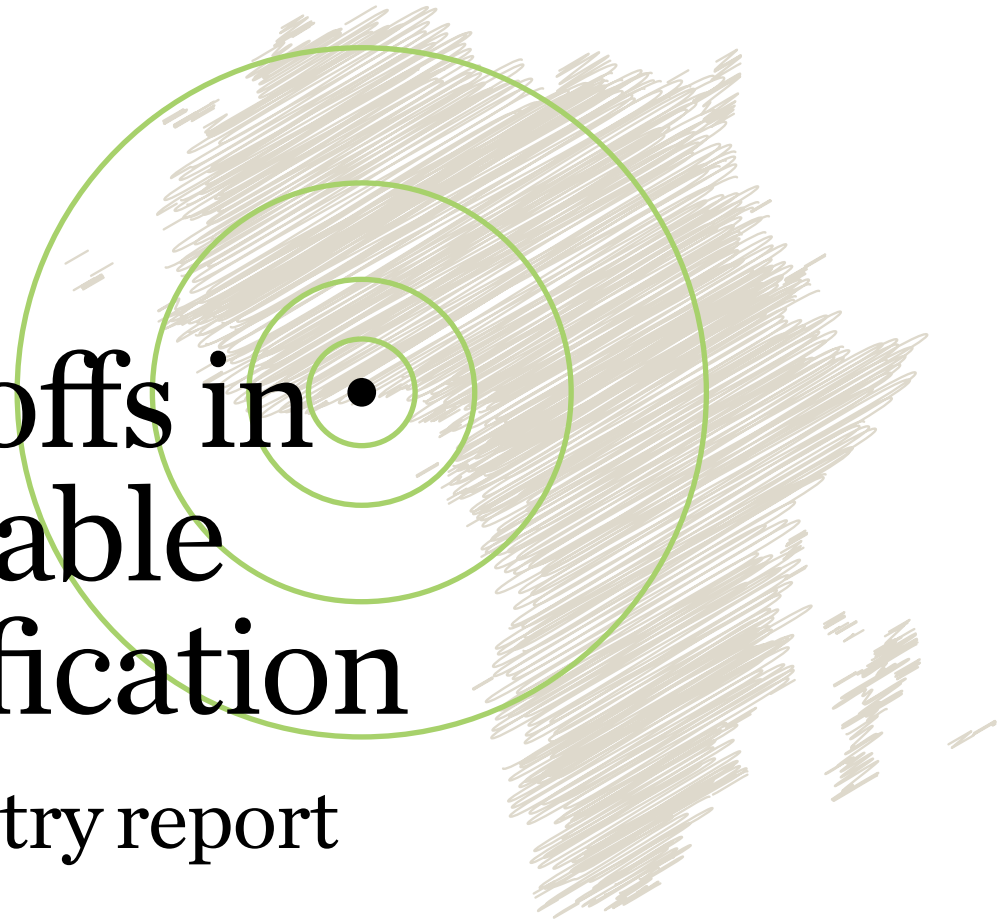

Trade-offs in sustainable intensification

Ghana country report

Francis Dakyaga, Emmanuel K. Derbile, Godwin K Naazie, Samuel Faamuo Tampulu, Daniel Faabelangne Banuoku, Evans Beyuo, Ebenezer Betiera Niber and Peter Gubbels

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About the project

SITAM (Sustainable Intensification: Trade-offs for Agricultural Management) was an action research project seeking to understand how smallholder farmers in Africa manage the trade-offs between production, sustainability, and other socioeconomic and environmental factors.

About our Funders

The SITAM project was funded by the Sustainable Agricultural Intensification Research and Learning in Africa (SAIRLA) programme. The SAIRLA programme was funded by the UK Department for International Development and managed by WYG International Ltd and the Natural Resources Institute, University of Greenwich. The SAIRLA programme sought to generate evidence and design tools to enable governments, investors and other key actors to deliver more effective policies and investments in sustainable agricultural intensification that strengthen the capacity of poorer farmers, especially women and youth, to access and benefit from sustainable intensification in Burkina Faso, Ethiopia, Ghana, Malawi, Tanzania and Zambia.

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Smallholder farmers in Ghana face a constant challenge: to choose between many, often competing, social, economic and environmental objectives while also meeting expectations to intensify their farming practices sustainably and produce 'more with less'. Farmers manage this situation by making trade-offs; choosing and prioritising goals based on household circumstances and by weighing immediate productivity/financial gains against long-term goals.

This report presents findings from the SITAM project, which explored how farmers in Ghana manage these trade-offs. It draws conclusions and recommendations for what national and sub-national government can do to support more sustainable choices at farm level in Ghana.

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Acronyms

ACDEP	Association of Church-based Development Projects
CIKOD	Center for Indiegenous Knowledge and Organizational Development
ELD	Economics of Land Degradation
FMNR	farmer-managed natural regeneration
GHS	Ghanaian Cedi (Ghanaian currency. US$1 = GHS5.8 as of April 2020)
PFJ	Planting for Food and Jobs
MoFA	Ministry of Food and Agriculture
NGO	nongovernmental organisation
RESULT	Resilient and Sustainable Livelihoods Transformation
SAI	sustainable agricultural intensification
SAIRLA	Sustainable Agricultural Intensification Research and Learning in Africa
SITAM	Sustainable Intensification: Trade-offs for Agricultural Management
SWC	soil and water conservation
VSLA	village saving and loans association

Summary

This report presents an analysis of the trade-offs in sustainable agricultural intensification (SAI) in Ghana. The project researches the challenges and opportunities of smallholder farmers, particularly poor farmers and women farmers, in managing the trade-offs between production and other socioeconomic and environmental factors to develop grounded policy recommendations for more effective SAI support in Ghana.

SAI involves increasing the use of resources, farm inputs, labour and land as efficiently as possible in changing environmental conditions. To explore how smallholder farmers manage trade-offs in SAI, the study first explores the evolution and main changes in the smallholder farmers' farming and livelihood systems over time. Second, it assesses smallholder farmers' perceptions of their livelihoods' sustainability under changing environmental conditions. Third, it analyses how farmers manage trade-offs/competing objectives in SAI in Lawra municipality and Nandom district in Ghana's Upper West Region.

We collected and comparatively analysed three data sets:

- A document review analysing rural livelihoods, farming systems and resilience (March 2017)
- A quantitative questionnaire survey of 150 households (October 2017), and
- In-depth, longitudinal case studies of 12 households (2017–2019).

The selection criteria for our case study households reflected major categories within a typology of households developed from our analysis of the quantitative surveys. For the second and third data sets, our researchers systematically and frequently presented the main findings to the communities involved. This enabled them to foster in-depth discussion (and validation) of the findings by the communities and other local stakeholders, which in turn informed the process of developing recommendations.

We conducted the study in two farming communities — Tanchara (Lawra municipality) and Ko (Nandom district). We selected these communities because of the domination of smallholder farmers. The major natural resources include bush fields, home fields/compound farms, dry season gardens, forest reserves, pasture/grazing areas, hills and water bodies/streams. The inhabitants of these settlements cultivate food crops predominantly in compound farms and village farms, mainly for domestic consumption. They also rear livestock for commercial and traditional purposes.

To ground our research within the context, we obtained data on many characteristics of the current farming system. This included seed varieties, livestock and poultry rearing, use of inputs and farm machinery, processing, farm crop storage and marketing, agricultural input supply, and extension services. The researchers also reviewed how population growth, climate change, trends in water resources, food security, household assets and gender issues in farm production affected the farming system.

Managing competing objectives: trade-offs and synergies in SAI

One of our findings was that there have been major changes in the farming methods used by different smallholder farmers in Nandom and Lawra districts. By constructing an in-depth description of these changes, we gradually identified and then analysed the main trade-offs that farmers have faced to achieve their objectives. These have informed their decision making about changes in farming practices over time.

This study defines a trade-off as a compromise between two desirable, but to some extent incompatible, objectives. Managing trade-offs is about farmers seeking to maximise the overall level of achievement and benefits within several dimensions — economic, environmental and social. Synergies exist where the achievement of one objective enhances the achievement of another, so the overall achievement is greater than if the two had been unrelated. The aim of farmers' livelihood strategies is to maximise synergies and minimise trade-offs, within the confines of the resources available to them (including their own knowledge and understanding).

Across the 12 case study households, we identified the main objectives that required major trade-off decisions by farm families. We also found that not all changes in the farming system required managing trade-offs between competing objectives, as smallholder farmers identified potential synergy/trade-off practices in their efforts to develop a more sustainable, intensive and resilient farming system. These fall into three broad categories:

1. Trade-offs between economic and environmental objectives, with economic objectives often having a higher priority for farmers
2. Trade-offs between short and long-term objectives, with short-term objectives receiving higher priority for small farmers who need to meet immediate food security and cash needs, and
3. Trade-offs between individual and communal objectives for managing natural resources, with individual gains often receiving higher priority than communal gains if there are no effective local institutions /bylaws in place to effectively manage natural resources.

Conclusions and recommendations

Our analysis of these trade-offs and synergies indicated that decisions about adopting new farming practices vary greatly between categories of smallholder farmers — based on age, gender and access to resources, land, and labour — even within similar agroecological zones. Smallholder farmers operate under highly diverse socioeconomic and ecological conditions. Many face significant resource constraints.

Overall, however, the study indicates that farmers in the Nandom and Lawra districts are adopting a mix of three types of strategy or 'pathway' for increased productivity. These pathways affect SAI in a positive or negative way, depending on how different types of household and farmer – including women and youth — manage trade-offs.

The data strongly shows that most households consider a single pathway —for example, one that considers primarily short-term economic gains and producing for markets and that excludes food self-provisioning without concern for stability and sustainability – to be too risky. At the same time, an alternative pathway that gives the highest priority to sustainable and resilient production, based on agroecological methods, without concern for use of external inputs and markets, also has significant drawbacks for all types of farmer. It is within this framework that most smallholder farmers are making trade-offs.

The in-depth household studies show that many farmers take actions based on short-term imperatives, despite being aware of the long-term damage to their farm production systems. Many are locked into situations that lead them to use practices that degrade their own resource base, including soils, trees, biodiversity and water. Farmers indicate they are often obliged, or 'locked in' to taking a short-term perspective in decision making, as immediate needs are more pressing.

Our policy recommendations generally address ways to support farmers to overcome these 'lock-ins', by enabling diverse and heterogeneous categories of farmers to make a transition to longer-term, sustainably intensive and resilient farming practices while still meeting their short-term pressing needs.

These recommendations imply significant changes in current agricultural research and extension processes in Ghana, which tend to make very general recommendations for seed and fertiliser use across an entire region and promote a simple, one-size-fits-all solution for problems across extremely diverse types of households and conditions.

This study also suggests that a radical transformation of farming systems for SAI may not be feasible. The general and specific policy recommendations in this report, together with support and highly tailored interventions, will likely only nudge various types of household in the direction of SAI, in a progressive, step-wise process. This will require identifying the optimal combinations and sequences of new (more sustainable) practices suited to multiple categories of farm household to address their specific mix of stressors, drivers and system functions. The focus must be on improving the efficiency of resource use, by addressing total factor productivity.

Although our recommendations were developed in the context of Nandom and Lawra, they have highly relevant implications for promoting SAI across Ghana as a whole.

1 Introduction

1.1 Background

The Sustainable Intensification Trade-offs for Agricultural Management (SITAM) project[1] aimed to address the challenges and opportunities of smallholder farmers, specifically resource-poor farmers and women farmers, in managing the trade-offs between production, sustainability and other socioeconomic and environmental factors. This dilemma has been well studied and documented in the context of agricultural development and natural resource management. By understanding the specific challenges for small farmers, it was possible to identify entry points for interventions that can support farmers in making 'better' trade-off decisions, that strengthen, rather than weaken sustainable intensification.

SITAM was part of a DFID-funded research programme, Sustainable Agricultural Intensification Research and Learning in Africa (SAIRLA),[2] that addressed sustainable intensification through eight research projects in six sub-Saharan African countries. The project conducted a three-year (2016-2019) research study on smallholder farmers' decision making in relation to sustainable agricultural intensification (SAI) in the Guinea Savannah Zone of Ghana's Upper West Region. This report summarises the analysis of farm household case studies undertaken in 2018 and 2019 and an earlier quantitative survey (Jambabdu and Derbile 2017).

1.2 Methodology and study objective

This study used a mixed research method to examine farmers' decisions around production and what they seek to achieve with these decisions. The research was carried out in Tanchara and Ko, two farming communities, between 2017 and 2019.

The initial stage involved a livelihoods analysis based on literature review and key informant interviews. This helped us gain a better understanding of the context, including previous SAI-supporting interventions. This was followed by participatory development of SAI indicators, involving community members in both communities who defined what they considered to be SAI and worked with our researchers to identify possible indicators for measuring SAI (see Annex 1 for details).

The research team then collected quantitative data on smallholders' farming and livelihood systems. This method was suitable for obtaining in-depth information to understand how different farmers manage trade-offs in SAI to address competing objectives and changing environmental conditions. We collected the data in the form of questionnaire survey with a representative sample of 150 smallholder farmer households in the communities, randomly selecting household heads from the survey sample. Where the household head was absent, we interviewed the spouse.

We used the quantitative household survey to assess household performance along the SAI indicators previously developed with local farmers — including household income levels, food security and coping mechanisms — to help us understand the economic, environment and social dimensions of different types of households' pathways towards sustainability.

1 https://www.iied.org/trade-offs-sustainable-intensification
2 https://sairla-africa.org/.

Our qualitative data had two major sources: a document review on farming and livelihood systems in the region and a longitudinal study of 12 households. We purposively selected our 12 case study households from among the questionnaire survey participants to represent a range, including households with high, medium and low performance in terms of key SAI indicators. We collected data on coping mechanisms and how smallholders manage competing objectives to sustain their production and livelihoods.

We also conducted six focus group discussions across the two communities, targeting two women's groups, two men's groups and two youth groups. The essence of the discussions was to validate findings gathered from the household case studies. Some of the initial findings are summarised in Amongero et al (2018).

After tracking and documenting decisions at community level, we tracked and monitored our 12 case study households' decisions throughout the 2018/19 production cycle. We used an SAI framework to categorise each of the decisions within and across domains, across spatial scales, across time and across type of farmers. We also identified the desirable objectives of these decisions to identify trade-offs and synergies.

Staff from SITAM partners Center for Indigenous Knowledge and Organizational Development (CIKOD) and the University for Development Studies conducted the field work, with initial training and technical support from Groundswell International, the International Institute for Environment and Development, and Practical Action Consulting.

The objective of the household case studies (step 5 in Figure 1) was to understand different households' and different household members' perceptions and visions of SAI, particularly in terms of the main influences on farmer decisions that establish trade-offs and synergies. The SITAM team aims to use these findings and insights to change the knowledge, awareness, attitudes and capacity of decision makers and other actors at local and national levels in support of proven pro-poor approaches for scaling up sustainable intensification that recognise farmers' perceptions of synergies and trade-offs.

Throughout the report, we use infographics to show key information about the case study households in a clear, visual way. We anonymised household data by assigning a number to each of the case study households, in order of household size (by population). So Household 1 is the largest with 13 members, and Household 12 the smallest, with only three members (see Figure 12 for details).

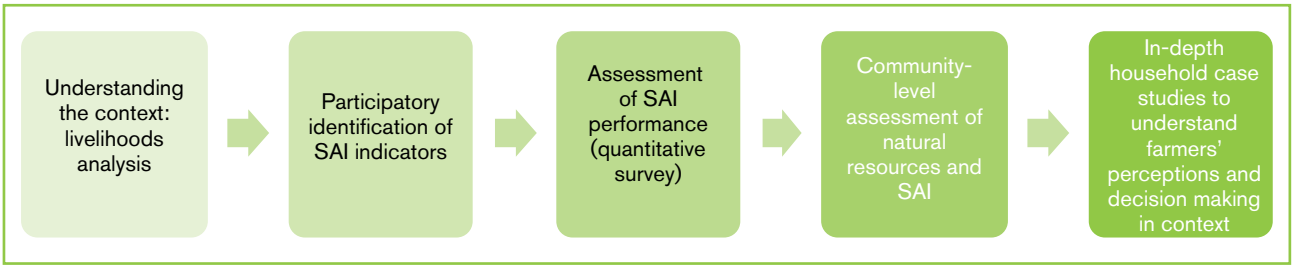
We were specifically interested in understanding the convergence and divergence in households' perceptions of SAI, the factors that influence their decisions and the linkages between them. In particular, we wanted to study different categories of farm households, and their consideration of short-term and longer-term methods for SAI.

The latter are often less tangible and immediate. This is because it is more difficult for farmers to notice the longer-term environmental impacts of certain decisions. These may well affect the community overall or certain parts of the community only, whereas economic outcomes tend to affect households on an individual level.

The aim was to develop detailed participatory findings on trade-offs and synergies and their level of success in terms of SAI. This included an emphasis on the perceptions of women and youths (either as key decision makers or as observers who are excluded from decision making), and the specific barriers they experience in moving towards SAI.

We used these findings to formulate specific recommendations for how to effectively promote SAI in the Lawra and Nandom districts of Ghana's Upper West Region, and then to determine to what extent these recommendations can be extrapolated for application across Ghana.

Figure 1 The SITAM research steps



2

Farming and livelihood systems in the study area

Tanchara and Ko are farming communities in the Lawra and Nandom districts – see Figure 2, indicating the location of the communities and districts within the Upper West Region of Ghana (with the capital Wa). Both communities are dominated by smallholders, mostly on compound farms that are located around their houses within the settlements. People no longer have bush farms, i.e. fields at some distance from their village.

Ko is characterised by undulating, low-lying areas and hills popularly called the Yesu Tang or Jesus' mountain. The community has no specific grazing land, except the area around the Yesu Tang. Both communities have trees (forest species and others) between farms and on individual farm fields.

2.1 Natural resources

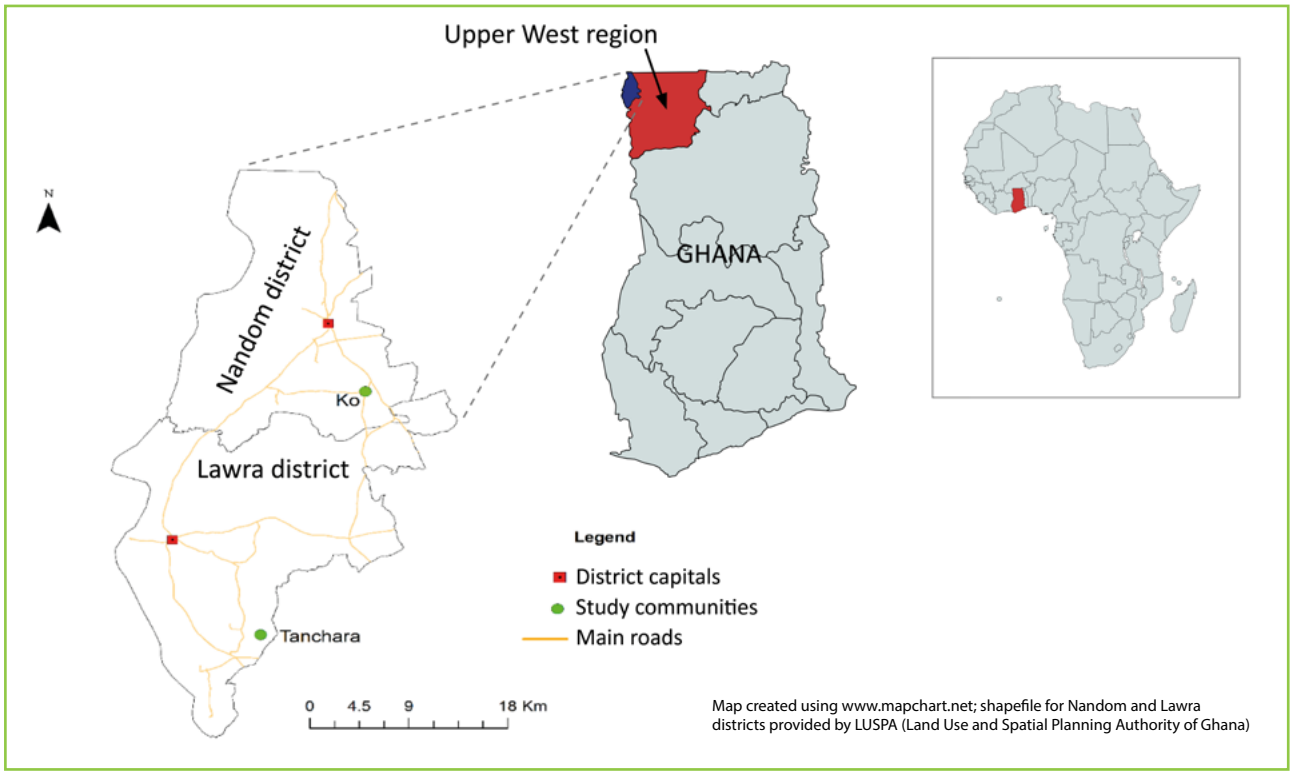
The major natural resources found in both communities are farmlands, vegetation, pasture/grazing areas and water bodies/streams. The most commonly found trees are the dawa-dawa (*Parkia biglobosa*) shea (*Vitellaria paradoxa*), ebony (*Diospyros crassiflora*) and the 'yellow berry', thought to be the marula tree (*Sclerocarya birrea*). Farmers collect firewood mostly from the land surrounding their compounds.

The farmers told us that compound farms in the area have reduced in quantity and quality over the past ten years as a result of increased population and housing development. Pasture/grazing areas on the outskirts of their communities have also increased because fewer people are cultivating their bush farms and livestock numbers have fallen. There are various reasons for this, including livestock diseases, theft (particularly of cattle) and the fewer people available for herding livestock due to schooling and migration. There are few places for animal grazing within settlements because of the concentration of cultivation within the houses (home fields).

In both communities, our case study farmers reported that the quality and extension of vegetation reserves have declined due to felling of trees and bushfires. Farming and hunting activities around the vegetation contributed to burning, deforestation and degradation. We observed that in Ko, bushfires and overgrazing have contributed to increased erosion, reducing the quality of highland areas including the Yesu Tang. Vegetation cover has declined in the hilly areas of both communities as a result of ongoing tree-felling and an increase in population, housing development, farming, burning and hunting activities. Both communities have instituted bylaws around tree cutting and bushfires, but these are not fully implemented.

Water resources have also declined over the years. Tanchara, which has two streams and three dams, has better water resource availability than Ko, which has only one stream. But all these water bodies dry up shortly after the end of the rainy season. Smallholder farmers associated the decline in water resources with reduced rainfall intensity and patterns as well as siltation through soil erosion.

Figure 2 Map of Ghana showing the location of study districts and communities



2.2 Crops

Our case study respondents revealed that they cultivate both the improved/hybrid and indigenous crops and vegetables varieties, with male-headed households more likely to grow improved/hybrid crop varieties than female-headed households. Local and indigenous food crop varieties are gradually being lost due to changes in rainfall patterns and the promotion of improved/hybrid crop varieties by nongovernmental organisations (NGOs) and the Department of Agriculture in the study communities. Smallholder farmers, especially male-headed households, cultivate more early-maturing food crop varieties or blend the improved/hybrid with the local/traditional crop varieties to adapt to changes in food crop yields and production uncertainties.

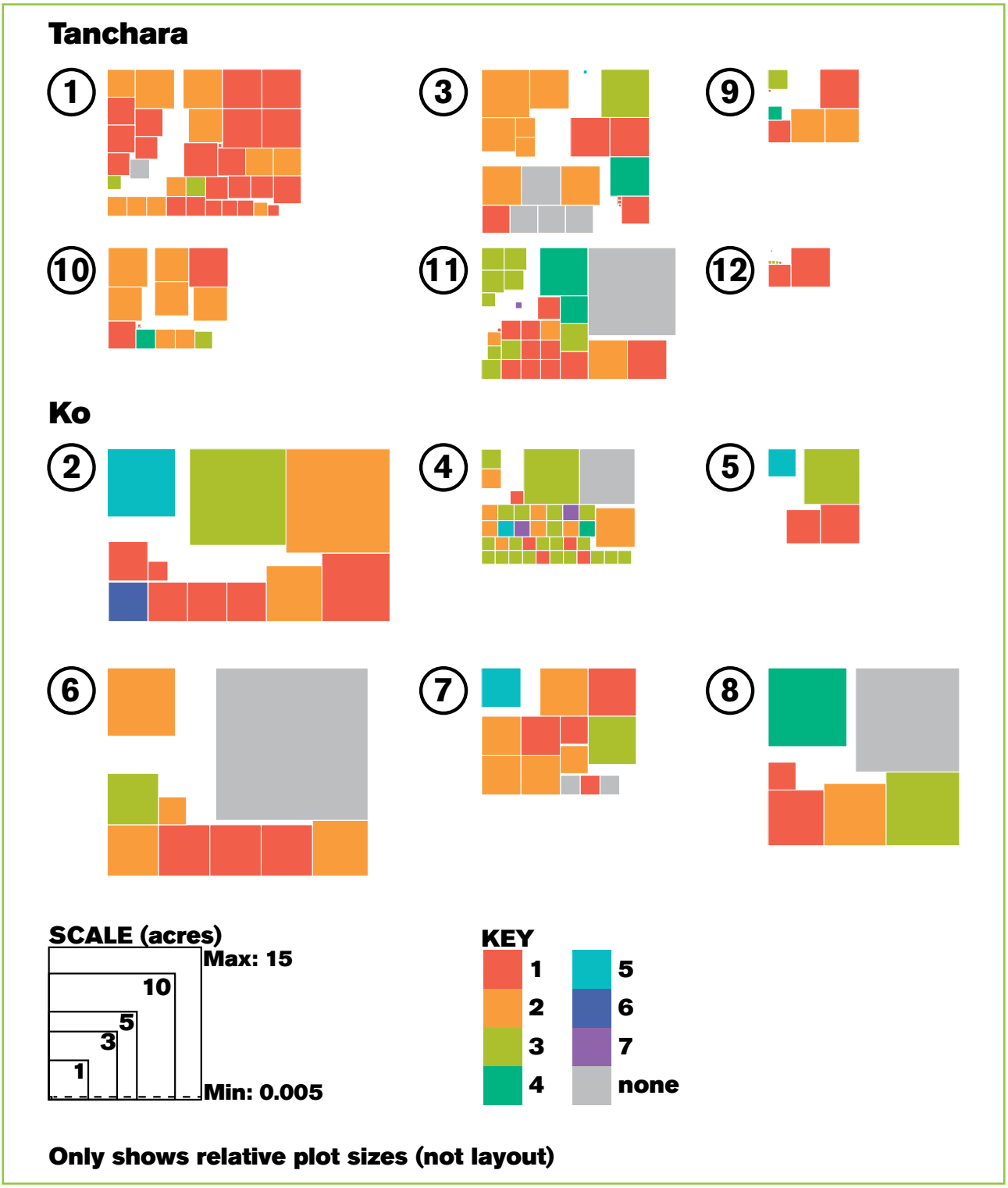
The improved/hybrid crop varieties cultivated include: maize, sorghum (dorado variety), cowpea, soya beans, groundnut (China variety), sweet potato, vegetables, garden eggs (aubergines) and tomatoes. Most farmers use seeds stored from the previous years' harvest; a few buy new seeds from input dealers every year. The local crop varieties include: sorghum (guinea corn variety), bambara beans, *kama zinzin* (early maturing maize), groundnut, millet, yam, aerial yam and vegetables such as pepper, *bier* (fibre leaves), okra and pumpkin leaves.

All households cultivate maize, groundnut and vegetables. There is a marked difference between the crops cultivated by female-headed households and female spouses of male-headed households. Male-headed households also cultivate guinea corn sorghum and millet for traditional rites such as funerals, as the role of providing these grains is traditionally ascribed to men. Female-headed households commonly cultivate groundnut, maize, bambara beans, dorado sorghum, peppers and vegetables, and female spouses in male-headed households are commonly in charge of managing groundnut and bambara beans, which are easier to manage as they require a lower time commitment and fewer external inputs. The youth mostly cultivate groundnut and peppers to sell for their personal financial needs.

With 94% of households growing maize, it is the most-cultivated crop in both communities. Only 6% of respondents said they do not cultivate maize. Other popular crops included groundnuts (91%), millet (63%) and sorghum/guinea corn (39%).

Most households cultivate several crops in the same plot, either intercropping in rows or growing some crops on the border of the field with others in the centre. Figure 3 shows the number of plots, the number of crops on each plot and the farm size for each of our case study households. The case study households were numbered by household size, with household number 1 in Tanchara having the highest number of household members (13) and household number 12, also in Tanchara, having the lowest number of members (three).

Figure 3 Crops, plots and farm size, by case study household



Source of data: SITAM household case studies (2018–19)

Our case study farmers reported that they like improved and hybrid crop varieties because of their early maturity and higher crop yields, but they cannot use these for traditional ceremonies. Therefore, farmers in Tanchara hardly use improved/hybrid dorado sorghum and bambara beans because they need to perform traditional rites before harvest. These rites are performed in late October or early November. Smallholders cultivate indigenous crops such as guinea corn sorghum mainly for traditional reasons, to preserve their cultural heritage. One respondent said: "The local seeds are as old as the mud walls that our grandfather left behind for us. Much as we cannot destroy the old mud walls our grandfathers left behind for us, nor can we destroy or leave the local seeds completely" (member of Household 8, elderly male-headed household, Ko, 31/07/2019).

Another farmer explained that growing traditional crops was a mechanism for minimising risk, avoiding crop failures and adapting to climatic events, likening them to indigenous-owned assets (whereas improved/hybrid crop varieties are like borrowed assets) for combating food crop production uncertainties. He told us: "When you hold the chief's weapon, [you] also hold your own" (Household 4, elderly male-headed household, Ko, 31/07/2019). In other words, in the event of war/trouble, if the chief collects his weapon, you will also have your own to defend yourself. So, although households grow improved/hybrid seeds/varieties — especially dorado sorghum — they should still grow the local guinea corn. In the event of problems with the improved/hybrid varieties (lack of access, high cost and so on), they can rely on the local variety to sustain household food consumption.

Farmers acquire improved crop variety seeds from several sources. In both study communities, they generally save or store seeds including improved varieties from the previous year's harvest for planting or receive them as gifts from relatives, friend and neighbours. They also buy some seeds — especially cowpea, soya beans and bambara beans — from input dealers in the markets. Some farmers first received these seeds — especially improved varieties — from NGOs such as the Association of Church-based Development Projects (ACDEP) and Ministry of Food and Agriculture (MoFA) officials.

The decision to cultivate improved/hybrid seed or local/traditional crop variety on a particular piece of land depends also on the nature of the soil. Farmers tend to cultivate local/indigenous crop varieties in better soil because they require fewer inputs especially chemical fertilisers to enhance yields. Improved/hybrid crop varieties, on the other hand, are input-intensive so can grow in poorer soil, supported through the application of chemical fertilisers to enhance yield.

2.3 Livestock

Every case study household owns at least one kind of livestock or poultry. These animals are a source of both income and organic manure, which farmers use to improve soil fertility on their farmlands. Our respondents rear goats, sheep, pigs, cattle, chickens/fowls, guinea fowls, ducks and turkeys. Occasionally, households keep rabbits and doves, but these were not recorded in the survey. Goats are the most popular, followed by fowl and sheep (see Table 1). More households in Tanchara rear goats than in Ko. Most women rear fowls and about half rear goats across both study communities. Most of the sheep and goats reared by women were provided by ACDEP or relatives. In our sample, only men were rearing cattle, ducks, and guinea fowls.

Poultry and livestock production have decreased over time in both communities. Theft of livestock — particularly sheep, goats and cattle — is also a big

Table 1 Livestock ownership in in the two study communities

Source: SITAM questionnaire survey (2017)

LIVESTOCK TYPE	PROPORTION OF HOUSEHOLDS KEEPING THIS TYPE OF LIVESTOCK	OF THESE: PROPORTION OF MEN AND WOMEN	
	BOTH COMMUNITIES %	WOMEN (%)	MEN (%)
Goats	81	51	49
Fowls	67	97	3
Sheep	52	27	73
Pigs	39	9	91
Guinea fowls	26	-	100
Cattle	14	-	100
Ducks	5	-	100

problem, especially in the dry season. Both study communities have experienced a steep decline in cattle ownership after most households had their cattle stolen in the dry season when they were released for free-range grazing, a practice that has gained prominence in the study communities. This grazing system involves farmers either tracing their cattle and bringing them home in the evenings or leaving them to graze until the onset of the rainfall season. This is because the children, who would have previously herded the cattle, have either been enrolled in formal education or prefer to migrate to work in southern Ghana, where two rainfall seasons allow year-round farming. So, although farmers perceive cattle/livestock rearing as lucrative, they cannot afford to replace stolen stock and often do not have enough family labour manage them.

Poultry, pigs and goats have a high mortality rate. Our case study farmers reported that the premature death of livestock, particularly goats, occurs due to various factors. Many cannot afford to seek the veterinary services and inputs they need to increase livestock production. Even households engaged in significant livestock and poultry production report that they do not earn enough to buy vaccines to protect against common diseases and buy or build pens to fence their livestock. This would protect them from both theft and eating grasses sprayed with herbicide (glyphosate, locally known as 'condemn').

Cattle are commonly used as dowry, which depletes cattle stocks of households with many males of marrying age. On the other hand, it increases stocks of those households with girls of marriage age. As part of the traditional marriage ceremony in both communities, the groom's household head or father sends two heads of cattle (and other items) to the bride's family. Many households rear cattle for this purpose; otherwise, they have to buy cattle from other households to pay their dowry.

The decline in cattle rearing has contributed to a decrease in food crop production and yield levels. Farmers cannot plough farmlands with animal traction and they have less manure and compost for their crops. The decrease in livestock and poultry production has also affected income levels in smallholder farm households. This is significant because farmers use income from livestock and poultry sales to buy farm inputs and hire, provide food for social pool labour[3] and cope with and adapt to lean season stresses and stocks.

In both communities, the decision to sell livestock and poultry is often influenced by food shortages and other household needs. They may sell livestock and poultry to buy crop seeds for the next farming season or use them for traditional rites and ceremonies. One of our case study farmers explained:

"Our livestock keep increasing and decreasing, especially the goats. The poultry get lost most frequently due to diseases and theft, and this is affecting our farming activities; how to entertain guests and social pool labour is a challenge now. We cannot prepare food and kill an animal to serve visitors (hired labour) during farm work. We do not also have adequate livestock droppings (manure) for farmlands. Getting veterinary services is also a challenge, fencing around our farmlands towards the intensive system of farming and rearing to increase livestock production is a challenge" (Household 5, female-headed household, Ko, 19/09/2018).

In Tanchara, smallholders make efforts to increase production by improving livestock and poultry housing and providing feed for livestock in both dry season and wet season. These efforts seek to address theft and prevent disease.

2.4 Farm sizes

Our survey found that the average farm size is 4.2 acres in Tanchara and 5.5 acres in Ko - but there are also considerable variations. About 32% and 45% of smallholder farmer households in Tanchara and Ko, respectively, own over 5.1 acres of farmland. In both study communities, smallholders said that their farm sizes have decreased over the years. At the same time, the number of plots closer to the homestead (compound farms) has increased. Farmers are often not able to cultivate all the land/fields available to them because of a shortage of labour and / or other inputs. Of the estimated 155.8 acres of arable lands owned by our 12 case study households, around 121.9 were cultivated, 24.5 were left to fallow and 9.4 were abandoned.

Factors contributing to the reduction of the land cultivated by farm households include:

- Declining rainfall
- Reduced available farm labour due to diminishing family sizes, migration and enrolling children in formal education
- A decrease in manure availability due to reduction in livestock numbers
- Challenges with compost preparation and application and
- Inadequate household income for buying inputs (fertiliser, seeds) and hiring labour.

3 Social pool labour refers to a communal system of labour common in West Africa. Individuals (mostly women) from different households form a group and work on different farmers' land – for example, weeding, sowing or doing other agricultural activities. Members of a social labour pool are paid in food, cash or a combination of both. This system provides women with some cash income for their household and personal expenses. See Benneh (1988) for an account of the different types of farm labour in Northern Ghana.

Table 2 Household and farm sizes in Ko and Tanchara

HOUSEHOLD SIZE (MEMBERS)	NUMBER OF HOUSEHOLDS OF EACH FARM SIZE				TOTAL HOUSEHOLDS	
	0–0.5 ACRES	0.6–1 ACRES	1.1–5.0 ACRES	OVER 5.1 ACRES	NUMBER	%
1	0	3	1	0	4	2.7
2–4	2	5	24	10	41	27.3
5–8	1	5	43	33	82	54.7
9–12	0	0	8	12	20	13.3
>12	0	0	1	2	3	2
Total households	3	13	77	57	150	100%

Source: SITAM questionnaire survey (2017)

To cope with the scarcity of labour, farmers intensify production on the compound farms around their houses. This has improved the quality and quantity of compound farms, particularly in terms of soil nutrient levels due to the concentration of compost and manure application (see Table 2).

Overall, farm sizes are determined by a household's labour availability, crop management capacities, membership in the social labour pool and available for buying inputs and/or hiring labour. Other factors include the proportion of farmland owned, willingness of households with larger farms to offer arable land to those with less land and willingness to cultivate large farms.

Women and youth cultivate their own crops on smaller pieces of land, as well as supporting the management of household plots. Around 77% of the household survey respondents said they farm their own family lands. Only 10% rent land from other households to grow their food crops. Those with a small amount of arable land can expand their farm size by borrowing/renting land from relatives and friends, often free of charge. Overall, only 4% of households in the study communities rent farmlands for food crop production.

The majority (75%) of women said they cultivate their food crops on family lands, 13% grow food crops in their own farmlands and 15% rent lands within and outside their communities for food crop production. Most (79%) of the men also cultivate their food crops on family lands; 13% farm on their own lands and just 2% rent land for food crop production.

Farmers told us during the focus group discussions that the nature of farm production constrains women's ability to contribute to their households' food security and dietary diversity. A growing population and higher competition for arable lands, coupled with continuous cultivation, is making it harder for farming households — especially those that own less land — to access arable land. In many cases, households with vast arable lands only cultivate proportions within their capacities and leave more than half of their arable fields as grazing lands.

2.5 Farming methods

In both communities, smallholders use different methods to farm various crops and for different plots. The most common farming methods include growing crops on ridges or mounds. This is particularly used for yam and maize, but not for groundnuts. Smallholder farmers apply organic and/or inorganic fertilisers to improve soil fertility and increase yield. Although farmers expressed an interest in preparing their own compost to improve soil fertility, they are hindered by the lack of efficient means of conveying residues and water to the compost pit to prepare the compost and of transporting prepared compost back to their farmlands. Compost preparation is also labour intensive, requiring the services of women and children to collect and process crop residues and tree leaves. Hence it can be an additional burden for these groups.

Our study found that smallholders use more than one soil and water conservation (SWC) practice, including boundary bunds, tied ridging, farmer managed natural regeneration (FMNR) and mixed cropping. Boundary bunds consist of large earthen ridges constructed around the entire field to retain rainfall. Tied ridges have a similar purpose, but create a barrier across the ridges or rows in a field, across the slope, spaced at regular intervals, to trap rainfall and prevent the water from flowing down the rows. FMNR protects young trees or shoots from tree stumps to encourage them to grow. Respondents to the questionnaire survey reported using boundary bunds on 18% of their farmlands and boundary bunds with tied ridging on 17%. Only 4% cultivate on ridges instead of flat land, which allows

them to plant more crops and increases moisture on their plots. Seventeen percent of households do not use any SWC practices on their farmlands.

Our case study households in both communities have received technical advice and training from NGOs CIKOD (through the Agro-ecology in the Sahel (AES) project) and ACDEP, (through their Resilient and Sustainable Livelihoods Transformation (RESULT) project), as well as the MoFA. This has influenced the way they prepare land and conserve trees on cropping land. Farmers in both communities are increasingly using bunding and planting in rows, while improved compost making has contributed to food production and increased food crops yields (see Table 3).

Respondents in both communities noted indicated that the rate of degradation of natural resources has slowed significantly, or started to improve as a result of tied ridging and other SWC practices, community bylaws against inappropriate cutting of trees for firewood and bushfires and intensifying farming activities through compound farms.

In Tanchara, changes in the regularity and amount of rainfall and labour have prompted farmers to intensify their agriculture, through SWC and FMNR practices applied to small fields, often near the household compound. In Ko, SAI is influenced by household asset levels, as those with more arable land expand their farm sizes.

Farmers stated that training on FMNR and agroecological farming techniques were the main contributors to recent positive trends in natural resource regeneration. They said that SWC practices had increased soil fertility (mostly due to composting) and improved soil moisture, which has in turn resulted in

Table 3 Soil and water conservation practices used on plots in Ko and Tanchara

SOIL, WATER CONSERVATION PRACTICE	PLOTS ON WHICH THE PRACTICE IS USED	
	NUMBER	PROPORTION (%)
Single practice		
Boundary bunds	115	17.6
Minimum tillage	43	6.6
Crop rotation	39	6.0
Mixed cropping	39	6.0
Tied ridging	23	3.5
FMNR	10	1.5
Combination of two practices		
Boundary bund/tied ridging	108	16.5
Boundary bund/crop rotation	30	4.6
Boundary bund/mixed cropping	19	2.9
Minimum tillage/mixed cropping	14	2.1
Boundary/soil mulch	1	0.2
Combination of three practices		
Boundary bunds/tied ridging/mixed cropping	24	3.7
Boundary bunds/crop rotation/tied ridging	21	3.2
Crop rotation/mixed cropping	4	0.6
Boundary bund/FMNR/tied ridging	3	0.5
Boundary bund/crop rotation/mixed cropping	2	0.3
More than three practices	**50**	**7.7**
No SWC practices	**108**	**16.5**
Total responses	**653***	**100**

Source: SITAM questionnaire survey (2017)

Note: *Number exceeded 150 because of multiple responses (several plots per household).

higher yields. Improved shorter cycle crop varieties are better adapted to current climatic conditions. Respondents noted that new, agroecological farming methods are useful for improving food crop yields, when applied appropriately.

2.5.1 Labour

Around half of our case study households depend exclusively on family or household labour for crop production. And while the other half depend primarily on household labour, they also hire labour and use social pool labour for production. Of the household survey respondents, 57.6% depend on hired labour for land preparation and 21% depend on social pool labour. The other 21.4% depend entirely on household labour to prepare the land and manage, harvest and store their crops.

Men and boys commonly engage in preparing the land, tillage, weeding (for all crops except groundnut and bambara beans, which are more usually grown by women) and preparing earthen bunds. Women and girls engage in sowing, clearing land, weeding groundnut and bambara bean crops and harvesting. Hired labour is commonly used for tilling, weeding and preparing earthen bunds and ridges.

Women mostly depend on hired labour, animal traction or tractor services for land preparation and social pool labour among themselves for weeding. They often borrow money through village savings and loans associations (VSLAs) to pay for hired labour. The youth tend to rely on their own labour and social pool labour for land preparation. The youth provide labour in their larger family fields, but many also obtain plots of land from the head of the household, which they cultivate crops to earn their own income.

In both communities, many households noted a decrease in farm labour availability as a result of out-migration of the youth and the enrolment of their children in formal education, trends that also contribute to the decline in interest in farming among children. Marrying out of their daughters also affects the extended family system and labour reserve for smallholder farmer households. Farm labour limitations means that most smallholders cannot cultivate larger farm sizes.

Although farmers expressed an interest in tractor services for land preparation, none of the case study households had hired tractor operators for this purpose at the time of the surveys. They attributed this to the delay in obtaining tractor services early in the rainy season. Any time there is a major rain, many farmers want to plant at once. With shorter or irregular rains due to climate change, farmers seek to sow early. Another factor discouraging farmers from using tractor services is that tractor operators do not take time to plough close to trees or other barriers in a field. This means that there are still significant parts of a field that a household has to prepare for sowing by hand, after hiring a tractor. This can be difficult for a farm household with limited cash or family labour. They also perceive that tractor ploughing reduces soil fertility compared to manual or hand and bullock tillage. Inappropriate ploughing by tractor operators — in other words, going too deep — buries the fertile topsoil, leaving infertile soil on the surface.

2.5.2 Use of other inputs

Farmers use several farm inputs — including chemical fertilisers, manure, compost, lime, crop residue or green manure — often applying one or more on different fields. Although our case study household respondents indicated that chemical fertiliser, hybrid seed, herbicide and pesticide use has increased in the past five years, the wider survey respondents said they apply chemical fertilisers on 21.5% of their plots. In the 2018 season,

Table 4 Soil fertility management inputs applied in Ko and Tanchara

FARM INPUT	PLOTS ON WHICH PRACTICE IS USED	
	NUMBER	PROPORTION (%)
Fertiliser	164	21.5
Manure	259	33.9
Compost	135	17.7
Lime	22	2.8
Crop residue	171	22.4
Green manure	13	1.7
Total plots	**764***	**100**

Source: SITAM questionnaire survey (2017)

Note: Number exceeded 150 because of multiple responses (several plots per household).

farmers in both study communities managed soil fertility by applying a range of organic and inorganic inputs (see Table 4).

Overall, our household survey found that farmers applied some sort of soil amendment to about 75% of their plots. They applied herbicides on 9.5% of their plots and pesticides on 3.8% of plots. To pay for farm inputs, some farmers take loans from the VSLA; others do masonry or carpentry work or sell poultry and other farm produce, such as maize.

Farmers often apply chemical fertiliser and manure to lands that are degraded and have lower soil fertile, particularly when the pattern or amount of rainfall is likely to impact negatively on crop yields and so applying chemicals will most likely significantly increase crops yields.

Farmers apply chemical fertilisers to all food crops except bambara beans. In both communities, they commonly apply them to maize plantations for improved yields. Maize is the most preferred staple food, produced by 98% of households in both communities. Although growing, the use of chemical fertiliser is lower in Tanchara than Ko. Many farmers cannot afford to buy chemical fertilisers due to low cash incomes and the high cost of chemical fertilisers. In Tanchara, farmers often use manure instead.

Farmers noted that there are positives and negatives associated with using chemical fertilisers, but also with manure. Case study farmers said that chemical fertilisers increase food crops yields but harden the soil and increase soil temperature compared to manure. Applying manure directly after ploughing, on the other hand, stimulates microorganisms in the soil and contributes to higher yields in the long term without using chemical fertilisers. But preparing and applying manure or compost is labour intensive. It can take up to six months or longer to produce compost from crop residues, household wastes, other organic materials, ash and animal droppings.

Farmers also noted possible synergies in using both inputs. Applying fertiliser on a maize plot and then planting other food crops — such as millet, sorghum and/or groundnuts — in the next farming season without adding fertiliser contributes to higher food crops yields due to the residual effects of the fertiliser and rotation. Our case study farmers told us that applying only manure is less likely to generate high food crop yields in the short term as manure requires both time and large amounts of water to release its nutrients and have an effect on crop growth.

Some households purchase herbicides to prepare their land for sowing. On a very few plots, households also apply insecticides to seeds to pre-treat bambara beans before planting them out, using hired labour which they pay for with VSLA loans. They use herbicides to kill grasses and weeds in the field for easy tillage. This speeds up land preparation, which helps adapt to reduced rainfall patterns. However, herbicide use also degrades or hardens the soil.

As noted in Section 2.2, hybrid/improved seeds increasingly popular in both study communities, particularly among male-headed households. During a focus group discussion in Tanchara, farmers said that they use improved/hybrid seeds to lessen the period of seasonal hunger. Planting fast-maturing varieties will reduce the hunger gap, which is particularly harsh in the rainy season. But the downside is that they have to buy new seeds every year.

Factors influencing a household's decision to grow improved/hybrid seeds include:

- The severity of the lean season at cropping time
- Their financial capacity to buy the seeds, and
- Their desire to ensure that they celebrate traditional harvest rites, as the improved seeds are not suitable to use in these.

2.5.3 Harvesting, processing, storage and marketing/sales

Farmers in both study communities tend to manually harvest their produce. Some manually shell their groundnuts before selling them in the local markets as they think that this increases their profits. Farmers usually dry grains, legumes and some vegetables before preservation and storage. They sell tomatoes immediately after harvesting, while other vegetables — such as okra and pumpkin leaves —they either sell immediately or dry for storage and future sale.

Households use many indigenous methods to prevent pest damage when they store their produce. For example, they use a local grass (*lodal/pieernatugu*) or oak (*kog*) bark, pounded into powder, to store groundnuts, cowpeas, maize, sorghum and some other grains and legumes. These local are more effective than modern insecticide powder or *yelle tieen*, but they are only used to preserve food grains. They are too bitter to use for leafy vegetable storage.

The increasing incidence of bushfires caused by hunting and farming activities makes it difficult to access *lodal* or *pieernatugu* grasses. And with shorter rainy seasons, the grasses dry up sooner. Many smallholders said they prefer using *lodal* and *kog* because the sources are known and locally available, whereas they have to pay cash for *yelle tieen*. Some farmers, however, have used *yelle tieen* when the local grasses and *kog* have been unavailable and as insecticides become increasingly available. They apply the chemical insecticide by mixing it with groundnuts, maize and cowpeas after they have been dried and put into sacks.

The chemical powder can only be applied to crop produce that is stored three months or longer before sale or consumption to prevent food poisoning. The farmers told us this precaution is widely practised after a whole family in Ko nearly perished after eating cakes made from chemically preserved cowpeas. Some of the case study households also mix fine sand or ashes with crops such as bambara beans and cowpeas after drying them and storing in pots. They sometimes store roots and tuber crops in special pits or sheds made from sorghum stalks. Households with more income purchase storage sacks for grain storage.

2.6 Occupations and livelihood activities

Smallholder farmers have several sources of income, including causal labour in and outside of their communities, remittances from family members and relatives and borrowing from financial institutions.

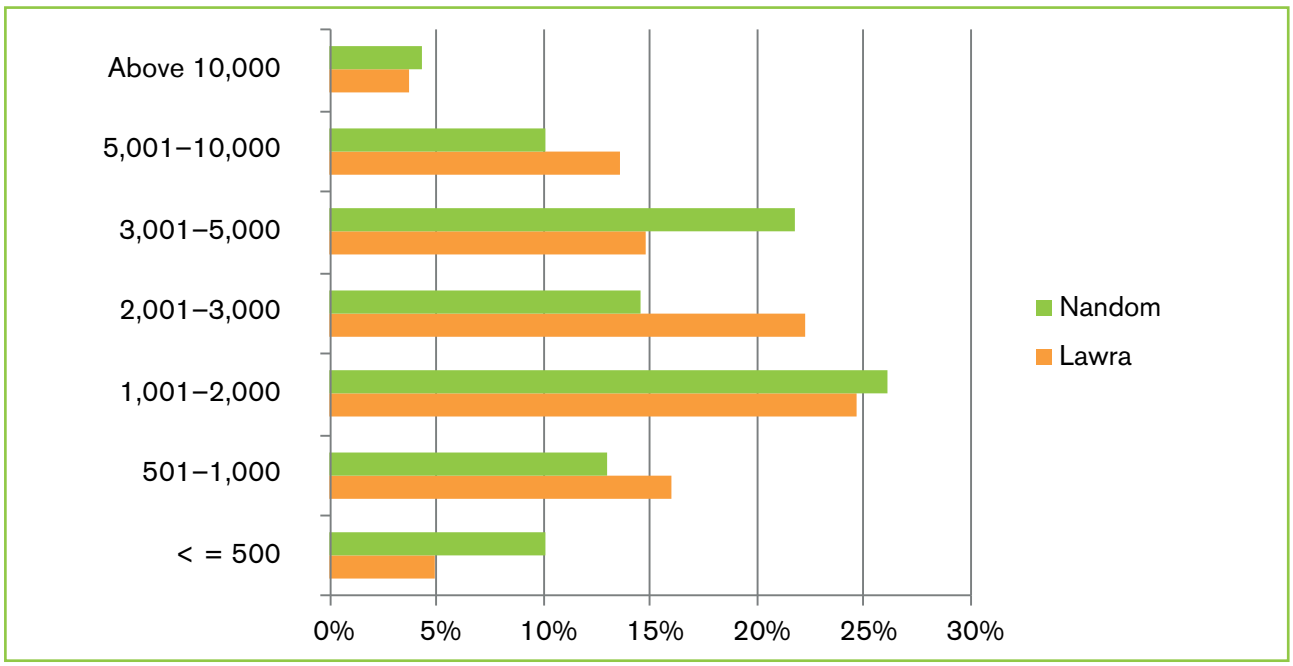
In both communities, some household members migrate for work to earn money to buy farm inputs for the farming season. Others engage in casual labour shelling groundnuts and building mud houses within their communities. But work in groundnut shelling has declined due to a fall in groundnut yields and production and out-migration among youths has therefore increased in the past 12 months.

Some people also engage in artisanal activities such as weaving cloth or baskets and harvesting calabash during the dry season. Households who engage in weaving sell an average of GHS900 in a year, with profits of GHS200 or more.

About 11% of household survey respondents said they get income from selling firewood. Only 5% receive remittances from family and relatives who have travelled to southern Ghana or get loans through the VSLA groups to fund farming activities. But 55% of respondents in Tanchara and 45% in Ko are members of a VSLA group; they use loans to satisfy households basic needs such as medication, clothing, and children's' education. Households can borrow GHSS100–700 from the VSLA, depending on their repayment ability. The repayment terms are usually three months, in cash, with GHS10 interest in local currency on every GHSS100 borrowed. Many households rely on VSLA due to easier access to getting loans. VSLA loans are of lower risk than formal financial institutions, where defaulters are prone to police arrest.

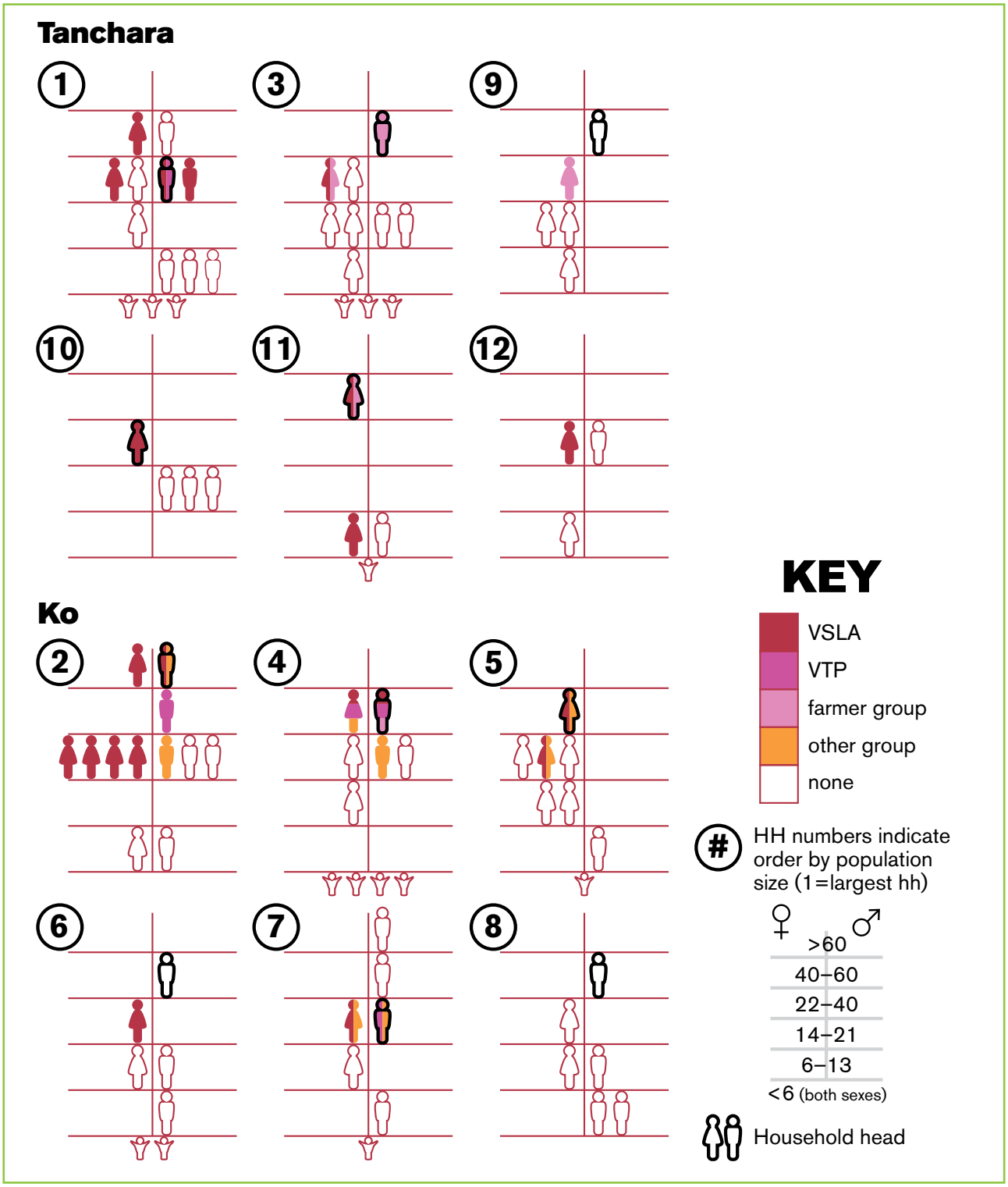
As we discussed in Section 2.3, cattle ownership has declined in both study communities. But despite the overall loss of cattle, households are better off in income terms and most have progressed from very low to low income levels. Figure 4 shows that the estimated annual income of 27% of households is GHS1,001–2,000, while 22% have an annual income of GHS2,001–3,000. Only 4% of farmers earn GHS10,000 a year. Farmers associated the changes in income levels to increased asset ownership with the availability of livelihood programmes/strategies.

Figure 4 Proportion of households by annual income category



Source: SITAM questionnaire survey (2017)

Figure 5 Household membership of groups



Source of data: SITAM household case studies (2018–19)

Figure 5 shows how our case study household members belong to several groups, including the VSLA, volunteer tree promoters, farmer groups and other groups. Most households belong to the VSLA and farmer groups. The case study farmers in Tanchara stated that they cannot access loans from financial institutions. Some households in Ko, however indicated that had access to loans from the Nandom Rural Bank.

2.7 Agricultural services

Our case study households benefit from formal agricultural services through a wide range of interventions carried out by governmental organisations and NGOs, including the MoFA, ACDEP and CIKOD Ghana. Projects include routine extension services, such as RESULT and FMNR.

The services of these organisations and departments offer are complementary. For example, many agricultural households have benefited from ACDEP and MOFA activities, which trained farmers in chemical fertiliser, herbicide and pesticide use. They have also benefited from the promotion of improved/certified groundnut, maize and soya bean seeds as well as techniques such as sowing in lines, both introduced by the RESULT project. ACDEP's RESULT project and CIKOD Ghana's FMNR project have both raised awareness of improved agronomic practices. CIKOD Ghana and MOFA have also trained farmers in agroecological practices such as making ridges and bunds in the land preparation stage and making compost to increase soil fertility.

2.8 Assets, income and food security

Household assets in both study communities include houses, livestock and poultry and arable lands. Some had other assets: bicycles (78%), mobile phones (78%), sewing machines (22%), televisions (13%), guns 13%, carts (5%), motorbikes (2%) and tricycles (1%). All survey respondents in both communities agreed that household assets have been increasing over the years and that inequalities in asset ownership have reduced in the last five years. They thought that most households had moved from the 'very low' to the 'low' asset ownership category in the last five years.

Our case study respondents noted that an increase mobile phone ownership among households in the 'very low' category, who five years ago did not have phones. Housing types have also changed, with more people living in houses with iron-sheet roofs, cemented walls and floors. This is now considered an indication of local wealth.

Although the evidence points to significant improvement in the annual income levels in both communities, Ko's estimated annual income is comparatively higher and more dispersed than Tanchara's.

More households are diversifying their livelihoods to increase their income levels. Most (62%) of smallholders earn money through selling their food crops, but other income sources include: selling firewood (11%), casual labour (8%), petty trade (7%), remittances (5%), charcoal (3%), selling livestock, borrowing food and money from relatives and friends, obtaining loans from a susu — a saving circle, or group support system whereby members collectively contribute an agreed amount of money weekly to support each other in a rotational manner — and getting credit from VSLAs. Many Farmer households engage in more than one of these income-earning activities.

About 26% of the farmer households spend their income on farm inputs, 20% use it to pay school fees, 15% to purchase foodstuffs for their households and 11% for other things.

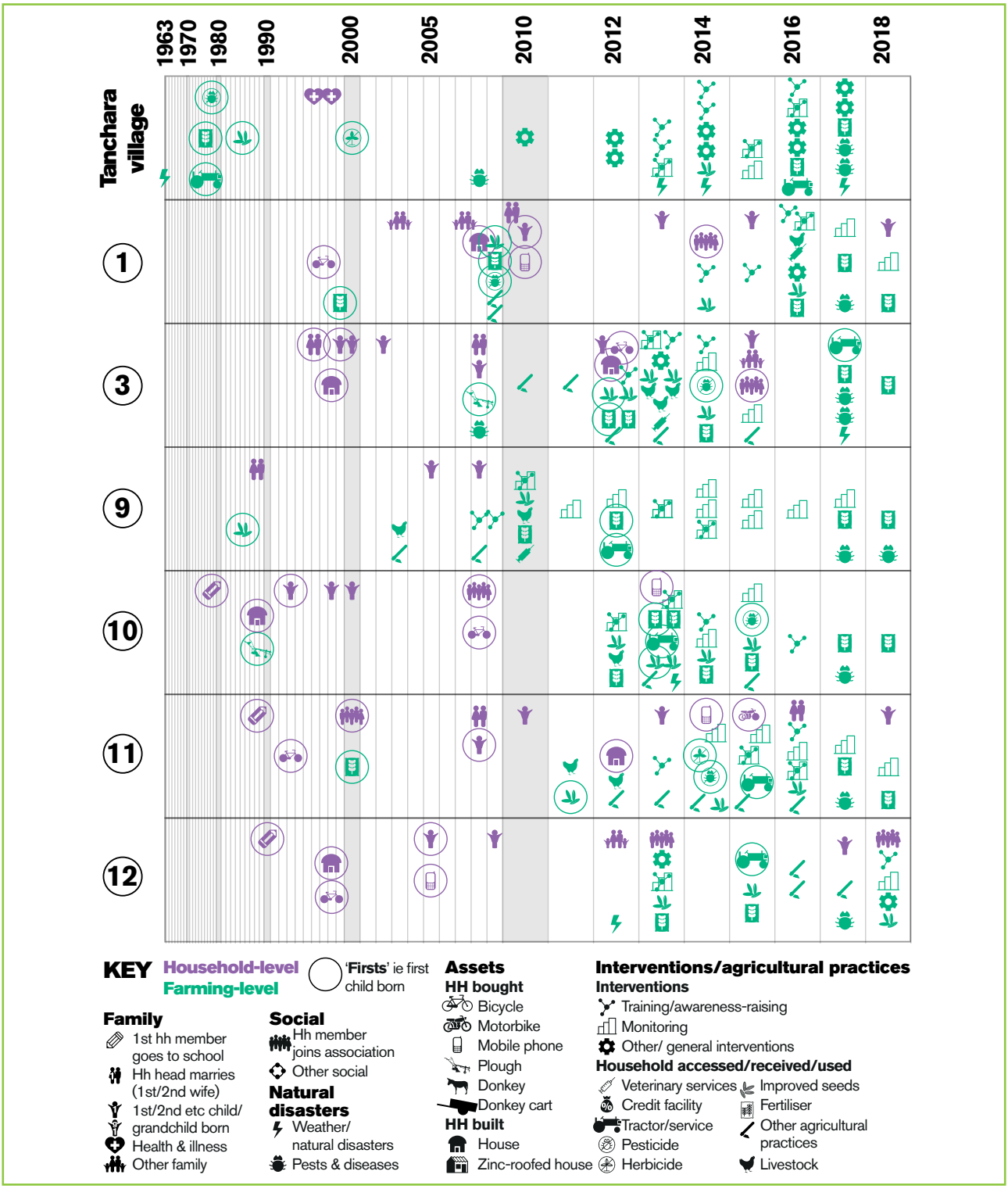
The study found differences in the levels of food security in the two study communities. For example, in Tanchara, about 77% of respondents think that food security problems have decreased in the past five years, whereas in Ko, 58% indicated no change in their level of food security.

But the study also indicates that more households are able to feed themselves from self-production. Another — perhaps a more significant — reason for improved food security is that more households get remittances from relatives who have completed senior high school or higher education and are now working in the formal sector.

During an exercise to validate the results of the quantitative survey, the farmer participants disagreed with the survey's findings of high incidence of food insecurity, saying these reports were exaggerated. They believed that the data underestimated the real level of food security. In the case study households, smallholders said that there are indeed more households that can feed their families throughout the year and that just a few are unable to do so. Figure 9 shows that households in Ko are able to feed their families for longer than their counterparts in Tanchara.

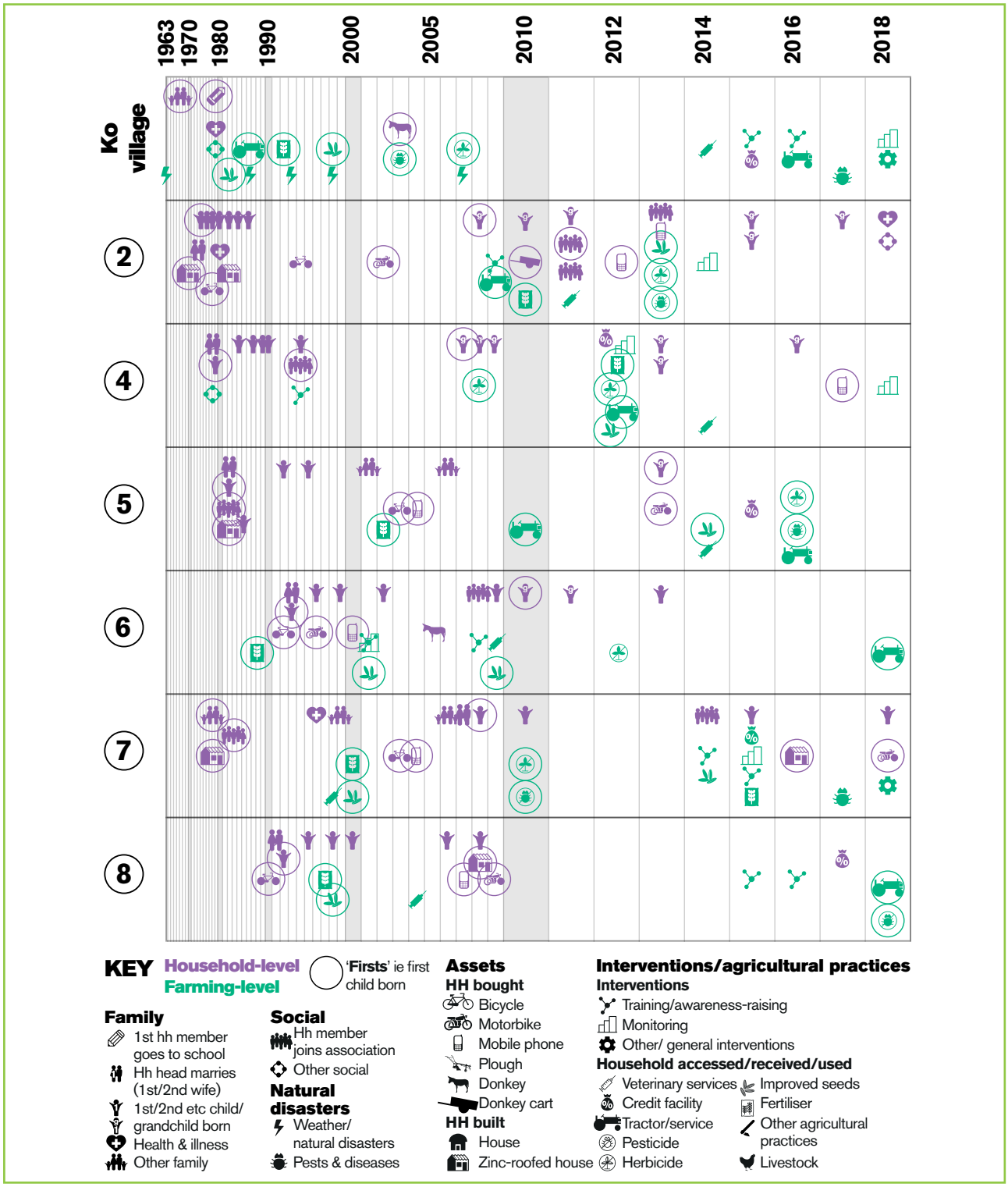
Overall, farm production lasts for an average of 9.75 months in Nandom, but only 7.5 months in Lawra. Around 25% of farmer households in Nandom can feed their families throughout the year but none of the Lawra respondents are able to do so. Almost half (48%) of Nandom households can feed their families with their own farm food for 10–12 months, compared to just 22% in Lawra, so Nandom is more food secure than Lawra. Respondents said that some households initially gave an estimate of their level of food security that was worse than their actual situation, because they anticipated that claiming a greater level of food insecurity might lead to increased support through project-based interventions.

Figure 6 Timeline of family and farming events in Tanchara at household and village levels



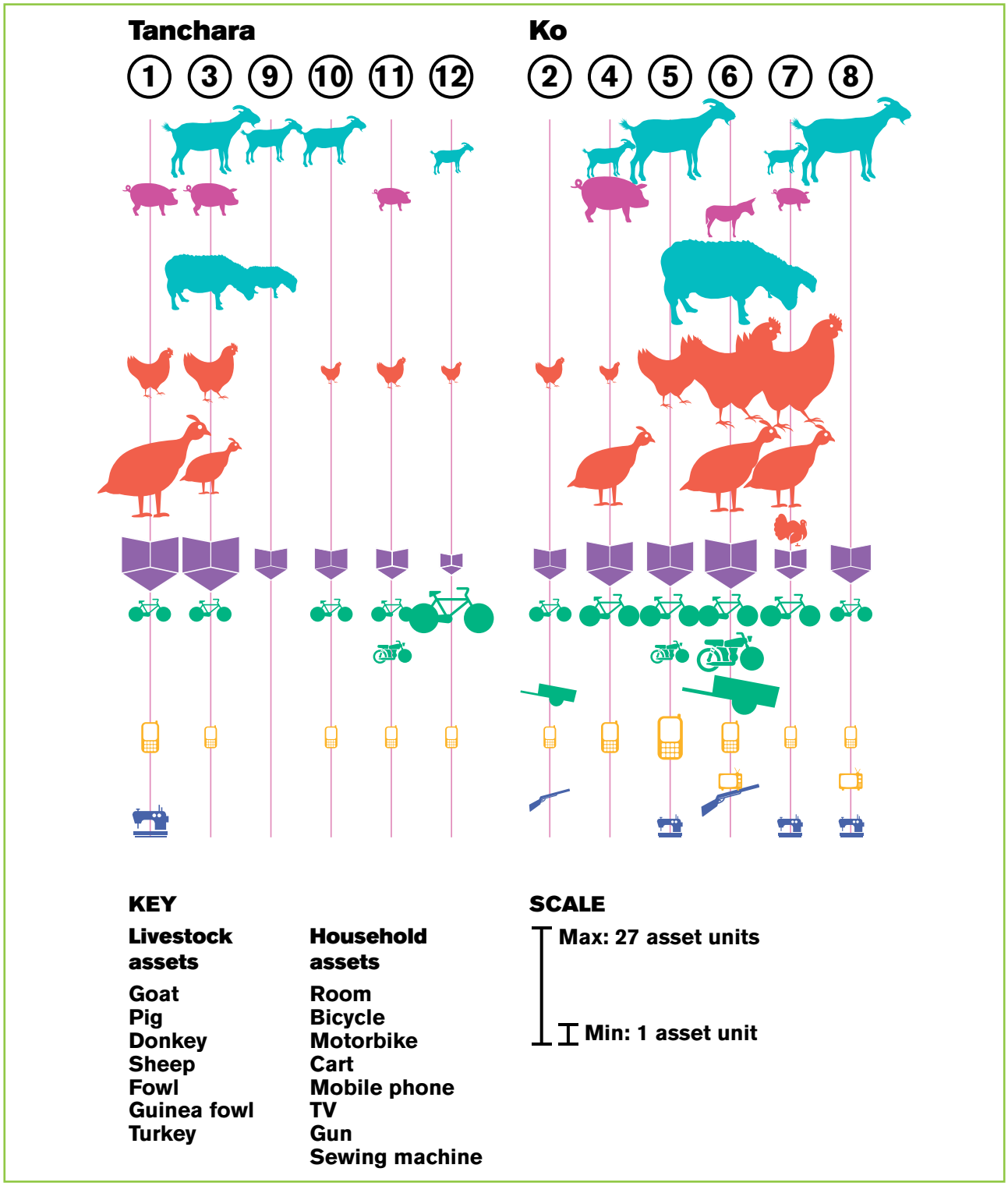
Source of data: SITAM questionnaire survey (2017)

Figure 7 Timeline of family and farming events in Ko at household and village levels



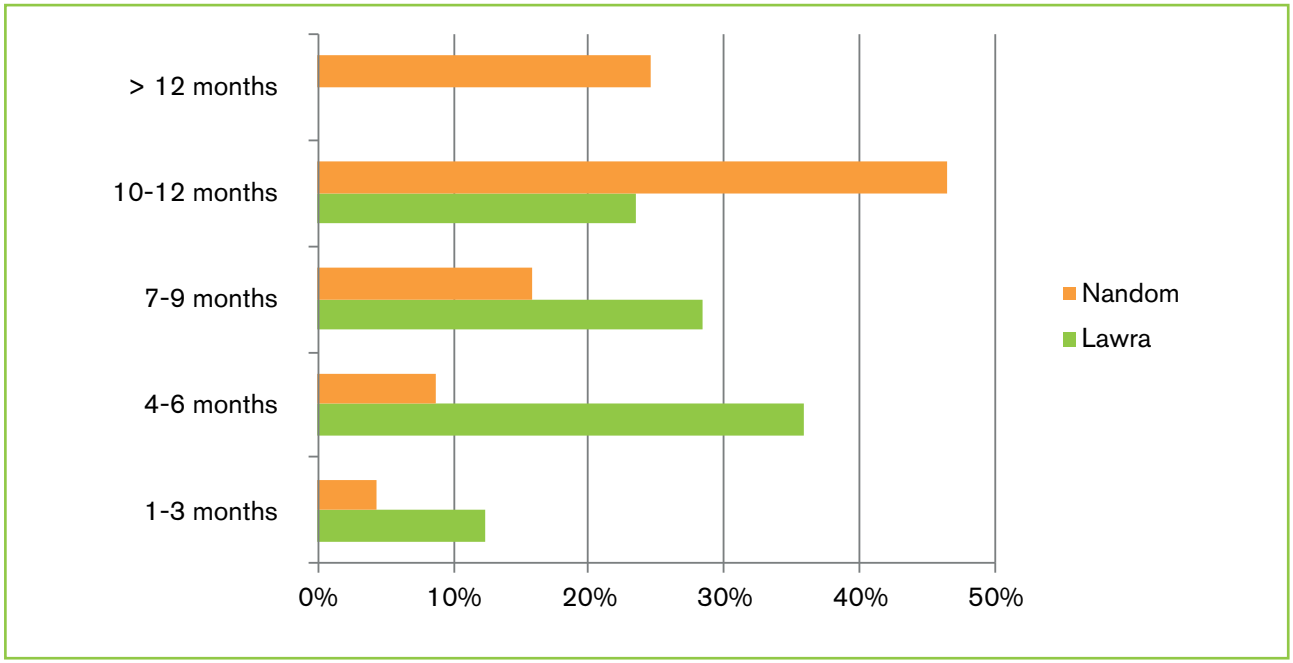
Source of data: SITAM questionnaire survey (2017)

Figure 8 Case study household assets (2017/18)



Source of data: SITAM questionnaire survey (2017)

Figure 9 Proportion of households by number of months they can feed their family with own farm food produce



Source: SITAM questionnaire survey (2017)

The household case studies indicated that food security levels vary significantly from year to year within households. In general, respondents indicated that food insecurity was most severe in 2013, with most households experiencing hunger from June to September in 2013. Only a few experienced hunger for the shortest period, from June to July. In 2017, another food-insecure year, many farmer households went hungry for longer than other years due to an armyworm infestation. Across all the case study households, farmers were relatively better off in terms of food security in 2014 and 2016. Respondents tended to witness variable increases in food production in years when they had enough labour and resources to invest in farming during the rainy season.

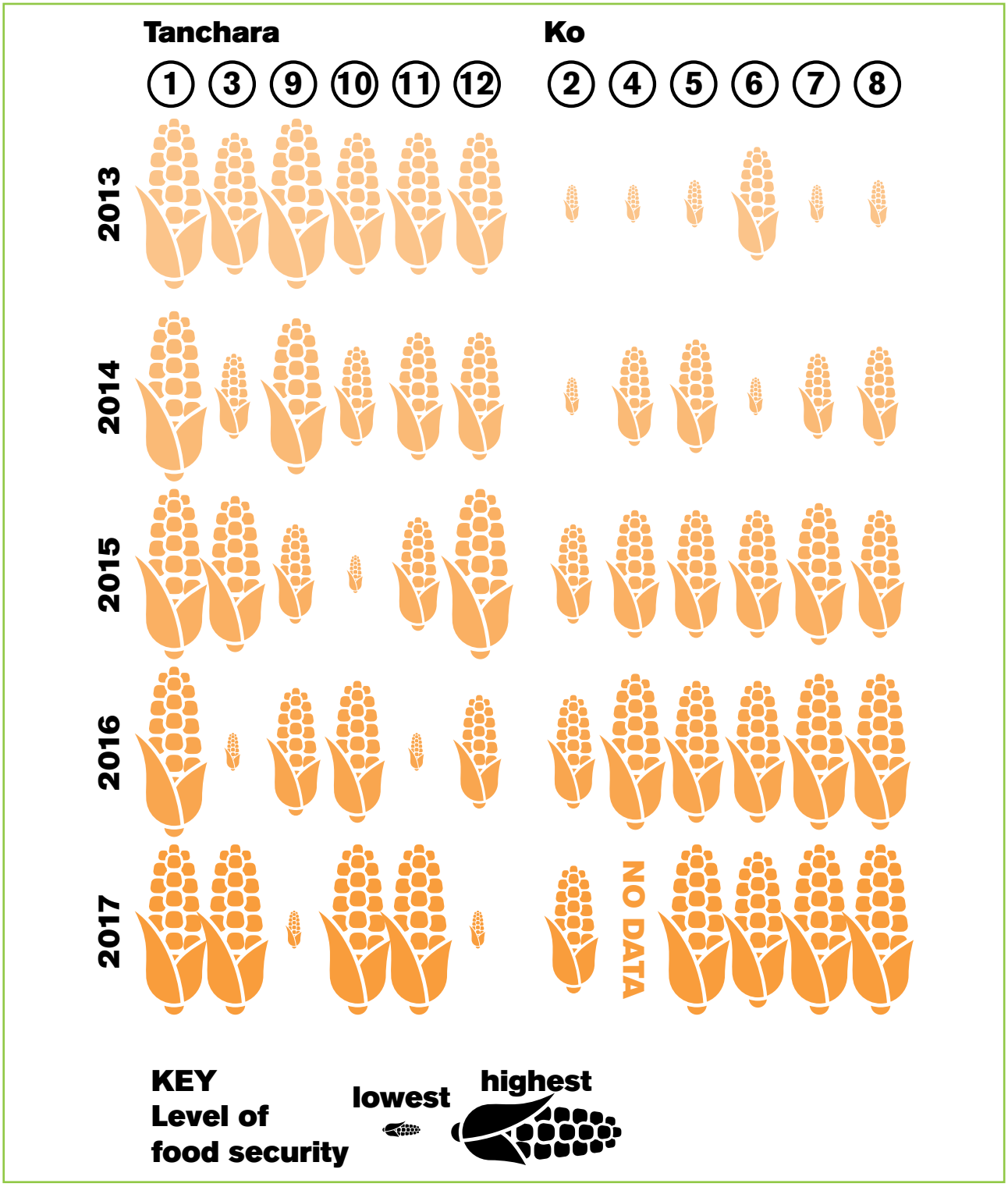
2.9 Social outcomes: coping strategies for hunger

Farmers devise diverse strategies to cope with hunger in times of household food insecurity. The most common strategy respondents cited was undertaking off-farm activities in the lean season. These ranged from casual labour and migration to borrowing food or money from relatives, friends and the VSLA. Times of food insecurity are often characterised by worries, reflection over food issues and a reduction in the amount of food consumed compared to times of sufficiency. De-facto female-headed households (case study households 5, 10 and 12 – the male head of the latter household has migrated) seemed to be comparatively better off in terms of coping strategies than the male-headed households. Of the 12 case study households, two of the three female-headed households interviewed did not have to resort to eating non-preferred food or smaller meals or skipping all meals in a day during the lean season.

Some respondents told us they had borrowed GHS100–500 from the VSLA and GHC50–80 from relatives and friends. They repaid monies borrowed from the VSLA through regular contributions and repaid relatives and friends with labour during the farming season. Women frequently borrowed foodstuffs from their brothers when food was short in their husbands' households.

Table 5 shows coping strategies by the 12 case study households, which included skipping meals, eating wild fruits and vegetables or using income from carpentry, masonry and other jobs. Our survey showed that in some farmer households, young and elderly adults even skip meals during lean periods — sometimes for full days — feeding only the children to ensure that their meagre foodstuffs last through to the times when green vegetables and leaves are available.

Figure 10 Relative levels of food security in case study households (2013–2017)



Source of data: SITAM household case studies (2018–19)

Table 5 Case study households' coping strategies during the lean season

HH NUMBER	MONTHS UNTIL OWN FOOD LASTS*	EATING NON-PREFERRED FOOD	EATING SMALLER MEALS	NOT EATING ALL DAY	OTHER COPING STRATEGIES
Tanchara					
1	Year-round	No	No	No	None; the household is food secure
3	Year-round	No	No	No	Reduced/skipped meals Depended on vegetables Borrowed food from a trader Household head migrated south to establish brother's farm Later received food from the brother in the south
9	February/ March	Yes	Yes	No	Ate wild and home-grown vegetables Borrowed GHS150 from VSLA Sold two sheep Sold groundnuts
10	Year-round	No	No	No	Worked for other people, weeding or fetching sand for construction Petty trading Sold animals to buy food they prefer to eat Borrowed GHS500 from VSLA Worked on other people's plots, weeding groundnut for money Sold some livestock
11	Year-round	Yes	Yes	No	Received GHS200 from brother in the south Borrowed GHS100 from VSLA Worked on other people's plots Depended on vegetables Reduced/skipped meals Borrowed GHS100 from VSLA Received food from brother in the south Borrowed food from nephew
12	March	Yes	Yes	No	Worked on someone else's plot in return for food Borrowed GHS100 from VSLA Received GHS250 from household head's brother Received food from husband in the south
Ko					
2	Year-round	Yes	Yes	Yes	Sold animals (eg poultry) Food support from the wife's family
4	Year-round	Yes	Yes	Yes	Loan from the Nandom Rural Bank to purchase food

HH NUMBER	MONTHS UNTIL OWN FOOD LASTS*	EATING NON-PREFERRED FOOD	EATING SMALLER MEALS	NOT EATING ALL DAY	OTHER COPING STRATEGIES
5	Year-round	No	No	No	Withdrawing savings from the Nandom Rural Bank to purchase food
6	Year-round	No	No	No	None; the household is food secure
7	Year-round	Yes	Yes	No	Borrowed money and food stuff from people Repaid it with social pool labour
8	Year-round	Yes	Yes	No	Borrowed through a Nandom Rural Bank susu saving circle Sold produce and livestock (goat/ fowls)

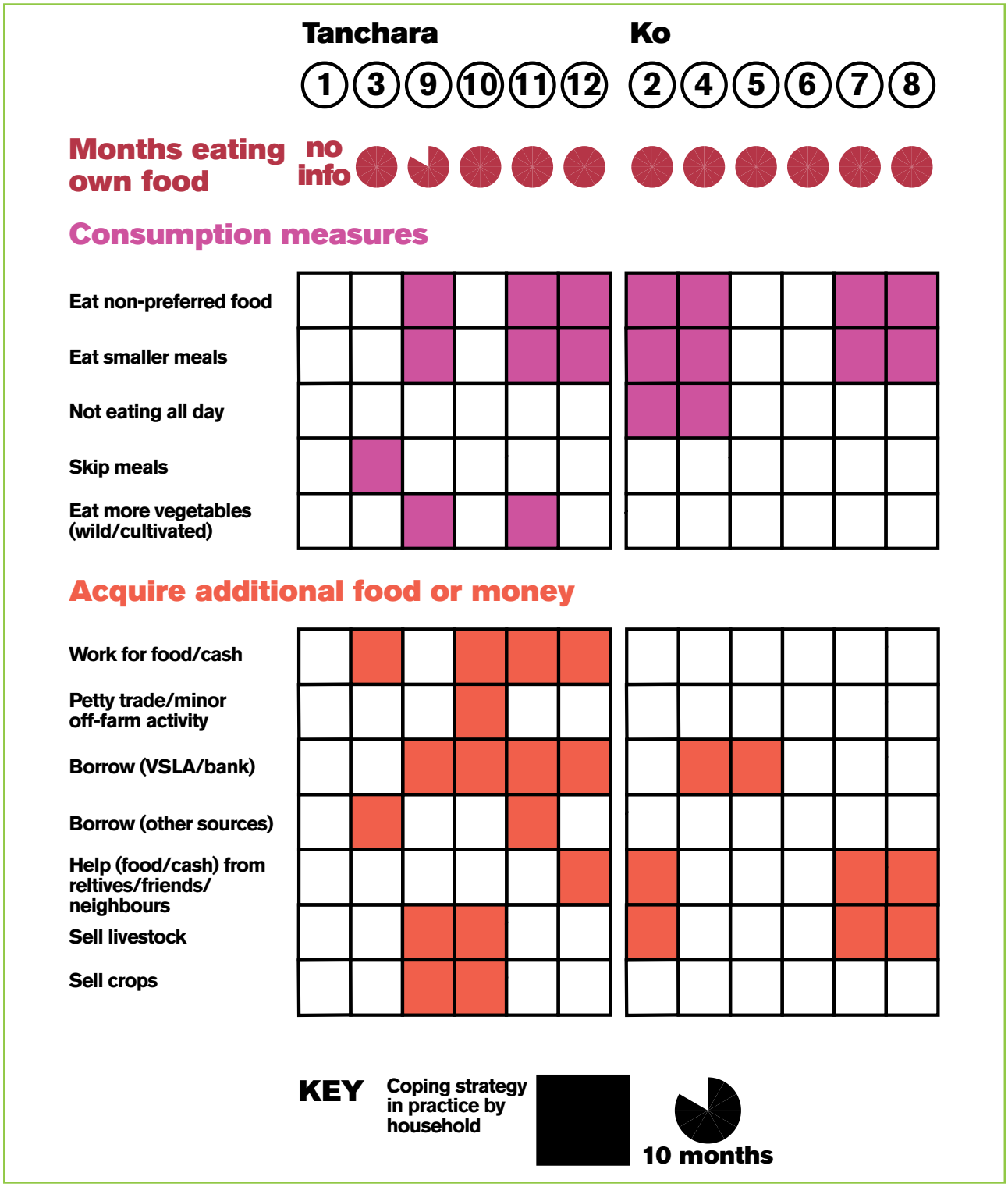
Source: Household case studies (2018–19)

Note: * When the household usually needs to find food from other sources — such as using money from remittances or off-farm activities to buy food, or asking neighbours and relatives for food — until the harvest, which is usually in April/May. Most households do this year-round

Figure 11 shows that households combine strategies in the lean season to buy food or money. The most prevalent strategy is borrowing money from the VSLA or bank to buy food from the market or neighbours. The next most common strategy is selling livestock to buy foodstuffs and getting help from relatives and friends.

More households in Tanchara need to buy food from the markets compared with Ko, where a greater number of households can rely on their own food production. Both male and female-headed households buy food during the lean season. The lean season sometimes coincides with the ripening of wild fruits and vegetables, such as *jankgoro*, a wild leaf vegetable commonly eaten in both communities. Households pick and boil these vegetables for the adults to eat. Relatively better-off households save income from crop sales in years of bumper harvest and use this to buy foodstuffs in the lean season.

Figure 11 Case study households' coping measures



Source of data: SITAM household case studies (2018–19)

3

Farmers' perception of sustainability

The study also explored farmers' perceptions of the economic, social and environmental considerations of SAI. We look at whether they think productivity has increased, what they think about the profitability of farming, the value addition to farm produce and selling and marketing the produce. On the social side, we consider whether SAI has increased human wellbeing, reduced inequalities including the gender gap and preserved traditional knowledge. Finally, we examine farmers' perceptions of the sustainability of natural resources, including trees, soil, water and grazing lands.

3.1 Economic dimension of sustainability

3.1.1 Increasing crop production

Our respondents indicated that the sustainability of an increase in crop production is unpredictable due to changing rainfall patterns, external input-intensive production, declining labour size and continuous cropping on single arable lands. Crops yields fluctuate over the years as yields of common crops such as maize and groundnut are vulnerable to rainfall patterns and the nature of the soil.

We found that 73% of all farmer households in both study communities — 77% in Ko and 69% in Tanchara — have continuously cultivated food crops on their farmlands for more than 20 years. Our case studies farmers revealed that their production expectations vary from season to season and have either not been met or only partially met over the years. Male youth-headed households were more likely to say they are sustaining production and have often met their production objectives than female and elderly male-headed households.

Farmers' production objectives cut across social, economic and environmental dimensions and included:

- Harvesting enough to feed the family
- Storing seeds for the next farming season
- Selling foodstuffs to recover production costs
- Settling debts
- Meeting other household needs
- Using income from sales to buy inputs for the next year's production
- Cultivating in other family plots to safeguard them
- Using part of the harvest for traditional rites, and
- Sharing with neighbours.

One female-headed household told us: "Our expectations for the production last season were to harvest enough food, get seeds to store for the following cropping season [2019], sell some to cover the expenses we incurred during the [2018] cropping season, meet other household expenses such as the renewal of health insurance for members and to sell and pay back the monies we borrowed to support production. But the yields were poor, especially groundnut. We could not even sell to cover the costs we incurred in production nor to pay off the debt we owned." (Household 12, female-headed, Tanchara, 2019).

Another (male-headed) household explained: "…we farm to feed the family, to sell some to support family's health issues and pay for children's school fees. We could not meet all the previous year's farm objectives because we did not have surplus food produce to sell, though we got some to eat. So, we did not sell any of

our foodstuffs because we were afraid that we could run out somewhere along the season. But we were able to prepare our plots, weeded them well, used the crop residues for ridge preparation and bought and applied some fertiliser..." (Household 2, male-headed, Ko, 2019).

Despite having different expectations, the most common objective is to feed their families: "The households' major production aim is to feed their families. This is more important than education and other [aims] because a hungry person is a mad person." (Elderly farmer, Household 6, Ko, 2019).

However, farmers perceive that, with a reliable rainfall pattern, it is possible to sustain an increase in crop production largely through the sustainable application of compost/manure, good crop management, weeding, using earthen tied ridges or bunds, planting or sowing two or three seeds per hole, adequate spacing out of crops, crop rotation, having available labour, and planting in lines that are vertical to the windward side. Farmers also noted that having additional plots/arable land for alternative cultivation and tricycles/wheelbarrows to help transport compost to farmlands would enable them to practice fallowing and sustain an increase in production. Farmers in Ko said that production had increased since adopting good agronomic practices such as routinely applying manure, compost and chemical fertilisers and early control of weeds on their compound farms.

3.1.2 Increasing livestock production

Respondents in both communities were doubtful about whether they can increase and sustain livestock production because of rising theft, yearly outbreaks of livestock diseases, livestock deaths, improper housing/pens for livestock and a lack of accessible veterinary services. But they acknowledged that sustaining livestock production would help improve food crop production, allow them to continue performing traditional funeral and marriage rites and provide a coping mechanism (selling livestock to buy foodstuffs) during the lean season

The decline in livestock production shows that traditional livestock practices are unsustainable. The decline has decreased more sharply in Tanchara than Ko, although both communities face similar challenges. Sustaining an increase in livestock production requires continuous feeding and care, especially during the dry season, when animals are more prone to theft. Respondents indicated that they cannot afford to invest in disease prevention, parasite treatment, other health issues or improvements in animal housing.

3.1.3 Profitability of farming

In both communities, farmers said it was difficult to get high profits from farming because production practices are input-intensive. Hiring labour and/or animal traction services to prepare their land is also expensive. Households that engage only family labour throughout the production process achieve higher yields per hectare compared to farming households that hire labour to harvest their food produce.

Respondents indicated that they often incur losses when employing the services of hired labour due to the cost involved in providing food for labourers. Households that hire in labour to complement their immediate family labour said that they had to sell their produce immediately after harvest, when prices were low, to pay their labour costs. There have also been incidents of produce theft among the hired labour, especially where there is no strict monitoring in the harvesting process.

Overall, the decline in family sizes, a declining interest in farming as a livelihood, particularly among children enrolled in formal education and out-migration all hinder farmers' ability to gain higher levels of food production at the end of the growing season.

3.1.4 Adding value to farm produce, marketing and sales

Almost all households sell their farm produce without adding value. Only a few add some value to their produce — for example, they tend to shell groundnuts and bambara beans prior to get a higher price per unit measure. They dry some vegetables to increase storability.

Households do not frequently sell foodstuffs such as maize and millet, with sales of these food crops usually restricted to surplus and mostly at the end of the year. They usually store foodstuffs as insurance against food shortages during the lean season. Most selling takes place at the farm gate or in local markets. In Ko, households mostly sell their produce at the Nandom Tuopare market, especially 'dorado' sorghum in April and May. In Tanchara, households mostly sell their food crops to traders in the Babile market, without adding value to it. Sales happen at different times of the year, depending on a household's cash requirements.

The more commonly sold food crops include groundnut and 'dorado' sorghum. There is higher demand for these crops, especially dorado, which is used for pito brewing and to a lesser extent in traditional ceremonies. Farmers only tend to sell other food crops — such as cowpeas, bambara beans and local potatoes — when there is enough surplus. They sell little guinea corn sorghum and millet due to their traditional value for ceremonies and preferred food preparation.

Respondents use income from food crop sales to pay for health insurance renewals, school fees, transport repairs, chemical fertilisers and other farm inputs or to pay hired labour. But they tend to only sell produce when they anticipate a surplus at the end of the year.

3.2 Social dimension of sustainability

3.2.1 Increasing human wellbeing

Despites the fluctuations in food crop production, several farmers perceived continuous improvement in their households' wellbeing over the years, manifesting a willingness to support other needy households in periods of food shortage. One farmer from Tanchara recalled giving 50 of the 150 tubers he harvested to friends and relatives. Other households gave food (for example, one bucket full) to needy households, especially those whose members had helped them with the harvest. The most commonly shared foods were bambara beans, cowpeas, yams, groundnuts, guinea corn and maize. Respondents also anticipate that the increased use of modern farm inputs will improve wellbeing levels, especially in those households that can afford chemical fertilisers.

3.2.2 Gender gap

Female-headed households are disadvantaged in agricultural production in several ways, including their lack of adequate income to hire tractor services. But despite such setbacks, two out of our three female-headed case study households indicated can feed their households throughout the year using their own production. Women's ability to sustain production, however, is often dependent on their ability to hire labour for land preparation and crop management in the absence of immediate household labour. We found from the questionnaire survey that 95% of female-headed households depend on the hoe for land preparation and only 4% hire animal traction for land preparation. Many are afraid of hiring tractor services and making payments at the end of the season for fear of defaulting. So, they tend to favour less capital-intensive production.

Most women farmers are wives and members of male-headed households. They have to work on the household's farms as well as their individual plots. In both male and female-headed households, most women have access to family land but do not have control over their usage for seasonal production. The household's labour force helps to weed all the household farmlands. After the initial land preparation, this work is mainly done by the women and children.

Overall, however, our respondents from female-headed case study households anticipated an increase in food crop production through their access to VSLA loans VSLA and income from groundnut sales.

3.3 Environmental dimension of sustainability

3.3.1 Tree cover in the study areas

In both communities, the vegetative cover has declined, although the number of trees per acre on farmlands varies considerably across households. Farmers manage trees on their farmland to improve the vegetative cover and soil fertility for crop production. Ko has a higher density of trees on it farmland (82–191 trees per acre) than Tanchara (12.5–87.5 per acre), where low tree regeneration rates are the as a result of regular slash and burn practices in the past. Average plot sizes in Ko are 5.5 acres; in Tanchara, they are 4 acres. Our respondents are hopeful that vegetation cover will improve.

Common tree species include teak and neem (mostly not on farm plots), ebony, shea, *Dawadawa* (locust bean) and *Faidherbia albida* (apple ring acacia). Benefits to farmers include edible fruits, branches for roofing or to stake yams, animal feed and fuelwood. Farmers do protect trees on their farmlands but they also consider them to be obstacles to land preparation, particularly when using tractors. It is difficult to plough by tractor where there is a high density of trees as these areas have to be worked manually. The time and effort needed to prune trees and bylaws on indiscriminately cutting down trees and clearing vegetation also make it harder for farmers to cultivate new farms.

3.3.2 Soil

Soil types in Tanchara's farmlands vary across the various neighbourhood sections that compose the community. Some have predominantly clay soil with traces of gravel, while others are characterised by loamy soil with adequate humus for crop production. In Nandom District, the soil is generally a mixture of loam and clay, with traces of gravel.

In both Nandom and Lawra districts, our respondents noted that the soil fertility levels have decreased due to continuous plot cultivation without fallowing and low application of manure/compost. They also anticipated that soil fertility would decline further unless they intensify agroecological practices. Although some farmers could allow their farmlands to fallow, they cannot always do so because they allow other households with limited arable lands to farm them. Social norms dictate that they cannot deny their friends and relatives space to grow crops — as one respondent told us: "one cannot have food while one's relative dies of hunger". They believe that land is food, as it is the means for growing food crops for consumption.

Farmers in both communities manage soil nutrients with manure and compost produced from crop residues and use ridges and bunds to conserve water in the soil,

retain nutrients to improve on the soil fertility and prevent erosion. They also use FMNR methods for improving soil moisture retention. Although households in both study communities think that preparing ridges and bunds are useful for conserving water and soil nutrients, their household labour pool is shrinking — and there are fewer youths and other people available to form a social labour pool. At the same time, low incomes and insufficient food crops also limit households' ability to pay and feed hired labour to build ridges on their land. Some farmers have had to stop using ridges and bunds, as they plough with animals and/or tractors for timely land preparation. They put out bushfires in their farmlands to prevent crop residues from being burned, as they help create partial soil cover, which conserves moisture in the soil.

3.3.3 Livestock grazing lands

Our study found a decrease in pasture lands, especially within settlements, due to the concentration of farming activities within them. Generally, neither district has any specific communal grazing land set aside for farm animals. Instead, livestock can graze on all uncultivated land where grasses abound. In the wet season, livestock are controlled to prevent them from grazing on cultivated lands. They also graze on crop residues after farmers have harvested and gathered the crop residue they need for compost preparation. Most pastures in both communities are unsuitable and inadequate due to the drying up and occasional fires that that burn grasses.

To prevent their livestock from moving further distances to graze — for example, to low-lying areas such as rivers, valleys and along major water bodies, which often leads to theft — some farmers gather and dry the residues of leguminous crops such as cowpeas and fresh groundnuts from their farmlands as fodder. But this is both labour intensive and time consuming and farmers cannot prepare fodder in large quantities. As a result, they either reduce the number of animals they rear so they can feed them and keep them safe or they rear them in the free-range system, where they graze on the outskirts of their communities, increasing the risk of loss or theft.

3.4 Farmers' environmental, economic and social objectives

Farmers want to maximise production for consumption and sale to generate income while also minimising the costs land preparation. For farmers who rely on family or social pool labour for land preparation, hiring a tractor for this job to be a costly alternative. Instead, they rely on family, social pool or hired labour (paying in cash or cash with food and drinks).

Households aim to achieve timely land preparation and crop planting to meet the variations in rainfall patterns. So, they start preparing land from the onset of the rains, focusing on farming rather than off-farm activities during the raining season. They often also opt for ploughing flat with animals or tractor, then plant in lines and make ridges during weeding, shifting earth from the centre of a row against the plants to cover weeds and prevent the crops from falling due to rain and wind. Because they have limited access to tractor services and cattle for traction, some farmers form small social labour pools to help speed up farm operations on each other's land.

Farmers also want to maintain their traditional and cultural values, including:

- Growing crops and rearing livestock and poultry to perform traditional rites such as funerals
- Households with more farmlands allowing those with less/no farmlands to cultivate them
- Sharing crop production with the needy during and after harvesting
- Collectively helping physically weak or disabled people in the community on their farms.

They also wish to maintain and protect local/traditional seed varieties so they can continue to produce in the event of shock, as they have no control over the production and supply of improved and hybrid seeds. They see traditional or local seed varieties as more resistant to drought during production and to insect infestation when stored.

Farmers also expressed an interest in conserving biodiversity on their farms and in the soil by practicing FMNR, using manure/compost and adopting other agroecological techniques.

Households seek to maximise crop production by increasing livestock production and exploiting forward and backward linkages between crops and livestock. Crops provide forage for animals, which helps improve animal production, while more animals generate more manure, which can be used to increase crop production.

Finally, they seek to build synergies by investing in their children's education now in return for future contribution of knowledge and income/remittances that will improve food production and security.

4

Managing competing objectives: trade-offs and synergies in SAI

4.1 Definitions and framework

For the purpose of the SITAM project, we define a **trade-off** as "a compromise between two desirables but to some extent incompatible, objectives". Managing trade-offs is about maximising the overall level of achievement. **Synergies** exist where the achievement of one objective enhances the achievement of another. The overall achievement is greater than if the two had been unrelated. The aim of farmers' livelihood **strategies** is to maximise synergies and minimise trade-offs, within the confines of the resources available to them, including their own knowledge and understanding.

To analyse trade-offs, we used the Sustainable Intensification Assessment Framework (Musumba et al. 2017) shown in Table 6. The framework differentiates between trade-offs within and across social, environmental and economic sustainability domains and across, spatial scales, time and farmer types. It enables us to present trade-offs in a systematic way, showing the competing objectives for each one.

Table 6 Types of trade-off and synergy

CATEGORY	DECISION	EXAMPLE TRADE-OFF	POTENTIAL SYNERGY
Within a domain	Land allocation	Legumes v maize	Intercropping increases harvest for both
Across domains	Crop residues	Fodder v soil fertility	Integrated system with effective manure use
	Level of input use	Production v pollution	Fertiliser stimulates improved soil carbon cycling
Across spatial scales	Land use – intensification or extensification	Farm-level profitability can lead to landscape level habitat loss via agricultural expansion	Investing in diversified agriculture expands habitat (land sharing)
Across time	Time preference in soil management	Immediate gain and long-term loss v short-term loss and long-term gain	Multipurpose legumes for food, fodder, fuel, income and / or soil fertility
Across farmer types	Community grazing norms during dry season	Crop growers control residues v herders with free access	Manure from herders enriches soils of farmers

Source: Musumba et al. (2017)

4.1.1 Household characteristics

Our survey found that the age composition, level of education and income sources of farmer households across both study communities are quite diverse. Generally, they have an active labour force, commonly aged between 22 and 40, who are directly involved in farming and other livelihood activities. They also have students/pupils in formal education and dependants who have no role in production or a job elsewhere.

According to the questionnaire survey, which included a representative sample of households, farm households in Tanchara are larger in terms of having more dependants and a bigger active labour force than those in Ko. In Tanchara, households had an average of seven dependants and 17 household members directly involved in production. Households in Ko, on the other hand, had an average of one dependant and two active persons directly involved in farming and other livelihood activities.

The increasing shortage of labour for agricultural activities in smallholder farmer households is observable in the number of persons enrolled in formal education. Figure 12 shows that most of the case study households have at least one child enrolled in formal education. Comparing household sizes with the number of children enrolled in formal education, we found from the wider questionnaire survey that households in Ko have more children enrolled in formal education than those in Tanchara.

For instance, of the average five persons per households in Ko (Nandom), three children are enrolled in formal education. In Tanchara (Lawra), an average of six children are enrolled in formal education out of the average ten persons per household. So, Tanchara (Lawra) households are mostly composed of active labour force, students and dependents, while in Ko (Nandom), they are more students, active labour force and fewer dependents.

Household income sources are diverse, cutting across agriculture, petty trading, skilled/hand work and formal sector employment. The wider survey showed that most households are either engaged in agriculture production as their sole source of income, or they combine agriculture production and petty trading or agriculture production and skilled activities such as sewing, tailoring or weaving. Some household members migrate seasonally to southern Ghana for work.

Households make different decisions in terms of food crop production. Cereals are the most popular crop, followed by legumes and vegetables. Some households cultivate roots and tuber crops but not many grow cash crops due to the climatic conditions.

The questionnaire also showed that most farmers in both study communities cultivate multiple crops per plot, though the kind of food crops they produce varies between communities and across gender and age. Households in Tanchara, for example, cultivate more cereals, while in Ko they grow more leguminous food crops. Figure 13 shows the mix of crops our case study households grow.

4.2 Farm and household-level trade-offs and strategies

In this section, we present the trade-offs based on household histories and experiences on farming activities over the years, exploring in depth some of the decisions made by our case study households and the factors that influenced them. Due to the detailed nature of the data we collected, we cannot present all the households individually. Instead, we selected four case studies to show the differences in decisions, characteristics and influencing factors: two from Ko and two from Tanchara. Annex 2 shows the ten trade-offs and synergies we identified across the 12 case study households, where objectives were compromised and/or enhanced for the achievement of others.

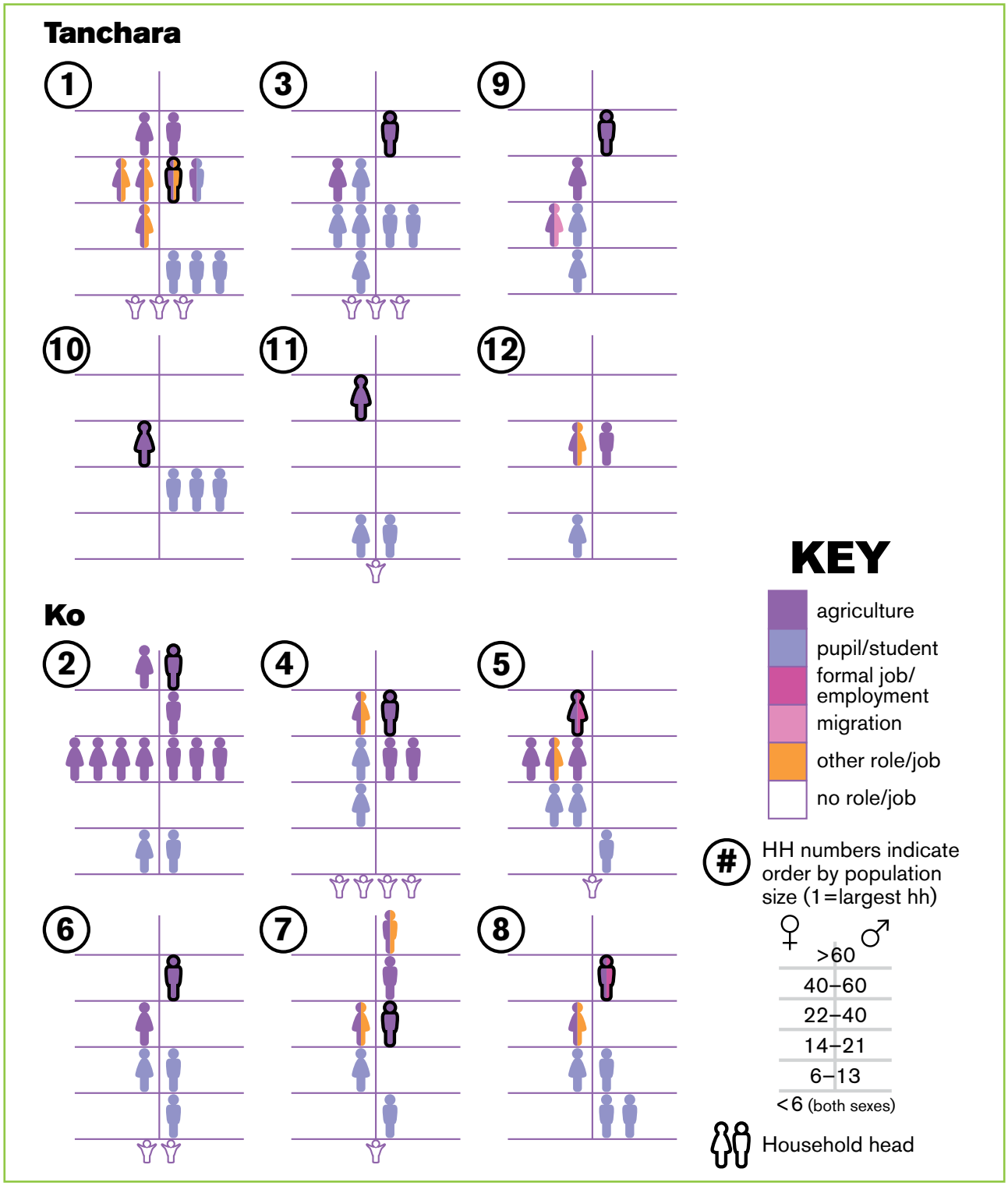
We found that farmers prioritise some objectives, either implicitly or explicitly. In the short term, there is a tendency to prioritise economic outcomes (food security and income) over environmental ones (biodiversity conservation, soil fertility, tree cover and so on).

4.2.1 Case study household 1 (Tanchara)

This male-headed household has ten members who live permanently in the village: the head, his mother, his wife, his brother, his four children and two nephews. Another ten household members have migrated south but come home occasionally. At the time the case study was carried out, there were normally 13 household members present in the village. The household acquired a bicycle in 1997, built an improved house in 2008 and got a mobile phone in 2010. The first household member enrolled into formal education after Ghana's independence in 1957 and their first formal sector employment was in 2000. They experienced drought and famine in the 1960s, floods in the 1960s and 70s and armyworm damage in 2017.

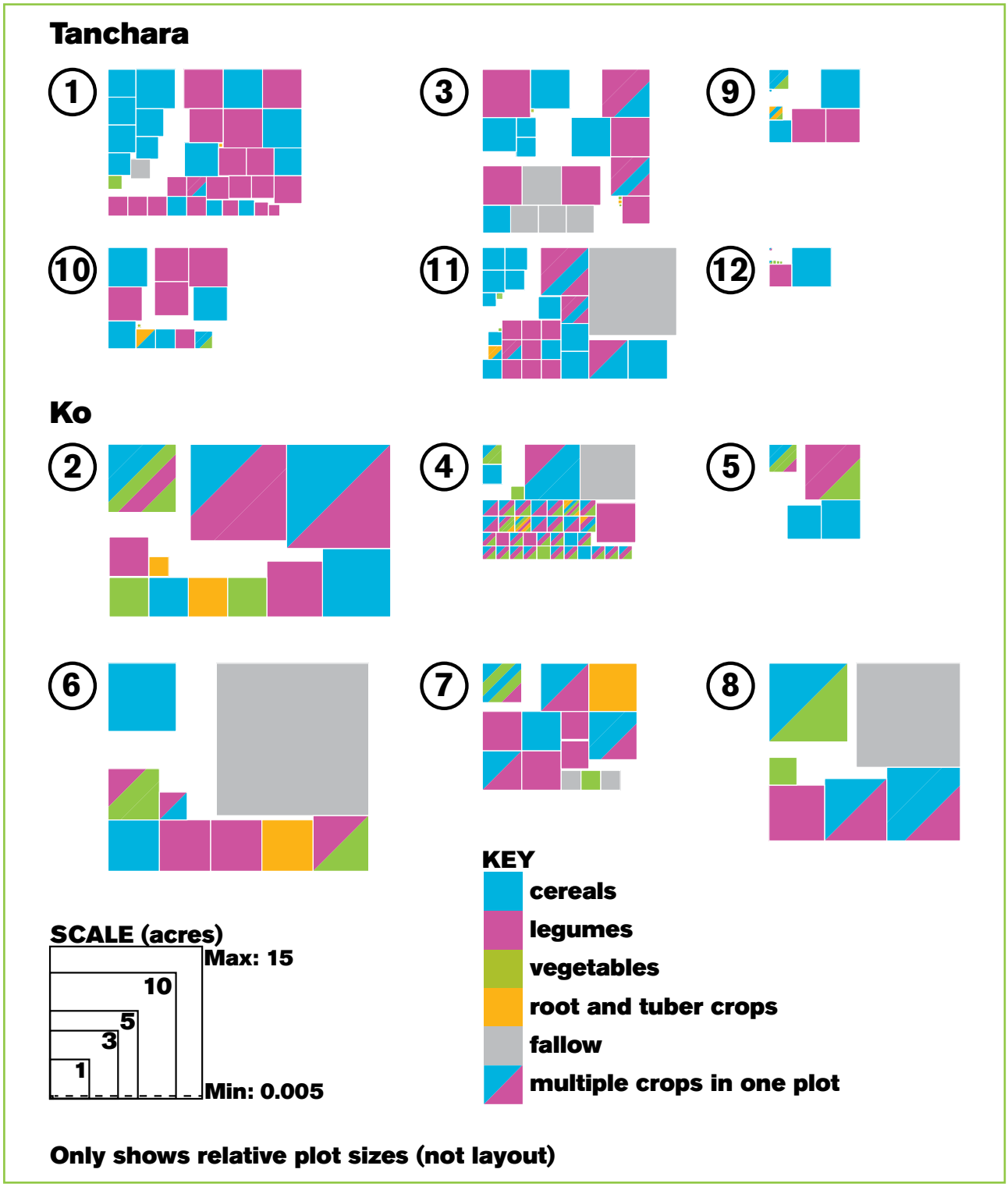
They have never hired tractor services to ploughing their farmlands. They used chemical fertilisers for the first time in 1999, almost exclusively on maize fields, to increase yields. They have never used herbicides for weed control. They started using pesticide in 2009, when they planted new cowpea varieties to prevent insect infestation.

Figure 12 Demographic characteristics of and occupations in case study households



Source of data: SITAM household case studies (2018–19)

Figure 13 Crops grown by case study households



Source of data: SITAM household case studies (2018–19)

As well as food crops, this household also grows groundnuts as a cash crop, mainly to pay educational expenses. Household members did most of the land preparation and planting in the last season, with hired and social pool labour doing a small proportion of ploughing, weeding and earthing-up work (building ridges or bunds). The household uses crop residues to make compost, layering groundnut, maize and sorghum residues in a pit, adding ash and water and then turning the pile from time to time to ensure proper decomposition. In 2018, they produced and applied about 50 buckets of compost/manure.

The household used to clear and burn grasses on their lands, but they stopped doing so to improve the level of organic matter in the soil and increase yield. Although they rotate crops and use residues on all their plots, compost/manure application depends on the quantity they have available, the type of crop they are planting and existing levels of plot fertility.

The household has changed the crop varieties they grow, planting both indigenous and new improved seeds. They grow the former for cultural or social purposes and the latter for early maturity to adapt to changes in the rainfall pattern. They have also changed their planting methods, increasing the space between plants and adding fewer seeds per hole. In the last season, they bought fertiliser, improved seeds and pesticides to apply on improved cowpeas.

The household head also earned income from masonry and carpentry work and selling poultry and maize. Their cropping decisions and methods of planting were influenced by external sources of information from CIKOD, MoFA and ACDEP. To meet their targets in terms of number and size of plots and types of crops to cultivate, the household head recently stopped his other jobs to focus on farming. He devoted all his time to farming, working on the farm in the morning, resting in the afternoon and working again in the evening. He now focuses on farming in the rainy season and masonry, carpentry and poultry trading in the dry season.

4.2.2 Case study household 4 (Ko)

The household head told us that his family settled in Ko a couple of generations back. He also told us that the community's full name is Lang-Ko which means 'come'. The household consists of the head, his wife, six children and six grandchildren — not all of whom lived in the village when the case study was carried out. The growth of the family through marriage and birth is one of the main changes in their household over time. Both the household head and his wife are members of the Nandom Farmers' Cooperative.

No one in the family is engaged in any off-farm employment. The household head was the first in his family to have received formal education and theirs was the first household in the village to have built a house with a zinc roof after Ghana's independence in 1957. He was married in 1978. They bought their first bicycle in 1994 and a mobile phone in 2017. They experienced flooding in the 1960s and famine in the 1970s; the community also experienced land conflicts between Guo and Ko.

They first saw tractor ploughing in their community in 2010. In 2012, they hired a tractor for the first time because there was not enough time to manually prepare all their fields for planting. But they have not used a tractor for ploughing since, having observed that it turned over and buried the soil's organic matter and brought infertile soil to the top, which resulted in low yields.

They first noticed the use of improved seed varieties and chemical fertilisers in their community in 2008, but only started using these new seed varieties and chemical fertiliser in 2012. They chose to continue using fertilisers after 2012 because some of their fields were not fertile. They first observed the use of herbicide in the community in 2015, but did not use it themselves until 2018, when the grasses on one plot were so high that it was not feasible to use hand labour for tillage. But they found out that herbicides kill the soil micro-organisms and contribute to soil infertility and decided not to use it again. Pesticides were introduced to their community in 2010. The household first used them in 2012 to store some crop produce, and again in 2014 to protect a new variety of cowpeas against insects. They have since been less interested in using pesticides, expressing health concerns.

The taste of vegetables influences the household's decisions about whether to apply organic or chemical fertilisers. The elder son said that tomatoes cultivated using compost taste better and sweeter than those grown with chemical fertiliser. For natural resource management, they prune trees but do not burn the leaves. They consider compost making as useful to sustain food production.

The household reported a positive change in their income generation activities when the children and wife got some off-farm employment. Most of the household members are engaged in farming and only a few earn money from off-farm employment. The household head noted that if such changes had occurred in the past, he himself would not have dropped out of formal education. He also said that any children in the family who do not succeed with their education will join those working on the farm.

Although the extra income helps finance farming activities, sales of farm produce and loans (especially from the credit union) have enabled them to balance immediate and long-term cash needs. The household considers the availability of animals and stored crops before deciding whether to sell some to buy farm inputs.

4.2.3 Case study household 7 (Ko)

This household has seven members: the household head, his wife, two cousins and three children. They believe that their family originally came from Cape Coast; their great grandfather was a blacksmith who settled in Ko. The major change in the household was a decrease in size following a split in the extended family when some members established their own families and built their houses in other locations. This move has resolved conflicts within the household.

The household head was the first to have attended school in the 1950s. He obtained public sector employment in the 1970s. The household joined the susu savings group and engaged in CIKOD's tree planting and management association in 2014. They were the second household in their community to build an improved house with a zinc roof; they bought a bicycle in 2003, a mobile phone in 2010 and a motorbike in 2018.

They first used improved seeds in 2000, explaining that one benefit of the new dorado sorghum seed is that it matures earlier than local guinea corn. Local varieties — especially the sieemonga groundnut — do not mature as early. This influenced their decision to switch to an earlier maturing variety.

They were the first in their community to apply chemical fertilisers on their fields. They first used herbicides and pesticides in 2010 and suffered an armyworm infestation in 2017. They prefer compost to chemical fertiliser because they observe that the effects of compost last longer. The household increased its income through off-farm employment and remittances from household members who migrated south. Both these sources complemented food security from farming. Joining the susu savings association in 2014 has also allowed them to take out loans to meet family needs.

The household foresees increasing the number of buildings with zinc roofs in their compound as a possible change in the near future, in anticipation of increased income. They identified the likely sources of increased income as off-farm work activities and sales of livestock and surplus crops. They foresee a gradual reduction in agricultural activities in the near future, with off-farm activities becoming the mainstay of their livelihood strategy. They believe that farming may not be very economical in the future due to the effects of increasing population and housing development. The younger household members may decide it is preferable to engage in more off-farm business instead.

4.2.4 Case study household 12 (Tanchara)

This small female-headed household consists of the household head and her three children, aged between two[4] and 14. The older children are in school. They settled in the community from Techiman in the south in 2012 and started farming in 2014 after they realised it was not sustainable to depend on remittances and helping people in exchange for food. Her husband and their other children still live in Techiman and visit occasionally. They acquired their first bicycle and first built a zinc roofed house 20 years ago. The household head was the first household member to attend school in the 1990s. In 1983, a member of the household first joined a *susu* group.

The household first used a tractor in 2015. They have used one ever since they started land tillage, especially on the groundnut farm. The exception was in 2018, when they used hired labour due to a delay in accessing tractor operators. Though they would like to add extra plots to increase their production, they do not have the household labour — or access to enough social pool labour — to manage them. They think they could increase production through the continuous application of compost/manure and timely management practices that meet the rainfall. Although they would like to have trees pruned and protected on their farmlands, they do not have the labour to prepare plots fast and work on portions under trees that the tractor cannot plough.

Their expectation from farming is being able to produce enough to feed the family, store/save seeds for the next cropping season and share some of their harvest with neighbours in need. They were able to partially achieve this in the 2018 cropping season but a short drought after planting meant they did not produce enough to settle the farm expenses, pay off the debt incurred during the farming season and meet household needs such as renewing National Health Insurance.

They grow crops that are easily managed by women: groundnuts, bambara beans, peppers, eggplant, okra and a small patch of maize. They grow the improved/hybrids seeds which they received from ACDEP. But they mainly grow local varieties as the seeds are more easily available and because the improved crops varieties are input-intensive.

They have not used herbicides and pesticides due to the negative effects associated with their use and because they could not afford them. The household was

4 The youngest child was born after the questionnaire survey was carried out – so it is not included in the infographics.

affected by drought in 2014 due to erratic and short rainfall. In 2017, they had a severe armyworm infestation, which they managed with ash.

They have used chemical fertiliser, combined with compost and manure, since 2015. They use more compost on the peppers than the maize, because it significantly improves pepper yields. They prefer manure/compost to fertiliser but have difficulty accessing it. They rely on their few livestock for manure and limited labour means they cannot produce a lot of compost with their crop residues, which they leave these on the field for grazing and as mulch. They cannot expand their livestock production to increase manure because of high animal mortality rates and the lack of access to veterinary services.

The household also does cloth weaving to generate extra income and receive remittances from the husband and a brother who is engaged in cash and food crops farming in southern Ghana.

4.3 Discussion

The ten trade-offs and synergies we identified across the 12 case study households fall into three broad categories. These are trade-offs between:

1. Economic and environmental objectives, with the former usually prioritised, particularly in the short term
2. Short and long-term objectives, with the former usually prioritised to meet immediate food security and cash needs, and
3. Individual and communal objectives, with individual gains receiving higher priority than communal gains, especially where there are no effective local institutions /bylaws in place.

All our case study households showed a clear awareness of the challenges resulting from trying to meet competing objectives. Most normally seek a compromise strategy that enables them to achieve several objectives to a lesser extent, rather than maximising one objective and not meeting others.

Trade-off 1: Mechanised versus manual land preparation

Across both study communities, smallholders have multiple objectives, including timely land preparation to meet rainfall patterns and making the best use of their household labour force. Although farmers expressed interest in both mechanised and manual land preparation, 11 of our 12 case study households use manual methods. Just one household owns bullocks and engaged in both manual and mechanised farmland preparation. The study found no difference between youth, female and elderly male-headed households on their land preparation decisions, but households headed by young men are perceived to be more energetic. All households commonly use manual land preparation methods, drawing on hired labour and social pool labour as necessary.

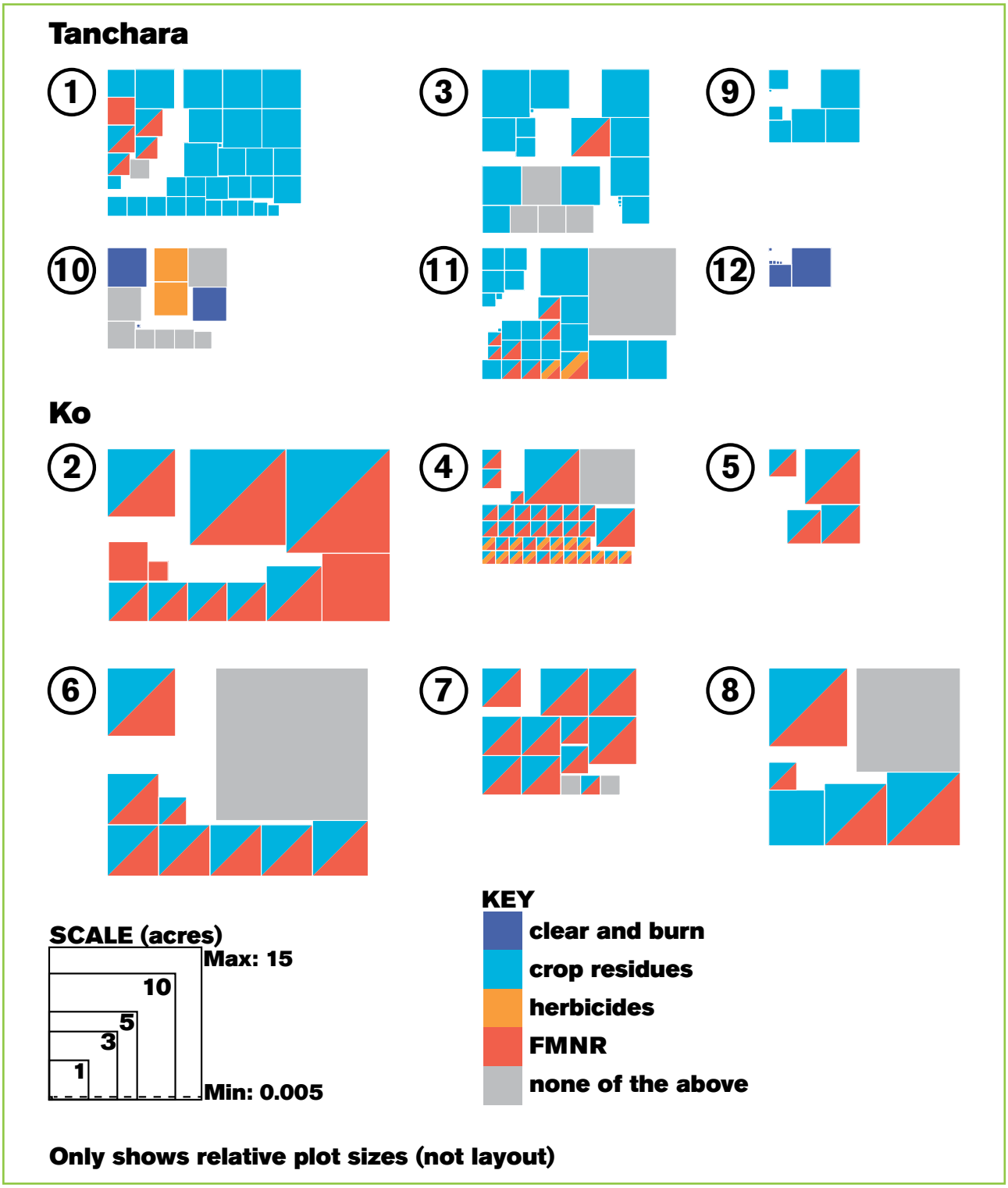
The 11 households that prepare their land manually work their farmlands either with household labour and/or by joining the social labour pool to support each other. Some households ensure that all active household members join different social pool labour groups. Not only does this allow them to gather collective strength for cultivation, keeping the need for hired labour to a minimum, it also ensures timely land preparation and planting, allowing them to make best use of the short rainy season and cultivate their plots as soon as the rains have started .

Our case study respondents said that manual land preparation reduces costs, conserves tree species and retains soil fertility. Making ridges and bunds enhances yield and conserves water and soil nutrients, which is lost when using tractor services. Disadvantages include delays in land preparation when they do not start early, elderly and female-headed households' lack of physical strength for preparing large portions of their farmlands and the cost of providing food for hired labour. Nevertheless, farmers perceive it as the better option.

Many case study farmers expressed an interest in hiring tractor services to prepare the land. They believe that using tractors would speed up land preparations, better meet the production needs of the short farming season (late onset of rainy season) and allow them to till their land regardless of soil hardness. Other advantages include being able to cultivate plots quickly and with limited labour, reducing the labour required. Farmers in Ko indicated that tractor ploughing represents a better alternative than manual land preparation, especially when the soil is too hard to till by hand. In Tanchara, farmers perceive that tractor services can provide an alternative because irregular rainfall patterns require faster ploughing before farmlands dry up after one rain.

In both communities, farmers mentioned negative effects of using tractor services. Many still need extra labour — whether social pool, household or hired labour — to break up and smooth out the surface of the soil when the land is not properly ploughed. Ploughing with tractors can clear tree species from farmlands, especially very young shoots and hinders the regeneration of tree species in their fields. Farmers in both communities observed that ploughing too deep, which often happens with untrained tractor operators and unsuitable tractor implements, buries the topsoil under less fertile soil deep down. This reduces soil fertility, nutrient absorption and crop yields, necessitating the constant application of chemical fertilisers and manure/compost. As a result, households in Ko expressed a strong preference for animal traction using ridgers, rather than tractors with disc ploughs.

Figure 14 Case study households' land preparation methods, by plot



Source of data: SITAM household case studies (2018–19)

Farmers who plough their farms on credit are also pressed to sell their harvested crops fast — when market prices are low — to pay for tractor services. If the harvest fails, they may be unable to pay their debts.

Farmers' decisions on mechanised land preparations are further complicated by the low number of available tractors and bullocks in the two communities. In Ko, animal traction is limited due to cattle rustling, so the increased competition for the few available services hinders timely land preparations.

From the focus group discussions we know that, in both communities, men get first access to tractor services in the community, although the women and youth in Tanchara use tractor services more because they have limited time to work on their farmlands. In Ko, women and youth use either the tractor service or animal traction depending on which option is available. In the questionnaire surveys in both communities, only about 17% of respondents said they could afford to hire tractor services; the other 83% said they depend on manual ploughing, though they remain interested in the services of tractors. During the focus group discussions, some attributed the negative effects of the limited number of tractors. This made it difficult for all the farmers who wanted to sow early to get their land ploughed. Farmers were also discouraged by tractor operators' tendency to inflate the number of acres ploughed — thus increasing the payments due — and by their tendency to plough too deep, bringing up infertile soil.

Despite the disadvantages of tractor ploughing, some farmers are willing to compromise several of their objectives to gain the benefits of timely land preparations for early crop sowing. Household income level also influenced such decisions.

Trade-off 2: Hybrid/improved versus traditional seeds

Farmers aim to optimise their agricultural production by using the resources at their disposal efficiently. Almost all farmers in both communities grow a mix of improved/hybrid (often early-maturing) seed varieties and traditional varieties. Planting both types of seed helps them spread risks and achieve all their objectives to some extent. But the primary rationale for maintaining a mix of crop varieties in SAI is to sustain smallholder agriculture under varied environmental risks and stressors. Environmental change, climate change and rainfall variability has increased farmers' desire to cultivate hybrid or improved seeds.

Growing seasons are getting shorter as a result of climate change and improved/hybrid crop varieties — with their early maturing genetic seeds and reduced engagement required in production — are better able to match these shorter seasons. This reduces the risk of crop failure, improves food security and produces higher crop yields.

The presence of improved/hybrid seed sellers and government and NGO interventions that have introduced improved/hybrid seeds have also influenced the rise in hybrid/improved seed use. But many households have neither the resources nor the time to only cultivate these seeds. The cost of both the seeds and the inputs needed to grow them successfully remans a barrier. To successfully cultivate hybrid/improved seeds, farmers need to make regular seed purchases for each year's production. They also have to buy and apply chemical fertilisers and pesticides to obtain increased yields.

Our study found that both elderly and youth male-headed households are increasingly reducing production of local/traditional crops varieties in favour of the early maturing crops. Women, on the other hand, tend to favour traditional seeds.

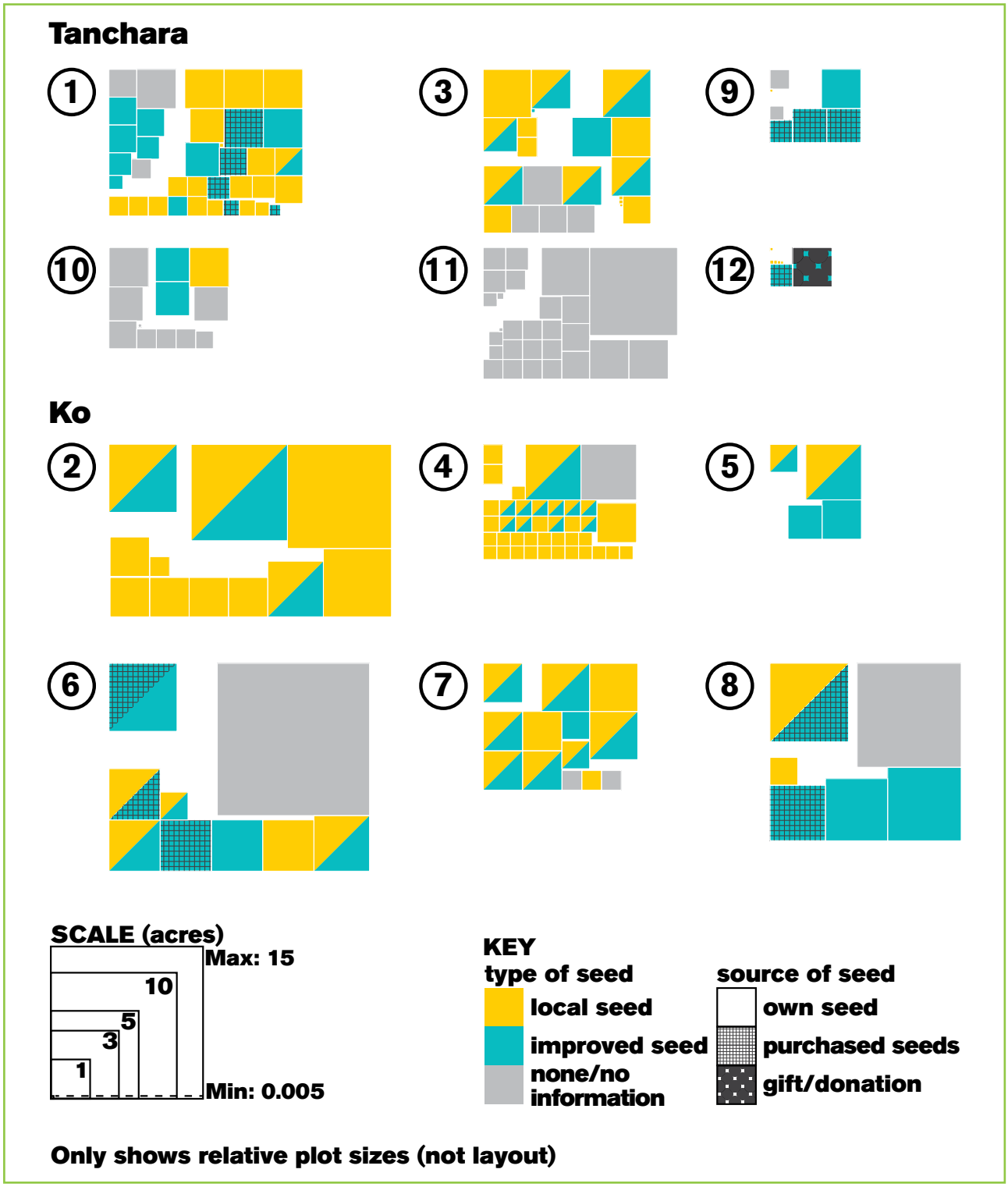
Households still need local crop varieties for traditional ceremonies and other purposes as they mature at the time for performing traditional ceremonies. Local seeds are also more resistant to drought, disease and insects, especially during production and storage. They can also be used for intercropping and do not require labour and input-intensive practices such as planting in lines, fertiliser, pesticides and other modern farming methods.

Trade-off 3/Synergy 1: Inorganic versus organic fertilisers: short-term economic costs to achieve long-term environmental benefits

With the advent of trade liberalisation, farmers are exposed to modern production farm inputs such as chemical fertilisers and other agrochemicals and many use a mix of local and modern inputs. Given the general lack of affordability of these modern inputs, the risks of inappropriate applications and the associated health risks, a more sustainable approach to integrated SWC is imperative. Poorer farmers struggle to afford fertiliser even when subsidised and can rarely spare labour to invest in land improvement technologies that will bring about benefits in the longer term but do not improve food security and incomes in the short term.

When faced with deciding how to best manage soil fertility, farmers must consider several factors, including the labour and capital required for different options. There is also a time dimension to this decision, because adding organic matter in the form of manure, compost or crop residues improves soil biophysical properties and fertility in the longer term but does not necessarily boost production in the short term. Applying manure after ploughing helps retain nutrients, improve soil fertility and maintain the structure of the soil. But it also requires a good amount of rainfall to decompose well and for plants to absorb the nutrients. In both study communities, farmers indicated that applying manure alone does not necessarily generate good yields in its earlier stage; rather, it fosters a gradual increase over

Figure 15 Type and source of seed used by case study households



Source of data: SITAM household case studies (2018–19)

time. And even under optimum management, farmers are unlikely to be able to produce enough organic matter to replace the nutrients their crops take out of the soil.

Applying chemical fertilisers quickly helps increase food crop yields in the same season. These fertilisers dissolve easily and plants can absorb them even with only a little moisture or rain. But continuously applying chemical fertilisers hardens the soil, which makes manual tilling more difficult. This then generates a preference for tractor ploughing. Chemical fertilisers also kill beneficial micro-organisms in the soil that convert plant remains into nutrient-rich organic matter, damaging the natural makeup of soil and gradually acidifying the soil in the long term.

Chemical fertilisers are increasingly popular, even though their benefits are only maximised when used in combination with manure. Most farmers are aware of the issues and tend to use a combination of both: the chemical fertilisers increase crops yields in the short term, while the compost/manure builds and maintains soil fertility in the long term.

The local availability of chemical fertilisers and support from external organisations and donors such as ACDEP and the crop department of the Babile agricultural station exposed farmers to chemical fertilisers. These organisations, as well as the NGO CIKOD also helped them improve their compost/manure preparation. Farmers are increasingly engaged in preparing compost; indeed, in Ko, the application of chemical fertilisers is decreasing as they get better at preparing compost and have limited income to purchase fertilisers.

Overall, household income level and the availability of chemical fertilisers and manure are key determinants of farmers' ability to continuously apply both. Farmers in both study communities commonly apply chemical fertilisers to improved maize and dorado sorghum and compost/manure to maize, guinea corn sorghum, yams and high-value crops such as pepper, garden eggs (aubergines) and other vegetables. Across our case study households, we found no difference between youth, elderly, female or male-headed households' use organic or inorganic fertilisers. However, the household head is normally the first to have access to household compost/manure, with women and youths having access only once the household head's needs have been satisfied. This is despite women and youths doing the bulk of the work involved in compost preparation and application.

The distance between farmlands and compound houses also influences farmers' decision about applying both chemical fertiliser and manure/compost on a piece of land for improved yields. They tend to prepare compost in their backyard farmlands, avoiding the need to transport it and making it easier to spread over compound farms.

Trade-off 4: Intensive versus extensive land use

Farmers constantly assess how to use the various production factors at their disposal — land, labour, financial and social capital, knowledge and so on — to optimise production and income for food security. Sustainable intensification focuses on land as the key production factor aiming to increase production per unit area by increasing the use of other factors.

So, farmers could achieve sustainable intensification by increasing the amount of labour or the amount of capital (in the form of improved seeds and other external inputs) per unit area, as long as they can also avoid any negative impacts on the economic, social and environmental dimensions of sustainability.

Our study found that many smallholders in both study communities are generally intensifying their production. Our case study households are increasingly reducing the cultivation of bush fields, focusing instead on intensifying their compound farms that are closer to home. This is due to labour limitations, limited access to arable lands, insufficient income for buying farm inputs and changing rainfall patterns. Expanding the size of the fields they cultivate requires more labour and farm inputs. By focusing their limited resources on compound farms instead, farmers are better able to plough and manage their farmlands within a shorter time period. By investing the same labour and inputs onto a smaller area, they can meet the changing climatic conditions and maximise crops yields.

Although we found that the general shift is towards intensification, some of our case study households headed by elderly farmers are cultivating larger proportions of their farmlands. This is mostly to safeguard their land against encroachment or theft of harvest, although one household indicated that they are increasing their farmlands to improve their food security. Their approach is to use more external inputs — tractors, fertilisers, improved seeds, herbicides and pesticides — on large plots, hence maintaining a similar level of cropping intensity overall. But population growth has decreased access to land within settlements overall and most households can no longer farm extensively or use long fallow periods to restore soil fertility.

Farmers in both study areas have several (sometimes competing) objectives but they generally aim to:

- Produce enough food for their household, and sometimes excess to sell
- Not rely on hired labour unless they have off-farm income sources to pay for it or enough food to feed them
- Reduce labour requirements altogether and invest in mechanisation instead

- Balance production risks and food preferences by growing a combination of local and improved crops varieties
- Maintain the productive capacity of their land (reducing or halting soil erosion), and
- Ensure that the land remains within the household and can be passed on to their children.

Our study revealed that different combinations of objectives may evolve, depending on a household's assets, ownership and control of resources. In Tanchara, the availability of family labour and compost/manure influence households' decision to intensify. Most households confirmed that they have intensified production because of reduced family labour, reduced ability to engage in social pool labour for collective production or an inability to hire labour to expand their farmlands.

In Ko, households with adequate amounts of arable land continue farming relatively extensively, while those with fewer arable lands tend to intensify production. We also observed that more households have intensified their production because the distance between bush fields and the household compound make it difficult to control or manage them for improved yields. Their larger size also cause many farmers to fall behind in weeding, and some households with large amounts of arable land still chose to intensify. Indeed, some farmers who had expanded their land in the past years have abandoned their bush fields and are concentrating their efforts on improving yields on their compounds due to the climatic conditions, leaving uncultivated lands as grazing lands or giving them to neighbours to cultivate. At the same time, households with limited arable lands have expanded production by borrowing arable lands from their neighbours.

Trade-off 5/Synergy 2: Protecting trees on cropping lands and forests benefits farmers and the environment

Managing the wider landscape and maintaining tree cover has multiple benefits for the community. Traditionally, many tree species have been protected because they provide food or other useful household products. Maintaining and managing some tree cover on farm land — which the Food and Agriculture Organization calls agroforestry parkland (Boffa 1999) — has been widely practised and promoted in the West African savannah regions as a way of arresting land degradation and desertification and maintaining essential ecosystem services, including providing habitats for wildlife and biodiversity and services to local communities.

In both study communities, well managed trees and forests provide fuel, fodder, food and shade for animals. Leaves and roots can also help improve soil fertility. In Tanchara and Ko, some farmers prune trees and work to reduce bushfires to improve long-term soil fertility. Others depend more on chemical fertilisers to improve soil fertility in short term, and quite a few use both methods on different parts of their farm.

Some trees on farmlands provide wild fruits, vegetables and fuelwood for domestic use, while their dry leaves eventually decompose and add nutrients to the soil. Our case study farmers' decisions to increase the density of trees per acre on crop land by protecting tree shoots during land preparation is influenced by both CIKOD's FMNR trees initiative and community-instituted bylaws to protect trees and forests.

But there are also trade-offs, as managing trees can compete with other household objectives. With many farmers facing labour shortages, mechanised land preparation is increasingly attractive.

Trade-off 6: Using herbicides for rapid land preparation versus manual weeding

Timely land preparation is very labour intensive, and farmers have started using herbicides to speed up land preparation and to get rid of perennial weeds that are difficult to control manually. Land preparation is a crucial step in the agricultural cycle, and delaying it delays planting and can contribute to poor yields, if rains stop before the crop has matured. Herbicide use is thus a labour-saving strategy to reduce the risk of crop failure.

Out of the 12 case study households, three have used herbicides in the past, and several others are interested in trying it out. The most commonly used herbicide is Roundup, used to clear all vegetation at land preparation stage. So far none of the case study households has used herbicides for weed control in the standing crop, because intercropping is widely practised, making it difficult to use selective herbicides that affect different types of plant (see Annex 2).

But herbicides have a number of other disadvantages. In particular, farmers are concerned that they kill micro-organisms in the soil and affect livestock that is grazing on land that has been treated with herbicides. Hence there is trade-off between long-term soil and animal health, and short-term production objectives.

Trade-off 7: Composting crop residues versus feeding the animals

This classic farm- or plot-level trade-off has been studied extensively. There are two competing objectives: improving soil fertility by using residues for composting and feeding livestock on residues. But there is also potential for synergy: with careful management of livestock and manure, farmers can achieve both objectives. And they often do, using some residues for composting while leaving some on the field. The way livestock is managed is key here, because roaming

livestock could consume all residues and move on, leaving few or no benefits to the farmer whose crop residues they had eaten.

In both communities, farmers practise both types of residue management. Some transport all or part of their crop's residues to their compound farms to prepare compost but most leave them on the fields as fodder for their animals. The decision to leave residues for livestock or use them to make compost is influenced by the availability of grazing lands in bush fields, a household's income (to pay for transport), the cost and availability of chemical fertilisers, NGO or government interventions to promote compost/manure preparation, labour availability and the proximity of the field/compound farms.

Some farmers have maximised synergies by collaborating with pastoralists, who can camp with their herds on their farms after the crop has been harvested, maximising the amount of manure left on the land. But there is scope to improve the management of crop residues and compost making, as much of the manure is left to dry out on the field and so has limited benefit for future crop production.

Trade–off 8/Synergy 3: On-farm versus off-farm activities: short-term economic costs to achieve long-term environmental benefits

Our case studies revealed complementarities and synergies between crop farming and livestock production. Combining on and off-farm activities allows farmer households to reduce risk and meet various household and personal objectives. Off-farm activities can make a significant contribution to food security by providing the capital needed to buy inputs and labour. However, it can also be detrimental to farming activities; if household members are absent during the cropping season, key activities are not always done to the required standard or on time. Improved land management (such as SWC, making and using compost and FMNR) require labour outside of the cropping season and so compete with off-farm employment and migration in that season.

The choices farmers make reflect their own situation, including family and household size and composition — particularly the number of able-bodied individuals of working age and the ratio of working to non-working people such as children and elderly people — the nature of the off-farm work (skilled and well remunerated or lowly paid), the size and type of farm lands and so on.

Farmers in both study communities often face a choice between diversifying their livelihoods by engaging in off-farm activities to increase their income or investing time and money into SWC/FMNR practices to improve soil fertility and vegetative cover. Doing this will limit the time they have available to engage in income-generating activities. Labour limitations is often the main factor influencing farmers who choose to engage in off-farm activities to earn income to buy chemical fertilisers for improved yields over working on the farm making ridges and bunds for SWC/FMNR. Other factors include the outbreak of livestock disease and livestock theft, as in losing their livestock, farmers also lose a supply of manure, which could have provided useful inputs to improve soil fertility.

In Ko, some farmers invest all their family labour resources into making ridges and bunds for SWC and apply complementary agroecological practices instead of doing off-farm work for earning income. And although some households sell food through the 'chop bars' (small food kiosks) they also pay more attention to their farm work through SWC/agroecology. In Tanchara, farmers usually give up their off-farm jobs in masonry, carpentry and poultry sales during the cropping season to focus on farming. During the farming season, farmers devote themselves to farming, working on their farms all day. They only engage in their off-farm activities in the dry season.

Households that engage in off-farm activities can invest the extra income in chemical fertiliser, hired labour, tractor services and other inputs such as livestock. Buying more livestock could increase manure production, which could improve soil fertility; so increasing livestock production could have a multiplier effect on crop production. Investing labour in the short term, building physical soil and water conservation structures such as stone or earthen bunds, ridges or mounds, will reduce erosion in the long term.

Trade–off 9/synergy 4: Livestock production versus off-site activities

Some farmers invest time caring for their livestock to benefit from their sales in the long run, which will provide income to pay school fees, buy supplemental foodstuffs and meet other household needs. They use income from livestock activities to hire labour, acquire farm inputs and buy fodder and vaccines for livestock. In both study communities, farmers protect their livestock to acquire manure and increase production, but risk losing them through theft and diseases. Protecting their livestock against theft also requires them to reduce the time they can commit to short-time income generating activities, because they have to be in the village or nearby to keep an eye on their animals.

Some farmers make equal commitments to growing food crops and livestock production. Alongside other income-generating activities, livestock rearing serve as insurance cover against shocks or hard times. In all cases, the decision of whether to rear livestock is influenced by fear of theft or disease, labour availability and availability of fodder, particularly in the dry season.

Trade–off 10/Synergy 5: Investing in farming versus education and other domestic needs

Although smallholder producers tend to have multiple objectives for production, meeting household consumption needs is a common primary goal of production. Multiple factors constrain food crop production, access and use and farmers need to prioritise objectives that require cash investments and allocate their scarce resources accordingly. Again, the timeframe of investment and benefits is important, because some investments will only provide benefits in the long term.

Farmers particularly want to make a long-term investment in their children's education. But they also wish to invest in agricultural production. This means using family labour and income on the farm to make sure they have enough food during the next year and to meet other immediate household needs such as medical expenses. In Tanchara, some households prioritise using their income for household needs such as children's education and buying food rather than investing in farming activities.

Synergies occur when farmers invest their household income in agriculture and manages to earn enough income through returns from production to support educational and related domestic needs. At the same time, investing in children's education gives long-term returns, as educated children eventually get work and provide income to help their household buy farm inputs to support their farming production.

5

Priorities for accelerating SAI

It is clear from our study that smallholders operate under highly diverse socioecological conditions and that many face major resource limitations, which strongly influence their trade-off decisions. Our review of the trade-offs farmers in Ko and Tanchara are making indicates that they are taking three pathways to sustainable intensification, which balances competing environmental, social and economic objectives:

1. Depending on externally purchased inputs
2. Focusing on enhancing ecological processes, or
3. A combination of the two.

All of these pathways can benefit or harm the SAI process, depending on the selection and management of trade-offs or synergies across household types, by gender and by age.

The data implies that both a single approach that considers only economic production for markets and excludes food self-provisioning and an alternative approach based on agroecological methods that excludes inputs and markets, or markets without concern for stability, sustainability and resilience can subject farmer households to livelihood risks. A diversified strategy that pursues both food self-sufficiency and market integration increases resilience and reduces risk.

It is within this framework that farmers are making trade-offs.

In keeping with the needs of their family members, households are changing their farming systems, combining different practices according to their resources, age and gender. This approach allows them to balance short-term profitability with long-term sustainability and support market-oriented production with self-provisioning of food and dietary diversity.

Most households find it important to ensure that food production for household consumption is addressed as an important function of agriculture. But because self-provisioning does not generate cash, households seem less willing to invest substantially in purchased inputs to meet their needs.

It is clear that farmer household decisions about which practices they adopt within an SAI framework are highly context-specific because balances in trade-offs and farmers' objectives vary significantly across different household categories, age and gender, land and resource access, and even within similar agroecological zones (in this case, Nandom and Lawra).

The SITAM research approach has been strongly grounded in a farm systems research perspective. This perspective has helped us understand the trade-offs that various types of farm household are making between multiple objectives, including those with different time frames. Our household case studies show that many farmers base their actions on short-term imperatives, even when they are aware of long-term damage to their production systems.

Many farmer households are locked into situations that lead them to use practices that degrade their own resource base. Farmers said that they often need to take a short-term view when making decisions, as immediate needs are pressing. But many SAI practices affect slow variables in the system — such as soil quality — and give only long-term payoff.

The question, therefore, is how to best enable highly diverse and heterogeneous farming systems to transition toward increased SAI that addresses both short- and longer-term concerns. Current agricultural research and development processes tend to make general recommendations for seed varieties and fertiliser levels

for the entire region. This approach explicitly or implicitly favours simple, one-size-fits-all solutions for extremely diverse problems and households. This is clearly not optimal. The economic and environmental sustainability of these solutions is doubtful.

On the other hand, a radical transformation of farming systems for sustainability does not seem feasible. At best, appropriate policies and highly tailored interventions can nudge different categories of farmer in the direction of SAI. It is clear that SAI must be seen as a stepwise process, aiming to continually enable households to move towards a farming system that exhibits not just increased yields and productivity, but also sustainability of natural resources (soils, water, trees) and resilience to the effects of climate change while also addressing equity and gender issues.

The approach requires identifying the optimal combinations and sequences of new practices households can use to address their own specific set of multiple stressors, drivers and system functions.

Farmer households believe that the economic and environmental costs of their dependence on purchased inputs is increasing. So, one of the main strategic options for SAI is prioritising ways to improve resource use efficiency — in other words, total factor productivity — through available synergies and other ecological mechanisms.

There are three main levels of overarching priorities for future action to promote and strengthen SAI:

Biophysical: There is a need for appropriate research to determine how much incremental or transformative potential each farming system has in different contexts. This requires a review of the evidence base, identifying critical gaps and priority research questions.

Social, political and institutional: We need to better understand the opportunities, barriers and constraints to implementation at political and institutional levels. This will include understanding the timescales that different processes operate in, the stakeholder interest groups that are for and against change toward SAI and why.

Community and farmer household: There is an urgent need to determine how farmers can better access the requirements for change and overcome the 'lock in' barriers to change identified by the International Panel of Experts on Sustainable Food Systems (IPES-Food 2016). We need to establish the appropriate incentives that can or must be in place to motivate and support adaptation in various combinations of improved sustainable intensification of farming and those can enable farmer households to take a longer-term perspective for sustainability in their trade-off decisions.

6

Policy implications and recommendations

In light of these conclusions and priorities for future action, the SITAM research team proposes the following recommendations to improve policy in support of SAI in Nandom and Lawra districts. Although these recommendations arise from the analysis of a very specific context, we believe that they are relevant and adaptable to many other regions of Ghana.

6.1 General recommendations

These recommendations should be undertaken through collaboration of all stakeholders engaged in promoting SAI.

R1 **Identify options for making the investment in longer-term intensification practices more attractive.** Develop bundles of options with short- and long-term payoff, using incentives or payments for environmental services or subsidies and regulation to offset start-up costs.

R2 **Improve the productivity of low-input systems and reduce risks** by improving biomass and nutrient recycling, pest control and multiple outputs on farms.

R3 **Improve integration of crop, livestock, soil, pest and farm system management** through diversification and biological interactions to reduce pest and disease pressures. Identify synergies that maximise resource use efficiencies within the farming system, linking its productive components so that the outputs of one subsystem are inputs for another.

R4 **Make labour and energy use more efficient to reduce the labour intensity of many SAI options.** Identify appropriate low-cost options for tools and mechanisation that would reduce drudgery and labour constraints while generating enough returns to make them viable for smallholders.

R5 **Improve input use efficiencies**, promoting more precise timing and location of the application of fertilisers in the field to coincide with crop uptake. This should also be based on specific soil types, use of soil tests and specific crops within an integrated soil fertility management approach.

R6 **Promote agroecological innovations** that help farmers adapt to the multiple effects of climate change and reduce risks. MoFA should increase support to climate-resilient agricultural production, including:

- Preparing and increasing compost use to increase the soil's water-holding capacity
- Supporting farmer-based conservation practices
- Supporting livestock and poultry-rearing to enhance compost preparation, and
- Effectively integrating trees with crops for dispersed shade to protect against high temperatures, to prevent wind and water erosion, raise the water table and increase leaf litter and mulch.

6.2 Specific recommendations

These more specific, targeted recommendations relate to the priority trade-offs identified in the study. They can be adapted to multiple agroecological locations through stakeholder engagements and policy dialogue with smallholders.

6.2.1 Tractor services and ox ploughing

Households with larger farm sizes have interest in hiring tractor services for farmlands preparation. Those with smaller farm sizes but more energy, especially youth-headed households, use household or hired labour for land preparation. Farmers with smaller farm sizes who have less energy to engage in preparing farmland often seek animal traction services for this job. But all farmers perceive tractor services as less accessible and less advantageous, as they increase the risk of degrading their farmlands and reducing soil fertility.

This is because most tractor operators are undertrained and unregulated. The disc ploughs they use are not appropriate for shallows soils, as they plough too deeply and bury compost deep down, out of reach of the plant roots. They also uproot young trees, which farmers want to preserve. Farmers often still have to engage in manual land preparation to break up and smooth out the surface of the soil and to reach the corners and the land around established trees. Tractor operators cannot always define and identify the boundaries of scattered farmlands and may end up ploughing adjoining plots by mistake.

Tractor services come at a high cost, as demand outstrips supply, especially in peak season. Smallholder farmers lack organised groups to pool their bargaining power around tractor operators. Most still depend on social pool labour because they cannot pay cash for tractor services.

Farmers call for an increased availability of tractors to improve access at the right time, enabling them speed up land preparations at the start of the rainy season. They anticipate that increasing the availability of tractors in their communities will foster inclusivity in access to tractors, especially among poorer farmers and female-headed households.

Farmers need appropriate, affordable mechanisation. Having access to lighter implements and animal traction will allow them to preserve the soil structure and keep trees on their farmlands. There are some initiatives in our study districts and elsewhere in Ghana to improve access to appropriate mechanisation:

- Lawra Municipal Assembly is making efforts to organise tractor service providers under one umbrella to collectively operate and at a set cost
- Nandom District Assembly is organising, registering and issuing identification cards to farmers for easier targeting of tractor services
- The Northern Development Authority promotes tractors with smaller discs
- The Centre for no-Till Agriculture near Kumasi, Central Ghana, is making technological progress in promoting rippers that combine land preparation and fertiliser application, and
- The government's Planting for Food and Jobs (PFJ) policy (MoFa 2017) aims at improving access to affordable agricultural machinery and mechanisation services by revamping and upgrading existing agricultural mechanisation service centres to strengthen their operations.

We recommend that district assemblies, the Department of Agriculture and the Environmental Protection Agency develop a better relationship and improve communications with tractor service providers for clearer regulation, registration and certification of the tractor operators, collective agreement on the kind equipment that is suitable for land preparation, amid technical guidance. Table 7 outlines specific recommendations for different actors on this issue.

Table 7 Recommendations for different actors around appropriate mechanisation

R7 PRIORITISE THE SUPPLY AND USE OF APPROPRIATE MECHANISATION FOR SMALLHOLDERS (INCLUDING WOMEN)	
National government	Prioritise appropriate mechanisation to reduce drudgery, alleviate labour constraints and foster soil health and sustainable land management, with smaller, more agile and lighter machinery Increase the supply of appropriate technologies for mechanising land preparation and farm transport, including: Rippers, smaller disc ploughs and ridgers that are suitable for the shallow soils of the savannah region Animal-drawn weeding implements, such as those available in Nyankpala, and Bicycle trailers, wheelbarrows and donkey carts Upgrade and expand agricultural mechanisation service centres to supply and service implements such as ridgers or rippers Create regulations for mandatory training and certification of registered tractor ploughing services

R7 PRIORITISE THE SUPPLY AND USE OF APPROPRIATE MECHANISATION FOR SMALLHOLDERS (INCLUDING WOMEN)	
MoFA	Provide mandatory training to all tractor operators to till in an environmentally sustainable way that is appropriate for the soil type Revise the existing tractor ploughing credit scheme to enable entrepreneurs and farmers to buy small-scale, appropriate mechanisation equipment that others can hire
Agricultural research	Collaborate with farmers in farm conditions to identify, test and adapt appropriate technologies for mechanising soil tillage and weeding that are accessible to smallholders Conduct research on technical and socioeconomic conditions, alternative implements such as the Centre for no-Till Agriculture's ripper and institutional arrangements that are suitable for small or poorer farmers
District and municipal assemblies	Organise tractor service providers under one association and publish the names and contact details of all registered and trained tractor operators for easier access by smallholders Ensure strict adherence to mandatory training of registered tractor operators Develop communal agreements on operational ploughing standards — especially when working with FMNR — and for using the Global Positioning System or measuring plot sizes
Local NGOs	Support organised farmers' groups to gain access to appropriate mechanisation services and credit Make credit repayment arrangements more flexible by enabling smallholders to pay for mechanisation services in instalments, to avoid having to sell their crops early Encourage and support smallholders to participate in a functioning warehouse receipt or inventory credit system
Communities, farmer organisations or groups	Organise into groups to pool collective bargaining power when negotiating and coordinating with registered tractor operators Collaborate with municipal or district assemblies to develop communal agreements on operational standards for ploughing services

6.2.2 Improved varieties and local varieties: getting the best out of both

Farmers' interest in seeds is shifting from the local varieties towards improved/hybrid crops. They perceive that the latter enables them to adapt to more erratic and short-term rainfall patterns and have a higher yield potential.

But to get good yields, improved seeds often require costly external inputs and more labour. Crop management practices promoted by NGOs and agricultural extension services include improved spacing of crops, placing single seeds per planting hole, manual weeding and making ridges and bunds.

Many poorer farm households cannot afford the seeds and external inputs and do not have the household labour required to manage improved seeds. The high cost of hiring labour requires credit and smallholders are often compelled to sell their crops immediately after harvest, when prices are at their lowest, to repay their debts.

The government's support systems do not help smallholders overcome these constraints. Its subsidy programme promotes farmers' access to improved seeds through the development of four seed zonal facilities. Its PFJ initiative seeks to increase access to improved seed varieties by distributing selected commodity/crop seeds to farmers at a subsidised price through the Department of Food and Agriculture and its local partners (including private inputs dealers). Many of our study respondents would like to cultivate improved/hybrid seeds but find it difficult to access this programme or obtain these varieties locally. As a result, they cannot benefit from the higher yields and shorter cycle of improved seeds.

The government also has established an inventory credit/warehouse receipt system in the Upper West Region and a warehouse storage facility programme, designed to reduce smallholders' post-harvest losses and create marketing opportunities within the agriculture value chain. But these facilities are only present in some districts and are inaccessible to most smallholder households.

Table 8 Recommendations for different actors around seed varieties

R8 GET THE BEST OUT OF USING IMPROVED AND LOCAL SEED VARIETIES	
National government	Improve the effectiveness and outreach of the extension and input supply system for smallholders Increase extension-related support services, including the inventory credit warehouse system, quality control of local and improved/hybrid seeds and the warehouse storage system through the 'One District, One Warehouse' programme Ensure that organic and inorganic fertiliser subsidies reach poorer and women farmers, so they can increase productivity and maximise profits
MoFA and NGO extension services	Promote accurate spacing and crop management for locally appropriate improved seed varieties

Private traders provide the agrochemical inputs farmers need to make use of improved seeds. But they generally require payment in cash or in kind immediately after harvest, when markets prices are low. Farmers report that this arrangement sometimes results in conflict between traders and smallholders, with some cases ending up in court.

Some NGOs provide loans to farmers to enable them to purchase chemical fertilisers, but such support programmes have proved unsustainable, due to the risks involved. If there is a poor harvest, many farmers are unable to repay their debt and NGOs have to write off the debt or pursue the farmers.

Given that many farmers are interested in increasing their productivity and income by adopting improved/hybrid crops varieties, on at least some of their fields, this study proposes a number of recommendations to enable farmers to overcome these constraints and better manage the trade-offs involved. Table 8 outlines specific recommendations for different actors on this issue.

6.2.3 Organic and inorganic fertiliser

Smallholder farmers have become exposed to — and increasing dependent on — modern farm inputs to improve soil fertility. Many now use a combination of both local and external inputs. The key challenges around chemical fertilisers for SAI are their general lack of affordability, the environmental impact of inappropriate applications and their economic inefficiencies.

Integrated soil fertility management is a more sustainable approach that can help farmers overcome these challenges.

Our study found that smallholders often seek to build synergy by blending organic and inorganic fertilisers. NGOs such as CIKOD have done extensive training on compost preparation, but our case studies revealed that many farmers face major constraints in applying this practice. They lack resources such as manure, labour, water, shovels, local materials to build a compost pit and labour-saving devices to transport compost/manure to more distant fields.

Table 9 Recommendations for different actors around fertiliser use

R9 PROMOTE SYNERGISTIC AND APPROPRIATE USE OF ORGANIC AND INORGANIC FERTILISERS	
National government	Reform the Farm Input Subsidy Program to improve access to fertilisers for poor farmers, limiting access for better-off farmers and focusing on poorer farmers Prioritise increasing the production, availability and distribution of high-quality compost and organic fertilisers from city waste and other materials in the subsidy programme
MoFA and extension services	Prioritise training smallholders in compost production methods using local organic materials and its effective, timely application Promote the use of bicycle trailers, wheelbarrows or donkey cards as labour and time-saving methods of transporting compost to and from farmlands, particularly among women farmer groups Strengthen agricultural extension programmes to more effectively promote integrated soil fertility management based on soil testing, more detailed soil maps, site-specific recommendations for appropriate use of chemical fertilisers and agronomic practices such as rotation with legume crops to foster soil health and fertility

Transport is a major constraint that especially affects women and girls, who bear the brunt of labour as they often have the task of transporting crop residues from the field to their homes for composting and from their homes back to their farmlands when composted. Some households with many younger girls can undertake the process, as they traditionally do this work. However, farm households with few women, or headed by an elderly female, are often unable to go through compost preparation/production chain due to the workload involved.

The government is aware of some of these challenges. Recognising the resource and income disparities in smallholder farming communities, its PFJ initiative distributes chemical fertilisers in different size bags (25kg and 50kg), giving smallholders with limited financial capacities access to subsidised fertilisers. The initiative also subsidises and supplies organic fertilisers and has started to promote practices to make effective use of compost and chemical fertiliser in combination.

The government has not provided any support for improved rural transport. Bicycle trailers exist but are mostly used for street cleaning. They could easily be adapted to support the transport needs of rural farmers to prepare and transport both compost and chemical fertilisers. This would be of great benefit to women farmers. Other recommendations for how to foster and promote the synergistic and appropriate use of both organic and inorganic fertiliser are presented in Table 9.

6.2.4 Intensification versus extensive land use

Smallholder farmers are shifting from extensive towards intensive food crop production. Our study found that an increasing number of smallholders who engaged in extensive land use can no longer manage their fields (including weeding) to obtain higher yields. As a result, many are intensifying their agriculture by reducing the size of their larger bush fields and concentrating their limited labour and inputs on smaller plots and land areas. This is a result of reduced labour availability, a growing scarcity of arable land, insufficient income to buy external farm inputs for larger fields and changing rainfall patterns.

While farmers aim to ensure better crop management and maximise crop production using fewer inputs, there are trade-offs. Land tenure is one of these. Some smallholders still extensify, mainly to safeguard their (unused) farmlands against encroachment by other, land-poor farmers who may also lack the labour and financial resources to fully engage in intensification agriculture.

This study makes clear that an urgent effort is required to help farmers more effectively intensify their agricultural production, in a way that generates higher yields while also lowering risk and costs. This would benefit SAI because extensive land use reduces the size of grazing areas for livestock, tree species, biodiversity and vegetative cover. Table 10 outlines some specific recommendations for different actors on this issue.

Table 10 Recommendations for different actors around SAI support to farmers

R10 HELP FARMERS MORE EFFECTIVELY INTENSIFY THEIR AGRICULTURAL PRODUCTION, IN A WAY THAT GENERATES HIGHER YIELDS, BUT LOWERS RISK AND COSTS	
MoFA extension services	Decentralise the identification and dissemination of highly context-specific best SAI practices to farmers, prioritising farmer-to-farmer learning and exchange Foster bi-directional learning between researchers, extension officers and farmers to adapt best practices in light of farmers' knowledge and practical experience Consider different farming methods across different farmer categories (including women) and across villages — due to availability of land and labour and sociocultural factors — when identifying best SAI practices
NGOs and community leaders	Create better awareness among smallholders of ways to manage trade-offs and achieve synergies Encourage smallholders to adopt more intensive and sustainable farming practices that are suitable to their resources and needs

6.2.5 Farmer-managed natural regeneration and agroforestry

Smallholder farmers are increasingly interested in conserving and regenerating trees on their farmlands, recognising that protecting trees provides valuable benefits, including firewood, wild fruits, building materials, fodder and other useful household products. They have learned that pruning and managing the trees on their crop land can improve crop production by reducing wind and soil erosion, generating organic matter, contributing to soil cover with leaf litter and raising the local water table.

But while they regenerate and increase tree density on their crop land to seek these benefits, farmers note a major challenge. Labour constraints cause them to be increasingly interested in mechanised land preparation to ensure they are ready for the shorter rainy seasons. But tractor ploughing often destroys young emerging trees on crop land. Other factors that inhibit farmers from adopting FMNR include: bush fires, in some cases, the belief that trees reduce crop yields and extensive tree cutting to respond to the increasing demand for firewood.

Despite these challenges, a good number of farmers, who are aware of the benefits, have started to protect various young tree species on their land. Some communities have instituted bylaws to limit the cutting of trees and bush burning, but these are not always effectively enforced.

Several organisations have fostered increased awareness among farmers, providing them with information on agroforestry. These include the Economics of Land Degradation (ELD) programme[5] with its component Regreening Africa,[6] funded by the European Union, the Federal Ministry of Economic Cooperation and Development of Germany (BMZ) and the United Nations Development Programme. CIKOD has extensively trained volunteer tree promoters in FMNR in many communities in Lawra and Nandom.

For researchers and policymakers, ELD undertook a detailed cost-benefit analysis of FMNR (Westerberg et al. 2019), which indicates that it gives smallholders strong economic and environmental benefits within an SAI framework. The Planting for Expert and Rural Development programme, linked with the government's PFJ initiative, seeks to develop the tree crops subsector to provide raw materials for factories as avenues for employment.

The CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS) is also working to reduce bushfires in farming communities by promoting bylaws.[7] The work of CIKOD and community-level organisations is paramount for promoting and enforcing bylaws.

Because of the strong benefits of trees in SAI, and the interests of farmers themselves, this study recommends that government at all levels, agricultural research bodies and NGOs provide incentives and promote practices to help farmers overcome the challenges and expand the adoption of FMNR. Table 11 outlines specific recommendations for different actors on this issue.

Table 11 Recommendations for different actors around FMNR

R11 PROMOTE FMNR AND OTHER WAYS TO INCREASE TREE CROPS AND AGROFORESTRY	
MoFA extension services	Incorporate FMNR promotion and training as a major component of efforts to strengthen SAI
District and municipal assemblies	Collaborate with communities to identify and select suitable tree crops that have strong socioeconomic and environmental advantages Support and validate community/traditional bylaws around bush burning and hunting
NGOs	Continue to promote FMNR as a key component of SAI within farmer communities through advocacy for tree regeneration on their farmlands Develop methods to direct-seed fast-growing indigenous trees in lines along contour lines to prevent problems with mechanised land preparation Continue to support and promote the ELD's Regreening Africa research findings to strengthen the commitment and engagement of government agroforestry extension services
Communities and local leaders	Strengthen the enforcement of bylaws that ban bush burning and regulate tree cutting on crop lands in support of FMNR

5 www.eld-initiative.org/en/knowledge-hub/regreening-africa/
6 https://regreeningafrica.org/
7 https://ccafs.cgiar.org/ghana-0#.Xrq842j0mUk

Table 12 Recommendations for different actors around herbicide use

R12 PROMOTE SAFE AND APPROPRIATE HERBICIDE USE TO REDUCE ENVIRONMENTAL DAMAGE	
Environmental Protection Agency	Review and strengthen regulatory measures on herbicide use and training farmers on appropriate herbicide application
MoFA extension services	Greatly increase smallholder training and awareness on responsible, safe and appropriate herbicide use, particularly around safety, protective clothing, avoiding spray drift in windy conditions and negative effects on the soil, water and animals Actively encourage alternative weed control methods by making available labour-saving hand- or animal-drawn implements and demonstrating how planting in rows allows easier penetration of the implement between crops
PFJ Initiative	Strengthen measures to ensure that smallholders receive training on appropriate agrochemical use and agronomic practices and technologies for improved yields and food safety
District assemblies, NGOs and donors	Continue to promote responsible herbicide use through directives on application for dealers and smallholders

6.2.6 Herbicides versus manual weeding

With climate change bringing shorter rainy seasons, farmers in Ghana need to be quick preparing their lands to ensure they benefit from the first rains. Among the many decisions farmers face is choosing whether to use herbicides or weed manually. Herbicides have financial and environmental costs, but manual weeding is more time-consuming and labour-intensive.

Smallholder farmers are increasingly using herbicides as works out cheaper and requires less labour. But herbicides often cause livestock who graze on local grasses that have been sprayed — either directly or indirectly — to become sick or die. They also pollute local water resources and can affect human health if sprayed without protective gear.

Major efforts are required to address these trade-off issues to promote safe application and usage of herbicides, and to explore cultural practices as cover crops or increased the availability of animal-drawn weeding implements. Table 12 outlines specific recommendations for different actors on this issue.

6.2.7 Using crop residues for compost/ mulch versus livestock feed or other household use

Our household case studies indicated that smallholders are increasingly using crop residues to make compost. But they can also use crop residues as fodder for livestock or as fuel for cooking. With livestock numbers decreasing and access to firewood with FMNR improving, farmers are increasingly tending to use residues for compost.

Bush burning and using fire to enable hunting are also becoming more common and often result in the destruction of crop residues, particularly in the more distant bush fields. Some farmers also still favour burning to quickly clear their farmlands and control termites.

To better support SAI, this study recommends that local governments, village chiefs and NGOs institute and enforce bylaws to reduce bush fires.

6.2.8 Off-farm work versus investing in agriculture

In the changing context of smallholder agriculture, many households are blending direct investment in agriculture production with off-farm and non-farm work to improve their livelihoods and food security.

Agricultural processing could offer substantial opportunities in rural areas but farmers are constrained by a lack of capital. Some of our case study households had previously engaged in small businesses to supplement their livelihood but had to drop them to focus on the farm. A lack of capital and the inability to fulfil customers' demands for items on credit have discouraged farmers from seeking extra income from both on-farm production and off-farm activities.

Our study revealed that several farmer households seek to balance both. They do this by focusing on agriculture in the rainy season and with some household members seasonally migrating to work in other regions of Ghana, returning to work the family farm with the onset of the rainy season.

Efforts to promote SAI should seek to increase farmers' potential to diversify farming by increasing livestock production and promoting local off-farm activities. Table 13 outlines specific recommendations for different actors on this issue.

6.2.9 Rearing livestock versus crop farming

Farmers need to choose whether to engage in crop farming and livestock rearing or to pursue just one of these options. Food crops farming requires prudent and timely management against weeds to ensure high yields, while feeding and guarding livestock against theft is also a full-time commitment. Both remain the major sources of income for farmer households in our study communities.

Despite the income value of livestock rearing, farmers lack the motivation to solely engage in it because of the lack of access to vaccines and veterinary drugs, the lack of improved housing for livestock, the risk of theft and the care and management required, especially in the dry season. The number of extension staff from the MoFA's Directorate of Animal Production is limited in both study communities, as veterinary colleges do not offer funding waivers to trainee veterinarians in the same way that teacher training colleges do.

Some years ago, NGOs such as ACDEP, Care International Ghana, ActionAid Ghana and CIKOD distributed small ruminants to households, in response to some of the challenges of livestock production in the study communities. This has helped some households diversify their farming activities and access manure. However, local authorities consider livestock theft to be a household issue, not a policy issue. So it is left to affected households to search for their stolen livestock, asking friends and relatives for assistance. The authorities do not act if households fail to find their missing cattle.

Considering the linkages between smallholder livestock production and food crop farming, farmers need support to better integrate the two. Moving forward, local authorities and traditional leaders need to consider livestock theft as a local policy issue, not an individual or household affair. Local governments, especially the MoFA, and district-level NGOs should support smallholders with basic training on livestock production and create awareness of how farmers can better look after their livestock to minimise theft and increase production.

6.2.10 Investing in education versus investing in farming

Our study indicated that many farmer households have to choose between investing in their children's education and improving their agriculture production, which would compromise the former. Some households prioritise their children's education and supplemental food over farming activities.

But in the longer term, households achieve a degree of synergy between these investment strategies. Those that invest more in productive agriculture can potentially generate extra income, which they can use to support their children's further education beyond primary level. At the same time, investing in their children's education could enable those children to gain employment elsewhere and channel some of their income to help their families buy farm inputs or invest in more productive and sustainable ways of farming. Overall, farmers are interested in building synergy.

Table 13 Recommendations for different actors around farm diversification and employmente

R13 PROMOTE FARM DIVERSIFICATION, OFF- AND NON-FARM EMPLOYMENT	
MoFA extension services	Strengthen and expand animal husbandry advice and veterinary services to help smallholders better integrate and manage livestock production — particularly poultry, goats and sheep — and improve livestock management and healthcare and reduce livestock mortality
Rural Enterprise Programme	Increase support to farmers through capacity building and training on alternative enterprises — particularly animal rearing, agricultural processing and marketing — to generate income
NGOs	Improve and expand training for smallholders, especially among the youth, in basic skills in small-scale business management such as book-keeping and customer management

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Annex 1.SAI indicators developed with farmers in Ko and Tanchara

INTENSIFICATION	ECONOMIC/ PRODUCTION/ INCOME	SOCIAL	HUMAN	ENVIRONMENTAL
▪ Plots grown on different parts of the farm and current yields for each ▪ Yields for different types of crop on different parts of the farm 5–10 years ago. If farmer can't remember, ask for trend: higher or lower? ▪ Current farm size (by different types of land: compound, bush, valley bottom) ▪ Farm size (5–10 years ago) ▪ Management of crop residues (multiple choice: burn, compost off-farm, leave on land and incorporate, feed to livestock, use as fuel, use for fencing) ▪ Use of SWC measures (field bunds, ridges, use of compost) ▪ Use of tractor for ploughing, ▪ Use of external inputs (fertiliser, herbicide,pesticide)	▪ Number of months per year that the farm family could live off the food produced on the farm (but need to include a conversion for farmers who grow cash crops and buy food with that income) ▪ Proportion of food produced that is sold (and price) ▪ Remittances received from migrating family members ▪ Sources of household income (multiple choice) — people say that farmers would not tell actual amounts ▪ Livestock ownership: number of chickens, goats, sheep, cattle owned by the household ▪ Ownership of other assets: bicycles, motorbikes, radios, TVs, mobile phones, etc (to assess what wealth category the household belongs to) ▪ Source of credit (VSLA), debt (eg whether people had to borrow money or food to feed family in lean season)	▪ Sources of knowledge about agriculture and types of knowledge they get (market information, technical information, etc.) ▪ Dietary diversity — what people have eaten during the past week	▪ Levels of education of family members and whether children are in school ▪ How many family members work on the farm, how many migrate — do they migrate permanently or seasonally? ▪ Contribution from migrants: food, remittances, knowledge, technology (to crosscheck the other questions on sources of income and knowledge) ▪ Knowledge about, awareness of and adoption of different agroecological, productivity-increasing and SWC measures or methods	▪ Estimated tree cover on different parts of the farm ▪ Proxy indicator for land quality on different parts of the farm: presence of termites; presence of certain plants ▪ Whether any part of the farm has been taken out of production (over the past 5–20 years) due to low productivity ▪ Fallow period (for bush field plot) – now and 5–10 years ago

Annex 2. Trade-offs and synergies experienced by case study households

DECISION	CASE STUDY HOUSEHOLD NUMBER – TANCHARA HOUSEHOLDS					
	1	3	9	10	11	12
Decision 1: Mechanised versus manual land preparation	Manual using household, social and hired labour Prefer tillage Labour available Tractor: untimely access and negative impact on land	Manual using social pool labour Tractor is costly, untimely access and bad for land	Manual: No money for tractor Late preparing land so had to abandon some plots	Manual using social pool labour Tractor too costly and bad for land Started tillage very early	Manual using social pool labour Tractor is costly, untimely access and bad for land	Both: Want early land preparation but have labour shortage and limited access to tractor services
Decision 2: Hybrid/ improved versus local seed varieties	Both: Improved / hybrid seeds mature early for hunger gap Local yield better	Both: Short duration maize is good	Both: Improved seeds are short duration Local seeds for rituals	Both: Improved / hybrid seeds yield more Local seeds to conform to norms	Both: Short duration beans for hunger gap Improved / hybrid seeds require more inputs	Both: Hybrid/ improved seeds need more inputs
Decision 3: Inorganic versus organic soil fertility management	Both: Complementary, concentrates scarce compost on compound farm for vegetable, yam and maize	Both: Farmer is conscious of benefits from using both	Both, but insufficient quantities due to loss of livestock	Both, but insufficient quantities due to loss of livestock, challenge of producing compost, and lower household income	Both, but mostly compost / manure to control striga and reduce costs in the long term	Both: More organic on pepper and more inorganic on maize
Decision 4: Intensive versus extensive land use	Intensify and expand to be food secure through crop diversification	Intensify and contract due to limited labour	Intensify and contract due to labour shortage	Intensify and expand to safeguard land and availability of labour (children)	Intensify and contract, focusing on fields near the house	Intensify and expand: Take on new plots before reaching intensification threshold
Decision 5: FMNR — protecting trees on farmland?	Few trees due to slow regeneration Protect trees Aware of SF (soil fertility) benefits Would like to see bylaws enacted to increase tree population	Few trees due to slow regeneration Protect trees Aware of SF benefits	Few trees due to bush fire Trying to increase tree cover	Few trees due to slow regeneration and illegal cutting Selective in protecting	Few trees due to slow regeneration and uncle chopping them Aware of SF benefits	Few trees due to usage of tractors

DECISION	CASE STUDY HOUSEHOLD NUMBER – TANCHARA HOUSEHOLDS					
	1	3	9	10	11	12
Decision 6: Herbicides versus manual weeding	Manual: Pre-treat bean plots with herbicide to kill weed before tillage and planting Do not use selective herbicide because of mixed cropping	Manual: Have no sprayer Intend to use herbicide in the future	Manual: Have no sprayer	Manual: Pre-treat groundnut plots with herbicide to kill weed before tillage and planting	Manual: Use herbicides for earthing up Do not use selective herbicide because of intercropping	Manual: Has no sprayer
Decision 7: Using crop residues for compost versus livestock feed or household uses	Compost Mulching Livestock feed Leave some on plots Energy source to heat water	Compost Livestock feed Mulching Household needs Leave on land	Livestock feed Compost (small amounts due to labour shortage) Grazing	Compost Garden fence Mulching Livestock feed and bedding Leave some on plots	Compost Mulching Livestock feed and bedding Leave on land	Animal bedding Leave it on the field Do not compost as have no pit
Decision 8: Off-farm work versus agricultural investment	Both: Off-farm activities in the dry season to invest in farming	Farming Gardening in dry season	Both: Migrate during dry season	Both: More farming and fewer off-farm activities	Prioritise farming Need food, otherwise would have to buy	Both: Husband migrates south Wife works in weaving in the dry season
Decision 9: Crops versus livestock	Both, with focus on crops due to livestock deaths, theft, market	Both but focus on crops because livestock is difficult to manage	Both, but emphasise crops because livestock is higher risk	Both, but emphasise crops due to livestock diseases and death, might shift attention to livestock with better access to veterinary service	Both but focus on crops Want to increase livestock	Emphasise crops Livestock is higher risk through disease, death and theft Fewer resources to expand
Decision 10: Invest in education versus invest in farming	Both	Both Feed children well	Both	Both	Both Feed children well	Both

Source: SITAM household case studies (2018–19)

DECISION	CASE STUDY HOUSEHOLD NUMBER – KO HOUSEHOLDS					
	2	4	5	6	7	8
Decision 1: Mechanised versus manual land preparation	Manual, but left out some plots Tractor is costly to hire and bad for land	Manual: Cannot afford tractor and think it's bad for the land	Manual: Tractor is inaccessible and bad for land, though cheaper than manual labour	Both: Tractor helps expand plots	Manual: Tractor damages the land	Bullock: Own bullocks No need for tractor service
Decision 2: Hybrid/ improved versus local seed varieties	Both: Improved / hybrid seeds mature early Local seeds for social responsibility	Both, for risk reduction	Both: Improved / hybrid maize matures early and is high yielding Local seeds for social responsibility	Both: Local seeds are disease-resistant and used for social functions	Both, for risk reduction Local seeds are disease / drought resistant Improved / hybrid seeds are early maturing and high yielding	Both, for risk reduction Improved / hybrid seeds are high yielding
Decision 3: Inorganic versus organic soil fertility mgt	Both: Prefer manure, but lost cattle so do not produce enough	Both: Would like to produce more compost	Both: Prefer manure Inorganic fertiliser requires yearly application	Both: Inorganic, especially on maize	Both: Prefer compost / manure, but are struggling to produce compost	Both, to maximise the long-term benefits of manure use
Decision 4: Intensive versus extensive land use	Intensify Reduce plots due to poor rainfall	Intensify: Larger plot would need more labour and cash to prepare	Intensify: Less capacity and fewer resources, Plots belong to other people	Intensify and expand See farming as a business	Intensify due to less household labour	Intensify: Managed well and maximised yield Large plot would require more resources
Decision 5: FMNR – protecting trees on farmland?	Protect and manage trees Aware of SF benefits	Many trees Protect trees Aware of SF benefits	Protect and manage trees Aware of SF benefits	Many trees Protect trees Aware of SF benefits	Many trees Protect trees Aware of SF benefits	Protect trees Aware of SF benefits
Decision 6: Herbicides versus manual weeding	Manual: Believe herbicides kill micro-organisms	Both but think that herbicides kill micro-organisms in the soil	Manure sprayed on the maize farm	Both: Use herbicides to prepare land for planting, despite thinking they kill micro-organisms in the soil	Both: Use herbicides to prepare land for planting, despite thinking they kill micro-organisms in the soil	Manual: Experience of losing goats that grazed on herbicide-treated field

DECISION	CASE STUDY HOUSEHOLD NUMBER – KO HOUSEHOLDS					
	2	4	5	6	7	8
Decision 7: Using crop residues for compost versus livestock feed or household uses	No data	No data	No data	No data	No data	Livestock feed Compost
Decision 8: Off-farm work versus agricultural investment	Prioritise farming due to limited off-farm opportunities	Farming only to make sure they produce enough	Prioritise farming Off- farm work Food and drinks sales	Both, to reduce risks Prioritise farming	Prioritise farming because earnings from off-farm are lower Petty trading	Both: Farming to be food secure Off-farm work to meet other household needs
Decision 9: Crops versus livestock	Both but livestock theft is a challenge	Both but focus on crops Use livestock for cash expenses / 'medical insurance'	Both (complementary)	Both but focus on crops Use livestock for cash expenses / 'medical insurance'	Both but focus on crops Use livestock for cash expenses / 'medical insurance'	Both but focus on crops Use livestock for cash expenses / 'medical insurance'
Decision 10: Invest in education versus invest in farming	Both but education is more important	Both but food is more important	Both	Both but education is more important	Both but food is more important	Both

Source: SITAM household case studies (2018–19)

Smallholder farmers in Ghana face a constant challenge: to choose between many, often competing, social, economic and environmental objectives while also meeting expectations to intensify their farming practices sustainably and produce 'more with less'. Farmers manage this situation by making trade-offs; choosing and prioritising goals based on household circumstances and by weighing immediate productivity/financial gains against long-term goals.

This report presents findings from the SITAM project, which explored how farmers in Ghana manage these trade-offs. It draws conclusions and recommendations for what national and sub-national government can do to support more sustainable choices at farm level in Ghana.

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