



Do participatory scenario exercises promote systems thinking and build consensus?

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Abstract

Participatory scenario processes are associated with positive social learning outcomes, including consensus-building and shifts toward more systemic thinking. However, these claims have not been assessed quantitatively in diverse cultural and socio-ecological settings. We convened three stakeholder workshops around the future of agricultural development and rural livelihoods in Burkina Faso, Nigeria, and Malawi, using a participatory scenario generation process to examine proposed research and action priorities under conditions of uncertainty. We administered pre- and post-workshop surveys, and used a paired t-test to assess how stakeholders' rankings of research priorities changed after participating in the scenario visioning exercise. Workshop participants also listed their own priorities for research and implementation on both the pre- and post-survey forms. We found indications that the workshops promoted consensus-building around the research priorities, including a reduction in standard deviation of priority rankings post-workshop compared to pre-workshop; and a higher incidence of identical volunteered responses. We did not find evidence to support shifts in thinking to more systemic views of agricultural development. However, participants viewed themselves as having learned throughout the process. We conclude that scenario visioning does have the potential to foster consensus-building (one element of social learning) among diverse stakeholder groups. We urge researchers to continue to monitor and measure systems thinking outcomes from scenario visioning so that these processes may be designed to be more effective.

Introduction

Agricultural development in sub-Saharan Africa is currently grappling with complex environmental and social challenges that defy a traditional, technocratic approach to research and planning. Examples include climate change (Parry et al., 2005; Vermeulen et al., 2012); persistent low yields and soil degradation (Licker et al., 2010); rapid population growth and resulting changes in land tenure and land use (Boserup, 2005); and political and economic transitions. These challenges have led many development and food security scholars to call for an approach to decision-making that embraces stakeholder engagement and planning in the face of uncertainty (Cash et al., 2003; Vermeulen et al., 2013).

Scenario exercises can provide a framework for this type of engagement and planning under highly uncertain future conditions (Kahane, 2012). A scenario is a "structured account of a possible future." (Peterson et al. 2003, p.360) Scenarios describe futures that could plausibly happen, rather than predictable outcomes. They are particularly useful when making plans or decisions in the context of unpredictable and uncontrollable 'game-changing' events which could alter the future state of a system (Swart et al., 2004). Scenarios which are generated by stakeholders themselves rather than by scientists or quantitative models are uniquely well-suited to participatory planning and group exploration of the future of a complex system (Kok et al., 2011). Recent scenario planning exercises around agriculture in Africa include planning and development strategies in Tanzania (Enfors et al., 2008); and the Climate Change, Adaptation and Food Security scenario planning activities conducted by the Consultative Group on International Agricultural Research (CGIAR) Future Scenarios research team in East and West Africa (Vervoort et al., 2014).

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Scenarios and social learning

One of the posited benefits of participatory scenario visioning methods is their ability to promote social learning. Social learning is a type of feedback process in which individuals learn from a group process, and this individual learning in turn enhances group knowledge (Reed et al., 2010). In the environmental domain, the concept of social learning is central to the fields of community-based natural resource management (Bouwen and Taillieu, 2004) and adaptive management (Berkes, 2009), because group planning under uncertainty is a crucial part of these management approaches. In the field of agricultural development, scholars such as Pretty (1995) and Chambers (1997) have long called for social learning to take place jointly between scientists and stakeholders when developing research and management priorities.

Scenarios are often cited for their use in promoting social learning when applied in a participatory context, as they provide a forum in which stakeholders from different sectors can exchange information and perspectives on complex problems (Schmitt Olabisi et al., 2010). This allows participants in the scenario process to learn about how others experience and comprehend the systems in which they are commonly embedded, laying the groundwork for future collaboration (Schusler et al., 2003). There is an abundance of anecdotal evidence from the literature that participatory scenario processes promote social learning. These claims are usually supported by the self-reporting of the workshop participants, who often enjoy the experience of participating in the scenario activity and claim to have learned from their peers and from the process itself (Albert et al., 2012; Johnson et al., 2012). Observations of social learning have also been recorded by facilitators and scientists involved in the scenario process, who report that group discussions are qualitatively different at the end of a scenario workshop compared with the beginning (Wollenberg et al., 2000). However, quantitative evidence that learning has taken place during a scenario exercise is largely absent from the scenario literature. Our objective for this study was to find indications that social learning can result from participation in scenario exercises. Below, we discuss the specific elements of social learning which were relevant to our study context.

Scenarios and systems thinking

Systems thinking is one element of social learning which may be fostered by scenario exercises. Schoemaker (1993) describe scenario planning involving multiple scenarios as one tool which may encourage 'systemic thinking'. Enhanced systems thinking is one of four types of social learning outcomes proposed by Johnson et al. (2012) which may be assessed in a participatory scenario workshop (others are appreciation of others' perspectives, new or enhanced social relationships, and anticipated behavioral impacts and outcomes). Systems thinking is arguably easier to assess in an immediate post-workshop setting than enhanced social relationships or behavioral impacts, which could take months to years to manifest post-workshop.

Systems thinking may be defined as the ability to comprehend dynamism and complexity, which together constitute systems behavior (Meadows, 2008). While there is still no broadly accepted definition of systems thinking in the context of scenario planning, Savage and Ward (1998) and Chermack (2004) propose that systems thinking is characterized by understanding the "whole" in addition to the components of a system; and seeing interrelationships and patterns rather than isolated events. The system dynamics modeling literature, which has also attempted to assess learning in a complex systems context, proposes similar aspects of systems thinking, including comprehending the whole rather than parts; understanding interconnections and feedback; understanding dynamism; and understanding how system structure generates system behavior (Forrester, 1994; Hmelo-Silver et al., 2008; Hopper and Stave, 2008).

Scenario planning exercises help to promote systems thinking by encouraging participants to think of the future in complex and dynamic terms (Schmitt Olabisi et al., 2010; Schoemaker, 1993). By considering multiple plausible futures that may result from actions taken in the present, scenario planners consider the dynamic long-term behavior of current system structures. In addition, participants in the scenario process learn about how others experience and comprehend the systems in which they are commonly embedded, thereby experiencing the system from multiple perspectives for a more holistic view (Schusler et al., 2003). Scenario exercises also encourage participants to consider future states that represent a dramatic break from current trends, thereby promoting understanding of non-linear behavior which is common in complex systems (Swart et al., 2004). Glick et al. (2012) found evidence that scenario planning improves participants' systems thinking skills, as indicated by shifts in their mental models observed post-scenario exercise.

In this study, we measured participants' ability to think systemically by their relative ranking of the effectiveness of actions taken at the systems level (the broader agricultural sector) compared with the individual farm level. If scenario exercises indeed promote systems thinking, post-workshop participants should be better able to understand how the complex system that is the agricultural sector in each country determines outcomes for farmers and farm-level processes.

Scenarios and consensus building

We also wished to assess the efficacy of the scenario process for group consensus-building. Scenario exercises are often lauded for their ability to promote consensus among diverse groups of stakeholders around priorities for research and action (Palomo et al., 2011; Schmitt Olabisi et al., 2010), yet this claim has been contested (Kallis et al., 2006), and has not been tested empirically in different cultural and ecological contexts. Consensus-building requires feedback between group and individual processes. Stakeholders must examine their own priorities, consider the priorities of others in light of future uncertainty, and come to a conclusion about the most urgent course of action. In an uncertain and complex planning context in which multiple stakeholder groups are involved, building consensus around a common set of actions is an important but potentially elusive goal. One of the strengths of participatory scenario processes is their deliberate emphasis on divergent views of the future (Johnson et al., 2012; Patel et al., 2007). In this way, they are different from other types of mediated processes that primarily seek common ground. Scenario exercises ‘expand to focus’, an important aspect of the process.

Examining specific claims of systemic learning and consensus-building will help scientists and facilitators design scenario workshops and other processes for planning in the face of uncertainty. We developed the following hypotheses to test over the course of three scenario workshops held in different countries in sub-Saharan Africa:

- (1) Participatory scenario visioning workshops build consensus around research and management priorities among diverse stakeholder groups.
- (2) Participatory scenario visioning workshops shift participants’ mental models of effective management and research strategies (Glick et al., 2012). In particular, they lead participants to prioritize strategies that involve systemic interventions over farm-scale interventions.

Methods

Overview and research priority development

The scenario research in Burkina Faso and Nigeria was conducted in collaboration with the International Crops Research Institute for the Semi-Arid Tropics, which coordinates the Dryland Systems research program for West Africa. The Dryland Systems research program is one of the cross-cutting research programs for the CGIAR network. The scientists involved in this program in West Africa have developed hypotheses to guide their work, and wished to test these hypotheses against a scenario process involving stakeholders from the regions in which the hypothesis-driven research would be implemented. The results of the scenario exercise in Burkina and Nigeria would therefore inform the implementation of the research priorities developed under the Dryland Systems program. In Malawi, we worked with the Africa RISING program to conduct a similar exercise. The research priorities tested in Malawi arose out of the country-specific project interventions developed by Africa RISING scientists and their stakeholder partners. In addition, a Bill and Melinda Gates Foundation project aiming to assess the potential for perennial grains in Sub-Saharan Africa provided support for the Malawi workshop. The results of the scenario workshops in Malawi therefore served to inform the Gates Foundation’s interest in perennial grain development. At all three workshops, we introduced the development of perennial cropping systems as a research priority for stakeholder ranking, consistent with the aims of the Gates project.

All three workshops therefore represented an opportunity to use stakeholder engagement through scenarios to evaluate research priorities identified by scientists. Both the Dryland Systems and Africa RISING programs have as an ultimate goal the sustainable intensification of regional farming systems, and the improvement of smallholder farmer livelihoods, although they operate in different regional contexts. In dryland West Africa (a region which encompasses Bobo-Dioulasso, Burkina Faso, and Kano, Nigeria, the sites of the two workshops), vulnerability to drought is a key concern, and cropping systems are relatively diverse, typically dominated by sorghum and millet. Rainfall follows a unimodal pattern, with the rainy season occurring in June through October. In Malawi, cropping systems are maize-based, and land availability is low. The rainy season in Malawi occurs from November to April. There is some evidence that climate change is creating a more erratic rainfall signal than previously experienced by farmers, contributing to low yields (Parry et al., 2005). In response, Africa RISING has been testing intercropping of maize with legumes for improved household food security and soil fertility, with some success (Snapp et al., 2010).

Workshop description

Stakeholders in each workshop were selected by in-country researchers working with either Dryland Systems (Burkina and Nigeria) or Africa RISING (Malawi). Invitees were chosen to represent diverse perspectives on agricultural development and included members of local government; non-governmental organizations; farmer organizations; extension services and development projects; the media; universities; CGIAR centers;

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Table 1. Occupations of participants at each workshop location (self-reported)

Burkina	Nigeria	Malawi
Forestry agent	Fabrication	Agriculture Crops Officer
Researcher (6)	Scientific officer (2)	Agriculturalist
Ph.D student	Teaching/research	Farmer (7)
Agricultural technician	Animal nutritionist	Irrigation Engineering
Trader	Farmer (4)	Student
Agricultural researcher	Farming/electrical	Agriculture Extension Officer (2)
Agricultural extension (2)	Engineer (2)	Land Resources Conservation Officer
Assistant administrator	Teaching/farming	Commodity Trade Manager
Plant breeder	Agricultural engineering (2)	Lecturer in Agricultural Extension
Farmer	Extension agent (3)	Monitoring and Evaluation Officer
Technical advisor for rural development co-ops	Teaching/research assistant	Accountant, Banker and Entrepreneur
Agroallied fabricator	CIP Researcher	Rural Development and Extension
Professor	Agronomist	Agricultural Extension
Agronomist (3)	Camera operator	Technical Officer Responsible for Quality Control and Assurance
Agricultural economist	Seed marketer/distributor (2)	Forest Management and Agro-Forestry Lecturer
Scientific officer	Civil servant (6)	Developmental Worker
Economist	Farmer/head womens' group	Extension and Rural Development Scholar
Producer	Farmer association	–
Research assistant	Journalism	–
Technician	–	–
Administrator	–	–

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and the private sector. Participants in the Burkina workshop were from regions of Mali, Ghana, and Burkina Faso that comprise a West-East research transect for the Dryland Systems program. Participants in the Nigeria workshop were all from the Kano region, with the exception of some CGIAR scientists. Most of these participants in the Burkina and Nigeria workshops worked at the district, or state, level. In Malawi, participants came from all over the country. A balance of male and female participants was sought, although female representation could have been greater at the workshops. In the Burkina and Malawi workshops, most attendees were housed on site for the duration of the workshop, while in the Kano workshop, some attendees were housed on site and others commuted from their homes to the workshop daily. Table 1 contains summary information about workshop attendees.

The scenario workshops used the (I)NSPECT process, which was developed by Richard Bawden to generate holistic scenarios with the goal of promoting flexible and resilient thinking about the future (Johnson et al., 2012). The (I)NSPECT process, as indicated by the acronym, walks participants through a consideration of the natural, social, political, economic, cultural, and technological aspects of the future as considered from their individual (I) perspectives. The most important outputs of the (I)NSPECT process are therefore not the scenarios themselves, which are merely a means to an end. Rather, outputs from the scenario process should include plans or a research agenda that is robust and successful in the broadest possible range of divergent futures. The (I)NSPECT process is described in detail in (Johnson et al., 2012) and (Schmitt Olabisi et al., 2010). Each workshop took place over three days, and included a scenario generation phase as well as an inhabitation phase (in which participants imagine themselves living in a scenario, and develop strategies to pursue their goals in the scenario) and a backcasting phase (in which participants discuss what research or management priorities could have been implemented in the present day to make coping with the future easier, no matter which scenario comes to pass). The focal question used for scenario elicitation was, “What do our agricultural systems look like in the year 2050, and how are rural people making their livelihoods?” (for the Burkina workshop, all materials, including the focal question, were also translated into French). Once the scenarios were generated, facilitators grouped them into loose categories using axes of change that emerged from the main drivers of the scenario dynamics. This represents a different way of using axes, as a post-scenario generation organization tool, rather than as a tool to constrain the scenario generation itself (Klooster and Asselt, 2006).

Survey instrument

We developed a survey instrument to elicit participant perceptions of the Dryland Systems Research Program and Africa RISING research hypotheses for West Africa and Malawi, respectively, which we framed as research topics, while simplifying the language (Appendix S1). The survey instrument was presented to participants in both French and English for the two West Africa workshops; for those who spoke neither, members of the facilitation team verbally translated the survey into Hausa, and recorded participant responses. Identical copies of the instrument were administered before and after the workshop, and participants were assigned a unique identifier to match these pre- and post- surveys. The purpose of repeating the survey was to test for mental model shifts generated by the scenario process, as measured by changes in the way participants understood their agricultural systems and the research needed to improve those systems.

As part of the survey, respondents were asked to rank research topics for their usefulness in promoting agricultural production and farmer livelihoods in their districts on a Likert scale from 1 ('extremely helpful') to 5 ('not helpful at all') in Burkina and Nigeria; and from 1 to 10 in Malawi. The lower the numerical ranking, therefore, the higher the priority. Workshop participants were also invited to write down other research priorities that they felt were important which were not included on the provided list. These priorities were coded and grouped into categories by the researchers.

We also classified the priorities in terms of whether they represented primarily on-farm benefits or systemic benefits (Table 2). All of these priorities, if adopted across the landscape, would obviously provide systemic benefits in addition to on-farm benefits, but we wanted to classify them in terms of how the stakeholders would understand them, so that we could monitor shifts towards more systemic thinking. Systemic priorities may not manifest immediately for the farmer but improve the system over the long-term. In Malawi, because of the workshop focus, perennial crops were discussed separately at the end of the workshop, and were not included in the survey instrument as they were in Nigeria and Burkina Faso.

T-test analysis

Two-tailed paired t-tests have been used to determine the statistical significance of the differences in the means of pre- and post-survey item responses in learning and scenario workshops (Glick et al., 2012). The t-test was applied to the survey respondents pre- and post-workshop using the same set of questions. This was to assess whether the differences in the means of pre- and post-survey responses were due to workshop effects or coincidental (Malinowski and Fortner, 2010; Robles-Morua et al., 2014). Therefore, to determine the shifts in the thinking of the three workshops' participants, using Excel, we conducted two-tailed paired-comparison t-tests of respondents' pre and post survey mean responses. We used only responses from (1) pre and post- surveys with identical unique identifiers, and (2) respondents who completed and returned both the pre and post workshop surveys. As a result, the sample sizes for the Burkina paired-comparison were n=20; Nigeria, n=16; and Malawi, n=24. Furthermore, we coded qualitative responses to each of the

Table 2. Priorities ranked by workshop participants during the pre- and post-workshop surveys, categorized according to whether they would provide primarily on-farm or more systemic (long-term, landscape-scale) benefits

Burkina and Nigeria	
On-farm priorities	Systemic priorities
Dual purpose crops (for food and fodder)	Enriching agro-biodiversity
Increased production from better tree/crop/livestock integration	Empowering disadvantaged groups (women, youth, migrants) in decision making, resources & technology
Improved access to markets	Effective water harvesting and management
Land tenure security	Strengthening local and national institutions, laws, bylaws and conventions
Improved access to credit, savings, subsidies, and insurance	Incorporation of indigenous knowledge in agricultural systems
Development of perennial crops	Development of perennial crops
Malawi	
On-farm priorities	Systemic priorities
Improving soil fertility	Managing post-harvest losses and food waste
Saving labor	Reducing erosion
Increasing maize yield	Water conservation and management
Increasing legume production	Diversifying farming systems
Developing disease and drought tolerant crops	–

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Table 3. Drivers of change and scenario titles identified by participants in the three workshops^a

Burkina ^b	Nigeria	Malawi
Drivers		
Pace of ag. development	Population pressure	Population pressure
Technology	Environmental concern	Land degradation
Shifting land tenure	Degree of ag. dev't.	Climate change
Cultural Change	Technology	Poverty
Environmental concern	Climate change	Decentralization of gov't.
Foreign investment	Environ. degradation	Political representation
Locus of ag. dev't.	Cultural change	Technology
	Youth unemployment	Cultural change
Scenarios		
Extreme Capitalism	The Effects of Bush Burning, Deforestation, Desertification, and Global Warming in Bukala ^c	Malawi at 86
A State for All Modernization of Agriculture	Had I Known ^d	Malawi in 2050
Sustainable Development	Something Has to be Done	<no title>
Advanced Technology and Prosperous Countryside	Future Nigeria Development	Chigumula ^e
West African Agriculture at a Crossroads	The More You Look, the Less You See	–

^aTerms in bold were selected by the facilitators as axes for differentiating the four scenarios used in backcasting and inhabitation exercises (see text for more detail).

^bAll terms from the Burkina workshop translated from the original French.

^cBukala is a village in the Kano region of northern Nigeria.

^dTerm translated from the original Hausa

^eMeaning 'flood' in Chewa, referring to a scenario of environmental destruction

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open-ended questions on the pre- and post-surveys to identify and analyze common patterns based on the frequency of occurrence of emergent specific qualitative patterns. We analyzed the responses to each of the open-ended questions individually.

Results

Scenario descriptions

Participants developed six scenarios in the Burkina workshop; five in the Nigeria workshop; and four in the Malawi workshop. The titles of these scenarios and the major drivers of change behind them are detailed in Table 3. As described in the methods section, facilitators chose two to three drivers of change in each location as axes for differentiating scenarios for the backcasting and facilitation exercises (Figure 1).

Two major drivers (cultural change and technology) were common across all three scenario workshops. Drivers common to two regions included population pressure, environmental/land degradation, and climate change (Nigeria and Malawi); and degree of environmental concern on the part of leaders and farmers (Burkina and Nigeria).

Agricultural development was seen as inevitable in the Burkina scenarios—there were no scenarios in which agricultural production and rural livelihoods 'regressed'—while there were at least some scenarios from Nigeria and Malawi which envisioned degradation, declining yields, and failing rural livelihoods. Drivers identified in the Burkina workshop were largely in the political, social, and cultural domains, while in Nigeria and Malawi the drivers were natural as well.

Survey responses

Overall, research priorities did not display significantly different rankings at the $\alpha = 0.1$ level according to t-test results in the pre-workshop surveys compared to the post-workshop surveys, with a few exceptions. These exceptions included dual-purpose crops, land tenure security, and empowering disadvantaged groups being ranked *higher* in importance after the Burkina workshop; and perennial crops being ranked *lower* in importance after the Nigeria workshop. No t-test results from the Malawi workshop were significant.

Land tenure security, improved market access, and water management were rated as the highest priorities in Burkina before the workshop (Table 4). Post-workshop, land tenure security, dual-purpose crops, and increased productivity from tree/crop/livestock integration were rated most important. In Nigeria, dual-purpose food

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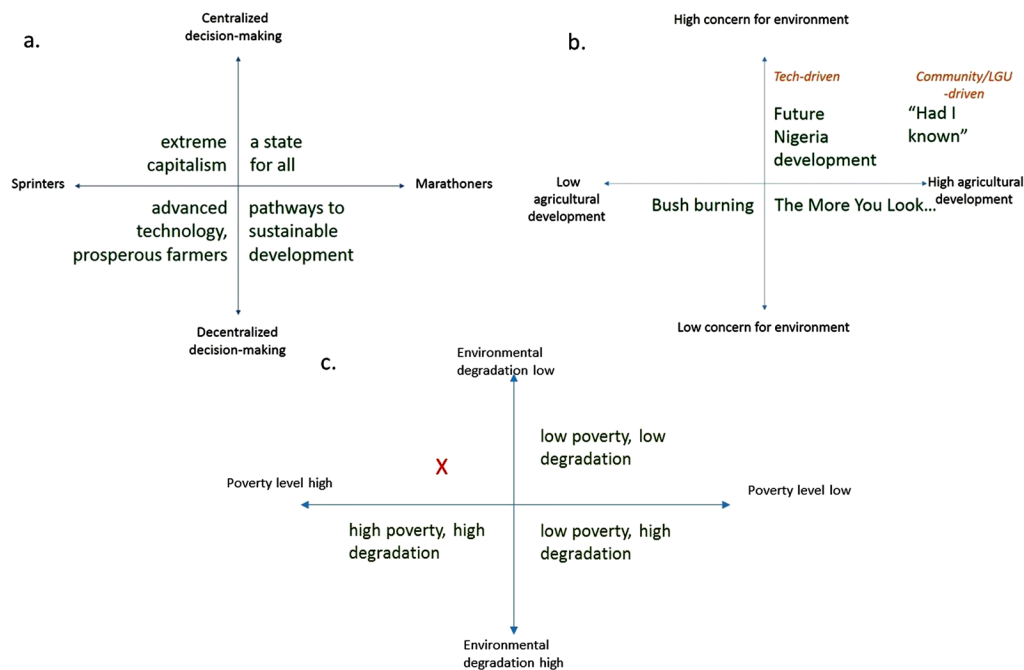


Figure 1
Scenario spaces envisioned by participants at the Burkina (a), Nigeria (b) and Malawi (c) workshops.

'LGU' stands for 'Local Government Unit' (a lower administrative level than the state level in Nigeria). The 'x' in panel C denotes a scenario space which workshop participants in Malawi did not deem plausible (high poverty, low environmental degradation). Therefore, it was not considered in the scenario analysis.

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and fodder crops, empowerment of disadvantaged groups, and tree/crop/livestock integration were ranked as most important before the workshop; after the workshop, water management was added to the top three priorities, while empowerment dropped out. In Malawi, soil fertility, erosion control, and diversification were the top priorities before the workshop. Post-workshop, water management was added to the top three priorities, substituting for erosion control.

A total of nine people listed 'youth mentoring' in the portion of the Burkina post-workshop surveys allowing open responses, while only one did so in the pre-workshop survey. Other priorities identified in Burkina post-workshop included research on fruit tree diseases; using urban/commercial waste as fertilizer; soil improvements; machinery/technology for small producers; pest management; and access to land. Pre-workshop priorities included soil restoration; weed management; use of urban waste; mechanization; and sustainable farming. Nigerian priorities pre-workshop included three general calls for research to help farmers; development of resilient crops; addressing climate change (2 responses); storage systems enhancement; market access (2 responses); small-scale mechanization; and political stability. Post-workshop, suggestions included more extension education dealing with risk; integrated crop management approaches (2 responses); improving rural amenities; attracting youth to agriculture; development of resilient crops; storage and value addition;

Table 4. Research priorities in rank order in each location before and after the scenario workshop^a

Burkina		Nigeria		Malawi	
Pre	Post	Pre	Post	Pre	Post
Imp. Access	Land Tenure ^b	Inc. Prod.	Dual-P Crops ^b	Soil Fertility	Soil Fertility
Land Tenure	Dual-P Crops ^b	Dual-P Crops	Inc. Prod ^c	Erosion	Diversification ^b
Water	Inc. Production ^b	Empowerment	Water ^b	Diversification	Water ^b
Inc. Production	Imp. Access ^c	Imp. Access	Imp. Access	Water	Crop Loss ^b
Institutions	Water ^c	Water	Credit ^b	Crop Loss	Erosion ^c
Dual-P Crops	Empowerment ^b	Perenn. Crops	Biodiversity ^b	Drought Tol	Drought Tol
Credit	Credit	Ind. Knowledge	Empowerment ^c	Legumes	Legumes
Biodiversity	Institutions ^c	Biodiversity	Land Tenure ^b	Inc. Yield	Inc. Yield
Ind. Knowledge	Biodiversity ^c	Institutions	Institutions	Labor	Labor
Empowerment	Ind. Know ^c	Land Tenure	Ind. Know ^c	–	–
Perenn. Crops	Perenn. Crops	Credit	Perenn. Crops ^c	–	–

^aPriorities in b rose in priority order after the workshop, while those in c diminished in priority post-workshop. See Table 2 for full priority descriptions.

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and climate change adaptation. In Malawi, these other stated priorities were similar before and after the workshop, with the exception that five people listed conservation agriculture as a priority in the post-survey, while only one did so in the pre-survey. Conservation agriculture is a set of practices which includes minimal tillage, agroforestry, basins, and manure application (Hobbs, 2007). Improved crop varieties, crop rotation, fiscal/monetary policy and 'alternative farming systems' were described as priorities in the pre-workshop survey but were not mentioned in post-workshop comments. Soil fertility management (as opposed to soil conservation), the use of scenario planning, and 'learning from past mistakes' were mentioned as priorities in the post-workshop survey, but not in the pre-workshop survey.

The standard deviation of priority scores was lower post-workshop compared to pre-workshop for seven out of ten priorities in Burkina (the exceptions were biodiversity, indigenous knowledge, and perennial crops). The top three research priorities post-workshop also achieved a higher share of the number one rankings compared to the top three research priorities pre-workshop in Burkina (42% compared with 37%). In Nigeria, standard deviation of priority scores was lower post-workshop compared to pre-workshop for all but one priority (increased production). However, the top three priorities received 39% of the number one scores post-workshop, and 47% of the number one scores pre-workshop. In Malawi, standard deviation of priority scores was lower post-workshop compared to pre-workshop for five out of nine priorities (crop loss, drought tolerance, legumes, diversification, and labor). The top three priorities accounted for 60% of the post-survey number one rankings, and fifty-four percent of the pre-survey number one rankings.

Discussion

The drivers and scenarios generated by the respondents in the three locations demonstrated considerable diversity, reflecting the different agricultural systems present. Most notably, participants in Nigeria and Malawi developed at least one 'negative' scenario depicting lack of development (or even a regression in agricultural production) and environmental degradation, while in Burkina no such scenario emerged. Nigeria and Malawi both face rapidly growing populations and increasing land pressure, which if poorly managed could lead to significant strain on productive resources (population and land/environmental degradation were key drivers that emerged from these workshops). In contrast, Mali and Burkina Faso have not faced such land constraints historically, although this could change in the future. Burkina participants seemed aware of this potential, ranking land tenure security as the most important priority post-workshop.

Given the different views of the future in the three countries, there was relatively little difference between them in terms of the systems thinking outcomes, or the consensus building outcomes. In all three locations, there is some indication that the scenario visioning exercises allowed participants to achieve greater consensus around research priorities in dryland systems (Burkina and Nigeria) and Malawi. This is demonstrated by the smaller standard deviations around priority rankings in most priority categories post-workshop compared to pre-workshop. It is worth noting that the priorities which demonstrate improved consensus were explicitly discussed in the workshop, in the context of the scenarios used for backcasting and inhabitation. For example, given that the Burkina scenarios universally described a future of agricultural development, discussion in this workshop centered around how smallholder farmers might be supported and empowered through agricultural development, and about how to mitigate the potentially negative impacts of development. Improved land tenure security, empowerment of female and young farmers, access to credit and markets, and institutional design were explicitly discussed as priorities which would allow small-scale farmers to reap the benefits of agricultural development and modernization. The Nigeria workshop featured lively debate around the role of the federal government in facilitating agricultural development. In Nigeria there was relative consensus on the importance of the research and implementation priorities described in the surveys, even as there was disagreement about who should implement them.

Malawian participants demonstrated a very high degree of consensus around visions of the future during the workshop—every scenario was virtually the same, and the facilitators had to push participants to generate divergent futures using the driver axes. For example, in the original set of scenarios there was no 'low poverty, high degradation' scenario in which development in Malawi comes at the expense of the environment. Given the high beginning level of agreement around Malawi's current situation and trajectory, it is not surprising that the degree of consensus achieved by the Malawi workshop was lower compared with Burkina and Nigeria, as measured by the number of priorities around which the standard deviation of ratings declined. In Malawi, the priorities listed by participants in addition to those provided by the researchers also demonstrated increased consensus, with a greater number of people listing a fewer total number of priorities post-workshop compared to pre-workshop. This was also true in Burkina, where there was a high consensus around facilitating youth involvement in agriculture post-workshop.

That the workshops apparently helped to achieve increased consensus around research priorities is especially remarkable given that the scenario workshops featured a diversity of thought and worldviews. In all three workshops, the diversity of participants and the opportunity to hear from diverse perspectives was cited

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by participants as a top strength in the workshop evaluation form. Building stakeholder consensus around scientific research priorities is an important outcome for scientists who want to do salient and credible research in a complex and uncertain context; these results suggest that scenario processes can help to facilitate this.

No significant pattern is present in any of the workshop locations in terms of shifted priorities. This is somewhat unexpected given that ‘learning’ was listed by participants as a major positive outcome in all three workshop evaluation forms. In Burkina, three of the four priorities that demonstrated lower scores (and therefore higher rankings) post-workshop compared to pre-workshop were on-farm rather than large-scale priorities. In Nigeria, two of the five priorities that gained in importance after the workshop were classified as on-farm. Malawi was the only location in which all of the research priorities that shifted in importance were large-scale as opposed to on-farm. However, these shifts were not large enough to be considered significant at the $\alpha = 0.1$ level according to the t-test. There is therefore no evidence to suggest that the scenario workshop process pushed participants to think at a larger scale or more systemically according to the metrics we analyzed.

Limitations of the study and further research

There are two reasons to believe that the metrics we used to measure shifts in thinking yielded incomplete results. First, it is possible that the participants viewed all of the research priorities as strong priorities, with clear benefits regardless of future conditions. If this were the case, participants would not necessarily change their thinking about these priorities, because the workshop would serve to further highlight their importance. There is some indication that this is the case—average priority scores across all priorities were lower (indicating increased importance) post-workshop compared to pre-workshop in Burkina and Malawi (although not in Nigeria). In addition, the discussion throughout the workshop naturally focused on several of the priorities, although the facilitators did not explicitly bring them up. This suggests that the thinking of the scientific teams that developed the priorities was fairly consistent with the stakeholders’ thinking, both before, during, and after the workshop. Furthermore, the priorities listed by participants themselves on the post-survey forms in all three locations were overall more specific and focused than they were on the pre-survey forms (for example, ‘conservation agriculture’ compared with ‘alternative agriculture’ in the Malawi post-survey; specific research goals rather than general calls to help farmers in the Nigeria post-survey). This suggests that the workshop may have helped participants to sharpen their thinking around effective strategies for enhancing agricultural productivity and rural livelihoods.

Secondly, there may have been shifts in thinking on the part of the participants that were not captured by the priority rankings. Participants may not have fully understood the meaning of the priority statements, even though the research team made an effort to convey them in lay language rather than their original scientific phrasing. For example, during the scenario discussions it became clear that most participants thought that ‘perennial crops’ referred exclusively to trees, when the researchers intended it to encompass legume and grain crops as well. Furthermore, many participants in the Nigeria workshop discussed at length the need for young people and women to get more involved with agricultural decision-making. In fact, this was a major theme of one of the scenarios, which featured a young man returning to the village and beginning to farm after failing to find employment in the city. However, ‘empowerment of marginalized groups’, which the researchers took to include women, young people, and ethnic minorities, was ranked higher (indicating a lower priority) post-workshop compared to pre-workshop. Future workshops might benefit from careful explanation of how each research priority is understood by scientists before participants have the opportunity to rank or comment on them—although facilitators would thereby run the risk of over-influencing the innate priorities of participants.

We recommend that further research assess learning during the scenario process using a more nuanced assessment tool. For example, interviews with participants pre- and post-workshop could elicit their mental models of research priorities and system drivers (Scott et al., 2013). Participants could also be asked for the reasoning behind the priority ranking, as this may have shifted during the workshop even if the rankings themselves remain the same. Transcription and coding of the workshop discussions, although time-consuming, could provide qualitative evidence of learning outcomes throughout the scenario workshop. Following up with participants over a longer time period would also reveal whether the effects of the workshop were transient, or whether they represented permanent shifts in consensus.

Conclusions

Participatory scenario processes have been hypothesized to facilitate social learning on the part of participants, but there is a need to test this hypothesis empirically. Focusing on two learning elements—systemic thinking and consensus-building—we found some indication that participants in three scenario workshops in sub-Saharan Africa emerged from the workshop with greater consensus and possibly greater clarity and focus around research priorities for the future. This is an important result, because processes that facilitate consensus building among diverse stakeholder groups are needed to generate research and management options that foster a shift to sustainability. We did not find consistent evidence that improved systems thinking occurred,

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as measured by a shift in participants' research priorities as a result of the workshops. However, the methods we used to assess learning, which consisted of simple priority rankings pre- and post-workshop, likely did not capture the nuances of the learning process which participants experienced. In all three workshops, participants stated that 'learning' was a strength of the workshop process—but we may need better tools to measure it. We conclude that scenario visioning does have the potential to foster consensus-building (one element of social learning) among diverse stakeholder groups. We urge researchers to continue to monitor and measure systems thinking outcomes from scenario visioning so that these processes may be designed to be more effective.

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Contributions

- Contributed to conception and design: LSO, JA
- Contributed to workshop and survey design: PST, MNK, JA, LSO
- Contributed to data collection: MNK, JA
- Contributed to data analysis: JA, LSO
- Prepared manuscript: LSO, JA

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Competing interests

The authors declare no conflict of interest.

Supplemental material

- **Appendix S1. Survey instruments.**
Survey instruments administered pre- and post-workshop in the Burkina Faso and Nigeria workshops (pages 1–2) and in the Malawi workshop (pages 3–4). (DOC)
doi: 10.12952/journal.elementa.000113.s001
- **Text S1. Malawi data analysis. (XLSX)**
doi: 10.12952/journal.elementa.000113.s002
- **Text S2. Mali-Burkina-Nigeria data analysis. (XLSX)**
doi: 10.12952/journal.elementa.000113.s003

Data accessibility statement

The datasets generated include survey responses by unique identifier pre- and post-workshop for the three countries. These are uploaded as supporting information Text S1 and Text S2.

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