



Challenges to scenario-guided adaptive action on food security under climate change



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ABSTRACT

This paper examines the development and use of scenarios as an approach to guide action in multi-level, multi-actor adaptation contexts such as food security under climate change. Three challenges are highlighted: (1) ensuring the appropriate scope for action; (2) moving beyond intervention-based decision guidance; and (3) developing long-term shared capacity for strategic planning. To overcome these challenges we have applied explorative scenarios and normative back-casting with stakeholders from different sectors at the regional level in East Africa. We then applied lessons about appropriate scope, enabling adaptation pathways, and developing strategic planning capacity to scenarios processes in multiple global regions. Scenarios were created to have a broad enough scope to be relevant to diverse actors, and then adapted by different actor groups to ensure their salience in specific decision contexts. The initial strategy for using the scenarios by bringing a range of actors together to explore new collaborative proposals had limitations as well as strengths versus the application of scenarios for specific actor groups and existing decision pathways. Scenarios development and use transitioned from an intervention-based process to an embedded process characterized by continuous engagement. Feasibility and long-term sustainability could be ensured by having decision makers own the process and focusing on developing strategic planning capacity within their home organizations.

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1. Introduction

Climate change is a significant driver of change for food security in the developing world, because it threatens food production and its stability as well as other aspects of food systems such as storage, food access and utilization (Wheeler and Von Braun, 2013). The impacts of climate change interact with other change dynamics across economic, political, temporal and biophysical dimensions and from local to global levels (Ericksen et al., 2009). These changes are marked by uncertainties that confound attempts to develop linear and unilateral policies (Funtowicz and Ravetz, 1993; Kriegler et al., 2012; van der Sluijs, 2005).

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Facing these uncertainties are actor groups operating in different sectors and at multiple levels, with often widely divergent interests (Ingram et al., 2010). The challenges around ensuring sustainable food security are systemic, and therefore require system-wide actions from decision-makers (Ericksen et al., 2009; Vermeulen et al., 2013). For instance, national policies, global food prices, or competition between land use types may restrict or enable adaptation for local actors such as small-scale farmers or poor urban communities (Mandemaker et al., 2011). Similarly, a lack of local-level mechanisms and resources for adaptation and innovation can make large-scale policies or investments ineffective (Bourgeois et al., 2012).

There is an increasing recognition of the urgent need for science focusing on food security in the developing world to overcome its relative inability to play a role in decision-making that leads to positive impact (Vermeulen et al., 2013). This need is now broadly recognized by stakeholders providing support for development and adaptation research. They are urging researchers to critically re-examine how their work seeks to engage decision-making and practice. In the context of adaptation planning, social-ecological systems science has the potential to help decision makers consider a wide range of interacting stressors and to help them explore adaptation pathways (Folke et al., 2010). However, a number of challenges exist for such research to make a difference. First, attending to what is the relevant scope for collaborative action for actors with diverse perspectives is important. There is a need to engage stakeholders at different levels and from different sectors with diverse and often contesting types of expertise, experience, values and interests, between whom power differences exist and who have incentives to behave strategically (Flood and Jackson, 1991; Jasanoff, 2004; Kristjanson et al., 2009). The perceived credibility, legitimacy, salience and timeliness of science changes depend on the actor groups involved (Cash et al., 2003; Ostrom, 2010). Secondly, rather than focusing on single interventions and single adaptation actions, researchers should engage decision-makers in a demand-driven fashion to help co-manage change along continuously adaptive pathways, attending to diverse and shifting contextual challenges (Kristjanson et al., 2009; Reid et al., 2009; Stafford Smith et al., 2011). Finally, there is a need to develop long-term capacity for collaborative decision making. Attempts to guide actors and decision-making from different sectors and across different system levels can run into serious feasibility challenges when the aim is to develop shared strategic capacity in the longer term (Gibbons, 1999; Wilkinson and Eidinow, 2008).

This paper presents an effort to tackle these challenges through the development and use of explorative multi-stakeholder scenarios (Wilkinson and Eidinow, 2008) around agriculture and food systems at the sub-continental level in multiple global regions initiated by the CGIAR, a global agricultural development partnership (Vermeulen et al., 2012, 2013).

The objective of this paper is a critical appraisal, based on iterative learning, of the potential of multi-stakeholder scenarios for decision-making to overcome the above challenges in agriculture and food security in the face of climate change interacting with other stressors at multiple levels. We will first provide a theoretical background on scenarios development and use, with a specific focus on the role of scenarios in a multi-stakeholder, multi-level, multi-dimensional context (Section 2). Initial results from the development and use of scenarios for East Africa will be presented (3), followed by the lessons learned through that process and how these lessons have been applied in multiple global regions (4). Finally, we will discuss these learning steps and their outputs, and what they show about the ability and challenges of scenarios development and use to tackle the challenges of scope and collaboration, engaging in adaptation pathways and developing long-term strategic capacity (5).

2. Concepts: the development and use of scenarios in multi-level, multi-stakeholder contexts

Explorative scenarios are defined here as “multiple plausible futures described in words, numbers and/or images” (van Notten et al., 2003). Scenarios methodology is based in systems science and seeks to recognize and explore uncertainty and complexity in the decision-makers’ context rather than limiting or simplifying that context with the pretence of providing a single forecast when such prediction is not possible (Kok et al., 2006; van der Sluijs, 2005). More linear sense- and decision-making processes that do not incorporate multiple scenarios still have underlying assumptions about the future, effectively operating from a single scenario that is not examined. This failure of traditional planning to engage with uncertainty has proven to be problematic in complex systems (van der Sluijs, 2005; Wilkinson and Eidinow, 2008).

In multi-stakeholder contexts, exploratory scenarios can engage multiple legitimate perspectives involved in framing and addressing messy challenges such as food security and sustainability (Reilly and Willenbockel, 2010). Bourgeois et al. (2012) give an extensive overview of scenarios used in the context of agriculture and food security. Scenarios generated by groups of stakeholders will naturally be biased towards the perspectives of those groups (Schoemaker, 1993). In addition, there may be aspects of future developments that the groups have difficulty exploring or producing, such as biophysical processes (e.g. climate change) or detailed land use change dynamics responding to international markets. Quantitative simulation modelling can provide a complementary perspective against which stakeholders can test their ideas about plausible futures. Simulation modelling has several benefits for this purpose. It can outline the scenarios in numbers that can be used for more concrete analysis of the consequences of the scenarios, as well as the impacts of policies, investments and strategies tested against the scenarios. Simulation modelling can test the coherence of stakeholder assumptions and help point out contradictory elements in the scenarios. Through the application of a consistent set of assumptions, simulation models can generate counter-intuitive effects of the scenarios not originally imagined by the participants. However, simulation models are characterized by their own assumptions about systems. Whereas exploratory scenarios, developed as narratives and other formats, are able to incorporate a wide range of different factors and interactions, the scope of simulation models is pre-defined. Moreover, the models are developed in reference to the past and present and may not be able to adequately represent transformative scenarios (Reilly and Willenbockel, 2010). Therefore, stakeholder-generated scenarios can and should also challenge the assumptions of models.

Explorative scenarios are suited for the exploration of multi-dimensional and multi-level aspects of decision contexts (Herrero et al., 2014; Wilkinson, 2009). Zurek and Henrichs (2007) outline different ways in which scenarios processes as well as scenarios themselves can be integrated across geographical levels.

A number of researcher-generated explorative scenario sets, notably the SRES scenarios (Nakicenovic, 2000) and the *Millennium Ecosystems Assessment* (2005) scenarios, have been adapted across multiple geographic levels and yet their use in decision-making has been limited (Wells et al., 2006). The combination of exploratory scenarios with normative back-casting can link contexts to decision pathways (Kok et al., 2011; Robinson et al., 2011). Normative back-casting is distinct from explorative back-casting used to develop explorative scenarios. Both types of back-casting work from an end point back to the present. However, normative back-casting starts with a desired goal and then works out what needs to happen before that goal is achieved, until the present is reached. Normative back-casting has been used by

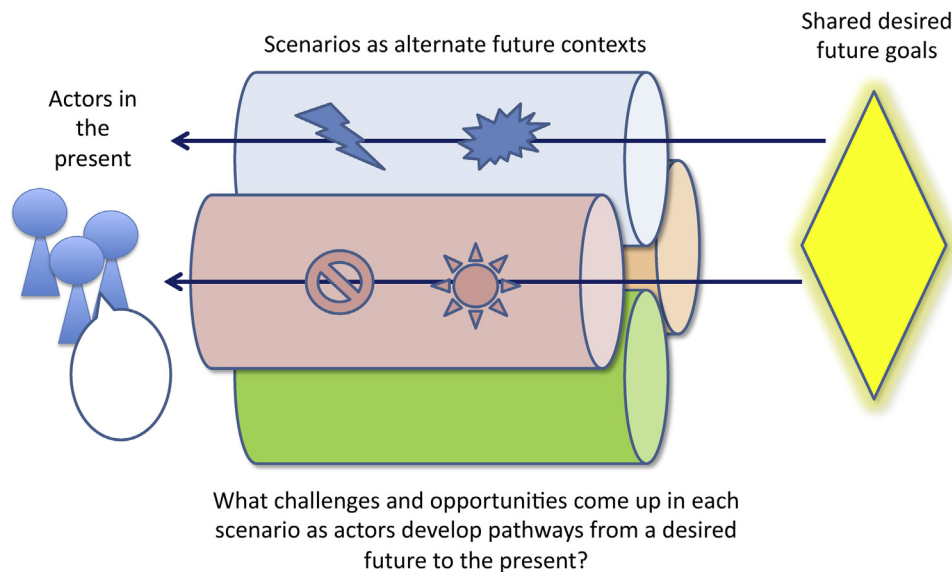


Fig. 1. Using scenarios to develop adaptation pathways through “back-casting” from a shared vision, encountering different future challenges and opportunities in each scenario.

Kok et al. (2011) and Robinson et al. (2011) in conjunction with explorative scenarios. By combining explorative scenarios and normative back-casting, decision-makers create what could be described as normative decision scenarios within contexts outlined by explorative scenarios, thereby exploring decision pathways in the context of multiple plausible futures that each offer different challenges and opportunities (Fig. 1). This way, robust or flexible decision pathways can emerge that take a number of contingencies into account. The combination of plausible explorative scenarios about decision contexts and the normative back-casting of decision pathways can also be adapted to examine the feasibility of existing policies, investment plans or strategies. An alternative to the attempt to separate explorative and normative elements in scenarios development and use is the generation of normative scenarios, which does not offer clear contexts for adaptation planning but can capture diverse discourses and worldviews (Moss et al., 2010; Reilly and Willenbockel, 2010).

Though explorative scenarios have shown utility in the context of decision-making in complex socio-ecological systems (Bourgeois et al., 2012; Kok et al., 2011), challenges remain. The development and use of scenarios is associated with difficulties that relate to our three challenges. First, exactly because explorative scenarios processes seek to address broad factors of change and take a holistic systems view of decision contexts, they may be perceived as being far removed from actions to be taken unless and until they are used directly in planning (Bourgeois et al., 2012; Kriegler et al., 2012; Reilly and Willenbockel, 2010; Wells et al., 2006). Secondly, scenario development often happens in intervention-style processes that may not be tailored to diverse stakeholder demands, or compatible with the need to develop longer-term adaptation pathways that deal with evolving multi-dimensional challenges because they focus too much on single actions (Berkes and Folke, 2002; Wilkinson and Eidinow, 2008). Finally, multi-stakeholder scenarios processes can be costly and time-consuming, while familiarity with such methods may be low among decision-makers. Co-ownership of such processes by decision-makers, and a focus in scenarios processes on developing the internal capacity of planning bodies to develop and use scenarios themselves as a sustainable skill, is often missing (Kok et al., 2011).

3. Methods and initial results in East Africa

Processes to develop explorative scenarios and use them to guide various decision pathways through normative back-casting have been initiated in multiple focus regions in the Climate Change, Agriculture and Food Security programme, selected for a high vulnerability of agricultural systems and food security to climate change. These regions are East Africa, West Africa, South Asia, Southeast Asia, Central America and the Andes region. The development of scenarios was initiated first with stakeholders in East Africa from Ethiopia, Kenya, Uganda, Tanzania, Rwanda, Burundi. The initial results from East Africa generated lessons that were applied to further work in East Africa and in similar processes in the other regions. The main steps of the process are stakeholder-driven explorative scenario development, the quantification of such explorative scenarios through multiple models, and the use of the scenarios through normative back-casting to evaluate decision pathways with different user groups.

3.1. Scenarios development: initial results

In East Africa, explorative scenarios were developed at the regional level to examine key uncertainties for agriculture and food security under climate change. Over two regional-level workshops, stakeholders from regional research organizations, governments and civil society focusing on agriculture, food security, environmental change and economic development generated qualitative scenarios and made assumptions for quantification. The overall topical scope agreed by the stakeholders was “the future of agriculture, food security, livelihoods and environments in East Africa” – later specified further to a number of indicators (see Table 1 and Appendix A). Stakeholders saw 2030 as the appropriate horizon for the scenario time lines. The “deductive”, two-axes approach was used to frame the scenarios (Van der Heijden, 2005). This approach entails that stakeholders identify key factors of future change, decide which of these factors are most uncertain as well as most relevant to the scope of the exercise, and produce two axes that each represent two plausible future states for a factor. The combination of these axes produces end states for four development pathways for contextual factors in four distinct scenarios.

Table 1

Indicators of interest outlined by the participants in the East Africa scenarios development process. An × indicates which of these indicators are either produced by the models or used to provide inputs into the models. See Appendix A for directions of change outlined for these indicators by the participants.

Scope of indicators for scenarios	Model inputs	Model outputs
Gross domestic product	×	
Corruption		
Political stability		
Infrastructure	×	
Urbanization		
Yields for rain-fed crops	×	
Yields for irrigated crops	×	
Area for rain-fed arable land		×
Area for irrigated arable land		×
Livestock numbers		×
Livestock yields	×	
Calorie availability per capita per day		×
Regional production of commodities		×
Regional demand for commodities		×
Import and export of commodities		×
Agricultural input costs	×	
Nutrition		
Dietary diversity		
Poverty		
Equity		
Access to health care		
Land use change		×
Biodiversity		
Emissions		×

One uncertain and relevant factor according to participants was the question whether East Africa will integrate economically and politically, or end up maintaining its fragmented status quo. Another uncertain and relevant factor according to participants was whether pro-active or reactive governance by state and non-state actors with regard to the specific issues of agriculture and food security, livelihoods of the rural poor and environmental degradation would dominate in the region. Initially, climate change was treated the same across all scenarios, given the relative certainty around this driver up to 2030 perceived by stakeholders based on [Jones and Thornton \(2009\)](#). Similarly, with a time horizon up to 2030 the participants assumed that the different scenario pathways did not have diverging impacts on population, which was therefore kept constant across the scenarios and followed the United Nations 2010 projection ([United Nations Population Division, 2010](#)).

The initial features of each scenario were developed into narratives by breakout groups in the first workshop, and subsequently developed into 10 page narratives by the breakout groups between the first and second workshop. A second workshop was organized to review and refine the scenario narratives – a process that the breakout groups again continued after the workshop.

The four scenarios generated for East Africa are as follows, illustrated in [Fig. 2](#). 'Industrious Ants' is a world where state and non-state actors are proactive and committed to regionalization. This scenario has many benefits for food security, environments and livelihoods, but new challenges emerge around an active

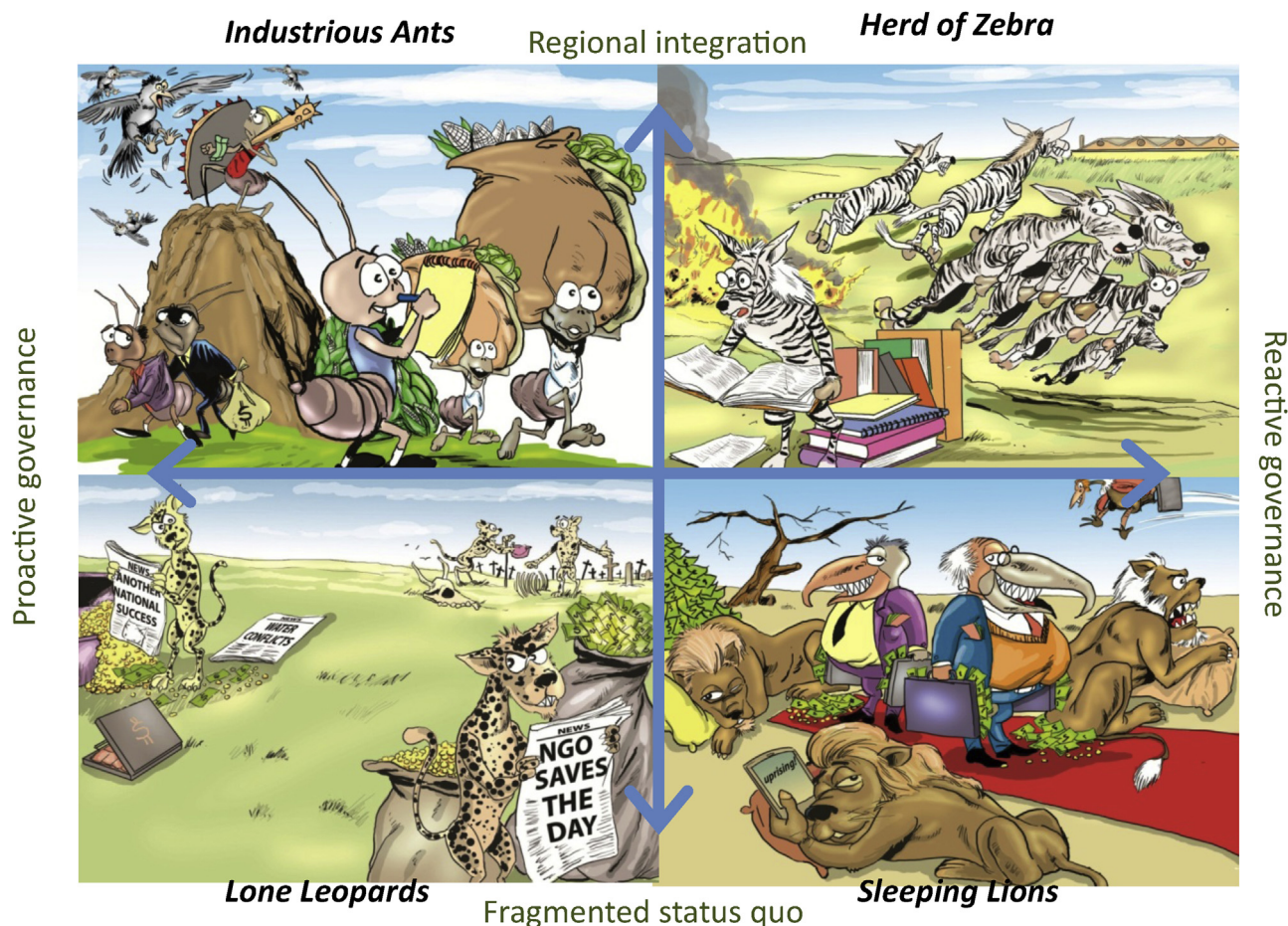


Fig. 2. The key uncertainties that structure the East Africa regional scenarios, with visual summaries of the scenario narratives by cartoonist Mauvine Were. See Appendix A for textual summaries and indicators.

struggle with corruption and the consequences of a regional push for autonomy in the global arena. 'Herd of Zebra' is a world where regional integration has developed, but the focus is mainly on industrialization and economic growth and little attention is given to food security, environments and livelihoods until crises occur. Inequality characterizes the region. 'Lone Leopards' is a world characterized by fragmented but proactive governments and non-state actors that achieve scattered though sometimes strong and fast successes; however, there is much mistrust among countries and organizations, and the region is marked by political and economic instability. 'Sleeping Lions' is a world that sees self-interested governments and non-state actors turning a blind eye or profiting from regional and international exploitation of land and resources. This leads to public unrest time and time again, but never to structural change. Appendix A provides more extensive summaries of the scenarios.

3.2. Explorative scenarios as suitable contexts for decision-making

When scenarios are designed not to be standalone products, but to be part of an active use process such as combining explorative scenarios with normative back-casting, the choice can be made to separate plausible, explorative "what may happen?" futures from normative "what decision-makers want to achieve" scenarios as much as possible (Kok et al., 2011). This way, explorative scenarios are only about contextual factors that decision-makers have no direct control over, to allow users space to freely consider their (normative) objectives and pathways towards those objectives under a range of different plausible futures (Robinson et al., 2011). However, the decision space differs depending on the actor: for instance, a rural village has a decision space that is different from the East African Community. Moreover, if the contextual, explorative scenarios are too far removed from a given actor's decision space, for instance only describing global-level factors without detailing regional responses, they may lose salience to that actor. The process organizers aimed to ensure appropriate decision spaces for users of the East Africa scenarios. First, in the use of the scenarios, on a case-by-case basis, decision-makers were given the opportunity to first adapt the scenarios to be plausible and salient from their perspective. Secondly, the basic scenarios were further developed with the stakeholder group to explore possible unintended consequences of scenarios that might at first glance be considered purely desirable from the perspective of many users, and to explore the opportunities offered by scenarios that might be considered purely undesirable. For instance, in the Industrious Ants scenario, East African actors struggle with the formulation of policies aimed towards developing independent regional food production, while in Sleeping Lions there is a vitalization of civil society.

3.3. Quantifying scenarios

Two models were chosen to quantify the East Africa explorative scenarios: the International Model for Policy Analysis of Agricultural Commodities and Trade (IMPACT) (Nelson et al., 2010) and Global Biomass Optimization Model (GLOBIOM) (Havlík et al., 2011). These are both global partial equilibrium models, which means that they are not simulating entire economies but instead focus only on markets related to agricultural products. Each model has different features. IMPACT is designed to examine alternative futures for global food supply, demand, trade and prices, while GLOBIOM is designed to provide policy advice on global issues concerning land use competition between major land-based production sectors. While IMPACT and GLOBIOM are global models, they are being modified to enable specific regional applications to be simulated.

These two models were chosen because together they covered some significant elements of the scenarios in complementary ways

(Table 1). Compared to the qualitative scenarios, however, the scope of the models is relatively narrow. Both models are most detailed on the production side of food systems and while they feature demand, intermediate elements of food systems are not detailed. As partial equilibrium models, they do not address general economic development (gross domestic product and population are exogenous). The two models do not simulate differences between socio-economic groups. They also do not offer information on agriculture as a source of livelihoods. Environmental change indicators are restricted to agriculture-driven land use change. Furthermore, both models are designed to explore long-term trends and do not currently take short-term variability or shocks into account (Fuss et al., 2011). These characteristics of the models have consequences for how their results can and cannot be used and communicated (Section 3.4). These models were chosen because they have elements of other models (general equilibrium models, broader integrated assessment models, pure land use change models) but provide more detailed information on the production, demand and trade of agricultural commodities. However, expansion of the quantification of the scenarios into other model types has been a goal (see Section 4.1).

To provide stakeholder-generated inputs into the models, a third workshop was organized. This workshop was also an opportunity to involve a broader diversity of expertise as indicated by the original participants, including social scientists and representatives of the media. Because in comparison to the qualitative scenarios, the two models only produced part of the indicators of interest to the participants, the process organizers and participants agreed that a broader set of semi-quantitative indicators would be outlined, determined by the scope of the scenarios rather than the models. This way, scenario users are provided information about directions of change even for indicators that are not part of the model simulations, and can serve to inform other model types for further quantification. Table 1 provides the full list of indicators and highlights those either used as inputs for, or provided as outputs from, the models.

Participants provided what they thought were the directions and magnitudes of change for each indicator over multiple time steps, and provided the logic for these changes from the relevant scenario narrative. Capturing the logic behind each change helps interpret further analyses using the scenarios as well as the quantitative model outputs. Semi-quantitative assumptions provided by the stakeholders were then translated into fully quantified driver inputs for gross domestic product, yields, different production systems, infrastructure and production costs and land use policy, referencing historic data and using the Food Security, Farming, and Climate Change to 2050 scenarios analysis of the International Food Policy Research Institute (Nelson et al., 2010) to compare assumptions.

A first set of outputs was generated by the two models and presented to a representative group of participants from the explorative scenarios development process. Any comments on the plausibility of the model results in the East African context were taken up and used to adapt the drivers for a new run. Appendix B provides results and insights from the revised outputs.

3.4. Using scenarios to enable adaptation pathways

The East Africa scenarios were used in normative back-casting in a regional-level workshop in Arusha, Tanzania with state actors (20 policy advisors from diverse departments, representatives of regional governance bodies, the Eastern African Community and the Lake Victoria Basin Commission) and another regional workshop in Nairobi with non-state actors (22 civil society, NGOs, representatives of farmers' and agricultural entrepreneurs' associations). By starting with separate meetings between government

actors on the one hand and non-state actors on the other, the process allowed each of these groups to make their strategic positions clear and to show where each group needed the other.

In each workshop, participants were asked to review the scenarios on (1) plausibility and (2) relevance to their decision contexts, and to adapt them to improve the scenarios on these criteria. This was done by having the original scenario narratives plotted on a timeline that included dimensions on socio-economic changes, food security, livelihoods and environments, and then asking participants to remove, replace or add elements of the scenarios.

These changes could not be reflected in the model results, though trends from the models were general enough to provide room for multiple interpretations. The model results were used mostly as reference in discussions when numeric information was required, while the adapted scenario narratives were the central focus of the exercises. The presentation of the model results and the main insights they generated (Appendix B) was done in a plenary session that focused on how the models related to the narratives and the differences between the two models. As an example, Appendix C shows the policy advisors' stated responses to the model results. In the meeting itself, the discussion of the model results largely focused on clarifying that these results were explorative rather than forecasts, and illustrative of some key elements of the scenarios rather than covering their entire scope (Appendix B). Time was spent highlighting and discussing key limitations of the models such as a lack of a connection between agricultural production and income and the lack of short-term variability in the results.

Having adapted the scenarios, participants re-examined previously collectively and broadly defined normative goals in small groups with the aim of coming up with concrete 2030 objectives and plans for themselves and their organizations, i.e. what each could contribute in order to achieve, together with fellow participants, these joint objectives. Following this, each of the groups assigned to a particular scenario was asked to back-cast from these more concrete objectives to determine what previous steps were needed (in 2025, 2020 and further backward) to achieve them. However, the development of these reverse pathways did not happen in a vacuum, but in an adaptive fashion with regard to contextual challenges and opportunities offered by each adapted scenario. This way, each scenario challenged the participants' ideas about how to get to their specific goals by asking them to find alternative pathways or to reframe their goals. Industrious Ants offered opportunities for regional development not currently available, and therefore challenged participants to think beyond current 'crisis-mode' problem solving, as well as how to deal with new problems related to regional corruption and regional autonomy. A key factor in this scenario was the assumption that the full benefits of regionalization would take a long time to be realized, and that regional institutions also meant slow decision-making processes. Policy makers who were seeking to effect change in the Herd of Zebra scenario stood relatively alone, and civil society, non-governmental organizations and social entrepreneurs had very few government resources to draw upon except for funds related to larger development, which meant that the framing of activities would be important. Lone Leopards allowed policy advisors and non-state actors to consider solutions at the national level where action could be taken relatively effectively compared to the regional level. On the other hand, the relative lack of regional collaboration meant that there was much to be improved at this level. Finally, Sleeping Lions provided very few options, with a reactive, fragmented East Africa – and therefore both policy advisors (isolated in this scenario) and non-state actors were challenged to consider alternatives and focus on unorthodox partnerships and bottom-up strategies.

The pathways developed in the context of different adapted scenarios were evaluated in terms of their feasibility in other

scenarios. In some cases, pathways developed in scenarios with more favourable conditions than others were not transferable to those with less favourable conditions. In most cases, though, core ideas could be implemented across multiple scenarios, but the pathways to achieve them would have to be different – resulting in an analysis of a range of feasible pathways towards improved food security and environmental change depending on the need to adapt to different future conditions.

Table 2 summarizes vulnerabilities identified using the scenarios in both the state and non-state workshops regarding the governance of East Africa for future agriculture, food security, livelihoods and environments under climate change, and proposals developed to tackle these vulnerabilities. The table shows under which scenarios these proposals were considered to be feasible. Generally, Industrious Ants offers the most favourable conditions for decision-making while Sleeping Lions is the most restrictive, but both scenarios have a mix of challenges and opportunities. This mix is especially pronounced in the Lone Leopards and Herd of Zebra scenarios, where on the one hand certain types of policy appear favourable but on the other hand gains can be made by going against the regional gain.

The proposals emerging from the normative back-casting received statements of support from diverse non-state organizations, the different ministries and regional bodies. There was also an identified role for the Climate Change, Agriculture and Food Security programme to provide science and for convening actors in a number of the proposed actions. In addition, the Forum for Agricultural Research in Africa and the African Climate Policy Centre both showed interest in supporting their own organizations and the government ministries they were working with to develop the capacity to use scenarios for strategic planning purposes.

4. Applying lessons on suitable scope, guiding decision-making and developing longer-term capacity

Insights from the East Africa process were used to shape scenarios processes in the other focus regions where scenarios processes were conducted (West Africa, South Asia, Southeast Asia, the Andes region, Central America) as well as subsequent stages in East Africa.

We improved the suitability of explorative regional scenarios sets as decision contexts for diverse actors, and the usefulness of scenarios methodology and engagement in general through a number of steps. The first step was to provide a more inclusive scope for the general regional scenarios sets. The second step was shifting to a model of demand-driven, active support for flexible adaptation and reinterpretation of the regional scenarios in order to use them for regional, national, sub-national and sector-specific decision processes. The third step was to focus on longer-term development of the internal capacity of diverse regional actors to develop and use scenarios.

4.1. Extending the scope of the regional scenarios

Several changes were made in response to requests from multiple actors to extend the scope of the sets of explorative scenarios, making them more useful to a wide range of potential users.

4.1.1. Extended time line and combination with climate scenarios

In East Africa and West Africa, scenarios were originally developed up to 2030 following participants' bounding of the processes. However, subsequent users of the scenarios in both regions wanted to use scenarios up to 2050 and see the socio-economic scenarios directly combined with climate scenarios. With this time horizon, the combination of socio-economic scenarios and

Table 2

Institutional vulnerabilities identified by non-state actors and policy advisors in the East Africa back-casting workshops, and summaries of proposals developed to overcome each of these vulnerabilities. The table shows the feasibility of each proposal in a given scenario, summarizing a possible pathway to enable its implementation.

Vulnerability	Collaborative proposal	Industrious Ants	Herd of Zebra	Lone Leopards	Sleeping Lions
(1a) The observer's role of the East African Farmer Federation in East African Community policy means that there is not enough of a direct link between farmers' issues and priorities and decision-making	(1b) Proposal: organize processes with specific regional bodies for the East Africa Farmers Federation to have a more proactive voice in agricultural and food security policy processes	Conditions for improving this vulnerability are most favourable; though efficiency is challenging and conditions are expected to improve only slowly	Regional platforms exist but little support is available for agricultural development. Guiding investments is more challenging and has to be related to large-scale commercial agriculture	Conditions at the national level are supportive but no regional platform – East Africa Farmers Federation to focus on supporting national-level farmers' voices and coordinate regionally	The East Africa Farmers Federation are largely left to their own devices and plan accordingly, working with select individuals, bottom-up communities and international organizations instead
(2a) The lack of knowledge exchange between ministries within countries and between countries at the regional level in East Africa	(2b) Proposal: exchange programmes on farmer's schools associations, linked to "farms of the future" programme; on indigenous, alternative crops; rural–urban agriculture	Regional conditions are supportive of knowledge exchange, but developments are slow and this programme should be at the forefront to turn regional integration on paper into a reality	Much effort needed to make regional policy makers see need for such a programme, which is not a priority. Therefore, the need for regional integration is more urgent. Start with small example case studies	Exchange at a national level is stimulated. Regional exchange is blocked – though this proposal can be used to break down regional barriers	In Sleeping Lions this proposal has to rely on working with unorthodox networks of individuals and on incremental development
(3a) The lack of effective collaboration between civil society, social entrepreneurs and governments on agriculture and food security	(3b) Proposal: a series of meeting to explore state/non-state partnerships and compatibilities for climate adaptation is to be organized, as well as training to build the capacity for collaboration	Funding opportunities and institutional arrangements are available. Faster action requires those looking to make connections to set the example	Aim to find ways to make use of mechanisms for state/non-state collaboration that exist primarily for big business	Non-state actors can link with governments at the national level; make connections across borders that are difficult for governments in this scenario	Actors who seek active improvement of rural conditions have work with civil society. Civil society organizations must help get exceptional individuals into offices
(4a) Vulnerability: a lack of links between Early Warning Systems for food security at the regional level, and a lack of a connection to any regional food reserve	(4b) Proposal: linking existing Early Warning Systems for food security to regional food reserve planning	Regional food reserve planning coupled with Early Warning Systems will easily be accepted in this East Africa, though implementation will be slow	This scenario relies strongly on imports. It will be a challenge to get such an idea funded, and it may end up on paper only unless the need for Early Warning Systems is framed correctly to get private sector support	National food reserves are easily strengthened and linked to Early Warning Systems. Regional coordination of resources will be a political challenge	Any development of regional reserves and Early Warning Systems will be under stress from political instability and corruption. Support from outside the region, at the global level, may be key
(5a) Vulnerability: A lack of institutional transparency and problems of corruption	(5b) Proposal: help progress towards regional ombudsperson for the East African Community collaboration with the East African Business Council; council of ministers and regional ombudsman	This proposal is feasible, but the challenge will be to make it effective and to avoid it from being undermined as time goes on	It would prove challenging though not impossible to establish this council, though few resources will be available and the framing should be focused on large economic development	There will be almost no institutional structures to build on. At a national level, it will be easier to ensure transparency of governance which can then be developed further to the regional level	Establishing a governing body against corruption would be most needed and least likely to be successful. Setting up small topical commissions within ministries was proposed which can set a good example, supported from the bottom up and global level
(6a) Vulnerability: climate information systems are not effective, and not integrated with other sources of information, with consequences across scenarios	(6b) Proposal: create multi-sector climate information for meteorological services, agriculture sector ministries, the Climate Prediction and Application Centre, African Union and the Economic Commission for Africa	The actors involved in this proposal could utilize the beginnings of improved regional collaboration and be ahead of the change to provide an example to speed up integration around climate information systems	Actors involved in this proposal can try to find large-scale commercial uses of climate information and find investment there in a social entrepreneurship approach that also benefits vulnerable rural communities	National-to-local organization of climate information is feasible. Large-scale investment in regional coordination is not, but information networks can still be established	Absence of available investment at a national/regional level; funding from outside the region combined with bottom-up efforts by farmers' organizations might be the only way to enable provision of climate information

Table 3

Uncertain scenario factors outlined for South Asia resulting in scenarios (scenario names tentative). Here, a combination of 6 factors was used instead of 2 to provide a broader framing of the scenarios with a view to adaptability.

Tentative scenario name	Knowledge, education, information (human capital)	Governance and institutions	Science, technology and innovation	Political stability and conflict	Economic structure	Demography
<i>Union of South Asia</i>	Aware, informed, educated population	High institutional capacity and high coordination across agencies	High transfer and availability of science and technology	Political stability in the region	Agricultural sector is not dominant	Low population growth and medium urbanization
<i>Jugad</i>	Unaware, uninformed, uneducated population	Low institutional capacity and low coordination across agencies	Low transfer and availability of science and technology	Political instability and conflict in the region	Agricultural sector is dominant	High population growth and high urbanization
<i>Unstable flourishing</i>	Aware, informed, educated population	High institutional capacity and high coordination across agencies	High transfer and availability of science and technology	Political instability and conflict in the region	Agricultural sector is dominant	Low population growth and medium urbanization
<i>People Power</i>	Aware, informed, educated population	Low institutional capacity and low coordination across agencies	High transfer and availability of science and technology	Political instability and conflict in the region	Agricultural sector is not dominant	Low population growth and medium urbanization
<i>Precipice</i>	Aware, informed, educated population	Low institutional capacity and low coordination across agencies	Low transfer and availability of science and technology	Political instability and conflict in the region	Agricultural sector is dominant; informal urban economies	Medium population growth and medium urbanization

climate scenarios in a quantitative manner also became relevant. Though climate variability is relevant before 2030, it is only after 2030 that climate scenarios start to diverge in longer-term trends that significantly impact agriculture and food security as represented by IMPACT and GLOBIOM. Therefore, 2050 became the time horizon for scenarios in all regions. The scope of quantification has been expanded because of the activities of new process co-organizers that are interested in and capable of extending that scope. This includes land use change modelling (Schaldach et al., 2011), risk simulations (Antón et al., 2013), household modelling (van Wijk et al., 2012) and a model that simulates shocks on food prices and livelihoods (WFP, 2011).

4.1.2. From a two-axes approach to outlining the scenarios through multiple factors

The use of the two-axes approach was seen by a minority of users as having a restrictive scope and an overemphasis on some factors over others, based on observations during the back-casting workshops. For this reason, an alternative approach was used in South Asia, Southeast Asia, the Andes region and Central America that generated diverse sets of scenarios based on four to six factors instead of two (Bourgeois et al., 2012). Table 3 shows the factors used to generate five scenarios for South Asia. Both methods still go on to outline a wider range of factors for each scenario. We have found that the prominence of more factors in the scenario definition, besides providing more basic structure to the development of the scenarios, has been perceived by many participants to generate an inclusive and adaptable scenarios sets, while the two-axes approach could communicate the differences between the scenarios more directly.

4.1.3. Linking all sets of regional scenarios to a single set of global scenarios

Finally, the Shared Socio-Economic Pathways, global explorative socio-economic scenarios generated by the global environmental change community related to the Intergovernmental Panel on Climate Change (Kriegler et al., 2012; Moss et al., 2010) were used to guide the quantification of the scenarios in all regions. First, the regional stakeholders provided the basic logic of the regional scenarios. Drivers for the IMPACT and

GLOBIOM models were chosen by comparing driver inputs from the regional scenarios with those used in the global Shared Socio-economic Pathways for each region. This helped determine where the regional scenarios were similar and where they differed from the assumptions of the global scenarios, and why. The link to global-level scenarios makes the regional scenarios comparable to other case studies, including scenarios processes in the same programme generated in other regions. This allows for a global, multi-region analysis of the scenario sets generated by stakeholders in different regions. Furthermore, it allows for the regional scenarios to function as a bridge that translates between global scenarios and national or local decision-making.

4.2. Using explorative scenarios to guide diverse adaptive decision pathways in a demand-driven fashion

Initial results of using the scenarios in East Africa indicated that there are limits to normative back-casting processes that seek to include many actors together in a single process for the formation of new collaborative decision pathways. This approach was shown to help establish new links between participants that did not work together previously (Appendix C) and to bring up proposals for change (Table 2). However, the weakness of using a shared planning for many stakeholders is that such a shared process generates new, additional plans and is not necessarily attuned to existing decision-making processes. Therefore, the likelihood that the plans resulting from such a process will be implemented is not high and opportunities may be missed to guide existing planning processes. Therefore, a more demand-driven approach was established that focused on more specific groups of stakeholders and existing decision-making processes. On-going engagement was organized in a service style, rather than through a single intervention. This shift prompted several changes as outlined below.

4.2.1. Moving quickly from the development of scenarios to using the scenarios in a diversity of planning processes

The need to improve the ability of the regional scenarios processes to respond to the existing knowledge needs of focused

Table 4

Processes conducted or proposed by regional stakeholders to guide institutional change, policy and investment in their region. The table includes the collaborative back-casting described in Section 3.4, but also outlines policy processes with specific actors at the national level as well as at the regional level.

Examples			
East Africa	Regional level: state and non-state actor workshops and implementation of regional proposals (as described in Section 3.4)	Tanzania: review of food security policies organized by European Commission-funded project TransMango on the future of food in Europe in a global context	United Nations Environment programme World Conservation and Monitoring Centre to commission Uganda, Rwanda, Burundi policy guidance on trade-offs and synergies between agricultural development and conservation
West Africa	Economic Community of West African States: regional investment strategies, capacity building in futures methodology	Mali: review of National Adaptation Plan of Action	Ghana: Testing results of adaptation research programme in the context of scenarios with national policy stakeholders platform
South Asia	Pakistan: Pakistan-based Leadership for Environment and Development non-profit organization to convene policy guidance process on food security under climate change	Bangladesh: review of National Adaptation Plan of Action supported by the Asian Development Bank	India: Backbone Implementation Network (Planning Commission of Indian Government) policies on food security under Climate Change facilitated by Yes Bank, a development bank
Southeast Asia	Regional level: United Nations Environment programme World Conservation and Monitoring Centre to lead policy guidance on trade-offs and synergies between agricultural development and conservation	North Viet Nam: United Nations Food and Agriculture Organization to organize process for policy guidance and investment into Climate Smart Agriculture proposals	Cambodia: regional scenarios coordinator to lead revision of National Adaptation Plan of Action

groups of stakeholders had consequences for the timing of the process. The emphasis in each process was shifted from time spent on the development and review of explorative scenarios to time spent on exploring diverse opportunities offered by regional actors for using, and therefore experimenting with and improving, the regional scenarios. The East African scenarios process made clear which steps could be made more efficient or removed, making it possible to reduce the process of scenarios development for the programme as it expanded into Southeast Asia, the Andes region and Central America to a single, condensed workshop. The testing and revising of the scenarios was envisioned to happen through using the scenarios in actual planning processes, rather than through tinkering in an extended development process. This way, the usefulness and quality of the scenarios could be evaluated and improved in real situations while encouraging a critical perspective on the scenarios by users in those case studies. In the single workshop, regional factors of change were outlined and combined to produce diverse scenarios, narratives were established, and key indicators and model inputs quantified.

In addition to the development of scenarios, a session in this single-workshop model was organized to ask participants to identify decision-making processes that could be guided by adapted versions of these regional scenarios. Participants were asked to provide very concrete information, including opportunities for the funding of such adaptations and uses of the scenarios in each case. Across six global regions, 81 such opportunities were identified by participants, with 23 taken forward initially. Table 4 shows examples of such cases for the use of the regional explorative scenarios by specific stakeholder groups.

4.2.2. Adapting the regional scenarios to the needs of different user groups

The shift from using scenarios for collective normative back-casting aimed at potential regional-level policies and interventions, to a more demand-driven process led by decision-makers has led to proposals developed by stakeholders in the six regions focusing on national and sub-national policies as well as those from specific sectors. This has had implications for the methodology used to adapt the regional scenarios across levels and sectors.

In the East African non-state and state-focused back-casting workshops, the first step followed the principle of letting new users of scenarios adapt these scenarios to enhance their plausibility and relevance. It also served to create a sense of

ownership of the scenarios by these participants, who removed, replaced or added elements to the scenario narratives. This worked because the same geographic level was being considered.

When the scope of a group of actors differs more, e.g. when national and local level decision-makers are brought together, a more complete translation is necessary. Adapting the scenarios in such cases was done by first outlining a set of relevant indicators for a specific scope that is of interest to the actors involved in the case. For instance, a local-level case study might have specific indicators related to the dominant local forms of agriculture, local infrastructure and local power structures, among others. Then, participants interpret what each broader regional scenario means for that specific set of indicators, specifying directions of change using a semi-quantitative scale and describing the narrative logic for the change, the volatility of the indicator, their level of agreement about the change in this indicator in the scenario, their self-perceived ability to say something meaningful about the indicator and what additional expertise and sources should be used to develop it further. Trials with this approach for East and West Africa showed that this works as long as the scenarios are interpreted flexibly and some case-specific factors that have no direct link with the broader scenarios are also incorporated (Antle and Nelson, 2013).

4.2.3. Shifting to an on-going engagement model based on regional expertise

The move to multiple stakeholder-identified applications of the scenarios for decision guidance in existing decision processes shifts the organization of the process away from an intervention-based model to a model of continuous engagement (Reid et al., 2009; Selsky and Parker, 2005). The initial back-casting workshops in East Africa highlighted that such meetings should be the beginning of longer-term partnerships to have impact. Workshops (over several days) are not necessarily the most effective approach for engaging the highest-level decision-makers who are in the best position to turn the ideas generated into actions.

The shift to continuous engagement has implications for the organization of the structure of the scenarios process in terms of expertise. In the early stages of the East Africa scenarios process, the engagement with stakeholders was largely driven by method experts not embedded in regional policy networks. The recognized need for continuous, day-to-day engagement to ensure effective partnerships with decision-makers to address real issues has meant

that in all regions, more of the process organization has been shifted to regional coordinators who are experts on the regions and linked into regional networks. This approach, though more resource-intensive, increases the likelihood that opportunities for the scenarios to be used in decision-making are taken forward.

4.3. *Developing long-term ownership and strategic capacity*

The scenarios process to date has continually involved the researchers who have designed and led the process in each region. Our lessons in East Africa, however, led to a shift in focus towards providing demand-driven support to diverse specific decision-making processes that various regional actors are involved in. This has raised questions around the feasibility in terms of resources, the ownership of such processes, and the longer-term capacity that they develop. For a scenarios methodology to be a feasible and sustainable tool for decision-makers in the longer term, the ownership of such processes, and the capacity to implement them, should ultimately be increasingly with the home organizations of the decision-makers themselves.

4.3.1. *Creating co-ownership of decision guidance processes*

To ensure feasibility and ownership, the organizers of the scenarios processes presented in this paper have sought to use their own resources to generate the regional scenarios (so that the basic decision-making tool is available), with possible contributions from partners, and then let national entities (such as the Leadership for Environment and Development non-profit organization in Pakistan), regional bodies (such as the Economic Community of West African States) and global institutions (such as the United Nations Food and Agriculture Organization) take the lead on various opportunities for decision guidance (Table 4). Several elements important to help establish this co-ownership have been recognized. The degree to which those involved in organizing the process are involved in relevant networks determines how many opportunities for co-ownership of scenarios processes are recognized and pursued. The addition of regional coordinating experts to the team organizing the scenarios processes is an example of this. Additionally, the degree to which partners' objectives and ideas about best practice are similar to the organizers of the scenarios programme has proven a relevant factor for collaboration. Those partners co-owning the scenarios processes have stated that the combination of stakeholder-driven explorative scenarios and quantitative exploration of those scenarios combined with the use of these scenarios focused on normative (policy, investment, institutional) objectives is what interests them. Related to this point is the early involvement of potential partners in scenarios development to generate co-ownership of the content. Finally, publicity and media generated interest in the methods and results from potential partners.

4.3.2. *Developing internal capacity in decision-makers' organizations*

To ensure a longer-term strategic capacity among decision-makers to develop adaptive decision pathways, there is a need to develop internal familiarity with scenarios methodology within their organizations. Following the processes described in this paper, many local, national and regional actors have requested aid with developing such internal expertise further. Of particular note is the request by a number of farmers' organizations worldwide for help in developing internal expertise on scenarios methodology to help strategize and dialogue with other actors about farmers' futures. The teams involved in the scenarios processes outlined in this paper, together with the Global Forum on Agricultural Research' Global Foresight Hub, have provided time to help develop this internal capacity with farmers' organizations through trainings and methodological backstopping.

5. Discussion and conclusions

The development and use of explorative scenarios is not about the capacity to provide solutions to known problems but rather the development of capacity to produce and structure anticipatory knowledge (Wilkinson, 2009). Decision processes that do not take the uncertainty associated with contextual changes into account miss a context against which to explore adaptive decision pathways (Kok et al., 2011; Robinson et al., 2011). This includes processes that use normative back-casting exclusively without applying that method in the context of multiple scenarios. Conversely, processes that only develop explorative scenarios but do not actively use them may not be able to guide decision pathways. Rather than using one method, the combination of explorative scenarios and normative back-casting aims to use the strengths of multiple methods in a complementary fashion (Flood and Jackson, 1991). However, it is important to recognize that the approach presented here is only one of many potential ways to integrate explorative and normative elements into planning (Flood and Jackson, 1991). The Agrimonde (Paillard et al., 2011) scenarios use an alternative approach – these two scenarios are normative. From the perspective of adaptation, they integrate context and actor actions, which in our view make them less useful for active planning. However, they offer fundamentally different internal logics based on different worldviews and discourses, which means that each scenario has a fundamentally different scope.

This case study has generated clues on how to ensure appropriate scope, move to continuous engagement and ensure the future longevity of scenarios work in multi-actor, multi-level contexts. However, our challenges have far from disappeared.

In terms of providing an adequate scope, though the explorative scenarios used in East Africa are adaptable and include multiple dimensions of food systems, they still emphasize the production dimension, especially the quantitative elements with regard to the largely production-oriented models (Bourgeois et al., 2012). Broadening their qualitative and quantitative scope requires new types of expertise and methods. Similarly, the challenge to make the assumptions of simulation models more flexible and less past-oriented remains. For example, iterative learning between models and stakeholder-generated content can be taken further to propose changes to model structures and scope. There is a challenge of informing higher-level explorative scenarios through bottom-up processes. For the process described in this paper, this challenge works both ways. Local-to-national level processes can inform the regional scenarios. The regional scenarios can in turn inform global scenarios to conduct a global-level analysis of contextual challenges and opportunities for food security across the developing world, based in the perspectives of regional actors (Kriegler et al., 2012).

In terms of enabling adaptation pathways, the focus on collaborative proposals used in East Africa assumes that such collaboration is desired or possible between different actors, but in many cases it may not be (Flood and Jackson, 1991). So far, the engagement of state actors and non-state actors in normative back-casting processes has provided the first steps for these different groups to overcome the unwillingness they initially reported about working together and consider collaborative action. However, the explorative scenarios have not yet been used to foster collaboration between actors that are diametrically opposed or antagonistic, though scenarios methodology has been used for conflict resolution (Kahane, 2010). After the initial East Africa experiences with normative back-casting in multi-stakeholder platforms, the shift of focus to the policies of specific organizations and government places less emphasis on collaboration between multiple actors and more on a diversity of efforts (Ostrom, 2010). If feasible, we would encourage that both types of

engagement are pursued: the focus on specific policies (such as national adaptation plans) provides “lower hanging fruits” and can offer successful case studies. On the basis of these examples, new decision pathways with less precedence and involving new combinations of stakeholders (such as a constellation of ministries, the media and regional research organizations) can be developed and potentially be used to resolve conflict.

In terms of developing internal capacity for strategic planning beyond the lifetime of the project, the research presented in this paper has worked from the assumption that it is important to stimulate stakeholders to take ownership of the process. This could overcome the divide between scenario developers and users observed in other attempts to generate useful food security scenarios (Reilly and Willenbockel, 2010). However, explorative scenarios and normative back-casting methods have a steep learning curve (Schoemaker, 1993) and more effort is needed to help develop decision-makers’ facility with such methods to the point where they become part of daily decision-making practice where up to now more linear planning models dominate. Decision-makers in all regions described in this paper have emphasized this need. New tools for training, education and experimentation are therefore needed to enable familiarity with the development of explorative scenarios and their use in decision guidance through back-casting and other methods. That way, research organizations can shift from driving scenarios processes, to process facilitators, to a position where they are mainly providing methodology and science support to internal experts in decision-makers’ organizations and platforms. A key solution could be offered by online learning tools that formalize scenarios methodology in an accessible way (Vervoort et al., 2010), especially if they can be based in social learning principles (Kristjanson et al., 2014).

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Appendix A. Supplementary data

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