Agricultural Systems 154 (2017) 13–24

Contents lists available at ScienceDirect

Agricultural Systems

journal homepage: www.elsevier.com/locate/agsy

Prioritizing investments for climate-smart agriculture: Lessons learned from Mali

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ARTICLE INFO

Article history:
Received 3 November 2016
Received in revised form 7 February 2017
Accepted 19 February 2017
Available online xxxx

Keywords:
Climate change
Decision support
Adaptation
Mitigation
Agricultural development
West Africa

ABSTRACT

Agricultural productivity and growth in Mali are under threat from erratic rainfall, resulting in more frequent dry years. The national economy is vulnerable to climate change due to 50% of the gross domestic product coming from the agricultural sector and 75% of the population living in rural areas. The Climate-Smart Agriculture (CSA) concept arises from a need to provide innovative solutions towards the complex and integrated goals of increasing yields, improving resilience, and promoting a low emissions agricultural sector. A major challenge for policymakers to operationalize CSA is the identification, valuation (cost-benefit), and subsequent prioritization of climate-smart options and portfolios (groups of CSA options) for investment. This paper presents the process, results, and lessons learned from a yearlong pilot of the Climate-Smart Agriculture Prioritization Framework (CSA-PF) in Mali. Key national and international stakeholders participated in the co-development and prioritization of two CSA portfolios and related action plans for the Malian Sudanese zone. Initial steps towards outcomes of the process include inclusion of prioritized CSA practices in ongoing development projects and prompting discussion of modifications of future calls for agricultural development proposals by regional donors.

1. Introduction

In West Africa, many smallholder farmers deal with low and unpredictable crop yields and incomes, as well as chronic food insecurity. These challenges are particularly acute in the dry lands, where land degradation, depleted soil fertility, water stress, current climate variability, and high costs of fertilizers contribute to low crop yields (Zougmoré et al., 2014). Moreover, annual cycles of rainfall are strongly determined by the position of the inter-tropical convergence zone, making the climate of the region one of the most erratic in the world and predictions of future changes in climate, especially rainfall, highly uncertain (Traore et al., 2013).

Despite contrasting scenarios of climate change for this region, all models expect an increase of climate variability (Cooper et al., 2008; Jalloh et al., 2013). Consequently, climate change will pose huge challenges to food security (Waongo et al., 2015) and particularly to child nutrition and health (Johnson and Brown, 2014).

African farmers have consistently been exposed to high variability in their production environment, and therefore already use a broad spectrum of coping strategies including the selection of drought tolerant varieties or crops, traditional water harvesting techniques (e.g. zai), the diversification of income sources by combining cropping with livestock rearing, and off-farm activities (Abdulai and CroleRess, 2001; Dostie et al., 2002; Thomas et al., 2007; Thornton et al., 2007). These coping strategies may not be sufficient to face the expected increase in climatic variability of unknown magnitude, which will likely result in novel solutions (Andrieu et al., 2015). Therefore, coping strategies in a perspective of transformational adaptation need to be considered. Rippke et al. (2016) concluded that in some areas in the Sahel production of nine of the major crops will become unviable by 2050, with the most affected crops being maize and bananas. Areas in northern Ghana, northern Benin, and northeastern Ivory Coast will become unsuitable for growing bananas without technical and socio-economic transformation, as will large swathes of Mali, Senegal, and Burkina Faso for growing maize.

The climate-smart agriculture approach is proposed as a solution to transform and reorient agricultural systems to support food security in the face of climate change (Lipper et al., 2014). CSA aims to co-achieving

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http://dx.doi.org/10.1016/j.agsy.2017.02.008

three objectives or pillars: sustainably increasing agricultural productivity; enhancing resilience (adaptation); and reducing or removing greenhouse gas emissions, where possible, enhancing the achievement of national food security and development goals. Ideally CSA aims to attain 'triple win' outcomes from the local to the global scales and over short and long time horizons, but trade-offs must be made often in agriculture development. Identifying synergies and weighing costs and benefits of different options based on stakeholder objectives is needed to derive locally acceptable and feasible solutions. The fact that CSA strives to reach multiple objectives at the system level makes it particularly difficult to transfer experiences from one context to another. CSA interventions are not climate-smart everywhere or in every time period. Given this challenge, identifying context specific and socially relevant and viable options must be done using evidence in participatory processes to take into account how components of agroecosystems interact at different levels and also different institutional arrangements and political realities.

The Government of Mali has been mainstreaming climate change through the National Action Plan for Climate Change Adaptation (Traoré et al., 2016). This National Action Plan aims to (1) take into account climate change in sectorial policies and strategies; (2) improve the resilience of ecosystems, production systems, and social systems; (3) contribute to global effort for stabilization of emissions; (4) promote national research and technology transfers; (5) strengthen national capacities on climate change. Indeed, Mali is already experiencing irregular rainfall patterns, resulting in dry years. These are becoming more frequent due to climate change, threatening agricultural productivity and growth. The national economy is vulnerable due to 50% of the gross domestic product coming from the farming sector and given that 75% of the population lives in rural areas, social welfare is also at stake (De Sherbinin et al., 2014; Sogoba et al., 2014). In the Country's Nationally Determined Contribution (NDP) presented at the twenty-first session Conference of the Parties in Paris, CSA was one of the strategies identified to meet its adaptation and mitigation targets. These are major steps that demonstrate intentions to actualize CSA, but translating these plans/commitments into action remains a challenge. The country will need to fine-tune their proposals, identify context specific and relevant priority options, and leverage funding from the national budget and bilateral and multilateral international development actors and financial institutions. There is consequently the need for processes aiming to prioritize CSA investments addressing the urgent climate risks to food systems.

The objective of this paper is to present and discuss the use and modification of the Climate-Smart Agriculture Prioritization Framework (CSA-PF) conducted in Mali from October 2014 to October 2015. The development and use of the CSA-PF in Latin America, Asia, and now Africa was driven by the need for a sound methodology and criteria to (1) quantify the impact of CSA practices on the three pillars using limited time and resources, (2) prioritize locally relevant best bet CSA options, and (3) ensure ownership and engagement by key stakeholders and potential funders/donors (Campbell et al., 2016). The CSA-PF aimed to conduct analyses relevant to specific CSA policy and program implementation question, therefore providing directly actionable results for stakeholders. This paper will present the study area, the phases of the CSA-PF, the criteria used to monitor the process, its specific implementation in Mali and first outcomes. The discussion explores the strengths and limitations using the monitoring criteria.

2. Materials and methods

2.1. Overview of the national institutional context on climate change in Mali

The Agency for Environment and Sustainable Development (AEDD) was created by the Malian government in 2010 with the mandate to integrate climate change issues and coordinate government adaptation and mitigation actions in Mali. AEDD is the coordinator of a national science-policy dialogue platform for climate change and food security (CCASA platform), which was created with support from the CGIAR Climate Change, Agriculture, and Food Security (CCAFS) research program (Sogoba et al., 2014). The CCASA platform aims to foster and facilitate communications and interactions between experts and policymakers and is made-up of key structures and organizations working for adaptation of agriculture and food security to climate change. The goal is to provide a forum for development of a shared vision of research priorities and to translate findings from researchers into policy decisions. The CCASA platform is involved in initiatives at regional (e.g. ECOWAS, NEPAD) and at global levels (e.g. UNFCCC, Global Alliance for Climate-Smart Agriculture) and is facilitated by the Malian Association of Awakening to Sustainable Development (AMEDD - Association Malienne d'Eveil au Développement Durable), an Non-Governmental Organization (NGO).

2.2. Components of the CSA-PF

In Mali, the CSA-PF process was led by the AEDD. The facilitator of the process was the NGO AMEDD, given its previous role as facilitator of the CCASA platform. CIAT/CCAFS scientists were involved in the methodological support, sharing lessons learned from CSA-PF processes conducted in Latin America (Sain et al., 2017), and documentation of the process and findings.

The CSA-PF was established as an evidence-based decision-support framework for stakeholders to use to identify CSA investment portfolios that maximize desired impacts for agriculture development in the face of climate change (Campbell et al., 2016). The framework was designed to be replicable globally, applicable for use from regional to sub-national levels, and highly flexible to accommodate various data and resource constraints while still providing added value to decision-making processes. It is a four-phased stakeholder-driven process that integrates analyses with participatory forums to evaluate and narrow-down locally-relevant CSA practices/options (Fig. 1).

The first phase clarifies the scope of the assessment for the implementing organization (AEDD in Mali), including the geographic areas and production systems, selected based on socio-economic and climate vulnerability analyses. CSA practices relevant to the selected scope are then compiled into a 'long list' based on literature review and regional experts and compiled by the facilitating organization, AMEDD in Mali. Indicators of CSA are then selected from a list of 29 suggested indicators associated with the three pillars (Rosenstock et al., 2016). The goal being to analyze practices based on the CSA outcomes stakeholders deem most critical for the study area based on the challenges being faced and the vision for development in the region. Practices are evaluated by the experts against CSA outcomes using these indicators.

During phase two, participatory workshops are conducted with relevant actors at national, sub-national, and community levels, as necessary, to validate the selection of CSA practices, indicators, and analyses conducted by the experts during the previous phase. Stakeholders use these forums to select eight to ten best-bet practices ('short list') based on the results of the indicator evaluation and their own criteria, which consequently needs to be elicited during the process. Stakeholders are engaged in this way recognizing that not all factors critical to decision-making can be analyzed by experts involved in phase one and therefore opportunities for decision-makers to openly discuss, debate, and rank priorities collectively allow for additional analysis of the pros and cons of practices to take place when narrowing the list of practices of interest for further investigation.

In phase three, an economic cost-benefit analysis (CBA) is conducted to assess the potential profitability of the practices in the 'short list' from phase two. Many economic models and frameworks, such as willingness-to-pay or social return on investment, can be used to cost actions proposed to address climate change (Chaudhury et al., 2016, Khatri-Chhetri et al., 2017), however CBA is widely used and is often

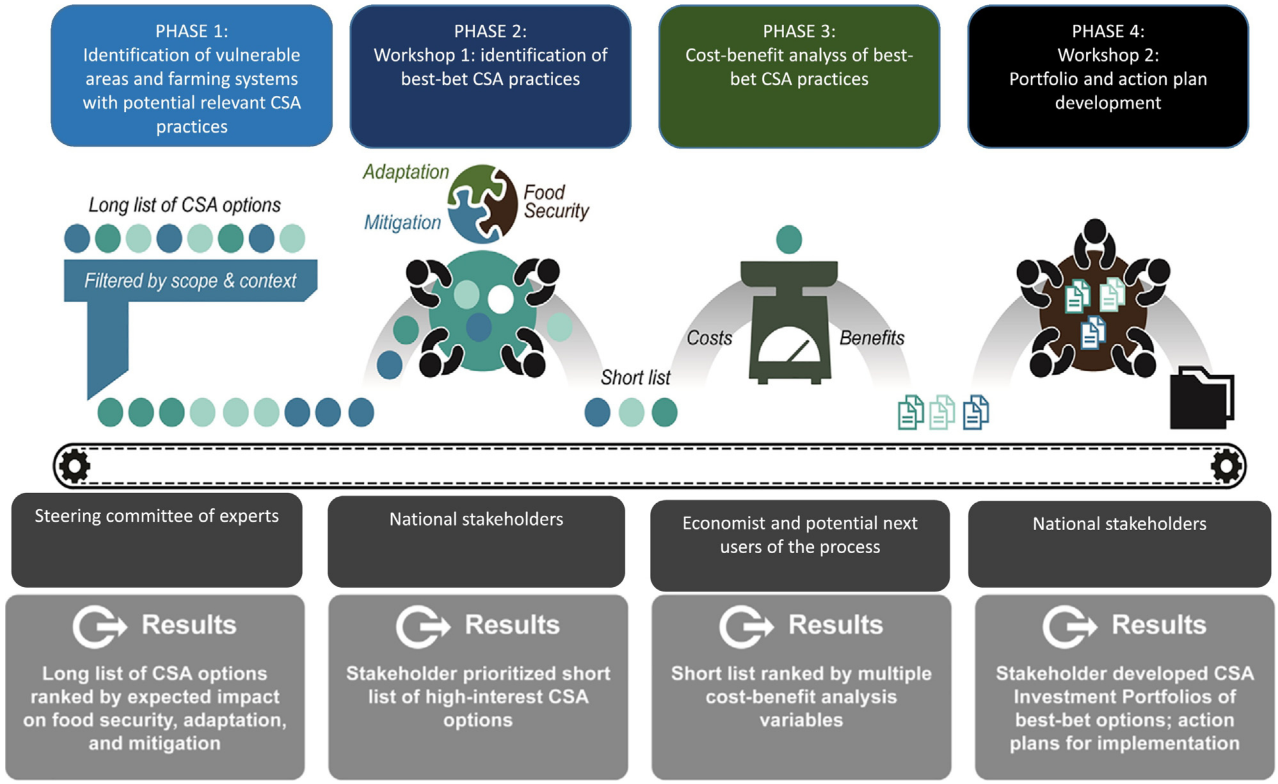

Fig. 1. Overview of the CSA-PF demonstrating the phases and their goals, stakeholders involved, and results (adapted from Campbell et al., 2016).

requested by implementers and government planners for decision-making. The cost-benefit analysis conducted as part of the CSA-PF in Mali was from the perspective of farmers' profitability related to the adoption of the CSA practices. It determines the relative profitability of each CSA practice compared to the initial practice before its potential introduction, and takes externalities into account. CBAs that focus solely on costs and benefits of agricultural practices can often distort assumptions about the likelihood of adoption at scale due to the exclusion of critical externalities and limited discussions of risk (Brent, 1996; Sain et al., 2017). Economic indicators such as Net Present Value (NPV, Eq. (1)) or Internal Rate of Return (IRR, Eq. (2)) are calculated. The NPV is the incremental flow of net benefits generated by the alternatives being compared over their lifetime period. The IRR is defined as the discount rate that makes the NPV equal to 0, i.e. it is the discount rate that makes the present value of the flow of future net benefits exactly equal to the initial investment.

$$NPV = \sum_{t=1}^{n} \frac{BN_t}{(1+i)^t} - I_0 \tag{1}$$

BN_t is the net benefits per period, I_0 is the initial value of investment, and n is the number of periods considered.

$$IRR = \frac{-I_0 + \sum_{t=1}^{n} BN_t}{\sum_{t=1}^{n} BN_t} \tag{2}$$

In phase four, stakeholders are reconvened during a workshop to review the results from the economic analysis of the 'short list' and identify CSA investment portfolios. Portfolios of practices can be constructed from the perspective of different investor groups, to target specific challenges facing the study area, specific scales of intervention, or for different types of farmers. The number of practices included in portfolio will depend on the goal of the stakeholders involved and in the CSA-PF usually consists of three to five of the practices from the 'short list'. Portfolios generally aim to minimize trade-offs, maximize benefits and synergies, and address priorities discussed by stakeholders. Barriers to adoption of practices are explored along with pathways to overcome these, which leads to the outlining of action plans.

In Mali a steering committee was established in October 2014 and was made up of four members of the national agricultural research center (IER – Institut d'Economie Rurale), two representatives from Malian universities, and one representative from the Helvetas Swiss development incorporation. AMEDD developed the committee to provide diverse scientific and technical background (soil, environmental, entomology and rural development expertise) guidance to the CSA-PF process.

The expert steering committee identified and engaged additional institutions that could be able to fund the wide scale implementation of the prioritized CSA actions. The objective was to establish close communication with a wide range of potential users of the outputs ('end users') from the beginning of the process, allowing for better understanding and inclusion of their interests. This provided opportunities to adjust the CSA-PF to various user needs and foster improved uptake of the outputs and translation into implementation actions. These potential end-users included two donors, the national directorate of agriculture, and two national NGOs. The specific implementation of the CSA-PF in Mali and associated outputs are presented in Section 3.

2.3. Monitoring of the process

For the CIAT/CCAFS scientists supporting the process, one goal was to better understand the benefits of using a participatory stakeholder driven approach to establish CSA priorities. Given this, it was critical to analyze the outputs, but also to analyze stakeholder involvement and ownership of the process itself. Neef and Neubert (2011) identified different dimensions with associated attributes to characterize the diversity of stakeholder involvement in the planning, implementation, and evaluation of a participatory research. These dimensions are (1) the project type (for whom is the research and in which institutional context is it implemented?), (2) project approach (how flexible is the research plan?), (3) researchers' characteristics (what are the researchers' experience, attitudes, and commitment?), (4) researcher-stakeholder interaction (who contributes to knowledge generation and who controls the research process?), (5) stakeholders' characteristics (what are the stakeholders' experiences and perceptions of the research process?), (6) and stakeholders' benefit (what are the outcomes of the participatory research?). The scientists adapted their work formulating specific attributes to characterize the stakeholder participation in the research (Table 1). Criteria were selected and monitored, which allow for the momentum created by the CSA-PF process to be captured and assessed for the leading to rapid first outcomes. We used these attributes and criteria to discuss the relevancy of the process.

3. Results

3.1. The CSA-PF process in Mali

3.1.1. Phase 1: preliminary selection and evaluation of CSA options

Using the Mali climate vulnerability mapping done by USAID (De Sherbinin et al., 2014), the steering committee proposed to conduct analyses related to three of the four agro-climatic zones in Mali with contrasting vulnerability: zone A located in the Sahelian region where livestock systems are predominant, zone B located in the Sudano-Sahelian region with mainly dry farming, agroforestry, and livestock, and zone C located in the Sudanian region with mines, cotton, and forestry (Fig. 2). The northeastern region, which consists of the Sahel desert, was not included in the assessment.

Through experts' knowledge of soil, environment, entomology, and rural development for the different agro-climatic zones of the country, literature review and multiple deliberations, the steering committee selected an initial list of 24 relevant practices (Table 2; e.g. Dorlochter-Sulser and Nill, 2012; INERA, 2000). Eleven CSA indicators (Table 3) were selected by the experts from the list of 29 proposed indicators based on relevance, in relation with the CSA pillars and practices, and feasibility, based on data availability.

The 24 practices were assessed by the steering committee according to these indicators. For each practice a score between −10 (for a negative effect) and +10 (for a positive effect) was attributed to each indicator and an average score per pillar was calculated for each practice (Table 2). In this case, 0 was used when the practice had no impact on the indicator.

Practices such as rational management of land, drip irrigation, or zaï pits were found to have the best synergies between the three pillars (highest average score), whereas practices such as assisted natural regeneration or system of rice intensification were found to have tradeoffs between adaptation and mitigation.

3.1.2. Phase 2: participatory identification of best-bet CSA options.

The results of phase one were presented during a two day-workshop conducted in November 2014. The steering committee selected 30 participants that represented ministries, district authorities, academia, NGOs, the national research institute, and donors. Participants were divided in sub-groups corresponding to specific agro-climatic zone to allow for representation of different types of institutions in the prioritization across zones. Each group selected a set of fundamental criteria for the prioritization of practices in each zone, mainly linked to the social feasibility of practices and relevance to biophysical constraints. For example, in both the Sahelian (zone A) and the Sudanese (zone C) zones it was critical that all selected practices respected the rules of access to land given existence of conflicts between livestock and non-livestock farmers, and between owners and users of land. Through this effort practices in the ‘long list’ (24 practices) were either validated as relevant, adjusted, removed, or some additional practices were added. For example, in the Sahelian zone, from the initial practice called “development of inland valley for rice cultivation” another one was proposed called “development of inland valley with solar pumps” taking into account the high radiation in this zone. In the Sudanese zone, the hedgerow practice has been removed from the initial list because planting trees can be seen as an appropriation of the field from the traditional owner of the land and exacerbates conflicts.

Lists of 9 to 10 practices were prioritized per zone (Table 4) using the prioritization criteria. Consequently, practices specific to certain zones were selected, such as sand dune stabilization in the Sahelian zone, sorghum-cowpea intercropping for the Sudanian zone, and contour bunding for the southern zone. For each identified practice, participants identified the enabling environment required to facilitate implementation or adoption of the practice (type of program, organizational change, service, or policy to be developed or strengthened).

3.1.3. Phase 3: CBA of the best-bet practices

Due to limited resources for this pilot, the CBA was only conducted for the practices selected for the Sudanian zone (zone C), which is the agricultural breadbasket of the country. CBAs were conducted for each practice identified in phase 2 except rational' management of land' determined to be too abstract for the economic analysis. The different costs and benefits were compared over a five-year timeframe, which was considered sufficient to capture yield response for all the practices and allow comparison of their profitability. For contour bunding, fertilization of fields by animal corralling or on-farm compost, analyses considered adoption of practices in relation to the main crops found in the zone: sorghum, millet, maize, and cowpea and was compared to the conventional practice for these crops (use of mineral fertilizers). Rice cultivation in inland valleys was compared to pluvial rice. Intercropping

Table 1
Dimensions and attributes monitored to assess the participatory aspects of the CSA-PF process.

Dimension	Attribute	Criteria	Source
Project type	Institutional context of the research favorable to CSA	Institutional landscape linked to CSA	Interviews with facilitator, literature review
	Characteristics of the next users of the CSA process	Institution Scale of action Existing CSA strategy	Documentation during the process
Research approach	Flexibility of the research process	Capacity to adjust the methodology	Documentation during the process and comparison with other pilot in Guatemala (Sain et al., 2017)
Characteristics of the stakeholders involved in the CSA process and of their interaction	Interaction between researchers, end-users, and local stakeholders	Function in the process	Documentation during the process
	Previous experience with CSA	Expertise on CSA	
Stakeholders benefits of the CSA process	Improved knowledge of the participants, end-users in terms of CSA and capacity to co-design solutions	Perception of participants on new knowledge gained from the process on CSA	Monitoring of the workshops: participant self-evaluation on completion of each workshop of the added value on the addressed concepts
	Improved decision-making	Selected action plans Project development	Monitoring 6 months after the final workshop

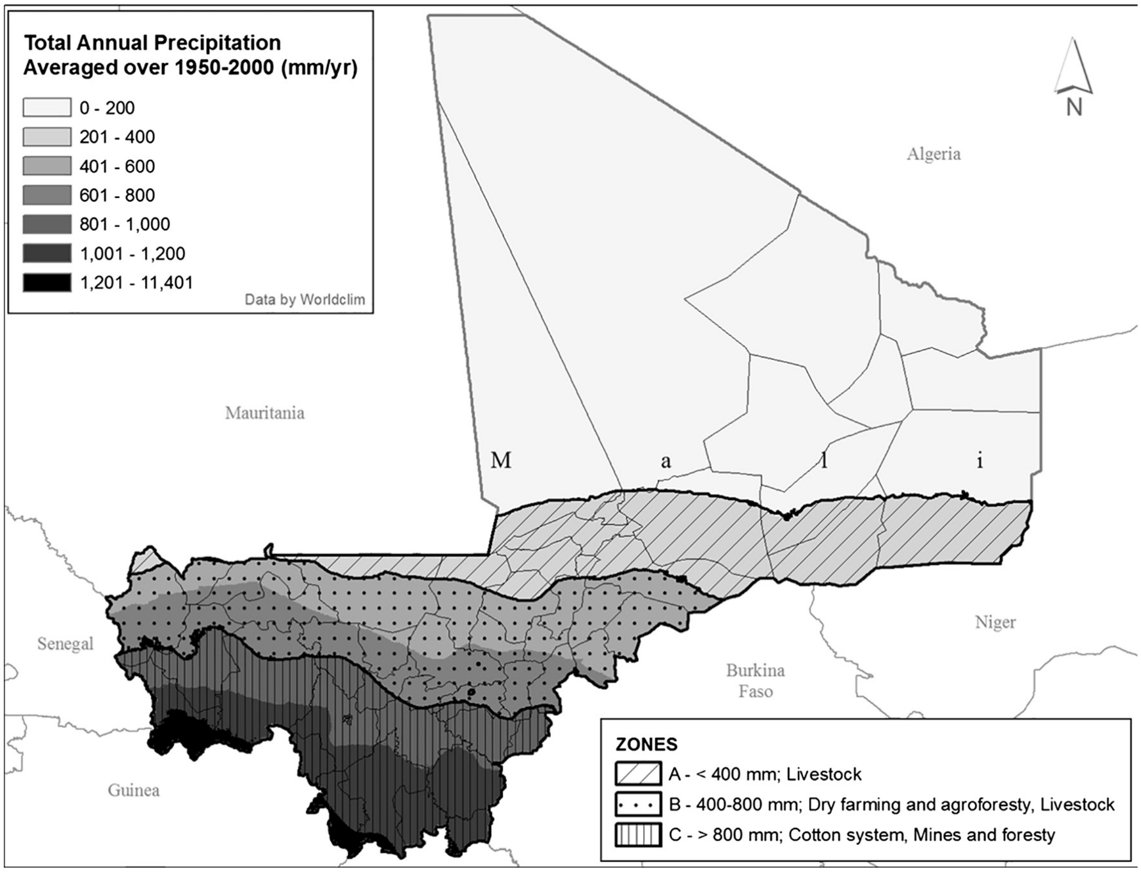

Fig. 2. Agro-climatic zones identified during phase 1 of the CSA-PF process.

was compared to sole cropping of sorghum, improved varieties of sorghum, millet, maize, cowpea, and rice were compared to the conventional varieties. Early sowing of millet and sorghum were compared to the conventional practice for these crops.

Three externalities were selected with the end-users of the process as priorities for inclusion in the economic assessments.

1. Carbon sequestration – An important area to track for development of low emissions agriculture and a focus of many agricultural development projects conducted in Mali by the end-users.
2. Gender – Practices can have negative effects on women when they result in increased workload or positive effects when they support diversification of income for women leading to gender disaggregated

Table 2
Aggregate results of the indicator evaluations by CSA pillar (−10 to 10), demonstrating the expected outcomes of each CSA practice on the 'long list.'

Practice	Productivity	Adaptation	Mitigation	Average score
"Rational" management of land (management of flooded and dewatered areas)	6.8	4.9	8.0	6.5
Development of inland valley for rice cultivation	7.5	6.3	5.0	6.3
Drip irrigation	6.8	5.4	6.0	6.1
Zaï pit technique	6.5	5.6	6.0	6.0
Land charters for community management of natural resources	4.8	3.3	9.0	5.7
Industrial bio-fertilizer	7.3	5.9	2.0	5.0
Half-moon technique	6.5	5.4	3.0	5.0
System of rice intensification (SRI)	7.5	6.4	1.0	5.0
Improved varieties adapted to different agro-climatic conditions	7.3	5.7	1.0	4.7
Assisted natural regeneration of trees	3.0	2.9	8;0	4.6
Contour bunding	5.3	5.4	3.0	4.6
Production and use of on-farm compost	6.5	4.9	2.0	4.5
Fertilization of fields by animal corralling	8.3	5.6	−1.0	4.3
Hedgerows	2.5	3.0	7.0	4.2
Tree nursery and transplanting of receding flood areas	6.0	5.4	1.0	4.1
Pisciculture	7.3	4.1	1.0	4.1
Aviculture	6.8	3.1	2.0	4.0
Sorghum-cowpea intercropping	4.5	4.7	2.0	3.7
Apiculture	5.3	1.7	3.0	3.3
Direct and early sowing of millet and sorghum	5.8	3.7	0.0	3.2
Contour stone bunds	2.5	3.4	3.0	3.0
Rabbit farming	5.0	1.9	2.0	3.0
Cattle fattening	6.8	2.1	-2.0	2.3
Soaking of seeds to reduce dormancy	4.5	2.1	0.0	2.2

Table 3
CSA indicators used to evaluate expected outcomes of adoption of practices.

CSA pillar	Selected indicators
Productivity	Yield
	Variability
	Labor
	Income
Adaptation	Food access
	Efficient use of water
	Efficient use of fertilizer
	Efficient use of other agrochemicals
	Use of non-renewable energy
	Gendered impact (labor by women)
Mitigation	Emission intensity

analysis to be important components for many agricultural development projects.

3. Social conflicts related to changes in land use are relevant in the West African context where land belongs to families historically from a village. Migrant families are allowed to use land owned by the previous ones, but some practices are difficult for migrants to implement as they are seen as an appropriation of land and may lead to conflicts between users and owners of the land. Conflicts may also exist between crop and livestock farmers, particularly at the end of the cropping season when livestock roam the savannah areas in order to graze crop residues.

Despite the existing controversies, the externalities were monetized for CSA practices to highlight their impact on non-marketed services and to provide information in terms that could make sense to donors (La Notte et al., 2015; Everard, 2016). Existing literature and assessments by the experts of the steering committee were used to estimate the costs, benefits, and associated externalities of the practices (Supplementary data). For example, proxies such as the cost of 1 ha of land or the cost of the tax paid due to the damages caused by livestock to the crops of crop farmers, were used to value social conflicts.

NPV (Eq. (1)) and IRR (Eq. (2)) were calculated for each practices. A discount rate of 10% was used as that is a common estimate of the social cost of opportunity for the money by development programs and banks.

CBA calculations were conducted using data for both average yield values and minimum yield values (based on the national census for considered crops) recognizing that average yield may not be a sufficient base of calculations given future negative impacts of climate change on yield. For inland valleys for rice cultivation it was assumed that no fluctuation in yields would occur from climate risk due to access to irrigation.

Results of the CBAs showed that all the practices generate economic benefits, except compost, with regards to both NPV and IRR (Fig. 3). Most of the practices, except development of inland valleys for rice cultivation and fish ponds, require low installation costs (mainly seeds, fertilizers, and/or labor) and therefore are profitable within the first year of implementation. The development of inland valleys for rice cultivation and fish ponds had a high NPV over the five-year period analyzed given they introduce high value addition commodities (gardening, fish). Compost led to negative NPV due to a productivity/yield response lag. The results of the CBA analyses led to an alternative ranking of practices compared to the output of phase 2. Contour bunding, the top priority from phase two, had a lower NPV than sorghum and cowpea intercropping or improved varieties, which were ranked second and fourth respectively in phase two. Intercropping and early sowing showed the highest IRR for the average yield scenarios and early sowing and improved varieties being highest in the minimum yield scenarios, with contour bunding coming in fourth under average yield scenario and third under minimum yield scenario.

3.1.4. Phase 4: participatory prioritization of CSA investment portfolios and action plan development

The CBA methodology and results of the previous phase were presented and discussed in a second workshop conducted in October 2015, which involved the same institutions that participated in phase two. During this final workshop, participants were tasked with prioritizing CSA practices and creating portfolios of three to five best-bet CSA practices for the Sudanese zone of Mali.

Portfolios were developed in three subgroups, with participants randomly assigned. Groups used the results of the indicator assessment of practices against the CSA pillars (phase 1), the prioritized short-list (phase 2), the CBA analyses (phase 3), and their own expertise to determine the objective, scale of implementation, and content of their desired portfolios. The subgroups defined if practices should be selected for their synergistic qualities at the field, farm, or landscape level and/or for having a major impact on a specific CSA pillar and/or for being financially profitable. Participants compared the tradeoffs between practices and between different portfolios of practices using a spreadsheet tool that created automated graphics to aid them in selecting final portfolios (Fig. 4).

Two of the three sub-groups chose the same practices (portfolio A), whereas the third group selected portfolio B (Table 5). Portfolio A was designed to include a complementarity set of “good” agronomic practices to sustainably improve crop productivity that were expected to be applicable as a package at the field level by a broad range of farmers. The expectation was that farmers would select 2 or 3 of the four practices depending on given available productive resources (labor, land, animals, etc.). When developing the portfolio, workshop participants selected what practices to combine based on what maximized the average economic performance (association of sorghum and cowpea) and

Table 4
‘Short lists’ of prioritized practices per agro-climatic zone.

Rank	Sahelian (zone A)	Sudano-Sahelian (zone B)	Sudanian (zone C)
1	Sand dune stabilization	Intercropping(sorghum/cowpea)	Contour bunding (for management of cultivated fields)
2	Development of inland valleys for rice cultivation with solar pumps	Assisted natural regeneration of trees	Intercropping (sorghum/cowpea)
3	Agro-climatic information	Contour bunding (for management of cultivated fields)	Development of inland valleys for rice cultivation
4	Assisted natural regeneration of trees	Contour stone bunds	Use of adapted improved varieties to different agroclimatic conditions
5	Hedgerows	Half moon	Fertilization of fields by animal corralling
6	Use of adapted improved varieties to different agroclimatic conditions	Zaï pits	“Rational” management of land
7	Tree nursery and transplanting of receding flood areas	Fertilization of fields by animal corralling	Early sowing - millet, sorghum
8	System of rice intensification	Development of shallow areas	Development of fish ponds
9	Cattle fattening	Use of adapted improved varieties to different agroclimatic conditions	Production and use of n-farm compost
10	Fodder stock of Bourgou (*Echinochloa stagnina*)	Cattle fattening	

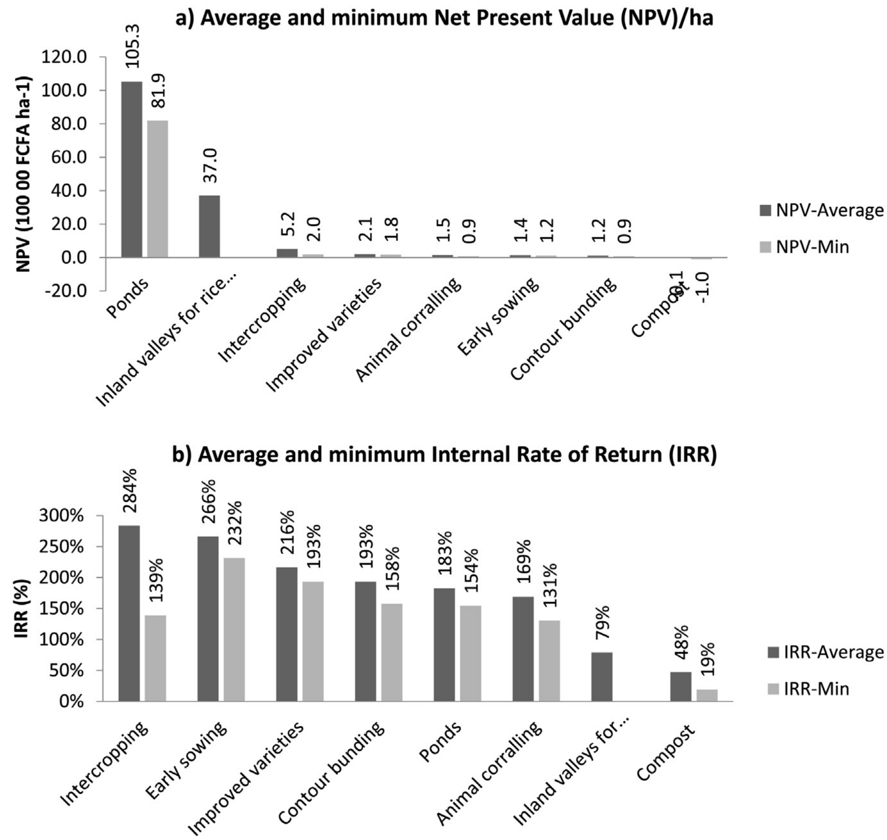

Fig. 3. Average and minimum a) NPV/ha and b) IRR of the eight selected best-bet practices analyzed using CBA.

took into account practices that performed poorly on this metric (compost). The choice of compost, despite its limited economic benefits, was selected due to its higher performance in terms of adaptation and mitigation than animal corralling. In general, participants recognized that mitigation was not a priority decision criteria for the selection of a practice given that adaptation and productivity were the main priorities for farmer livelihoods and national economic growth.

Portfolio B was selected as a set of practices requiring landscape planning, due to the need for shallow areas for the development of rice cultivation or ponds. The practices were not intended to be used by the same farmers, but rather applied as appropriate across diverse agroecosystem from the landscape level perspective. Rice valleys and ponds require farmers to organize themselves to approve and maintain implementation of the practices, which was thought could decrease rural-urban migration due to increased opportunities for agriculture. Although not specifically quantified by the indicators, it was also expected that the selected practices would address water scarcity challenges. Furthermore, 2 of the 4 practices (inland valley for rice cultivation and ponds) were expected by participants to facilitate diversification of the conventional cropping systems, currently based on millet, sorghum,

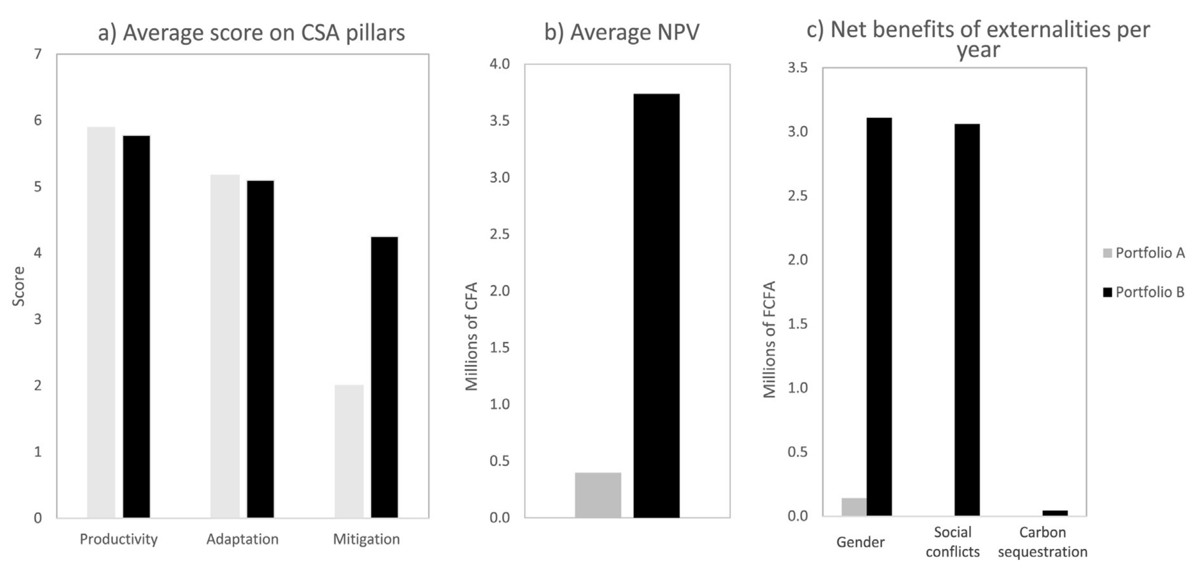

Fig. 4. Portfolio analysis and comparison related to a) CSA outcomes, b) average NPV, and c) net benefits of externalities for the average yield scenario.

Table 5
Selected portfolios of CSA practices for the Sudanian zone.

	Main portfolio objective	Scale of implementation	Practices
Portfolio A	Improving food security and income, supporting adaptation to climate change	Field	Compost Contour bunding Improved varieties Intercropping (sorghum-cowpea)
Portfolio B	Gendered improvement of food security and income, supporting adaptation to climate change	Landscape	Development of inland valleys for rice cultivation Fish ponds Improved varieties Contour bunding

and cowpea. The gender implication of these shifts was a special focus of the group, and 3 of the 4 practices demonstrated a positive impact on female income. Finally, 3 of the 4 practices had high economic, productivity, adaptation, and mitigation performances.

Participants recognized that many of these practices were well known and have been promoted for decades, particularly portfolio A. According to participants, low adoption rates were linked to lack of organization of the value chains and lack of training of farmers. They consequently proposed action plans to strengthen the enabling environment to improve uptake of the portfolios. Participants identified specific key activities to be conducted, the human and financial resources needed, and the institutions that could be responsible for each activity. These action plans were organized around four sets of activities namely:

1. Improved research on the current barriers for adoption of these practices;
2. Capacity building of farmers on climate change and on the promoted practices: suggestion to attempt a scale out to 20,000 farmers in the Sudanese zone;
3. Implementation of local innovation platforms linking farmers to the different stakeholders of local value chains; and
4. Implementation of the promoted practices and monitoring and evaluation on outcomes with farmers.

The first drafts of action plans were intended open discussion with the institution(s) interested in using the selected portfolios in a project or program. Specific actions happened within the first six months following the workshop including the presentation of the conclusions of the process to the Parliament and the introduction of selected portfolios in on-going development projects (Table 6).

4. Discussion

4.1. Prioritizing CSA investments

This CSA-PF contributes to growing literature on participatory processes aiming to support climate change policy planning (Rannow et al., 2010; Schroth et al., 2015; Vervoort et al., 2014), with some processes explicitly aiming to promote CSA (Mwongera et al., 2016). A key recognition around CSA planning is that the combined use of biophysical, social, and economic indicators is critical to allow stakeholders to assess practices against various end-user goals. Synergies and trade-offs of different practices and portfolios of practices can also be assessed against CSA goals, specifically profitability. While other research initiatives exist to compile available data on the outcome of practices against CSA goals (Rosenstock et al., 2016) the CSA-PF is one of the first frameworks to explore incorporating these questions into a stakeholder driven process. Stakeholders and experts in this process play two main roles. First, they are needed to fill in the gaps in the data by providing expert evaluation on practice performance against indicators, as experimental data on many CSA practices in agroecological zones of interest is currently missing (Rosenstock et al., 2016). Second, stakeholders guide the prioritization processes, identifying the criteria that are deemed most important for decision-making in a specific context. Without this, prioritization of CSA practices for investment or scaling is likely to either be a rapid process with little data input or a multi-year study aiming to assess practices on a multitude of criteria and using highly detailed data collection methods. The CSA-PF process was designed to take a simplified and quick approach to assessing CSA practices given the intention of the CSA-PF is for any planning body to be able to use it. It aims to provide a pathway for users with limited resources and lack of advanced climate scenario development and modelling (Claessens et al., 2012; Rodriguez et al., 2014), which require significantly more expertise to implement. Furthermore, some studies have noted (Dittrich et al., 2016) that a focus on no regret options (options that yield social and/or economic benefits irrespective of whether climate change occurs, delivering benefits now and building future resilience), such as the practices considered in this study, inclusion of climate scenarios is not required. The intention is that once implementation of prioritized CSA initiatives begins, new data can be collected and the CSA-PF process can be done iteratively to update priorities and implementation actions.

The most technical component of the CSA-PF is the inclusion of CBAs. These analyses require specific expertise and can be time-consuming, especially when exploring the literature needed to parametrize the economic indicators. Understanding the costs and benefits of CSA practices though is critical to assess return on investment for various stakeholders and aspects of adoption, especially for public investment. Donors involved in the CSA-PF in Mali confirmed their interest in the use of CBA to assess the potential profitability of the policies they promote. They noted that inclusion of externalities was relevant for them, but often considered less relevant for farmers. The use of CBA for planning can

Table 6
First actions implemented six month after the final workshop.

Action	Implementer	Budget (USD)	Donor	Date
Implementation of CSA options in the Mopti, Segou and Sikasso regions	Two national NGOs identified as end-users of the process	5,177,250	Project funded by the Ministry of Foreign Affairs of the Netherlands	2016–2018
Improving the productivity of mixed cereal leguminous cropping systems in the context of climate variability	AMEDD	1,100,000	IITA-USAID, Foundation McKnight, Louis Dreyfus Foundation projects	2015–2018
Presentation of the conclusions of the process to the Rural Development Committee of the Parliament	The Rural Development Committee of the Parliament	–	–	December 2015

also be debated given the range of assumptions made for the estimation of the economic indicators and particularly for the estimation of environmental externalities and associated discount rates (Baum, 2009; Spash, 2007). The CSA-PF process aimed to take this limitation into account by transparently outlining the choices and assumptions made in the parametrization step with end-users and participants, including discussions on the limits and opportunities for use of the results.

Even if the prioritized practices were already known and promoted by research and development institutions, it should be noted that they were generally promoted individually without exploitation of potential synergies between practices and that they were often not being widely adopted (van Rijn et al., 2012). The low adoption of potential CSA practices highlights the need to go beyond the sole assessment of practices and to identify solutions to strengthen their enabling environment. The process of implementing the CSA-PF, aside from the analyses, created a space for discussions on desired change in agriculture systems and barriers to adoption and, through drafting of action plans, outlined opportunities to strengthen the enabling environment for scaling CSA investment priorities.

4.2. Lessons for successful participatory CSA planning processes

A main objective of the work in Mali was to assess the ability of the CSA-PF process to be used in the Malian context and if it provided a functional process to support decision making and prioritization of CSA investments. Adapted from the analytical framework proposed by Neef and Neubert (2011) the study analyzed the ability of the CSA-PF to achieve its objectives as related to the institutional context, characteristics of the end-users of the process, the research approach, and stakeholders involved in the process. The aim was to distill lessons learned for leveraging and developing enabling environments for prioritization of CSA options and linking those with opportunities for achieving CSA at scale.

4.2.1. Project type

The existence of an institutional network associated with CSA themes in Mali was a major factor supporting the CSA-PF process. The CCASA Platform meant that stakeholders already had a basic understanding of climate change and agriculture challenges, literature and data was available to estimate CSA indicators, and institutions working on the topic were already identified. The influential network allowed for quick national resonance of the process through media and governing bodies, such as congress, and also facilitated quick integration of the selected portfolios into ongoing applied research. This platform also played a key role in the integration of CSA into the Malian Nationally Determined Contribution (NDC) submitted to the UN Framework Convention on Climate Change, establishing an enabling policy environment for the implementation of the practices selected in the process. Prioritization processes are directly applicable in countries with highly developed enabling institutional environment. Without this, an initiative would have been needed to open dialogue with decision makers about the role of CSA in Mali, opportunities for CSA investment given existing policies, and the potential need to develop programs for CSA action. While the enabling environment in Mali can favor insertion of practices in ongoing development projects, more incentives are needed to support the adoption of practices by farmers. This could be done through the development of associated value chains or trainings of farmers on the challenge of climate change, which was highlighted by workshop participants in the proposed action plans.

Five potential end-users (two donors, the ministry of agriculture, and two national NGOs) were identified in the first phase of the CSA-PF process in Mali, the majority were already involved in the CCASA platform. The process could have been conducted separately with the different end-users to ensure high specificity of defined portfolio, but, by addressing multiple end-users, a broader perspective was gained in the prioritization process. The likelihood that the process could led to the inclusion of the portfolios proposed in future planning was also expected to be greater given opportunities for end-users to collaborate and more stakeholders being included. The Ministry of Agriculture and the two national NGOs were the quickest to adopt the outputs of the process. For the donors, immediate uptake of results was challenging as the timing of the end of the CSA-PF process did not align with the planning cycle for future calls for proposal. The donors noted that had the timing been aligned the results would have likely been incorporated to modify calls. Participants in the CSA-PF process are exploring opportunities for this moving forward, but recognize the risk that the momentum created by the process will diminish over time. A key lesson for future implementation of the CSA-PF is to both identify relevant end-users and, plan analyses and interventions to coincide with opportunities for influence. Tradeoffs between a wide engagement approach as opposed to a unique 'client' based approach to engaging end-users should be considered.

4.2.2. Research approach

The process of prioritizing practices took into consideration multiple dimensions of CSA, including economic analyses, associated social considerations (social acceptability of the practice), and priority goals of stakeholders (development of women for example). Consequently, the final results of the process are specific to the selected participants and the process is not prescriptive with regards to methods or results, instead allowing for participants to shape the research agenda and questions. Implementation with other stakeholders would likely have led to the selection of other portfolios, and therefore it is critical to document indicators used and other criteria for prioritization to ensure the specific goals of each CSA-PF process, and subsequent results, can be used adequately by CSA implementers not involved directly in the process.

Participants focused more on the CSA goals of adaptation and productivity and less on mitigation. This reflects the different between country priorities and research and international climate change priorities, which would have led to higher prioritization of practices such as assisted natural regeneration of trees or hedgerow practices which have high mitigation potentials. This lesson is salient for a concept like CSA, where recognition of differentiated goals and appropriate application given local contexts and needs is critical to appropriately funding outscaling of the approach.

Furthermore, the utility of processes like the CSA-PF is not focused on achieving one set of non-debatable recommendations based on accurate calculations of indicators, but rather in the collective interrogation of data, provocation of discussion, and networking of stakeholders around CSA (Voinov and Bousquet, 2010). Deliberation and documentation of priorities allows for systematic and transparent filtering of practices of high interest for further in depth analyses. The process is consequently a boundary object (Cash et al., 2003; Trompette and Vinck, 2009) that means an artefact permitting the facilitation of partnerships between researchers and decision-makers, producing a common language around CSA to guide effective action. However, this strength is also the main limitation since the divergent needs and aspirations between stakeholders can lead to a soft compromise that does not match with the real environmental challenges that may require drastic decisions to be taken (Hueting and Reijnders, 2004). The facilitator consequently has an important role to ensure that the options prioritized in the process are rooted in the evidence presented and the challenge caused by climate change.

Flexibility was built into the prioritization processes to support modification of indicators used and of associated analytical methodologies in order to allow specific next-users to start the whole process again according to his/her own priorities, scale of action, expertise, and available data. The CSA-PF process conducted in Mali was consequently different from the previous pilot in Guatemala where the CSA-PF was used by the Ministry of Agriculture and Food to assess CSA options incentivized by existing policies (Sain et al., 2017). In Guatemala, practices were analyzed across 15 indicators (versus 11 in Mali) and portfolios were defined by groups of different types of actors allowing the Ministry to understand the diversity of propositions from the academic, government, or farmer perspective as related to their policy interventions. In Mali, the different types of actors were mixed in each sub-group and defined portfolios according to an objective and scale of implementation they selected together, allowing for actors to identify opportunities to work together on scaling interventions.

In contexts where access to data and analytical skills are higher, more indicators and increasingly complex analyses can be utilized to support prioritization. In phases 1 and 3 of the CSA-PF, assessment of the prospective effectiveness of practices according to climate change scenarios could be introduced through the use of modelling to add another input into the decision making. The CBA could be conducted taking into account the specific vision of each stakeholder involved in an agricultural project: the donor and the policy maker that may be interested in the monetization of different externalities, and the farmer that may have different priority considerations to include. In other contexts, where accurate data availability is low, the number of indicators can be reduced (e.g. one indicator for the three CSA goals) and the assessments of costs and benefits can be simplified (e.g. income used instead of probabilistic economic costing).

4.2.3. Characteristics of the stakeholders involved in the process

Ownership over key design parameters was in the hands of the steering committee and the facilitator (AMEDD) in Mali, and the research team mainly provided methodological support, analytical tools, and literature on the concepts and CSA practices.

AMEDD played a central role incorporating knowledge on the national institutions and linking the research team and steering committee with the end-users. AMEED's recognized expertise on climate change and agriculture in Mali also built legitimacy for the CSA-PF for other stakeholders, who when pro-actively engaged by AMEDD during existing CSA dialogue supported by the CCASA allowed for the CSA-PF process to be embedded in ongoing discussions and decision-making opportunities. AMEDD itself was interested in the outcomes of the process, for example participation in potential proposals rising from the process, and its knowledge on ongoing and future agricultural research and development projects permitted identification of opportunities for the implementation of the defined portfolios. In such participatory processes, the role of facilitators also called “innovation brokers” has been highlighted (Klerkx et al., 2010; Schröter et al., 2015). However, it has been shown that process facilitators can be biased and guide the process towards its own objectives and expertise (Schröter et al., 2015). The role of research on these processes itself is consequently to assess this risk through monitoring and evaluation to alert when this bias diminishes added value of having a participatory process.

Workshop participants were selected to specifically include different political, scientific, and technical views, which was addressed by reaching out to academia, farmers, and government stakeholders. It was also important that the stakeholders involved had knowledge and experience on climate change and agriculture to ensure they could actively participate in decision making. While some participants had limited technical expertise on climate change issues they had experience implementing projects or programs in relation to the topic. Participants declared after going through the CSA-PF that their skills in the topics addressed had improved and they could potentially facilitate the CSA-PF process again on their own in the future to improve or create new portfolios, potentially with other objective or in other regions, and to scale out CSA in line with relevant mandates, strategies, and priorities.

As in any stakeholder driven initiative it was viewed as critical to permit ownership of the outcomes of the CSA process to establish clear roles between research team, facilitator, members of the steering committee, and stakeholders participating in the workshops.

4.2.4. Stakeholders benefits of the CSA process

The majority of workshop participants (60%) perceived that they acquired new knowledge participating in the CSA-PF. In the first workshop this was related to introduction of CSA concepts, potential CSA practices, and CSA indicators. In the second, the focus was on CBA concepts, externalities and multi-criteria assessment of CSA practices.

Even if mitigation was not considered as of priority for the country, taking this criterion into account in the assessment of practices allowed participants to gain awareness of how their priorities would affect mitigation, showing usually unexplored synergies between adaptation and mitigation interventions.

AMEDD also noted improved skills in assessing the profitability of CSA practices and social and environmental externalities given they conducted the CBA analysis with a new methodology for the institution. Donors and government officials also now recognize AMEDD as an institution capable of analyzing practices promoted in ongoing projects, with an informal proposition made to assess an ongoing donor project.

Knowledge of the institutional landscape in Mali, related to climate change, was also noted as improved by 75% of participants, with 44% of participants in the second workshop crediting their awareness of institutions working on climate change due to links made in the first workshop. Collective action was strengthened after the process as some participants were involved in an on-going project intended to upscale CSA in 2016 after the CSA-PF was completed (Table 6). However, it was clear that rather than creating new organizations, the process supported pre-existing forms of social capital permitted by the CCASA platform.

The first operationalized actions that occurred six months after the closure workshop (summarized in Table 6) are the best illustration of the benefits of this kind of informed-decision making process.

A proposal submitted by the two NGOs that participated in the process was funded, aiming to promote large scale adoption of practices strengthening the capacity of farmers from the Sudanian zone to face climate change. Their involvement in the CSA-PF allowed them to include CSA as a clearer target in their action plan.

AMEDD included the prioritized practices in four ongoing projects that it was leading in Mali and Burkina Faso.

AMEDD also presented the conclusions of the CSA-PF process to the Rural Development Committee of the Parliament, the latter being covered by two national media outlets. The expectation is that the media coverage of such an event will put emphasis on the need for national stakeholders and programs to promote CSA practices in medium and long term. These follow on actions demonstrate the CSA-PF provides both a space for immediate interrogation of CSA options, and also builds a network that catalyzes continued action even after research groups and formal facilitators complete the process.

5. Conclusion

This article analyzes the implementation of the participatory CSA-PF process in Mali, which aims to provide evidence-based decision-support to identify CSA investment priorities. The 12 month-process involved around 30 decision-makers from national government, district authorities, academia, international and national research institutions, NGOs, and donors. It resulted in the implementation of prioritized practices in research and development programs and the request for support to mainstream CSA by the Ministry of Agriculture and the Parliament.

Four main lessons were learned from this process:

1. The CSA-PF initiative is relevant in countries where there are supporting institutions aware of climate change and interested in implementing CSA. This type of enabling institutional environment ensures coherent linkage of results with national and regional realities, needs, and challenges,
2. CSA investment prioritization processes are most successful when led by a local stakeholder engaged in CSA planning that has working

knowledge of ongoing and future agricultural projects and can therefore identify opportunities for the implementation of the defined portfolios throughout the process,

3. The main role of research scientists is to monitor the process and to ensure that there is limited facilitator bias,
4. The utility of the indicator assessments of the CSA process is not primarily in achieving accurate calculations of outcomes, but rather in being able to relatively compare practices, provoke discussion of priorities, and network stakeholders,
5. The definition of agriculture development portfolios based on the performance of practices against CSA goals favors identification of synergies between sectorial objectives and the assessment of the economic performance of portfolios assists in identifying practices that have higher potential for adoption by farmers.

The process has already attracted funding and further interest, but new initiatives on the ground have only just begun implementation. Following the selection of CSA investment priorities, it is consequently critical to assess the pathway towards ultimate impact through (1) the monitoring and evaluation of the implementations, across the three pillars, (2) the identification of synergistic effects between practices on farms and across landscapes, and (3) the scaling out of the CSA practices through incentive mechanisms or institutional and governance changes needed to support adoption.

There is global momentum to better understand how to achieve agricultural development that takes into account productivity, resilience, and mitigation. Given this it is critical that policy-makers, planners, and implementers identify processes for prioritizing investments in agricultural that match with the institutional, biophysical, and socio-economic realities and also push for inclusive decision-making to ensure equitable, effective, and sustainable solutions for agricultural system and stakeholders in the long-term. The CSA prioritization in Mali was only a first step to achieving CSA outcomes at scale, and ongoing agricultural programs incorporating CSA priorities must be followed.

Acknowledgement

This work was implemented as part of the CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS), which is carried out with support from CGIAR Fund Donors and through bilateral funding agreements (the CGIAR Fund Council, Australia (ACIAR), European Union, International Fund for Agricultural Development (IFAD), Ireland, New Zealand, Netherlands, Switzerland, USAID, UK and Thailand). For details please visit https://ccafs.cgiar.org/donors. We acknowledge the Malian officials, Representatives of the European Union in Mali, and other stakeholders that participated in the process. We are thankful to the teams of researchers that piloted the CSA-PF and shared methods and lessons, especially from Guatemala and Cauca, Colombia. The views expressed in this document cannot be taken to reflect the official opinions of these organizations.

Appendix A. Supplementary data

Supplementary data to this article can be found online at http://dx.doi.org/10.1016/j.agsy.2017.02.008.

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