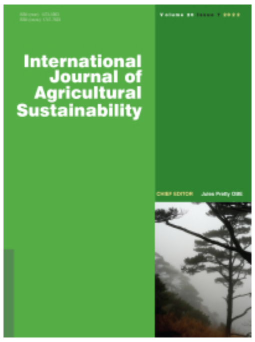

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International Journal of Agricultural Sustainability

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/tags20

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To cite this article: Aboubakar Iyabano, Cees Leeuwis, Rico Lie, Aurélie Toillier & Ann Waters-Bayer (2023) Making decisions about agroecological innovations: perspectives from members of farmers' organizations in Burkina Faso, International Journal of Agricultural Sustainability, 21:1, 2239056, DOI: 10.1080/14735903.2023.2239056

To link to this article: https://doi.org/10.1080/14735903.2023.2239056

Published online: 27 Jul 2023.

INTERNATIONAL JOURNAL OF AGRICULTURAL SUSTAINABILITY
2023, VOL. 21, NO. 1, 2239056
https://doi.org/10.1080/14735903.2023.2239056

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Making decisions about agroecological innovations: perspectives from members of farmers' organizations in Burkina Faso

Aboubakar Iyabano[a,b], Cees Leeuwis[a], Rico Lie[a], Aurélie Toillier[b] and Ann Waters-Bayer[c]

[a]Knowledge, Technology and Innovation Group, Wageningen University, Wageningen, The Netherlands; [b] UMR Innovation Institut Agro Montpellier-CIRAD, Montpellier, France; [c]Prolinnova International Support Team c/o Agrecol Association for AgriCulture & Ecology/Associate Research Fellow, German Institute for Tropical & Subtropical Agriculture (DITSL), Witzenhausen, Germany

ABSTRACT
There is a growing promotion of agroecological techniques in many Sub-Saharan African countries as a response to the current climatic variability challenges. In the case of Burkina Faso, a number of studies have mentioned the role of Farmers' Organizations (FOs) in the promotion of agroecological techniques. Although previous studies have highlighted the role of FOs in agroecology, more detailed studies on the effectiveness of their intermediation activities and especially those focusing on the way the FOs influence farmers' agroecological innovations decisions are still scarce. This study addresses this gap by providing the answer to the question of what drives farmers' decisions to implement agroecological innovations and how their FOs influence these decisions. The results show that the implementation of agroecological innovations varies, with some farmers using many and others few of the innovations promoted by their respective FOs. Farmers' implementation of these innovations is largely influenced by the actions of their FOs on at least one of the three drivers of individual motivation or innovation behavior (Vroom 1964): instrumentality, valence, and expectancy. Finally, the study calls for policy actors to increase funding support to FOs for widening their continuous provision of agroecology development activities.

ARTICLE HISTORY
Received 16 February 2023
Accepted 16 July 2023

KEYWORDS
Sahel; systems perspective; innovation brokers; sustainable agriculture; soil restoration

Introduction

Agroecology is increasingly recognized by many agricultural development actors as a promising solution to the persistent food insecurity and ecosystem degradation issues (Bellwood-Howard & Ripoll, 2020; Bottazzi & Boillat, 2021). Initially considered as a scientific application of ecology in agriculture, agroecology is now also viewed as a movement for food sovereignty, including the right to produce one's own food and maintain autonomy (Altieri & Toledo, 2011; Anderson et al., 2019; Iyabano, 2023) and/or a practice based on farmers' production of their own inputs (Van Hulst et al., 2020; Wezel et al., 2009). Agroecological techniques are usually developed by taking into account farmers' existing knowledge and practices (Altieri, 2002; D'Annolfo et al., 2021; Mier Terán Giménez Cacho et al., 2018) by following one of these three principles (Van Hulst et al., 2020): efficiency (in terms of production of own inputs); substitution (of one input/practice for another like the case of conversion from conventional to organic agriculture), and (iii) redesign of the relations between agriculture and other economies (through the integration of agriculture with other economic activities such as healthcare and the provision of ecological services). Agroecological techniques include crop associations/rotations, crop-livestock integration, biological control of pest and disease, organic fertilization, crop-

CONTACT Aboubakar Iyabano aboubakar.iyabano@wur.nl; iyabano1aboubakar@yahoo.fr Knowledge, Technology and Innovation Group, Wageningen University, P.O. Box 8130, Wageningen 6700 EW, The Netherlands

residue mulching and anti-erosion measures (Altieri & Toledo, 2011; Ameur et al., 2020; Rodenburg et al., 2020; Slingerland & Stork, 2000; Wezel & Silva, 2017).

There is a growing promotion of agroecological techniques in many Sub-Saharan African countries as a response to the current climatic variability challenges (Gliessman, 2021; Haggar et al., 2020; IPES-Food, 2020). As the International Panel of Experts on Sustainable Food Systems (IPES) report argues, agroecological techniques are important in strengthening farmers' resilience to climatic variability as they encourage farmer-to-farmer knowledge sharing in order to produce their own inputs (Gliessman, 2021). There are several agroecological techniques currently promoted in many semiarid and sub-humid West African countries with the aim of helping these farmers to increase their agriculture production in a sustainable way (Debray et al., 2019). In the case of Burkina Faso, a number of studies (cf. Andrieu et al., 2015; Dugué & Girard, 2009; Inter-réseaux, 2015; Iyabano et al., 2023; Toillier et al., 2021; Zorom et al., 2013) have mentioned the role of agroecological techniques in the restoration of degraded land. These techniques are usually promoted by farmers' organizations (FOs) where these serve as connection bridges between farmers and agricultural development institutions (Iyabano et al., 2021; Konate, 2013; Lamy, 2005).

The bridging actions of FOs can be traced back to the last stage of colonial times and were later reinforced (in the 1990s) with the advent of the structural adjustment reforms of the World Bank and the International Monetary Fund (DSDR, 2015; Zett, 2013). Following the implementation of these reforms, most of the Burkinabè FOs started to go beyond serving as connection bridges between farmers and development institutions by becoming more involved in the organization of many agricultural development activities (Konate, 2013; Zett, 2013). FOs' activities include the provision of input credit, technical training, product processing and collective marketing. They are thus playing the functions of innovation intermediaries (see Iyabano et al., 2021; Kilelu et al., 2011; Yang et al., 2014). While previous studies have highlighted the importance of FOs as innovation intermediaries for Burkinabè agricultural development in general (see e.g. Arcand, 2004; Kaminski et al., 2011; Zett, 2013) and the promotion of agroecological innovations[1] in particular (cf. Bancé, 2013; Iyabano, 2021; Métouolé Méda et al., 2018), more detailed studies on the effectiveness of these intermediation activities (at the farmer level) – especially those focusing on the way the FOs influence farmers' decisions – are still scarce.

Understanding farmers' agroecological innovations decisions is particularly relevant for agricultural development actors such as policymakers and NGOs, as it can provide valuable information necessary for supporting the smallholder farmers' transition to agroecology. Furthermore, understanding farmers' decisions about these innovations can also contribute to the ongoing debates related to the influence of the structural elements (i.e. actors, institutions, interactions and infrastructure, cf. Hekkert et al., 2007; Kebebe et al., 2015) of the innovation systems on farmers' innovation behaviour. This is because many studies on farmers' innovation behaviour tend to focus on the individual in isolation (Leeuwis & Aarts, 2020). According to Shang et al. (2021) and Engler et al. (2019), systems perspectives tend to centre on the dynamic of the interactions between institutions and actors in analyzing farmers' decisions about innovations by acknowledging that farmers' behaviour is likely to be influenced by the existing institutional rules and arrangements (Engler et al., 2019; Shang et al., 2021; Winowiecki et al., 2021). Also, institutions favour the creation of resources and incentives that may modify farmers' innovative behaviour in multiple ways (Leeuwis & Aarts, 2020). For example, the availability of innovation infrastructure such as input credit, knowledge and training facilities are positively influencing farmers' innovation decisions (Adolph et al., 2020; Lamboll et al., 2021; Métouolé Méda et al., 2018; Ndah, 2015; Ochieng et al., 2021).

In the context of developing countries, Hrabanski (2010) and Yang et al. (2014) and Iyabano et al. (2021) have noted that these innovation infrastructures are provided mainly by FOs since they are one of the main types of intermediary organizations (see Esman & Uphoff, 1984) actively involved in managing agricultural development activities. Thus, the aim of this study is to analyze the factors that influence farmers' decision-making regarding agroecological innovations in order to unravel the influence of FOs' activities on these decisions. Following this introduction section, the next sections present a conceptual framework for analyzing farmers' decision-making processes about agroecological innovations with a particular focus on FOs and the research methods employed. Then follows the section that presents the results of the study. The last section discusses the key points from the results and concludes by highlighting some implications for theory and policy.

A conceptual framework for analyzing FOs' influence on farmers' implementation of agroecological innovations decisions

Systems perspectives (see Damtew et al., 2018) are recently gaining more consideration in the study of farmers' decisions regarding innovation (Engler et al., 2019; Ndah, 2015). Systems thinking approaches such as the Agricultural Innovation Systems (AIS) (cf. Klerkx et al., 2012; World Bank, 2006) perspective consider farmers' innovation decisions or behaviour change as a collective process involving multiple interrelated actors (Ndah, 2015). Such perspectives imply the identification of various coordination mechanisms and policies/components in the agricultural innovation development processes (ibid). The innovation systems analysis distinguishes both the structure, i.e. four system elements (actors, institutions, interactions and infrastructure), and the functions, i.e. types of activities conducted in supporting the development and implementation of innovation (Schiller et al., 2020a; Hekkert et al., 2007; Kebebe et al., 2015).

The structural elements of the systems include actors (i.e. farmers, FOs, government agencies, knowledge and research institutes, donor organizations, etc.); institutions (see North, 1990), i.e. the rules and arrangements (such as policies, standards and regulations orienting actors' interactions); interactions (for resource leverage and knowledge sharing among actors); and infrastructure (i.e. the availability of assistance such as input credit, subsidies, equipment, knowledge or marketing facilities) (Schiller et al., 2020a; Hekkert et al., 2007; Kebebe et al., 2015). The effective operation of these elements largely determines the dynamics of the development and spread of innovations (Kebebe et al., 2015). Such dynamics are usually examined by mapping the key innovation activities or functions performed by different elements of the system. These functions can cover resource mobilization, knowledge development, knowledge diffusion and market formation (Schiller et al., 2020a; Hekkert et al., 2007).

The combination of functional and structural innovation systems analysis (cf. Kebebe et al., 2015), helps to identify various actors and the existing institutional arrangements that enable the development and implementation of innovations. The prevailing policies (such as those related to credit, subsidies, pricing systems, knowledge and information) and regulations (such as certification standards) have significant effects on farmers' decisions to innovate or not (Ndah, 2015; Leeuwis & Aarts, 2020; Shang et al., 2021). They affect farmers' aspirations or values by altering their assessment of trade-offs between multiple goals (Leeuwis & Aarts, 2020) depending on their interactions with the overall system. FOs can play an important role in several such interactions (Kilelu et al., 2017; Yang et al., 2014). FOs are very active in connecting farmers with diverse innovation system actors so as to better organize the provision of innovation infrastructure (Cerf et al., 2017; Groot Kormelinck et al., 2019; Kivimaa et al., 2019; Mangnus & Schoonhoven-Speijer, 2020). Therefore, the focus in this study is on FOs in order to understand farmers' decisions about agroecological innovations and the way these decisions can be influenced by the actions of their FOs. Farmers' decisions were analyzed specifically on the three main components of Vroom's expectancy equation of motivation (Vroom, 1964). As Herath (2010) has pointed out, motivation is essential for understanding farmers' behaviour with respect to agricultural innovation.

Vroom's equation states that an individual's motivation is a product of his or her instrumentality (i.e. the knowledge of the relationship between work efforts and desired behaviour or outcome), valence (which is the value attached to the outcomes and the extent to which the outcomes are desirable) and expectancy (which is the individual's belief in his or her ability to perform the work successfully) (Chen et al., 2016; Suciu et al., 2013; Vroom, 1964). Vroom's equation of motivation was further operationalized by linking its components to some categories of determinants affecting innovation behaviour identified by Leeuwis and Aarts (2020): individual knowledge, aspiration or values, and ability. Figure 1 presents the framework developed for analyzing the FOs' influence on farmers' decisions about agroecological innovations. This framework will be used to answer the following questions: What role do FOs play within the broader structural elements of the Burkinabè agroecological innovations system? What do farmers' situations for implementing agroecological innovations look like in each FO studied? What drives farmers' decisions about agroecological innovations and how do their FOs influence these decisions?

Methods: data collection and analysis

This study is based on data collected from both primary and secondary sources. Primary data were

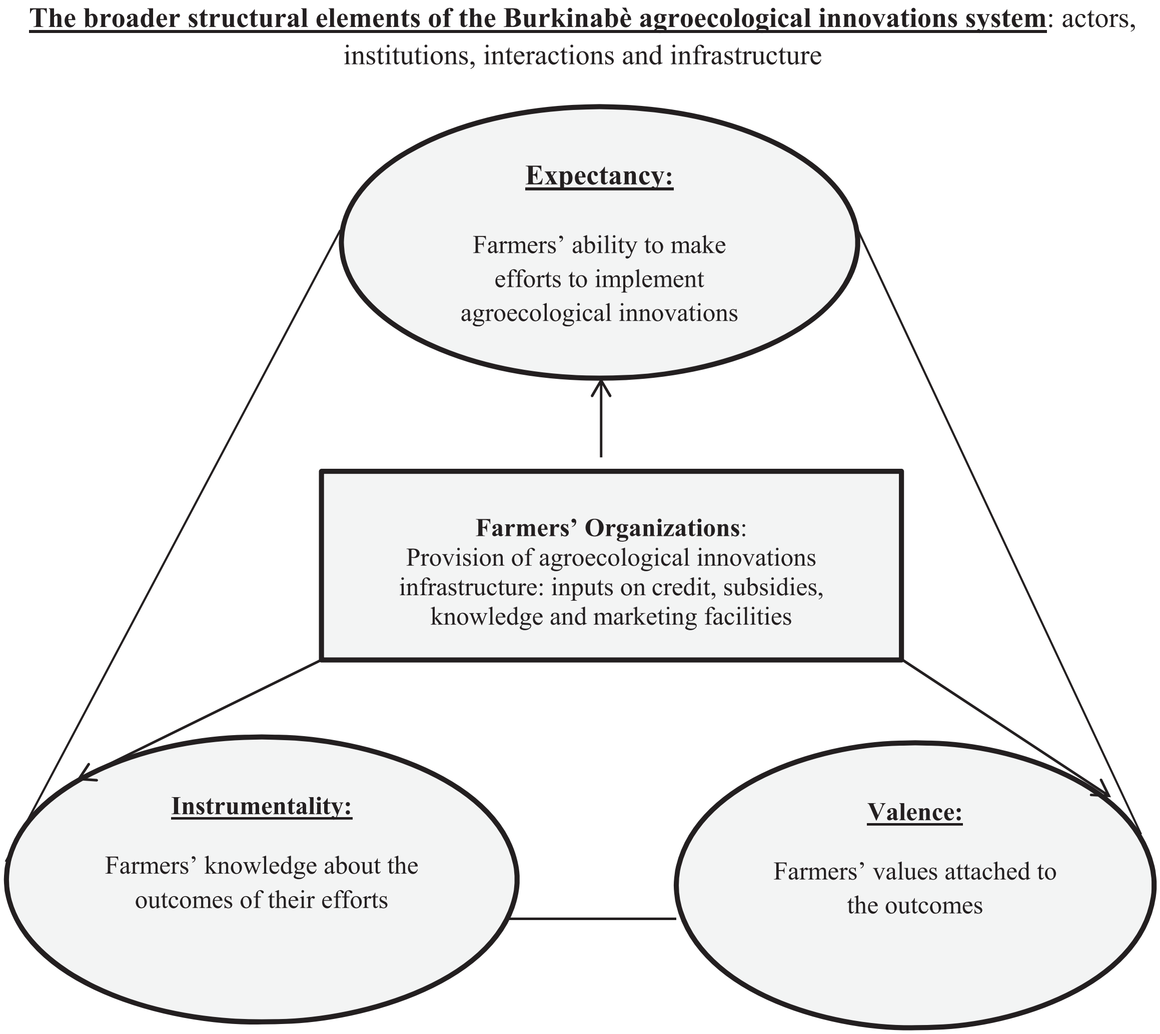

Figure 1. A conceptual framework for analyzing FOs' influence on farmers' decisions about agroecological innovations. Source: Own elaboration based on Vroom (1964); Leeuwis and Aarts (2020); Engler et al. (2019); Shang et al. (2021); Schiller et al. (2020) and Kebebe et al. (2015).

collected directly from farmers through semi-structured interviews conducted by the first author between February and May 2018 with a total of 44 farmers. These farmers were selected from three cases of Burkinabè FOs (see Table 3 in Appendix A for the description of these FOs) actively involved in promoting agroecological innovations with three distinct goals. The goals of the selected FOs were to enhance commercial crop productivity (which was the case of the *Union Nationale des Producteurs du Coton du Burkina Faso*–UNPCB), to improve subsistence farmers' resilience (in the case of the *Association Inter-zones pour le Développement en Milieu Rural*–AIDMR) and to enhance both the commercial crop productivity and subsistence farmers' resilience (in the case of the *Union des Groupements pour la Commercialisation en commun des produits agricoles de la Boucle du Mouhoun*–UGCPA).

Farmers were selected with the assistance of the administrators and advisors in the three FOs. A purposive sampling strategy was used in each FO and the selection criteria included farmers' involvement in the production of organic crops (concerning UNPCB), farmers' involvement in irrigation farming (regarding AIDMR) and farmers' involvement in maize farming (concerning UGCPA). The use of these criteria helped to cover a large diversity of agroecological innovations implementation situations in order to unravel the influence of FOs on their decisions about the innovations. Almost all the interviews were conducted in local languages (*Mooré* or *Dioula* depending on the farmer's location within the agroecological zones of the country) with direct translation into French by the field assistants (FOs' advisors). Information obtained from interviewees included the general description of farmers (according to their gender, farm size, types of inputs used and cropping system); the types of agroecological innovations implemented; and the outcomes and benefits derived from implementing these innovations. The information in the interviews focused on farmers' explanations for the relationship between their decision to implement agroecological innovations and their FO's provision of training, credit, subsidies and marketing facilities.

Besides interviews, document research also helped to gather information for the description of the landscape of the Burkinabè agroecological innovations system. All the collected data were analyzed by using qualitative content analysis and descriptive statistics related to the frequency of the use of agroecological innovations. The qualitative approach was used to obtain meaningful information from the data so as to elucidate the key role of FOs in the Burkinabè agroecological innovations system and the way the FOs influenced the farmers' decision-making about agroecological innovations. The FOs' influence was analyzed by focusing on the FOs' actions on their farmer members' instrumentality, valence, and expectancy (cf. Figure 1 in the conceptual framework section). The analysis mainly concerned 12 cases of farmers out of the 44 farmers sampled. The 12 farmers were selected because they were those showing the highest (i.e. implementing many agroecological innovations promoted by their FO) and the lowest (i.e. implementing a few agroecological innovations promoted by their FOs) agroecological innovations implementation situations (see Section last sub-section of the results). Quotes were also used to show some of the farmers' explanations of their agroecological innovations decisions in this analysis.

Results

In this section, we present the landscape of the Burkinabè agroecological innovations system by emphasizing the central role of FOs in the development and implementation of the innovations. We also examine the farmers' agroecological innovations implementation situations and analyze the influence of FOs on the three drivers (i.e. instrumentality, valence and expectancy) of their innovation decisions.

The central role of FOs within the Burkinabè agroecological innovations system

The study (Table 1) shows the existence of all the agroecological innovations system structural elements (see the conceptual framework section above) that favour or constrain the development and implementation of agroecological innovations in Burkina Faso. These elements include actors, institutions, interactions and infrastructure. Weaknesses in one of these elements will constrain the development of such innovations. The main actors in the Burkinabè agroecological innovations system are farmers, FOs, NGOs, knowledge and research institutes, agro-companies and market actors. NGOs are the dominant type of actors supporting the development of agroecological innovations in Burkina. This started during the two droughts periods (in the 1970s and '80s) that struck the country and later increased during recent decades with the introduction of organic niche markets (Iyabano et al., 2021; Roose et al., 1999). NGOs' activities are organized around the

Table 1. Overview of the structural elements of the Burkinabè agroecological innovations system.

Structural elements	Key features
Actors	The key actors are small-scale farmers (grouped into FOs), FOs and NGOs. NGOs are the main actors in charge of mobilizing resources necessary for farmers' development of agroecological innovations.
Institutions	There are established (in some FOs) credit and subsidy policies, as well as predefined standards for organic products that aim to encourage farmers' agroecological behaviour.
Interactions	These deal with the overall actions of FOs as the intermediary organizations in charge of establishing linkages with several agroecological innovations actors. These linkages help to ensure the flow of innovation-supportive infrastructure from diverse actors (which can be from NGOs to FOs or from FOs to farmers) and the marketing of farmers' products.
Infrastructure	These are investments made by FOs (with the support of NGOs) regarding the organization of provision of knowledge, input credit, subsidies and marketing facilities necessary for stimulating their members' agroecological innovations behaviour.

Source: Adapted from Iyabano et al. (2021).

provision of technical and financial assistance to farmers grouped into various types of FOs. As is elaborated further in the next section, the extent to which farmers in each FO use agroecological innovations varies (see also Table 2).

The majority of these FOs were created to structure the agricultural value chains and/or to promote community development activities. As intermediary organizations (between farmers and other system actors), FOs[2] are very active in stimulating their members' agroecological behaviour.[3] They do so to fulfill their broader goal (i.e. enhancing commercial crop productivity; improving subsistence farmers' resilience; enhancing both commercial crop productivity and subsistence farmers' resilience) by performing many activities such as resource mobilization, knowledge development, knowledge diffusion and market formation. FOs are mobilizing resources mainly by establishing linkages and collaboration with NGOs. Besides collaborating with NGOs, some FOs (namely those promoting commercial crops, such as UNPCB and UGCPA in this study) are also involved in establishing relationships with an agro-company (i.e. the cotton FO) and/or local microfinance organizations for securing additional resources.

FOs support the development of agroecological knowledge by organizing group training to facilitate knowledge exchange (among farmers and/or between farmers and the FOs' advisors) and by setting up some demonstration plots (Iyabano et al., 2021). Frequently, topics discussed during training activities include the requirements of organic agriculture technology and the overall ecologically-based agricultural techniques. These techniques are usually promoted as a set of recommendations developed by the FOs' advisors through the technical assistance of their supporting partners' teams. This can be a joint team composed of advisors from NGOs and a national research institute (concerning the value-chain-based FOs) or a single team of NGOs' advisors (regarding the community-development-based FO, i.e. AIDMR in this research).

In addition to knowledge, some FOs also provide incentives such as subsidies (e.g. compost-making tools, bio-gas equipment, Faidherbia seedlings) and input credit, e.g. in the form of improved seeds or biopesticides (Iyabano et al., 2021). The latter is mostly seen in the value-chain-based FOs (i.e. UNPCB and UGCPA), as they are those concerned with the production and marketing of organic products (e.g. cotton, hibiscus, sesame and soybean). Examples of the types of input credit (provided by one of the FOs involved in promoting agroecological innovations) include the provision of organic cotton seed and commercial biopesticides (commonly known as *Batik*). The FO deducts the cost of the inputs directly from the revenue obtained from selling the organic cotton. The commercial biopesticides are usually promoted to complement those made by farmers (by

Table 2. Farmers' use of agroecological innovations.

FO	Farmer categories	Cropping system	Level of chemical input use	Frequency of implemented agroecological innovations: Soil fertility management	Pest and disease management	Soil and water conservation measures
UNPCB	Category 1 (*n* = 14)	Organic cotton (rotation with soybean and/or sesame)	0	Compost (74%), manure (49%), cotton rotation with soybean (62%), mulching (42%)	Biopesticides (100%), trap crop (100%), improved seeds (100%)	-
AIDMR	Category 2 (*n* = 10)	Mixed sorghum-cowpea and sesame	0	Manure (93%), compost (93%), mixed sorghum with cowpea (93%)	Improved seeds (60%), biopesticides (26%)	*Zaï* (93%), stone-bunds (93%), *demi-lune* (6%)
	Category 3 (*n* = 5)	Mixed sorghum-cowpea; sesame and irrigated vegetables (cucumber, watermelon, carrot, okra, etc)	+			
UGCPA	Category 4 (*n* = 5)	Maize (sole crop) and mixed sorghum-cowpea	++	Manure (86%), compost (20%), mixed sorghum-cowpea (66%), sorghum-cowpea rotation (40%), mulching (13%)	Improved seeds (100%)	Tree preservation: *Faidherbia* and sheanut (93%)
	Category 5 (*n* = 10)	Mixed sorghum-cowpea, organic hibiscus, and cowpea	+			

0 = No use of chemical inputs; + = Average use of chemical inputs; ++ = High use of chemical inputs.
Source: Own analysis based on data obtained from 44 farmers interviewed in 2018.

processing neem seeds) for controlling organic cotton pest and disease attacks. Moreover, the inputs on credit can also come through the financial assistance of their supporting NGO partners (such as the Catholic Relief Services for UNPCB and *Oeuvre leger* for UGCPA) in the form of subsidies.

Description of farmers' situations for implementing agroecological innovations

The results of the study revealed the existence of various situations of farmers in implementing agroecological innovations (cf. Table 2). These situations differ from FO to FO and sometimes between farmers within the same FO depending on the members' cropping system and (to some extent) their use of chemical inputs. Farmers' different situations for implementing ecologically-based techniques can be grouped into five categories.

The first category is composed of men and women farmer members of UNPCB involved in producing organic cotton. These farmers are located in both north and south agroecological zones of Burkina with farm sizes usually varying between 1 and 2ha. These farmers are managing their soil and crop health by applying only agroecological techniques (i.e. compost, manure, biopesticides, etc).

The second category is composed of men farmer members of AIDMR who grow mostly subsistence crops (i.e. sorghum-cowpea and sesame) with farm sizes ranging between 0.5 and 5ha. This category has only men farmers because they are the ones traditionally responsible for producing household cereals; this is the dominant type of farmers (including non-members of the FOs) found in northern Burkina (i.e. the sub-Sahelian and north-Sudanian agroecological zones). The region is characterized by persistent land degradation (due to the extensive droughts) causing many farmers to engage in implementing agroecological techniques such as composting, manuring and making *zaï* pits and stone-bunds.

The third category is composed of men and women farmer members of AIDMR who grow mostly sorghum (primarily the men farmers), cowpea and sesame through implementing many agroecological techniques. Their farm sizes vary between 0.5 and 5ha, like those of Category 2 farmers. Besides growing subsistence crops, some of the Category 3 farmers (especially those located near water sources such as dams) are sometimes involved in commercial production of irrigated vegetables. They grow the vegetables by applying chemical pesticides in combination with manure and/or compost for controlling soil fertility and pest attacks.

The fourth category includes men farmer members of UGCPA who grow cereals (i.e. maize and sorghum), with an average farm size of 5ha. This category is composed mainly of men farmers because they are the ones with the largest farms in the Boucle du Mouhoun region, which is located within the north and south Sudanian agroecological zones. These farmers are involved in producing both subsistence and commercial crops (i.e. cereals and cowpea) by using chemical inputs (fertilizers and pesticides) as well as applying manure and/or compost (mostly for their maize farms).

The fifth category is composed of men and women mixed sorghum-cowpea farmers (members of UGCPA) with an average farm size usually less than 5 ha. Like Category 4 farmers, these farmers also apply both chemical and ecological inputs in their farms. Moreover, some of the Category 5 farmers are sometimes involved in producing organic hibiscus, depending on the market demand. They grow hibiscus on plots far from their conventional plots of cereals and cowpea to reduce possible contamination of the organic hibiscus with residues of the chemical inputs.

Overall, the results in Table 2 show that all the farmers, regardless of their FO and the above-mentioned category they belong to, are involved in implementing some ecologically-based soil management techniques such as manuring and composting. This can be due to the fact that some of these farmers are constantly faced with land-degradation issues as observed with members of AIDMR and, in some cases, UGCPA. The case of UGCPA mostly concerned the farmers located in the north Sudanian agroecological zone, as they are the ones who are always challenged with problems of depleted soil fertility. This explains the combined use of both chemical and organic (i.e. manure/compost) fertilizers observed among the Category 4 farmers. The use of compost/manure by UNPCB farmers (Category 1) is rather connected to their involvement in producing organic products, which do not allow the use of chemical fertilizers.

Instrumentality, valence and expectancy as the main drivers of farmers' agroecological innovations decisions

This sub-section presents farmers' explanations for their decisions to implement agroecological innovations by focusing on the FOs' influence on the three main drivers of their decisions. The explanations are focused mainly on 12 cases of farmers purposively selected from the three FOs. These farmers were selected because they were those identified as showing the highest (i.e. farmers F1, F2, F3, F4, F5, F6, F7 and F8) and lowest (i.e. farmers F9, F10, F11 and F12) degree of implementation of agroecological innovations. The selection of these cases enabled the unraveling of the role of FOs in influencing farmers' decisions about agroecological innovations. All the selected farmers (regardless of their implementation situations) belong to one of the categories mentioned in the second sub-section of the results: the first category concerns farmers F1, F2, F9 and F10; the second category concerns farmers F3, F4, F5, F6 and F7; the third, fourth and fifth category concern farmers F11, F8 and F12, respectively.

- **Farmers' instrumentality for agroecological innovations**

Farmers' instrumentality for agroecological innovations is mainly connected to their knowledge about the outcomes of their efforts related to implementing agroecological techniques. All the farmers interviewed have recognized that their farms' performance largely depends on the application of some agroecological techniques. Examples of these include the application of compost (which concerned farmers in all the three FOs), biopesticides (which was observed with UNPCB's farmers and one farmer in AIDMR) and improved seeds (which is observed with one UGCPA farmer). Concerning compost, most of the identified farmers stressed its efficiency in enhancing crop productivity. Examples are shown in the following quotes: 'if we don't apply compost, we will not have good yield' (farmer F2, member of UNPCB) or 'compost gives well, whereas chemical fertilizers require a lot of water; that is why I use the chemical ones for my irrigated crops' (farmer F6, member of AIDMR).

Similar to farmers F2 and F6, farmer F8 (member of UGCPA) also highlighted the importance of compost for crop productivity and further mentioned its positive effects in reducing Striga infestation of his maize farm. Apart from the farmers' personal experiences on their farms, the farmers have also reinforced their interest in making compost after participating in training sessions organized by their FOs. The compost produced during this training is directly applied in the demonstration plots usually managed by the FOs' advisors. By looking at the demonstration plots, the farmers could compare the quality of their self-made compost with that of the compost produced by their FO and could contact their FO's advisors for further clarifications.

Besides compost, the demonstration plots are also helping the FOs' advisors to show farmers the outcomes of implementing some agroecological techniques such as a sole-crop cowpea variety, *zaï* and stone-bunds and biopesticides as observed in UGCPA, AIDMR and UNPCB respectively. Concerning the cowpea variety promoted by UGCPA, most of the members acknowledge its high production of seeds and leaves (which also serve as animal feed) despite its high susceptibility to pest and disease. Similar to UGCPA farmers, AIDMR and UNPCB farmers also believe in the relationships between the implementation of techniques like *zaï* and stone-bunds (concerning AIDMR) and biopesticides (regarding UNPCB and in some cases AIDMR) and the increased production of their respective farms. The farmers emphasized mainly the effectiveness of these techniques in restoring degraded lands and controlling (organic cotton and vegetable) pest and disease attacks.

- **Farmers' valence for agroecological innovations**

Farmers' valence for agroecological innovations is the value they attached to the outcomes of the implementation of agroecological techniques. We find that different categories of farmers emphasize different values, varying from profit (which was more observed with UNPCB's members, i.e. farmers F1, F2, F9 and F10), restoration (which mainly concerned AIDMR's members, i.e. farmers F3, F4, F5, F6, F7 and F11), autonomy (concerning UNPCB's members) and food security (which was more witnessed with UGCPA's members, i.e. farmers F8 and F12 and AIDMR's members). Farmers derived profits by selling organic cotton and sometimes the rotation crops such as sesame and soybean, depending on the market demand for these products. Farmers' profits are usually higher for organic cotton because of the purchase price differences between organic and conventional cotton. The prices given by UNPCB (in 2018) for a kilogram were 335 Franc CFA (the currency of several francophone African countries) for organic cotton and 224 CFA for conventional cotton. It is important to note that the price of organic cotton largely depends on the types of international buyers (who always propose a higher price than conventional cotton) from the FO after harvesting and primary processing of the organic cotton.

Besides prices, the high profits observed in organic cotton farming also come from farmers' production of their own inputs (i.e. compost and biopesticide from neem) with low demand for input credit (except for organic cotton seeds and sometimes *Batik* in the absence of subsidies from external support) from their FO. An example of input autonomy as an explanation is illustrated in the following quote from farmer F2: 'I gain more with organic cotton … There are no credit-related issues (for getting chemical fertilizers and pesticides in conventional cotton) with organic cotton'. The social value of the outcomes of implementing agroecological innovations is mostly related to the increase in crop production for food security. The majority of farmers (members of AIDMR) with this value are growing crops such as sorghum, millet, sesame and cowpea primarily to satisfy their household needs. They do so by applying many soil and water conservation measures to restore their degraded land. An example of a farmer's explanation for the reduction in land degradation is illustrated in the following quote: 'My objective is to never abandon a land; it is always necessary to work on that land in order to restore it' (farmer F3). Although these farmers focus on subsistence crops, the results show they can sometimes sell (to the local markets or nearest neighbours) some of their crops, especially cowpea and sesame, in the case of urgent need of cash (e.g. for paying hospital bills or for children's school fees). Lastly, the combination of profit and autonomy values of the outcomes of implementing agroecological innovations is principally associated with the dual aim of increasing food production and profits. This was the case of UGCPA's members, who are gaining profits from selling some part of their harvested maize and cowpea. The FO (UGCPA) supports the marketing of farmers' products by negotiating prices with potential buyers (wholesalers). Overall, the results show that, although some farmers give attention to autonomy and sustainability (this example of restoration), most of them are driven by other values such as profit and food security.

- **Farmers' expectancy with respect to agroecological innovations**

Farmers' expectancy is mostly related to the belief in their individual ability to make necessary efforts to implement agroecological techniques. This ability differs according to the existing practical constraints associated with the implementation of different types of agroecological techniques. These constraints include lack of skill, lack of labour (for collecting manure and making compost, collecting neem seeds for the production of own biopesticides), and poor availability of neem-based products and improved cowpea seed in the market. The FOs are reducing some of these constraints by organizing skills training necessary for improving members' ability to implement labour-intense techniques such as composting and *zaï*. The FOs are doing that with the aim of helping farmers to comply with the standards of organic certification (concerning UNPCB) or to strengthen the farmers' integration of ecological principles in their farm management strategies (which was observed with UGCPA and AIDMR). The promoted techniques are based on the improvement of existing farmers' traditional practices such as the production of compost in piles (which is less labour demanding as compared to the techniques of compost pits) and the positioning of *zaï* in an equilateral triangle (which optimizes water retention).

The compost produced by the application of updated techniques therefore helped the farmers to restore their degraded land by applying them in *zaï* pits, which was the case with AIDMR's members. The produced compost also helps organic cotton growers (in UNPCB) and maize growers (in UGCPA) to ameliorate the soil fertility of their farms. Although the FO-promoted techniques are helping farmers to reduce the labour constraints associated with compost production, the results show that some farmers are experiencing other labour constraints that also hamper their time investment in compost production. This was mainly observed with farmer F10 (member of UNPCB) and farmer F11 (member of AIDMR). Farmer F10 believes in her ability only to collect and apply manure (which is also in line with the organic certification standards) in her cotton farm since she already invested her time and labour in walking long distances searching for manure around the village. Farmer F11 mentioned the physical layout of her farm (which is located in a swampy area) as a limiting factor for producing her own compost because of the time investment in soil preparation and irrigation of commercial irrigated okra.

Besides the provision of training in less labour-intensive techniques to manage soil fertility, FOs like UNPCB and AIDMR are also improving their farmers' ability in ecological management of crop health techniques by providing training in biopesticide production. A typical example of a skill acquired by farmers was explained by farmer F4, a member of AIDMR, who mentioned his ability to now apply self-made biopesticides (from a mixture of neem and bark of cailcedrat in his irrigated vegetable farms) following his participation in a training session organized by his FO. Farmers in both UNPCB and AIDMR acknowledged the high demand for labour associated with producing biopesticides since this requires a time investment for collecting and ginning neem seeds. In the case of UNPCB, the labour constraints associated with the production of biopesticides are sometimes reduced by the FO's provision of ready-made commercial biopesticides in subsidies (depending on the availability of funding from external partners). The provision of subsidies was also very helpful in reducing UGCPA farmers' constraints related to access to improved cowpea seeds. This variety is promoted by UGCPA to complement the less productive existing varieties (that farmers usually grow in association with sorghum) through the technical and financial assistance of *Oeuvre leger* (an NGO).

Analysis and discussion

It becomes clear from the above results that farmers' agroecological innovations decisions are a result of the combination of their instrumentality, valence and expectancy. A farmer can decide to implement agroecological innovations if he/she sees a clear link between his/her farm performance and the application of these techniques; and the extent to which this performance is desirable for him/her; and whether he/she is convinced about his/her ability to make efforts to apply agroecological techniques. As the results show, farmers' decision-making is widely influenced by the actions of their FOs on at least two of the three above-mentioned drivers (see Figure 2). The action of FOs on farmers' instrumentality is related to the setting up of demonstration plots (at selected members' farms) to enable their farmers to see the relationship between the application of agroecological techniques such as compost, biopesticides and improved cowpea seeds discussed (by the advisors) during training sessions and the actual farms' performance (i.e. the demonstration plots).

The action of FOs on farmers' valence is mainly linked to their contribution to the increase in farmers' profits (for UNPCB and UGCPA) and autonomy (concerning UNPCB). Both UNPCB and UGCPA are involved in the collective marketing of their members' products. They do so by always seeking buyers who can offer higher prices for their members' organic products, i.e. cotton, sesame or soybean in the case of UNPCB and hibiscus in the case of UGCPA.

The action of FOs on farmers' expectancy is seen mainly in their constant improvement of farmers' skills to apply efficient agroecological techniques such as the less labour-intensive composting techniques and techniques that optimize water harvesting such as the equilateral triangle for *zaï* positioning. Besides improving skills, the FOs are also providing (depending on the availability of financial partners' assistance) some inputs on credit and/or subsidized such as commercial biopesticides (*Batik*) or cowpea seed to strengthen the farmers' ability to apply agroecological techniques.

The results show the existence of a spectrum of farmers' implementation of agroecological innovations ranging from high to low use. And also some farmers are pragmatic as they use agroecological innovations when it suits them, but they also use conventional practices (using chemical inputs) if that is to their advantage. This is because these farmers are implementing some of the agroecological innovations (promoted by their FO) for their demonstrated effectiveness in increasing agriculture production and (in some cases) efficiency in terms of profits. The results support the idea that the FOs as the main intermediary organizations (Iyabano et al., 2021) play a central role in the promotion and implementation of agroecological innovations since farmers' agroecological innovations decisions are largely shaped by the actions of their FOs on at least one of the three drivers (i.e. instrumentality, valence, and expectancy) of their decisions. FOs are thus acting on these drivers by establishing policies that favour the organization of agroecological training activities, the promotion of higher prices for organic products, and access to incentives such as subsidies and credit.

On the one hand, the FOs are establishing these policies as part of their strategy to encourage their members' engagement towards agroecology (this concerns all three FOs regardless of the type of crops they are promoting). On the other hand, the FOs (namely those partially or fully involved in the promotion of organic crops) are establishing the above-mentioned policies to help their organic farmers comply with the global standards of organic

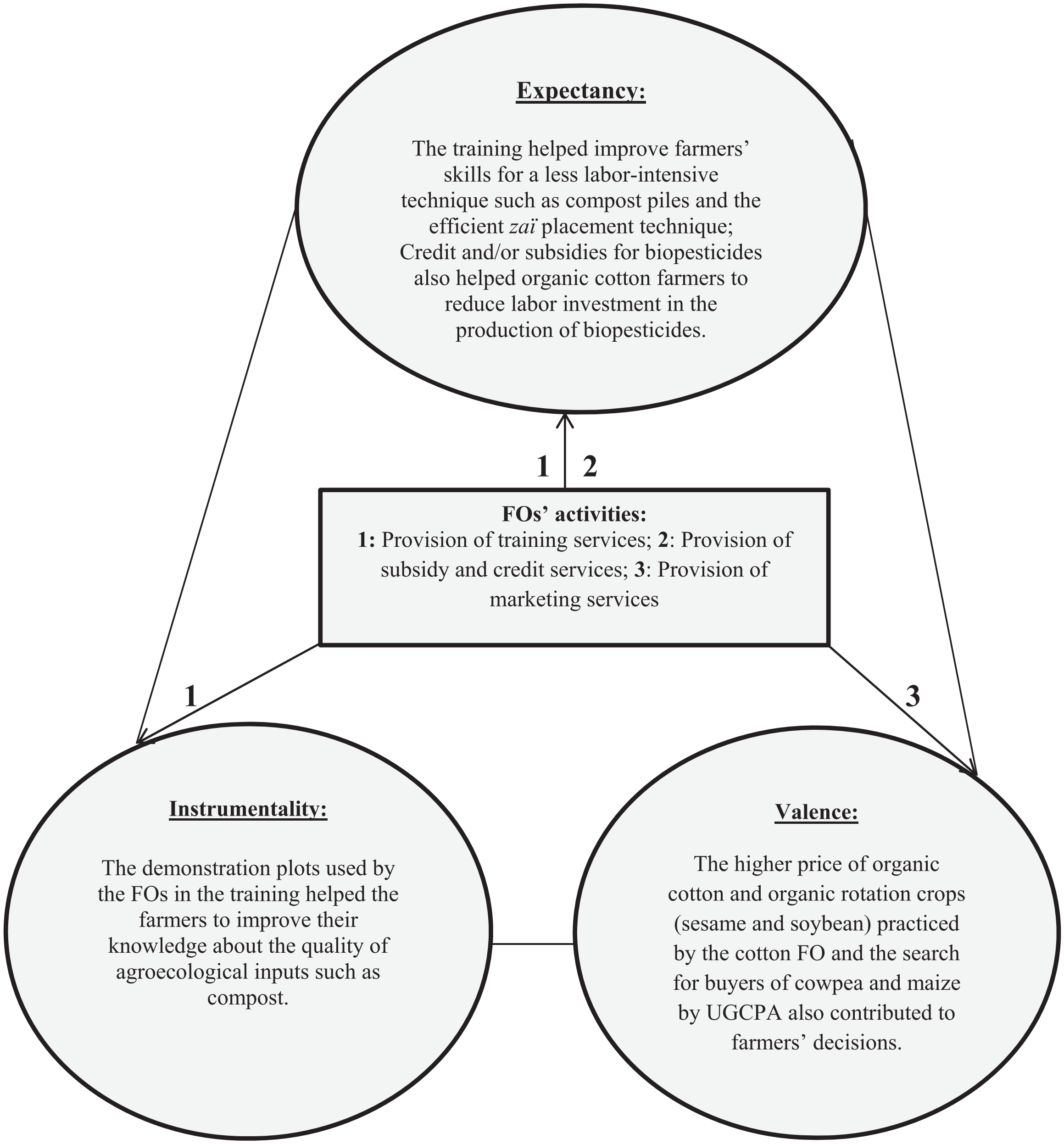

Figure 2. The influence of FOs' activities on the main drivers of farmers' agroecological innovations decisions. Source: Own analysis.

certification. Among these policies, the availability of incentives appears to be among the main influencers of farmers' decisions in favour of agroecological innovations. This can be due to the fact that some FOs are offering higher prices for organic products and this encouraged many conventional farmers to take such opportunities by shifting from conventional to organic cotton farming (which relies on the full application of ecologically-based techniques).

These results confirm what Ndah (2015) has argued regarding the influence of incentives on farmers' innovation decisions. This also resonates with the argumentation of Engler et al. (2019) on the relationship between individual farmers' innovation decisions and the existing institutional arrangements, and observations elsewhere that institutional settings broadly influence farmers to produce in a specific manner (Leeuwis & Aarts, 2020). The results also show that all the actions of FOs were not isolated from their external environment, as these depend on their interactions with the wider agroecological innovations system actors. Prominent among these actors are NGOs and international buyers of organic products. Changes in these interactions would likely affect farmers' decisions to implement agroecological innovations. For example, any decrease in the demand for organic products (in the international market) can reduce the purchase price of these products. This will alter price incentive practices by FOs and thus influence farmers' interest to grow organic crops, thereby affecting their decisions to implement many agroecological innovations.

Similarly, a longtime absence of NGO support can also affect the FOs' provision of some training facilities like the creation of social learning space for knowledge sharing (see Lamboll et al., 2021) and the provision of subsidies to their farmers. This may have an effect on farmers' implementation of some agroecological innovations since the actions of FOs play an important role in reinforcing their decisions in favour of these innovations. This shows the existence of interdependencies (Leeuwis & Aarts, 2020) between individual farmers' agroecological innovations decisions and the wider institutional environment of the agroecological innovations system. These results are in line with other systems thinking conclusions (cf. Kebebe et al., 2015; Schiller et al., 2020a; Adolph et al., 2020) regarding the importance of the functions of all the system's structural elements (i.e. actors, institutions, interactions and infrastructure) in the development and implementation of innovations.

However, contrary to the results of Kebebe et al. (2015) showing the poor interaction among dairy innovation actors in Ethiopia, this study rather demonstrates that the development of agroecological innovations in Burkina Faso is facilitated by the construction of multiple linkages among system actors through the intermediation of FOs (see also Iyabano et al., 2021). As innovation intermediaries, FOs are involved in what Anderson et al. (2019) called 'transformative agroecology learning' by promoting a set of locally adapted innovations that support the agroecology paradigm and thus contributing to the transformation of the Burkinabè food system. Such learned-oriented activities enabled FOs' members to engage in diverse forms of agroecology (Iyabano, 2023) by taking control of the production of their own inputs, which is an essential objective in the social movement (cf. Wezel et al., 2009) dimension of agroecology. Finally, while efforts were made to capture the diversity of farmers' situations for implementing agroecological innovations and the broader influence of the institutional environment on farmers' decisions, this study has some limitations related to the methodology employed. The limitations mainly concerned the small number of farmers sampled on account of the time limitations for fieldwork.

Conclusion

In conclusion, this study has examined the way FOs influence farmers' decisions to implement agroecological innovations. This was done mainly by demonstrating the actions of FOs on the main driving forces of farmers' decision-making: expectancy, instrumentality and valence. These actions were materialized by setting-up demonstration plots for reinforcing farmers' knowledge about the outcomes of the application of agroecological innovations, contributing to the increase of farmers' profits by negotiating a favourable price for organic products, and improving farmers' skills in the available efficient agroecological techniques. While farmers are the final decision-makers, this study shows that their decisions are largely shaped by the availability of incentives and less by their convictions with regard to agroecology. These incentives usually come from their interactions with the agroecological innovations system actors through the intermediation of their FOs. The study has contributed to an improved conceptual understanding of farmers' innovation decisions as a dynamic process resulting from the interactions of the individual farmers with their broader institutional setting. It is therefore important to look beyond the individual argumentative (cf. Leeuwis & Aarts, 2020) in order to better understand farmers' reasons for implementing agroecological innovations. These results call for reflection on policies meant to encourage smallholder farmers to transition towards agroecology. This could be by calling for increased funding support to actors such as FOs to widen their provision of agroecological innovations development activities in order to stimulate more farmers' implementation of these innovations.

Notes

1. In this study, agroecological innovations are considered to be all types of agricultural techniques developed by

integrating ecological principles, referred to here as agroecological techniques or ecologically-based techniques.

2. See Iyabano (2021) for more insights into the diversity of FOs involved in promoting agroecological innovations in Burkina Faso. See also Iyabano et al. (2021) for detailed explanations of some selected FOs' development of agroecological innovations.
3. It is important to note that – except for AIDMR, which promoted only ecological agriculture – UNPCB and UGCPA are involved in promoting both conventional and ecological agriculture.

Acknowledgements

We are grateful to Guy Faure and Laurens Klerkx for feedback and comments on earlier versions of the paper. All the participants to the study were informed about the purpose of the study and gave informed oral consent to participate in the study. All the interviewees participated on a voluntary basis and discussion was held (at the end the interviews) to share our understanding on what will be reported in the study.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Funding

This research was funded by the Education, Audiovisual and Culture Executive Agency of the European Commission under the Joint Doctorate Program Grant AGTRAIN agreement. The views expressed are those of the authors only and do not represent the formal position of the European Commission.

Data availability

The data collected and analyzed for this study can be shared upon request.

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Appendix A

Table 3. Description of FOs' case studies.[a]

FO	Date of establishment, objectives and number of members	Types of agroecological innovations promoted
UNPCB *Union Nationale des Producteurs du Cotton du Burkina*	Established in 1998 to ensure the organization of the cotton value chain through the provision of agriculture innovation infrastructure such as input credit, marketing facilities and technical training. The FO promotes both conventional and organic cotton with about 325,000 members grouped into many local farmers' groups.	Soil fertility management: Compost, mulching, manure, rotations and associations of cotton with nitrogen-fixing crop (i.e. soybean) Pest and disease management: Biopesticides and trap-crop (such as okra to attract cotton pests)
AIDMR: *Association Inter-zones pour le Développement en Milieu Rural*	Established in 1993 to support the development of subsistence crops such as sorghum, millet and cowpea of village members of the centre and northern regions of the country. The FO is composed of about 700 farmers grouped into village associations.	Soil fertility management: Compost, mulching, manure, mixed sorghum-cowpea (a nitrogen-fixing crop), and rotation sorghum-cowpea Pest and disease management: Biopesticides and improved seeds Soil and water conservation measures: *Zaï* (which is a technique that consists of digging planting pits to optimize the utilization of water and compost/manure), stone-bunds and *demi-lune* (half-moon basins) and agroforestry
UGCPA: *Union des Groupements pour la commercialisation en commun des produits agricoles de la Boucle du Mouhoun*	Established in 1993 to organize collective marketing of surpluses of sorghum and millet, maize and cowpea in the Boucle du Mouhoun region. The FO is composed of 2700 members (grouped into various village groups) and later started the promotion of organic hibiscus.	Soil fertility management: Compost, mulching, manure, mixed sorghum-cowpea (a nitrogen-fixing crop), rotation sorghum-cowpea and improved cowpea seeds Pest and disease management: Improved sorghum seeds Soil and water conservation measures:*Zaï*, stone-bunds, *demi-lune* and agroforestry

Source: Own elaboration based on Iyabano (2021) and Iyabano et al. (2021).
[a]See Iyabano et al. (2021) for a detailed description of the structure and operation of the three FOs' case studies.