



Report

Understanding patterns of climate resilient economic development

Rwanda

Helen Parker

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Overseas Development Institute

203 Blackfriars Road
London SE1 8NJ

Tel. +44 (0) 20 7922 0300
Fax. +44 (0) 20 7922 0399
E-mail: info@odi.org.uk

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The author takes full responsibility for all errors or omissions.

Key Messages

- An agriculture focused development paradigm can reduce poverty, improve food security and support high levels of economic growth
- However, agriculture is highly exposed to climate risks, and so climate hazards can have significant negative impacts on agricultural economies
- Public investment in land management and irrigation can reduce short and medium term sensitivity to floods and droughts
- Education, sub-sector diversification and commercialisation complemented by disaster risk reduction fosters medium term adaptive capacity
- In the medium to longer term, agricultural growth can catalyse an economic shift, to support secondary and tertiary sectors, livelihood diversification, reduced gender and income inequality, and improved climate resilience

Abbreviations

DFID	UK Department for International Development
DP	Development Partner
DRC	Democratic Republic of Congo
DRRM	Disaster Risks Reduction and Management
EAC	East African Community
EIU	Economist Intelligence Unit
EDPRS	Economic Development and Poverty Reduction Strategy
EWS	Early Warning System
FAO	Food and Agriculture Organisation of the United Nations
FEWS-NET	Famine Early Warning systems Network
GCAP	Global Climate Adaptation Partnership
GCM	General Circulation Model
GHI	Global Hunger Index
HDI	Human Development Index
IGC	International Growth Centre
IPCC	Intergovernmental Panel on Climate Change
IWRM	Integrated Water Resource Management
MDGs	Millennium Development Goals
METEO	Rwanda Meteorological Agency
MIDIMAR	Ministry of Disaster Management and Refugee Affairs
MINAGRI	Ministry of Agriculture and Animal Resources
MINALOC	Ministry of Local Government
MINECOFIN	Ministry of Finance and Economic Planning
MININFRA	Ministry of Infrastructure
MINIRENA	Ministry of Natural Resources
NAEB	National Agricultural Exports Board
NAPA	National Adaptation Programme of Action
ND-GAIN	Notre Dame Global Adaptation Index
NGO	Non-Governmental Organisation
NISR	National Institute of Statistics Rwanda
PSTA	Strategic Plan for the Transformation of Agriculture
RAB	Rwanda Agricultural Board
REMA	Rwanda Environment Management Authority
RPF	Rwandan Patriotic Front
SEI	Stockholm Environment Institute
UN	United Nations
UNDP	United National Development Programme
UNFCC	United Nations Framework Convention on Climate Change
UNHCR	United National High Commission for Refugees
USAID	United States Agency for International Development
WFP	World Food Programme

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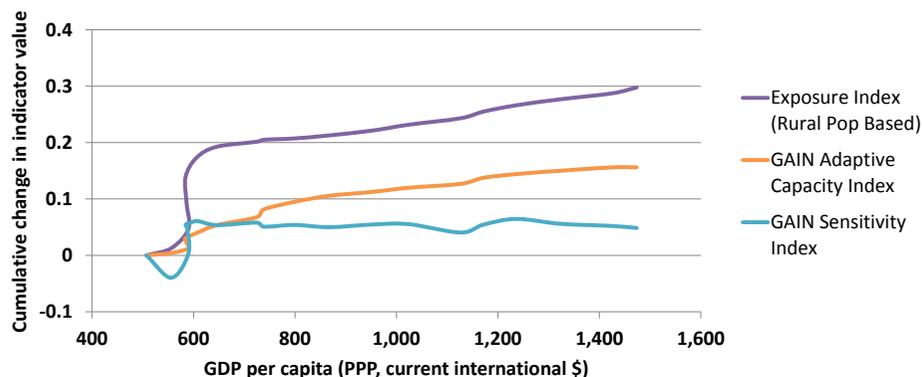
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Executive summary

The Rwandan government's agriculture-led development agenda reduced the sensitivity of the sector and built adaptive capacity among its workforce but did little to diversify the economy and thus, the risks it faces. Moderate increases in exposure to flood risk from capital investments were outweighed by reductions in sensitivity from productivity gains, soil conservation and irrigation. Economic development contributed to adaptive capacity through poverty reduction and improvements in education and training. This was complemented with risk management policies such as agricultural insurance and disaster planning. However, due to the high economic dependence on agriculture, Rwanda remains vulnerable to climatic



As Rwanda's GDP per capita has grown beyond \$600, an **exposure** index, based on an approximation of people living in areas at high risk of drought, has also steadily increased. **Sensitivity** and **adaptive capacity**, as measured by the relevant components of the ND-GAIN vulnerability index, have stayed broadly constant and continued to rise with economic development respectively.

The case study addresses the question: 'What are the linkages between agricultural transformation, poverty reduction, and resilience to climate variability in Rwanda?' over the 2000-2015 period. It drew from desk-based research and fieldwork including the review of technical reports, policy and legal documents, national and international databases and interviews.

The direction and relative scale of the impacts presented in the scorecard below are subjective judgements based on quantitative data wherever possible. Due to the availability of credible and accurate data, approximations are used for each indicator which may vary by geographical focus or time period and others may draw from qualitative research. A full discussion of analytical constraints is given in the synthesis presentation.

Change in resilience due to change in indicator

EXPOSURE

The presence of people and assets in places that could be adversely affected by climate change.



There was little overall change in the population in areas at a relatively high risk of drought, which are mostly rural, as high rates of urbanisation were offset by strong rural population growth. While not attributable to economic development, average rainfall decreased over the period increasing the likelihood of droughts. Those who have migrated from the semi-arid East will be exposed to new risks of floods and landslides in urban centres. A pilot resettlement programme was established to tackle flood risk but remains small-scale. Significant investments in both soil conservation and irrigation infrastructure were concentrated in the South and were also exposed to landslide and flood risk as a result.

SENSITIVITY

The degree to which a system is affected by or responsive to a climate stimuli.



Public efforts to transform the agricultural sector led to substantial productivity gains and output growth, doubling calorie production per person. This strengthened food security and reduced sensitivity by providing a buffer to climatic impacts. However, this has made Rwanda's export base more reliant on agriculture despite a recent decline in the revenue share of food due to falling food prices relative to minerals. Significant improvements in the Human Development Index reflected broad improvements in standards of living reducing the health impacts of a climatic disaster. Disaster risk reduction and management (DRRM) activities included terracing, irrigation, mitigation of soil erosion, increased fertiliser use and the introduction of more climate-resilient seed varieties.

ADAPTIVE CAPACITY

The potential or capability of a system to adapt to, or alter to better suit, climatic stimuli or their effects or impacts.



Rising incomes and moderate decreases in inequality, as measured by the share of income earned by the poorest quartile, contributed to a reduction in poverty and an increase in adaptive capacity. Measures of political stability improved over the period suggesting an increased ability to design and implement co-ordinated (climate) policies. An increase in the tertiary enrolment rate, an indicator of educational development, also signalled improved adaptive capacity in addition to the creation of training programmes for farmers on climate resilience. This was complemented by efforts to institutionalise DRRM through establishing food stores, early warning systems, support programmes for climate-smart agriculture as well as assigning responsibility for climate risks among government Ministries.



Are impacts different for the poorest?

The poorest have seen some of the largest improvements in climate resilience in Rwanda due to the high proportion that depend on the agricultural sector either for employment or subsistence. In addition to poverty reduction, progress has been made in terms of health, education and gender equality, **helping to improve both sensitivity and adaptive capacity.**

Although poverty rates are high at 45 per cent, the average consumption growth rate from 2000-2011 was significantly higher for the poorest: 4.8 per cent for the poorest 10 per cent of the population, 4.0 per cent for the second poorest and 3.6 per cent for the richest. This is partly due to the integration of social welfare policies with agricultural interventions that target marginalised groups – the poorest, landless and women – and provide sources of income, assets and skills. These factors **provide women and the poorest with the tools needed to build their resilience and adapt to climate variability.**

However, more women than men work in subsistence agriculture and **they are diversifying into alternative livelihoods at a slower rate, indicating that women are still more climate-sensitive than men.** Evidence suggests that societal norms are preventing targeted agricultural programmes from generating significant benefits for women.



Are impacts locked in?

Irrigation and terracing infrastructure may cause physical lock-in as they have high fixed capital costs and long lifetimes. **While worsening exposure to floods and landslides, if maintained and managed effectively, these investments could reduce the sensitivity of the agricultural sector.** However, mismanagement can result in soil loss and nutrient leaching of terraced land and irrigation infrastructure can displace other uses for scarce water resources.

Policies prioritise crops that are in demand in the region but are also more sensitive to climate variability than traditional crops. As the market is characterised by a high degree of risk aversion for untested seeds, a lack of choice among crop varieties and poor certification, **this may lead to economic and political lock-in of increased sensitivity for the lifetime of the policy.** A more efficient market supported by publicly available research and innovation may help correct this issue.

Economic lock-in of increased sensitivity may also occur through ongoing dependence on agriculture compounded by a concentration of public sector investment. However, the government is taking notable steps to reform the business environment and encourage growth of alternative sectors such as mining and tourism.



What are the policy implications?

If the most vulnerable groups in society disproportionately work in a specific sector, supporting that sector is an effective method to build their climate resilience. Rwanda is an example of where economic and climate policy incentives align. Increased productivity in and commercialisation of the agricultural sector supported broad-based economic growth and poverty reduction. Technology and process improvements directly reduced the sensitivity of workers' (often women and the poorest) livelihoods and indirectly improved their adaptive capacity through rising incomes. In this way, standard economic development policy has helped to build climate resilience.

However, this case study also shows there are trade-offs between policies that promote economic development and those that aim to increase climate resilience. For example, the more support offered to a specific sector, the more likely the economy will become dependent on that sector. This can create economic and political lock-in if that sector is particularly sensitive to climatic impacts. Sector support policies that are time limited, have an exit strategy and exist within a wider, cross-sectoral and integrated programme are less likely to cause lock-in. Economic policy must encourage diversification of economic activity across sectors for both market and climate shocks.

1. Introduction

Project background

The physical effects of climate change will have direct and indirect impacts on economic and social structures and natural systems, and these impacts will have high costs (IPCC, 2001; IPCC, 2014; Stern, 2006). Although the manifestation of climate change will vary across regions, at the global level the Intergovernmental Panel on Climate Change (IPCC) projects an increase in temperatures, melting ice sheets and rising sea levels, and changing climatic variability potentially leading to more extreme events such as flooding and drought (IPCC, 2014; Field et al., 2012). Many of these trends are already occurring, with attributed impacts on the fundamental components of human development, including livelihoods, health and food production (*ibid*; Sachs, 2014; Fischer et al., 2005).

Within this context, it is important to consider how to build resilience, at both the macro, national level and the micro, household and individual level, to reduce or avoid the economic and societal costs of climate change. This will allow decision makers within government and bi- and multi-lateral donor agencies to identify what development trajectories can support climate resilient growth and poverty reduction. As such, this research aims to understand how patterns of economic development affect vulnerability and exposure to climate impacts across sectors and populations, including distributional effects. This project is embedded within a broader agenda exploring the nature of climate resilient growth in lower-income countries, in order to mitigate risks and avoid 'locking-in' vulnerability to hazards.

This report presents a case study from Rwanda that explores the relationships between economic development and climate change. Commissioned by the Climate and Environment Department of the UK Department for International Development (DFID), it is one component of the research project 'Understanding Patterns of Climate Resilient Economic Development', to improve understanding of how climate change will affect economic development, and in turn, how economic development shapes resilience to climate extremes and changes. This phase of the research presents four in-depth case studies to analyse how economic development has influenced vulnerability and exposure to climate impacts and the distribution of this vulnerability across different groups. It will make practical recommendations as to how policymakers in developing countries can influence patterns of economic development to avoid or reduce the costs of climate impacts.

Context of the study

Rwanda is a developing economy in central Africa which has experienced positive trends in terms of GDP growth rates, poverty reduction and political stability since 2000 (World Bank, 2013). This development progress is particularly impressive given the devastation of the 1994 civil war and genocide and Rwanda's context of 'post-conflict' recovery. However, macro-economic growth has not generated economic diversification, and a significant proportion of national growth, trade, employment and household income is dependent on the agricultural sector, which is exposed to climate and other risks (World Bank, 2015). Rwanda's current climate is subject to high levels of variability within and across years, and this may increase with climate change, leading to a rise in climate hazards which could affect economic growth and investment in poverty reduction (GCAP, 2014).

Conceptual framework

This case study was developed around a conceptual framework which aims to capture how patterns of sectoral and geographic development affect resilience, while also considering distributional effects, in particular the impact on the poor and marginal groups (Tarazona et al., 2014). Resilience is conceived within the IPCC-recognised framework of exposure and vulnerability to climate-related hazards, i.e. the presence of people or assets at risk to climate variation, and the degree to which a system is susceptible to or unable to cope with adverse climate impacts (IPCC, 2001; IPCC, 2014). Vulnerability can be disaggregated as a function of sensitivity, the degree to which a system is affected by positive or negative climate shocks, and adaptive capacity, which measures a system's potential to adjust to climate changes, to moderate damage, capture opportunities and cope with consequences (ibid). These different aspects are integrated into the framework in Figure 1.

Figure 1: Conceptual framework for climate resilient patterns of economic development

	Vulnerability		
	Exposure	Sensitivity	Adaptive capacity
Sectoral			
Geographic			
Distributional			

Source: Vivid Economics and ODI, 2014, developed from Tarazona et al., 2014

Methodology

The methodology for this study included both desk-based and field research, from January to July 2015. Initially, the author collected and reviewed socio-economic reports and data about Rwanda and generated a list of research questions and data needs based on the conceptual framework. The second phase of the research involved meetings and interviews with stakeholders in Kigali, Rwanda, over a two week period in March 2015. More than twenty individuals from thirteen different organisations responded to interview questions, and provided relevant data, policies and other critical documents. Although the research was based in Kigali, many interviewees work extensively in rural areas, as agricultural programme officers and advisors. A list of the background papers, organisations consulted during fieldwork and information about databases and other sources of information is included in the references chapter at the end of the report.

Rational for selection of case study

Rwanda represents an interesting and important case study for the theme of resilience in developing economies. First, in many ways Rwanda is an example of 'good development', where effective governance, prudent macro-economic policies, targeted public spending, infrastructure investment and substantial aid inflows have supported robust growth and significant poverty reduction, primarily driven by transformation of the agricultural sector (World Bank, 2013; 2015). However, poverty rates are still high, measured at 45% in 2011, and the economy is vulnerable to external and internal shocks, registering a 4 percentage point year-on-year decline in GDP in 2013 as a result of external aid suspensions and poor agricultural outputs after failed rains (although the relative distribution of effects is not clear, see NISR, 2012; World Bank, 2013). This illustrates how the national economy is sensitive to both market and climate risks, with implications for national planning and public spending and key service provision at the local level.

Rwanda also faces many challenges which create barriers to growth and poverty reduction in emerging economies, including: the economy relies on primary commodities and extractive industries, underdeveloped markets and value addition, limited sectoral diversification and private sector growth, credit constraints and high interest, under-developed key infrastructure, over dependence on foreign aid, budget and trade deficits driving high debt, regional instability which threatens domestic security, low Human Development Index (HDI), young and/or unskilled population growing rapidly and unplanned urbanisation. In addition, Rwanda is a small, landlocked country, which drives up operational costs and reduces regional comparative advantage. Climate change, particularly increased variability and extreme events, represents an emerging threat with the potential to amplify existing pressures and risks in the economy, such as reliance on rain-fed agriculture, and to create new challenges, such as water resource competition between agriculture and increasing demand across other sectors (World Bank, 2015). As such, Rwanda is now at a critical point, when strategic decisions will have lasting implications for future economic development in the context of a changing climate.

Structure of the report

The remainder of this study will analyse how Rwanda's success story, of aid and agricultural led growth and poverty reduction, has affected resilience to climate variability. The report is structured according to four main chapters. Chapter 1 provides an overview of historic sectoral and geographic patterns of development in Rwanda. Chapter 2 assesses the impact of these patterns on resilience, in relation to the framework of exposure, sensitivity and adaptive capacity. Chapter 3 discusses distributional impacts of Rwanda's development pathway, key policy drivers and lock-in. The conclusion provides a final summary and recommendations for policy and practice to drive climate resilient development.

2. Overview

Context

Rwanda is a low-income country with a population of 11.2 million, of which 80% live in rural areas and are primarily engaged in subsistence agriculture (NISR, 2015). The population growth rate from 2002 to 2012 was 2.6%, and Rwanda is the most densely populated country in Sub-Saharan Africa (NISR, 2012). Rwanda has experienced a strong recovery since the 1994 civil war and genocide. Driven by an ambitious government agenda and substantial donor support, Rwanda has made significant progress in realising the Millennium Development Goals (MDGs) (UNDP, 2012). Poverty rates declined from 59% in 2001 to 45% in 2011, however, Rwanda still has a low HDI, ranked at 151 out of 187 countries in 2014, with GDP per capita of USD 718 (UNDP, 2014; NISR, 2014). Robust growth rates constituted the critical foundation for higher incomes and improved welfare. The economy grew at an average of 8.5% from 2000 to 2014, driven by effective use of donor financing and high public expenditure (World Bank, 2015). The underlying reasons for Rwanda's success are varied, but commentators recognise the role of the majority political party, the Rwandan Patriotic Front, (RPF) and President Kagame, who was instrumental in ending the civil war (Bergamaschi et al., 2014). Since his succession in 2000, and consecutive landslide election victories in 2003 and 2010, President Kagame has steered an effective autocratic state with zero tolerance for corruption and a strategic determination to achieve development results (EIU, 2014).

Rwanda's development progress has created a 'Rwanda rising' narrative and attracted the attention of bi- and multi-lateral development partners (DPs) and influential global figures, who leverage significant funds (Crisafulli and Redmond, 2014). For these actors, Rwanda represents a global paradigm of post-conflict reconciliation and a model for market oriented, pro-poor economic growth. Donor investment combined with accountable governance and policy implementation has created a virtuous cycle of development and aid flows. Coordinated under the 2006 National Aid Policy, Rwanda received USD 1 billion of official development assistance (ODA) in 2012, constituting 40% of GDP, of which 70% was untied, and USD 391 million disbursed directly through the government as general and sector budget support, up from USD 200 million in 2005 (MINECOFIN, 2014). Donor programmes are designed to realise the national government's overarching strategic goals related to economic transformation and poverty reduction, outlined in Vision 2020 and the second Economic Development and Poverty Reduction Strategy (EDPRS II). DP priority sectors include health and education, but also agriculture and trade, in an effort to facilitate broader structural change.

Notably, Rwanda's high growth rate has not yet generated economic diversification. Investment is dominated by a large, aid-dependent public sector, non-tradables, stimulated by donor financing (health, education, retail and construction contributed 73% of growth from 2006-2013) and a few private actors (World Bank, 2014). Growth since 2000 has been led by expansion of the service sector, supported by the aid economy, followed by agriculture, with minor contributions from industry (construction) and manufacturing. Although export volumes are increasing, there is also limited diversification of export commodities, which are dominated by coffee, tea and minerals. This illustrates that to better understand how Rwanda has sustained both growth and poverty reduction, it is necessary to look at sub-sector

developments, particularly agriculture. The agricultural sector is the primary source of employment, the main driver of income growth and the dominant sector for revenue generation domestically, regionally and in international markets.

However, Rwanda's agricultural sector is also exposed to high levels of existing climate variability (intra- and inter-annual), natural hazards (storms, flooding and drought) and future climate change (see IPCC, 2014). The Stockholm Environment Institute (2009) found that Rwanda was not adequately adapted to existing climate risks, and that climate change could cause additional net economic losses of at least 1% GDP annually by 2030. Risk analysts Maplecroft (2013) categorise Rwanda at high risk in terms of climate change vulnerability, due to limited capacity to respond to disasters, high poverty rates and reliance on rain-fed subsistence agriculture. As such, agricultural policy envisions a shift towards a private-sector dominated, commercialised sector which supports GDP growth, exports and off-farm jobs. Macro-economic and fiscal policy is focused on stimulating private investment, value addition and diversification at both sector and sub-sector level. In the long run, the 2011 Green Growth and Climate Resilience Strategy envisions a low carbon development trajectory supported by strong services. This would allow Rwanda to become a regional knowledge centre and to develop a diversified, robust and flexible economy which can respond and adapt to climate change.

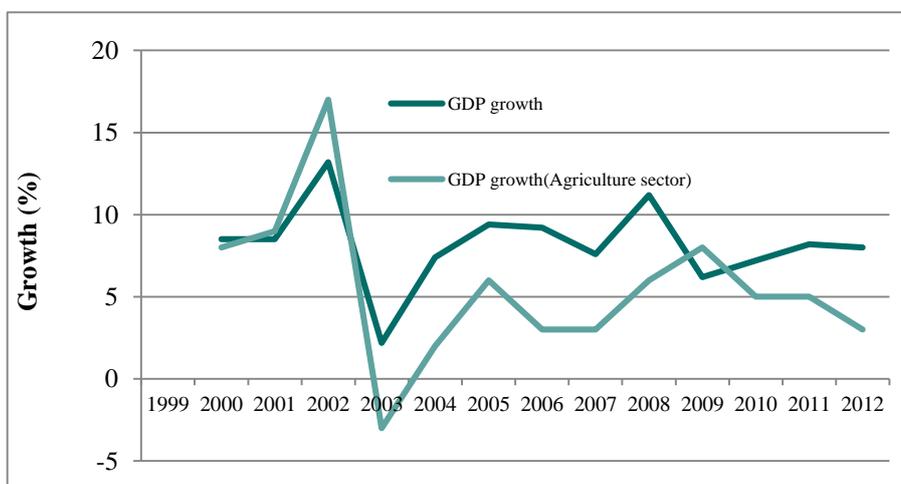
Therefore, this case study aims to explore how Rwanda's development trajectory from 2000-2015, of agricultural led growth and poverty reduction, has affected climate resilience. The following key trends will form the basis of the analysis:

1. Sectoral patterns of agricultural growth, value addition, increased production and productivity, and improved food security
2. Geographic patterns of investment in agricultural infrastructure
3. Geographic patterns of poverty reduction

Historic sectoral patterns – agricultural growth

Rwanda's growth has not yet facilitated the process of economic transformation to create an industrialised, diversified economy. Agriculture and the service sector dominate contributions to GDP growth, and manufacturing and industry are under-developed. Figure 2 shows how GDP growth rates since 2000 remain coupled to agricultural growth.

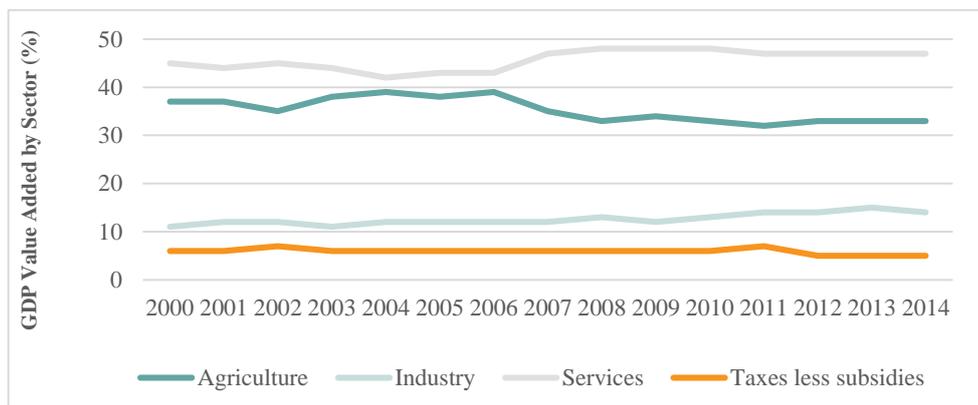
Figure 2: GDP and agricultural growth from 2000 to 2012



Source: NISR, 2013

The proportion at which different sectors have driven national growth since 2000 has remained relatively constant, although in 2006-2007 there is a minor decrease in the contribution of agriculture, and an increase in the importance of services (NISR, 2015, and figure 3). This was partly due to the first Programme for the Strategic Transformation of Agriculture (PSTA I, 2005) creating new off-farm jobs to provide ancillary services to the expanding sector. The key role of agriculture and services in the Rwandan economy means there is limited use of intermediate inputs and therefore few opportunities for value addition across supply chains. Rwanda's intermediate input ratio was measured at 40% in 2011, with huge variation across sectors: 70% in industry contrasts with only 6% in agriculture (World Bank, 2015). This represents how industry requires more complex products and services, but it also demonstrates the lack of development within agricultural markets.

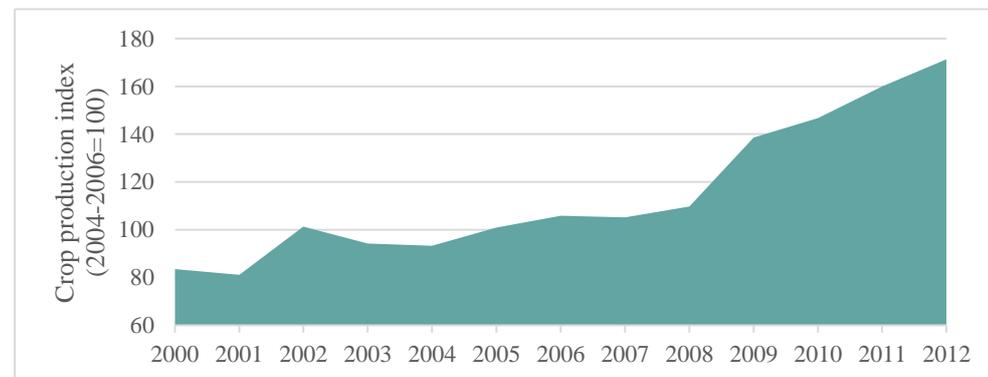
Figure 3: Proportion of GDP value added by sector



Source: NISR, 2015

The lack of macro-economic diversification highlights the role of sub-sector transformations in driving Rwanda's broader development agenda. Agricultural production and productivity have increased substantially. Production figures for key staple food crops almost doubled between 2000 and 2012, with most gains realised post-2007 under PSTA I (World Bank, 2015). The policy 'push factor' of investment in the sector meant that agricultural GDP grew at an average of 5.4% between 2008 and 2013, supported by year-on-year increases in food crop revenues of 6% (ibid). Figure 4 shows increased production for all crops (excluding fodder) from 2000 to 2012 relative to the base index. The rate of increase accelerates at the start of PSTA I. To complement production gains, there was a drive to decrease post-harvest losses, from 25% to 12% from 2008 to 2012 (MINAGRI, 2014). The result was increased output for domestic consumption, and surplus to sell at market, i.e. a pattern of increased production and shift towards commercialisation.

Figure 4: Increase in crop production index from 2000 to 2012

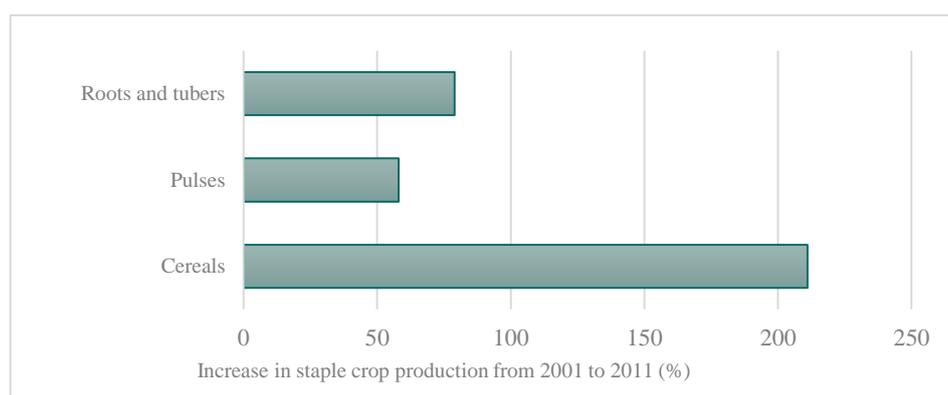


Source: MINAGRI, 2013

Under PSTA I, the primary policy instrument to improve agricultural productivity and reduce losses was the government led Crop Intensification Programme (CIP) focused on high potential food crops. CIP had two objectives: to ensure national food security and to support growth and development of the agricultural sector. Land consolidation was the first step, bringing farmers with contiguous plots together to grow the same crop and create economies of scale, facilitating the shift from subsistence to commercialisation (MINAGRI, 2014).

Consolidated land was subject to extensive investment in terracing and soil conservation, which provided incomes and work for the poorest households while also protecting cultivated areas from Rwanda's natural hazards and variable climate. Farmers were organised into cooperatives to jointly manage production and marketing of newly created surpluses, and the government provided targeted packages of inputs (improved seeds and fertiliser) and extension training. As a result of CIP, staple crop productivity increased significantly, as production rose without a significant expansion in cultivated land areas (figure 5). The share of production marketed also increased from 21.5% in 2005/6 to 26.9% in 2011, which is a relatively modest figure, but represents a clear trend towards market utilisation. With further development and integration of markets, i.e. strengthening the 'pull' or demand side of the sector, this proportion should continue to rise. Market development, value chain integration and private sector led growth is now a policy and donor priority.

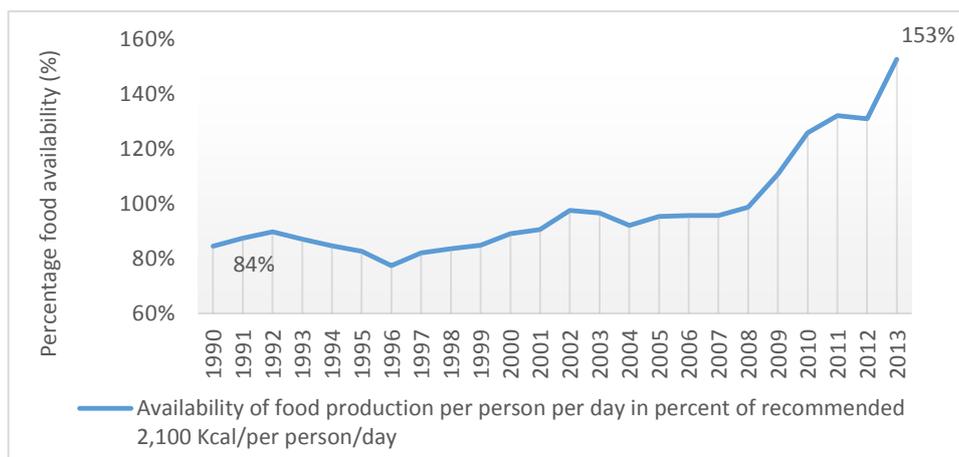
Figure 5: Increase in production for key staple crops, as a percentage from 2001 to 2011



Source: World Bank, 2013

As a result of the CIP drive for increased production and productivity of staple crops, Rwanda has also shown positive progress in terms of food security, which is a critical indicator of resilience for both the agricultural sector and a country's broader development. The Global Hunger Index (GHI, 2013), based on undernourishment, underweight children and child mortality, recognised Rwanda's progress in comparison with regional neighbours - between 2000 and 2012, infant mortality reduced from 20% to 5%, and Rwanda is now ranked third in Africa. Production gains rose faster than population, generating a surplus in availability of calories (figure 6). In 2012, partly as a result of CIP driven increased crop yields, only 17% of the population was classified as borderline food insecure, with 7% classified as poor, a reduction from 2006 when 50% of the population was classified as borderline food insecure and 28% classified as poor (CFSVA 2005 and CFSVA 2012, NISR). However, the 2006 score also represents the impact of a major drought that year, affecting a million people (OFDA/CRED, 2013). There is no prior data to compare.

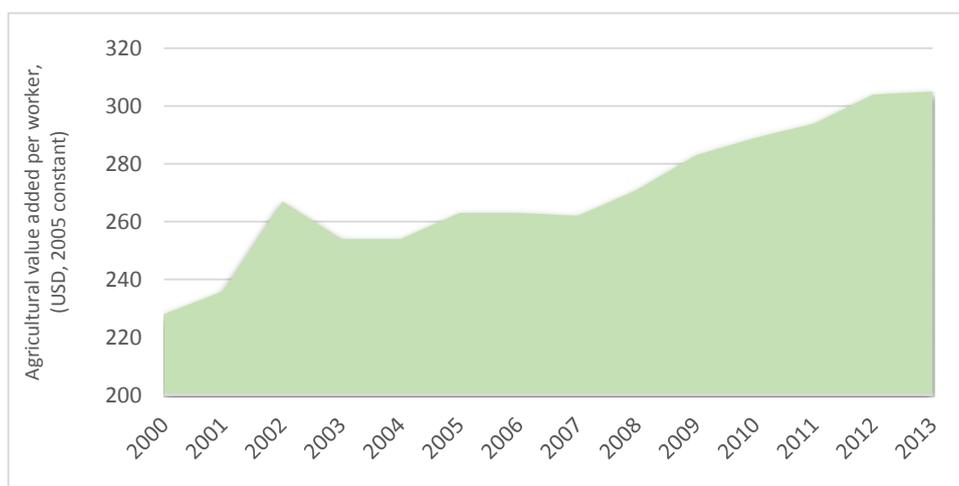
Figure 6: Energy availability as a percent of adult consumption of 2,100 Kcal



Source: GHI, 2013

In terms of labour productivity, the agricultural sector also shows positive trends, even in comparison with better resourced regional competitors. Value added per worker in the agricultural sector accounts for outputs from forestry, crops and livestock, less intermediate inputs. The World Bank (2013) has recorded an increasing trend in the agricultural sector since 2000, which has contributed to the rise in sector outputs and GDP growth (figure 7). This is promising as it suggests that the agricultural sector is still able to absorb Rwanda’s high labour availability, and that the sector is creating value. This is important given land constraints and high population density which limits the possibility of increasing outputs through expanding cultivated areas. Rwanda recorded USD 305 value added per agricultural worker in 2013, on a par with the more developed and well-endowed, land and resource rich countries of Kenya (USD 390) and Tanzania (USD 306).

Figure 7: Value added per worker in the agricultural sector 2000-2013



Source: World Bank, 2013

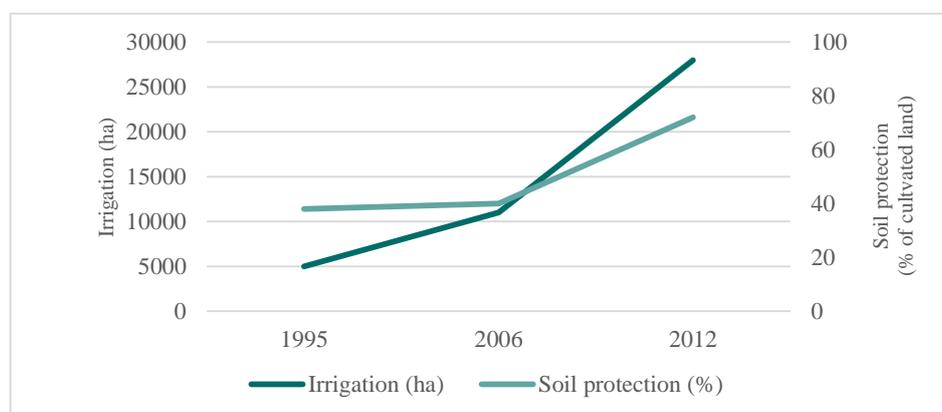
This section demonstrates that agriculture has played a pivotal role in Rwanda's economic development since 2000. However, high household reliance on subsistence agriculture and high economic dependence on agricultural outputs means the sector may act as a portal to transmit negative climate shocks. Furthermore, the World Bank (2015) suggests that strategic plans under PSTA III could make the sector more vulnerable to current and future risks, generating a slow-down in the sector. Therefore, key research questions are:

1. How have sectoral trends affected Rwanda's exposure to climate risks?
2. To what extent has agricultural development changed sector sensitivity to climate variability?
3. What capacity is there to plan for, manage and mitigate the impact of climate related shocks in agriculture?

Historic geographic patterns – investment in agricultural infrastructure

The development of Rwanda's agricultural sector was achieved through a dual policy under PSTA I and CIP of investment in infrastructure to drive up productivity (soil erosion control and irrigation) and investment in cooperative building, producer training, input provision and market systems (storage, processing, information and roads) to commercialise the sector. Both soil conservation and irrigation are included in the Vision 2020 development plan as focus areas for agriculture. However, the creation of fixed, expensive assets such as irrigation and terracing can change a region's climate risk profile both positively and negatively. Figure 8 indicates the increase in irrigation area and the proportion of land under soil erosion protection infrastructure. The change in rate of increase in 2006 coincides with the introduction of PSTA I and a wave of donor financing into the sector.

Figure 8: Increase in irrigation and soil erosion infrastructure



Source: MINAGRI, 2014

Soil erosion is a major issue in Rwanda due to the country's steep topographies. Loss rates vary from 50 to 100 tonnes per hectare per annum, with detrimental impacts on productivity and long term soil sustainability (Olson and Berry, 2002). Under a flagship PSTA I policy, with the theme 'unfolding Rwanda', soil conservation infrastructure increased from less than 30% in 2005 to 73% of cultivated land in 2013 (MINAGRI, 2014). This was a result of donor and government funded programmes, in collaboration with community involvement through voluntary labour and targeted welfare provision such as food for work. Infrastructure includes progressive (gradual) and bench terraces, which aim to reduce run-off and mitigate the impact of high intensity rainfall.

The hydrological landscape is more complex. The existing climate in Rwanda experiences high levels of spatial, inter- (seasonal) and intra-annual variability, the latter strongly associated with El Niño – Southern Oscillation (ENSO) events (GCAP, 2014). As such, some regions are subject to prolonged seasonal dry periods, while others (mostly the east) are vulnerable to consecutive failed seasons, generally correlated with La Niña events. The government first adopted a comprehensive approach to irrigation under the 2004 National Agricultural Policy to allow intensification of production systems, growing seasons during drought and conversion of marshlands. As a result, total irrigation coverage increased from approximately 6,000 ha in 2000, to 24,700 ha of marshland, 1,600 ha of hillside and 150 ha of small scale schemes in 2013 (MINAGRI, 2014).

However, these investments have high costs. The average cost of combined irrigation and land conservation per hectare in 2012 was USD 15,500 for hillside areas, USD 9,300 for marshlands and USD 1500 for small scale schemes (MINAGRI ASIP, 2014). The expansion of irrigation has only been possible due to major, multi-million dollar donor projects funded by multi-lateral donors. Irrigation schemes have generally focused in areas of high poverty (the south) and areas with high need due to their drier climatic conditions (the east), while terracing has primarily focused on areas with steep topographies (the north and west). Total irrigated areas still represents only a tiny fraction of approximately 1.9 million ha of cultivated land (World Bank, 2014).

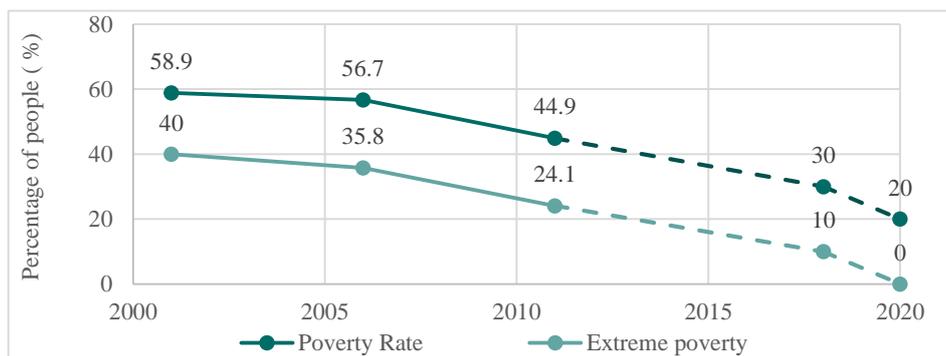
Key research questions in relation to resilience are:

1. Is infrastructure investment focused on areas exposed to climate risk (landslides, droughts, floods)?
2. Can investment in irrigation and terracing change sectoral sensitivity?

Historic geographic patterns – poverty reduction

Rwanda's population has risen steadily since 1995, at an average rate of 2.5-3% annually, with highest fertility in rural areas (World Bank, 2014). Urbanisation is also rising at a rate of 4.5%, with continued projected growth (*ibid*). Despite population growth, Rwanda's economic success has also supported higher incomes, and poverty and extreme poverty fell from 2000 to 2011, with the rate accelerating between 2006 and 2011 under EDPRS I and PSTA I (figure 9). This translates to lifting one million people out of poverty in five years, an achievement widely recognised by the development community (World Bank, 2013). Urban poverty declined from 28.5% in 2005, to 22.1% in 2011, but rural poverty is much higher, declining from 61.9% in 2005 to 48.7% in 2011 (NISR, 2014). The Gini coefficient for inequality was 0.45 in 2012, down from 0.53 in 2006, with a 2020 target of 0.35 (World Bank, 2015). This means there are still relatively high levels of inequality, representing the missing middle-class, but graduation from poverty shows potential for improvement.

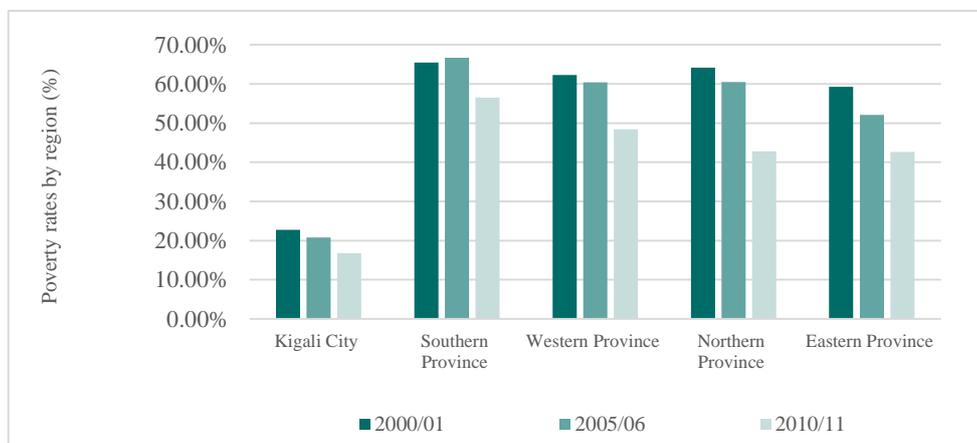
Figure 9: Poverty since 2000, with projections from EDPRS II and Vision 2020 targets in dashed lines



Source: NISR, 2014

Poverty rates vary by region (figure 10). Kigali consistently has the lowest poverty levels, which illustrates the central concentration of wealth, economic activity and service provision. All other provinces had relatively similar levels of poverty in 2000, but poverty reduction has occurred at a heterogeneous rate. By 2011, the Northern Province has made notable progress, supported by the vibrant economy of Musanze, a centre for agribusiness and tourism which intersects trade routes to Uganda and the Democratic Republic of Congo (DRC). In comparison, the south still has a poverty rate of 56.5% in 2011, despite also containing trade routes, the Nyungwe rainforest national park and historical capital of Butare. However, the Southern province does not have major agricultural processing facilities, and has received less targeted donor financing for terracing projects or new public-private partnerships. This illustrates the role of agricultural development in poverty trends.

Figure 10: Poverty by region, from 2000 to 2011

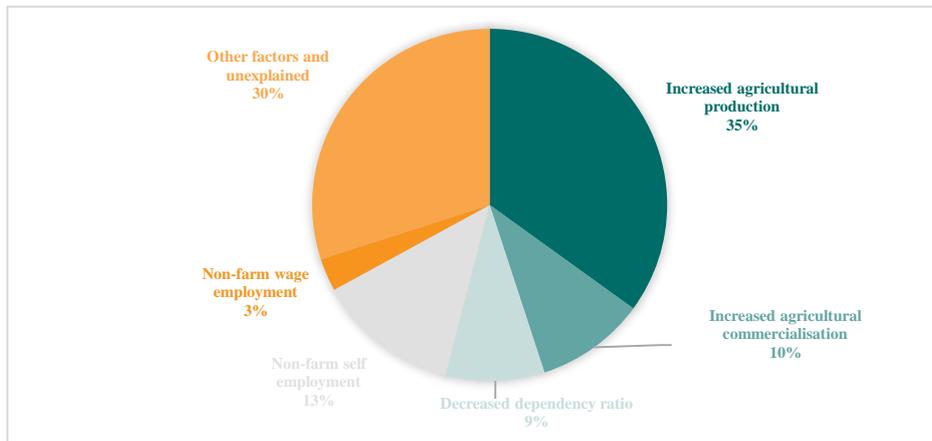


Source: EICV III, 2012

The World Bank (2013) identified the primary drivers of poverty reduction (figure 11). The most important factor is agriculture, contributing at least 45% of the 14 point reduction in poverty through improved production and commercialization (ibid). This represents how the trends discussed in section 1.2 and 1.3, particularly the increase in crop production and productivity, value added per worker and infrastructure developments have directly contributed to greater incomes for the poorest. This figure could be greater considering off-farm jobs tied to the sector. The rise in incomes has also been complemented by improvement across development indicators, including health and education. Life expectancy at birth increased from 48 years in 2000 to 64 years in 2011, and 69% of births are now

attended by skilled health staff, from 31% in 2000 (NISR, 2014). Access to education has increased at all levels and literacy increased from 64% in 2002 to 68% in 2012 (EICV III, 2012). This shows the cumulative benefits of growth translating into improved well-being through public investment in basic service provision.

Figure 11: Primary drivers of poverty reduction between 2001 and 2011



Source: World Bank, 2013

Therefore, from a geographic perspective, Rwanda shows positive trends since 2000, although there are challenges. Population density and poverty rates are high, including in areas subject to climate risk, and inequality remains high, although it is decreasing. Key research questions to be explored in the next chapter are:

1. How has agricultural sub-sector development including commercialisation, infrastructure and diversification provided better welfare for rural households?
2. How has employment changed and what does this mean for adaptive capacity?

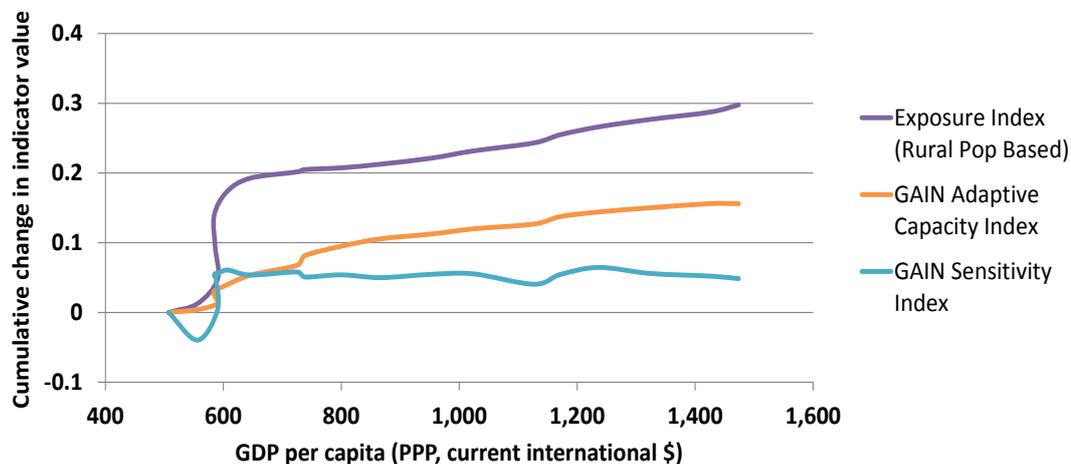
Summary

Since 2000, Rwanda has followed a development trajectory of sustained economic growth and improvement in poverty indicators. This growth has been driven by effective public investment and sub-sector developments in agriculture. However, Rwanda has not yet experienced substantial sectoral diversification and value-addition is low. Growth in agriculture has been driven by policy instruments to support both increased production and commercialisation, including major investments in soil conservation infrastructure and irrigation, market infrastructure, crop input provision and cooperative formation and capacity building for farmers. This has resulted in positive productivity trends for both crops and agricultural labour. There has also been an improvement in domestic food security. As a direct result of agricultural investments, rural households have higher incomes, and there is growing employment diversification. However, poverty rates are still relatively high and the economy remains disproportionately dependent on agriculture.

As a result of the trends discussed in this chapter, it is possible to develop a preliminary framing of Rwanda's development within the exposure, sensitivity and adaptive capacity framework of climate resilience (figure 12). The exposure index represents the proportion of the total population who live in rural areas, and therefore are likely to pursue livelihoods in the agricultural sector which are exposed to climate variability. The composite sensitivity and adaptive capacity

indices are from the Notre Dame Global Adaptation Index (ND-GAIN). The trends are measured from the year 1995, and mapped according to increasing GDP per capita. As GDP rises from USD 600, the exposure index has also steadily increased. Sensitivity has stayed broadly constant, while adaptive capacity has improved with economic development.

Figure 12: Exposure, sensitivity and adaptive capacity index



Source: Vivid Economics, 2015

The rest of this report will assess in detail how the historic economic and geographic patterns related to agriculture and discussed in chapter 1 have affected resilience. The analysis will unpack the overview provided above to assess how particular policy drivers have resulted in changes to exposure, sensitivity and adaptive capacity to climate vulnerability.

3. Analysis: impacts on resilience

Sectoral patterns - Impacts on resilience

Exposure

Exposure assesses the presence of people and assets in areas that would be adversely affected by climate change. In order to understand how exposed Rwanda's sectoral profile is to climate risks, it is necessary to consider the trend of reliance on agriculture as a primary source of growth and employment, in the context of current and future climate risks. The key indicator is the relationship between Rwanda's agricultural and GDP growth, contributing on average 36% of GDP from 2008-2014, and low levels of economic diversification and value addition (World Bank, 2015). Agriculture remains the dominant economic activity throughout the country, including in the semi-arid East which is periodically subject to drought, and the mountainous North and West which has high flood and landslide risk (NAPA, 2005). Agriculture is a function of climatic, land and water conditions, and as such is highly exposed to climate variability and future climate change and feedback effects on soil and water cycles. A representative of the Ministry of Environment (MINRENA) explained how, "climate change in Rwanda has a direct impact on agricultural productivity. Many crops have a specific, optimum temperature range for growth." This means that the national economy is exposed when climatic hazards affect agricultural outputs.

The impact of droughts and floods since 2000 illustrate how Rwanda's sectoral profile is exposed to existing levels of climatic variability and hazards (see GCAP, 2014 for climate data). In 1999-2000, 2003 and 2005-2006 droughts occurred, classified as below average rainfall for consecutive seasons, which resulted in food insecurity and falls in production, reflected by lower growth in these periods. In 2012 failed rainy seasons and a below average harvest led to a drop in agricultural growth (MINAGRI, 2013). This was followed by a 4% decline in 2013 GDP growth, which was attributed to lower agricultural outputs combined with aid shortfalls, although the relative effects are difficult to disentangle (World Bank, 2013). The impacts of flooding tend to be more localised, and as such it is difficult to determine a direct effect at the national level, though SEI (2009) estimated economic costs of up to USD 22 million for major flooding in 2007, as a result of death and displacement, destruction of up to 700 homes, flooding of 2500 ha of agricultural land and infrastructure damage. With climate change potentially exacerbating variability and the likely increased intensity of extreme events, the impact of negative climate shocks affecting agriculture could increase.

Sensitivity

The sensitivity of a system reflects the degree to which it is affected by climate variability or change. To analyse how sectoral trends within agriculture, particularly the increase in production and productivity, have affected sensitivity of the sector to climate risks, it is important to assess the impact of specific policy interventions. The majority of funding for agricultural sector strategies PSTA I and II from 2006 to 2012 was focused on interventions to drive up yields through the Crop

Intensification Programme (CIP). The primary indicators for sectoral sensitivity are crop production, staple crop productivity and crop diversity, which all contribute to food security. Production and productivity have shown positive trends since 2000, for example cereal crop production increased 211% from 2001-2011 (World Bank, 2013). These substantial productivity gains and output growth have doubled domestic calorie production per person, resulting in improved food security. However, this may have occurred at the expense of crop diversity, which must be considered as a trade-off.

CIP as a policy instrument comprised of a package of interventions aimed at improving the supply side of agricultural value chains. Investment in land consolidation, soil erosion and irrigation targeted the sector's resource base as the primary factor of production (discussed more in the next section on geographic trends). The second stage of interventions focused on input provision, through measures to improve soil fertility (fertiliser, agro-chemicals) and certified seeds, distributed through government managed, subsidised transport and distribution channels. Fertiliser use increased to an average of 29 kg/ha/year in 2012, up from 4.2 kg/ha/year from 1998-2005, and the number of farmers using improved seeds increased from 29% in 2008 to 40% in 2012, both generating significantly improved yields (MINAGRI, 2013). The third part of CIP aimed to build the technical capacity of the sector through farmer training. Finally, investment in post-harvest reduced crop losses and improved processing (discussed in the adaptive capacity section).

CIP has supported priority staple crops based on the 2004 National Agricultural Policy, with later additions. Selected crops are rice, maize, beans, Irish potato, wheat, cassava and banana. As a result of CIP, productivity of target crops has increased significantly. Maize yields rose 400% from 2000 to 2010, and wheat yields increased by 250% (MINAGRI, 2013). The pattern for increased productivity across the sector supports reduced sensitivity to climate variability as it means there is a greater potential buffer in case of a negative shocks which affect production. Increased productivity also has positive multiplier effects as it allows economies of scale for harvesting, processing and marketing. However, although the CIP has had resulted in productivity gains, the focus on a selection of staple crops means there is a reduced crop diversity, and fewer varieties. Dependence on certain crops increases the sectoral sensitivity to each crop's individual risk profile. Research and seed production is focused on a limited number of varieties, and farmers are subsidised to focus planting and harvesting efforts on a narrow crop portfolio (for example subsidized fertiliser can only be applied to CIP crops).

Focusing on a select group of crops and varieties could be positive, if climate resilient options are adopted, although generally varieties offer increased yields because they are optimised to certain climate conditions. Therefore, there is the risk of displacing traditional, less marketable commodities, which may be more resilient, with crops which increase sensitivity to climatic variability or changes (box 1). The impact of pests and diseases will also be magnified, illustrated by the disproportionately costly impact of cassava mosaic disease and brown streak virus in Rwanda in 2014, which destroyed 80-90% of production in the central plateau districts (Bucyensenge, 2014). However, despite the potential increased risk, it is also difficult to justify a counter-factual without a comprehensive approach given the need to drive up production for economic growth and to support household incomes and food security. Therefore, CIP has increased productivity, reducing overall sector sensitivity, but limited crops, seed varieties and restrictions on planting creates sensitivity to certain other risks. Furthermore, the economic focus on agriculture and a limited range of crops has entrenched Rwanda's reliance on a limited number of agricultural commodities for export, which are subject to global market volatilities and downward price pressures.

Box 1: Crop choice and lock-in

Agricultural policy has promoted selected crops and a narrow range of seed varieties, chosen to improve food security and provide cash income for farmers. As a result, crops such as maize, which commands a high market price and is in demand regionally, have displaced non-priority crops. However, maize is a climate sensitive crop: a heavy consumer of water and less resilient to deficits than, for example, traditional sorghum. A senior government advisor explained that “anytime we reduce the range of crops, we are at risk. Maize diseases are now more serious than they were before CIP. The programme has been important to increase incomes, but changes the riskiness of the sector through reliance on certain crops.” Another respondent working in the Ministry of Agriculture stated that farmers face an ‘unknown risk’ as a result of the public-sector driven production shift towards wheat, maize and rice.

Even for specific crops, a UN agronomist explained that the limited availability of seed varieties was a challenge for the sector: “all small countries in Africa have the same issue, in Rwanda we have less than one new variety, per crop, per year, in Namibia there are up to fifteen new varieties per commodity ... In the EU we have a common catalogue of about 40,000 seeds”. Crop varieties are essential to reduce sensitivity to climate risks and pests and build a productive sector in the longer term. However, some respondents described how government and DPs seemed reluctant to enact the major reforms required to liberalise the seed market - implementation of the unpublished Seed Policy was subject to bureaucratic delays, despite its inclusion in the current sector strategy, and research funding is limited. Farmers are unable to access untested or uncertified seeds, and as a result the existing system is unable to provide adequate choice to build a resilient sector.

The World Bank (2015) conducted a recent risk analysis for emerging sector threats. It was suggested that further mono-cropping and land consolidation could increase the impacts of pests and disease, while climate variability was a risk across the sector. However, reform of the seed sector supported by improved research and innovation could help mitigate these risks. There is support among certain DPs but the government must buy-in.



Adaptive capacity

Adaptive capacity represents the ability of a system to successfully adapt to and cope with the effects and impacts of a changing climate, by mitigating damage and capturing new opportunities. In Rwanda, various sectoral trends within agriculture have improved adaptive capacity, particularly through enhanced abilities to manage and mitigate shocks. Broader transformation and commercialisation of agriculture also support adaptive capacity at the macro-economic level. Key indicators for adaptive capacity within a sectoral framework are training and capacity building (such as extension worker ratios), and disaster risk reduction and management (DRRM) planning through buffer systems like EWS, insurance, food stores and food security levels, introduction of climate smart initiatives, and macro-economic trends regarding investment, diversification and value addition, value chain development and market creation.

Cooperative formation, extension training and farmer field schools (FFS) develop the adaptive capacity of the sector, as farmers are trained to mitigate the impacts of and more quickly recover from negative shocks, such as flood or dry periods. Under PSTA I-III the Ministry of Agriculture, supported by donors such as the Belgium government, has integrated farmer education with CIP and other policy interventions, to equip farmers with the skills to maximise and protect production, optimise utilisation of complementary interventions such as fertiliser and preserve and maintain infrastructure for soil erosion control and irrigation. From 2008 to

2012, the households per extension worker ratio decreased from 2,920 to 839, meaning that extension workers can better target training and capacity building for smaller groups (MINAGRI, 2014). The FFS approach is also increasingly used, engaging farmer promoters and peer-to-peer learning to encourage adoption of best practice. In 2014 the government also rolled out the new 'Twigire' Extension Strategy, which aims to strengthen decentralised service provision.

The ability to prepare for, manage and recover from disasters across the sector has also improved, according to key interviewees. For disaster planning, the USAID funded FEWSNET produces reports on food availability, household stress and potential crises, and disseminates information to a committee including government ministries and DPs. One interviewee noted that "there is good awareness at the national level of alarming situations, and this allows action to be taken". However, a government representative mentioned that the system was not fully embedded, particularly to enable local government to act, and an interviewee working in emergency management emphasised the need for better coordination and harmonisation of responses vertically and horizontally across government. To mitigate the effects of disaster, the Ministry of Agriculture plans to scale up existing crop weather index insurance programmes, to help farmers hedge against adverse weather and seasonal variability. By 2012, only 20,000 farmers were covered, but the target is to reach 200,000 by 2017 (GoR, 2012).

The sector has also adopted a pro-active approach to storage, which buffers the impact of a climate disaster and failed harvest in one area, by reducing or mitigating the speed and intensity at which negative supply shocks translate through markets. The National Strategic Reserve, built by the government and partially funded by USAID, has been operational since 2010, with a capacity of 40,000 MT for maize and beans (MINAGRI, 2013). This is possible due to the increasing trend for national food security. The aim is to provide a market buffer for times of shortages for key staple crops, when the government will release the commodities into the market to stabilise demand and prices. All inputs are purchased from local farmers. However, in 2014 stock was significantly below the 15,000 MT targets due to successive failed harvests (MINAGRI, 2014). Private sector actors and cooperatives are also encouraged to build warehousing facilities, but one interviewee explained that farmers do not yet fully buy-in to the rational, reflected by critically low household storage. One interviewee noted, "households may not have the capacity to respond or adapt to warnings, due to a lack of storage and alternative livelihood options". The government is attempting to counter this through provision of both local stores and sensitisation on their use, emphasising how capacity building helps realise the benefits of resilience interventions.

Regarding future planning for the sector, government and DPs are increasingly interested in climate smart agriculture, with proposed new programmes for small scale irrigation technologies (SSIT), targeted and efficient 'briquettes' of fertiliser and nutrients, and more robust seed varieties which have also have nutritional benefits. Climate change is addressed in the new sector strategy PSTA III and there is an environmental sustainability sub-working group with stakeholders across the sector. New financial resources aim to incentivise and support innovation. A senior government stakeholder explained "climate change is a top priority for government ... because there is a lot of money behind it, a lot of resources." For example, the climate fund FONERWA established with GBP 21 million of DFID seed funding supports 'green growth' projects from government, the private sector and civil society. Although MINAGRI have not yet secured funding, FONERWA is financing district level land management (soil conservation, rain-water harvesting and agro-forestry). Other projects also indirectly support agriculture, such as the government agency METEA which has funding to improve weather service information and collection. One respondent noted this would improve seasonal planning, and is part of a broader government agenda to improve climate data

gathering, analysis and dissemination. Although recent, these initiatives illustrate the commitment across government and DPs to integrate climate considerations.

In terms of building longer-term adaptive capacity, sub-sector developments to improve markets and attract new investment supports agricultural competitiveness and diversification. Respondents highlighted the growing commercialisation of the sector and increasing involvement of private actors. From the supply side, mobile innovations such as market price systems allow farmers to identify the best market for their goods. Mobile penetration is high, so even poor households can access information to optimise incomes (RURA, 2013). Extension agents also work with cooperatives to establish contracts with processing facilities or whole-sale buyers. Across value chains, government has privatised sub-sectors (e.g. tea), constructed factories and processing facilities for hand-over, and opened a Special Economic Zone. As a result, the sector registered USD 514 million of private investment from 2000-2014 (MINAGRI, 2014). This illustrates the first stages of commercialisation, with ambitious plans for further transformation under PSTA III and a new Task Force for Investment. PSTA III aims to align all areas of the agricultural sector with a market based orientation, for example encouraging export crop diversity through expansion of CIP best practice into the horticultural sector. The under-developed livestock sub-sector is receiving attention as a potential growth area. This diversification could also help counter some of the issues discussed in the previous section. Notably, the drive for private sector development is also aligned with climate sustainability at the policy-making level. A new DFID funded investment screening tool considers two questions: (i) does investment spending increase or decrease resilience, i.e. ability to respond to climate change, (ii) does investment spending increase or decrease forces leading to climate change.

Government and DPs hope that the macro-economic shifts starting with sub-sector developments in agriculture will create a more diversified economy. As incomes rise and people diversify their livelihoods, the national economy is less directly exposed to the effect of climate risks, as alternative sectors contribute more to GDP and value addition. However, this may result in a changed risk profile overall, as increased exports and service sector development are subject to market and political risks (price volatility for international commodity markets, exchange rate risks and reputational sanctions, see World Bank 2015). Furthermore, there may be trade-offs in terms of poverty reduction and economic growth. Dercon (2012) highlights that 'green growth' is not necessarily 'pro-poor'. It cannot be assumed that climate screened private investment will automatically generate higher incomes and decreased inequality for the poorest people, who tend to benefit from labour intensive, low-skilled jobs or direct investment in smallholder livelihoods. Therefore, since 2000 Rwanda has strengthened its adaptive capacity in terms of knowledge building and disaster planning and mitigation. However, with increasing focus on climate resilience, and the political drive for broader economic transition and 'green growth', the public sector faces the challenge of designing and implementing policies which drive growth beyond agriculture, but also include and protect poor farmers. As described by a senior government advisor "trade-offs are key. Decisions are framed in the context of risk and reward – there will be higher risks [with agricultural modernisation], but the expected value and return is higher than for lower risks".

Geographic patterns - Impacts on resilience

Exposure

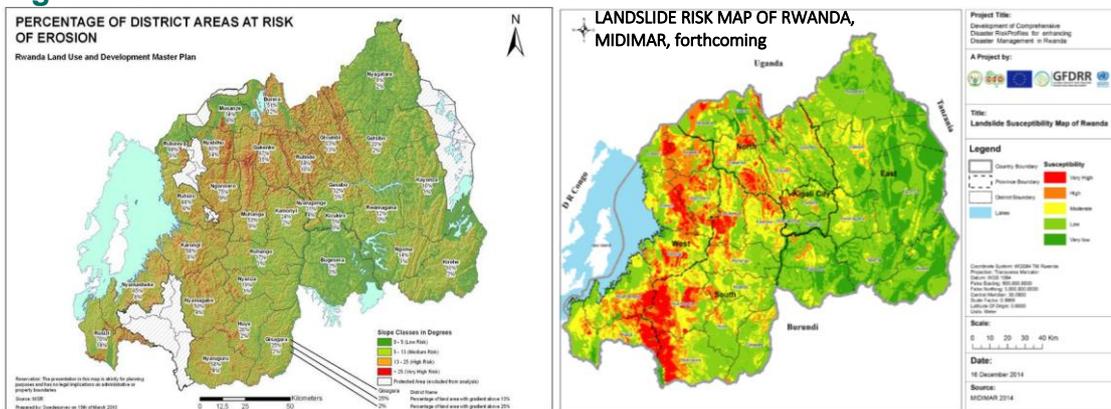
To explore how exposure levels have changed, it is important to map climate risks against changing patterns of investment in agricultural infrastructure. Key indicators for exposure and geographic patterns are focused on levels of investment in infrastructure in areas exposed to climate risk and the number of people of live in

areas subject to climate hazards such as droughts, floods and landslides. There is also an increased risk of climate variability according to climate models.

(A) Assets

Investment in agricultural infrastructure has increased the value of assets exposed to climate risks at the national scale, but has also changed sector sensitivity (discussed in the next section). Investment has focused on soil conservation measures and irrigation. A high proportion of terracing projects focused on the North and West, which have steeper topographies and are therefore at higher risk of erosion and landslides, particularly during the rainy seasons with high volume, intense rainfall (figure 13). Planned investment in terracing from 2008-2012 was approximately USD 250 million, although figures on execution are not available (MINAGRI ASIP, 2009). Although these terraces are now ‘exposed’ to climate risks, the net effect is to improve resilience through reduced sensitivity.

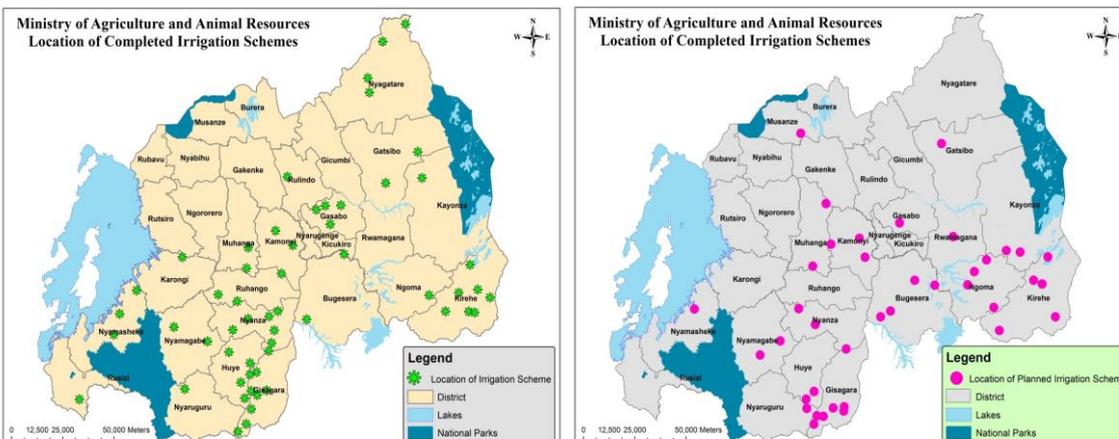
Figure 13: Erosion and landslide risks



Source: GoR, 2014

Irrigation infrastructure presents a similar pattern. Irrigation investments have focused on areas which have socio-economic or climactic vulnerabilities, with the majority of completed and planned sites located in the poor South, which experiences flooding and landslides, and the semi-arid East, which is subject to periodic drought (figure 14). Planned investment in hillside and marshland from 2008-2012 was approximately USD 300 million (MINAGRI ASIP, 2009). Irrigation infrastructure can be easily damaged by major flood or landslide events- as such infrastructure is at risk. Furthermore, irrigation is a high cost asset with mixed effects on other aspects of resilience, as there are dynamic interactions across temporal scales of climate risks, and an integrated water resource management is required to understand the trade-offs at stake (see next section and box 2).

Figure 14: Completed and planned irrigation schemes



Source: MINAGRI, 2014

(B) People

A detailed analysis of demographic trends of exposure focused on migration patterns at the national scale is beyond the scope of this report. Initial scoping suggests that there has not been major demographic shifts in the number of people exposed to climate hazards, as high rates of urbanisation were offset by strong rural population growth. In relation to agricultural development and climate resilience, it is worth noting that all regions in Rwanda experience complex patterns of climate hazards. Movement from rural areas such as the semi-arid east to cities may reduce an individual's direct exposure to climate change through the agricultural sector, but Kigali and secondary cities also experience climate risks such as flooding, landslides and strong storms. Often the only settlement options for low-income, newly arrived households are poorly served spontaneous settlements in marginal land on urban peripheries, such as the steep, poorly built settlements of Nyabugogo in Kigali, where informal housing accommodates tens of thousands (Manirakiza, 2014). In Rwanda, slums are not yet a major issue, but they potentially represent a challenge in the medium term.

From a policy perspective, since 1994 the government has encouraged 'villagisation' in rural areas, to allow centralised provision of local government and services, from schools to extension workers. Current government programmes, supported by donors, focus on risk reduction. The Ministry of Local Government (MINALOC) coordinates the scheme 'Resettlement Programme from High Risk Zones'. A government stakeholder described that the aim was "to move people away from areas of high risk, such as close to marshlands, in very sloping land near rivers and lakes which could flood. The government has established clear guidelines to resettle people with better houses and services." The interviewee explained that "this is a spatial adjustment for climate change." A pilot project focuses on three districts which are experiencing high flood risks. Newly resettled households are targeted for agricultural and community interventions to re-establish after the move. This scheme should help reduce exposure, but resettlement is a multifaceted task and can be controversial as it is difficult to fully compensate for the loss of social and bio-physical networks which a community develops over time. Furthermore, this remains a small scale pilot programme.

Sensitivity

Geographic patterns related to investment in fixed assets can change both sector and household sensitivity through reducing the impact of a climate risk, for example irrigation can compensate for failed rains in the drought-prone east and terracing can reduce the devastating impact of storms on crop production. However, it is important to consider the risk of locked-in development pathways in the long run, for example encouraging cultivation in an area which may be marginal is a risk, as infrastructure could defunct in the longer run due to a lack of supply (multi-year drought) or the water use may have a very high opportunity cost against alternative uses (such as urban supply or hydropower generation). Selected indicators related to sensitivity include DRRM activities such as terracing, irrigation and integrated water resource management (IWRM) planning.

The expansion of terracing under PSTA I-III to cover three quarters of cultivated land is a positive trend to reduce sensitivity to the impact of climate hazards including heavy rains, flooding and landslides. Terraces slow the passage of water, catch run-off and prevent loss of fertile soil. Terraces also allow cultivation in steep topographies such as the North, West and South, allowing an expansion of cultivated land and production. Finally, terraces and complementary planting techniques support increased productivity, a fundamental component of the CIP policy mechanism focused on natural resource management. Furthermore, terraces have directly and indirectly supported reduced household sensitivity to climate hazards. Terraces provide income opportunities for households in more marginal

areas which would otherwise not be planted. Also, many government and donor terracing programmes have incorporated social welfare programmes which support marginalised people through payments to build and maintain infrastructure. Finally, indirectly, by supporting increased productivity, terracing has also provided a foundation for the 45% of poverty reduction generated by the agricultural sector (World Bank, 2013). However, a government agronomist highlighted the importance of continued terrace monitoring, maintenance and rehabilitation, as the gradual degradation of terraced land could lead to abandonment, resulting in gully erosion, “worse than before”.

Irrigation investment targeted certain areas to reduce risks of rainfall shortages, and also reduce poverty by providing a catalyst for higher incomes. MINAGRI has worked with large donors, particularly the World Bank, on major schemes such as the five-year, USD 112 million ‘Land Husbandry, Water Harvesting and Hillside Irrigation Project’ (LWH), with 92,000 beneficiaries. Irrigation can reduce sector sensitivity to certain climate shocks by providing a short and medium term buffer to potential losses as a result of water shortages. At the household level, irrigation also protects farmers. However, one respondent noted that current investment has targeted a disproportionately small number of farmers, noting “only 4% of the population benefitted from the massive World Bank projects... as if we have a select ‘VIP’ group of farmers who are climate resilient.” He emphasised the need for “a sector wide approach for irrigation and water management, which is effective and cost-efficient, for example, more functional water user associations could attract more investors for schemes for purchase and contract farming.” This highlights the need to balance investment in high-cost fixed assets with more diffuse and decentralised investment in institutional management structures, organisational and community capacity building and regulatory systems.

As a result of high costs, irrigation infrastructure covers only a tiny fraction of cultivated land (MINAGRI, 2014). MINAGRI is now prioritising SSIT in an effort to expand the household level benefits of irrigation. However, irrigation is a controversial approach to developing sector and household resilience, because it is an expensive asset which relies on a continued flow of water resources, which are uncertain in a changing climate. In the medium term, irrigation can buffer the impacts of short-term delayed rains, seasonal shortages and agricultural droughts. However, it may be unable to reduce sensitivity to long-term, multi-year drought if the water sources it relies on are also affected. In Rwanda, there is a high amount of uncertainty regarding future precipitation trends (Shongwe et al., 2010; GoR, 2011). One government representative described a lack of data and “high levels of hydrological and meteorological uncertainty” for both current surface and ground water availability and supply and demand dynamics, and future trends. Irrigation can also lock-in the use of water for agriculture as opposed to other productive uses such as energy or domestic consumption (box 2).

Box 2: Irrigation and lock-in

Irrigation can reduce sector and household sensitivity to immediate risks of water shortages but it has issues as a longer term policy response to resilience building in the context of a changing climate. In Rwanda, there is a high level of uncertainty over future changes to water supply and demand from climate change, although risks of a demand-supply imbalance are likely to be dominated by socio-economic development factors and not climate (GCAP, 2014). There is now a national Water Resources Master Plan, which extends to 2040, but it does not contain analysis of climate change impacts, reflecting the lack of appropriate and relevant data. Therefore, in the long run, irrigation technology built now may not be supported by future water availability.

Furthermore, in the short term, respondents highlighted the lack of cohesive planning across Ministries such as energy, agriculture and utility providers regarding water usage. For example, a representative of the Ministry of Infrastructure (MININFRA), explained that planned expansion of irrigation schemes could conflict with hydropower developments, which provides 52% of Rwanda's total energy production (38% of which is domestically produced, MININFRA, 2015). He described how, "water resource development is not coherent. Ten years ago a major agricultural project drained all the wetlands in an area, massively reducing the output of a major hydro plant and Rwanda's two biggest dams". The Rwanda Environment Management Authority (REMA), with a grant from the Global Environment Facility (GED), organised wetland restoration and the site's hydro output has now returned to normal, but this highlights the level of competing demands. Through the new IWRM plan, the government will be able to better manage this. However, by building expensive, fixed irrigation assets, MINAGRI and donors are making implicit assumptions about the best allocation of water under a potential future scenario of increased scarcity. Plans for improved hydrological and meteorological data should allow for better assessment of future water usages and optimal use of public funds.

Adaptive capacity

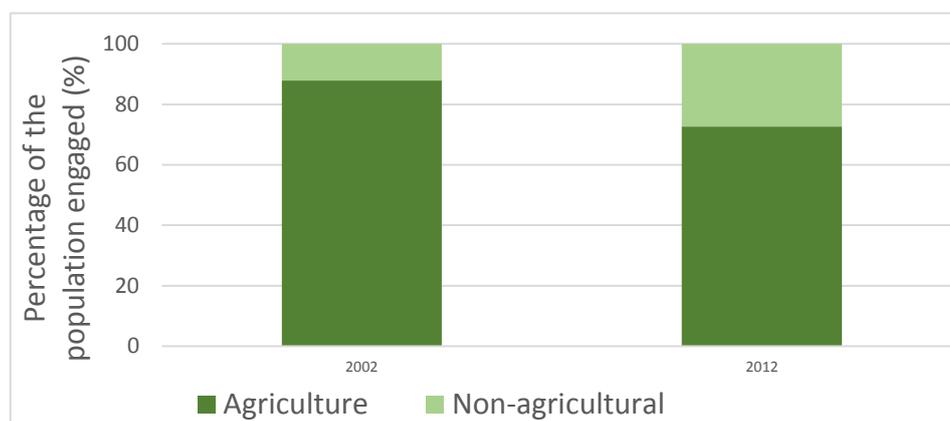
From a long-term perspective regarding ability to adjust to a new norm of increased climate variability and other risks, geographic patterns of investment in assets building and poverty reduction are supporting the gradual sectoral shift towards more productive and commercialised agriculture, and a robust and diversified economy. Key indicators are infrastructure, output sold at market, employment and poverty.

After the success of efforts to increase production and productivity, the government recognised the importance of complementary demand side interventions to create access to markets. Under PSTA II and now under PSTA III, the government has invested heavily in market infrastructure including roads, market centres and factories. Major donor programmes funded by the EU and USAID have supported construction, maintenance and rehabilitation of feeder roads, and transport links with regional centres and border crossings. As a result, Rwanda has the highest concentration of paved roads in the region, with 14,000km of roads in 2012, of which more than 1,000 km was paved, and plans for construction of 22,000 km more by 2018 (NISR, 2014). A government representative explained how good roads and public transport help build adaptive capacity, as "increasing transport capability and decreased costs of transport decreases overall risk as it allows people with localised risk to access inputs from more distant centres. The government can also provide them with what they need through roads". Although these roads are built to connect farmers to markets, they bring positive multiplier effects of greater mobility for both labour and capital. Growth of markets is highlighted by the positive trend of agricultural commercialisation, at 26.9% in 2011.

The increasing commercialisation of agriculture and the creation of ancillary off farm jobs is illustrated by changes in the employment market. In 2002, 87.9% of the population was engaged in agriculture as their primary source of employment, mostly as subsistence farmers, declining to 72.7% in 2012 (figure 15, although sources offer higher figures due to different classifications of agricultural jobs, e.g.

NISR, 2014 c.f. MINAGRI, 2013). Declining agricultural employment was facilitated by the creation of one million off-farm jobs in the service sector, some of which support agricultural industries. The contraction of subsistence farming shows that sub-sector development has created wage employment at higher levels in the value chain, providing opportunities for income generation, product diversification and competitive advantage, catalysing macro-economic shifts and adaptive capacity.

Figure 15: Labour force participation in agricultural and non-agricultural activities, in 2002 and 2012



Source: NISR, 2014

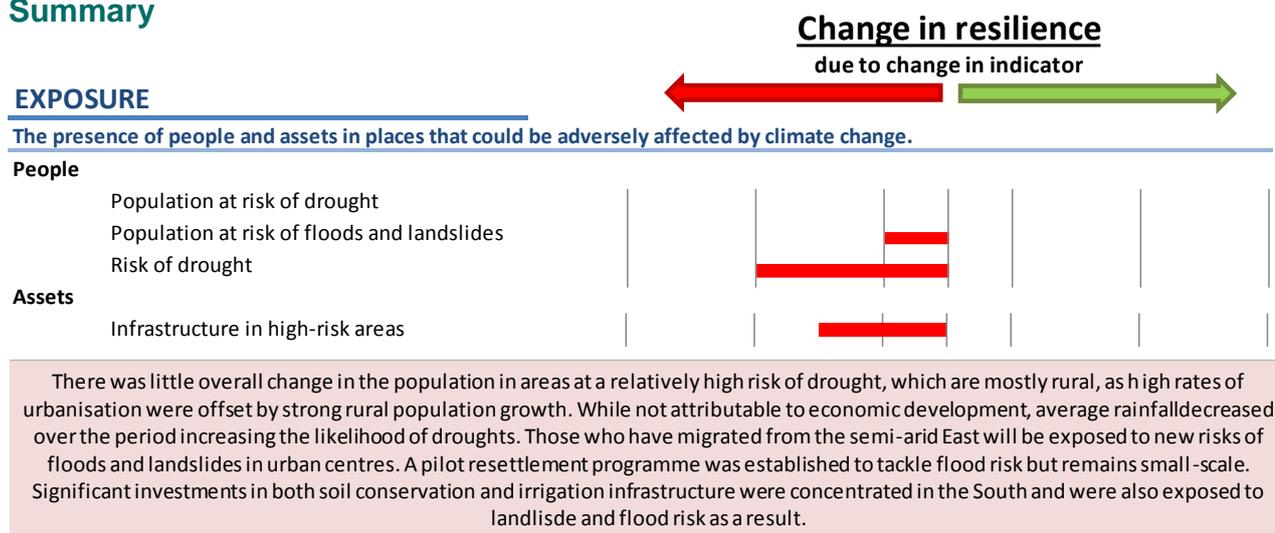
Although rural households now have more employment and mobility options, notably, the landscape differs according to gender. When disaggregated by gender, more women work in agriculture. In 2002, 93.4% of women worked in agriculture, compared to just 80.9% of men. In 2012, 82.3% of women were engaged in agriculture, in comparison with 62.5% of men working in the sector. Labour force participation is relatively equal, at 85.5% for men and 86.5% for women (NISR, 2012). However, men are disproportionately represented in off-farm jobs. This shows that men are graduating out of agricultural employment more quickly, often into higher paid, more skilled jobs. Therefore, sector development and off-farm jobs may not be benefitting men and women equally. This reflects comments made by key respondents during interviews. Although gender is now a major policy priority, line ministries have not yet fully integrated gender sensitive programming and budgeting into their systems. However, the situation is improving after the launch of the 2011 Gender Mainstreaming Strategy by the Ministry of Agriculture, and new requirements to disaggregate targets and reporting systems by sex. This should address the unequal trend for building resilience for men and women.

The final crucial consideration in terms of adaptive capacity is poverty rates, and the pattern for sustained poverty reduction across all regions since 2001. Rwanda's achievement has been internationally recognised by the donor community. The World Bank (2013) attributes at least 45% of this directly to increased agricultural production and commercialisation. Poverty has reduced in some of the areas which are most at risk from climate hazards (the north and east), but areas such as the south still experience high levels of poverty and are also at risk in the context of increased climactic variability. Reduced poverty improves adaptive capacity as it allows households a buffer should a negative shock occur – this buffer can be material (household food stocks, savings, other assets such as livestock), technical (skills which can be sold at market) or physical (the ability to move, relocate in search of work, wages, food etc.). The majority of interviewees recognise that the main policy driver for poverty reduction by the agricultural sector was the CIP approach, despite the potential risks in terms of reduced crop choice. However, poverty rates remain relatively high and the government must ensure that under the

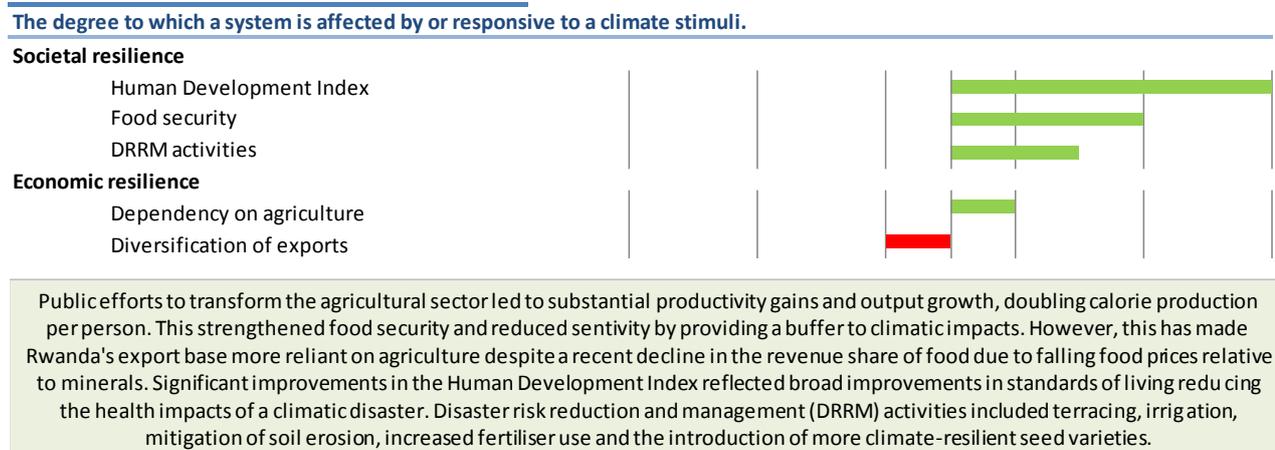
private sector focus of PSTA III, the livelihoods of smallholder farmers are not neglected, which illustrates the trade-offs which must be explicitly accounted for.

Therefore, historic trends in terms of development of market infrastructure, increased employment diversification and reduced poverty has resulted in improved adaptive capacity for the agricultural sector, but also for the households who rely on agriculture for their livelihoods. Agricultural development has provided households with more options in terms where and how they can make money, and built the foundations for economic diversification and broader structural transformation.

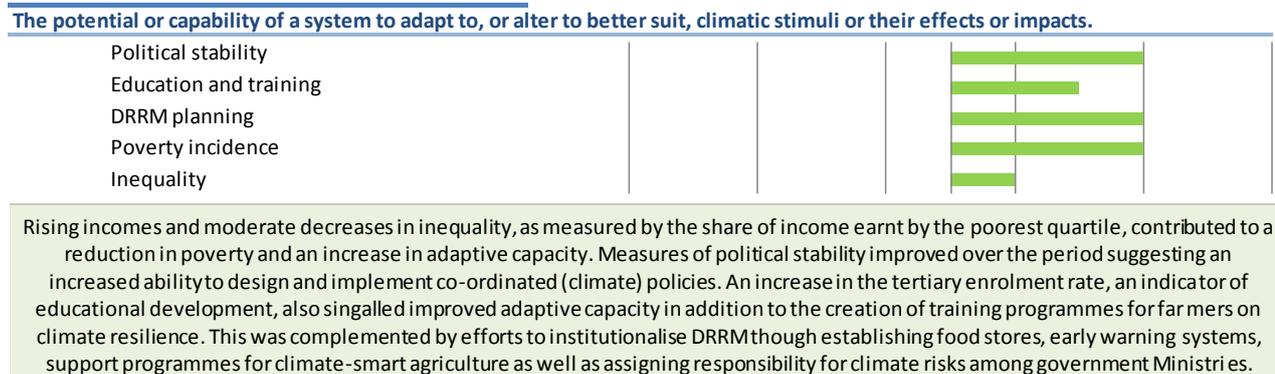
Summary



SENSITIVITY



ADAPTIVE CAPACITY



This chapter considered the impacts of Rwanda's agricultural driven sectoral and geographic developments on resilience, according to the analytical framework of exposure, sensitivity and adaptive capacity.

Overall, the scores suggest that through aid financed and agricultural led development, the agricultural sector, and therefore the Rwandan economy is relatively more resilient in 2015 than in 2000, although the story is complex. Sub-sector developments in agriculture have generated sustained economic growth and poverty reduction. The sector has reduced the potential impact of some climate risks, changed the risk profile, and introduced some new risks for example through mono-cropping. This shows that the relationships between sector growth, poverty reduction and resilience are complex. Growth does not build resilience alone. Poverty reduction supports reduced vulnerability for poor households, but it is also important to look at dynamics within households, for example gender inequalities. This analysis has highlighted the different impacts and trade-offs of certain sub-sector policy interventions across the resilience framework.

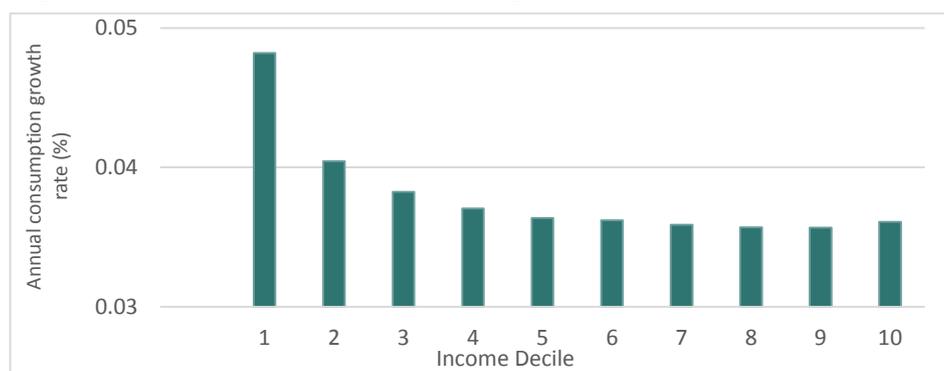
4. Discussion

Distributional impacts - resilience of the poor

The key focus for this case study was to understand how Rwanda's development success story, following an economic model of agricultural led growth and poverty reduction, has supported resilience. The agricultural sector is inextricably connected to livelihoods in Rwanda. The majority of people, and most people living in poverty and extreme poverty, depend on the sector either directly or indirectly for employment, incomes and subsistence. Sub-sector trends in terms of increased productivity and greater marketing of products has supported continued poverty reduction since 2001. This is particularly impressive given Rwanda's history of civil conflict, regional insecurity and the 1994 genocide, which devastated communities and infrastructure, and destroyed social networks and institutions. By 2014, Rwanda is one of the safest countries in Africa, with a stable and transparent government, which has made impressive gains in HDI components including life expectancy, health, education and gender equality in addition to poverty reduction.

Furthermore, income inequality has decreased, which highlights that the poor are actually benefitting from national prosperity, and not just the elite. Therefore, although poverty rates are high at 45%, Rwanda's agricultural led development has had positive distributional impacts which has improved the resilience of the poorest. This is well illustrated by the growth incidence curve in figure 16, which highlights that the annual consumption growth rate from 2000-2011 was significantly higher for the poorest deciles (PovCal net, 2015). This is significant because it presents declining inequality in terms of consumption patterns – the poorest 10% of the population experienced a consumption growth rate of 4.8% annually, in contrast to 4% for the second poorest 10%, and 3.6% for the top income decile (the richest). This can be partly attributed to the integration of social welfare policies with agricultural interventions, such as food for work and cash for work for major terracing projects, and livestock distribution programmes including the flagship 'Girinka', One Cow per Poor Family. These programmes targeted marginalised groups – the poorest, landless and women – and provided sources of income, assets and skills. Schemes were subsidised by the state and donors, but illustrate the multiplier effect of agricultural interventions targeting both productivity and poverty. By investing in agriculture, the public sector has provided women and the poorest with the tools to build resilience and adapt to climate variability.

Figure 16: Annual consumption growth rate from 2000 – 2011



Source: Data from PovCal net (2015), graph and calculations by the Author

However, within the aggregated data related to poverty reduction, there are some trends which required further attention. More women in Rwanda work in subsistence agriculture, and women are diversifying into alternative income sources at a slower rate than men. Anecdotal evidence from interviews also suggests that agricultural programmes, even those targeted directly at women, struggle to engage women and to maintain their engagement throughout the length of the scheme. A respondent working with new agricultural technologies described how often, when new technology is introduced for work dominated by women, men will often become more involved and reap the benefits of the project. She noted that “the majority of people working in agriculture are women, but the decision-making process and business model is dominated by men. The policies are in place but the mind-set change required on the ground has not happened yet”. This illustrates the need for continued careful gender mainstreaming across sectors, and to design programmes which consider women’s specific vulnerabilities in relation to homecare, travel and earning constraints. Fortunately, Rwanda has a well-designed policy and institutional framework to facilitate female empowerment, ranging from high levels of political representation, improved access to family planning and requirements for gender sensitive budgeting, programme implementation and monitoring and evaluation.

The second area which requires further discussion is food security and nutrition. Food security has shown positive trends since 2000 as a result of agricultural development, however, the story for nutrition is more complex. Nutrition indicators for childhood wasting and being under-weight have also improved, which shows that the short-term impacts of food crises are now felt less acutely. However, an important counter trend is the persistently high level of stunting, caused by prolonged inadequate or inappropriate feeding practices. Rates of stunting, which can cause permanent development problems for children, have remained high, from 43% in 2000 to 44% in 2011 (NISR, 2014). The issue is not a lack of food, but poorly diversified diets and a lack of education. Therefore, although domestic food security provides resilience at the national level and reduces the impact of short-term negative food shocks on critical nutrition indicators such as wasting, it does not guarantee improvement in chronic malnutrition represented by stunting. Inequality dynamics within households, and a lack of education regarding childhood feeding means that children can remain marginalised and under-fed in a food secure context. The government and donors have now adopted a broad-based sectoral approach to tackle the underlying causes of stunting, involving the ministries for health, education and agriculture under the Nutrition Action Plan (2012-2017). This illustrates the need for cross-sectoral and integrated approaches to tackle the more ‘wicked’ problems associated with poverty, which also make individuals less resilient. Key actors must engage these integrated approaches to ensure positive distributional effects are realised across the most vulnerable.

Through the process of EDPRS II and PSTA III and the emphasis on economic transformation, Rwanda must ensure that the poor continue to be included in development and growth, particularly with commercialisation of agriculture and the drive for exports. There are trade-offs. One interviewee with extensive experience in agriculture explained that “the sector has committed to green growth, but there are risks. People are personally committed to green growth at the leadership level and are willing to sacrifice farmer incomes for green growth. In principle, there should be compensation but it doesn’t happen – other people may end up paying the price for growth”. However, this contrasts with achievements since 2000 and consistent political commitments to poverty reduction at the highest level. The government explicitly recognises the need to continue to combine growth policies with integrated interventions for social protection, smallholder productivity, empowerment of women and access to education and health for women and children. Existing schemes such as social payments for terrace construction are climate smart and provide a foundational source of income and skills for marginalised groups. Government and donors must continue to work together to

ensure the public sector strengthens programmes which benefit the most vulnerable while the private sector plays a greater role.

Policy drivers and resilience

Recent agricultural policy in Rwanda has targeted rural development, poverty reduction and land management, with many positive impacts on climate resilience. All government policies are based on the Vision 2020 strategy which aims to achieve middle-income status for Rwanda by 2020, with increased exports, reduced dependence on agriculture and a diversified economy. To some extent, this vision represents a 'resilient economy', as households will have higher incomes and employment options, and the national economy is based on diverse revenue streams. The first EDPRS (2008-2012) was designed to create a cohesive government approach to both poverty reduction and economic change, based on growth through agricultural development, social welfare programmes and strengthening governance. EDPRS II (2013-2018) aims to accelerate the process of structural transformation, particularly through education and creating off-farm jobs. EDPRS II also encompasses a major shift in the role of the state, from provider to facilitator of development, to foster private sector development, competitiveness and economic diversification, with the longer term goal to reduce dependence on development assistance and public spending.

Climate change is increasingly integrated across government strategic processes with the 2011 Climate Strategy, as a cross-cutting issue for EPDRS II, and through climate mainstreaming indicators included in the budgeting process. Interviewees recognised that Rwanda has one of the most developed regulatory and institutional frameworks around climate change in Africa. In 2005 Rwanda submitted its First National Communication to the United Nations Framework for Climate Change (UNFCCC) and in 2006, the government finalised the National Adaptation Programme of Action (NAPA), a framework process for developing countries to consider and respond to urgent climate risks. In 2009, a study on the economic costs of climate change in Rwanda (SEI, 2009) raised awareness of the potential risks across Government. This laid the foundation for the 2011 Green Growth and Climate Resilience strategy, which outlines fourteen actions to reduce exposure and vulnerability to climate hazards and stimulate low carbon economic development through a multi-sector approach. The strategy aims to allow Rwanda to leapfrog destructive development pathways and build a stable, green economy (GoR, 2011). Vision 2050 is the overarching goal, for 'Rwanda to be a developed, climate resilient, low carbon economy by 2050'.

Given the role of agriculture as a major economic sector, national level economic and climate policies highlight agricultural development as a crucial modality for Rwanda's sustainable development trajectory. Sector policies including the 2004 National Agricultural Policy and PSTA I-III aim to facilitate this process through an integrated approach to poverty reduction and developing agriculture as Rwanda's primary resource (there are limited mineral or other endowments). As discussed, policy has focused on driving productivity gains, through the CIP's dual approach to crop intensification (resource management and technical inputs and training) complemented by value chain and market development. The specific programme areas have been discussed in detail: land consolidation and cooperative formation, terracing, irrigation, soil fertility management, seeds, farmer training, post-harvests, disaster management, market centres, feeder roads and increased investor engagement. Many of these represent standard agricultural policy mechanisms for early stage sector development away from a pre-dominantly subsistence sector.

The notable success of the Rwandan government has been to implement agricultural sector policies in an integrated way to support resilience of the sector, with also a strong focus on inclusion and sustainability. By driving up productivity

and building risk management capacities through food security, disaster planning, farmer training and value chain development, the government has reduced sensitivity and improved adaptive capacity of both agriculture and the national economy. Furthermore, consideration of marginal groups and farmer incomes has provided the foundation for flagship programmes, which has built household resilience through poverty reduction. High levels of public sector subsidies made possible through donor financing and including direct transfers to farmers through, for example, land consolidation and distribution, have helped realise an ambitious agenda of agricultural development which also helps the poor. A key policy lesson is that, if the most vulnerable groups in society disproportionately work in a specific sector, supporting that sector is an effective method to build their climate resilience.

Recent strategic documents such as the 2011 Gender Mainstreaming Strategy, 2014 Nutrition Action Plan and the 2011 Strategic Environment Assessment for Agriculture target cross-cutting areas which are lagging behind. Gender has now become increasingly prioritised across intervention areas, although entrenched socio-economic dynamics mean that achieving gender parity in programme results will take time. Nutrition is major theme across PSTA III and a donor funding priority. Although environmental management has long been prioritised through soil conservation, a broader, climate based approach has now been adopted in the latest Agricultural Sector Investment Plan (ASIP). Interviewees at the Ministry of Agriculture recognised the importance of climate change planning with sector interventions, highlighted by new tools such as investment screening. This shows how the sector pro-actively adopts policy responses to critical issues. In order to assess the benefits of this programmes, it would be useful to have comprehensive gender or social impact analysis to be conducted alongside major interventions. This would also be useful data for the sector. There is an opportunity for donors to lead and assist the government in facilitating these assessments as part of a shift towards evidence-based policy making.

Under EDPRS II the government is also pushing the private sector agenda as a response to political uncertainties and a declining aid resource envelope, combined with the need for structural transformation. Within agriculture, private investment could enhance sector diversification, sustainability of programmes and have positive multiplier effects, if well planned, with considerations of how to include the poorest. This should address the limitations in terms of economic resilience as a result of dependency on agriculture and limited diversification of exports.

Finally, the Rwandan government has created relatively capable, ambitious and effective institutional and financial structures in comparison to many developing economies to implement the policies described. DPs and major global actors recognise this and it is reflected through aid volumes. During interviews, key respondents outside of government praised state systems and their effectiveness. One interviewee described how “in Rwanda, government policy is very positive and proactive.... Policy is not just a pretty thing that sits on the shelf. In many African countries, the government is very passive. In Rwanda, policy documents are implemented.” However, there are still delays between policy formulation and implementation. This is particularly evident in some controversial or ‘sticky’ policy areas, such as seeds, which can exacerbate existing ‘lock-in’ risks. It can be difficult with vested interests and inertia to validate and implement certain policy documents. Furthermore, occasionally, coordination issues hamper policy implementation, particularly for cross-cutting issues such as environmental management (illustrated by the issues with water resource development), nutrition (shown by delays in validation of the Nutrition Action Plan) or emergency response (such as drought planning). However, this reflects the reality of governance in complex socio-economic environments, faced with multiple ‘wicked’ problems at different scales, and competing objectives, which all governments must manage through the political process.

Vulnerability and lock-in

As climate change becomes a physical reality all national economies must reassess their investments in social, economic and physical infrastructure to ensure that decisions made now result in climate resilient outcomes, i.e. limit exposure and reduce sensitivity to climate risks and hazards, and build adaptive capacity to the new normal in the context of a changing climate and high physical and socio-economic uncertainties. As a result of the civil war Rwanda does not have a high baseline of investment in expensive infrastructure or a long history of economic or technical specialisation in certain industries. Our analysis suggests agricultural policy since 2000 has had a net positive income on climate resilience. However, there are areas, which have been highlighted in boxes in this report, which could potentially create 'locked-in' development pathways. Policy decisions since 2000 which could cause medium/longer issues term for resilience relate to physical investments (in irrigation and terracing), technical trade-offs (based on certain crop choices and seed varieties) and economic pathways (continued dependence on agriculture and aid for government revenues).

As described, Rwanda and donors have invested significant funds in irrigation and terracing infrastructure. However, if terraces are abandoned and decay, or if input application is poorly managed, it can actually exacerbate soil loss or nutrient leaching. Furthermore, irrigation infrastructure is vulnerable to damage by flooding, or longer term supply shortages as a result of physical or economic scarcity, i.e. reduced input due to competing demands from different sectors or reduced capacity or original source during times of reduced precipitation under climate change). Indicators which can reveal high risk of lock-in for infrastructure are levels of capital investment, encouraged by sector growth, high fixed capital costs, long asset lifetime, and the inability to retrofit existing technology. All of these apply to irrigation technology. However, the alternatives of counterfactuals to agricultural development through land and water resource management are limited, particularly given Rwanda's high poverty levels, high proportion of the population dependent on agriculture, and limited capacity to develop other sectors. As such, the investments in irrigation and terracing since 2009 are justified as a short/medium term bridge technology to provide crop productivity growth, a minimum level of household resilience to short term climate hazards (delayed rains or single failed seasons) and poverty reduction. Furthermore, through the recent Water Resources Management Plan the government has illustrated a commitment to the IWRM approach required to ensure cohesive water development and mitigate risks of competing demands. The lesson for future practice is the importance of considering potential climate resilience trade-offs in an explicit decision-making framework.

A further risk relates to the CIP selection of a limited number of crop choice and the low availability of new seed, which are tied to sector level preferences for marketable crops and a high risk-aversion for untested seeds. The government has prioritised planting of crops such as wheat and maize which are more in demand in the region, but also less well adapted to high levels of climate variability than traditional crops such as beans, cassava or banana (which are also CIP, but some planting displacement has occurred). In the context of existing variability, the potential for increased variability under climate change (particularly seasonal changes) and moving vectors for pest and disease, the sector is now more sensitive to the potential risks which will most severely impact CIP priority crops. Changing crops to more resistant varieties has a time-lag given market inefficiencies, farmer inertia and inappropriate skills, capacities and technologies.

The issue is exacerbated by a lack of seed varieties, certification and inefficiencies within the public sector seed market. An agronomist interviewee explained that risk aversion regarding seed varieties is common in Africa, and reflects political protectionism combined with inertia and vested interests. In Rwanda, the seed

market, and the need for research and innovation more generally, remains an under-developed policy area. However, despite the potential risks, CIP has made impressive gains in terms of poverty reduction through increased productivity, and the counter-factual of continued reliance on subsistence farming is not a realistic approach to poverty reduction. Certain agents are now pushing the diversification agenda, and in the medium term decision makers must embrace new seed varieties in order to hedge the risk of CIP, while also fostering ongoing sector diversification through export crops and livestock. More efficient and competitive agricultural markets, supported by improved research and innovation, will help to mitigate and correct this issue. Although the reliance on limited crops and seeds may seem easily reversible, it is also an immediate issue which must be addressed. Otherwise, the impacts of a failed season which disproportionately impacts a major crop such as maize can be devastating, resulting in a drop in incomes, reduced food stores, migration and a fall in GDP (see FEWSNET, 2012).

Finally, through ongoing reliance on agriculture, and the concentration of public sector investment, there is the potential to create economic and political lock-in which encourages path dependency, agglomeration and a cycle of continued dependence. However, the Rwandan government is taking notable steps in EDPRS II to move beyond agriculture for growth – to reform the business environment and foster market development and private sector investment, while also supporting growth of alternative sectors such as mining and tourism. This should facilitate the economic transformation towards a more diversified and resilient economy.

5. Conclusions

Key findings

Two decades after the war, Rwanda has demonstrated impressive development results in terms of GDP and income, driven by a broad-based agricultural and aid led economic model. Since President Kagame's succession in 2000, government policy, through implementation in close partnerships with donors, has focused on reforming the foundations of Rwanda's economy: its natural resources and key input materials which support agriculture (land, water, production), and the employment and skills of the population engaged primarily in subsistence livelihoods, to move towards a more commercial sector. By combining sub-sector transformation with inclusion of marginal groups, Rwanda has managed to drive down both poverty and inequality (income and gender based), while other development indicators such as health and education have improved. However, Rwanda's rapid development faces many challenges, which could be amplified by climate change. Socio-economic systems remain inextricably linked to agricultural production. At the national level, economic growth, value addition and exports are determined by seasonal production. At the household level, most Rwandans still rely on primary production, selling small amounts of surplus or farm labour to support themselves. This requires analysis in the context of resilience to existing and future climate variability and hazards, as the agricultural sector is highly affected by climate related variables.

This case study has explored historic development patterns in terms of sectoral and geographic trends tied to agricultural transformation. Since 2000, the Rwandan government has pursued a programme of transformation across the agricultural sector and the broader economy, under EDPRS I and II, the National Agricultural Policy, PSTA I to III and the CIP. This development agenda has resulted in growth of agricultural production and productivity, driving up food security, but GDP growth remains coupled to agricultural growth and value addition of the agricultural sector is low, which disproportionately affects value addition of the economy as a whole. Investment in physical infrastructure has increased the area of land under soil conservation and infrastructure, while investment in targeted sector interventions which also benefit the poorest has resulted in agricultural-driven poverty reduction. These development patterns have had mixed effects on the resilience framework of exposure, sensitivity and adaptive capacity. The trends for exposure are not positive, as the sector is highly exposed to climate risks. Sensitivity presents mixed results. Increased productivity reduces sector sensitivity, while increased incomes can reduce household sensitivity, but conflating factors related to longer term impacts of certain decisions (crop choice and irrigation lock-in) result in a mixed risk profile. In terms of adaptive capacity, innovations such as farmer training and DRRM planning through insurance, food stores, EWS and market information supports the sector's capacity to manage and mitigate disaster, while investment diversification within agriculture and across the economy provides a macro-economic buffer and drives structural transformation.

As a result, although Rwanda is still exposed to current and future climate risks, this analysis suggests that overall the agricultural sector, and therefore both the economy and households are more resilient to climate variability. With EDPRS II, Rwanda will experience more rapid development. The government, through

continued effective partnerships with DPs to build institutional capacity, must capitalise on its best practice to build resilience for the economy, its sectors and poor people, while also reducing dependence on primary agriculture and external assistance, to strengthen Rwanda's pathway to climate resilience.

Policy implications

This case study has identified key policy lessons:

- Targeted packages of agricultural interventions which combine land management, inputs and farmer training can result in increased productivity
- Increased productivity of staple crops combined with government efforts to store and manage production can support domestic food security which reduces household and national level sensitivity to climate variability
- Increased productivity and commercialisation of agriculture can support growth and poverty reduction if agriculture is the dominant economic sector
- If the most vulnerable groups in society disproportionately work in a particular sector (e.g. agriculture), supporting that sector is an effective method to build their climate resilience
- Aid financing can complement public sector investments to support high growth rates and social protection, e.g. through agricultural programmes targeting the poorest and landless, to ensure positive distributional effects
- However, some interventions e.g. those required to support productivity growth have a more mixed effect on resilience, for example crop specialisation, limited varieties and investment in capital intensive assets
- Farmer education improves adaptive capacity and can allow for more rapid uptake of new technologies, mitigating the potential risks of specialization
- DRRM planning can support adaptive capacity to manage and mitigate the impact of disasters including insurance, storage (national and household level), a strategic food reserve, disaster/climate management planning (EWS) and assignment of responsibilities across stakeholders
- Investment in market related systems including market information, roads, market centres and investment partnerships (including leveraging greater involvement of the private sector) can facilitate sub-sector diversification, and a broader economic shift towards secondary and tertiary economic sectors, off-farm jobs, livelihood diversification and reduced dependence on primary production for GDP growth, trade and employment
- Many policy interventions will involve trade-offs, some of which could also 'lock-in' certain development pathways - policy makers should be aware and explicit about these throughout decision making processes
- As such, information plays a crucial role for building resilience strategies and avoiding 'lock-in' - data around climate and hydrology is required to plan and make appropriate investment decisions for irrigation and IWRM, while social impact and gender assessments contribute to targeted and effective evidence-based policy making with positive distributional impacts

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- It is important to adopt cross-sectoral and integrated approaches to tackle the ‘wicked’ problems associated with poverty which also affect resilience, such as entrenched gender inequalities, extreme poverty and stunting
 - With economic diversification and growth, reduced exposure or sensitivity to climate hazards can introduce new risks (market and reputation) - policy-makers must consider integrated risk hedging for changing risk profiles
 - Although current and future climate risks are important, sometimes socio-political and economic risks will demand more urgent action, for example the need to reduce poverty and ensure domestic security.

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UN - <https://data.un.org/>

World Bank - <http://data.worldbank.org/indicator>
- <http://www.doingbusiness.org/rankings>
- <http://iresearch.worldbank.org/PovcalNet/>

List of Organisations Consulted in Rwanda:

Centre for Tropical Agriculture	Ministry of Finance and Economic Development
European Union	Ministry of Infrastructure
Food and Agricultural Organisation	United Kingdom Department for International Development
Global Green Growth Initiative	United States Agency for International Development
International Fertiliser Development Corporation	World Bank
Ministry of Agriculture and Animal Resource	World Food Programme
Ministry of Environment and Natural Resources	Independent Consultants



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Overseas Development Institute
203 Blackfriars Road
London SE1 8NJ
Tel +44 (0)20 7922 0300
Fax +44 (0)20 7922 0399

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