



Interlinkages between leverage points for strengthening adaptive capacity to climate change

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Abstract

While systemic leverage points have been identified as a powerful approach for planning and assessing policies and interventions for sustainability transformations, few studies have explored how leverage points interact and how this affects the desired change. In this study, we explored how the interlinkages between leverage points enable or constrain adaptive capacity to climate change of food system actors. We found 24 interlinkages when drawing on results from semi-structured interviews and a participatory visual art method used in focus groups in a case study in the Northern Region of Ghana. Nine interlinkages were identified as barriers to the adaptive capacity of the communities and actors of the local food system. For example, when studying the interlinkages between the place-specific leverage point of agricultural extension services and the generic leverage point of gender equality, we found that women have less access to agricultural extension services compared with men. Fifteen interlinkages were presented as enabling adaptive capacity; for example, women's savings groups had many enabling interlinkages with gender equality such as creating unity and empowering the members. We argue that interlinkages between a set of leverage points (1) play a pivotal role in enabling or hindering the leverage points, (2) may instigate a chain of leverage and (3) may affect the system including the related leverage points in a deep or shallow way.

Keywords Leverage points · Interlinkages · Adaptive capacity · Climate change · Sustainability

Introduction

Systemic leverage points are increasingly recognised as an important lens for planning and assessing policies and interventions that support sustainability transformation. Leverage points provide guidance on where to intervene

effectively in complex systems, and can be used to instigate deep, transformative change (Fischer and Riechers 2019; Meadows 1999). Finding efficiencies, synergies, and avoiding trade-offs and antagonistic interlinkages are key to maximising sustainable transformation. Abson et al. (2017) claim that leverage points are not independent and that acting on one leverage point may cause unexpected and complex results. Further attention is needed to

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understand how a set of related leverage points interact to enable or constrain desired change (Riechers et al. 2021, 2022). This enabling or antagonistic interaction is what we have referred to as interlinkages in this study.

The role of interlinkages between system elements has been explored in several scholarly fields under slightly different terms including connectedness (Townsend and McWhirter 2005; Ives et al. 2017), interdependency (Niforou 2015), interlinkages, (Alcamo 2019; McCollum et al. 2018), interplay (Dale et al. 2000) and nestedness (Takemoto and Kajihara 2016). Within the climate change adaptation literature, we know that synergies exist both between different adaptation goals as well as between climate change adaptation and sustainable development goals (Masson-Delmotte et al. 2018; Sanchez Rodriguez et al. 2018). But these synergies are often not capitalised on. In a feasibility assessment of climate change adaptation options reviewing 24 cases across Africa, it was concluded that a better understanding is needed of how interdependencies between adaptation efforts work within institutional, social and economic arrangements and the importance of the local context (Williams et al. 2021).

To date, research on interlinkages between multiple related leverage points has mainly focused on how shallow and deep leverage points enable one another (Burgos-Ayala et al. 2020; Pérez-Ramírez et al. 2021). Shallow leverage points, such as numbers and structures of material stocks and flows (for tangible examples see Table 1), are easier to act upon but have less potential to bring out transformative change compared with deep leverage points. Deep leverage points, on the other hand, concern worldviews, values and mental models that are mostly hard to modify (Abson et al. 2017). Deep leverage points, such as relational values of nature, are generally accepted as helping operationalise shallow leverage points such as policies (Mattijssen et al. 2020; Riechers et al. 2022). However, Manlosa et al. (2019) found that over time, shallow leverage points can enable deeper change in societal structures and norms related to gender equality in Ethiopia.

While studies incorporating multiple leverage points seek to investigate the interlinkages between deep and shallow leverage points, they do not provide an in-depth understanding of how leverage points interact through nested systems scales to enable or constrain desired change. Nestedness is

Table 1 Abson et al.'s (2017) relationship between the four realms, Meadows's (1999) twelve leverage points, and examples of leverage points for climate action in a food system context

Realms of leverage by Abson et al (2017)	Leverage points 12-step framework by Meadows (1999)	Examples of leverage points for climate action in a food system context
Parameters <i>Coded as very shallow</i>	Constants, parameters, numbers	Level of farming subsidies that incentives climate-smart agriculture
	Size of buffer stocks, relative to flows	Security supplies of staple foods
	Structure of material stocks and flows	Nutrient run-off from fields into water systems
Feedback <i>Coded as intermediately shallow</i>	Length of delays, relative to rate of system change	Climate change mitigation measures that slow down climate change, for example reduction of farming systems with extensive grazing that leads to deforestation
	Strength of negative feedback loops	Climate change adaptation measures that enable agriculture production, for example more drought-resistant crops
	Gain around positive feedback loops	Population growth and growing demand for meat
Design <i>Coded as intermediately deep</i>	Structure of information flows	Access to agricultural extension services
	Rules of the system (incentives, constraints)	Rules on land use that controls the expansion of agriculture land to pristine, biodiversity rich, natural forest
	Power to change system structure or self-organised	Self-organised farmer-based organisations in the Global South that advocate climate justice
Intent <i>Coded as very deep</i>	Goals of the system	Policies that steer food systems towards climate-smart food systems and global food security
	The mindset or paradigm underpinning the system	Social norms and values of what is acceptable to eat
	Power to transcend paradigms	Acceptance that options to the present climate regime and food system exist and are within reach

The table is adapted from Fischer and Riechers (2019)

a concept stemming from systems thinking and network science and describes the hierarchical structure of a system's scales in which system subsets interact with each other (Holling 2001; Mariani et al. 2019). Leverage points can also be nested with each other as part of a broader socio-ecological system. We defined a socio-ecological system as a relationship between an ecosystem and a social system (Collins et al. 2011). Indeed, recent commentaries have indicated that understanding how leverage points work in connected or nested systems is a major research question facing sustainability science and practice (Leventon et al. 2021). To understand multiple leverage points interacting with and enabling one another, Fischer and Riechers (2019) introduced the importance of creating a 'chain of leverage'. Explicit work on how such a chain of leverage can emerge has so far been under-researched. We define a chain of leverage as a situation within a system in which more than two related leverage points hold a synergistic impact on each other. The chain of leverage differs from what is called nested leverage points as the term "nested" does not reveal whether the interlinkages between the related leverage points are enabling or antagonistic.

To address the above-mentioned knowledge gaps, for this article, we used qualitative methods to explore interlinkages between related and simultaneously addressed leverage points for strengthening adaptive capacity to climate change of actors of a food system in the Northern Region of Ghana, Africa. We answer the following research questions:

1. How do three place-specific leverage points, and their interlinkages with four generic leverage points, enable or constrain adaptive capacity?
2. How do the interlinkages interact to form a chain of leverage for strengthening adaptive capacity?
3. What is the depth of the interlinkages identified?

Theoretical background

Leverage points for strengthening adaptive capacity

Adaptive capacity is one of the key concepts of climate change adaptation and refers to the latent ability of mobilising necessary resources when needed (Armah et al. 2015; Engle 2011; Siders 2019). Adaptive capacity is influenced by the ability to act collectively, the networks and knowledge at hand, and the willingness and agency to act (Adger 2003; Brown and Westaway 2011; Engle 2011).

Building on Cinner et al. (2018), Rosengren et al. (2020) proposed two ways to approach adaptation planning: (1) using so-called generic leverage points and (2) place-specific leverage points for strengthening adaptive capacity. The generic and place-specific leverage points operate on two distinct system scales, the generic on a higher scale and

the place-specific on a lower scale. Generic leverage points for strengthening adaptive capacity, as the name alludes to, are broader and more general in nature and need to be combined with meaningful context-specific interventions. The generic leverage points for strengthening adaptive capacity are: (1) *access to finance*, (2) *access to and use of information and knowledge including traditional, local and indigenous knowledge*, hereafter referred to as simply *information and knowledge*, (3) *social learning*, and (4) *gender equality*.

Place-specific leverage points for strengthening adaptive capacity fall under these four generic leverage points and relate to them topic-wise. The place-specific leverage points are more tangible in nature compared to the generic leverage points as they zoom in on specific geographical and contextual needs. In this article, we studied three place-specific leverage points defined below: (1) *savings groups*, (2) *agricultural extension services* and (3) *innovation platforms*.

Four generic leverage points for strengthening adaptive capacity

The four generic leverage points were identified to strengthen the five domains of adaptive capacity: assets, flexibility, social organisation, learning and agency (Cinner et al. 2018; Rosengren et al. 2020). Below we elaborate on how the four generic leverage points strengthen the five domains of adaptive capacity.

Access to finance means opportunities for people to borrow money or accept credit, which improves the asset, flexibility and agency domains of adaptive capacity. In a Global South context, this can transpire through a savings group or microcredit provider (Marsden et al. 2020). However, managing finances and identifying business opportunities can be difficult without relevant information and knowledge. **Information and knowledge** including local, traditional, and indigenous knowledge are important aspects for finding solutions to climate change adaptation (Makondo and Thomas 2018). Having the right information, knowledge and skills improves a person's options to shift and adapt livelihood practices and hence improves one's flexibility and agency. In a farming system, this may include having the knowledge about a more drought-resistant crop, how to get hold of the seeds and how to cultivate the crop.

Social learning is a way to facilitate knowledge sharing, joint learning, and co-creation of experiences between stakeholders around a shared purpose in ways that support change beyond the individual to communities, networks, or systems and enables new, shared ways of knowing that lead to practical changes (Ensor and Harvey 2015). Social learning holds the potential to improve social organisation, flexibility, learning and agency (Biesbroek and Wals 2017; Pelling et al. 2008).

Gender equality addresses gendered power imbalances. These imbalances impact women's ability to adapt to climate change (Adzawla et al. 2019). Women's adaptive capacity globally, and especially in sub-Saharan Africa, is weaker compared to men due to a number of inequalities. According to the "World's Women 2020: Trends and Statistics" portal maintained by the United Nations Statistics Division, sub-Saharan Africa has the highest rate globally of child marriages (impacts agency) and holds the highest gender disparity of literacy (men 73% and women 59%), which affects the learning domain of adaptive capacity. Furthermore, women own fewer resources, including arable agriculture land (impacts assets, agency and flexibility), and are less represented in decision-making positions within both the political and corporate sphere (impacts agency and social organisation) and hold the main responsibility for providing unpaid domestic and care work (impacts assets and flexibility). Climate change has reinforced pre-existing gender inequalities (Eastin 2018). Gender norms filter through culture and the entire social system influencing how society is structured. Gender norms determine what role men and women have and what opportunities and barriers there are related to matter such as resource possession, decision-making power and networking opportunities (MacArthur et al. 2022). As a leverage point, *gender equality* addresses values, worldviews, social norms and structures, and can hence be described as a deep leverage point (Manlosa et al. 2019).

Place-specific leverage points for strengthening adaptive capacity

The three place-specific leverage points included in this study were previously identified in a case study in the Northern Region of Ghana. These three are (1) *savings groups*, (2) *agricultural extension services*, and (3) *innovation platforms*. Multiple place-specific leverage points exist (see Rosengren et al. 2020). For simplicity, we incorporated only those place-specific leverage points with the most interlinkages into this study. Below we elaborate on how the three place-specific leverage points strengthen the five domains of adaptive capacity: assets, flexibility, social organisation, learning and agency (Cinner et al. 2018).

Savings groups are a place-specific leverage point falling under the generic leverage point *access to finance* and strengthens people's assets and flexibility from an adaptive capacity perspective. A savings group in the case study area is a group of mainly women meeting regularly, typically once a week. Each week the members of the savings group contribute a small amount of money. In addition to supporting money saving, the group provides opportunities for members to take out loans when needed. It is well-established that savings groups have a positive impact on poverty reduction and food security and have increased

household income and expenditure especially in rural areas of the Global South and especially where people have little access to formal banks in sub-Saharan Africa (Karlan et al. 2017; Steinert et al. 2018). According to Flynn and Sumberg (2018) even more importantly savings groups teach members how to control expenses, which strengthens the learning domain of adaptive capacity, and provides a platform on which to build social capital, which strengthens the social organisation.

Agricultural extension services are a place-specific leverage point falling under the generic leverage point *information and knowledge* and strengthens the domains of learning and agency. In the case study area, agricultural extension services are part of the government administration under the Ministry of Food and Agriculture of Ghana. The agricultural extension agents' main task is to circulate in rural communities, where they raise awareness of good farming practices. Agricultural extension services were identified as one of the main information sources in the case study area. This information is related to how to adapt farming to the challenges posed by the changing climate (Bidwell et al. 2013; Rosengren et al. 2020).

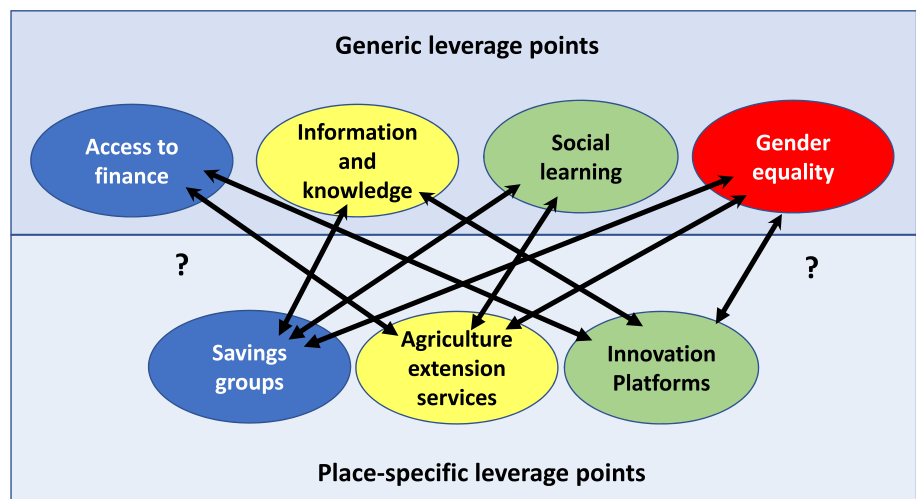
Innovation platforms in this work refer to self-organised social platforms that build trust and social cohesion and provide a platform for collective learning. In the case study area, two innovation platforms were established that ran for approximately one year prior to data collection in this study. (See "[Sampling](#)" for more information). The innovation platforms had convened seven times since the platform's establishment when the data were collected. The cultivation of soya beans using a particular technology offering higher yields was the main focus of the group discussions.

The place-specific leverage point *innovation platforms* falls under the generic leverage point *social learning* and strengthens adaptive capacity through supporting collective action, social organisation, learning and agency (Schut et al. 2016; Van Rooyen et al. 2017). Innovation platforms and agency contribute to resourcefulness, which here refers to the capacity of a rural community to change its resource use (Franklin 2018) and adapt to climate change and plays a vital role in rural resilience. Resourceful communities are essentially place-based: people work together and are spatially connected, dealing with the characteristics, potentialities, and resources of a specific place.

Interlinkages between leverage points

Our study set out to identify interlinkages between the three predefined place-specific leverage points and the four predefined generic leverage points for strengthening adaptive capacity of the food system actors of the case study in the Northern Region of Ghana. Figure 1 shows the study setting with two system scales: generic leverage

Fig. 1 The study setting. The two-headed arrows show the potential interlinkages that are explored in this study



points operating at a higher system scale, and place-specific leverage points operating at a lower system scale. In this study, we were interested in the nestedness and interlinkages between these two scales. From a systems thinking perspective, the interlinkages across scales are of utmost importance for understanding how systems operate and change over time (Walker and Salt 2012). Such understanding gives us insight into how to promote desired change, which in this study includes how to strengthen the adaptive capacity of the actors of the food system in the case study area.

The two-headed arrows between the two system scales symbolise the possible bidirectional interlinkages that the study set out to explore. For example, the place-specific leverage point *savings groups* falls under *access to finance*. The study does not include the identification of interlinkages between *savings groups* and the associated generic leverage point *access to finance* but explores instead how interlinkages between *savings groups* and the other three generic leverage points *information and knowledge*, *social learning* and *gender equality* emerge and how the identified interlinkages enable, amplify or hinder desired change. As Fig. 1 shows, the generic leverage point *gender equality* does not have an explicit associated place-specific leverage point as the study incorporated only those place-specific leverage points with the most interlinkages into this study.

We also study the characteristic of the interlinkage: whether the interlinkage is enabling or is a barrier vis-à-vis another leverage point for strengthening adaptive capacity. A barrier to climate change adaptation, generally defined as a challenge or constraint that impedes adaptation, is a well-established concept within the scientific adaptation literature (Biesbroek et al. 2013; Eisenack et al. 2014). The opposite of a barrier to adaptation is often referred to as an opportunity, driver or enabler of adaptation.

Material and methods

Case study area

The case study area is situated in the Northern Region of Ghana. The area has a semi-arid climate and belongs to the savanna agroecological zone (Aniah et al. 2019). Climate change is already impacting the area. A study tracking rainfall patterns between 1960 and 2007 found the patterns to have changed (Boafo et al. 2016). There is a decrease in rainfall (Asare-Nuamah and Botchway 2019) and temperatures are rising (Abbam et al. 2018) and it has been predicted that they will continue to do so (Sylla et al. 2016). This poses a direct threat to predominantly rainfed subsistence farming (Wossen and Berger 2015). Poverty is prevalent, and people's ability to deal with shocks is limited (Wossen and Berger 2015). Literacy rates in rural areas of the Northern Region are 25% for men and only 15% for women, according to the Ghana Statistical Service (2019). Livelihood diversification is low, which deepens the population's vulnerability (Dumenu and Obeng 2016).

The study area is predominantly Muslim, and polygamous marriages are common (Agadjanian and Ezeh 2000; Vercillo 2020). The social structure is patriarchal, placing women in a subordinate role to men. This is reflected in girls' lower rate of access to education (Atta 2015), genital mutilation (Amoakohene 2004), girls experiencing sexual harassment from teachers (Atta 2015), early marriage (Amoako Johnson et al. 2019), marital violence (Tenkorang et al. 2013), and women being excluded from decision-making regarding livelihood matters (Apusigah 2009) (Fig. 2).

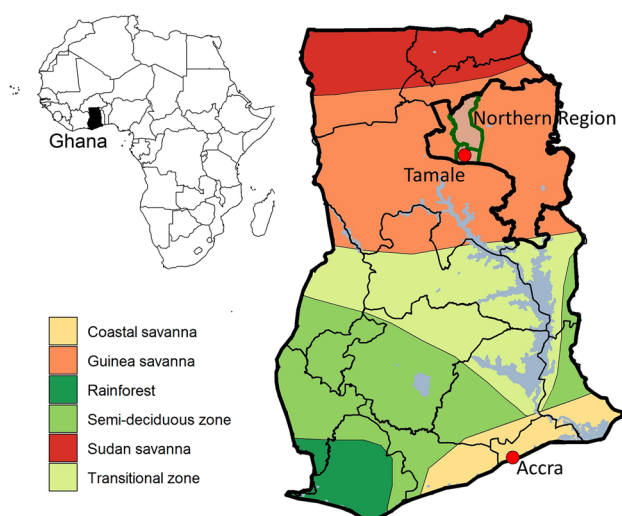


Fig. 2 Map of the case study area and the agroecological zones adapted from Osei and Stein (2017). The green line within the jurisdictional area features the two districts where the data was collected. The capital of Ghana—Accra—and the regional capital—Tamale—are marked with red dots

Sampling

The study included two samples: a key informant sample ($n = 12$) and a sample consisting of stakeholders from the local food system ($n = 38$). We chose these two sample groups to form a diverse data set and an in-depth understanding of place-specific leverage points and related enablers and barriers to fostering adaptive capacity, along with gaining information on how the participants envisioned the necessary changes needed for operationalizing the leverage points in a food system influenced by climate change.

The key informant sample included academics working in the region, a village chief, a microcredit representative, government agriculture administration representatives, NGO workers, and a farmers' organisation executive. The food system sample contained two sub-samples: one comprising female farmers ($n = 20$) from Langa village and the other comprising stakeholders of the local food system ($n = 18$) including farmers, processors, retailers, and a consumer representative. The key informant sample was formed using purposive sampling following the method presented by Tongco (2007). The local food system sample selection was based on members of two already existing innovation platforms.



Fig. 3 Photo of the participatory visual art method. Photo taken by Linda Rosengren

Data collection

The study included two types of data collection: (1) semi-structured interviews principally covering the three place-specific leverage points and (2) focus group discussions including a participatory visual art exercise covering the four generic leverage points. We conducted interviews with both samples while the focus group discussions were only carried out with the food system sample.

Interviews

The open-ended interview questions principally covered the following topics: (1) *savings groups*, (2) *agricultural extension services* and (3) *innovation platforms*, (see Appendices I and II for the interview script). The interview team included one European and three Ghanaians. The interviews were conducted in Dagbani. All interviews were recorded after consent had been given by the interviewee and later translated into English during transcription.

Focus group discussion including a participatory visual art method

A participatory visual art method involving discussions and drawing (Mitchell et al. 2011) was undertaken during two focus group discussions ($n = 2$), one for each food system sub-sample. The visual art method was chosen to enable a rich exploration of participant views, perceptions, and reflections on partly sensitive topics. The method allowed discussions about the power structures in society. The drawing exercise was used to move the participants' attentions away from the facilitators to the topics we covered.

Prior to the focus group discussions, a training session was held with the workshop facilitators to deliberate on why and how to execute the participatory visual art session. The breakout group members, approximately five people per group, were agreed upon. It was decided that the order of the five topics to be covered would be different in each group. By doing this we avoided having all groups covering the same topic last, when the participants' and facilitators' energy levels were likely to be lower (see Appendix III for more details) (Fig. 3).

On the day of the workshop, we conducted the visual art exercise in breakout groups, with each group guided by a facilitator. The workshops were conducted in Dagbani. Participants were asked to discuss the barriers and enablers to achieving each of the four generic leverage points along with a fifth topic on climate change adaptation. We then asked each group to synthesise their main insights through drawings.

In addition to the 23 drawings produced, the group discussions around each drawing were an important aspect of the exercise, creating a collaborative meaning-making of the illustrations. These discussions were recorded, and notes were taken by designated reporters, one in each breakout group. The text, rather than the drawings, was the main data source used in the study analyses.

Analysing results

Our study set out to identify interlinkages between two system scales of predefined leverage points: generic leverage points at a higher scale and place-specific leverage points at a lower scale. Each place-specific leverage point was associated with one of the generic leverage points. The place-specific leverage point *savings group* was associated with the generic leverage point *access to finance*, the place-specific leverage point *agricultural extension services* was associated with the generic leverage point *information and knowledge* and the place-specific leverage point *innovation platforms* was associated with the generic leverage point *social learning*. All three place-specific leverage points were associated

with the generic leverage point *gender equality* due to their systemic and deep nature. In the analysis, we identified interlinkages between a place-specific leverage point and a generic leverage point *other* than the one that the place-specific leverage point fell under, as shown in Fig. 1. For example, we explored how *savings groups* interlink with the generic leverage points: *information and knowledge*, *social learning*, and *gender equality*. But we did not explore how *savings groups* interlink with *access to finance*.

The two qualitative data collection methods led to approximately 380 pages of transcribed text that formed the basis for the analysis. We triangulated data across the two samples by systematically tracking similarities and differences in the statements by members of the two samples.

Identifying interlinkages between leverage points

We used thematic analysis following Braun et al. (2019) using NVivo software. We searched the data for instances when participants mentioned a given interlinkage. Five variables were tracked: (1) interlinkages, (2) which two elements the interlinkage connects with, (3) the number of references made to each interlinkage, (4) whether the interlinkage was enabling or antagonistic vis-à-vis the leverage points, and (5) whether the interlinkage holds characteristics affecting the system in a deep or shallow way. In the results section we have presented the findings in a table with a column for each variable.

We drew on direct statements in the data and insights from theory to identify the associations between elements and interlinkages, and whether each association was enabling or hindering of a given change. For example, respondent F220 spoke about savings group: *It has been helpful to us. We are united with common goals; everyone is participatory and contributing*. Here we coded the statement and named it "Creates unity" as it was explicitly mentioned that the members are united. We have coded this node to connect with the generic leverage point *gender equality* and have a characteristic of enabling gender equality based on the literature on social capital, gender and adaptive capacity (Adger 2003).

In the Results section, we indicate the number of times an interlinkage was referred to with a number in parentheses, for example (5 refs.). The references made to a given interlinkage that arose from the participatory visual art exercise count as one reference. The references made to a given interlinkage that arose from the interviews count the number of interviewees mentioning the topic, not the total number of times the interlinkages were mentioned. The number of references made is highly place- and context-specific and is not generalisable. In addition, we did not seek to rank the interlinkages in order of importance according to how many times each interlinkage was

mentioned. Rather, we sought to explore how interlinkages that emerged from the data affected the system.

When quoting statements, we have indicated the gender of the respondent by marking F for female and M for male. We added each participant's number to the letter, so participant no. 305 was coded as F305. Quotes are marked in italics. Also, the leverage points are marked in italic.

Determining the depth of the interlinkage

When determining the depth of the interlinkages, we applied the leverage points framework originally developed by Meadows (1999) and further developed by Abson et al. (2017) who grouped the initial twelve leverage points into four realms according to system characteristics.

We analysed the interlinkages against the leverage point framework visualized in Table 1 to identify which of the four realms the interlinkages related to. We coded the interlinkages according to the four realms as follows: parameters = very shallow, feedback = intermediately shallow, design = intermediately deep, intent = very deep.

Results

Enabling and antagonistic interlinkages

Savings groups

A total of 13 interlinkages were listed by the respondents when discussing savings groups (Table 2). The interlinkages stemmed nearly equally from data collected from the food system and from the key informant sample and included both enabling (8) and antagonistic (5) interlinkages. Several interlinkages were mentioned by both samples, notably the three most frequently mentioned interlinkages. Most of the interlinkages were associated with *gender equality* (6). Four interlinkages related to *information and knowledge* and the three remaining interlinkages related to *social learning*.

Interlinkages having a synergistic nature vis-à-vis *gender equality* included the four most frequently mentioned interlinkages, i.e., the savings group “Creates unity” (24 refs.) among members, “Empowers” its members (19 refs.), “Creates commitment” to a given cause (15 refs.) and provides “Support during hardship” (12 refs.). The respondents also stated that the savings groups “Create independence” (8 refs.) among the female members. Past studies have shown that the feeling of independence created from being able to access credit makes women perceive themselves as having been empowered (Mayoux 2001; Shetty 2009). Unity, reciprocity, trust and

Table 2 The enabling and antagonistic interlinkages identified concerning the place-specific leverage point of savings groups

	Interlinkage with generic leverage point	Depth	Number of references	Sample
<i>Enabling interlinkage</i>				
Create unity	Gender equality	Intermediate deep	24	FS, KI
Empowerment	Gender equality	Intermediate deep	19	FS, KI
Create commitment	Gender equality	Intermediate deep	15	FS, KI
Support during hardship	Gender equality	Intermediate deep	12	FS
Create independence	Gender equality	Intermediate deep	8	FS
Teaches how to manage finances	Social learning	Intermediate deep	4	FS
Platform for development cooperation interventions	Social learning	Intermediate deep	3	FS
Enable social learning	Social learning	Intermediate deep	2	KI
<i>enabling Antagonistic interlinkage</i>				
Patriarchal gender norms	Gender equality	Very deep	9	FS, KI
Illiteracy	Information and knowledge	Intermediate deep	5	KI
Lack of capacity	Information and knowledge	Intermediate deep	5	FS, KI
Poor record keeping	Information and knowledge	Intermediate deep	6	KI, FS
Poor management	Information and knowledge	Intermediate deep	4	FS, KI

The table shows which generic leverage points the interlinkage links with; the depth of the interlinkage, the number of references made to the interlinkage; and from which of the two samples the interlinkage stems from, the food system (FS) or the key informant (KI) sample

commitment to a common cause and collective action are features of social capital that have proven to hold the potential to significantly empower women (Adger 2003). A female respondent described the savings groups: (F217) “It [the savings group] helps, gone are the days when we didn’t know how to manage our money well. We are able to save our money to help grow our businesses, solve unprecedented problems, and also [for] farming activities.”

The results also revealed an antagonistic interlinkage related to *gender equality* coded as “Patriarchal gender norms” (9 refs.). It was reported that it was usual for a man to have the role as an accountant in the group hence reinforcing existing gender norms. It was furthermore reported that a husband may forbid his wives from participating in savings groups. The reason for this was not explained.

Four interlinkages that connect savings groups with *information and knowledge* were all framed as barriers. They were “Poor record keeping” (6 refs.), “Illiteracy” (5 refs), “Lack of capacity” (5 refs), and “Poor management” (4 refs.). A key informant (M306) responded: “Most members of these groups are not educated, so keeping records is difficult, they also find it difficult to seek for help because of their lack of education. They do not have proper guidance on how to manage their affairs, and this also affects them greatly.”

Multiple interlinkages were found between *savings groups* and the generic leverage point *social learning*, all of which were framed as enabling. For example, “Teaches how to manage finances” (4 refs.), “Platform for development cooperation interventions” (3 refs.) and “Enable social learning” (2 refs.). Key informant M307 says: *These groups are interesting because development agencies can trust and invest in them. They are farmers or marketers who come together to form the group and set some common goals to be achieved and they go extra mile to get them achieved.*

Agricultural extension services

Agricultural extension services generated a total of six interlinkages (Table 3). Most of the interlinkages (4) were connected with the generic leverage point *gender equality*. All of these were framed as barriers to gender equality. Agricultural extension agents were reportedly few in number, with a ratio of one agent per several thousand farmers. Most farmers targeted by the extension agents are men, while women have considerably less access to extension services. Respondents provided a range of reasons for this injustice. While agricultural extension services generally experience a lack of funds, there is also a clear link with “Socio-cultural barriers for women to participate in agri-extension” (8 refs). Despite attempts by the governmental agriculture administration to be more gender inclusive, the district authorities and extension agents often overlooked the need for equal participation. Key informant F507 stated: *Local authorities (District Assemblies) aren’t showing much interest (in gender equality)*. Sometimes agricultural extension sessions pools farmers from several nearby communities into one common session. As women have restricted mobility due to religious and cultural factors, they are less likely to be selected to attend the sessions. The timing of the extension sessions had not been adapted to women’s daily schedules. Time poverty faced by women was also not taken into consideration. A male key informant (M307) stated: *Times (extension) sessions are going on is when the women are cooking, fetching water, bathing their children and other household activities meanwhile the extension agents are moving with time and cannot wait for everyone to finish before sessions are started*. In addition, the fact that “Women grow fewer cash crops compared with men” (2 refs.) was another explanation reported for why women have

Table 3 The enabling and antagonistic interlinkages identified concerning the place-specific leverage point of agricultural extension services

	Interlinkage with generic leverage point	Depth	Number of references	Sample
<i>Enabling Interlinkage</i>				
Knowledge dissemination	Social learning	Intermediate deep	6	KI
Peer-to-peer learning	Social learning	Intermediate deep	1	KI
<i>Antagonistic Interlinkage</i>				
Socio-cultural barriers for women to participate in agri-extension	Gender equality	Very deep	5	KI
Socio-cultural barriers for women to become extension agents	Gender equality	Very deep	3	FS, KI
Time poverty of women	Gender equality	Very deep	3	FS, KI
Women don’t grow cash crops	Gender equality	Very deep	2	KI

The table shows which generic leverage points the interlinkage links with; the depth of the interlinkage, the number of references made to the interlinkage; and from which of the two samples the interlinkage stems from, the food system (FS) or the key informant (KI) sample

less access to extension services. Male extension workers also feel awkward when working with women. A male key informant (M503) explains: *I cannot be talking to a woman and seek information or exchange information without her husband and all that, so I prefer to talk with the husband and hope that the husband will pass the information to the wife. So, for most training in the communities, it is the men that appear when called, and I hope that the men go back and share the information, but that hardly happens.*

Finding suitable female candidates to become extension agents is reportedly difficult due to “Socio-cultural barriers for women to become extension agents” (5 refs.). According to respondents, women are not interested in studying agriculture to become agricultural extension agents. This lack of interest in becoming an extension agent may be due to women being afraid of being mocked at their workplace (M307) and the job being considered dangerous. M506 states: *It is risky for a woman to travel alone on these dangerous roads, she could be attacked on her way.*

Two interlinkages connected *agricultural extension* with *social learning*, both of which were framed as enabling. One of the two represents the second most frequently mentioned interlinkage “Knowledge dissemination” (6 refs). The other factor linking with social learning was “Peer-to-peer learning” (1 ref). Key informant M303 explains: *Extension in general is conducted to assist the agriculture department to disseminate knowledge to farmers. They [extension agents] are the mouthpiece of the government to the farmers on policy implementations.*

Innovation platforms

Five interlinkages were identified from the data (Table 4), all of which were enabling. The interlinkages connect with the three generic leverage points but mainly relate to the generic leverage point *information and knowledge*. The interlinkage most referred to connected innovation platforms with *access to finance*: “Building networks” (7 refs.). M506 states: *It (the Innovation Platform) enables*

farmers know where to get what and when to get it. In a season some farmers find it difficult to get farm inputs, tractors and combined harvesters on credit. But when such a network is created, it enables them all to plan how to work with each other within a particular season. One other interlinkage connected with access to finance: “Good for agribusiness” (4 refs.). Respondent M307 describes innovation platforms: It is the best place for idea sharing among representatives of the food chain. They can discuss products that are in high demand and can benefit everyone.

Two interlinkages connected *innovation platforms* with the generic leverage point *information and knowledge*: “Sharing knowledge, experiences, ideas” (4 refs.) and “Provide new insights” (3 refs.). Key informant M306 describes the innovation platforms: *Their interactions allow for sharing knowledge, and it allows those implementing the policies to know what policy beneficiaries really want and to be able to adjust if possible.*

One interlinkage connected the innovation platform with *gender equality*: “Women are more empowered” (1 ref.). Respondent F117 says: *The men cheat us a lot when it comes to issues related to farming. This time we have learnt our lessons and we the women are willing to go to the farm to do all farming activities from scratch without any male involvement.*

All interlinkages except one stemmed from the key informant sample. The only interlinkage stemming from the food system sample was that women became more empowered.

Chain of leverage

Our results show that the leverage points were nested with each other, with a total of 24 interlinkages (Fig. 4). Of these interlinkages, 15 were framed as enabling and nine as antagonistic (Table 5). Based on the findings presented above, we identified where a so-called ‘chain of leverage’ emerged. We

Table 4 The enabling interlinkages identified concerning the place-specific leverage point innovation platforms

Enabling	Interlinkage with generic leverage point	Depth	Number of references	Sample
Build networks	Access to finance	Intermediate deep	6	KI
Sharing knowledge, experiences, ideas	Information and knowledge	Intermediate deep	4	KI
Good for agribusiness	Access to finance	Intermediate shallow	4	KI
Provide new insights	Information and knowledge	Very deep	3	KI
Women more empowered	Gender equality	Intermediate deep	1	FS

No antagonistic interlinkages were identified. The table shows which generic leverage points the interlinkage links with; the depth of the interlinkage, the number of references made to the interlinkage; and from which of the two samples the interlinkage stems from, the food system (FS) or the key informant (KI) sample

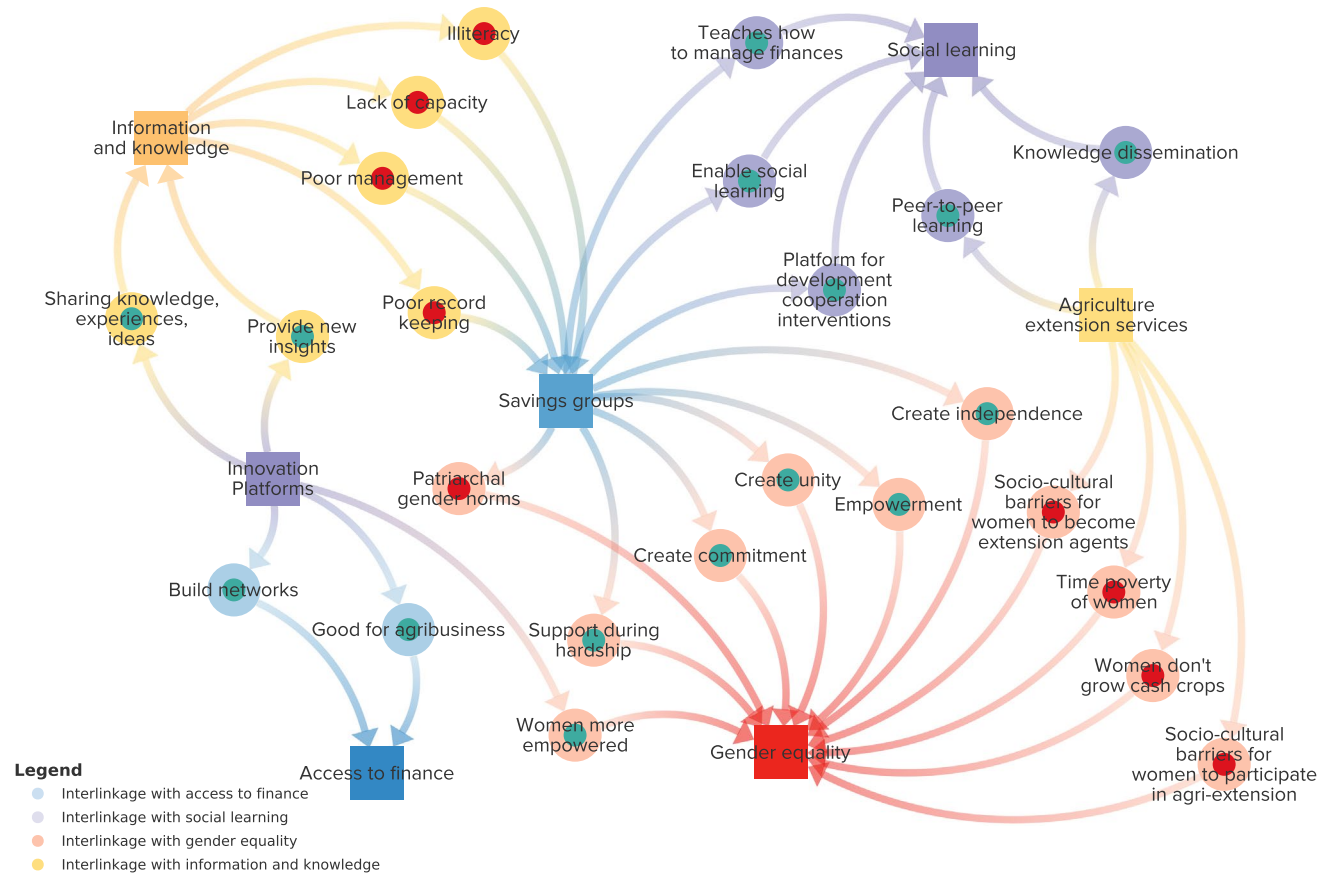


Fig. 4 The figure shows the nestedness of the leverage points and how the leverage points both enable and hinder each other. The leverage points are marked as squares and interlinkages as circles. The

enabling interlinkages are marked with a green bull’s eye and the barriers with a red bull’s eye. The arrows represent direction of the interlinkage

Table 5 A summary table of the identified enabling and antagonistic interlinkages

	Savings groups		Agricultural extension services		Innovation platforms	
	Enabling	Antagonistic	Enabling	Antagonistic	Enabling	Antagonistic
Interlinkages with access to finance	NA	NA	0	0	2	0
Interlinkages with information and knowledge	0	4	NA	NA	2	0
Interlinkages with social learning	3	0	2	0	NA	NA
Interlinkages with gender equality	5	1	0	4	1	0
Total number of interlinkages	13		7		5	

argue that a chain of leverage may occur where a synergetic interlinkage exists between more than two leverage points.

We found an enabling interlinkage between *savings groups* and *gender equality*. The savings groups “Create unity” among the female members, “Empowering” them, “Create commitment” and providing “Support to the women in hardship”. The findings moreover revealed that the savings group “Enable social learning”. On the other hand, the importance of the generic leverage point *information and knowledge* became clear to reach the full potential of the

savings groups. Respondents reported on “Lack of capacity”, “Illiteracy”, “Poor record keeping” and “Poor management” of the savings groups overall.

Agricultural extension services reinforced existing gender norms in a number of ways. Socio-cultural barriers make it difficult for women to participate in agricultural extension sessions. If there were more female extension agents, it would be more acceptable for women to participate in the sessions. However, it was reported to be difficult to recruit female extension agents and difficult to get women to study

agronomy to become extension agents due to “Socio-cultural traditions and social norms”. In this way, agricultural extension services were found to undermine *gender equality* in many ways.

Innovation platforms provided possibilities to meet new people and “Build networks”. It was also reported to be “Good for agribusiness”. These aspects have a synergistic impact on the generic leverage point *access to finance*.

Based on these findings we can see a potential “chain of leverage” emerge as follows: *innovation platforms* not only facilitate *social learning* but also provide an opportunity to network and improve agribusiness which improves income and livelihoods. This again provides a possibility to, if the community members so decide, to put more money aside in the savings group. *Savings groups* again facilitate *gender equality*. Savings groups were reported to empower their members and create independence.

Depth of the interlinkages

Finally, we studied the strength of the interlinkages by scrutinising them through a leverage points framework lens. Of the 24 interlinkages identified, 17 can be considered to be intermediately deep, six to be very deep and one to be intermediately shallow.

All except one of the interlinkages that could be considered to hold features affecting the system in a very deep way were related to *gender equality*. In discussions regarding *savings groups*, we identified one barrier affecting the system in a very deep way: “Patriarchal gender norms”. In discussions regarding *agricultural extension services*, we identified four barriers affecting the system in a very deep way, all of which were associated with *gender equality*: “Socio-cultural barriers for women to participate in agri-extension”, “Socio-cultural barriers for women to become extension agents”, “Time poverty of women” and “Women don’t grow cash crops”. The only interlinkage affecting the system in a deep way that was not related to *gender equality* was that *innovation platforms* were reported to “Provide new insights” to their members. These interlinkages can all be related back to “The mindset or paradigm out of which the system arises”, i.e., the second deepest of the total twelve leverage point types in the original Donella Meadow’s framework.

Most of the interlinkages can be considered to affect the system in an intermediately deep way. In discussions regarding *savings groups*, all but one of the interlinkages had features that influence the social structures and can hence be associated with the design realm (Abson et al. 2017). The enabling interlinkages associated with *gender equality* (Create unity, Empowerment, Create commitment, Support during hardship and Create independence) improved social cohesion and could be related back to “The power to add, change and self-organise system structure”. The enabling interlinkages

associated with *social learning* as well as the barriers related to the access and use of *information and knowledge vis-a-vis savings groups* (“Illiteracy”, “Lack of capacity”, “Poor record keeping”, “Poor management”) affected the system in an intermediately deep way and related to “The structure of information flows”. In discussions regarding *agricultural extension services*, two enabling interlinkages related to *social learning* were identified: “Knowledge dissemination” and “Peer-to-peer learning”, both of which can be related back to “The structure of information flows”. In discussions regarding *innovation platforms*, three intermediately deep enabling interlinkages were identified: “Sharing knowledge, experiences and ideas” “Build networks”, “Women more empowered”. Of these, the latter two could be related to strengthen the ability to “Add, change and self-organise system structure”, the fourth most powerful of the twelve leverage points in the Donella Meadows leverage point framework. Meanwhile, “Sharing knowledge, experiences and ideas” could be related to “The structure of information flows”.

Only one of the 24 interlinkages could be considered to affect the system in an intermediately shallow way. This was the enabling interlinkage “Good for agribusiness” that arose from the discussions associated with *innovation platforms*. We consider this to be related to the realm feedback with features related to “Driving positive feedback loops”.

Discussion

This study explored the characteristics of multiple interlinkages between leverage points, and how these enable or constrain desired change. We found a rich web of interlinkages (Table 4; Fig. 4) between the predefined leverage points for strengthening adaptive capacity to climate change of the actors of the local food system in the case study area in Ghana’s Northern Region. Some of the interlinkages enabled leverage points, while others hindered them. The development cooperation community, including both researchers and practitioners, have long known that areas such as equality, education, and economic empowerment are important for sustainability and resilience. We advance sustainability science showing the potential for leverage points to strengthen adaptive capacity. For example, *innovation platforms* not only facilitate *social learning* but also provide an opportunity for platform members to network and improve agribusiness. Expanded networks provide better business opportunities and hold the potential to improve the income earned, which may mean more money to put aside in the savings group if community members choose to do so. *Savings groups* again have an enabling impact on *gender equality* by empowering and creating independence among the savings group members. The fact that savings groups improve household business outcomes and women’s agency is in line

with previous studies (Adegbite et al. 2022; Karlan et al. 2017; Steinert et al. 2018). In this way, a possible “chain of leverage” emerges through which multiple leverage points reinforce each other. The result suggests that future climate adaptation strategies need a set of policies and interventions that mutually reinforce each other, creating synergies and efficiencies, as in a “chain of leverage”. From a planning and implementation perspective, it would also be valuable to know the best entry point to start a “chain of leverage”. In this case, it was the *innovation platforms* but in another context the entry point may be different.

Not all interlinkages in the study facilitate desired change. We found situations in which related leverage points undermine each other. This provides an important contrast to previous work that has focussed on the enabling aspects between leverage points (Burgos-Ayala et al. 2020; Chan et al. 2020; Tourangeau and Sherren 2020). For example, the results showed how the place-specific leverage point *agricultural extension services* undermine gender equality in many ways, while it has previously been identified as a leverage point for strengthening adaptive capacity. Agricultural extension services are a governmental service with the task of disseminating information and knowledge to communities concerning good farming practices, including how to adapt to climate change. Women are often side-lined, and the extension services benefit men, which reinforces the unequal social structures.

Most of the identified interlinkages may be described as affecting the system in an intermediately deep, or even in a very deep way. The first means affecting social structures and norms, and the second relates to affecting the mental models of people and the ultimate goal of an entire system. Examples of interlinkages affecting the system in a very deep way were barriers related to gender equality identified in discussions concerning agricultural extension services. These were “Socio-cultural barriers for women to participate in agri-extension”, and “Time poverty of women”. These interlinkages hold features of the second deepest of the total twelve leverage point types in the original Donella Meadows’ framework: “The mindset or paradigm out of which the system arises”. Typical for the very deep leverage points are that they may be difficult to act on (Abson et al. 2017). The results may indicate that it may be hard and slow to reform the existing agricultural extension service in the Northern Region of Ghana to become more gender inclusive despite the good intentions enshrined in government documents. On the flip side, providing gender-sensitive agricultural extension services could have a potentially large impact on farmers mental models regarding women’s role in the rural society in the Northern Region of Ghana.

Implications for climate change adaptation planning

One of the most striking results was how interlinkages with *gender equality* emerged from all three place-specific leverage points. Men were more inclined to benefit from agricultural extension services compared to women. Investing in climate information that targets mainly men may reinforce existing gender norms and may potentially even cause maladaptation meaning increasing vulnerability (Masson-Delmotte et al. 2018). *Savings groups*, with their many benefits, are more common among women in the case study area but also more broadly in Sub-Saharan Africa (Lukwa et al. 2022), coinciding with existing literature highlighting how men and women may experience climate change differently and hence have different adaptation needs. The results suggest that any given adaptation programme may favour women and men differently supporting existing scientific findings on how adaptation policies and interventions need to be gender-smart (Anneck 2002; Huyer and Chanana 2021).

Adaptation needs are often place- and context-specific (Siders 2019). The importance of place-based solutions has previously been presented in the sustainability literature and it is important to be mindful that leverage points may emerge from specific contexts and may be shaped by multiple intervening factors (Wilbanks 2003). This means that sometimes a leverage point that is powerful in one place and context is not so in another location and context. This is also what the literature on panacea traps argues and how simple one-size-fits-all solutions in environmental governance should be avoided (Ostrom et al. 2007). The interlinkages we have identified may create different connections in other contexts and hold a different characteristic by being antagonistic instead of enabling. When planning climate change adaptation-enhancing strategies, it is crucial to have a thorough understanding of the place- and context-specific features and the nestedness of the socio-ecological system (Balvanera et al. 2017; de Vos et al. 2019).

Limitations and future directions

This work describes the qualities or characteristics of interlinkages but does not seek to quantitatively explain how they directly or indirectly affect leverage points. Future work could quantitatively test the results using social survey and representative sampling techniques. Further testing between sub-groups would also be beneficial, such as between men and women or food system actor groups.

Conclusion

This study explored how interlinkages between leverage points may influence the system and contribute to or hinder climate change adaptation- and resilience-related policies and/or interventions. Three key messages emerge from the study: (1) understanding how certain related leverage points interact with each other is important, as the interlinkage may determine how well a policy or intervention succeeds in creating the desired sustainability transformation; (2) choosing leverage points that create synergies and enable each other may amplify the desired change that the policy or intervention seeks to achieve, and (3) interlinkages may affect the system in a “deep” way. If this deep interlinkage is of an enabling nature vis-à-vis a related leverage point it may prepare the ground for deep leverage points that normally are difficult to act on.

When planning adaptation policies and tangible interventions we should be mindful of the system’s nestedness. What is happening “behind the scenes” may have an important impact on how well an endeavour succeeds. The selected leverage points included in a strategy, policy or programme may contain antagonistic interlinkages, diluting the endeavour outcome and in the worst case, even lead to maladaptation.

Appendix 1: Interview questions: local food system sample

Interviewer says: *Before we begin, I would like to explain a bit about the project that we work with.* (Perform consent protocol)

Interviewer says: Now we are ready to begin the interview: (TURN RECORDER ON!)

Interviewer states: (this needs to be recorded!)

1. The date
2. The place
3. Name of person you are interviewing
4. Gender of person you are interviewing
5. Interview number (given before)
6. Your name, name of interviewer

Interviewer says: Many thanks for taking the time to have a discussion. I will ask you questions and please note that there are no right or wrong answers. I am only interested in hearing your thoughts. Please don’t hesitate to ask for clarification if needed.

First, I would like to discuss access to finance, first about credit or micro-finance and then about community-based savings groups. So, let’s start by discussing credit.

1. Can you tell me a bit about credit schemes here in Northern Ghana? What is your opinion about them? What are their weaknesses? What aspects are working well?
2. What are the general reasons why people are not taking out credit?
3. How would you like to see the credit scheme function in the future in an ideal situation?
4. What needs to be done to make this happen?
5. Who could be responsible for making this change happen? And what could they do? [Encourage participant to identify more than one organisation or individual]

Now let’s move on to discuss community members’ savings groups.

6. Can you tell me a bit about community savings groups? Are there several in your community? Who are the members?
7. What is your opinion of community savings groups? What are their strengths? What are their weaknesses? What things work well?
8. How would you like to see the savings groups function in the future?
9. What needs to be done to make this happen?
10. Who could be responsible for making this change happen? And what could they do? [Encourage participant to identify more than one organisation or individual]

Now I would like to talk a bit about learning

15. Do you know of any organisations that offer the opportunity for farmers to interact with other representatives of the food chain? Or where other members of the food chain, such as retailers, can interact with processors?
16. What is your opinion about the innovation platform you have participated in? What has it given you?

Now I would like to talk about the self-respect and well-being of people in the community you live in

17. Do you believe that all people, all men and all women, should have the same worth, respect, well-being, and opportunity to decide about their lives? (yes/no) Please explain why.
18. If yes, how could this be achieved? Could it be through education, or through changing cultural and traditional practices, through openly discussing the privileges that men have compared with women, etc.? If no, why not?
19. What would a community in which people, including all men and all women, have the same worth, respect, well-being, and opportunity to decide about their lives, look like?

These were all the questions; many thanks for sharing your time and thoughts!

Appendix 2: Interview questions: key informants

Interviewer says: *Before we begin, I would like to explain a bit about the project that we work with.* (Perform consent protocol)

Interviewer says: Now we are ready to begin the interview: (TURN RECORDER ON!)

Interviewer states: (this needs to be recorded!)

1. The date
2. The place
3. Name of person you are interviewing
4. Gender of person you are interviewing
5. Interview number (given before)
6. Your name, name of interviewer

Interviewer says: Many thanks for taking the time to have a discussion. I will ask you questions, and please note that there are no right or wrong answers. I am only interested in hearing your thoughts. Please don't hesitate to ask for clarification if needed.

First, I would like to discuss access to finance, first about credit or micro-finance and then about community-based savings groups. So, let's begin by discussing credit.

1. Can you tell me about the micro-finance practices in Northern Ghana? How do they work? What are their strengths? What are their weaknesses?
2. Who are the main credit givers to community members in Northern Ghana? What type and level of influence do they have on the community – please describe?
3. (If the respondent hasn't talked about the Government) Does the Government also offer micro-credit?
4. Are any schemes especially targeted at the poorest? What issues of justice does that create?
5. How would you like to see the scheme function in the future?
6. What needs to be done to make this happen?
7. Who could be responsible for making this change happen? And what could they do?

Now let's move on to discuss community members' savings groups.

8. Can you tell me a bit about community savings groups here in Northern Ghana? What are their strengths? What are their weaknesses? What aspects work well?

What challenges do they confront when implementing their initiatives?

9. How would you like to see the savings groups function in the future?
10. What needs to be done to make this happen?
11. Who could be responsible for making this change happen? And what could they do?

Now I would like to discuss climate change adaptation planning

20. What types of adaptation measures are farmers traditionally undertaking here in Northern Ghana? I mean adaptation measures that are indigenous, that have already been practised for centuries. Prompt for: drainage or changing the timing of planting and harvesting, etc.
21. Have you engaged in climate change adaptation planning, for example in how to deal with the changing weather in agriculture or the health sector, etc.? Yes/no. If yes, did the discussion mostly revolve around new practices or also around existing indigenous adaptation measures?
22. What benefits and challenges do you see in promoting indigenous adaptation measures in climate change adaptation training?
23. How would you like to see a change in the adaptation planning process look like in the future?
24. What are the necessary steps that need to be taken to establish such a process?

Now let's briefly discuss agricultural extension services

25. Can you tell me a bit about agricultural extension services as a source of information here in Northern Ghana? What are their strengths, what is working well? What are their weaknesses?
26. In our study from last year, several community members – men, not women, reported a bias in participation. Some felt that it was often the same favoured people that were invited to the sessions. Is this something that is common knowledge? What could be done to correct this?
27. Also, in our study from last year, it appeared that women tend to be less involved in agricultural extension sessions. However, most women in the rural setting participate in farm activities. What has been done to address the fact that the number of women involved in agricultural extension sessions is so much lower compared with men?
28. How would an agricultural extension service work ideally if it were to favour all people, including women?

29. What needs to be done to make this happen? Why are the efforts not working so far?
30. Some corrective action is not directly linked to additional funds such as the targeted recruitment of women extension agents, gender training of existing agri-extension officers, the targeted training of women farmers, etc. What is the reason these measures are not being implemented?
31. What could be done to address this?

Now I would like to discuss learning opportunities

32. Can you tell me a bit about what learning opportunities adults have in Northern Ghana? I am referring to vocational training and courses, especially ones free of charge, but also to peer-to-peer learning within the communities, where a more senior community member functions as a mentor to a younger community member. It could also be an NGO-led training, etc.
33. What type of learning opportunities would be especially important for adults with limited education here in Northern Ghana?
34. How could such learning opportunities be organised? Who would oversee what? What would need to be done?
35. Do you know of any organisations that offer an opportunity for farmers to interact with other representatives of the food chain? Or where other members of the food chain, such as retailers, can interact with processors?
36. What are the benefits of such a forum, where various representatives of the food chain would be able to meet and interact?

Finally, I would like to talk about the well-being of people in Northern Ghana

37. Do you believe that all people should have the same worth, respect, well-being, and opportunity to decide about their lives? (yes/no) Please explain why.
38. If yes, how could this be achieved?
39. What would such a community look like in which people have the same worth, respect, well-being, and opportunity to decide about their lives?
40. Is there a true interest among power holders, such as local politicians and village chiefs, to give equal rights and respect to all community members, including women?
41. What could be done to create a more just society and communities for women?

Those were all my questions, many thanks for sharing your time and thoughts!

Appendix 3: A co-creating workshop using participatory visual art

Objectives of the workshop

1. Define problems at hand and work towards a shared understanding of the situation
2. Identify what is working well and how to enhance these elements
3. Create visions of a desired future
4. Set goals
5. Set tangible steps for achieving goals

Overall structure of the event

1. Administration including consent protocol and attendance list
2. Plenary: Goal of the day
3. Break-out groups
4. Plenary: summary of group work, closing

Group work method

Group work broadly based on the World Café method (Carson 2011) including the following steps:

1. Define context and clarify purpose
2. Create a hospitable space
3. Small groups (5 people per group)
4. Explore given questions in the groups through discussion and the participatory visual art exercise (Mitchell et al. 2011)
5. Harvest, group presentation in plenary

Topic cards for facilitators

Access to finance: The facilitator will introduce the credit giving and savings groups and the importance of these for the farmers to be able to improve their livelihoods and their resourcefulness.

1. What are the challenges related to credit?
2. What are the barriers to a well-functioning community savings group?
3. What are the enablers to accessing credit?
4. What are the benefits of savings groups?

5. In an ideal situation, what would a money credit scheme look like? (Move to drawing)
6. What tangible things would need to be done to create such a situation? Who would be responsible for each step?

Information and knowledge: The facilitator will present the importance of information and knowledge for the farmers to be resilient and resourceful.

1. What are the various ways that farmers can get information on when to plant and when to harvest and what to do if the weather is challenging (for example)?
2. What are the barriers in getting the information needed to know when to plant or harvest, etc.?
3. In an ideal situation, how or through which channels would a farmer or a member of a food chain get information on important topics such as weather, farming practices, prices, and market opportunities? What other types of information and knowledge would the farmer need? (Move to drawing)
4. What would need to be done to create such a situation? Please list the steps that would need to be performed and who would be responsible for each step.

Social learning: The facilitator will state that learning can occur in many ways, through school, through learning from a senior person, from groups, from training, from networks, etc.

1. What are the ways in which you can learn?
2. What are the barriers preventing learning opportunities?
3. In an ideal situation, how would you be learning? (Probe: What are the different ways in which we can learn now and in the future? How will our grand and grand-grand children learn? (Move to drawing)
4. What needs to be done to create such a situation? Please list the steps that would need to happen and who would be responsible for each step.

Gender equality: The facilitator will state that in many ways women presumably do not have the same privileges that men do, for example the opportunity to be a member of the community assembly, inheriting land, and having the freedom to make decisions without consulting a male.

Now young girls are starting to attend school almost to the same extent as boys and will be more empowered.

1. What cultural, religious, and traditional privileges do men have that women don't have?

2. What could make women more empowered in the future?
3. Please draw a community or society in which all people, including your girls and female grandchildren are more actively taking part in decision-making in the household and community and beyond. (Move to drawing)
4. What would need to be done to create such a situation?

Climate change adaptation: The facilitator will initiate the discussion related to how the weather is becoming hotter, drier, and more unpredictable.

1. How is the changing weather and climate impacting farming and your livelihoods?
2. In the past, your ancestors had many good ways for adapting to difficult weather and a climate that you are still using today. What are these? Do you remember any other ways that aren't used anymore?
3. Please draw how you in your farming make use of existing ways to cope with difficult weather such as drought, storms, flooding, and changing rain patterns. (Move to drawing)
4. What steps need to be taken to inform farmers of how to use both the old traditional, indigenous farming adaptation techniques and new ones?

Small-group work

- Each small group has three topics to cover
- Each topic should take around 20 min
- Small group facilitators keep track of time
- After each topic we will pause for a couple of minutes so that the facilitators have time to make notes and take photos

Facilitation in small groups

- State clearly when you switch to a new topic
- Present the topic briefly using the guidance on the topic info card
- Then go through the guiding questions
- Ask people to stick to the topic
- Don't spend too much time on the first question and on the barriers
- Keep track of time!
- Cultivate free discussion
- Encourage everyone's contribution
- Connect diverse perspectives
- Listen for patterns

Reporting

- Reporters will take notes during the discussion using the reporting template
- After the group is ready with drawing take two photos of the drawing:
 - (a) One photo with a note of the group number and theme
 - (b) One photo with only the drawing
- Also, we will audio register the explanation of the drawing

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Data availability The data that support the findings of this study are not publicly available due to them containing information that could compromise research participants' privacy/consent.

Declarations

Conflict of interest The authors have no relevant financial or non-financial interests to disclose.

Compliance with ethical standards Our study followed the ethical procedures of the University of Helsinki and Natural Resources Institute Finland (Luke). Informed consent was obtained from all the research participants.

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