing dependence on agriculture and natural resources where these exacerbate CC risks, such as by increasing employment opportunities
Financial	• Analyse financial implications of CC for agricultural enterprises and national budget – such as rainfall changes leading to failure of tea plantations and consequent loss of tax revenues • Provide/enable financial services to farmers for CCA • Use financial instruments to encourage farmer behaviour resulting in greater resilience	• Provide safety nets to farmers against CC shocks and stressors • Review water pricing policy	• Develop financial instruments to reduce farmer risk at and after harvest	• Develop financial contingencies for emergency situations such as famine caused by harvest failure	• Establish off-farm and non-farm income-generating activities for risk-spreading

Information, knowledge management and social behaviour	• Provide information on CC causes, impacts, risks and options for building resilience • Monitor and learn from CC impacts on resilience of agriculture and natural resources • Encourage long-term continuity and consistency of support for CC resilience projects and programmes in agriculture • Enhance social networks, cohesion and gender equality for resilience	• Provide weather forecasting and information on adaptation options for farmers • Build on local knowledge and climate variability coping strategies	• Use media and extension methods to inform farmers of post-harvest value chain diversification opportunities	• Conduct demand monitoring and forecasting for farm products in response to CC • Reduce food wastage	• Advise farmers on how to reduce their exposure to CC risks through non-farm strategies
Technology and asset management	• Identify risks and protect agricultural assets from actual and anticipated climate hazards • Identify new approaches to agricultural and natural resource management that are resilient to CC	• Improve ecosystem health and buffering capacity • Develop and apply ways to use natural resources more efficiently • Devise and apply technical means to reduce CC risks to agricultural production through improved extension and other means	• Climate-proof agricultural post-harvest infrastructure • Adjust post-harvest technology to new climate realities	• Establish harvest failure contingency systems	• Establish contingency actions against extreme climate risks, such as resettlement or alternative employment

Box 5. Strengthening technical, policy and investment capacity for CSA

An FAO project in Zambia is building an evidence base on CSA practices, including incentives/barriers to adoption. This shows some farmers face difficulties adopting conservation agriculture (CA) practices. However, CA appears to be used as an adaptation response in areas of pronounced climate variability. The findings indicate entry points for agricultural policies to increase food security under CC.

The mapping of agricultural and CC policy instruments, stakeholders/institutions and policy formulation and implementation processes also aims to enable greater policy alignment and more coordinated institutional arrangements, and to facilitate policy dialogues between ministries of agriculture and of the environment.

The evidence base and policy work will be used in formulating investment proposals to support CSA implementation.

Source: www.fao.org/climatechange/epic/home

Box 6. No-regret strategies: promoting water-use efficiency as part of India's National Water Mission under the National Action Plan on Climate Change

Regardless of the direction of CC, policies for improving water-use efficiency in a region of increasing population and water demand will be beneficial. This can be achieved through improving water storage and infiltration, re-valuing water for irrigation, providing technical assistance and training to farmers on in-field ways to improve water use efficiency, encouraging equitable water distribution, reducing water conflicts, reducing water contamination and reducing water wastage.

Source: GoI (2009)

other stakeholders (Commonwealth of Australia, 2015)[12] and incorporating CC adaptation into environmental and agricultural planning processes (e.g. India has integrated CC resilience into its 12th five-year development plan (GoI, 2011)). In this context, ACT has been influencing policies and utilising institutional entry points to enable climate-resilient agricultural practices (explored in detail in Section 5.1).

Screen and climate-proof existing agricultural policies and institutions (targeting E, S and AC). This includes recognising climate risks, mainstreaming CC into agricultural policy formulation and implementation (OECD, 2009) and promoting low- or no-regret adaptation strategies[13] (Box 6).

Climate-proofing institutions includes assessing relevant institutions and their role, mandate and capacity (technical, physical and financial) with respect to agriculture and CC, and strengthening these where necessary (Box 7).

Design and deploy new policy instruments aimed at risk reduction for agricultural production through consultative processes (targeting E, S and AC). This includes funding and implementing the agricultural components of national CC strategies, National Adaptation Programmes of Action, Pilot Programmes for Climate Resilience and land tenure security policies that encourage long-term farm viability and investment in sustainable land management. Also, relevant here are policies to reduce the exposure of farming communities to climate-related risks and develop local policies (bylaws) that support resilience (e.g. reducing extensive grazing of cattle or burning of crop residues). An example of this is the establishment by the Department of Agriculture in Kerala, India, with the technical support of ACT, of a multi-sectoral cell to address the impacts of CC in the state (see Section 5.1).

Establish new institutions and approaches to ensure resilience and adaptation options reach and are adopted by farming families (targeting AC in particular). This includes establishing local Climate-Smart taskforces, establishing Climate-Smart clubs/villages (Box 8), adopting a CSA approach with elements of sustainable intensification and sustainable livelihoods and using farmer field schools to create a cadre of male and female farmers with an in-depth understanding of CC.

Review existing knowledge on CC risks to agriculture and fill knowledge gaps through research (targeting E, S and AC). This includes conducting research

12 The figure on page 24 of Commonwealth of Australia (2015) demonstrates the interconnectivity between sectors.

13 'No-regrets' actions are actions by households, communities and institutions that can be justified from economic, social and environmental perspectives whether natural hazard events or climate change take place or not (Heltberg et al., 2010).

Box 7. Hallmarks of institutions that are adapting to climate change

1. CC champions are clearly visible.
2. CCA objectives are clearly stated.
3. Flexible structures and processes are in place to assist institutional learning, upskilling of teams and mainstreaming of adaptation within codes of practice.
4. Progress in adapting is monitored and reported.
5. Comprehensive risk and vulnerability assessments are undertaken.
6. Guidance and training on adaptation are in place for operational staff.
7. Adaptation pathways are guided by the precautionary principle to deliver low-regret solutions.
8. Multi-partner networks are in place that are sharing information and resources.
9. Effective communication raises awareness of climate risks and opportunities, realises behavioural change and demonstrates adaptation in action.

Source: Wilby and Vaughan (2011)

Box 8. Climate-Smart villages in India

The CGIAR's CCAFS is promoting Climate-Smart Villages in India (Haryana and Bihar) and in Rupandehi in Nepal. These are sites where researchers, farmers' cooperatives, local government leaders, the private sector and key policy planners together identify CSA interventions appropriate to climate and agriculture challenges. The idea is to integrate CSA into village development plans and to enhance achievement of national food security and development goals. The measures work together to increase community resilience to climatic stresses while ensuring household food and livelihood security.

Source: CCAFS and CIMMYT (2014)

into adaptation options for the agricultural sector, incorporating CC into agricultural extension messages and options, conducting risk analysis (Danida, 2009), impact analysis and vulnerability assessments and identifying locations, social groups and enterprises that have low resilience to climate risks and building their resilience capacity accordingly.[14] To address this, ACT has been studying resilience of crops to CC across the chain to identify gaps and bottlenecks and providing recommendations to overcome them, across six of its locations (Section 5.1).

Develop climate-proofed food security strategies (targeting S in particular) that improve production and equitable distribution of food and develop policies to encourage the sustainable intensification of food production.[15] While food distribution and sustainable intensification will be needed even in the absence of CC, CC magnifies and accelerates this need. This means taking on the extra dimensions CC presents (accelerated rate of change, magnified risks and CC-imposed uncertainties).

Strengthen institutions providing services for agricultural adaptation and resilience (targeting S and AC), including disaster food relief systems and meteorology services, to improve information on which to make decisions,[16] and those providing farmer training on CC-related husbandry messages (Box 9).

Encourage farmers further into the value chain (targeting AC) as part of income diversification for risk-spreading and *develop and deploy policy instruments (targeting S)* to increase food access and availability, including the imposition of food price controls in extreme situations to stop profiteering in climate-induced crises.

Explore ways to reduce dependence on agriculture and exploitation of natural resources (targeting E), where these exacerbate CC risks, for example in environmentally fragile situations like steep, easily

14 Additional tools are useful in this context. **CRiSTAL** (Community-Based Risk Screening Tool – Adaptation and Livelihoods) was developed by the International Institute for Sustainable Development. It is aimed at helping project managers and planners understand the links between local livelihoods and climate; assess a project's impact on livelihood resources that are vital to adaptation; and devise adjustments that improve a project's impact on livelihood resources (www.iisd.org/cristaltool/). **CSDRM** (Climate-Smart Disaster Risk Management) was developed by Strengthening Climate Resilience, a consortium comprising Christian Aid, Plan International, and the Institute for Development Studies. CSDRM has been developed to gain a better collective understanding of how current efforts to manage disaster risk can be enhanced and scaled-up, in order to cope with the impacts of climate change through an integrated approach to disasters, development, and climate change (Mitchell and Ibrahim, 2010).

15 www.futureoffood.ox.ac.uk/sustainable-intensification

16 E.g. in Malawi Christian Aid's Enhancing Community Resilience Programme provides farmers with regular weather forecasts by text message (http://resilientlivelihoods.christianaid.org.uk/wp-content/uploads/2016/01/J4738-ECRP-Newsletter-v5-WEB3.pdf).

Box 9. Adaptation of husbandry methods to climate change

Examples of how crop and livestock farmers can adapt their husbandry methods to changing climate include:

- Changing to crop varieties and breeds that are adapted to the new climatic conditions
- Changing crop spacings and stocking rates to take account of the new conditions
- Changing planting times and depths according to the new seasonal patterns
- Planting in ways that reflect new rainfall patterns (e.g. on ridges or in basins)
- Using mixtures of varieties or crop species to reduce risk of failure
- Changing the use of inputs (fertiliser, water, pesticides, labour) to improve profit, production or food security according to the conditions and farmer imperatives.

eroded hillsides subject to increasingly heavy rains. Policies could be deployed to reduce pressure on the land, including education policies to improve vocational skills for non-farm employment (Onchan, 2004)[17] or the provision of more appropriate land for settlement.

3.2 Financial entry points

Analyse the financial implications of CC on agriculture (targeting E, S and AC) and set agricultural budgets accordingly. Provide credit to farmers for measures that increase their CC resilience, integrating this with existing agricultural finance channels (Box 10). Provide adequate finance for disaster preparedness to mitigate the impacts of climate-induced events such as inundation or destruction of coastal plantations by cyclones, and emergency relief funds for rebuilding agricultural livelihoods following extreme weather events.

Provide/enable appropriate CC financial services to farmers (targeting AC), including advice tailored to individual household needs and their ability to repay, establishment of savings and credit groups and financial assistance for transformative agricultural adaptation actions (e.g. transition from conventional to conservation agriculture or from extensive grazing to a zero-grazing system) (Box 11).

Use financial instruments to encourage farmer behaviour resulting in greater resilience[18] *(targeting S and AC)*, including tax breaks[19] and subsidies[20] to modify behaviour in favour of responsible and resilient activities and rewarding landowners for provision of eco-system services (Forest Trends and The Katoomba Group, 2008), as in Brazil, where the state allocates funds gathered from taxes on the sale of goods to municipalities to protect forested watersheds and rehabilitate degraded areas, and in Bolivia, where upstream landowners receive a beehive and training in honey production for every 10 ha of cloud rainforest conserved for a year.[21] The cloud forest improves water infiltration to reduce flooding and provide all-year stream flow.

Provide safety nets to farmers against CC shocks and stressors (targeting S and AC) such as crop/livestock insurance (Box 12), food relief, and seed and food reserves.

Review water pricing policy (targeting S) and electricity subsidy policy and reset at levels that encourage efficient, sustainable and equitable use of water (Molle and Berkoff, 2007). South Asia's water and

Box 10. Inclusive rural finance for climate change resilience

The International Fund for Agricultural Development (IFAD) provides rural finance support for CC resilience at the micro, meso and macro levels. It aims to promote a wide range of financial institutions, models and delivery channels; support demand-driven and innovative approaches; encourage market-based approaches; develop and support long-term strategies focusing on sustainability and poverty outreach; and participate in policy dialogues to provide an appropriate enabling environment. IFAD works with both government institutions and the private sector to scale up access to finance for all, and improve the quality of services, without distorting the market.

Source: Hamp (2015)

17 See also www.ilo.org/newdelhi/areasofwork/skills-and-employability/lang--en/index.htm

18 Note that resilience here can mean that of the public at large to CC impacts, not just that of individual farming families.

19 Local and state governments in Brazil, Costa Rica and the US give property tax breaks to landowners who manage (part of) their land for conservation (Ferraro and Simpson, 2002).

20 While subsidies can provide benefits, especially for the poor, they can also distort the market and be subject to quality, corruption and value-for-money concerns, as with the Public Distribution System in India. Subsidies can also inhibit adoption of adaptation initiatives by providing a safety net that distorts reality (Nawani, 1994).

21 http://www.naturaboliva.org

Box 11. Self-help groups in Bihar for diversification and enhanced incomes

The Indian government and the World Bank signed a $290 million credit agreement in July 2016 to help improve livelihood opportunities for poor rural households in Bihar. The Bihar Transformative Development Project, also known as Jeevika II, will mobilise rural population into self-help groups and help them gain access to markets, public services and a range of financial services. The project will scale up farm and non-farm value chain interventions, including setting up women-owned farmer producer companies. Having income streams that are not dependent on agricultural production that is vulnerable to climate risks reduces their sensitivity to climate variability.

Source: World Bank (2016)

Box 12. Livestock insurance in Mongolia

Harsh and unpredictable weather, exacerbated by CC, makes herders in Mongolia vulnerable to mass livestock losses. In 2010, 75,000 herders lost more than half their livestock. The Mongolian government's Index-Based Livestock Insurance (IBLI) Project, supported by the World Bank, developed innovative index-based mortality livestock insurance, now available in every Mongolian province. IBLI protects families from significant livestock loss by providing financial security, while also encouraging herders to adopt practices that build their resilience to extreme weather events. In 2012 alone, herders bought 16,000 insurance policies. The government is trying to form a comprehensive risk management strategy, which includes encouraging herders to adjust the number and types of their animals to meet pastureland's carrying capacity. Insurance is but one part of such an approach.

Source: CDKN (2013)

energy economies are tightly intertwined and, unfortunately, little is being done to understand the interrelationships and develop tools for effective co-management. If the two sectors continue to operate in silos, both are likely to suffer; truly holistic and integrated solutions are needed. One intervention suggested to break the nexus is to meter the power supply to agriculture to reduce the exploitation of groundwater. This can be combined with energy quotas for individuals to achieve sustainability in groundwater use along with efficiency (Kumar et al., 2011).

Develop financial instruments to reduce farmer risk at and after harvest (targeting S), such as warehouse receipt systems (WRS) that allow them to sell their crops at harvest at a good price,[22] government price controls in extreme situations or emergency relief schemes following harvest failure.

Establish off-farm and non-farm income-generating activities (targeting AC) for risk-spreading, such as wage employment, petty trading, sale of handicrafts, etc., and food-/cash-for-work schemes for the seasonally underemployed.

3.3 Information and social behaviour entry points

Conduct studies to provide information on CC causes, impacts, risks and options (targeting E, S and AC), including *ex-ante* studies and modelling of CC scenarios to inform resilience strategies and budgets and risk assessments using sensitivity and exposure surveys. Also, work towards increasing the predictive resolution of CC models to more local scales.

Encourage long-term continuity and consistency of support for CC resilience projects and programmes in agriculture (targeting E, S and AC) such as long-term planning at national level and community public service days and social safety net programmes to improve resilience at local level.

Enhance social networks, cohesion and gender equality for resilience (targeting S and AC) for solidarity, knowledge and materials exchange and temporary shelter during times of climate-induced crisis. Develop community cohesion and leadership, as these are key in times of stress and shocks, and work sensitively towards gender equality and cohesion within the household (see Box 13).

Develop information systems (targeting AC) that 1) provide weather forecasting and tailored information on adaptation options for farmers so they can make informed decisions, building on local knowledge and climate variability coping strategies

22 A WRS enables farmers to deposit storable goods in exchange for a receipt used as evidence that specified commodities of stated quantity and quality have been deposited. Usually, prices slump right after harvesting time. By deciding to sell the goods later, when prices have picked up, the depositor can avoid price risk (http://projects.nri.org/wrs/index.htm).

Box 13. Gender and climate change in Andhra Pradesh

Men and women are affected differently by CC impacts, and their responses also differ. Women are important food producers and providers but have limited access to and control of resources. Initiatives need to ensure they are included in adaptation and mitigation activities. FAO's work on gender and CC in Andhra Pradesh inspired collaboration between FAO and CCAFS to look at what kinds of institutional arrangements and action research approaches can help more equitable access to benefits. Training materials are being developed to cover three main research priorities: facilitating farmer exchange visits; facilitating daily and seasonal weather forecasts; and understanding and catalysing gender-sensitive CSA practices.

Source: www.fao.org/climatechange/micca/gender

Box 14. Transboundary risk assessment

The Transboundary Agro-ecosystem Management Project (Global Environment Facility/FAO) for the Kagera River Basin shared by Burundi, Rwanda, Uganda and Tanzania is helping restore degraded lands, sequester carbon, adapt to CC and use agricultural biodiversity in a sustainable way while improving agricultural production, rural livelihoods and food security.

Farmer field school activities promote farmer-to-farmer learning, while a land degradation and sustainable land management mapping process provides baseline information for use in analysing the type of land degradation occurring, devising the best strategy, policy-making, planning and budgetary allocations and establishing more integrated landscape management approaches.

Source: www.fao.org/nr/kagera

(Matthew and Moore, 2016) and using media (e.g. agricultural shows) and extension methods to inform farmers of post-harvest value chain diversification opportunities; and 2) provide future demand information for farming products in response to CC on which to base policy and research.

Increase the efficiency of food use (targeting S) and reduce food waste so less land has to be used for food production and more can be allocated for CC resilience-related environmental services (erosion control, shelter belts, biodiversity conservation, etc.)

Advise farmers how to reduce their exposure to CC risks (targeting E), through non-farm options such as exit strategies from agriculture to reduce pressure on land, and migration (seasonal or permanent) as a response to emergency. In this context, ACT has helped the Maharashtra government draft the 'CC impacts' section of a funding proposal for the Project on Climate-Resilient Agriculture (PoCRA), supported by the World Bank. One of the key focuses of this project is building farmer capacity to understand CC and to take requisite measures to adapt to it (Section 5.3).

3.4 Technical entry points

Identify risks and protect agricultural assets from actual and anticipated climate hazards (targeting E), through flood protection,[23] evacuation warning systems and participatory land use planning to avoid overexploitation of fragile environments such as mangrove swamps or those with other important environmental functions (Box 14). ACT has been creating a substantial body of work that aims to identify climate risk and channels through which it can be mitigated (Section 5.4).

Identify new approaches to agricultural and natural resource management that respond to CC (targeting AC), including transformative farming system change, land suitability classification and catchment/landscape approaches.

Improve ecosystem health and buffering capacity to reduce the impacts of CC (targeting AC) by means of soil cover, soil fertility, soil organic matter, biodiversity, soil and water conservation, pest and disease and pollution management and the management of climate buffer ecosystems (mangroves, wetlands and forests). Practice CA where appropriate.

Devise and apply ways to use natural resources more efficiently (targeting AC), including maximising land-sparing through intensification and mixed farming and land-sharing (that achieves environmental and social services along with agricultural provisioning). Also, integrate farm components (crops, trees,

23 E.g. improved flood defences for 1 million people in coastal Bangladesh, in which the aim is to empower rural community cooperatives to sustainably manage their defence, drainage and irrigation infrastructure (www.waterworld.com/articles/2013/03/flood-defences-to-be-improved-in-bangladesh.html).

Labourers rest during the potato harvest, Bamyan, Afghanistan.

animals) for greater efficiency; adopt wetting and drying practice for rice to save water and reduce GHG emissions; and increase water use efficiency (e.g. Pakistan and India (ADB, 2011)). ACT has also been supporting the Maharashtra government to promote 'efficient water management and agriculture technology adoption for climate adaptive and resilient farming systems' covering 51 villages, and provided recommendations to make one of its large watershed programmes (Jalayukt Shivar Abhiyan (JSA)) climate-resilient. One of the key tools developed is the Water Budgeting Tool, which that aims to achieve 'more crop per drop' (Section 5.4).

Devise technical means to reduce CC risks to agricultural production (targeting S), including the diversification of food and income sources (on-farm), and crop and animal husbandry practices that respond to changing weather patterns (Box 9 and 15).

Climate-proof agricultural post-harvest infrastructure (targeting E) and technology (targeting S) through establishing seed stores against crop failure, designing buildings and other value chain infrastructure to withstand predicted climate hazards, researching and promoting climate-appropriate storage technology and implementing post-harvest pest and disease control measures.

Develop emergency preparedness systems and procedures (targeting E), including drought early warning systems to mobilise food relief and the resettlement of communities if they are at extreme risk from climate-induced hazards.

Box 15. Flood tolerant rice varieties: scuba rice

New rice varieties tested in India and Bangladesh can survive up to two weeks of complete submergence in water, providing farmers with protection against short-term flooding. The flood-resistant SUB1 gene, when transferred into popular rice varieties, allows them to retain their characteristics. This research has led to the official release of flood-tolerant local rice varieties across Asia.

Source: IRRI (2011)

Table 4. Alignment of practical entry points for CRA with Exposure, Sensitivity and Adaptive Capacity

Practical entry points	E	S	AC
Policy and institutional			
Establish a favourable enabling environment for formulating and delivering CC policy for agriculture	■	■	■
Screen and climate-proof existing agricultural policies and institutions	■	■	■
Design and deploy new policy instruments aimed at risk reduction for agricultural production through consultative processes	■	■	■
Establish new institutions and approaches to ensure resilience and adaptation options reach and are adopted by farming families			■
Review existing knowledge on CC risks to agriculture and fill knowledge gaps through research	■	■	■
Develop climate-proofed food security strategies		■	
Strengthen institutions providing services for agricultural adaptation and resilience		■	■
Encourage farmers further into the value chain as part of income diversification for risk-spreading			■
Develop and deploy policy instruments to increase food access and availability		■	
Explore ways to reduce dependence on agriculture and exploitation of natural resources	■		
Financial			
Analyse the financial implications of CC on agriculture	■	■	■
Provide/enable appropriate CC financial services to farmers			■
Use financial instruments to encourage farmer behaviour resulting in greater resilience		■	■
Provide safety nets to farmers against CC shocks and stress		■	■
Review water pricing policy		■	
Develop financial instruments to reduce farmer risk at and after harvest		■	
Establish off-farm and non-farm income-generating activities			■
Information, knowledge management and social behaviour			
Conduct studies to provide information on CC causes, impacts, risks and options	■	■	■
Encourage long-term continuity and consistency of support for CC resilience projects and programmes in agriculture	■	■	■
Enhance social networks, cohesion and gender equality for resilience		■	■
Develop information systems			■
Increase the efficiency of food use		■	
Advise farmers how to reduce their exposure to CC risks	■		
Technology and asset management			
Identify risks and protect agricultural assets from actual and anticipated climate hazards	■		
Identify new approaches to agricultural and natural resource management that respond to CC			■
Improve ecosystem health and buffering capacity to reduce the impacts of CC			■
Devise and apply ways to use natural resources more efficiently			■
Devise technical means to reduce CC risks to agricultural production		■	
Climate-proof agricultural post-harvest infrastructure and technology	■	■	
Develop emergency preparedness systems and procedures	■		

Note: Purple= direct alignment with the criterion; grey = no direct alignment with the criterion

4. Critical challenges and knowledge gaps

This section sets out some of the broad challenges facing governments and organisations under four main headings.

4.1 Policy and institutions

Appropriate structures and processes are needed to enable the formulation of effective policies for climate resilience in agriculture. A multi-agency/sector approach is required, as is a strong evidence base from carefully commissioned research, providing criteria for prioritisation and data for geographic and social targeting (Box 16). Human capacity to implement and support policies effectively will need to be developed for all types of institutions (government, non-governmental and private) through relevant training courses and exposure to experience at all levels, as well as national and international partnerships (such as the Global Water Partnership workshop on CC impacts on water resources in South Asia (GWP and IWMI, 2011)).

Box 16. Multi-agency collaboration for CC planning

The Interagency Transportation, Land Use, and Climate Change Cape Cod Pilot Project in the US in 2010/11 was conceived by a federal interagency working group and jointly funded by the Federal Highway Administration, the National Park Service and the U.S. Fish and Wildlife Service. The pilot provided a transportation and land use development scenario for Cape Cod focused on reducing future GHG emissions and anticipating the potential impacts of sea level rise. This scenario was derived from a process of data collection, scenario development by a consultant and regional and local government representatives during a workshop and scenario assessment. The planning process informed and supported the region's long-range transportation planning and other related efforts, as well as those of other local, state and federal agencies.

Source: U.S. Department of Transportation (2013)

4.2 Finance

CC requires long-term continuity of purpose and funding to enable the development and application of new capacities and technologies and the refinement of methods and processes. Many development initiatives have a funding horizon of only three to five years. The challenge is to get development agencies and government to commit to 20-year programmes, like the Aga Khan Development Network's intervention in Afghanistan, which has been ongoing since 2002.[24]

The impacts of CC have to be dealt with alongside increasing populations, poverty and degrading natural resources, all of which compete for financial and other resources. Current agricultural investment flows are insufficient to adequately finance sustainable agricultural development – and most of this investment comes from farmers and livestock-keepers. National budgets will need to be reassessed, redistributed and supplemented by the capture of international funding for CC resilience, such as from the Adaptation Fund,[25] the Green Climate Fund (GCF) and other multilateral and bilateral sources.

4.3 Information and knowledge management

Adaptation and resilience are evolving concepts. A robust monitoring, evaluation and learning system with a set of consistent metrics (indicators) can show if programmes are meeting their aims and pinpoint where they need to improve (Ellis, 2014; Sadik and Rahman, 2009). This knowledge is also needed for prioritisation and targeting, and for application to international adaptation funding sources. The FAO CSA Sourcebook (FAO, 2013, pages 493–534) provides a good background for developing a Climate-Smart monitoring and evaluation system.

Climate prediction, especially of precipitation amounts and distribution, is not yet available at the local level, and local-level weather forecasting is still not accurate or reliable enough for farmers to base day-to-day decisions on. The situation should improve as more weather stations are set up and linked to computing power. In the meantime, the Institute for Social and Environmental Transition is combining knowledge from models with local

24 www.akdn.org/where-we-work/central-asia/afghanistan-0
25 www.adaptation-fund.org/

knowledge through Shared Learning Dialogues in Asian contexts to make the best possible decisions (Box 17).

4.4 Technology and asset management

The speed of CC can overtake the efforts of farmers to adapt, and oblige them to use unsustainable coping mechanisms, such as the short-term mining of soils, opening of forest land for cultivation, taking high interest loans and migration to urban areas. Research and extension need the resources to stay one step ahead of CC, introducing technologies that will enable farmers to adapt and governments to climate-proof livelihoods, landscapes, infrastructure and institutions.

Incremental change that reduces sensitivity and exposure may not be sufficient; radical change may be needed, such as land reform, changes in the farming system, the breeding of functionally different crop varieties, new land management techniques and the valuation of and payment for new classes of service from the land such as ecosystem services. Such transformational change has the potential to make a major difference, but also carries risks of maladaptation (Rickards and Howden, 2012). These risks can be reduced through good diagnosis of the problem in the first place, and sensitive monitoring from the start that allows for early modifications.

All four ACT countries have large areas with very variable agricultural environments, which will respond to CC in different ways. Mountainous areas, for example, will require tailored information and services, developed with farmers. Huge experience of participatory research within the region will assist this process.

While there is a recognised set of sustainable agriculture standards under the Sustainable Agriculture Network,[26] there are, as yet, no agreed standards for CSA against which to certify or reward farmers or farmer organisations. For example, it is widely agreed that soil organic matter is good for sequestering carbon (mitigation) and improving many soil properties that contribute to agricultural resilience (pH buffering, water retention, erosion resistance and stable crop yields). However, it has been difficult to reward farmers financially for husbandry methods that lead to improved soil carbon because there are as yet no appropriate methods for measuring or predicting soil carbon changes brought about by soil management. Further research is needed to provide a set of standards and a fair inducement system to incentivise farmers to meet the challenges of CC.

Box 17. The Shared Learning Dialogue: building stakeholder capacity and engagement for resilience action

Shared learning is an approach to participatory planning and problem-solving in complex situations, characterised by non-extractive, mutual learning among participants. The concept is straightforward: fostering iterative deliberation and sharing of sector- or group-specific knowledge and knowledge from both local practitioners and external experts will improve the quality and effectiveness of decision-making. Shared learning processes, when iteratively and carefully enacted, can also help break down established disciplinary and psychological divides and assist decision-makers to identify possible interventions, target potential constraints and set priorities.

Source: ISET (2010)

26 https://www.sustainableagriculture.eco/sustainable-agriculture-framework/

5. ACT and Climate-Resilient Agriculture

We now review the portfolio of initiatives undertaken by the ACT programme that fall under the thematic umbrella of CRA.

ACT has been active in South Asia since 2014. It focuses on CCA through integrating CC resilience into sectoral planning, policies and budgeting. The programme has a particular focus on initiatives that can build the climate resilience of the poor and vulnerable. Agriculture is a central component of ACT's work: the programme has now built up considerable experience on both policies and practices that can help build the climate resilience of farmers and farming systems.

ACT's workstreams in all locations were selected on the basis of a set of criteria developed at the start of the programme (Table 5). Governments (state and national) are ACT's key partners, and its key focus is to support initiatives where government's development priorities and CCA coincide. All ACT's workstreams are based on requests from either state or national governments. Agriculture emerged frequently during the process of identifying the work programme.

In Table 6, which is based on the matrix in Table 3, initiatives that ACT is supporting are placed into the appropriate cell. The following sections then discuss each row in the matrix in turn and provide an overview of the activities ACT is supporting. Many of the initiatives cover several of the topics represented in the matrix, and hence are shown in multiple cells and appear in several places in the sections below.

It is important to note that not all the ACT activities are as developed as each other; some are complex whereas some are more straightforward; some are complete, many are ongoing and several are very new and in the early stages of implementation.

This matrix indicates clearly how ACT's workstreams cluster in the first column ('pre-production/enabling environment'). This indicates the level of effort going into policy formulation/influence, scoping topics and seeking to understand both technical and institutional issues before working on the other areas of the agriculture value chain.

In addition, ACT's work is clustered in the two lower rows of the matrix ('information, knowledge management and social behaviour'; and 'technology and asset management'). This reflects the programme's focus on policy and institutions and the demand from our partners for information

Table 5. ACT's selection criteria for workstreams

- **CC relevance**: in particular, adapting to CC impacts
- **Real-world vulnerability**: important to livelihoods in the state, particularly for the poorest, most vulnerable
- **Effective demand** for the support, such as political commitment and/or a direct request from government
- **Related to institutional change**, including improved policies, systems, processes and capacity
- **Supports an existing programme/initiative** (probably, but not necessarily, government-led)
- Support that is solely **technical assistance can add value**
- **Supports a project/process that is already operational/approved**, with identified adequate finance
- Will result in a **clearly defined benefit**, using the overall resource allocation (days of expertise) available from the programme
- **Potential for scale-up, replication and learning** both within and beyond the location
- **Contributes to programme's outputs**, by contributing to one or more of these:
  - *Generating new tools for decision-making*
  - *Improving delivery mechanisms for services*
  - *Improving skills and systems (for policy/planning/implementation*
  - *Helping attract more finance (government, private or donor)*
- **Not a contested initiative** and no controversy associated with it

Table 6. **Entry points for ACT's CRA initiatives**

Value chain phases						
	Entry points	**Pre-production**	**Production**	**Post-harvest**	**Market**	**Non-farming options**
5.1 Policies and institutional entry points						
Afghanistan	Climate-proofing the National Natural Resource Management Policy	■				
Chhattisgarh, India	Capacity-building of the Agriculture Department for action on CC and resilience	■				
Maharashtra, India	Climate-proofing JSA	■	■			■
Pakistan	Water demand and agricultural vulnerability assessment	■				
Kerala, India	Multi-sectoral CC cell to address CC impacts	■				
Nepal	National Action Plan formulation	■				
5.2 Financial						
Afghanistan	Economic impact of climate change on agriculture	■				
Nepal	Climate change financing framework for agriculture	■				
Maharashtra, India	Agriculture cost-benefit analysis, Maharashtra	■				
5.3 Information, knowledge management and social behaviour						
Nepal	National CC impact survey	■				
Bihar, India	Automatic weather stations		■			
Chhattisgarh, India	CSA scoping	■	■	■		
Odisha, India	Agriculture and irrigation	■	■			
Maharashtra, India	Support to PoCRA	■	■			
Assam, Bihar, Maharashtra and Odisha, India; Pakistan; Bangladesh	VCA of climate-resilient crops	■	■	■	■	
5.4 Technology and asset management						
Bihar, India	Siltation study	■				
Maharashtra, India	Forestry Tool, Water Budgeting Manual	■	■			
Chhattisgarh, Maharashtra, India	Forestry Policy Review	■	■			
Odisha	India adapting agriculture to CC: training manual + installation of Ground Water Recharge System (GCF proposal)	■	■			
Chhattisgarh, India	CSA scoping and training	■	■	■		

Note: Purple = activity covers particular phase of agricultural value chain; grey = activity does not cover particular phase of agricultural value chain

and knowledge products; as well as frequent requests for practical responses to CCA that lead the programme into the technology and asset management entry points.

Some workstreams, such as analysis of the value chains of climate-resilient crops, spread across several areas in the matrix. This is not surprising as the matrix itself is based around the agriculture value chain, and also because these value chain analysis (VCA) initiatives cover multiple adaptation topics. In addition, a number of the project proposals that the ACT teams have helped partners develop also cover topics in more than one of the cells of the matrix, and this simply reflects the multiple levels and topics individual proposals address.

5.1 Policies and institutional entry points

Under 'pre-production/enabling environment' is a wide range of activities that look at developing a more enabling environment for CRA.

In Afghanistan, ACT supported the development of a climate-proof Natural Resource Management Policy. As agriculture is entirely dependent on natural resources, this policy is central to ensuring CRA practice in the country. A crucial component of this work entailed estimating the cost of CC for agricultural productivity. Both the government and donors are using the new strategy as the basis for designing and prioritising CC and environmental programmes. The Government has provided USD 124 Million for implementing this strategy, and ACT is now developing an Operational Manual that will permit subnational staff to execute this strategy.

In Chhattisgarh, ACT is assisting the government to review its approach to agriculture, which does not yet include prioritised responses to likely CC impacts on production. Recognising the importance of local contexts and capacities in this regard, ACT is supporting the state's Agriculture Department to build capacity to develop resilient responses suited to local conditions. ACT is collaborating with state-level institutions that are already engaged on agriculture and CC to identify capacity gaps and design suitable training.

The Maharashtra government's JSA aims to make the state drought-free by 2019. The project involves deepening and widening streams, constructing cement and earthen stop dams,

Winnowing wheat, Afghanistan.

working on channels and digging farm ponds.[27] ACT is helping examine the plans and processes for this initiative, based on the latest climate data, to ensure measures prescribed for dealing with water scarcity in Maharashtra are in line with expected changes or, at the very least, not maladaptive. ACT has identified opportunities to promote more climate-resilient agricultural production practices and provided guidance on water budgeting and a roadmap for stakeholder engagement to enhance water conservation and water use efficiency in agriculture.

In Pakistan, ACT's focus on key policy issues such as future water demand and agricultural vulnerability is providing the Punjab government with the analytical basis for institutional and policy reforms, as well as implementation initiatives, that will promote climate resilience.

For example, estimates of water demand under a variety of climate scenarios by different sectors within Pakistan up to 2050 suggest agriculture's demand for water will increase substantially while supply will reduce as a result of CC. This provides a unique long-range perspective for agriculture policy planners in the country to use in shifting practice to accommodate CC impacts.

ACT in Pakistan has also reviewed a number of existing programmes of the Punjab Department of Agriculture and identified their sensitivity and vulnerability to CC as well as pathways to enhance their resilience. This will feed into a broader programme of work to instutionalise the climate risk-screeening of all the state's agricultural programmes. Work is currently underway on how best to support diversification patterns that increase the cultivation of climate-resilient crops and varieties.

In Kerala, the Department of Agriculture is one of several agencies covered by ACT's support to the establishment of a multi-sectoral CC cell to address the impacts of CC. This cell now represents the core institutional mechanism to strengthen individual government departments' responses to CC impacts, as well as an institutional mechanism with government to strengthen multi-sectoral responses where required.

In Maharashtra, ACT facilitated dialogue between the government and several large private sector companies on focusing their corporate social responsibility on issues that will support CCA. Several companies agreed adaptation-focused initiatives in rural areas with a focus on watershed management in partnership with the government. These have significant positive impacts on agricultural practices and ensure the continued availability of water for agricultural production.

VCA of climate-resilient crops is being undertaken in Assam, Bihar, Maharashtra and Odisha in India, Punjab in Pakistan and Bangladesh. This includes analysis of relevant institutional and policy issues, as well as more practical interventions at the various stages of the agriculture value chain.

The objective of this work is to provide insights into how best to promote the adoption of climate-resilient crops and varieties. Crop diversification is recognised as key to tackling the vulnerabilities associated with shifts in weather and climate patterns. Yet diversification is not necessarily as simple as just cultivating a different variety or crop. VCA looks at the various stages of agricultural production, starting from access to land and inputs, moving through cultivation, harvest and storage to look at opportunities for post-harvest value addition and then on to final marketing. It also examines institutions and the impacts of policy, infrastructure and information flows.

Conventionally, government agricultural policies and agriculture department activities tend to focus on what happens on-farm, supporting improvements in productivity or the production of crops regarded as important to national food security. Often, policies and practices do not yet factor in likely CC impacts. Even when it is recognised that new thinking is required, it is difficult to know where to start and, unless the value chain of any individual crop is examined as a whole, opportunities and constraints to building resilience into agricultural systems can often be overlooked. VCA seeks to address many of these constraints to identify opportunities for adapting agricultural production systems and increase their resilience to the impacts of CC.

In each of the six locations where ACT is currently undertaking VCA, the initial 'climate-resilient' crops studied have been identified using a range of environmental and economic criteria, with final selection taking place in collaboration with the state agriculture department. The initial focus is on a small selection of crops in each state, refined around different agro-ecological zones. The intention is to demonstrate the usefulness of VCA as a guide to adjust agricultural policy and implementation in a climate-sensitive manner, as well as providing initial insights into opportunities to

27 http://mrsac.maharashtra.gov.in/jalyukt/

Charcoal at the roadside waiting for transport to urban centres. Malawi.

build greater climate resilience into the value chains of some of the most important local crops.

All these are important initiatives that are helping establish a viable enabling policy environment that promotes the development of more climate-resilient agricultural systems. The VCA work will also, as recommendations emerge, have impacts on other aspects of climate resilience.

5.2 Financial entry points

ACT is undertaking a considerable body of work on finance. This includes looking at budget processes and assisting governments to access international and domestic funds for CCA. Under this pillar, ACT has a set of initiatives that explicitly cover CRA.

In Maharashtra, ACT has completed a cost-benefit analysis of the 'priority' climate-resilient agricultural options proposed in the state adaptation plan. These include promoting organic farming and market access for organic produce; improving access to climate services, weather advisories and risk management strategies; promoting diversified cropping patterns and crop management; guidance to farmers on horticulture management; and expanding cold storage infrastructure and encouraging farmers to use accredited warehouses through credit-linked interest subsidies.

Maharashtra's State Action Plan on Climate Change provides little detail on implementing these priority actions so, for analytical purposes, ACT mapped each action with the ongoing government programmes/schemes, which were then evaluated for their potential costs and benefits. The analysis included both direct and indirect benefits, including environmental and social benefits. This work also identified indicators for monitoring and evaluation of each action during implementation. For the most part, activities were shown to have benefits that outweighed costs (e.g. cold storage at self-help

group level requires very large investment, which the government would have to pay for but could pay back in two or three years). In some cases, the benefits that can be realised depend on the crop focus (e.g. for organic cotton benefits outweigh cost, but it is not clear that the same level of benefits would accrue to conversion to organic vegetable production. This is because it is difficult to provide accurate estimation of some of the less tangible costs and benefits, such as actual market demand and level of enforcement of organic certification requirements).

Also in Maharashtra, ACT undertook an evaluation of around 20 Farmer Producer Companies (FPCs) – key players in the agriculture value chain – in four districts and provided a set of recommendations to improve their knowledge and capacity to access appropriate finance and technology and integrate climate resilience and gender and social inclusion in their business plans and practices (Box 18).

As a part of the VCA in Odisha, ACT will share recommendations to further examine financial instruments that may reduce weather-related risks for farmers. This workstream is in progress.

In Kerala, as a part of its provision of technical support to government to access climate funds for adaptation, ACT assisted the Fisheries Department in applying for the National Adaptation Fund for Climate Change to revive the highly bio-diverse and vulnerable coastal wetlands. The proposal submitted has been accepted, and a fund of $3.7 million allocated to introduce an integrated

Box 18. Building the capacity of Farmer Producer Companies in Maharashtra

FPCs are important institutional organs that enhance profitability along value chains by means of forward and backward integration for small farmers. They aim to support farmers in cultivating suitable crops and to provide access to modern technology through community-based processes. FPCs also build the capacity of farmers and value chain actors to access forward linkages in technology for enhanced productivity, value addition of feasible products and market tie-ups.

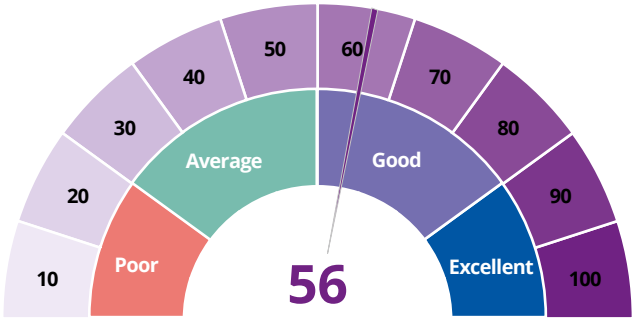
Maharashtra promotes a substantial number of FPCs under various programmes, which have been able to share best agricultural practices (seed production, input marketing) and promote value addition (primary processing facilities) and fetch a better price for farmers through collective bargaining. However, as policy practitioners have noted, a large majority of these FPCs fail to grow robustly after the initial push.

In this context, based on its evaluation of 20 FPCs, ACT provided recommendations for strengthening their capacity, and engaged with existing financial institutions to understand the barriers related to financing of FPCs. This culminated in the development of a comprehensive rating tool for FPC benchmarking.

The ACT FPC Rating Tool is designed to be an FPC-centred, gender and capacity needs-focused and data-driven assessment that can be readily put into practice. It will allow financing institutions to systematically evaluate the factors that facilitate or restrict FPCs' business operations and trade readiness. The tool will provide a broad overview of an FPC's capacity assessment, through scoring across eight parameters – establishment, governance, management, infrastructure, finance, business, capacity-building and climate resilience – with gender and social inclusion factored in, wherever applicable.

The tool was validated through rating 21 FPCs that were shortlisted for the field survey; it performed with consistency in the results.

Figure 2. Diagrammatic representation of FPC scoring based on the assessment criteria



SCORING CRITERIA

1. Establishment:	Core foundation strengths
2. Governance:	Control systems in place
3. Management:	Decision making processes
4. Infrastructure:	Assets and resources
5. Finance:	Financial base and health
6. Business:	Core business strength
7. Capacity:	Resource quality
8. Climate Resilience:	Adaptability to climate risk

intervention to address issues of CC, food security and livelihoods (Box 19).

5.3 Information, knowledge management and social behaviour entry points

ACT has numerous initiatives in this area, both underway and completed, ranging from the production of short policy briefs on specific agricultural topics to much larger analytical pieces such as the climate vulnerability analysis of agricultural extension and the water demand study in Pakistan. Often, knowledge products are developed to summarise part of, and add value to, other more complex initiatives.

For example, the wide-ranging and ongoing work on agriculture and CC in Odisha, which covers strengthening irrigation resources, capacity and training needs assessments and VCA of relevant crops from a climate resilience angle, has provided the opportunity to develop policy briefs. One has been prepared on a methodology for assessing training needs specific to CCA for both government and farmers. ACT is currently collaborating with the state's agricultural training centre to use this methodology to identify new training modules for both agricultural department staff and farmers.

Another policy brief covers the importance of integrated approaches, informed by agriculture VCA, to develop initiatives that will build climate resilience into agricultural production systems.

Similarly, ACT is working closely with key agriculture training and extension institutes in Bihar to develop modules on CRA and VCA that can be embedded in their existing training programme.

In Maharashtra, ACT supported the state government to draft the CC impacts section of a large funding proposal for PoCRA. The project is supported by the World Bank and aims to strengthen and promote the uptake of CRA in 4,000 villages across the state, with a particular emphasis on water management; farm mechanisation; improved crop varieties (especially those tolerant of drought and/or flood); diversifying cropping patterns; improving soil health; and building the capacity of farmers to adapt to changing weather conditions. ACT is working in partnership with leading development actors to ensure cutting-edge knowledge on CC is taken into account from the formative stages of an intervention aimed at ensuring the viability of agricultural practice in the face of CC. ACT has recently been asked to strengthen the state's FPCs to support production and uptake of climate-resilient crops.

Box 19: Promoting an integrated farming system in the coastal wetlands of Kerala

Traditional agriculture and fisheries in the intertidal coastal wetlands of Kerala have supported the livelihoods of local communities for centuries. However, these complex and sensitive ecosystems are extremely vulnerable to climate-induced variations. Of late, monoculture farming systems have seen considerable declines in yields and profits as a result of damaged peripheral bunds, frequent high tides and saline intrusion, which have led to land degradation and shifts from agriculture to non-agricultural practices.

ACT supported the Kerala Fisheries Department to access the National Adaptation Fund for Climate Change to revive these wetlands as a part of building resilience to CC in coastal areas. The proposal, for an innovative approach of integrating traditional and ecosystem-based solutions to address climate challenges, food security and livelihoods in the region has been accepted and a fund of $3.7 million allocated.

The project will address the increasing impacts of CC on 600 ha of Kaipad and Pokkali farming systems in the coastal wetlands of northern and central Kerala by reviving and restoring wetland farming. This includes strengthening earthen bunds by planting mangroves, installing traditional wood-based sluice gates and water pumps and integrating shrimp cultivation with growing a salt-tolerant rice variety. Sediment deposits from shrimp culture will reduce usage of chemical fertilisers, the natural filtration system of rice will help minimise risks of disease outbreak for shrimps and the post-harvest residue will serve as feed for shrimps.

This is expected to provide 1,21,680 people days employment, generate 1,500 tonnes of paddy and 450 tonnes of shrimps per year and create a revenue of over $3 million per year. Once revived, these wetlands will also act as a carbon sink, thereby helping mitigate CC.

ACT had earlier identified climate-resilient crops in Maharashtra and subsequently completed VCA studies for five of these; three of these are also PoCRA priority crops.

In Chhattisgarh, state-level sectoral planning has integrated very little thinking on how to strengthen the climate resilience of agriculture. Nevertheless, there is a considerable body of knowledge on climate impacts and possible responses in academic circles, and many adaptation examples in farm practices and farmers' understanding. Examples are farmers adjusting planting dates to take account of shifts in the timing of the monsoon and, at local level, adjusting cropping patterns in response to shifts in rainfall distribution. ACT has undertaken a scoping study that aims to bring this diverse knowledge together in a format that can assist the agriculture department to make more informed planning decisions that are sensitive to weather and climate impacts. The study findings are also feeding into a revision of agricultural training materials.

The provision of background information that feeds into large sectoral plans at both national and state level is an important part of ACT's work. In Nepal, ACT is supporting the government to structure a consultative and multi-sectoral process for formulation of the National Adaptation Plan (NAP) – which will be the nodal policy guiding Nepal's response to CC impacts. This entails the consolidation of seven sectoral Thematic Working Groups that are working to develop sectoral adaptation priorities that will be enshrined within the NAP. ACT worked with the Ministry of Agricultural Development to explore the likely impacts of CC on agricultural practice and to consultatively determine the pathways of ensuring the improved resilience of the sector.

At the 'production' stage, ACT is providing a range of knowledge and information support to partners. An example is the analytical work undertaken as part of the study to climate-proof Maharashtra's JSA programme, which will examine opportunities of promoting more climate-resilient agricultural production practices.

In addition, various elements of support for CRA feature in proposals to India's NAF that ACT has helped both Maharashtra and Odisha's state governments draft. For example, in Odisha, the project aims to reduce vulnerability and enhance resilience for traditional livelihoods in drought-prone Nuapada district by restoring a hill stream through constructing water harvesting structures to conserve water through the management of run-off. The project aims to achieve multi-sectoral improvements in water conservation, promoting horticulture, linking fishery activities to farming and encouraging more efficient use of water for agriculture.

In Bihar, ACT is supporting the government to develop a practical plan for managing data from an expanded network of automatic weather stations, which will provide far more detail of weather patterns at local level. This in turn will help develop local-level agricultural plans that take account of changes in weather patterns.

ACT's work on the VCA of climate-resilient crops in Assam, Bihar, Maharashtra and Odisha is expected to provide recommendations that cover all sections of the agriculture value chain, including opportunities to add value through post-harvest diversification. Similarly, it is examining issues around access to markets and market information to better understand constraints to, and opportunities for, marketing selected climate-resilient crops.

5.4 Technology and asset management entry points

ACT is a technical assistance programme and does not have finance to implement operational CRA projects at farm level. However, it has deliberately linked to other government- and donor-funded programmes that do have this reach. In this way, ACT has been able to provide useful support to identify practical ways to orientate existing programmes to be more climate-sensitive.

ACT is building a substantial body of work that seeks to identify climate risk and ways for farmers to mitigate the likely adverse impacts of changing weather and climate patterns by promoting improved approaches to agriculture and natural resource management. Examples include the VCAs in Assam, Bihar, Maharashtra and Odisha, the CSA scoping in Chhattisgarh, the JSA climate-proofing in Maharashtra and an assessment of CC impacts on agriculture in Odisha. Other examples of risk identification and asset protection include ACT's support for developing a web-based tool and mobile app that can be used for planning climate-sensitive forestry in Maharashtra. This tool will indicate which tree species are suited to specific agro-ecological areas, taking CC-induced risk and opportunities into account. It will aid government and non-government stakeholders in making evidence-based, climate-sensitive planning decisions for forestry/plantation programmes. All these examples are currently work in progress. As the programme progresses, ACT will be positioned to provide informed recommendations on locally specific adaptation options.

Vegetable seller, Kabul.

The six VCAs, the JSA climate-proofing and the Chhattisgarh and Odisha agriculture assessments all contribute to both the 'production and 'post-harvest' stages here. The forestry tool and the private sector pilots in Maharashtra are further examples of work contributing to on-farm technology and asset management at the 'production' stage in the matrix.

ACT supported the Maharashtra government to develop a project to promote 'efficient water management and agriculture technology adoption for climate adaptive and resilient farming systems', covering 51 villages of two districts. India's NAF now funds this project.

In Maharashtra, ACT along with the Watershed Trust Organisation (WOTR), Pune, prepared a Manual on Water Budgeting at the Village Level. This manual is targeted at rural agrarian communities in Maharashtra and is meant to be applied in the context of JSA, the ongoing large-scale water conservation programme in the State. This robust manual, written for facilitators and government functionaries, has an inbuilt provision for three scenarios of rainfall, ready and handy supporting statements for necessary calculations, and due consideration of reduction in storages/ contents. Once prepared for a village, basic rainfall data can be used for other villages in the vicinity. The main objective of this tool is to address the demand side of water management to ensure that drinking water and livelihoods needs are equitably and sustainably met.

ACT supported the government of Odisha to develop a proposal that has been approved by the GCF. The proposal integrates several aspects of CRA and sustainable groundwater management, and also looks into low-carbon agriculture practices. Groundwater is vulnerable, either directly or indirectly, to the impacts of CC. Rising global temperatures may result in greater heat stress for people and ecosystems, induce droughts and affect food security. Poor run-off management puts further stress on and increases the vulnerability of farming communities, and in particular poor

and marginal households. To respond to these challenges, the project's primary objective is to enhance groundwater recharge in community ponds and use solar pumps for irrigation to ensure water security and food security in vulnerable areas of the state. Results expected are 1) improved health and well-being of about 5.2 million vulnerable communities through improving water quality; 2) improved food security and enhanced farm incomes by around $7.5 million through increasing access to irrigation and establishing grey water reuse schemes in 10,000 tanks; and 3) reducing emissions by 3.27 million kWh/year and avoiding CO_2 emission of 2,614 tonnes/year by using solar irrigation pumps in 1,000 demonstration ponds as part of a low-emission, climate-resilient crop planning strategy.

6. Conclusion

Reviewing the state of global practice within the domain of CRA and the initiatives undertaken by the ACT programme provides a set of cross-cutting lessons.

First, CRA is not business as usual. Section 2 explored different paradigms of agricultural practice and underlined how CRA is specially aimed at enhancing the resilience of agriculture systems and the people who depend on these. More specifically, Section 3 argued that activities being framed as CRA must demonstrate the manner in which they are reducing vulnerability to CC by addressing exposure and/or sensitivity to climate shocks and stressors and/or increasing the adaptive capacity of target households, communities and state- and national-level organisations. Interventions that are blind to the adverse impacts on agriculture of the new shocks and stresses that CC is bringing will at best be ineffective and at worst prove maladaptive.

Second, woven through the global examples of CRA interventions and ACT's work in this domain is a clear acknowledgement of the importance of engaging multiple stakeholders in any process to make agricultural practice more resilient to the impacts of CC. Almost all of ACT's work involves multiple government departments (environment, agriculture, water, forestry) and actors (private sector, government, civil society, universities, farmers) to adequately support the confluence of varied streams of knowledge (technical, financial, institutional, behavioural) to deliver solutions that engage systemically with the impacts of a changing climate on agriculture. For instance, ACT's work on climate-resilient watershed management to ensure continued availability of water for agricultural production in Maharashtra brought together some of the largest corporations in the province with government departments charged with watershed development, as well as academic/technical experts with an understanding of specific interventions needed to ensure the resilience of watersheds for agricultural production.

Third, closely aligned with the preceding point, is an understanding of how far CRA is from being a purely technical issue. Enhancing the resilience of agricultural practice is shot through with politics and issues of power that need to be navigated carefully. Most interventions in this domain aim at the improved management of natural resources (water, soil, vegetation), which can be very contentious in an over-populated and resource-scarce environment such as South Asia. Section 3 and 4 showed that, in certain contexts, controlling the overuse of certain resources (e.g. groundwater) through changing energy subsidy regimes can be critical to enhancing climate resilience. Such processes are likely to disrupt existing interests and carry the potential for political backlash. All of ACT's initiatives commence with detailed context assessments and in-depth political economy analyses, to map the potential for such political pitfalls. The programme also maintains iterative feedback loops in programme management

Sale of Sal (*Shorea robusta*) leaves as plates by scheduled castes, India.

processes and financial systems to ensure such issues are tackled as they emerge.

Fourth, integrating initiatives with government priorities is essential for sustainable and institutionalised CRA. Governments continue to own the physical systems and organisational mandates for influencing agricultural practice and, in South Asian countries, agricultural policy is governed by complex configurations of provincial and national governments. To be sustainable, therefore, CRA must be operationalised in way that integrates with government systems. This is why this paper has implicitly argued for the need to mainstream CRA into governments' existing priorities, approaches and initiatives. ACT's work on climate-proofing the Maharashtra government's JSA programme and on the Natural Resource Management Strategy of the Ministry of Agriculture and Livestock in Afghanistan is a good example of prioritising processes that help government initiatives/policies take on board a clearer understanding of CC.

Finally, after reviewing the global state of play and reflecting on ACT's work across four vulnerable countries in South Asia, it is clear that there is an is urgent need to scale up CRA across the region. Sixteen of the seventeen warmest years ever have occurred since 2001 (NASA, 2017). It is predicted that South Asia will face increased warming, increased extreme temperatures (including heat waves), increased incidences of extreme precipitation and sea level rises as result of CC (CDKN, 2014). Agriculture is highly sensitive to the variability of weather systems and water regimes that CC will induce, which will have consequent serious adverse impacts on the livelihoods and welfare of the majority of people in South Asia. This in turn carries the potential for social unrest, economic downturn and political upheaval. Therefore, this paper intends to serve as a call to action to policy-makers, civil society, the private sector, universities, banks and other stakeholders to begin implementing actions to make agricultural practice more resilient. The framework and examples discussed in Section 3 demonstrate that a wide spectrum of organisations and individuals, engaged in diverse sectors at different levels of governance, can start making a positive contribution right away.

Operationalising these insights will ensure that marginalised populations in some of the world's most vulnerable areas are able not just to function and survive but rather to flourish and thrive, despite the impacts of CC.

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