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The agroecological transition of agricultural systems in the Global South

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Chapter 1

Co-design of innovative mixed crop-livestock farming systems in the cotton zone of Burkina Faso

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Producers in western Burkina Faso have to contend with high rainfall variability and very volatile agricultural prices (Cooper *et al.*, 2008). Such uncertainties have led the vast majority of them to diversify their production and practise mixed crop-livestock farming using low levels of inputs in order to ensure their food self-sufficiency while containing economic risks. Their mixed crop-livestock farming systems are based on cotton, cereals (maize, sorghum), legumes (groundnuts, cowpeas), and the rearing of cattle and small ruminants (Vall *et al.*, 2006).

Producers have, for a long time, favoured a strategy of extension of cropping areas and increase in herd sizes, as long as space is available to them to do so, both for extending cropping areas and for new pastures (Milleville and Serpantié, 1994). However, as population and, consequently, the pressure on the land increased, producers opted to implement strategies to intensify agricultural production (Ouédraogo *et al.*, 2016; Jahel *et al.*, 2017). Intensification of production is meant to enable them to maintain, or even increase, production levels to meet the growing local demand for agricultural products (Bricas *et al.*, 2016). Agricultural policies and development entities have thrown their weight behind this intensification to achieve food security and increase exports[1]. This has resulted in the decrease in fallows, the transition to continuous cultivation, overgrazing, and an increased use of synthetic inputs (Vall *et al.*, 2017). Producers have also intensified production by strengthening the association between agriculture and livestock husbandry in order to be more self-sufficient in agriculture energy, animal feed and organic manure. However, the sustained increase in agricultural and pastoral pressure on natural resources has resulted in their degradation

1. https://www.agriculture.bf (retrieved 23 March 2019).

and fragilization, leading to a decline in soil fertility (Bationo *et al.*, 2007), an impoverishment of pastures (Vall and Diallo, 2009), and a critical decline in the potential for production and regeneration of agroecosystems.

In such a context, an agroecological transition must be encouraged to diversify and increase agricultural production in a sustainable manner, while safeguarding agroecosystems. This kind of transition, however, requires profound changes in farming practices (Duru *et al.*, 2014; Tittonell, 2014) and, consequently, calls for efforts to co-design innovative farming systems with the involvement of producers to try out, assess and adapt new practices, and to provide support to producers in these changes (CIRAD, 2016). It is in this perspective that, since 2005, co-designing of innovative mixed crop-livestock farming systems was taken up in western Burkina Faso in order to analyse the interactions between vegetation, livestock herds and cropping at different scales (farm, territory), and to look for ways to optimize these interactions in order to achieve a sustainable intensification (Vall *et al.*, 2016a).

After recalling the principles of the co-design of innovative farming systems, we will present a summary of the developments observed in the mixed crop-livestock farming systems. We will then highlight examples of the design of agroecological, technical and organizational innovations, carried out at the scales of territories, farms and production systems. We will conclude by reviewing the lessons learnt from the successes and failures of such efforts.

Mechanisms for the co-design of innovative multi crop-livestock systems

Undertaken as a result of a combination of a desire for change by actors in the field and the willingness of researchers to support these actors in this effort, the co-design of innovative mixed crop-livestock farming systems aims to produce useful knowledge and to transfer knowledge and know-how required by the actors to successfully carry out their plans for change (Vall *et al.*, 2016a).

In theory, co-design relies on a multi-actor framework that includes voluntary members and partners, all adhering to an ethical framework that they have themselves created in order to protect the values and objectives negotiated at the outset. In practice, we first relied on village consultation committees (Koutou *et al.*, 2011) involving diverse producers, agricultural technicians and advisers, and researchers. Having recognized the limitations of a partnership formed by locally close entities in addressing issues raised by innovation that also depend on value-chain actors located upstream or downstream of the farms and also on actors involved in territorial governance, we established innovation platforms (Dabiré *et al.*, 2016) to broaden the partnership to include the actors of the agri-chains and local authorities.

At a functional level, co-design is also based on a progressive and iterative process involving phases of exploration, implementation of change, and assessment.

In the exploration phase, we attempt to understand the concerns and expectations of actors in the field, through farm- and territory-level diagnoses to analyse producer practices (causes, methods, performances), in order to identify ongoing changes, constraints, and the categories of local actors involved. We also explore the means employed by actors to solve problems (local knowledge and practices), and we make an inventory of the scientific knowledge available to address these problems. Computer models can be used to explore a wide range of possible future scenarios that incorporate profound changes, and to carry out *ex-ante* assessments of their effects on mixed crop-livestock farming systems through simulation, or in other words, to systematically study the feasibility of the desired options (Andrieu *et al.*, 2012). Restitution workshops help define a common representation of the initial situation and the problems to be addressed and, subsequently, to establish links between the problems and their possible causes, and finally, to propose research hypotheses and an initial list of possible solutions.

In the implementation phase of the change, we choose, from among possible innovations, those that correspond to the desired changes, and which are thus compatible with the available means. This exercise promotes reflections on the feasibility of all the innovations. Experimental protocols are then developed to compare the selected options by specifying the reciprocal commitments of the actors on the operations to be conducted. Finally, these options are tested by the producers based on their own management, and their performance is measured against the criteria defined in concert with the actors. In this step-by-step co-design approach, the producer gradually develops a new system, at the same time as he learns to use it, satisfies himself regarding its utility and benefits, and reorganizes his work and his means of production (Meynard *et al.*, 2012).

We use the assessment and appraisal phase to choose options that maximize the desired impacts while minimizing negative externalities. The *ex-post* assessment consists of verifying whether the objectives initially set were achieved or not in terms of outputs (creation of new products, new technologies, new organizations), outcomes (change in practices or modes of organization) that show actors have acquired know-how and skills and built up their capacity to innovate (changes of technical or organizational practices, etc.), and, if possible, in terms of the first impacts. A beginning of the adoption of the innovating principles legitimizes the initial hypotheses and marks the success of the effort. At this point, the actors can decide to disengage from the co-designing process. However, sometimes, when certain constraints and resources were omitted during the diagnosis, adoption does not take place. In such a situation, the process of defining the problem in the exploration phase must be reinitiated.

Changes observed in mixed crop-livestock farming systems

We analysed the changes in mixed crop-livestock farming systems based on diagnoses made in the exploration phases of the co-design work. We present below a summary of the developments observed.

On the whole, mixed crop-livestock farming systems in western Burkina Faso are still at an early stage of the agroecological transition, if we base ourselves on Tittonell's

(2014) framework for analysing this transition. They are characterized by the continued use of synthetic inputs at a moderate level, combined with the introduction of agroecological practices in a rationale of eco-efficiency or of a partial substitution of synthetic inputs by ecological processes.

Diversity and trajectories of change

The first studies showed that mixed crop-livestock farming systems are not homogeneous (Vall *et al.*, 2006). It was therefore clear that any reflection on technical changes in these systems would have to take into account this diversity to respond to the constraints of producers and the opportunities available to them. Three classes of mixed crop-livestock farming systems were identified (Table 1.1): farmers with cultivation-dominated systems, the predominant group (~ 60%) with variable farm sizes (C1, C2, C3); livestock breeders, a minority (~ 20%), with a system dominated by cattle husbandry with variable herd sizes (B1, B2) with also a cultivation of a food crop; and agro-pastoralists (AP), also in a minority (~ 20%), who cultivate large areas and own large herds.

Table 1.1. Classification of mixed crop-livestock farming systems (based on a sample of 350 farms in western Burkina Faso surveyed in 2008).

<table>
<tr><th>Groups</th><th>Classes</th><th>Cattle population (heads)</th><th>Cultivated area (ha)</th><th>Percentage (%)</th></tr>
<tr><td rowspan="3">Cultivators</td><td>C1</td><td rowspan="3">< 10</td><td>< 5</td><td>18</td></tr>
<tr><td>C2</td><td>5.1-10</td><td>26</td></tr>
<tr><td>C3</td><td>> 10.1</td><td>16</td></tr>
<tr><td>Agro-pastoralists</td><td>AP</td><td>> 10</td><td>> 7.5</td><td>20</td></tr>
<tr><td rowspan="2">Breeders</td><td>B1</td><td>10-29</td><td rowspan="2">< 7.5</td><td>5</td></tr>
<tr><td>B2</td><td>> 30</td><td>15</td></tr>
</table>

We then characterized the trajectories of these different classes of mixed crop-livestock farming systems to better understand the changes taking place, and thus determine if they exhibited any aspect of an agroecological transition. This work was carried out on a sample of about 40 farms belonging to these three classes. Data was collected by retrospective surveys for three periods: the establishment of the farm, the current state of the farm, and the medium-term future envisaged by the head of the farm. The analysis was based on structural variables and relied on multivariate analysis (see Vall *et al.*, 2017, for details of the method). Figure 1.1 shows the simplified evolutionary trajectories of the different categories of mixed cropping systems.

Figure 1.1 shows that, since the establishment of their farms, all producers sought to increase cultivation acreages, herd sizes and the amount of equipment they own. It also shows that the producers intend to pursue these objectives in the future, in spite of an ever-constraining land context. As far as cultivators are concerned, it is mainly the extension of cropping acreages that dominates. In the case of

C1-2 farmers, the change is modest, even problematic in some cases, with a reduction in the meagre livestock herd. C3 farmers seem to be aiming for the current situation of agro-pastoralists. In the case of livestock breeders, the increase in livestock clearly dominates the trajectory of evolution. As for agro-pastoralists, it is clearly the extension of cropping acreages that has been the dominant driver from the time of establishment of their farms to the present, followed by the desire to increase their herd sizes in the future thanks to the capitalization of agricultural surpluses into cattle.

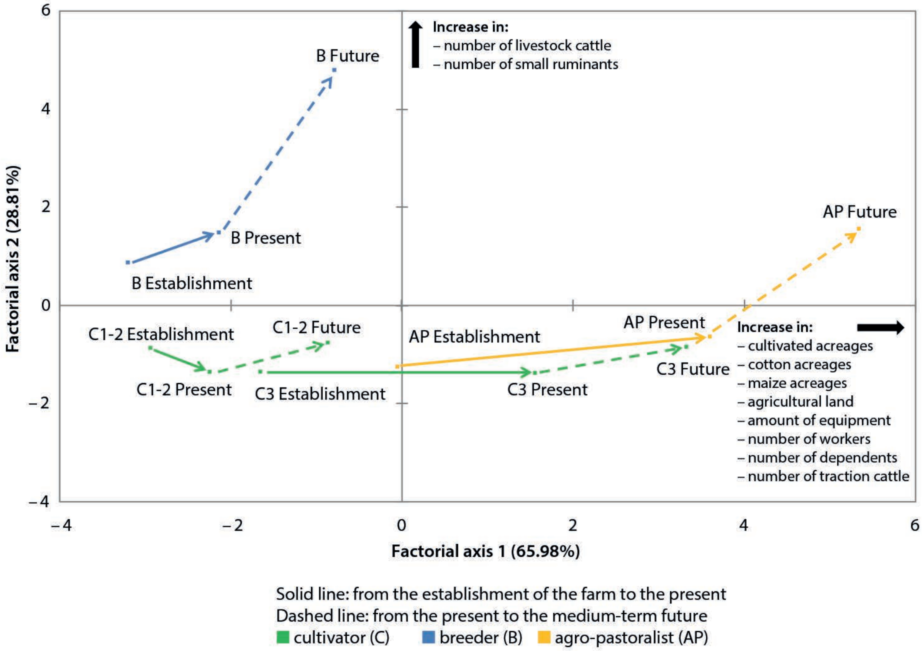

Figure 1.1 Simplified trajectories of evolution of mixed crop-livestock farming systems.
The sub-classes of C1 and C2 farmers have been merged, as have been those of the B1 and B2 livestock breeders. See Table 1.1 for more details on the characteristics of the sub-classes of mixed crop-livestock farming systems.

Evolution of agricultural practices

As far as agricultural practices are concerned, our work has shown the following developments: a trend towards crop diversification, an increased use of synthetic inputs (fertilizers, pesticides), and, at the same time, a strengthening of the association of cultivation and livestock breeding.

Producers diversify the crops they cultivate in rotations (Figure 1.2a and 1.2b) to widen their sources of income and to respond to the emergence of new markets (rice, sesame, soya, sunflower, etc.). The observed diversification does not yet reflect any agroecological practice, especially since this diversification involves pure crops and on very small crop rotation plots amidst acreages still largely dominated by cotton and maize.

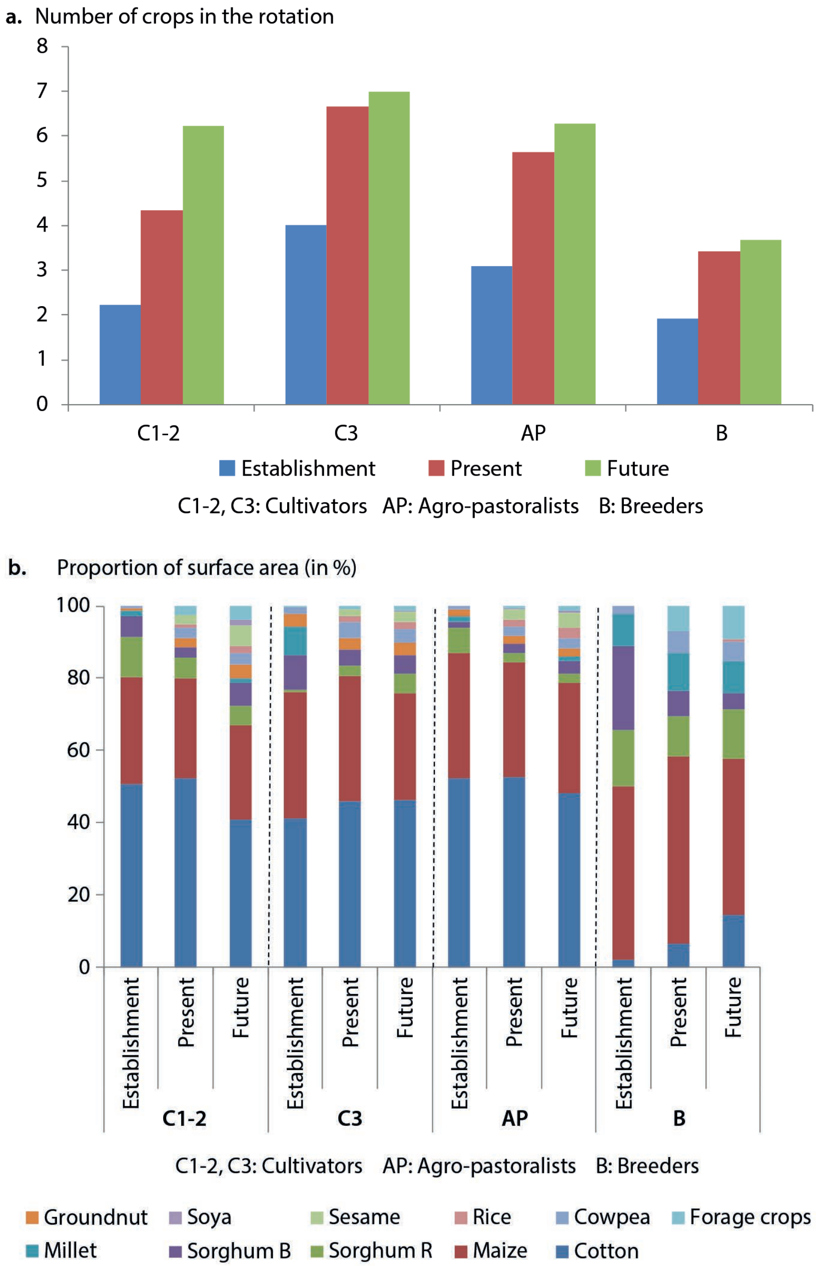

Figure 1.2. Changes in the number of crops (a), changes in crop rotations (b) according to the classes of mixed crop-livestock farming systems.

Producers rely more heavily on synthetic inputs such as mineral fertilizers (NPK and urea), herbicides and insecticides. For mineral fertilizers, this change was observed for all categories of farms. Producers who used mineral fertilizers only marginally until the 1990s increased their use substantially, initially for cotton, then for maize. They have also increased the doses, although they remain moderate compared to those in very intensive agriculture systems in developed countries. This trend towards increased dosages is clear for maize (Figure 1.3a) but has, on the other hand, decreased for cotton (Figure 1.3b); since intensive cotton has been cultivated widely for a longer period that maize, the doses were increased a long time ago. It was also observed that producers practise split applications of mineral fertilizers, something that did not occur previously. Producers started to use herbicides in the 2000s, which, today, represents a widespread practice.

Producers have increased the interaction between agriculture and livestock, and this trend is seen in all farm categories. They began adopting animal traction to extend cultivated acreages, especially since the mid-1980s for most of them. Today, some well-to-do producers, especially agro-pastoralists, have even adopted tractors. Producers have also significantly increased their production of organic manure and use it extensively on maize and cotton (Figure 1.4a and 1.4b), a practice they justify by the decline in soil fertility and the increase in the price of fertilizers.

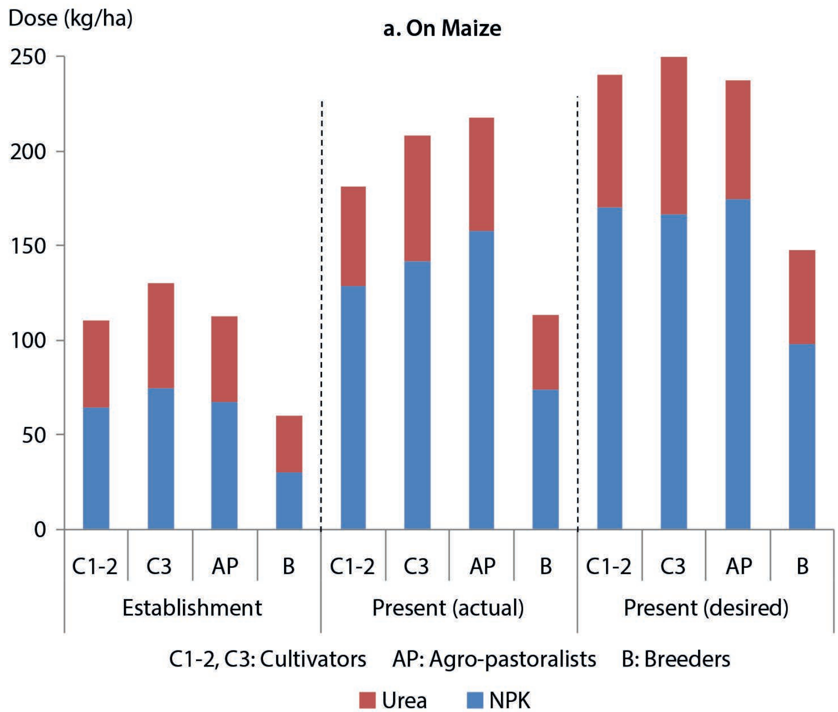

Figure 1.3a. Changes in mineral fertilizer doses on maize, between the time the crop was first grown and the present, and comparison made/desired for the current practice, according to the classes of mixed crop-livestock farming systems (see Table 1.1).

Producers have also begun to store crop residues increasingly systematically for animal feed purposes (Figure 1.5a). We have also observed the beginning of development of forage crops by a small number of livestock breeders and agro-pastoralists, who intend to increase the acreages for these crops in the future (Figure 1.5b).

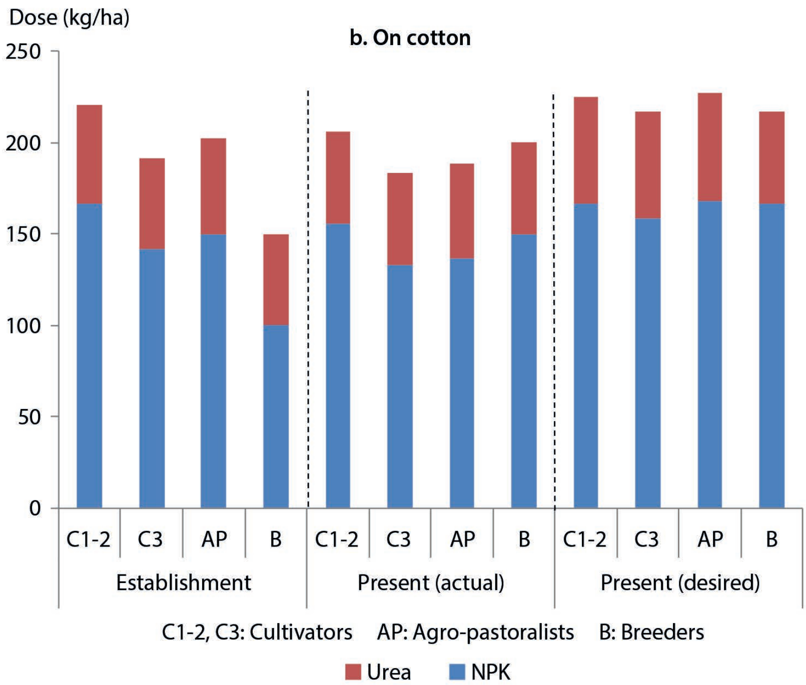

Figure 1.3b. Changes in mineral fertilizer doses on cotton, between the time the crop was first grown and the present, and comparison made/desired for the current practice, according to the classes of mixed crop-livestock farming systems (see table 1.1).

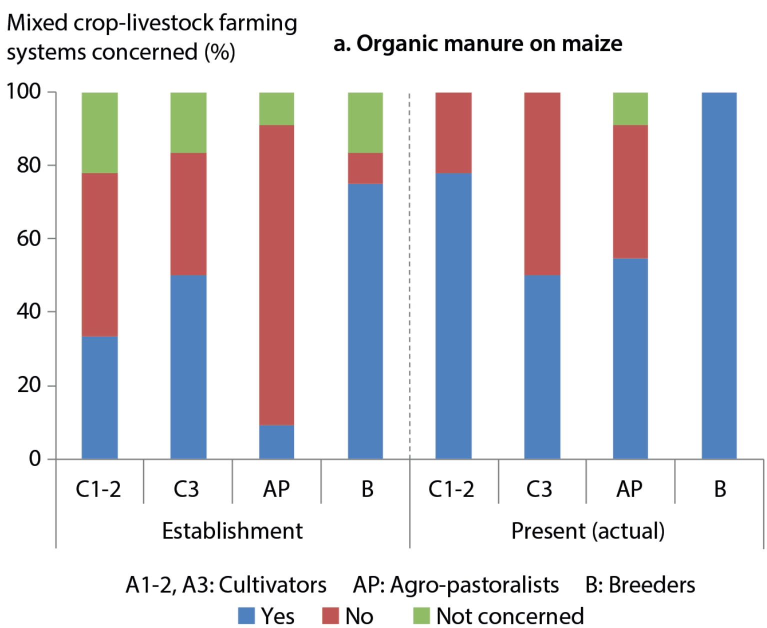

Figure 1.4a. Changes in the application of organic manure on maize, according to the classes of mixed crop-livestock farming systems (see Table 1.1).

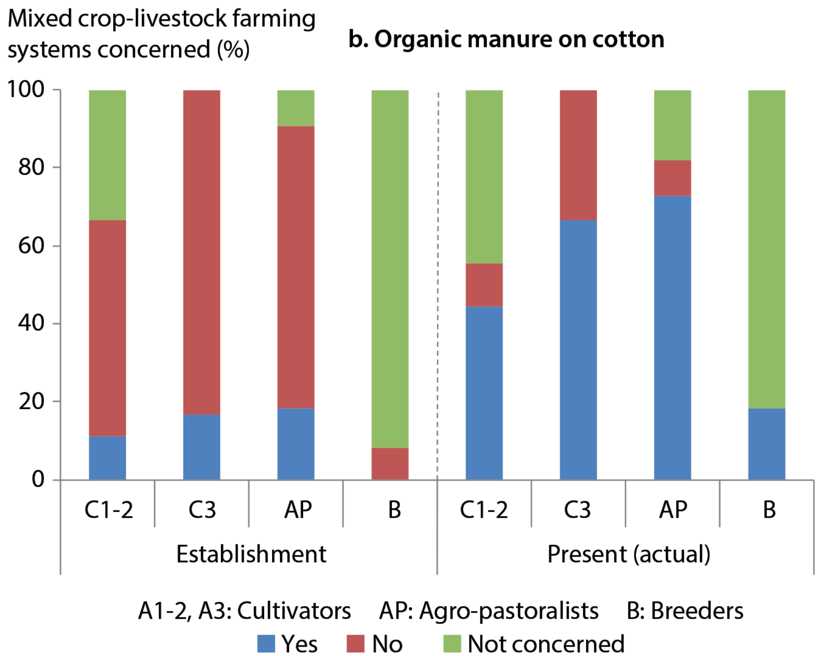

Figure 1.4b. Changes in the application of organic manure on cotton, according to the classes of mixed crop-livestock farming systems (see Table 1.1).

As concerns trees present on cultivated plots (Table 1.2), we did not find any obvious relationship between the classes of mixed crop-livestock farming systems and the types and density of trees. We did observe, however, that breeders tend to maintain a greater diversity of species.

Table 1.2. Density and types of trees in cultivated plots as measured in number of trees per hectare, according to the classes of mixed crop-livestock farming systems (sources: personal data, observations made on 40 farms).

Classes	All species	Shea (*Vitellaria paradoxa*)	Nere (*Parkia biglobosa*)	Balazan (*Faidherbia albida*)	Other species
C1-2	14 ± 5	9 ± 3	1 ± 2	1 ± 1	2 ± 2
C3	13 ± 5	8 ± 5	1 ± 1	2 ± 3	1 ± 0
AP	11 ± 4	8 ± 3	1 ± 1	1 ± 2	1 ± 1
B	14 ± 8	7 ± 9	1 ± 1	0 ± 1	6 ± 4
Avg.	13 ± 5	8 ± 6	1 ± 1	1 ± 2	3 ± 3

A still limited participation by mixed crop-livestock farming systems in the agroecological transition

In the mixed crop-livestock farming systems of western Burkina Faso, producers combine a strategy of extension of cultivated acreages and increase in the size of livestock herds with a strategy of conventional intensification (greater recourse to

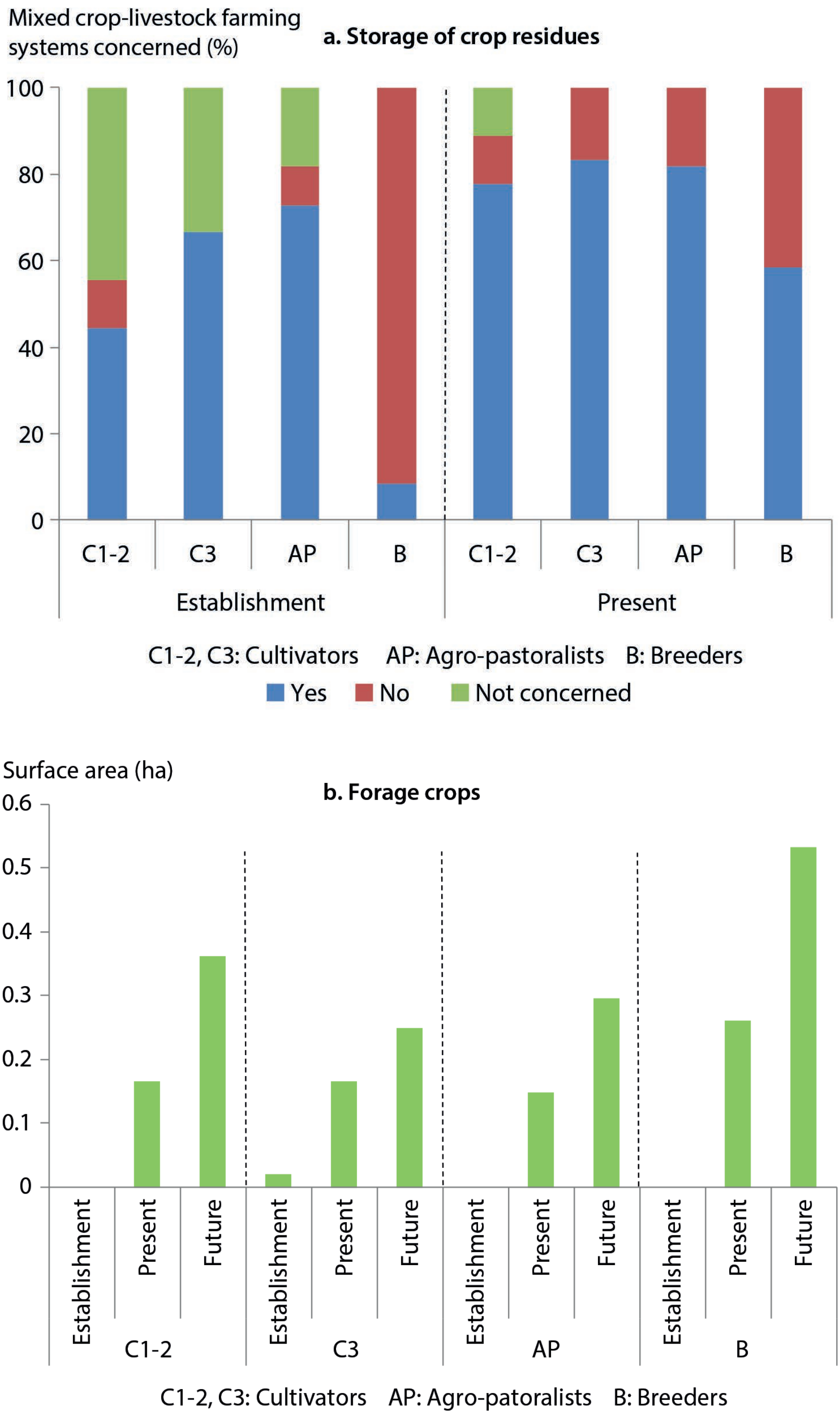

Figure 1.5. Changes in the practice of storing forage crop residues (a), forage crops (b) according to the classes of mixed crop-livestock farming systems (see Table 1.1).

synthetic fertilizers, improved seeds and agricultural equipment), coupled with an 'agroecological' intensification strategy based primarily on the combination of cultivation and livestock husbandry, and on maintaining trees in the agroecosystem. The association of cultivation and livestock husbandry is characterized by:
– extensive use of draft animals for agricultural tasks and transport;
– increase in the recycling of agricultural residues of farms, and the beginning of the cultivation of forage crops comprising of multipurpose species;
– improving the production of organic manure.

The mixed crop-livestock farming systems of western Burkina Faso have progressed little in the agroecological transition. They are at a stage at which producers continue using synthetic inputs at a moderate level, while introducing practices with an agroecological character based mainly on an association of cultivation and livestock husbandry. To support producers in undertaking a more meaningful transition, i.e. to create sustainable intensification impacts by leveraging better the possible interactions between natural vegetation, livestock herds and crops, as well as the recycling of biomass in farms and territories, we initiated the co-designing of technical and organizational innovations. The implemented approach has been systemic and multi-scale so that constraints at higher or lower levels do not inhibit change at other levels (Figure 1.6).

Co-design of innovations at the farm and territorial scales

We present a summary of this co-design work carried out to support the agroecological transition of mixed crop-livestock farming systems at different scales: territories, farms and production systems.

Co-design of rules for territorial resource management

In Burkina Faso, local authorities which were created following decentralization must renew the mechanisms for managing natural resources of their territories so as to exploit them sustainably, control competition and manage conflicts between users. Starting in 2009, changes in the land law have helped them implement local land charters. Inspired by local customs, uses and practices, but remaining in compliance with the country's laws and regulations, a charter determines, at a clearly defined scale, the specific rules for good and judicious management of territorial resources.

From 2008 to 2012, with backing of the Fertipartenaires[2] project, we supported the Koumbia commune in designing and implementing a local land charter to establish rules for the use of resources and space that are compatible with a sustainable management of resources and an agroecological transition (Vall *et al.*, 2015). Given the number of actors involved at the commune level (14 villages, 1358 km^2, 36,000 inhabitants) and beyond (province, country), a relatively complex mechanism for the representation of actors had to be implemented to establish the charter.

2. http://food-fertipartenaires.cirad.fr.

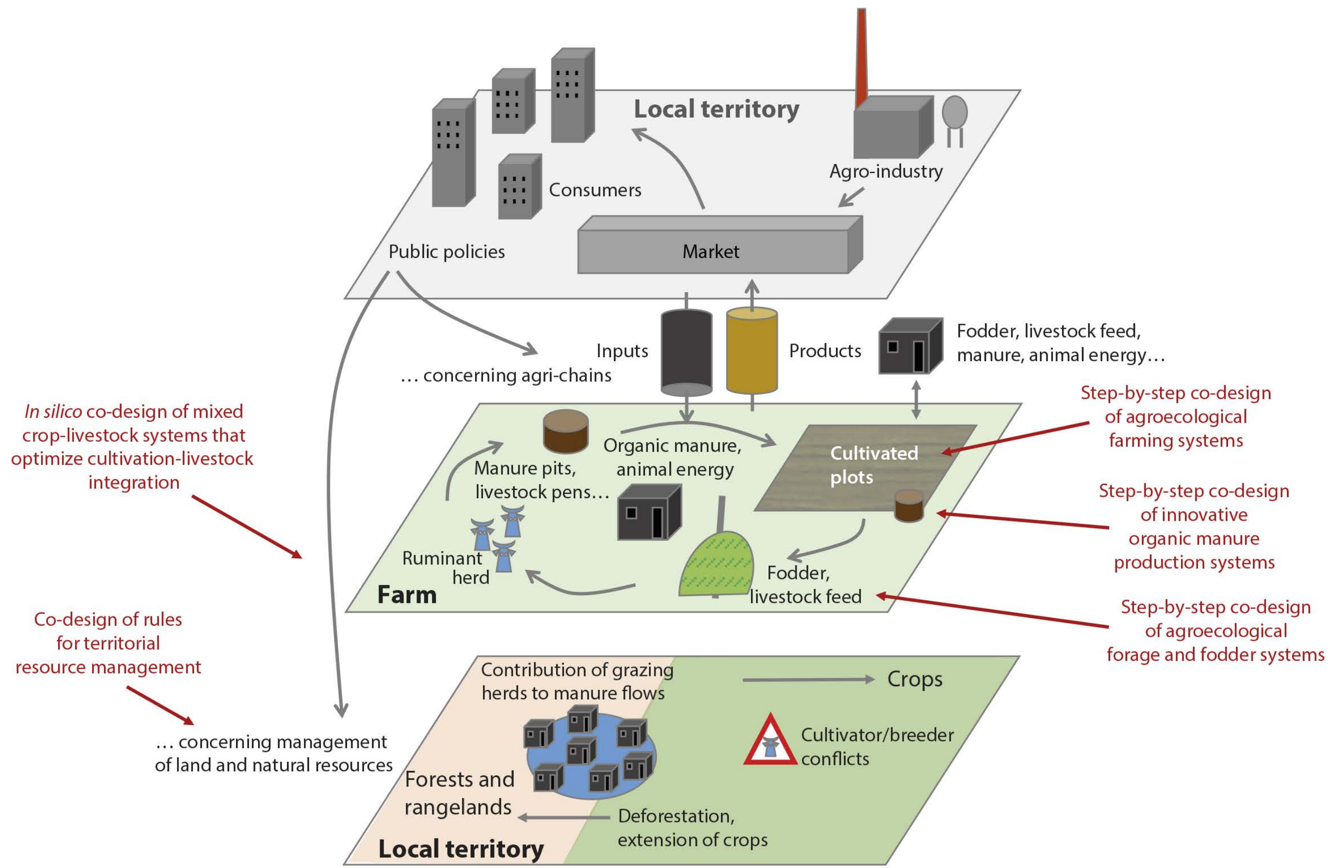

Figure 1.6. Interactions between cultivation and livestock husbandry in mixed crop-livestock farming systems in western Burkina Faso and context of co-design work carried out to support their agroecological transition.

During the exploratory phase, transitional consultation frameworks were mobilized in each village to take stock in a participatory manner and pre-identify resource management rules. During the drafting phase, an *ad hoc* consultation framework including village representatives, elected officials and the administration made it possible to adjust and fit these rules into the legal framework, and to design a project for drafting and implementing a charter.

The Koumbia municipal council adopted the charter in 2010 (Vall *et al.*, 2015). The aim of the third phase was to set up the commissions responsible for its application, and its articles concerning the management of agricultural land, pastures, forest areas, ponds and watercourses. However, in 2012, certain decrees pertaining to the implementation of the land law had still not been published. Furthermore, the events of 2014 (the fall from power of President Blaise Compraoré on October 31) prevented the application of the charter. In fact, to date, its impact on facilitating the implementation of agroecological practices and systems has not been evaluated and remains hypothetical. The implementation of the charter has to be taken up again and pursued to achieve the expected results.

In silico co-design to optimize cultivation-livestock integration

The management of a mixed crop-livestock farming systems is relatively complex because of the diversity of its components. A change of practice in one of the components has immediate repercussions on the others. This is why the modelling of the functioning of such a system is, in theory, very useful in trying to optimize the association of cultivation and livestock husbandry and to study the impacts on it due to changes in practices. Several farm simulation tools were tested in order to renew the approaches for co-designing production systems, and to support producers in a participatory approach framework involving researchers, producers and technicians of extension services.

The first is called *Cikeda* (which means 'agricultural farm' in the Dioula language) which helps calculate the effects of various farm-level technical and organizational alternatives on resource flows (residues, organic manure, cereals) in terms of the balances of forage, minerals, cereals and on incomes (Andrieu *et al.*, 2012). The second, *Simflex* (Andrieu *et al.*, 2015), simulates the farmer's main decision rules in the face of climatic and economic hazards. The third, *optimCikeda*, is a linear optimization model that maximizes the income of the farm when confronted with constraints.

These tools informed the strategic and tactical reflections of 6 and 18 producers respectively representing the three classes of mixed crop-livestock farming systems and who were participating in projects (Sempore *et al.*, 2015a, 2015b). In the first case (strategic reflections), the aim was to analyse, with six producers, the benefits of a new production activity, such as a cattle fattening unit. In the second case (tactical reflections), it was more a question of planning the activities to be carried out during the next cropping season (acreages of different crops, organic fertilizer inputs, amount of animal feed to be produced). These different tools helped build up the knowledge on integrating cultivation and livestock husbandry of all the producers who experimented with simulation tools, with *Cikeda* being perceived as the best of the three by the farmers due to its simplicity in representing the farm. An assessment of practices was also undertaken in the year following the use of the different tools, and showed an increase of more than 20% in the amount of compost produced, and in the introduction of fattening units and fodder crops by 80% of producers. More livestock-specific modelling tools were also developed and then used to design innovative livestock breeding units (Delma *et al.*, 2016).

Step-by-step co-design of agroecological farming systems

The work of co-designing agroecological farming systems had two objectives: first, to promote cropping systems based on conservation agriculture (no tillage, permanent crop cover and plant diversification) to limit the loss of soil fertility; and, on the other hand, to create associated cropping systems – mainly leguminous cereals – to diversify and increase security of production, while benefiting from the nitrogen supplied to the system by the leguminous plants.

Cropping systems based on conservation agriculture were tested for several years in farmers' fields with sorghum associated with pigeon pea (*Cajanus cajan*), followed by maize associated with cowpea (*Vigna unguiculata*). At the end of four years the results were as follows: yield of 2889 kg/ha maize grain and carbon stocks of 10.73 tonnes C/ha in the superficial horizon (5 cm) on conservation agricultural plots as against 2605 kg/ha and 6.35 tonnes C/ha respectively on conventional plots (Sanon, 2017; Coulibaly *et al.*, 2018). To date, however, few farmers have adopted these systems. This is due to persisting and significant technical difficulties (weed control, lack of knowledge on pigeon pea) or organizational and cultural ones (hard to retain residues on the plots). However, producers did evince interest in improving the fertility of degraded plots.

For associated crops in conventional systems, the main systems tested consisted of maize associated with various multipurpose legumes (food for human consumption, fodder, soil cover). Coulibaly *et al.* (2012) showed that the maize/cowpea association saved 30% of the cultivated area compared with pure maize and cowpea, and that the maize/mucuna combination (*Mucuna rajada*) saved 26% of the cultivated area in terms of the system's overall production. However, with the mechanization of weeding in cotton-growing areas, it is difficult to implement associations without an arrangement allowing intercropping, which largely explains the lack of adoption of intercropping, or even its disappearance when producers resort to herbicides. New research is planned to adapt the systems to ensure a more viable reintroduction of legumes in this new context.

Step-by-step co-design of agroecological forage and fodder systems

To cope with the reduction of grazing pastures and also the problems of accessibility and price of livestock feed on the market, which curb projects to expand breeding programmes on farms (purchase of draft animals, production of milk or cattle fattening) (Delma *et al.*, 2016), we assisted producers in the design and implementation of forage and fodder production and storage techniques.

An initial part of the work, carried out on a large scale (several hundred test plots on farms), concerned the production of forage legumes (*Mucuna deeringiana*, *Vigna* *unguiculata*, *Cajanus cajan*, etc.; Ouattara *et al.*, 2016). The producers tended to focus more on *V. unguiculata* for its multi-use character (food, fodder, fertility) and its good quality haulms (Gomgnimbou *et al.*, 2017), and on *M. deeringiana*, which is easy and economical to cultivate (2 to 4 tonnes of dry matter [DM] haulm per hectare).

Another part of the work concerned the establishment of very dense (20,000 plants/ha) fodder plantations of *Leucaena leucocephala* and *Morus alba,* also known as 'shrubby fodder banks' (Ollo *et al.*, 2016). The fodder banks enter into the production stage following the establishment period (12 months). While the initial results showed that production (4 to 10 tonnes DM/ha) fell short of the output targeted by farmers (15 to 20 tonnes DM/ha), the first fodder banks withstood the dry season, fires and termites, which makes them potentially very beneficial.

For the moment, the adoption of forage, annual and tree crops remains limited, and grazing, storage of residues and the purchase of feed remain the preferred options for breeders. However, this work resulted in some unexpected and promising outcomes, such as the creation of a mini-dairy by Fulani women in Koumbia, and the launch of a seed production activity of *M. deeringiana* by Kourouma farmers. These outcomes indicate a probable empowering effect of the co-design, and highlight the benefits of expanding the mechanisms of design to upstream and downstream actors of the value chain in order to better address the issues of sustainability and feasibility of innovations.

Step-by-step co-design of innovative organic manure production systems

The bulk of the manure production in western Burkina Faso takes place near habitation areas where animals are kept (Diarisso *et al.*, 2016). The transportation of litter and manure thus represents a significant workload and constitutes a real obstacle to the production of organic manure, especially since the extension of cultivated acreages leads to ever-increasing distances to be covered. We proposed to producers that they should decentralize the production of organic manure to the field itself by modifying the production methods in order to reduce this transportation constraint (Blanchard *et al.*, 2017; Benagabou *et al.*, 2017).

The objective was to produce good quality manure in the field itself with a minimum of labour and external inputs. Work carried out on a large scale (more than 1000 pits) between 2005 and 2012 helped design an organic manure production model in cemented pits in the field. They were filled at the end of the dry season (~20% animal waste, 80% agricultural residues), with a supply of rainwater, needed no shredding or turning over, and were emptied after 12 months, producing a yield of about 50%, a production of 150 kg DM/m^3, a composition of about 10 g C/100 g, and a carbon/nitrogen ratio of about 20 (Blanchard *et al.*, 2014).

The assessment carried out in 2015 of the impact of this work confirmed the adoption of this technique, and highlighted an early impact on the production of organic manure (increase of 7 tonnes per farm), on maize yield (+786 kg/ha), and, in the farmers' opinion, on improving soil fertility and on increasing their incomes and their food security (Vall *et al.*, 2016b). The increase in, and improvement of, agroecological manure production are topics that are still of interest to producers. Today, practices continue to develop with the installation of bio-digesters and fertilizer trials based on shea caterpillar droppings (Coulibaly *et al.*, 2016).

Conclusions

This work of co-design of innovative systems has helped transform local farming systems and support producers in an agroecological transition.

They produced two principal categories of outputs: potential agroecological innovations; and analyses of ongoing processes of change. Both types of results have been the subject of scientific and technical publications.

The developments observed show that mixed crop-livestock farming systems in western Burkina Faso are still at an early stage of the agroecological transition. Producers maintain the use of synthetic inputs at a moderate level, while introducing agroecological practices based mainly on strengthening the association of cultivation with livestock husbandry.

The results of the co-design work have also contributed to changes in practices in mixed crop-livestock farming systems. However, the level of adoption of agroecological practices has varied, based on the type of innovation proposed. When innovations were made part of transformations already underway, adoption and early impacts were observed more rapidly. This was true for innovations involving the strengthening of associations between cultivation and livestock husbandry, e.g. manure pits in the field. In contrast, the adoption of innovations that flowed counter to the intensification models favoured by development entities is still very limited, e.g. mulch-based cropping systems, or even intercropping. Unexpected changes were also observed in the activities of some actors involved in the co-design process, e.g. the setting up of a mini-dairy, bio-digesters, hay-lofts and marketing of *Mucuna* seeds. These changes illustrate an empowering effect of co-design through the extension of the action in a different direction, chosen by the actors in the field themselves.

The successes and failures of this work of co-design of innovative mixed crop-livestock farming systems have also led us to propose a few recommendations to make co-design more effective and to accelerate the agroecological transition:
– taking the time to properly study and understand the dynamics of changes underway to fine tune the proposals of innovation to the producers' constraints and objectives;
– preparing the co-design of innovative farming systems through studies of agroecological processes that can be mobilized at different scales and planning actions to support change in order to consolidate results;
– taking into account the adaptation of rules to manage territorial resources when co-designing innovative farming systems;
– including key value-chain actors and those involved in territorial management into co-design mechanisms such as innovation platforms;
– combining little-known innovations of actors in the field with ongoing innovations to increase their interest and to involve them.

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