Achieving sustainable future objectives under uncertain conditions: Application of a learning framework to adaptation pathways in rural Mali

Edmond Totin [a,*], Mary Thompson-Hall [b], Carla Roncoli [c], Amadou Sidibé [d], Laura Schmitt Olabisi [e], Robert B. Zougmoré [f]

[a] Ecole de Foresterie Tropicale, Université Nationale d'Agriculture du Benin, Kétou, BP, 43, Benin
[b] International START Secretariat, Washington DC, USA
[c] Department of Anthropology, Emory University, 201 Dowman Drive, Atlanta, GA, 30322, USA
[d] Institut Polytechnique Rural de Formation et de Recherche Appliquée (IPR/IFRA) de Katibougou, Koulikoro, Mali
[e] Department of Community Sustainability, Michigan State University, 151 Natural Resources, East Lansing, MI, 48824, USA
[f] International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Bamako, BP, 320, Mali

ARTICLE INFO

ABSTRACT

Adaptation Pathways have emerged as promising approaches for exploring sequences of actions to address challenges in uncertain conditions. This study elaborates on how pathway approaches operate in practice by applying a learning framework that identifies guiding propositions for successful adaptation pathways. The framework is used to analyze a transformative scenario planning case study from rural Mali. Findings confirm that adaptation pathways are highly context-specific, grounded in local institutions. The study also emphasizes that the adaptation pathways process requires a sufficient timeframe to allow for cross-level interactions and institutional changes to unfold as needed. The case demonstrates that the framework can be a useful tool for reflexive learning and identifying gaps in a structured way during pathway development. However, it needs to be adjusted to specific contexts to better capture the influence of and implications for power relations and social inequality in future adaptation plans.

1. Introduction

Climate change is one of the most critical challenges for agriculture and food security (Olsson et al., 2019), stemming from an interplay of stressors that affect interlinked social and natural systems. Efforts to adapt to climate change have had limited success despite investments in adaptation, partly because of inadequate understanding of adaptation trajectories and the disconnect between planned responses and local conditions (Ampaire et al., 2017; Burnham et al., 2018; Eakin et al., 2014).

A growing body of literature calls for a paradigm shift, moving from efforts to control change in a context assumed to be stable toward approaches that be customized to accommodate interacting uncertainties (Meadowcroft, 2009; van der Voorn et al., 2012v). Accordingly, research is seeking to develop configurations of possible adaptations centered on a multitude of flexible choices. Such approaches are to be grounded in contextual specificities, embedded in institutional arrangements, and inclusive of temporal and scalar interactions (Kwakkel et al., 2016; Wise et al., 2014).

An example of this new adaptation thinking is known as "adaptation pathways," which is used to carefully identify a portfolio of possible options in a context of uncertainties and complexities to avoid maladaptation (Burnham et al., 2018; Fischer, 2018; Haasnoot et al., 2013; Wise et al., 2014). The concept of "pathway" is not new, having been used in different fields, including natural resource management (Leach, 2008) and health (Leach et al., 2010a). It was adopted by climate researchers to assist in climate adaptation planning, prioritizing, and implementing responses. In particular, the Intergovernmental Panel on Climate Change Assessment Report 5 invoked the pathway concept to contend that technical options for climate risk management must be linked to effective social and political processes for vulnerability reduction (Denton et al., 2014). Leach et al. (2010b referred to these as 'alternative possible trajectories for knowledge, intervention, and change, which prioritize different goals, values, and functions.'

---

* Corresponding author.
E-mail addresses: edmond.totin@gmail.com (E. Totin), mthompson-hall@start.org (M. Thompson-Hall), carla.roncoli@emory.edu (C. Roncoli), sidibe.amadouy@gmail.com (A. Sidibé), schmi420@msu.edu (L.S. Olabisi), R.Zougmore@cgiar.org (R.B. Zougmoré).

Haasnoot et al. (2013) introduced the notion of 'tipping points,' which are 'the conditions under which action no longer meets the specified objectives' (Haasnoot et al., 2013;). Alternatives are identified and implemented to accommodate new circumstances when changes happened and before a tipping point is reached. This perspective inspired Wise et al. (2014 to explain the pathway as 'a set of possible specific actions under deep uncertainty about the future.' More recently, building on the definition of Wise et al. (2014), Burnham et al. (2018) and Fischer (2018) define adaptation pathways as the process of 'exploring and sequencing a set of possible actions based on alternative external, uncertain developments over time.' While climate scientists and adaptation planners have been responsive to the potential of pathways for decision-making, there has been no clear guidance on how to plan adaptation pathways and how to sustain the resulting responses. Such knowledge is critical for helping decision-makers to design plans that integrate both incremental actions and transformative agendas.

In a recent article, Werners et al. (2020) formulated a learning framework comprising seven primary propositions for the successful development of adaptation pathways. The framework was generated by a team of scientists and practitioners, including the first author of this article. It was derived from the review of 232 conceptual and applied studies of adaptation pathways in the context of climate change and aimed to guide systematic reflection, design, and implementation of climate adaptation pathways initiatives. The propositions and their underlying assumptions are presented in Table 1.

In this paper, we retroactively analyze the empirical outcomes of a climate adaptation project from rural Mali in terms of the relationships between the case and each proposition of the Werners et al. learning framework. We begin with a description of the research setting, followed by an account of the transformative scenario planning (TSP) process, which was implemented in the climate project in one of the rural districts of Mali. The core of the article consists of a critical reflection on the strengths and weaknesses of the TSP approach relative to the propositions defined by the adaptation pathways learning framework. We conclude with a discussion of how both (i) the scenario planning approach (TSP) could be improved to deliver effective adaptation pathways, and (ii) the learning framework of Werners et al. could be improved to allow its optimal use in a decision-making context.

2. Research context and design

2.1. Context

Mali is one of the largest countries in West Africa. However, most of its territory comprises the southern edge of the Sahara Desert. About 90 % of the population is concentrated in the south, exerting considerable pressure on natural resources, especially land and water (Skidmore et al., 2016). The combination of climate variability and environmental degradation contributes to food insecurity (Hilson and Garforth, 2012). Koutiala district (Cercle) is one of the country's leading agricultural areas and is characterized by a fast-growing population, estimated at 3, 02 % per year in 2018 (World-Bank, 2018). As a typical Sudano–Sahelian region, Koutiala receives about 850 mm of annual rainfall during a single rainy season that spans from May to October, though increasingly marked by frequent droughts and high inter-annual variability. In Koutiala, most agriculture is subsistence farming, primarily in rain-fed fields, which makes it highly vulnerable to uncertain rainfall conditions (Traore et al., 2017, 2015)

Local livelihoods are centered on cereal production, especially maize, sorghum, and millet, which are the primary staple grain crops accounting for respectively, 45 %, 38 %, and 32 % of planted areas (Diallo et al., 2020; Traore et al., 2017). Cotton is one of the major cash crops in Koutiala. Still, in recent years, the district has experienced lower cotton production, partly because of farmers' shift in priorities from cotton to maize due to the lack of production inputs (fertilizer) (Laris et al., 2015). Further, projected changes in precipitation are expected to significantly decrease cotton productivity and alter food production patterns in rural Mali (Assessment, 2015; Rivers III et al., 2017).

Given that agriculture is the primary source of livelihood for most Malians, and the sector is highly affected by climate variability, adaptive actions and policies promoting robust agricultural growth and food security have become a priority for the government (Diallo et al., 2020).

2.2. The adaptation pathways planning approach

The case study analyzed in this article is part of the Adaptation at Scale in Semi-Arid Regions (ASSAR) project, an interdisciplinary research effort within the broader Collaborative Adaptation Research Initiative in Africa and Asia (CARIAA) undertaken from 2014 through 2018 (Padgham et al., 2015). The project aimed to identify barriers and enablers for climate change adaptation in dryland regions (cf. http://www.assar.uct.ac.za/). In West Africa, it focused on the Upper West Region of Ghana and the Sikasso Region of Mali.

The ASSAR project aimed at identifying no-regret adaptation options to strengthen farmers' resilience in the face of climate uncertainty. A transformative scenario planning (TSP) exercise was central to the strategy. The TSP approach assumes that, to some extent, people can influence their future, and contrasts with adaptive scenario planning, which assumes that people can neither predict the future nor control it and, therefore, must adapt to it (Kahane, 2012). The TSP fits situations where participants see themselves in unacceptable, unstable, and unsustainable conditions and are motivated to bring about transformation (Kahane and Van Der Heijden, 2012). A significant assumption of the TSP is that people cannot change their condition on their own because of the unpredictability and the complexity of the social, political, and economic system within which they are embedded. Therefore, they must form collaborations and coalitions across multiple stakeholders to bring about transformation (Freeth and Drimie, 2016) across a broad spectrum of sectors (Chaudhury et al., 2013).

The TSP process is organized around a five-step process – the "U Process" - (Scharmer, 2009) - which engages a diversity of social actors

Table 1
Pre-conditions for sustainable adaptation pathways.

Propositions	Underlying assumptions
Targeting a specific decision or decision-maker	Adaptation pathways are most effective when they are embedded in local realities and focus on the needs and goals of decision-makers.
Engaging stakeholders with different values, goals, and knowledge across levels and sectors	The integration of a diversity of knowledge can enhance the quality of decisions by ensuring a more complete and inclusive information stream
Using an integrated systems approach, which considers responses to climate change as an integral component of sustainable development	Adaptation should not be addressed in isolation, but rather should be an integral component of broader development planning and sustainability goals
Addressing both symptoms and root causes of vulnerability	Adaptation processes are most successful and sustainable when it considers both causes and the symptoms/consequences of vulnerability
Considering future uncertainty in the adaptation process	Adaptation planning prepares for future uncertainties by specifying which measure(s) are to be taken now and which are to be planned for the future once an expected scenario materializes
Using a monitoring and evaluation system to inform implementation	Adaptation pathways can be designed to monitor and learn from experiences in ways that inform on-going decision-making and catalyze follow-up activities
Prioritizing visual communication of pathways	A visual representation of pathways can facilitate the communication of results from the adaptation planning process and promote collaborative learning

Source: Derived from Werners et al. (2020).

in a sequence of three or four workshops. The latter address goals such as: " *convening* a team from across the whole system; *observing* what is happening; *constructing* stories about what could happen; *discovering* what can and must be done, and *acting* to transform the system" (Kahane and Van Der Heijden, 2012;). In Koutiala, this scenario process was slightly modified to fit the limited timeframe of the ASSAR project by condensing the stages into two workshops. Due to this more limited scope, there was no expectation of resolving deep structural conditions as hypothesized by the full TSP approach (Kahane, 2012). The first scenario workshop was held in June 2016 and involved 28 participants in *observing* changes and *constructing* storylines (Table 2). For the selection of the participants, the project team first identified a Reference Group of three strategic people (one from the government environmental agency and two from a local NGO operating in climate change) whose primary purpose is to advise on the scope of the TSP and on getting the right people in the scenario process. In identifying and selecting potential external members for the Reference Group, the team considered stakeholders who have an interest in climate change adaptation and who can potentially extend the reach of participation to stakeholders that the project team did not have easy access to (e.g., policymakers, NGOs, community leaders, public servants, and farmers representatives). It was expected that stakeholder involvement would ensure ownership and sustainability following the phasing-out of project staff and resources.

During the workshop, scenario participants explored pressing climatic and non-climatic challenges for agriculture, natural resources, and food security in Koutiala, prioritizing the most influential drivers that may shape future vulnerabilities and adaptations in the district. Land degradation and water shortages were identified as the potential drivers and were then used to guide analyses of plausible futures for local agriculture and food security through 2035.

The second scenario workshop was held in December 2016. It brought together the same types of stakeholders (Table 2) and focused on exploring possible no-regret or low-regret response options. Participants designed a set of anticipated options and strategies, which they envisioned performing in response to the potential scenarios outlined during the first workshop.

2.3. Methodology

The Mali case study illustrates an iterative process of no-regrets option development strategy (Fig. 1), which started in June 2016 with the first scenario workshop. The set of selected options and strategies are

Table 2
Socio-demographic characteristics of scenario participants.

Parameters		First scenario workshop (n = 28)	Second scenario workshop (n = 25)
Social groups	District officials	2	1
	NGO staff	5	3
	Village leaders	2	3
	Public servants		
	- Extension officers	2	5
	- Planning officers	2	2
	- Meteorological agent	1	1
	- Journalists	2	1
	Farmer representatives	12	9
Age	Under 30	4	4
	31-50	10	7
	Over 51	14	14
Gender	Men	20	18
	Women	8	7
Education	No school	7	6
	Primary	5	8
	Secondary	12	8
	Post-secondary	4	3

currently being implemented by community members and local authorities with the flexibility to accommodate changing conditions over time. The Mali case's scenario planning outcomes were retroactively analyzed from the perspective of the learning framework outlined by Werners et al. (2020) to assess the relationships between the project outcomes and each of the framework's proposition. Lessons learned by applying the framework to this empirical case will enable the refinement of the pathway approach and its optimal use in a decision-making context.

Throughout the scenario process, a monitoring guide – composed of a set of questions and statements on the expected outcomes from each scenario workshop - was used before and after each session to assess outcomes and capture new insights (see Supplementary Materials). In total, 72 forms were collected from scenario participants. The resulting information was transcribed and thematically coded for the seven primary propositions of the learning framework to determine whether they were validated.

Besides, structured interviews were conducted with 18 scenario participants. They included eight farmers; two district officials, one NGO staff, one local leader; two extension officers; one planning officer; one meteorological agent, and two journalists. Each scenario participant was interviewed three times, respectively 6, 12, and 18 months after the project onset workshop. The interviews focused on the four dimensions that the TSP process focuses on – *understandings, relationships, intentions, and actions* (Kahane, 2012) –(see Supplementary Materials). Transcribed responses from these interviews were thematically analyzed to assess whether or not the propositions were met.

We documented what was done in the course of the project. We reflected on how the scenario planning agenda was configured, starting with identifying the focus and determining the appropriate geographic scales, sector, and stakeholders to involve. We subsequently examined the profile of the stakeholders engaged in exploring whether and how the diversity of expertise and priorities involved affected scenario outcomes. We explored how the strategies generated from the scenario workshops are connected to other development interventions in Mali, including both public and private initiatives in the socio-economic and environmental sectors. The scenario no-regret or low-regret responses were also examined to ascertain whether they included long-term perspectives and have the potential to address possible future changes.

The research also benefited from contextual knowledge produced by baseline research (Padgham et al., 2015; Totin et al., 2018), a multi-scale governance analysis (Sidibe et al., 2018), and an exploratory study on adaptive behaviors to food challenges (Rivers III et al., 2017). The study drew from the technical project reports produced (in total, nine work-reports). The project also capitalized on the linkages between the ASSAR project and the CGIAR research program on Climate Change, Agriculture and Food Security (CCAFS) in Mali. The two projects addressed the same climate changes issues, their timeframe and the intervention sites also overlapped, and they involved the same stakeholders (local leaders, district officials; NGO staff; and civil servants).

3. Results

3.1. Targeting a specific decision or decision-maker

This proposition suggests that effective pathway development should explicitly target concrete decisions or particular decision-makers. In the Mali case, local authorities were most concerned with food security. The following quote from a municipal council official illustrates this concern: "*Sikasso region is the main food crop production area, and this area is also exposed to drought and rainfall variability, which affect crop yields … In such conditions, it is a key priority in our development plan to find options to keep feeding our growing population. For us, food security is a major concern*". During the scenario workshops, stakeholders identified access to agricultural land (37 %; N = 18) and access to irrigation water (46 %; N = 18) as key drivers of food security in the district (Table 3). Then,
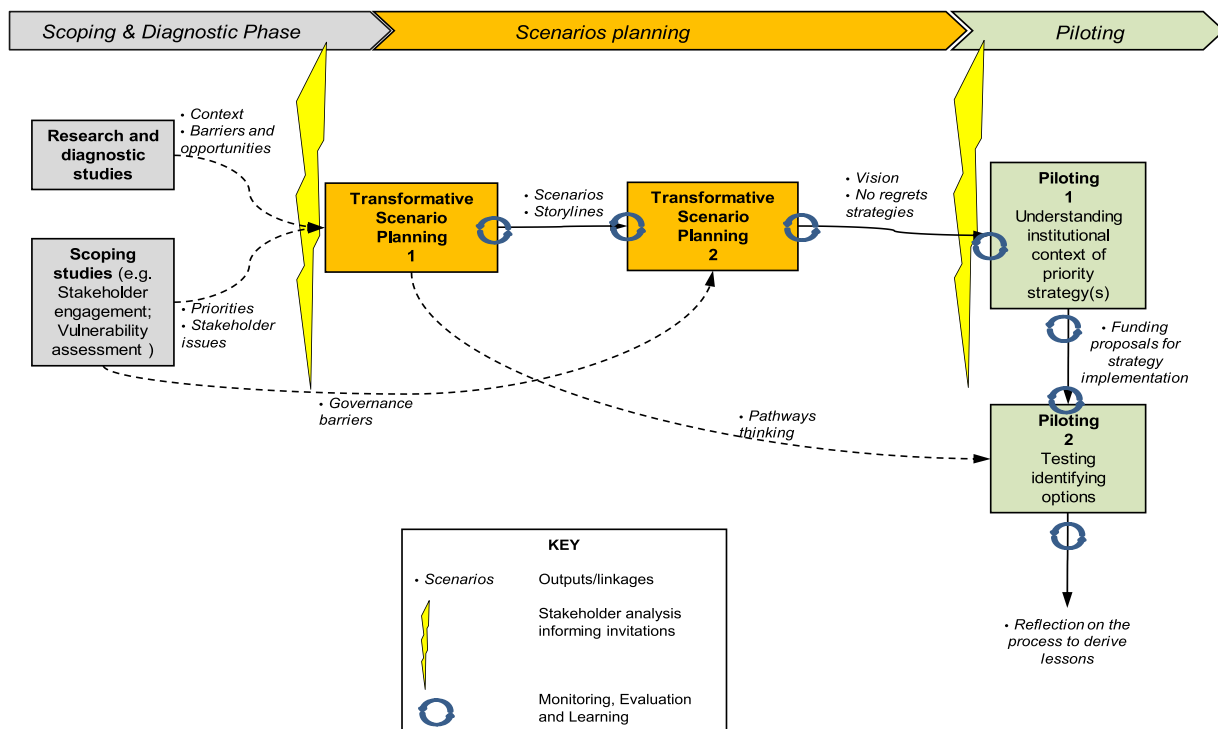
Fig. 1. Schematic representation of the three phases of adaptation planning adopted in the Mali adaptation pathways case study.

Table 3
Scores for each indicator given by the interviewees (n = 18) before and after the scenario workshop.

Indicators	Before (%) n = 18	After (%) n = 18
Three greatest drivers that agriculture and food security will face in the future?		
- Access to water for irrigation	37	46
- Access to agricultural land	28	37
- Access to inputs	15	7
- Availability of agricultural services	20	10
Two most important strategies for improving agriculture and food security in this area?		
- Implementing National Climate Change Program	6	6
- Building infrastructure for water conservation	31	42
- Enabling access to agricultural inputs and climate services	22	8
- Using short duration varieties	19	11
- Using soil fertility management practices	22	33
What is the most important thing you expect to/ gain (ed) from this workshop?		
- New contacts	0	6
- New information	17	22
- Sources of funds	0	6
- Power to act	28	28
- New ideas and solutions to my problems	56	38
How many years do you think about when you hear the word "future"?		
- 0–1 years	44	17
- 2–3 years	56	44
- 4–5 years	0	17
- 6–10 years	0	11
- More than 20 years	0	11

participants engaged in a shared visioning process, in which they agreed that better management of water resources and soil fertility could reduce their vulnerability to climate change. In response to these concerns, the project organized a study visit in Burkina Faso to expose Koutiala stakeholders to new soil fertility and water management techniques, including runoff catchments systems (*Bassin de Collecte des Eaux de Ruissellement* known as the acronym BCER) for supplemental irrigation. Subsequent to the visit, in 2018, two BCERs of 300 m³ each were constructed by the project team in the district to test their use for irrigation. The infrastructure has the potential to serve ten farmers regularly.

Targeting community priorities was central to the project, even though workshop participants had divergent interests and motivations for engaging in the process. Some of them were attracted by the capacity-building opportunities, while others were more interested in networking and problem-solving.

3.2. Engaging stakeholders with different values, goals, and knowledge

The project engaged a diversity of relevant stakeholders in analyzing and developing climate-resilient options. The inclusive nature of the process aimed to ensure that selected strategies and actions were prioritized in a way that accounted for all perspectives of participating stakeholders. (Totin et al., 2018). The interactions among stakeholders and reflections on their different experiences and perspectives enabled social learning (Innes and Booher, 2004). Participants were able to better understand the interconnections among different issues, such as the implications that pressure on land resources has for future food security. Likewise, through participants' discussions, it became clear that migration, which was initially framed as a climate change adaptation, was linked to the government land reform. One stakeholder commented: "*For two years now, our land was taken away from us because of the government land reform, and we are left with no alternative. My husband was obliged to move to a mining site. [...], because of the massive move of young people, it is not easy to get labor for farming.*"

The project assumed that meaningful stakeholder engagement would open up space for accommodating and mediating among different perspectives when designing future interventions. In practice, the process of involving various stakeholders met challenges, particularly in securing the equitable representation of all social groups. For example, the project had limited success involving powerful actors and national-level decision-makers in the scenario exercise. In part, this was because the scenario workshops were held in Koutiala, which is about 400 km from the capital city, Bamako, and central-level actors were unable or

unwilling to absent themselves from the capital city for several days. Additionally, though, an effort was made by the facilitation team to create space for participants to express their opinions, power, and education differences, hindered communication among participants. For example, some farmers reported that they were not comfortable challenging the view of local officials.

3.3. Using an integrated systems approach for climate change responses

The diagnostic study conducted at the onset of the project highlighted the interconnection between biophysical environments and socio-economic drivers of vulnerability to climate change. For instance, the occurrence of heavy rainfall events, the climate-dependent nature of local livelihoods, the limited social safety nets, the lack of coordination between state and local level planning were identified as factors contributing to local vulnerability (Padgham et al., 2015). Therefore, the scenario workshops did not use climate risks as the main entry point. Instead, the focus was on food production, which was identified as a community priority. Furthermore, the resilience of the food production system intersects with other development and environmental factors, including land tenure security and market access. The response options identified by participants to address possible food production challenges likewise reflected a diversity of potential responses by organizations and individual actors across scales. For example, participants prioritized training on sustainable water harvesting and soil fertility management practices for crop intensification. The assumption was that both advocacy for policy change (e.g., increase government investments and interventions in agriculture, including improved access to quality seeds) and agricultural innovation (e.g., improved water and soil fertility technologies) are all needed to ensure food production.

In sum, the scenario exercise sought to conjoin technological solutions with enabling policy, therefore concluding that investments were needed across scales – national and subnational – to enhance local food security in the face of climate change.

3.4. Addressing symptoms and root causes of vulnerability

Building on the scenario exercises, which identified land and water as key drivers of future food production, the project focused on capacity development on soil fertility and water management as ways of bolstering preparedness. However, during a follow-up meeting, one participant noted that land access intersects with many other problems: "*as an extension officer, I advise farmers on the amount of fertilizer to apply in their plots, but not all farmers follow. Over the years, I understood that it is quite challenging for farmers with relatively limited land assets to invest in fertilizer. To me, agricultural intensification should start with negotiation for alternative land tenure arrangement…* "

This feedback prompted the project team to recognize that the scenario process has underestimated the land tenure as a potential driver of change in the food production systems. This oversight exemplifies the challenge of ensuring that all participants have a voice in the course of participatory processes, especially when there are disparities of power and/or education among them (Chambers, 1997). Furthermore, it also highlights the need for greater engagement with communities and cross-scalar actors in pathway development. With this observation, the team acknowledged that the selected response options were unlikely to engender effective, long-term adaptation across all stakeholder groups unless land tenure was addressed. Though the remaining time for the project did not allow for the engagement of high-level actors to advocate for land tenure reforms, identifying the land tenure as a high priority is a meaningful contribution to future efforts.

3.5. Considering future uncertainty in the adaptation process

During the scenarios planning process, participants reflected on plausible changes they expected to be associated with climate change,

based on their knowledge of the local context as well as their understanding of scientific information available to them. They worked together to select what appeared to be the most likely "no-regret" strategy for achieving future food security under uncertain changing climate and socio-economic conditions. Such options were expected to ensure some advantage or benefit, even in the absence of climate change, as scenario participants noted: "*This exercise was useful in the sense that we think deeply to picture what could happen. We are not sure whether these will happen, but at least we are already prepared to deal with these likely changes. And of course, if these do not occur, we will still use the option to improve our livelihoods…*". For example, rainwater harvesting can improve farm productivity and prevent soil erosion and runoff, regardless of climate change impacts. Low-cost innovations such as mulching young plants to preserve soil moisture and construction of reservoirs for water catchment were seen as practical options for improving crop productivity. Given their ability to yield benefits in variable conditions and their relatively low-cost, these localized responses are more likely to be no-regret adaptations than high-cost large-scale investments.

3.6. Using a monitoring and evaluation system to inform implementation

A monitoring process was put in place to foster reflection on lessons learned, inform implementation, and assess outcomes. One participant remarked that reflection meetings allowed him to understand how previous ones inform each new step.

Other participants found the TSP process intimidating, as it requires them to interact with persons or in ways they were not familiar with. A woman farmer reported being uncomfortable openly disagreeing with male elders since this is socially unacceptable, especially for women. Another participant noted that more educated participants and local leaders dominated the process. While not all participants agreed with this observation, it does underscore that power disparities can influence group decision making.

Though participants found the scenario exercise useful for the development of long-term strategies, they did not always see how the approach can be applied to the shorter-term horizon of their daily life decisions. Before the scenario workshop, 44 % of interviewees stated that they are more likely to deploy shorter-term coping strategies by a maximum of one year rather than longer-term options, which require resources that are constrained by non-climatic barriers (Table 3). Through the scenario exercises, participants had increased their awareness of future changes and the need for more sustainable options. About 39 % of interviewees enlarged their future scope and stated that they could plan for longer-term, more than five years (Table 3). The exercise had equipped them with new skills.

3.7. Prioritizing visual communication tools

The TSP protocol recommends visual representations (drawing) of scenarios to help participants reflect on what they foresee as critical drivers of change. This is especially relevant where the literacy rates are low, such as in rural Mali, with 79 % of women aged 15–49 years who are not literate (Lasater et al., 2018). Therefore, facilitators asked each of the four scenario teams to map their envisioned future scenario based on the two top drivers of change – access to agricultural land and access to irrigation facilities. The scenario space was divided into quadrants by combining these two drivers in (i) low-low, (ii) low-high, (iii) high-low, and (iv) high-high. Each scenario space was visually represented to highlight the major characteristics of the food production systems in the district, given the combination of driver states they were assigned for 2035. Participants commented: "*the drawing was useful as it helped visualize the context we are describing with the scenarios. Also, each team member has the opportunity to materialize what one values the most in the future. In my group, I highlighted the irrigation water sources to show that food production is not possible without appropriate access to irrigation*

facilities".

Besides, each team verbally described their scenario in a large-group setting to help other participants to capture the stories and provide feedback. This approach is especially appropriate for African rural communities. They are more accustomed to oral than visual forms of knowledge transmission, such as storytelling by griots among Bambara rural communities (Austen and Jansen, 1996).

Visual and narrative representations were found to be useful tools by scenario participants as they enable them to share knowledge, compare experiences, and jointly analyze plausible future scenarios.

4. Discussion

This research used seven propositions identified from the literature on pathway processes as contributing to climate adaptation pathways and sought to assess their relevance to undertaking pro-active adaptation planning in rural Mali. Our following discussion reflects on how well the Mali case study exemplifies and validates the learning framework.

4.1. Limitations of the case study

By considering the complex nature of climatic challenges, the project sought to integrate strategies that bridge spatial scales and disciplines (Nyantakyi-Frimpong and Bezner-Kerr, 2015; Olsson et al., 2007). Furthermore, it intended to illustrate how such integration could address complex problems and promote collective actions in ways that accommodate uncertainties (Brown et al., 2016).

However, the Mali case fell short of these objectives in that it failed to engage influential decision-makers from central-level ministries, the private sector, and other partners. Only two national-level participants attended. Policymakers' participation could ensure the upscaling of selected-response strategies and adequate investments to enable communities to put envisioned options into practice (Burnham and Ma, 2017; Tompkins et al., 2008). The presence of high-level decision-makers would have created conditions for potentially influencing adaptation policies and planning and interaction across scales (Butler et al., 2015). While these central-level stakeholders invoked time constraints, they might also have been reluctant to face farmers' associations and traditional leaders who can use this opportunity to voice frustration with the growing insecurity and inadequate service delivery in the region (Lloyd, 2016). Also, their absence might have reflected the relatively low priority that national-level actors attribute to addressing climate challenge impacts as a major issue threatening development at the local level (Ampaire et al., 2017; Shackleton et al., 2015).

Building community resilience requires substantial resources that local authorities often cannot access (Matarrita-Cascante and Trejos, 2013). Their accounts stressed that the central government is not always accountable or connected to local level constituencies or committed to their efforts to address climate challenges (Amundsen et al., 2010). Doing so is instead entrusted to the district governments, as prescribed by the decentralization policy. But successfully initiating and sustaining resilience strategies requires long-term and multi-scale political commitment (Measham et al., 2011). In Mali, local elections are held every five years, and when the political regime or dominant party changes, priorities shift, undermining the continuity of local initiatives.

Another challenge pertained to the number and the diversity of participants in the scenario development process. The TSP approach can only accommodate about 25–35 participants (Kahane, 2012), assuming that facilitating a larger group may be challenging. While most scenario participants were able to contribute, the voices of the more educated and prominent participants were more influential in defining the TSP outcomes. It can also relate to certain socio-cultural norms, whereby it is inappropriate to challenge or disagree with authorities in public (Cornwall, 2003). To bypass this hurdle and enable more active participation, future facilitation of TSP processes in Mali could give deeper consideration to local rules and customs and relationships between different ethnic groups. The diversity and gender balance could be given more careful attention during the planning process to ensure that all participants, including the less powerful (i.e., migrants, women, youths, etc.), can influence the process and outcomes. As demonstrated in countless other cases, bringing people together does not ensure that all voices are heard and considered equally legitimate (Fairey, 2018; Jollymore et al., 2018).

The project's limited timespan did not allow for the full deployment of the TSP process. The case focused on identifying suitable options rather than the development of an adaptation pathway. The social transformation envisioned by the scenario process requires much more time to materialize. In Mali, the scenario exercise began mid-way through the project and then took about eight months to be completed. When it was time to implement the no-regrets option of water harvesting catchments, the project was nearing its end. Though efforts were made during the project to convene stakeholders and key development partners (i.e., NGOs) around the shared use and the governance of water-harvesting infrastructure, these were unsuccessful because of time constraints. Therefore, the work did not fully achieve the desired level of strengthening of adaptive capacities and resilience in the community during the project timeframe.

Overall, the Mali project succeeded in engaging a diversity of local stakeholders with complementary expertise and values that enabled interactions across disciplines, changing people's understandings of climate change and its implications, and change in the framing of climate change. However, it failed to include strategic policymakers to foster interactions across scales and enable institutional changes needed to implement response options. The case also was unable to address both symptomatic aspects and root causes of climate vulnerability as the learning framework suggested, and this curtailed its potential to engender lasting impacts. This finding highlights the complexity of the climate adaptation responses, which require sufficient time to materialize. Designing adaptation pathways needs careful consideration of the time frame to address major socio-institutional barriers that can hinder practical implementation.

4.2. Relevance of the learning framework for pathways analysis

This article reflects on the practicalities of the learning framework's seven propositions in the Mali case. The learning framework provides a conceptual space that enables us to consider when, how, and with whom one should develop adaptation pathways. The framework's propositions can serve as a checklist to assess the extent to which critical aspects have been addressed. However, the propositions do not pertain to discrete dimensions but instead may overlap; for instance, one condition recommends the integrated systems approach as a pre-requisite for effective pathway development. The same aspect is also reflected in another principle that suggests analyzing both symptoms and root causes of vulnerability. Consequently, it is essential to specify how these conditions are operationalized in each context.

The Mali case also shows that the framework's proposition on diversity does not adequately capture and account for power relations. Since pathway processes engage stakeholders from different social groups, it is undeniably an arena for power conflicts, where powerful actors may be unwilling to explore pathways of transformative change that may undermine their privileges. At the same time, the less privileged may be limited in their ability to express their opinions and in their agency to change established power arrangements (Bäckstrand, 2006; Brouwer et al., 2013). The framework also does not articulate how cultural differences have an impact on the way community members make decisions or get to a consensus. Scenarios participants are influenced by their cultural backgrounds, and ultimately when they make decisions, they also bring on their cultural identity (Odongo, 2016).

In general, the learning framework is a useful tool for a structured analysis of pathway development initiatives. It guides the exploration of

critical aspects that have been considered to ensure the sustainability of the process. While it does have analytical potential, the framework does not capture heterogeneity related to power disparities, cultural values, political agendas, and contextual influences. Further, the case illustrates a gap in the framework's propositions, as temporal dimensions are not accounted for in the list of optimal properties of pathway development.

5. Conclusions

The case study presented in this article shows that understanding the configuration of stakeholders before the pathway development is a critical step in adaptation planning. The case highlighted the importance of creating and sustaining networks that link stakeholders (e.g., multi-level stakeholder platforms) - and the resources they control - across institutional levels, temporal, and spatial scales. Because of the complex nature of climate challenges, engaging strategic partners, such as policymakers and the private sector, further foster interactions and resource mobilization to promote the sustainability of adaptive responses.

The emerging insights from this study support the claims that adaptation processes are highly context-dependent and are under socioeconomic, cultural, and political pressures (Arkema et al., 2017; Islam et al., 2014). Accordingly, there is no one-size-fits-all approach to develop climate adaptation pathways. An effective pathways process would require a deep understanding of the local conditions, including the historical, political, and social contexts that all shape the adaptation plans. Though our case does not focus specifically on adaptation pathways, it is obvious that with the context-specific nature of climate adaptation, it can be ineffective if an adaptation pathway approach that has worked in a specific context is replicated elsewhere without consideration of the institutional identity of the cases.

The analysis likewise shows that the learning framework is useful in guiding the systematic assessment of the process and identification of weak links. It can also serve as a tool for guiding stakeholder engagement in a planning process that accounts for cross-sector and cross-scale interactions and long-term perspectives on climate adaptation. However, the framework needs to be amended by adding other propositions to capture the need to address social and institutional drivers of vulnerability and adaptation, such as power relations, cultural norms, and political influences.

Authorship contributions

Conception and design of study: Edmond Totin.
Acquisition of data: Edmond Totin, Amadou Sidibé.
Analysis and/or interpretation of data: Edmond Totin, Carla Roncoli, Laura Schmitt Olabisi, and Robert B. Zougmoré.
Drafting the manuscript: Edmond Totin, Mary Thompson-Hall, and Carla Roncoli.
Revising the manuscript critically for important intellectual content: Mary Thompson-Hall, Carla Roncoli, Laura Schmitt Olabisi, and Robert B. Zougmoré.
Approval of the version of the manuscript to be published: Edmond Totin, Mary Thompson-Hall, Carla Roncoli, Amadou Sidibé, Laura Schmitt Olabisi, and Robert B. Zougmoré.

Declaration of Competing Interest

The authors report no declarations of interest.

Acknowledgments

Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.envsci.2020.11.013.

References

Ampaire, E.L., Jassogne, L., Providence, H., Acosta, M., Twyman, J., Winowiecki, L., van Asten, P., 2017. Institutional challenges to climate change adaptation: a case study on policy action gaps in Uganda. Environ. Sci. Policy 75, 81–90.
Amundsen, H., Berglund, F., Westskog, H., 2010. Overcoming barriers to climate change adaptation—A question of multilevel governance? Environ. Plann. C Gov. Policy 28, 276–289.
Arkema, K.K., Griffin, R., Maldonado, S., Silver, J., Suckale, J., Guerry, A.D., 2017. Linking social, ecological, and physical science to advance natural and nature-based protection for coastal communities. Ann. N.Y. Acad. Sci 1399, 5–26.
Assessment, N.C.f.e., 2015. Climate change profile (Mali). In: Unit, D.S. (Ed.), Dutch Sustainability Unit, Netherland, p. 21.
Austen, R.A., Jansen, J., 1996. History, oral transmission and structure in Ibn Khaldun's chronology of Mali rulers. Hist. Afr. 23, 17–28.
Bäckstrand, K., 2006. Multi-stakeholder partnerships for sustainable development: rethinking legitimacy, accountability and effectiveness. Eur. Environ. 16, 290–306.
Brouwer, H., Hiemstra, W., van Vugt, S., Walters, H., 2013. Analysing stakeholder power dynamics in multi-stakeholder processes: insights of practice from Africa and Asia. Knowl. Manag. Dev. J. 9, 11–31.
Brown, I., Martin-Ortega, J., Waylen, K., Blackstock, K., 2016. Participatory scenario planning for developing innovation in community adaptation responses: three contrasting examples from Latin America. Reg. Environ. Change 16, 1685–1700.
Burnham, M., Ma, Z., 2017. Multi-scalar pathways to smallholder adaptation. World Development.
Burnham, M., Rasmussen, L.V., Ma, Z., 2018. Climate change adaptation pathways: synergies, contradictions and tradeoffs across scales. World Dev. 108, 231–234.
Butler, J., Wise, R., Skewes, T., Bohensky, E., Peterson, N., Suadnya, W., Yanuartati, Y., Handayani, T., Habibi, P., Puspadi, K., 2015. Integrating top-down and bottom-up adaptation planning to build adaptive capacity: a structured learning approach. Coast. Manag. 43, 346–364.
Chambers, R., 1997. Whose Reality Counts. Intermediate technology publications, London.
Chaudhury, M., Vervoort, J., Kristjaanson, P., Ericksen, P., Ainslie, A., 2013. Participatory scenarios as a tool to link science and policy on food security under climate change in east Africa. Reg. Environ. Change 13, 389–398.
Cornwall, A., 2003. Whose voices? Whose choices? Reflections on gender and participatory development. World Dev. 31, 1325–1342.
Denton, F., Wilbanks, T.J., Abeysinghe, A.C., Burton, I., Gao, Q., Lemos, M.C., Masui, T., O'Brien, K.L., Warner, K., 2014. Climate-resilient pathways: adaptation, mitigation, and sustainable development. In: Climate Change, 2014. In: Field, C.B., Barros, V.R., Dokken, D.J., Mach, K.J., Mastrandrea, M.D., Bilir, T.E., Chatterjee, M., Ebi, K.L., Estrada, Y.O., Genova, R.C., Girma, B., Kissel, E.S., Levy, A.N., MacCracken, S., Mastrandrea, P.R., White, L.L. (Eds.), Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 1101–1131.
Diallo, A., Donkor, E., Owusu, V., 2020. Climate change adaptation strategies, productivity and sustainable food security in southern Mali. Clim. Change 159, 309–327.
Eakin, H.C., Lemos, M.C., Nelson, D.R., 2014. Differentiating capacities as a means to sustainable climate change adaptation. Glob. Environ. Chang. Part A 27, 1–8.
Fairey, T., 2018. Whose photo? Whose voice? Who listens?'Giving,' silencing and listening to voice in participatory visual projects. Vis. Stud. 33, 111–126.
Fischer, A.P., 2018. Pathways of adaptation to external stressors in coastal natural-resource-dependent communities: implications for climate change. World Dev. 108, 235–248.

Freeth, R., Drimie, S., 2016. Participatory scenario planning: from scenario 'stakeholders' to scenario 'Owners'. Environ. Sci. Policy Sustain. Dev. 58, 32–43.

Haasnoot, M., Kwakkel, J.H., Walker, W.E., ter Maat, J., 2013. Dynamic adaptive policy pathways: a method for crafting robust decisions for a deeply uncertain world. Glob. Environ. Chang. Part A 23, 485–498.

Hilson, G., Garforth, G., 2012. 'Agricultural poverty' and the expansion of artisanal mining in Sub-Saharan Africa: experiences from Southwest Mali and Southeast Ghana. Popul. Res. Policy Rev. 31, 435–464.

Innes, J.E., Booher, D.E., 2004. Reframing public participation: strategies for the 21st century. Plan. Theory Pract. 5, 419–436.

Islam, M.M., Sallu, S., Hubacek, K., Paavola, J., 2014. Vulnerability of fishery-based livelihoods to the impacts of climate variability and change: insights from coastal Bangladesh. Reg. Environ. Change 14, 281–294.

Jollymore, A., McFarlane, K., Harris, L.M., 2018. Whose input counts? Evaluating the process and outcomes of public consultation through the B.C. Water Act Modernization. Crit. Policy Stud. 12, 381–405.

Kahane, A.M., 2012. Transformative Scenario Planning: Working Together to Change the Future. Berret-Koehler, San Francisco, CA (USA).

Kahane, A., Van Der Heijden, K., 2012. Transformative Scenario Planning: Working Together to Change the Future. Berrett-Koehler Publishers.

Kwakkel, J.H., Haasnoot, M., Walker, W.E., 2016. Comparing Robust Decision-Making and Dynamic Adaptive Policy Pathways for model-based decision support under deep uncertainty. Environ. Model. Softw. 86, 168–183.

Laris, P., Foltz, J.D., Voorhees, B., 2015. Taking from cotton to grow maize: the shifting practices of smallholder farmers in the cotton belt of Mali. Agric. Syst. 133, 1–13.

Lasater, M.E., Beebe, M., Warren, N.E., Souko, F., Keita, M., Murray, S.M., Bass, J.K., Surkan, P.J., Winch, P.J., 2018. Dusukasi—The heart that cries: An idiom of mental distress among perinatal women in rural Mali. Cult. Med. Psychiatry 42, 930–945.

Leach, M., 2008. Pathways to sustainability in the forest? Misunderstood dynamics and the negotiation of knowledge, power, and policy. Environ. Plan. A 40, 1783–1795.

Leach, M., Scoones, I., Stirling, A., 2010a. Governing epidemics in an age of complexity: narratives, politics and pathways to sustainability. Glob. Environ. Chang. 20, 369–377.

Leach, M., Stirling, A.C., Scoones, I., 2010b. Dynamic Sustainabilities: Technology, Environment, Social Justice. Routledge.

Lloyd, R.B., 2016. Ungoverned spaces and regional insecurity: the case of Mali. Sais Rev. Int. Aff. 36, 133–141.

Matarrita-Cascante, D., Trejos, B., 2013. Community resilience in resource-dependent communities: a comparative case study. Environ. Plan. A 45, 1387–1402.

Meadowcroft, J., 2009. What about the politics? Sustainable development, transition management, and long term energy transitions. Policy Sci. 42, 323.

Measham, T.G., Preston, B.L., Smith, T.F., Brooke, C., Gorddard, R., Withycombe, G., Morrison, C., 2011. Adapting to climate change through local municipal planning: barriers and challenges. Mitig. Adapt. Strateg. Glob. Chang. 16, 889–909.

Nyantakyi-Frimpong, H., Bezner-Kerr, R., 2015. The relative importance of climate change in the context of multiple stressors in semi-arid Ghana. Glob. Environ. Chang. 32, 40–56.

Odongo, I., 2016. The influence of culture on judgment and decision making. Int. J. Adv. Legal Stud. Govern. 6.

Olsson, P., Folke, C., Galaz, V., Hahn, T., Schultz, L., 2007. Enhancing the fit through adaptive co-management: creating and maintaining bridging functions for matching scales in the Kristianstads Vattenrike Biosphere Reserve, Sweden. Ecol. Soc. 12.

Olsson, L., Barbosa, H., Bhadwal, S., Cowie, A., Delusca, K., Flores-Renteria, D., Hermans, K., Jobbagy, E., Kurz, W., Li, D., 2019. Land Degradation: IPCC Special Report on Climate Change, Desertification, Land 5 Degradation, Sustainable Land Management, Food Security, and Greenhouse Gas Fluxes in Terrestrial Ecosystems.

Padgham, J., Abubakari, A., Dietrich, K., Fosu-Mensah, B., Gordon, C., Habtezion, S., Lawson, E., Mensah, A., Nukpezah, D., Ofori, B., Piltz, S., Sidibe, A., Sissoko, M., Totin, E., Traoré, S., 2015. Vulnerability and Adaptation to Climate Change in the Semi-Arid Region of West Africa, ASSAR Working Paper. Available at. ASSAR, p. 142. http://www.assar.uct.ac.za/west-africa-0.

Rivers III, L., Sanga, U., Sidibe, A., Wood, A., Paudel, R., Marquart-Pyatt, S.T., Ligmann-Zielinska, A., Olabisi, L.S., Du, E.J., Liverpool-Tasie, S., 2017. Mental models of food security in rural Mali. Environ. Syst. Decis. 1–19.

Scharmer, C.O., 2009. Theory U: Learning from the Future as it Emerges. Berrett-Koehler Publishers.

Shackleton, S., Ziervogel, G., Sallu, S., Gill, T., Tschakert, P., 2015. Why is socially-just climate change adaptation in sub-Saharan Africa so challenging? A review of barriers identified from empirical cases. Wiley Interdiscip. Rev. Clim. Change 6, 321–344.

Sidibe, A., Totin, E., Thompson-Hall, M., Traoré, O., Traoré, P.S., Schmitt Olabisi, L.K., 2018. Multi-scale governance in agriculture systems: interplay between national and local institutions around the production dimension of food security in Mali. NJAS - Wageningen J. Life Sci. 84, 94–102.

Tompkins, E.L., Few, R., Brown, K., 2008. Scenario-based stakeholder engagement: incorporating stakeholders preferences into coastal planning for climate change. J. Environ. Manage. 88, 1580–1592.

Totin, E., Butler, J.R., Sidibé, A., Partey, S., Thornton, P.K., Tabo, R., 2018. Can scenario planning catalyse transformational change? Evaluating a climate change policy case study in Mali. Futures 96, 44–56.

Traore, B., Van Wijk, M.T., Descheemaeker, K., Corbeels, M., Rufino, M.C., Giller, K.E., 2015. Climate variability and change in southern Mali: learning from farmer perceptions and on-farm trials. Exp. Agric. 51, 615–634.

Traore, B., Descheemaeker, K., van Wijk, M.T., Corbeels, M., Supit, I., Giller, K.E., 2017. Modelling cereal crops to assess future climate risk for family food self-sufficiency in southern Mali. Field Crops Res. 201, 133–145.

van der Voorn, T., Pahl-Wostl, C., Quist, J., 2012v. Combining backcasting and adaptive management for climate adaptation in coastal regions: A methodology and a South African case study. Futures 44, 346–364.

Werners, S.E., Wise, R., Butler, J., Totin, E., Vincent, K., 2020. Learning from adaptation pathway development: key characteristics and guiding principles. in submission Environ. Sci. Policy.

Wise, R.M., Fazey, I., Stafford Smith, M., Park, S.E., Eakin, H.C., Archer Van Garderen, E. R.M., Campbell, B., 2014. Reconceptualising adaptation to climate change as part of pathways of change and response. Glob. Environ. Chang. 28, 325–336.

World-Bank, T., 2018. Mali: Growth and Diversification. The World-Bank, Macroeconomics, Trade and Investment (MTI) Global PracticeI Africa Region, Washington, p. 123.