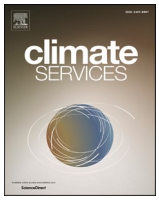
Stimulating small-scale farmer innovation and adaptation with Participatory Integrated Climate Services for Agriculture (PICSA): lessons from successful implementation in Africa, Latin America, the Caribbean and South Asia

Climate Services 26 (2022) 100298

Contents lists available at ScienceDirect

Climate Services

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



Stimulating small-scale farmer innovation and adaptation with Participatory Integrated Climate Services for Agriculture (PICSA): Lessons from successful implementation in Africa, Latin America, the Caribbean and South Asia

Graham Clarkson [a,*], Peter Dorward [a], Sam Poskitt [a], Roger D. Stern [b], Dominic Nyirongo [c], Katiuscia Fara [c], John Mwangi Gathenya [d], Caroline G. Staub [e], Adrian Trotman [f], Gloriose Nsengiyumva [g], Francis Torgbor [h], Diana Giraldo [i,j]

[a] University of Reading, UK
[b] Innovations in Development, Education and the Mathematical Sciences, UK
[c] World Food Programme, Italy
[d] Jomo Kenyatta University of Agriculture and Technology, Kenya
[e] Abt Associates, Rockville, MD, United States
[f] Caribbean Institute for Meteorology and Hydrology, Barbados
[g] International Research Institute for Climate and Society, United States
[h] Innovations in Development, Education and the Mathematical Sciences, Ghana
[i] University of Reading, UK
[j] CIAT, Colombia

ARTICLE INFO

Keywords:
PICSA
Climate services
Participatory extension
Smallholder farmers
Innovation
Empowerment

ABSTRACT

How to cope with climate variability and adapt to climate change are key challenges for smallholder farmers globally. In low-income countries, farmers have typically received little, if any locally relevant weather or climate information. Although climate services have contributed to increased availability and accessibility of climate information, this has rarely achieved the desired impacts for farmers' decision-making, adaptation and resilience to climate variability and change. This has been attributed to a lack of engagement with intended users of climate information and a top-down approach to development and delivery of climate services that fails to adequately consider and account for farmers' context-specific requirements. Participatory Integrated Climate Services for Agriculture (PICSA) is an approach that was developed to support and empower farmers in their decision-making processes. More than 200,000 farmers have been trained in 23 countries and this paper presents evidence from evaluations in 7 countries including that most (87%; n = 4,299) have made beneficial changes in their crops, livestock and/or livelihood enterprises. The approach has strengthened key institutions that support farmers through deliberative scoping, tailoring, and capacity-building activities with extension and meteorological services. It has been well received by those that use it and is being integrated into policy and training curricula. Key reasons for the success of the approach include the importance of supporting farmers as decision makers and empowering them to relate relatively complex weather and climate information to their own contexts. Key considerations for the future include ensuring sustainability and further scaling as well as maintaining quality.

Practical implications

Participatory Integrated Climate Services for Agriculture (PICSA) has been highly successful in supporting innovation by smallholder farmers. The approach has been effective across different countries and contexts in supporting farmers' individual analysis,

* Corresponding author at: School of Agriculture, Policy and Development, University of Reading, UK.
E-mail address: g.clarkson@reading.ac.uk (G. Clarkson).

https://doi.org/10.1016/j.cliser.2022.100298
Received 6 July 2021; Received in revised form 18 February 2022; Accepted 8 April 2022
Available online 22 April 2022

planning and implementation of a wide range of options that they have, individually and in groups, identified for their own contexts. Here we outline some of the key reasons why.

The underlying principles

PICSA respects each farmer (or household member) as best placed to make plans and decisions for their context (environment, resources etc…). The steps in PICSA provide new, transparent, information and decision-making tools for farmers to use themselves. The participatory tools are designed to enable trained farmers to work through an open process to make informed decisions for their individual contexts rather than be presented with 'solutions' already derived from less transparent processes or tools.

A logical and visual process

Each of the steps places an emphasis on visualisation, and the use of diagrams has proved useful for both non-literate and literate users. In addition, the approach takes advantage of the fact that most non and semi-literate people are numerate and so several steps include quantification, comparisons and/or straightforward calculations. Each of the steps has a specific purpose and logically and sequentially contributes to an overall process, empowering farmers to integrate relatively complex information into a process of developing strategies and decision making. For example, exploration of the historical climate information enables consideration of a location's climatology and informs decisions such as choice of the best crops and varieties for their location alongside appropriate soil and water management practices to reduce climate risks.

Addressing immediate needs and planning for the longer term

Many smallholder farmers are resource poor and operating in unpredictable economic and climatic environments. This means that households' priorities are often to ensure sufficient food and income for a given year, season, or even shorter timeframe. Making changes in farming practices is risky as failure may have grave consequences for farmers and their households, especially if scarce resources have been invested to do so. By integrating the historical climate information, PICSA facilitates planning for different time horizons. Farmers and extension workers are able to identify any emerging trends (climate change) that may affect their longer-term planning as well as better understand the variability they face year on year. We have observed that farmers and extension officers find that better understanding the extent of variability (in for example season start dates and amounts of rainfall per season /month) particularly informative. This means that farmers are able to identify and explore potential changes they may make to their farming and non-farming practices to address climate variability, but also take into account climate change and other longer-term challenges that influence farming decisions (e.g. declining soil fertility, unpredictable markets). These changes often include climate-smart options which address both more immediate and longer-term climate challenges. In addition, farmers have reported reinvesting gains made from the changes into existing and new farming enterprises, thereby contributing to the longer-term sustainability of the benefits they have achieved.

A focus on 'integration' rather than 'dissemination'

Rather than focusing on the delivery or dissemination of information, PICSA integrates information with decision making tools to help farmers to contextualise information for their own individual circumstances. In doing this, PICSA ensures that the information is useful and useable. PICSA also involves a 'whole farm' approach, acknowledging the farm as an integrated system rather than focusing on an individual crop or type of livestock. At the level of key stakeholders, the approach brings together National and Regional Meteorological Services (NRMS), Agricultural Extension Services, and farmers along with other key actors in the innovation system (seed suppliers, credit providers, NGOs) that often operate in isolation. Bringing these stakeholders together helps them to learn from each other's experiences and expertise and builds relationships that develop a stronger service for farmers.

Supporting extension and Met Services to do the jobs they are mandated to do

The approach supports Agricultural Extension Services and NRMS to meet their existing mandates. For extension, they are able to support farmer innovation and adaptation to climate change as well as integrating more participatory methods to genuinely empower farmers. NRMS build their capacity to be able to use and make useful their vast resource of historical rainfall and temperature data as well as adding considerable value to their existing short and longer-term (e.g. seasonal, 3 or 6 month) forecast products.

It is also important to outline some of the key opportunities and challenges that are associated with on-going and future implementations:

Sustainable implementation at scale

Sustainable implementation at scale requires inclusion in government policy and/or support from private sector actors and initiatives for integration into the roles and annual activities of those intermediaries and service providers that support smallholder farming systems. The main investment required is in the initial preparation and capacity building. Ongoing implementation requires fewer resources and directly addresses the existing mandates of key institutions (such as Ministries of Agriculture, NRMS and Universities) which suggests that there is a case for core funding to be provided by or through governments. Sustainability requires ownership by these key institutions which is beginning to be achieved in countries such as Malawi where the approach has been included in the national extension strategy (DAES, 2020).

Maintaining quality and integrity of the approach and its principles

As the approach scales to new contexts and to more farmers it is essential to maintain its quality and integrity. This includes:

- Allocating sufficient time and resources to ensure sufficient preparation, contextualisation and capacity building for local ownership.
- Implementing refresher training processes for trained facilitators during which they are able to reflect on their experiences with peers and plan their continued use of PICSA.
- Integrating the approach and the underlying principles in the curriculum of training colleges and Universities so that newly trained agricultural extension staff and managers are clear about the concepts and tools that support the approach.
- Backstopping the formal training processes with online materials including refresher videos, support forums and frequently asked questions.
- Developing improved materials such as visual step-by-step guides and examples of PICSA tools for farmers (including 'lead farmers') to refer to and share with their peers.
- A robust monitoring and evaluation process to track the effectiveness of the approach and ensure shared learning and iterative improvements.

Emphasis on the role of digitally informed climate services

There are opportunities to integrate information and communication technologies (ICT) as part of PICSA to support facilitators in their work with farmers and to directly support farmers with information and tools. A mobile app has already been piloted in Malawi that includes historical climate, probability and risk, and a participatory budget tool. Care is required to ensure that ICT and its use support the key principles of PICSA which are essential for its success.

Strengthening agricultural innovation systems

There is scope to directly link the integration of PICSA with other programmes or approaches that aim to support the wider

innovation system including access to finance, information and markets. PICSA stimulates innovation in smallholder farming systems. However, most farmers report that they would like to have made more changes but were unable for several reasons. Constraints that respondents reported included limited access to inputs, lack of financial resources, risk of unfavourable or extreme weather conditions, and access to or the need for further technical information on some innovations. PICSA would have greater impact when combined with stronger support systems for farmers, including with specific targeting for the least well-resourced farmers.

1. Introduction

Smallholder farmers are vital for food security and millions of households depend upon small-scale, rain-fed farming globally. Helping farmers to cope with climate variability and adapt to climate change is a major global challenge, as acknowledged in the 2015 Paris Agreement. Critical farming and household decisions depend upon local weather and climate conditions, such as the amount of rainfall, the timing of the rainy season, and the timing and extent of extreme events. Smallholder farmers in low-income countries have typically received very little, if any, locally relevant weather or climate information. When there has been information, little has been done to contextualise it, relate it to farmers' experience and make it useful for decision-making (Fisher et al., 2015; Ofuoku and Agbamu, 2012; Staub et al., 2020). In both climate services and agricultural extension, top-down and information/technology transfer approaches continue to be widely applied and are of limited use (Brooks, 2013; Lemos et al., 2012). Addressing these issues requires a bottom-up, scalable approach to support individual smallholders with planning and decision-making in their own complex environments and farming systems.

Participatory Integrated Climate Services for Agriculture (PICSA) was developed using an iterative and reflective process, working with smallholder farmers, government and non-government extension field staff and meteorologists in Zimbabwe (2011–13) and Tanzania (2013–15). The aim was to create an approach that would support and empower farmers in their decision-making processes related to on- and off-farm enterprises. This involved cycles of implementation, reflection and improvement. Implementation consisted of a series of training workshops for extension staff who then worked with established groups of farmers ahead of and during the agricultural season. Reflection and learning involved observing the use of the approach; focus groups and individual interviews with farmers and field staff during and after their use of the approach; and discussions with key institutions involved in agricultural extension and climate services. As a result the PICSA field guide, outlining the approach, was produced in 2015 (Dorward et al., 2015).

PICSA has, since 2015, been used in more than twenty countries in four continents and has consistently led to high proportions of trained farmers making beneficial changes to their farming and other livelihood practices. This paper draws together the findings and experience from a range of implementations of PICSA in multiple countries to identify key reasons for the success, as well as to consider future opportunities and challenges with respect to further scaling and sustainability. The following sections provide an outline of the scale and reach of the PICSA approach to date, the evaluation methodology that has been used, evidence of the success of the approach in stimulating change in smallholder farming systems, discusses reasons why the approach has succeeded and identifies key lessons learned and future opportunities.

2. Scale and reach of PICSA

To date PICSA has been implemented in 23 countries on four different continents (see Fig. 1) ranging from small-scale pilots to national level. These implementations have been funded by a range of international organisations (UN agencies, international research centres and donor organisations) and have been in collaboration with national governments and non-government organisations. For example, as part of the USAID funded Rwanda Climate Services for Agriculture Project, PICSA has been implemented in all 30 districts of the country and working with World Food Programme and United Nations Development Programme in Malawi has led to more than half the districts in Malawi receiving the approach. In each new country a series of activities outlined in Table 1 in section 3.2 are undertaken.

Globally, more than 5,800 agricultural extension workers and community volunteers have been trained as PICSA facilitators as part of a

Fig. 1. The locations and numbers of farmers trained in and using PICSA by 2020 – numbers based on field monitoring by implementing organisations in each country.

detailed and practical training of trainers' approach. These facilitators have subsequently trained more than two hundred thousand farmers. Evidence from a range of evaluations shows that most trained farmers informally (e.g., as part of community or religious meetings, with neighbours and other peers in the community and women's groups) share the tools and information learnt during PICSA training with their fellow farmers which means that benefits accrued from PICSA are well beyond the number of farmers trained and reported here. For example, each farmer trained in Malawi and Tanzania in 2015/16 shared with an average of 16 and 26 other farmers respectively (Steinmüller and Cramer, 2017).

Alongside institutions that focus on agriculture and food security, National and Regional Meteorological Services (NRMS) are at the centre of the PICSA approach. NRMS play a vital role in rescuing, cleaning and analysing their climate data to produce the products (see Fig. 3 in section 3.1) that are essential for farmers and facilitators as well as preparation and production of forecasts. Through their involvement in the PICSA implementation process, NRMS have not only rescued and analysed historical climate data but have become more aware of farmers' requirements, and the challenges they face, which enables them to carry out key functions of their service more effectively. For example, PICSA has helped the National Meteorological Services of Colombia, Honduras and Guatemala be better linked with the farming communities' demands (Loboguerrero et al., 2018). Overall, in many countries this has led to a shift, with a move from top-down, pushing of information from producers to a process in which information is created with the needs of the farmers closer to the fore.

3. The PICSA approach

3.1. PICSA as a process

PICSA incorporates analysis and communication of locally specific climate information with the identification and exploration of household response options, through a set of participatory decision-making tools. It is designed to help farmers make informed decisions that improve their ability to manage and adapt to climate variability and change. In practice, PICSA involves a 12-step process, which agricultural extension officers or other intermediaries, work through with groups of farmers (Dorward et al., 2015). These steps can be grouped into the following themes, as shown in Fig. 2, below.

Importantly, PICSA enables the empowerment of farmers to make their own decisions and identify and implement response options that they consider appropriate for their individual contexts rather than external organisations identifying and promoting 'one-size-fits-all' solutions. The approach is guided by two principles, "the farmer decides," and "options by context". These principles also mandate a commitment to communicate relevant climate information in a transparent manner, so that farmers can use it in their decision-making.

Each of the steps has a specific purpose, as part of a logical sequence of activities, and contributes to the overall PICSA process and its underlying principles (see Dorward et al. [2015] for a detailed breakdown of each step and their individual aims). Each farmer considers their own existing resources and activities (using Resource Allocation Maps and Seasonal Calendars), before working in groups to explore and analyse historical climate information and identify potential crop, livestock or other livelihood options (using options matrices) to address the challenges they face. Farmers then plan and evaluate these options in detail for their individual farms and households using participatory budgets. Seasonal and short-term forecasts are introduced ahead of and during the growing season to enable farmers to adapt or tailor their provisional decisions and strategies to predicted conditions for the next season, or in the coming days and weeks.

PICSA makes use of both historical climate information and forecasts. The historical information (presented as timeseries graphs covering the last 30 or more years – see Fig. 3) enables farmers to consider, quantify and explore characteristics of the local climate including amounts of rainfall received per growing season, dates of starts and ends of rainfall seasons, intensity of rainfall received, temperatures, occurrence of extreme events (a detailed step-by-step guide to this process in included in Dorward et al. [2015]). Whilst farmers have valuable observations and knowledge of indicators such as water levels, vegetation and crop growth they have not normally had the opportunity to actually measure and record either amounts of rainfall or levels of temperature and rarely, if ever, have the opportunity to see the results of climate data analysis even when such data are collected near their farms.

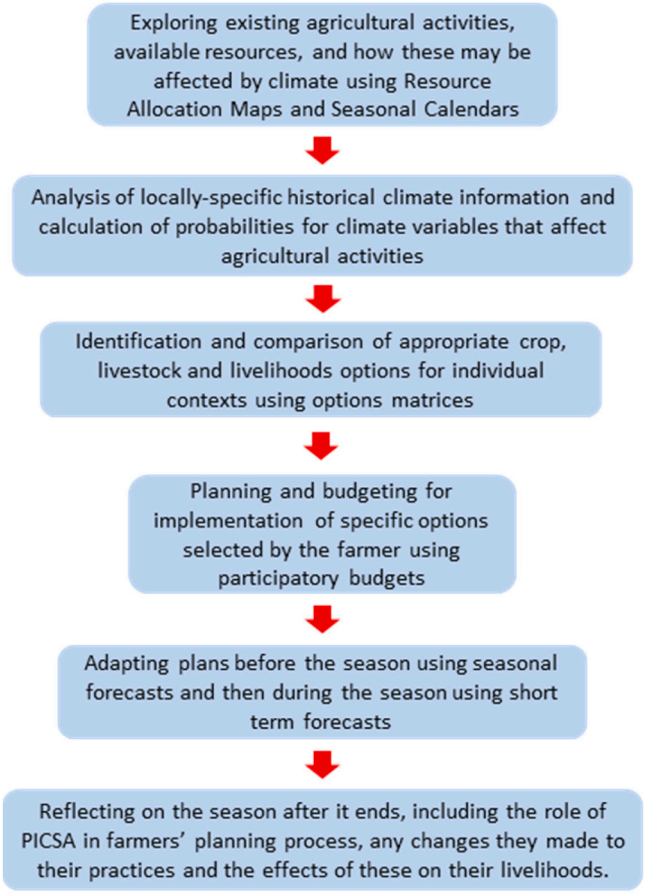


Fig. 2. Flow chart of the PICSA process.

The historical information firstly enables consideration by farmers (and extension workers) of key aspects of the local climatology and implications for agricultural decisions. For example, the timing and amounts of rainfall and suitability of different crops and varieties. Of particular value is consideration of the range of values normally experienced (climate variability) and this is often striking and of particular interest. Decisions farmers make on a seasonal or year-to-year basis are often directly influenced by interannual and intra-seasonal variability. PICSA includes steps that enable farmers to calculate basic probabilities (for example, the frequency of seasonal rainfall surpassing a given amount or a season lasting a given length) to aid in understanding and use of historical climate information that reveals locally relevant climate conditions. Secondly, historical information enables farmers to identify any trends (e.g. in rainfall amounts and timing, or in temperatures at particular times of year) and to consider in more detail how the climate is changing in a location. This also helps farmers to identify appropriate strategies to address climate change as well as climate variability. In addition, the historical climate information helps farmers to contextualise and interpret the seasonal forecast as it relates to their location and climatology.

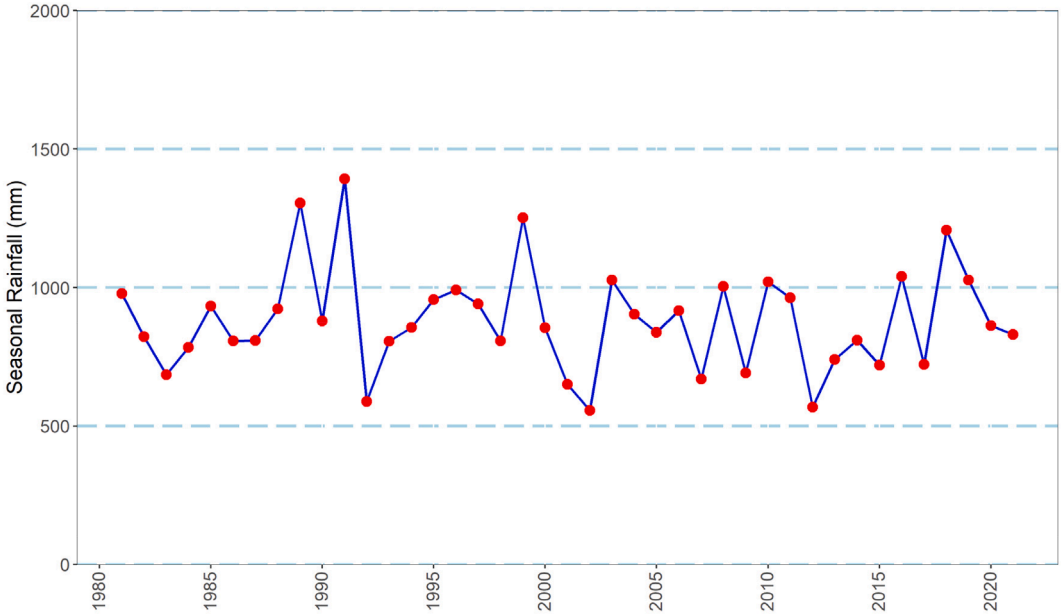


Fig. 3. Time series graph showing seasonal rainfall in Tamale, Ghana. This and similar graphs (e.g. dates of start of season, length of season, maximum and minimum temperatures inter alia) are useful for exploring questions such as, what are the actual amounts of rainfall farmers have received, the variability that they experience and whether there is evidence of longer term trends (Credit: Ghana Meteorological Agency).

3.2. Preparing for and implementing PICSA

There are several important activities required ahead of implementing the PICSA approach in a new location (e.g. a new country or agro-ecological zone). PICSA is designed to be integrated into existing activities, and to enhance connectivity between farmers, extension officers, NRMS, and other actors in the local agricultural innovation system. It is therefore essential to understand who these actors are, and to build relationships with them to encourage buy-in to the approach and its participatory principles. It is also necessary to understand the agro-ecological and climatic contexts in a specific location, and to tailor PICSA accordingly. Preparing for and implementing the approach therefore typically involves a series of scoping, relationship-building, training, and evaluation activities, as explained in Table 1, below.

If carried out successfully, the activities described in the table above achieve four things. Firstly, they help to develop relationships and mutual understanding between agricultural extension (and/or other intermediary organisations), NRMS, national and international NGOs, researchers, and other intermediaries. Secondly, they enable PICSA to be implemented with farmers in a specific location, in a way that is tailored to their decision-making needs. Thirdly, they build the capacity of organisations and individuals to continue implementing PICSA, which in turn encourages the scaling-out of PICSA within a particular country or region. Finally, the integration of monitoring and evaluation within the implementation of PICSA enables all parties to reflect on and learn from their experiences, such that it may be enhanced in future. The results of these evaluations also enable us to identify and explore the effects that PICSA has had for farmers in multiple countries, which is the focus of the rest of this paper, beginning with an explanation of the PICSA evaluation methodology, below.

4. Evaluation methodology

This paper draws on primary data from quantitative household surveys conducted in seven different countries as well from qualitative case studies collected in each. Sampling for each of the surveys followed a similar approach, targeting trained PICSA farmers and ensuring that proportions of men and women were similar to the overall proportions of those trained. Surveys were conducted across a range of regions and agro-ecologies to ensure that these factors were considered in understanding the overall effects and influence of the approach. Respondents were randomly selected from lists of trained farmers in each location. In all locations apart from Mozambique, quantitative surveys were followed up with qualitative case studies. Case study households were selected from respondents to the quantitative survey to ensure a range of perspectives. Selection criteria ensured that respondents were selected that had made changes in crops, livestock and/or livelihoods; had not made changes; and that came from a range of ages across the sample and different wealth categories. For the quantitative surveys, small teams of enumerators were trained and piloted the surveys ahead of data collection. Similarly for the qualitative work, research assistants who had previous experience in qualitative work were recruited and undertook careful training and piloting.

In each of the countries, the evaluation of the effects of the PICSA training was undertaken several weeks after respondents had harvested, to ensure that they had been able to experience effects of the decisions they had made for the preceding growing season. The survey tool was designed to explore whether respondents had received and understood the training on each of the PICSA tools and whether they had used them in their planning and decision making. After establishing this, farmers were asked whether they had made any changes that were directly linked to the training and information that they had received. In addition, respondents' perceptions regarding the effect of the training on their confidence, social standing, food security and income were explored using a set of positively and negatively worded Likert style statements. For each of the quantitative surveys we tested whether the proportion of responses were independent of gender and wealth category using a chi-square test. Respondents in each survey were categorised into 3 or 4 wealth categories based upon their Poverty Probability Index[1] score. As there were more than two categories for wealth we ran multiple pair-wise comparisons. Specific approaches to qualitative case studies varied slightly across the different evaluations but all included interviews with individual farmers that focused on their response to the training and the decision-making processes that led to any changes they might have made. These interviews were

[1] https://www.povertyindex.org/.

Table 1
Activities involved in preparing for and implementing PICSA with farmers.

Stage of preparation/ implementation	Details of what is involved
Scoping National and Regional Meteorological Services (NRMS)	• Explore the coverage of meteorological stations to ensure historical climate information is available for the location(s) where PICSA will be implemented. • Assess the completeness of historical climate information from available meteorological stations and perform data rescue where necessary, and possible. • Build the capacity of NRMS to produce graphs of historical climate information for specific locations. • Assess the availability and skill of national and downscaled seasonal forecasts.
Scoping agricultural innovation systems and agro-ecological systems	• Who the key actors and institutions are in a particular location (e.g. extension services, farmer organisations, NGOs, agro-dealers). • Identify the existing models of interaction between intermediaries and farmers. • Establish what information (types and content) is received by farmers already and how they use these. • Identify on-going climate related programs/ projects for potential linkages and synergies. • Identify the main agricultural activities undertaken by farmers in a particular location, and farmers' decision-making contexts, as well as how these are influenced by weather and climate. • Identify the types of crop, livestock and livelihood information that farmers would find useful for their decision-making.
Preparing and building relationships with partners	• Build relationships and hold conversations with partners during the above scoping activities. • Encourage collaboration and coordination between different partners. • Identify 'champions' within partner institutions who can lead the implementation of PICSA in-country.
Tailoring PICSA	• Analyse appropriate historical climate information for farmers' contexts. • Agree an appropriate mode of delivery for PICSA training, with intermediaries. • Consider and enact any necessary changes to the PICSA steps to maximise their relevance for farmers' decision-making contexts.
Training intermediaries	• PICSA experts train senior intermediaries (e.g. senior extension, NRMS, and NGO staff) as country-level experts in the PICSA approach. • These country-level experts then lead further 'training of trainers' workshops for field-level intermediaries.
Implementation of PICSA training with farmers	• Field-level intermediaries conduct a series of (usually 4–6) meetings, in which farmers are trained in each of the 12 PICSA steps prior to a specific agricultural season, giving farmers the opportunity to use PICSA in their decision-making and preparation for the upcoming season. • A 'Planning and Review' session is conducted with intermediaries shortly before the start of an agricultural season to review and reflect on training implementation with farmers, communicate the seasonal forecast, and plan for communication of short-term forecasts in the coming season.
Monitoring, evaluation and learning	• Train in-country enumerators to conduct a quantitative household survey to evaluate trained farmers' understanding, use and responses to the PICSA approach. • Identify and train in-country research assistants to conduct qualitative case studies to better understand the processes of trained farmers' use of PICSA tools and information and to explore in-depth the effects identified in the quantitative survey. • In-country teams conduct fieldwork. Analyse results and then share findings with partners and integrate lessons into future implementation of PICSA.

supplemented by participatory activities, including participatory budgets and effects diagrams that helped establish any difference that changes had made to respondents' various enterprises. Qualitative case studies were each recorded in the local language and then translated and combined with photographs of participatory activities for detailed examination under themes including: experiences of the PICSA training; how PICSA influenced decision making and planning; changes made in farming and other practices and reasons for these; effects on individuals, and their households. It is important to note that, when referring to the effects of any changes made as a result of PICSA, respondents to both quantitative and qualitative methods were encouraged to consider these in the context of the seasonal conditions that they had experienced (e.g. whether a good or bad rainfall season) so as not to over, or under, estimate the effects of the changes.

5. Effects of PICSA for farmers

Research has been conducted on PICSA to evaluate the effects of the approach for farmers in seven of the countries in which it has been implemented, using the methodology outlined above. Evaluations have taken place in more than one year in Malawi, Tanzania and Rwanda. Additionally, independent evaluations of PICSA have been conducted in Malawi and Tanzania (Steinmüller and Cramer, 2017) and Mali and Senegal (Dayamba et al., 2018). Further details on the results from individual countries can also be found in Clarkson et al. (2019) for Ghana, Poskitt et al. (forthcoming) for Bangladesh, and Staub and Clarkson (2021) for Haiti.

The results of this evaluation research have overwhelmingly shown that receiving PICSA training has had positive effects for farmers, their decision-making and their livelihoods. Table 2 shows the proportion of farmers trained in each of the PICSA steps who agreed that they found those steps useful for their planning and decision-making. The results show that in most cases, large majorities of farmers found each of the PICSA steps useful. To elaborate, using findings from qualitative case studies, the PICSA steps (both individually and together as a process) often help farmers to think more systematically about their farming and livelihood decisions. For example, the following woman in Bangladesh explained:

> *"From doing the participatory budgeting and crop options matrix exercise in PICSA training, I realised that I could grow vegetables like bottle gourds, pumpkins, snake gourd by myself and with minimum cost and effort, and in so doing could improve yield and income." (BD229, Bangladesh 2019).*

This farmer in Malawi indicated how different steps had helped him in different ways:

Table 2
Proportions of farmers agreeing or strongly agreeing that each of the individual steps within the PICSA approach were useful for their planning and decision making.

PICSA Tools	Bangladesh 2019	Ghana 2015	Haiti 2019	Malawi 2017	Malawi 2019	Malawi 2019	Malawi 2021	Mozambique 2021	Tanzania 2017	Tanzania 2020	Rwanda 2018
Resource Allocation Map	99%* (n = 280)	98% (n = 408)	89% (n = 89)	82% (n = 154)	94% (n = 420)	98% (n = 395)	93%* (n = 391)	95%* (n = 339)	80% (n = 627)	94% (n = 439)	86% (n = 480)
Historical Climate Information	80% (n = 279)	98% (n = 406)	89% (n = 71)	86% (n = 159)	94% (n = 442)	97% (n = 399)	92% (n = 376)	84% (n = 326)	85% (n = 656)	85% (n = 450)	81% (n = 466)
Probabilities and Risks	54% (n = 273)	95% (n = 390)	79% (n = 58)	73%* (n = 135)	95% (n = 434)	94% (n = 340)	92%* (n = 369)	84% (n = 310)	79% (n = 607)	80% (n = 411)	76% (n = 411)
Crops and varieties	93% (n = 243)	95% (n = 415)	98% (n = 87)	98% (n = 172)	97% (n = 459)	99% (n = 414)	98% (n = 401)	97% (n = 340)	53% (n = 428)	92% (n = 422)	96% (n = 495)
Options matrices	95% (n = 280)	99% (n = 399)	78% (n = 58)	80% (n = 145)	96% (n = 443)	98% (n = 389)	96% (n = 382)	96% (n = 338)	89% (n = 635)	94% (n = 459)	95% (n = 491)
Participatory Budgets	99% (n = 280)	97% (n = 399)	93% (n = 82)	80% (n = 156)	96% (n = 432)	98% (n = 391)	91%* (n = 371)	89% (n = 328)	83% (n = 635)	92% (n = 408)	88%* (n = 424)
Seasonal Forecast	n/a**	98% (n = 406)	85% (n = 46)	73% (n = 137)	95% (n = 381)	96% (n = 316)	84%* (n = 324)	99% (n = 339)	(77%) (n = 587)	92% (n = 432)	96% (n = 493)
Short term forecast	98% (n = 279)	95% (n = 362)	92% (n = 48)	64% (n = 156)	89% (n = 288)	85% (n = 202)	78% (n = 220)	93% (n = 331)	75% (n = 587)	86% (n = 393)	86% (n = 342)

* Men significantly higher than women.
** Seasonal forecast not available in Bangladesh at time of implementation.

> *"On the part of the participatory budget, I learned that I should start planning for every single activity and interpret it into monetary terms. I once used the Resource Allocation Map; through it, I realised that I could benefit quite a lot from my goat kraal by collecting manure, which I had not been using seriously before PICSA. I also used participatory budgeting. I sold one goat to finance buying 1 kg of NPK fertilizer for my crop farming." (MWPQSR317, Malawi, 2019).*

Whilst it is important to identify whether farmers received training in and found useful the different tools (Table 2), it is more important to explore the effects of the overall PICSA approach and its underlying principles (see section 3.1). As highlighted in Fig. 2 the individual tools build on each other as part of the overall planning and decision-making process. In each evaluation, we explored whether PICSA as a whole had encouraged innovation among farmers by asking whether they had made any changes to their crop, livestock, or livelihood enterprises as a direct result of the training they received. The results have shown that high proportions of farmers (52–99%) in all locations where PICSA was implemented have made changes as a result of the training as a whole (Table 3). The proportions of farmers making changes are similarly high across different countries, for both men and women, and across different levels of wealth. These results highlight the salience of PICSA for individual farmers with a range of different contexts.

In each location, farmers made a diverse range of changes reflecting their own individual contexts. Examples of changes include investing in new crops or planting a different variety of crop, changing the management of crops (soil or water management, timing of planting, etc.) and/or livestock enterprises (increasing scale, changing feed and veterinary practices, etc.), starting a new livestock enterprise and adapting wider livelihood strategies. In line with the different contexts of farmers in different locations, agro-ecological, climatic and social systems, the changes that farmers have made because of PICSA have varied substantially. To illustrate, in contexts where the amount of rainfall is a limiting factor, such as areas of Malawi, Northern Ghana and Rwanda, the most popular types of change were selecting crop varieties and management options that help to deal with dry conditions. By comparison, in some areas of Bangladesh where excess rainfall is a regular challenge, many farmers identified and implemented management options including improved drainage, changed timing of planting and improved shelters for livestock. In predominantly pastoralist areas of Tanzania, changing the management of livestock was the most popular type of change (see examples in Table 4), especially goats, for women, and cattle, for men.

Results from both the quantitative survey and more in-depth cases studies show that in most cases, the decisions made by farmers that were informed by PICSA training, have resulted in improved household food security and income.

Table 3
Proportions of farmers making changes in different countries and implementations of PICSA.

Evaluation	All
Bangladesh 2019 (n = 280)	90%
Ghana 2015 (n = 416)	97%
Haiti 2019 (n = 103)	70%[1]
Malawi 2017 (n = 175)	97%
Malawi 2019 (IRMP[1]) (n = 484)	85%
Malawi 2019 (M-CLIMES[2]) (n = 423)	98%
Malawi 2021 (n = 410)	99%
Mozambique 2021 (n = 341)	96%
Tanzania 2017 (n = 689)	52%[3]
Tanzania 2020 (n = 476)	88%
Rwanda 2018 (n = 502)	98%

A significantly lower proportion of the lowest wealth group (40%) made changes than other wealth groups (75–85%). This is likely to be because of resource constraints (Staub and Clarkson, 2021).

[1] IRMP = Government of Flanders funded 'Integrated Risk Management Programme'.

[2] M-CLIMES = Green Climate Fund funded 'Scaling up the use of Modernised Climate Information and Early Warning Systems in Malawi'.

[3] A lower proportion of farmers made changes in Tanzania following a 2015–16 implementation (52%). This was caused by the fact high levels of farmers were nomadic pastoralists, which hindered the availability of different options for them, as well as access to them by intermediaries. Prior to the subsequent 2019–20 round of implementation in Tanzania, further scoping research was conducted. As a result of this, implementation focused on women and young people in pastoralist communities, who tend to migrate less and have more options available. The Tanzania 2020 evaluation shows a high proportion (88%) of these respondents made changes.

Furthermore, PICSA has had important personal and social impacts for farmers, both through the impacts of the changes they made, and through the effects of the training itself. This included 91–98% agreeing that their confidence in planning and decision making had increased, 76–85% agreeing that their social standing had improved within their households and 67–91% agreeing that their social standing had increased within their communities. In most cases, farmers agreed they had increased agency to deal with climate-related challenges (63–90%).

These personal and social impacts are further illustrated in qualitative case studies. For example, the following male farmer in Malawi told

Table 4
Changes made and their impacts, as identified in qualitative case studies of farmers trained in PICSA.

Farmer	Changes made following PICSA training	Impact
Male farmer, northern region, Ghana	Reduced the scale of maize farm and used early maturing variety	Increased maize yield by 3 bags and reduced cash losses. Extra bags helped feed his family for 4 months and money saved helped pay school fees and purchase a goat
Female farmer, northern region, Ghana	Started regularly feeding and vaccinating her livestock	Increased profit from selling her sheep which was used to pay her son's school fees; some was used to purchase food and some to purchase two sheep
Female farmer, Balaka, Malawi	Early maturing maize and conservation farming techniques	After a difficult season, she was able to harvest while others were not. Paid daughter's school fees, fed extended family and bought seeds for the coming season (incl. trying new crops)
Male farmer, Longido, Tanzania	Introduced new cattle breed (more suited to dry environments), reduced the size of his herd and vaccinated	Some of the remaining money from sales of local breed were invested in building a house. He has also started to engage in crop agriculture, planting maize, some trees and vegetables which helps feed his family
Female farmer, Longido, Tanzania	Motivated to start getting her own income after PICSA training, joined a savings and loans group and sold a goat, which helped her to start a new business selling cooked rice, beans and soft drinks.	Increased income by USD310[1] over 6 months. This enabled her to meet household expenses and pay off a loan for her household to buy some land.
Female farmer, Bangladesh	Started growing new vegetables (okra, eggplant and bottle gourd), both commercially and for home consumption.	Harvested several times within the season, which supported her family's food security over four months.
Male farmer, Haiti	Grew a new variety of maize that matured faster.	Earned enough to buy some pepper seeds to grow peppers for home consumption, as well as some small commodities for his wife to sell through petty trading, and pocket money for his children to buy food before school.

[1] 1USD = 2,250 Tanzania Shillings at the time of the survey (January 2016).

how he had successfully produced enough maize to provide food for his family, which meant he no longer needed to do piece work (work on other farmers' land) to provide for his family. This shows that his self-confidence had increased, and also implies his social standing had improved through the effects of changes made following PICSA training:

> *"PICSA training has helped me access food (maize) from my own production. I should have been out doing piece work to provide food to my family. The training and availability of food in my household is helping me to channel my labour and energy to Dimba[2] cultivation. My children are well fed and can attend school without serious food challenges. I am liberated from begging for food.*
> *Do you know that doing piece work just to get food whilst you have your own unattended fields and work to do is one most dehumanizing thing?" (MWUNDP6)*

In another case study a woman in a pastoralist household in Tanzania said she had more freedom, because she no longer depended on her household's livestock enterprises. This provides clear evidence that this respondent was more empowered as a result of the changes she made:

> *"Doing business gives me additional income apart from depending on selling livestock. My business is not controlled by my husband as compared to the livestock. Therefore, I have more freedom on income earning from my business as compared to the income earned by the family through selling livestock." (LPCS16, Tanzania 2021).*

The following extract from a man in Bangladesh shows how he made more use of weather information following the PICSA training, which, along with identification of suitable responses, appears to have increased his ability to respond to weather-related shocks:

> *"After receiving a forecast of rainfall, during the ripening stage of my rice crop I harvested all of my cultivated rice, even though they were not fully matured. If I did not harvest I could have lost 25–50% of my crops. I also made drainage channels to remove excess water from my mustard and mung bean fields, which prevented crop damage during heavy rainfall. Now, I am more aware of climatic hazards." (BDQ26, Bangladesh 2019).*

It is clear from the above quantitative results and qualitative examples, as well as previous publications, that the PICSA approach has resulted in positive effects for farmers in multiple countries. Most of the farmers who received PICSA training have found it useful, which suggests that farmers' use of timely, location-specific climate data have improved, and that the PICSA process has helped them apply this information to their decision-making. The exceptionally high rates of farmers in different countries making changes as a result of PICSA show that PICSA has stimulated innovation by farmers in a range of different climatic, agro-ecological and socio-economic contexts. The impacts of these changes have improved farmers' food security, income, and empowered them to manage climate risks.

6. Why has the PICSA approach been successful in stimulating innovation by smallholder farmers?

PICSA has been effective in supporting farmers' decision-making in different countries and contexts. The question is why? This section draws from experience, reflections on and evaluations of multiple implementations and evaluations of the approach to discuss how it may have stimulated innovation in smallholder farming systems. We then consider future opportunities and challenges for the further use and development of the approach.

PICSA has been successful at prompting positive change in farmers' planning and decision-making partly because of the underpinning principles of '*the farmer decides*' and '*options by context*'. In contrast to 'top-down' approaches or those that seek to 'transfer' knowledge, technology, or recommendations, PICSA respects each farmer (or members of a household) as best placed to make plans and decisions. Considering Pretty's 'typology of participation', and applying it to

[2] A *dimba* is a small area/garden that receives more moisture and may also be farmed outside of the rainy season.

farmers and their households, PICSA is an example of 'interactive participation' and/or 'self-mobilization' (Pretty, 1995). The activities (or steps) in PICSA provide new, transparent, information and decision-making tools for farmers to use themselves. Likewise, the approach enables each farmer to focus on his/her own unique farm and household context, and to identify, evaluate and plan potential options and management actions. In addition, the step-by-step problem-solving process enables farmers to draw on and apply their extensive knowledge and experience. Transparency is a key element of this process with regards to the source/s of information, the quality and limitations of information and how derived information, such as risks, are calculated. In addition, the participatory tools are designed to enable trained farmers to work through an open process to inform their decisions rather than be presented with 'solutions' derived from 'closed' processes or tools.

Each of the steps or activities in PICSA is relatively straightforward. The high emphasis on visualisation and the use of diagrams has proved useful for both non-literate and literate users (Chambers, 1997). In addition, PICSA takes advantage of the fact that most non- and semi-literate people are numerate (Gill, 1993), and several steps include quantification, comparisons and/ or calculations. While being 'simple' to use, PICSA enables the consideration of relatively complex issues and puts them in individual farmers' own context. Specific examples include describing and analysing the use of resources on one's own farm, interpreting historical graphs to explore climatology of an area, developing participatory budgets and investigating how a new practice or enterprise may perform under different weather or price scenarios.

Each step or activity in PICSA has a specific purpose and logically and sequentially contributes to an overall process (as evident in Fig. 1 section 3.2). For example, exploration of the historical climate information enables consideration of the climatology of the location and implications such as identifying practices to cope with variability, but also later in the PICSA process helps contextualise and interpret seasonal forecasts.

Many smallholder farmers who are resource poor and operating in unpredictable economic and climatic environments, have relatively limited planning horizons. The main priorities are ensuring sufficient food and income for a given year, season or, in the case of the very poor, even shorter term. Furthermore, smallholders are risk averse and may be reluctant to make changes to their existing practices because failure can have catastrophic consequences, even more so if additional resources have been invested to make the changes. PICSA facilitates consideration of and planning for different time horizons. By exploring the historical climate information it is possible to see any emerging trends (climate change). However, we have observed that it is often the extent of variability (in for example season start dates and amounts of rainfall per season /month) that farmers and extension officers find particularly informative. Through the step-by-step process, farmers can identify and explore changes to their farming practices to address climate variability, but also take into consideration climate change and other longer-term challenges that influence farming decisions (e.g. declining soil fertility, unpredictable markets). From the 'menu' of potential changes that farmers create as a group, individual farmers subsequently identify and plan those that they consider suitable for their own individual contexts. Often it is climate-smart options, that address both more immediate and longer-term challenges, that farmers identify and then go onto practice. In addition, farmers have reported reinvesting gains made from the changes back into their farming enterprises, thereby contributing to longer term change.

Rather than simply focusing on the delivery of climate information or on individual technologies or 'solutions', PICSA is an 'integrated' approach. Firstly, it enables farmers to consider their 'whole farm' as an integrated system in their analysis and planning. Furthermore, the approach considers non-agricultural livelihoods and how they can support coping and adaptation. Secondly, it has provided a way to integrate climate services and agricultural extension with farmers in the field. It has enabled NRMS and extension services, that often operate in isolation (FAO, 2019), to operate together and utilise their different but complimentary skillsets to provide better support for farmers.

PICSA has been scaled up partly because extension services, and organisations working with farmers in general, support the approach. It helps them better implement their existing mandate (supporting farmer innovation) and address the more recent challenges associated with climate change, which many have felt inadequately equipped to do. For example, an extension worker at a PCISA training in Dodoma, Tanzania, asked '*why haven't we had this (approach and training) before*?'. In Malawi extension workers that had used PICSA reported that through use of PICSA they had been able to engage with and empower farmers in a genuinely participatory process, when previously this had only been an ambition stated in policy. Training of farmers in PICSA also fits the existing structures and ways that extension services and farmer organisations work i.e. through training and support of existing farmer groups and both senior staff and District heads of extension that have overseen PICSA have been keen to continue to implement PICSA in subsequent years.

Likewise, several NRMS who have been involved in providing climate information for PICSA and supported training of extension field staff in some of the PICSA steps have found that it is a way of providing a climate service that is well received by farmers and that they can support with limited staff available. As with extension, PICSA compliments and builds on existing activities rather than competing with them. PICSA provides a 'framework' into which the existing main products of seasonal and short-term forecasts by NRMSs can fit and contribute to, but also significantly adds value to them. The approach does however place additional demands on NRMS to prepare and provide some products for PICSA. Many NRMS have embraced this and further developed capacity to provide these. For example, the Department of Climate Change and Meteorological Services in Malawi took the initiative to train a team of more than ten staff to ensure they could support national scale roll out of the approach.

A key contributing factor to the scale and reach achieved by PICSA to date is that the approach has proved to be adaptable to different countries and contexts. Whilst the approach was initially developed in semi-arid areas of Zimbabwe and Tanzania it has subsequently been adapted for and used in a wide variety of social, economic, climatic, and agro-ecological contexts both within and between different countries. A few of many contrasting examples include, predominantly rice based systems in Bangladesh, mixed farming systems in Malawi, agro-pastoralist systems in the north of Tanzania, coffee farmers in Latin America and sheep and goat herders in Lesotho. A key reason for this adaptability is the underlying principles of supporting the farmer as the decision maker and exploring options by context which puts the focus on supporting the individual farmer whatever their circumstances. Farmers in all of these very different contexts have found the different participatory tools useful as they are widely applicable. For example, options identified and analysed in the options matrix exercise are completely different in different locations but the process is equally valuable whether considering livestock options in Tanzania or management of different crops in Guyana. Key to this success in different countries and contexts has been the preparation process outlined in section 3.2.

7. Opportunities and challenges

PICSA has achieved success in stimulating innovation and change in smallholder farming systems at scale. In this section we discuss opportunities and challenges associated with existing and future implementations, many of which are of relevance to climate services initiatives beyond PICSA. Key considerations include how to sustain the implementation of the approach over time, maintain its integrity and quality during scale-up, harness the potential of digital services whilst avoiding their limitations, and improve the effectiveness of the approach by strengthening the wider enabling environment.

7.1. Sustaining implementation

Sustainable implementation at scale requires inclusion in government policy and/or support from private sector actors and initiatives for integration into the roles and annual activities of those intermediaries and service providers that support smallholder farming systems. The main investment required is in the initial preparation and capacity building. Ongoing implementation requires fewer resources and directly addresses the existing mandates of key institutions (such as Ministries of Agriculture, NRMS and Universities) which suggests that there is a case for core funding to be provided by or through governments. Sustainability requires ownership by these key institutions which is beginning to be achieved in countries such as Malawi where the approach has been included in the national extension strategy and is also being integrated into the curricula for trainee extension officers at the Lilongwe University of Agriculture and Natural Resources. It should also be acknowledged that the priorities, motivation and expectations of key institutions and, at times, individual actors in some countries can create challenges, especially where there are competing responsibilities and workloads. Regarding the private sector there are also opportunities to benefit from and fund PICSA through farmer cooperatives and producer groups in commodity value chains as the changes farmers make through using the approach can help to address climate challenges and increase quality and profitability.

7.2. Maintaining quality

This paper has outlined a number of reasons why PICSA has been successful. A concern regarding quality and integrity is that the approach may be included in programmes without sufficient attention to the key reasons for its success. Some of the key elements that contribute to maintaining quality and integrity include the following. Ensuring careful design and allocation of sufficient time and resources to undertake the preparation and capacity building outlined in section 3.2. The use of periodic refresher training for trained facilitators during which they are able to reflect on their experiences with their peers and plan their continued use of the approach. Inclusion in the curriculum of training colleges and Universities to ensure that newly trained agricultural extension staff and managers are aware of the concepts and tools that support the approach. Making available online materials, including refresher videos and support forums to help 'backstop' formal training processes. The development of improved materials for farmers (including 'lead farmers') to refer to and share with peers including visual step-by-step guides and examples of PICSA tools. Continued monitoring and evaluation of the effectiveness of the approach and ensuring shared learning and iterative improvements.

7.3. Digitally enabled climate services

Emphasis on the role of digitally enabled climate services is increasing. In the context of PICSA, opportunities exist to integrate Information and Communication Technologies (ICTs) to support facilitators in their work with farmers. A PICSA extension toolkit has been developed to support trained facilitators by providing access to climate products (e.g. historical climate graphs for their location), PICSA tools (participatory budgets), training materials and refresher videos. Piloting in Malawi provided promising results and highlighted key limitations that need to be considered. The extension toolkit helped simplify tools and speed up some of the training processes; helped in interactive analysis and exploration of scenarios (e.g. the use of participatory budgeting); increased information seeking by facilitators and helped them to widen their networks and information sources. However, there was a range of digital literacy and technical ability and those facilitators who were not confident reverted to paper methods. Trade-offs were evident where some processes were sped up but may impact learning and engagement (e.g. calculating simple risks). Work is ongoing to further develop and integrate the extension toolkit in future implementations with care to ensure that it and its use support the key principles of PICSA which are essential for its success. A further example of integrating ICTs to support the PICSA process was the online training of young coffee farmers in Honduras necessitated by the Covid-19 pandemic. These young farmers were able to quickly grasp and utilise concepts and went on to train their families and peers in-person (Giraldo et al., forthcoming). The familiarity with and motivation of younger farmers and intermediaries to use ICTs may offer further opportunities in training, support and scaling up.

7.4. Strengthening the enabling environment

PICSA is stimulating innovation in smallholder farming systems and while most farmers are making beneficial changes, almost all report that they would like to have made more changes as a result of the training but were unable for several reasons. Respondents reported constraints including lack of financial resources, access to inputs, risk of unfavourable or extreme weather conditions, and access to or the need for further technical information on some innovations. It is likely that PICSA could have greater impact when combined with stronger support systems to create a more enabling environment for farmers, potentially with specific targeting for the least well-resourced farmers. There is scope to directly link the integration of PICSA with other programmes or approaches that aim to support the wider enabling environment including access to finance, information and markets.

8. Conclusions

The results presented in this paper and other evaluations provide evidence that PICSA is encouraging positive innovation and change in smallholder farming systems in different contexts and locations, and at scale. Key reasons for this success are the focus on equipping the farmer with a process, information and tools that enable them to make informed decisions for their context. Importantly, the approach does not aim to provide advice suitable for all farmers contexts, which is an impossible task. Instead, it helps enable farmers to consider and plan for the complexity of their own individual contexts and focuses on supporting rather than 'advising' the farmer. Scaling up PICSA is not always 'easy', and it requires preparation for different locations and farming systems as well as close collaboration with key institutions to encourage ownership and build the necessary capacity to support the process. There are key opportunities and challenges to further scale the approach, ensure sustainability and maintain the quality required to ensure farmers are empowered in making decisions that improve their livelihoods in the face of climate variability and change.

CRediT authorship contribution statement

Graham Clarkson: Conceptualization, Methodology, Formal analysis, Writing – original draft, Writing – review & editing. **Peter Dorward:** Conceptualization, Methodology, Writing – original draft, Writing – review & editing. **Sam Poskitt:** Conceptualization, Methodology, Formal analysis, Writing – original draft, Writing – review & editing. **Roger D. Stern:** Writing – review & editing. **Dominic Nyirongo:** Writing – review & editing. **Katiuscia Fara:** Writing – review & editing. **John Mwangi Gathenya:** Writing – review & editing. **Caroline G. Staub:** Writing – review & editing. **Adrian Trotman:** Writing – review & editing. **Gloriose Nsengiyumva:** Writing – review & editing. **Francis Torgbor:** Writing – review & editing. **Diana Giraldo:** .

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

Brooks, M.S., 2013. Accelerating innovation in climate services: The 3 E's for climate service providers. Bull. Am. Meteorol. Soc. 94 (6), 807–819. https://doi.org/10.1175/BAMS-D-12-00087.1.

Chambers, R., 1997. Whose Reality Counts? Putting the First Last. Practical Action Publishing, Rugby, UK.

Clarkson, G., Dorward, P., Osbahr, H., Torgbor, F., Kankam-Boadu, I., 2019. An investigation of the effects of PICSA on smallholder farmers' decision-making and livelihoods when implemented at large scale – the case of Northern Ghana. Clim. Serv. 14, 1–14. https://doi.org/10.1016/j.cliser.2019.02.002.

Dayamba, D.S., Ky-Dembele, C., Bayala, J., Dorward, P., Clarkson, G., Sanogo, D., Mamadou, M.D., Traore, I., Diakite, A., Nenkam, A., Binam, J.N., Ouedraogo, M., Zougmore, R., 2018. Assessment of the use of Participatory Integrated Climate Services for Agriculture (PICSA) approach by farmers to manage climate risk in Mali and Senegal. Clim. Serv. 12, 27–35. https://doi.org/10.1016/j.cliser.2018.07.003.

Department of Agriculture Extension Services, Malawi (DAES), 2020. National Agriculture Extension and Advisory Services Strategy 2020–2025. Agriculture Communication Branch, Lilongwe, Malawi.

Dorward, P., Clarkson, G. and Stern, R. 2015. Participatory Integrated Climate Services for Agriculture (PICSA): field manual. A step-by-step guide to using PICSA with farmers. Walker Institute, University of Reading, pp64. ISBN 9780704915633.

Fisher, M., Abate, T., Lunduka, R.W., Asnake, W., Alemayehu, Y., Madulu, R.B., 2015. Drought tolerant maize for farmer adaptation to drought in sub-Saharan Africa: Determinants of adoption in eastern and southern Africa. Clim. Change 133, 283–299. https://doi.org/10.1007/s10584-015-1459-2.

Gill, G. 1993. Are some 'participatory' techniques culturally biased? (or: are we hooked on Mom's apple pie?). *RRA Notes.* 18, 12-14. IIED, London.

Lemos, M.C., Kirchhoff, C.J., Ramprasad, V., 2012. Narrowing the climate information usability gap. Nat. Clim. Change 2 (11), 789–794. https://doi.org/10.1038/nclimate1614.

Loboguerrero, A.M., Boshell, F., León, G., Martinez-Baron, D., Giraldo, D., Recaman Mejía, L., Díaz, E., Cock, J., 2018. Bridging the gap between climate science and farmers in Colombia. Clim. Risk Manag. 22, 67–81. https://doi.org/10.1016/j.crm.2018.08.001.

Ofuoku, A.U., Agbamu, J.U., 2012. Influence of farmers' group cohesion on adoption of climate change adaptation strategies in Delta State, Nigeria. Glob. J. Sci. Front. Res. Agric. Vet. Sci. 12 (6), 29–35.

Pretty, J.N., 1995. Participatory Learning For Sustainable Agriculture. World Dev. 23 (8), 1247–1263.

Staub, C.G., Clarkson, G., 2021. Farmer-led participatory extension leads Haitian farmers to anticipate climate-related risks and adjust livelihood strategies. J. Rural Stud. 81, 235–245. https://doi.org/10.1016/j.jrurstud.2020.10.029.

Staub, C.G., Gilot, A., Pierre, M., Murray, G., Koenig, R.L., 2020. Coping with climatic shocks: Local perspectives from Haiti's rural mountain regions. Popul. Environ. 42, 146–158. https://doi.org/10.1007/s11111-020-00351-9.

Steinmüller, S., Cramer, L., 2017. Evaluation of Climate Services Interventions in the GFCS Adaptation Programme for Africa: Beneficiary Assessment Final Evaluation Summary Report. Statistics for Sustainable Development, Reading.

UN Food and Agriculture Organization (FAO). 2019. *Handbook on climate information for farming communities – What farmers need and what is available*. Rome. 184 pp. Licence: CC BY-NC-SA 3.0 IGO.