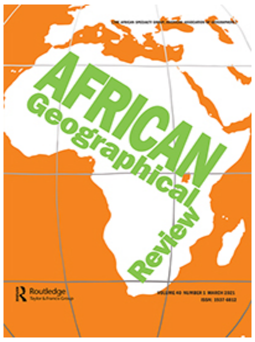

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Rapid participatory system mapping builds agri-food system resilience: evidence from Nigeria

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RESEARCH NOTE

Rapid participatory system mapping builds agri-food system resilience: evidence from Nigeria

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ABSTRACT

Participatory methods can be used to build food system resilience. However, it is widely acknowledged that these methods are usually highly time and resource consuming, which reduces their applicability. This study developed a novel rapid participatory system mapping method to elicit system conceptualizations from distinct value chain actors. This study also tested the method in a case study of rice value chains in Benue State, Nigeria. Participant evaluations of the rapid participatory system mapping method provide evidence of this method's potential to contribute to resilience building by facilitating social learning, informing better decision making, and promoting community problem solving. These contributions especially strengthen the two resilience factors of social self-organization and reflective and shared learning. This novel rapid participatory system mapping method can be used in the future as a self-standing research approach, or to complement other participatory methods of food system resilience building.

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System dynamics; soft systems methodology; rapid rural appraisal; Africa

1. Introduction

Food system resilience is an urgent challenge (Oliver et al., 2018). Tendall et al. (2015, p. 19) proposed to define food system resilience as the 'capacity over time of a food system and its units at multiple levels, to provide sufficient, appropriate and accessible food to all, in the face of various and even unforeseen disturbances.' Building on a long tradition of research on the resilience of social-ecological systems (e.g., Berkes et al., 2003; Folke, 2006; Gunderson, 2003; Holling, 1973), Cabell and Oelofse (2012) conducted one of the most extensive literature reviews on the topic and concluded that food system resilience is a function of a range of factors, which are summarized in Table 1.

While building food systems' resilience remains challenging, many participatory methods have been developed and tested which can be used to build resilience both in social-ecological systems, and specifically food systems (Fazey et al., 2007; Ravera et al., 2011; Reed et al., 2010; Rodela, 2011). One feature of participatory methods is that they enable a genuine system perspective, which, as various scholars have argued, is necessary for improving food system resilience and reducing its vulnerability (e.g., Ericksen, 2008; Stave & Kopainsky, 2015; also see Bala et al., 2017).

Participatory system mapping (PSM) combines the strengths of systems thinking (Sterman, 2000) and participatory research approaches. PSM helps portray the components of a system and its environment, which are represented using stock and flow maps and causal loop diagrams. Stave (2010) argued that PSM is one of a suite of system dynamics modeling approaches used to engage

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Table 1. Resilience factors (source: Cabell & Oelofse, 2012).

Resilience factor	Description
Social self-organization	The social components of the agroecosystem are able to form their own configuration based on their needs and desires
Ecological self-regulation	Ecological components self-regulate via stabilizing feedback mechanisms that send information back to the controlling elements
Appropriate connectedness	Connectedness describes the quantity and quality of relationships between system elements
Functional and response diversity	Functional diversity is the variety of ecosystem services that components provide to the system; response diversity is the range of responses of these components to environmental change
Optimal redundancy	Critical components and relationships within the system are duplicated in case of failure
Spatial and temporal heterogeneity	Patchiness across the landscape and changes through time
Exposure to disturbance	The system is exposed to discrete, low-level events that cause disruptions without pushing the system beyond a critical threshold
Resilience factor	Description
Coupling with local natural capital	The system functions as much as possible within the means of the bioregionally available natural resource base and ecosystem services
Reflective and shared learning	Individuals and institutions learn from past experiences and present experimentation to anticipate change and create desirable futures
Global autonomy and local interdependency	The system has relative autonomy from exogenous (global) control and influences and exhibits a high level of cooperation between individuals and institutions at the more local level
Ability to honor legacy	The current configuration and future trajectories of systems are influenced and informed by past conditions and experiences
Building human capital	The system takes advantage of and builds resources that can be mobilized through social relationships and membership in social networks
Reasonable profitability	The segments of society involved in agriculture are able to make a livelihood from the work they do without relying too heavily on subsidies or secondary employment

stakeholders in problem analysis. PSM has been often used as a transition between the creation of mental models and formal simulation models, but it also stands alone to inform diagrammatic reasoning, including clarifying assumptions, structuring a problem space, or identifying unexpected implications of unplanned disturbances or policy interventions (Henly-Shepard et al., 2015; Mendoza & Prabhu, 2006; Rzzzibeiro & Zwirner, 2010; Stave & Kopainsky, 2015). PSM has been previously used worldwide, and in West Africa. It has proved helpful in facilitating participants' learning about social-ecological systems, promoting social learning among participants, facilitating collective action, and building social capital to enhance management and to support decision making on wide-ranging issues including environmental management, forest management, food security, and climatic risks in agriculture (Mendoza & Prabhu, 2006; Stave, 2010; Feola et al., 2012; Henly-Shepard et al., 2015; Inam et al., 2015; Schmitt Olabisi et al., 2018; also see Bala et al., 2017).

However, it is widely acknowledged that PSM and other participatory methods for resilience building are usually highly time and resource consuming. For example, in certain contexts it may be difficult to secure participation for participatory processes that last longer than a day, while the set-up, facilitation and follow-up in participatory methods of longer durations may require substantial amount of resources for compensating participants, facilitators, interpreters (when applicable), transcribers, and room or equipment renting. Such investment may be beyond the capacity of research teams in more disadvantaged contexts, while in other cases researchers may not be willing to invest large amounts of time and resources in an exploratory phase (Bruggen & Nikolic, 2019; Cvitanovic et al., 2019; Kraker et al., 2011; Polk, 2015; Stringer et al., 2006).

Many rapid appraisal methods have been developed for resource scarce or more exploratory research studies (e.g., Barrett, Feola, Khusnitdinova & Krylova, 2017; Chambers, 1994), but to the authors' knowledge none of them has been evaluated specifically with respect to their contribution to building food system resilience. Therefore, the following questions have remained unanswered, and are tackled in this study: can rapid participatory research methods help build resilience, and if so, which resilience factors does this method support?

To answer these questions, this paper presents and discusses a rapid PSM method which can be used to build resilience in food value chains by eliciting and enabling the formation of a collective conceptualization of those chains among a diverse range of value chain actors. The method allows to conduct PSM in relatively little time and with scarce resources.

We illustrate the method through the case of a rice value chain in Benue State, Nigeria. The rice economy is an important source of food security and income for millions of households across Benue State. However, over the past decades, the rice value chain has shown signs of vulnerability to multiple climatic and market pressures. Interventions for building rice value chain resilience have lacked in Nigeria as in many other Sub-Saharan African countries, for reasons that include a want of systemic policy perspectives and existing tensions among actors along the value chain. These have hindered collective action as a response to climatic and economic pressures, such as market fluctuations (Terdoo, 2019; Terdoo & Feola, 2016). Therefore the case of Benue State is not only one in which application of PSM for food system resilience is needed, but also a suitable case in which to test whether the proposed PSM helps build resilience, and if so, which resilience factors does this method support. A total of six workshops, one each with rice growers, millers, and traders, were held in the two cities and rice economy hubs of Makurdi and Adikpo, and each workshop lasted one day. They were conducted in March, 2017.

2. Methodology

2.1 An overview of the study area

Benue State, also known as the 'food basket of Nigeria', can be described as an agrarian society, with well over 70% of its population dependent on agriculture. Geographically, Benue State is located in the North-Central region of Nigeria-a region known for its production of over 65% of the domestic rice produced in the country overall (Akpokodje et al., 2001; Erenstein et al., 2003). The State lies between latitudes 6° 25′ N and 8° 8′ N of the equator, and between longitudes 7° 47′ E and 10° 00′ E of the Greenwich meridian (see Figure 1) and has a total land area of 30,800 sq. kms (National Bureau of Statistics Nigeria, 2010). The monthly distribution of rainfall in Benue State is bimodal, with the annual total averaging between 1200 and 1400 mm (Ogungbenro & Morakinyo, 2014). The temperatures are constantly high throughout the year, averages range from 23° C – 32° C. The vegetation in the State is typical of that of the southern Guinea Savannah biome, which is the dominant vegetational belt of central Nigeria.

Three types of rice grower can be identified in Benue State: small, medium, and large landholders. Small landholders are the dominant group, growing nearly 90% of the rice produced in Nigeria (USAID, 2009). This group consists of resource-poor and weakly organized local subsistence and small growers who grow rice on relatively small fields or land area, usually about 2 hectares maximum, they sell nearly 80% of their total produce and consume the remaining 20% (USAID, 2009). After rice is grown and harvested, it is aggregated or assembled by unmilled (paddy) rice buyers and traders, sometimes referred to as village buyers (USAID, 2009). This group of actors plays a significant role in linking rice growers to millers and, as such, could manipulate the rice market, including prices. The key functions of this group of actors include, buying, assembling, storing, and transporting paddy to the processors (i.e., the millers). Generally, milling of rice in the state is carried out under either of two major milling arrangements, namely, through the conventional commercial rice mills or through the industrial, integrated, mills. The first is comprised of small and medium sized mills, and the second the larger, modern mills. The milled rice traded or distributed in Benue State, and across Nigeria, is sourced from both the domestic production and import channels. Key actors, such as wholesalers, retailers, and paddy traders, drive the distribution, trade, and sales activities.

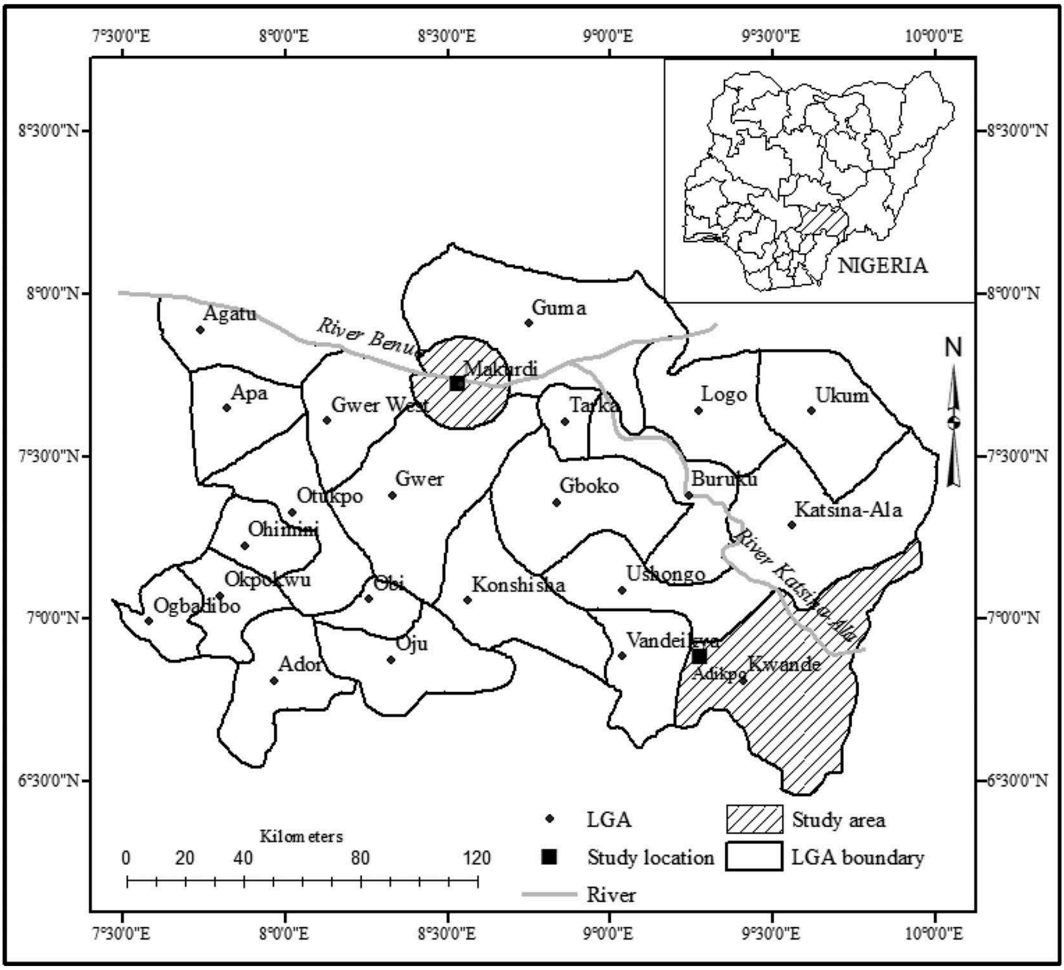


Figure 1. Location of Benue State and study sites.

2.2 Rapid participatory system mapping of rice value chains in Benue State, Nigeria

In this study, PSM was used as a rapid and stand-alone method in the framework of participatory research to uncover the distinct underlying system conceptualizations of rice value chains held by the different actors along the value chain (growers, millers and traders).

Table 2. Summary of the phases of the rapid participatory system mapping of the rice value chain. Following Luna-Reyes et al. (2006), the workshop included four phases: divergence, convergence, evaluation, and presentation.

2.3. Stakeholder identification and language issues

We selected diverse samples of male and female participants who represented a mixed number of small, medium, and large scale rice growers, and of small, medium, and large scale rice millers and traders. We conducted a total of 6 workshops involving 38 participants across the two study sites. In each of the two study sites, seven rice growers and millers and five rice traders participated in workshops held separately for each of the three actor types. In total, 86% of participants were male, and the remaining 14% female. The number of participants in each workshop was limited to a maximum of seven because groups of this size allow effective facilitation (Vennix, 1999) and

Table 2. Summarizes the phases of the rapid PSM method used in this study.

Phase	Activity	Aim	Approximate duration
Phase 1 (Divergence)	Individual conceptualization of the rice value chain	Elicitation of system understanding (system components)	20 minutes
Phase 2 (Convergence)	Group discussion	Achieving consensus on rice value chain components	60 minutes
	Collective visualization of the rice value chain	Elicitation of system understanding (system structure)	30 minutes
Phase 3 (Evaluation)	Group discussion	Building a common understanding of the rice value chain	30 minutes
		Critically reflecting on the common understanding of the rice value chain	30 minutes
Phase 4 (Presentation)	Group discussion	Identification of vulnerabilities and 'weak spots' in the rice value chain	30 minutes
		Identification of possible measures and interventions to build resilience in the system	30 minutes

facilitate team work (Hovmand et al., 2012), while also reducing the risk of unproductive group dynamics related to power relations in larger groups (Barrett et al., 2017).

All workshops, including the feedback sessions, were recorded and transcribed in the original language (Tiv) before being translated into English and stored in electronic form. Two assistants, both native speakers of the Tiv language, assisted the facilitator, who also had good knowledge of the Tiv language. The facilitator and the assistant both took notes during the workshop. These notes were used to complement the audio recordings.

2.4. Workshop structure

The first 20 minutes of the workshop were devoted to welcoming the participants, personal introductions, and explanations about the aim of the workshop. Background information on the research project was also provided, and ground rules of interaction during the workshop were established. Booklets, pens, paper, stickers and markers were provided to participants by the facilitator when they were needed to conduct different activities during the workshop.

The elaboration of mental maps of the rice value chain was based on scripts developed by Andersen and Richardson (1997) and used by Luna-Reyes et al. (2006) and Hovmand et al. (2012). These scripts were adapted to suit this study.

The elicitation of rice value chain components was carried out in two phases, which entailed individual and divergent thinking and collective convergent brainstorming respectively (Andersen & Richardson, 1997). The main activity carried out during the former phase was to list the components of the rice value chain in Benue State. Participants were asked to work individually for up to 20 minutes and to generate a list of the rice value chain components (e.g., rice growing, milling, and trading) and sub-components (e.g., use of chemical inputs and transport of rice). An exercise booklet and a pen were provided for each participant for this purpose.

Participants then convened in a plenary session for the convergent brainstorming phase. They worked together in one group to cluster the components and to agree on the classification of components into main and sub-components. The groupwork was aimed at reaching a consensus through a discussion that lasted for about 60 minutes.

The shared identification of system components formed the basis for diagramming the mental map of the rice value chain in Benue State. Before this activity, participants were introduced to stock and flow diagrams, the graphic and conceptual approach they were requested to follow to diagram their understanding of the system.

Then, participants were asked to present briefly the system component and sub-components they had agreed upon. No basic mental map was provided to the participants. The description of

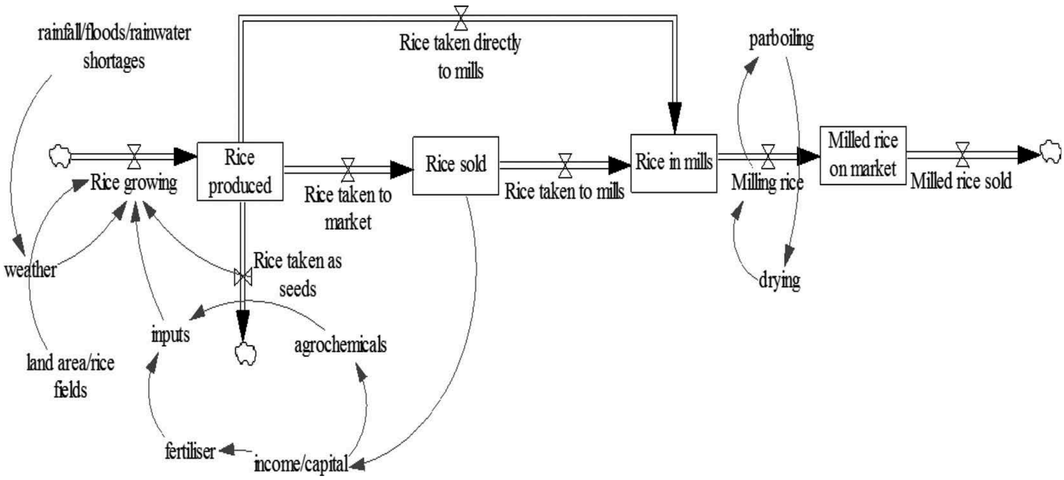
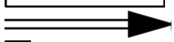


Figure 2. Stock and flow map for the rice growers in Adikpo.

Table 3. Annotations for the stocks and flows maps of rice value chains.

Annotation	Annotation name	Meaning
	Stock or Level	Accumulations
	Flow or Rate	Inflow and outflow
	Valve	Control the flow
	Cloud	Source and sink
	Connector	Links

each component was written on a large (A0) sheet of paper that was laid on a table at the center of the room, or on a sticker that was then placed on the paper. Participants then identified and drew relations between the major and sub-components. The resulting mental maps were presented in stock and flow diagram form (Figures 2–5).

Following an established convention in system dynamics modeling (Sterman, 2000), stock and flow maps are used to represent the systems (Table 3). Stocks (or accumulations) are represented by rectangles that suggest a container holding the contents of the stock. Flows (e.g., inflow and outflow) are variables measured over an interval of time. Inflows and outflows are both represented by a pipe (arrow) pointing into (adding to) or pointing out of (subtracting from) the stock. Valves control the flow while clouds represent the sources or sinks for the flows. The sources represent the stock from which the flows originating outside the model boundary arise, and sinks represent the stocks into which flows leaving the model boundary drains. The arrows represent the connector which links the elements in the map or model (Sterman, 2000).

Finally, the workshops ended with a plenary discussion on system vulnerabilities and 'weak spots' in the rice value chain, as well as on possible measures and interventions to build food system resilience. These discussions, which lasted for up to 60 minutes, were not designed to reach consensus, but were left open for participants to express their views and to explore similarities and differences. The facilitators ensured each participant had the opportunity to express themselves.

3. Results

3.1. System conceptualizations

Our application of this rapid PSM method produced important insights into different actors' understandings of the rice value chain and of the sources of its vulnerability and resilience. Here we briefly summarize these findings.

Firstly, PSM allowed participants to uncover different system conceptualizations. For example, they often disagreed on what defined the system boundaries. While the different lists made by the participants showed that growers perceived the rice value chain components as comprising both major and minor or sub-components, the lists tended to focus on the sub-components of rice production. In Makurdi, for example, the majority of the rice growers did not consider components such as transportation/distribution and trading or selling of paddy to be parts of the rice value chain (not shown in a figure), as these components, according to those participants, add much less value than production and milling. Participants generally did not map the flow of information (e.g., regarding demand, policy changes, and price and quality expectations), which governs how the flow of rice (e.g., quantities input to or temporarily removed from the market) at each stage of the chain changes the stock of rice, for better or for worse (Figures 2–5). However, the millers in Makurdi attempted to map economic flow (capital/income) as a factor that governs how rice is taken to mills (Figure 3), but did not demonstrate how it influences the consumption of different qualities of rice in the area.

Secondly, the depth of understanding of the rice value chain was very diverse, and generally participants had a detailed understanding of the components of the value chain to which they related more closely, and a significantly less developed understanding of components of the value chain that were more distant from them. For example, both in Makurdi and Adikpo, growers' lists highlighted less detail about processing or milling and trading of milled rice sub-components (Figures 1 and 2) just as traders and millers lists highlighted less detailed about farming (Figures 4 and 5). This finding indicates that farmers, millers, and traders generally lack an overview of the whole rice value chain, which hinders their ability to understand tensions between systems' components and to identify measures to build resilience into the rice value chain in Benue State, especially when collaboration between actors is needed.

By and large, participants were challenged by the effort to visualize and make sense of the complex interactions of multiple factors that may contribute to the vulnerability of the rice value chain in Benue State. This was particularly true for interactions of different types of system elements, such as the interaction of material (e.g., rice taken to the market or the mills), information (e.g., price information and price expectation that may have influenced the amount of rice taken to market), and economic factors (income or family needs that may have influenced a decision to take the rice to market).

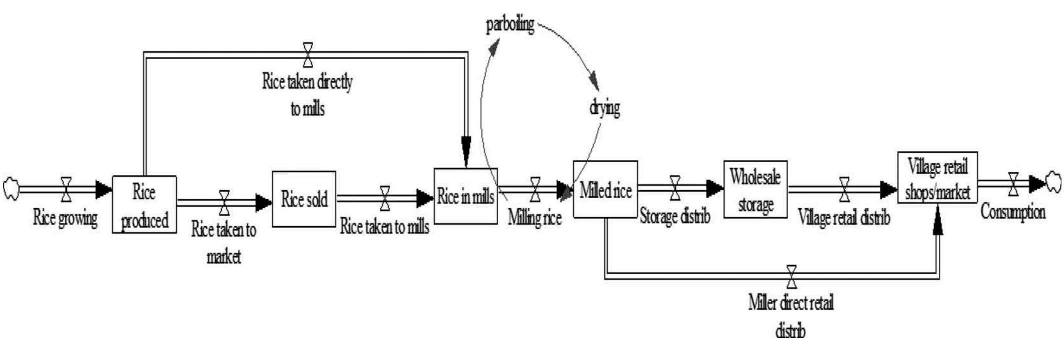


Figure 3. Stock and flow map for the milled rice traders in Adikpo.

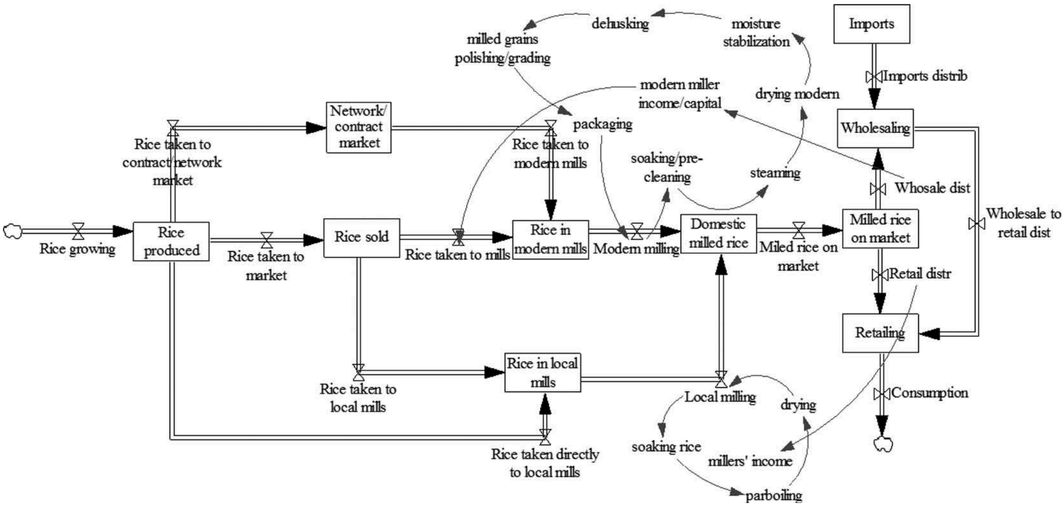


Figure 4. Stock and flow map for the rice millers in Makurdi.

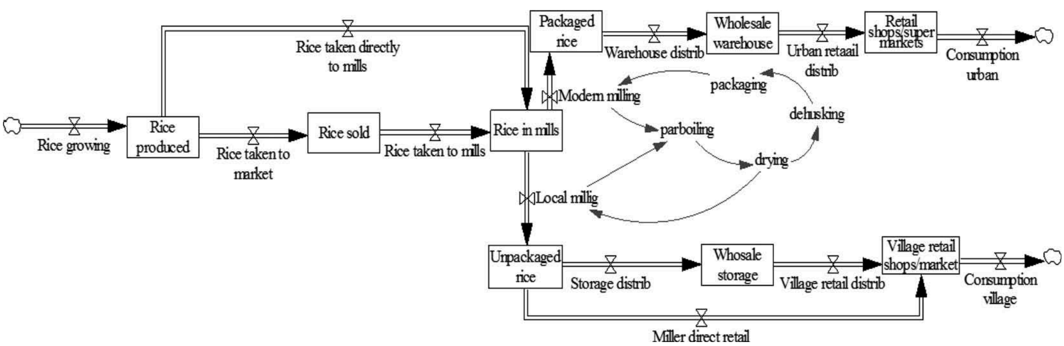


Figure 5. The stock and flow map for the milled rice traders in Makurdi.

Despite such varying levels of detail, the maps reflect the value chain's distinctive characteristics at the two study sites of Makurdi and Adikpo. The system maps that were produced differed as they reflected the various ways in which rice is transported and processed. Millers' representation of the rice value chain's components in Adikpo (Figure 3) did not include the processes of destoning, polishing, and packaging rice, which are not conducted there. In contrast, in Makurdi, those processes were represented alongside others, such as soaking, parboiling, drying, and milling, which characterize rice processing at this site (Figures 4 and 5).

3.2. Building resilience through participatory system mapping

Feedback on the workshop was requested of all 38 participants across the 6 workshops. Twenty-one participants (55%) provided a positive evaluation of the workshops. Of these, 10 were growers (approximately 71% of this type of participant), 4 were millers (approximately 26% of this type of participant) and 7 were traders (70% of this type of participant).

According to the feedback, the application of PSM in this study achieved three main outcomes in relation to resilience building (Table 4), which are substantiated here by evidence from workshop participants' interviews.

Table 4. Overview of the outcomes of participatory system mapping in Benue State.

Outcomes of Participatory System Mapping	Examples
Social learning about the rice value chain	• Understanding of how different value chain components are connected to each other • Visualization of processes that were overlooked in verbal representations of the system • Revelation of connections that participants did not expect or anticipate
Better decision making	• Appreciation of wider implications of the challenges faced • Identification of leverage points for intervention in the rice value chain • Identification of concrete vulnerability reduction interventions
Community problem solving	• Promotion of mutual understanding across actor groups

3.2.1. Social learning about the rice value chain

Participants with different roles in the rice value chain reported that the system visualizations made them aware of, and helped them acquire a better understanding of how different value chain components are connected to each other. Three participants commented as follows:

> The map is educative as it has made me see through the entire processes of the rice value chain. Importantly, it has helped me to see that all these processes are connected and each one is equally important as the other. [Male, grower, Makurdi]

> I see the mental maps to be interesting, engaging and enlightening, especially when all the activities of the rice production chain are drawn on a large sheet of paper like this. [Male, trader, Adikpo]

> . . . this interaction is important because as a grower I am only exposed to production, but my participation in this workshop has exposed me to different stages of the rice value chain. [Male, grower, Adikpo]

Participants also appreciated the use of stock and flow maps to visualize system complexity; they depicted processes that were overlooked in most verbal representations of the system:

> . . . I can see that the map is very complex, outlining the different ways we handle rice after harvest: some sell immediately they complete harvest, others leave it in storage for few months for prices to improve before selling, while others still go and have the rice milled before selling. One thing is that we are all trying to make something out of our investments. The same thing is true for other activities, including people who buy rice to eat. [Female, trader, Makurdi]

Other participants pointed out that the mental mapping exercise enabled them to understand how seemingly distant parts of the systems may be connected, such that changes in one part of the system affect other parts. One participant said:

> . . . I have learnt that all the components [. . .] of the rice value chain are interwoven and intrinsically linked, and that every component is important; it plays a unique role that altogether puts rice on the table. Therefore, if one component is negatively affected, the entire system is affected because the effect ripples through other parts and components. Just as having a good quality milled rice, for example, starts with growers planting a good variety of rice and seeds that in turn produce good quality paddy that goes to the rice mills. Once this is not done, forget it, no matter the quality of milling, the final milled rice product is not going to be of the high quality that consumers will want. [Male, miller, Makurdi]

Some participants were surprised that the system maps revealed connections they did not expect or anticipate. This, in turn, helps develop new knowledge that can help improve system performance. In the words of one participant:

> I have come to learn about other components, such as packaging of rice, which can potentially increase the volume of milled rice trading, although we are not investing in that now. [Male, trader, Makurdi]

3.2.2. Better decision making

Participants noted that PSM informs better decision making in various ways. Firstly, it helped them appreciate, or confirm, the wider implications of the challenges faced, which is an important first step in taking appropriate measures to address those challenges. According to one participant:

> . . . the maps have confirmed some of the challenges that we face here every season, such as poor seeds or less preferred varieties having negative effects on rice productivity, including the quality of the rice harvest, which attracts buyers and higher prices. On the other hand, the maps and discussions we are having here have challenged my beliefs that these challenges do not only affect growers or affect us. In fact, I now know that the effects go beyond us, even up to the rice millers, the traders on the market, and those who buy and cook the rice too . . . [Male, grower, Makurdi]

Participants begun to identify leverage points for intervention in the rice value chain. As one participant put it:

> I have come to see that not only production needs immediate government intervention, it is now obvious to me that other activities, such as milling and trading, need interventions too. In fact, they need it simultaneously. [Male, grower, Adikpo]

In addition, PSM helped participants identify concrete vulnerability reduction strategies in their own space of action. According to two participants:

> . . . the mental maps stimulated an idea of diversification to other parts of the chain, especially production to increase my income. [Female, trader, Adikpo]

> . . . for me, the maps stimulated an idea of engaging in both farming and processing. I think by engaging in two or more activities of the chain this is the best way for producing high quality rice, a grower should produce and process [mill) the rice himself. In this way, the quality will be high, and famers can make a profit at both ends . . . [Male, grower, Adikpo]

3.2.3. Community problem solving

Participants reported that PSM promoted mutual understanding required to create synergy and support collaboration among distinct actors along the rice value chain. In the words of two participants:

> . . . I have learnt from the lines that link or connect one stage to another that rice production, which I am actively engaged in, does not stand alone, it is connected or affected by the market as other stages affect others too . . . [Female, grower, Adikpo]

> . . . the mental maps stimulate my thinking about what other actors along the chain usually go through. I can now appreciate the contributions as well as the challenges of each actor along the chain. Their bits of activity culminate in the final milled rice buyers enjoy. Therefore, I can say that these maps have helped me to think outside the area of my primary interest in the chain, which is milled rice trading . . . [Male, trader, Makurdi]

4. Conclusions

This study has developed and tested a rapid participatory systems-based method to elicit system conceptualizations from distinct value chain actors. It has collected evidence of specific ways in which rapid participatory system mapping can contribute to resilience building. Specifically, rapid participatory system mapping (i) promotes social learning about the rice value chain through the visualization of system structures, challenges and opportunities, (ii) informs better decision making at either individual or group level, through the uncovering of connections and interdependencies between value chain sub-systems, and (iii) promotes community problem solving through the establishment of a collective space and a collaboration platform, and a common understanding of the value chain, its vulnerability, and potential for adaptation.

These outcomes contribute specifically to two resilience factors in food systems, namely (i) social self-organization and (ii) reflective and shared learning (Table 1). Moreover, these findings tend to confirm the reported outcomes of longer PSM and participatory methods with regard to social learning, decision making, building mutual understanding and trust (Henly-Shepard et al., 2015; Inam et al., 2015; Mendoza & Prabhu, 2006; Schmitt Olabisi et al., 2018; Stave, 2010). An evaluation of the durability and impact of those outcomes on actual vulnerability reduction was beyond the scope of this study but is an important avenue for future research. Furthermore, in this study a larger proportion of growers and traders than millers found the PSM method useful. This may be related to the fact that these actors are those at the two opposite ends of the rice value chain, and therefore have a poorer understanding of it. Consequently, growers and traders have more to gain from PSM than millers, who are better connected with growers on the one hand and traders on the other. Further research may further elucidate the relative benefit of participatory methods for different actors along food value chains. In summary, these findings suggest that the rapid PSM method presented in this research note can contribute to food system resilience, specifically in terms of social self-organization and reflective and shared learning, and therefore can be used to complement other participatory methods of food system resilience building.

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Disclosure statement

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