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Typology of Farms and Farmers' Perception of the Effects of Soil and Water Conservation Practices in Northern Burkina Faso

Pale Siébou*
Institut de l'Environnement et de Recherches Agricoles, Ouagadougou 04 Burkina Faso

Coulibaly Zoumité Christ Thierry Stephen
Institut National de la Statistique et de la Démographie, Ouagadougou 01 Burkina Faso

Yonli Djibril
Institut de l'Environnement et de Recherches Agricoles, Ouagadougou 04 Burkina Faso

Mason C. Stephen
University of Nebraska-Lincoln, Department of Agronomy and Horticulture, 279 Plant Science, Lincoln, USA

Prasad P.V. Vara
Feed the Future Innovation Lab for Collaborative Research on Sustainable Intensification, Kansas State University, Manhattan, Kansas, USA

Noufe Tiatité
Université de Ouahigouya, 01 BP 1412, Ouagadougou 01, Burkina Faso

Fofana Souleymane
Ecole Nationale de la Statistique et de L'Analyse Economique de Dakar, Dakar, Sénégal

Traore Hamidou
Institut de l'Environnement et de Recherches Agricoles, Ouagadougou 04 Burkina Faso

Zachary P. Stewart
Feed the Future Innovation Lab for Collaborative Research on Sustainable Intensification, Kansas State University, Manhanttan, Kansas, USA

Abstract

The continuous degradation of agroecosystem is a major concern for Sub-Saharan African countries, particularly Burkina Faso. To fight against this agroecosystem degradation, SWC such as stone rows, grass strips, zaï, filtering dikes, half-moons and agroforestry had been introduced in the Yatenga Province in Northern Burkina Faso several decades ago. Decades after introduction of SWC practices, a survey was conducted with 120 farmers equally distributed in four villages in the region to learn the farmers' perceptions of the effects of these practices on their farms. Results revealed a higher proportion of men in the study sites (63%) compared to women. The largest difference in proportions between surveyed men and women was observed in Bogoya where only 22% of the surveyed persons were women. The average years of the respondents across villages was 53 years with 57% of farmers being members of at least one farmer organization. The proportion of educated farmers was 73% and those who received training in SWC techniques represented 36%. Results indicated that white grain sorghum and pearl millet were the main crops produced by 95% of farmers and stone rows and zaï were the dominant SWC techniques used by 77-80% of farmers. Data from the survey indicated a fairly high proportion of big ruminant breeders and small ruminant breeders as well. In fact, 79% of farmers bred big ruminants and 78% bred small ruminants. The main beneficial and direct effects of SWC techniques perceived by farmers was their capacity to improve soil fertility, recover soil, reduce water run-off, and allow good water infiltration in the field, thus improving soil productivity. Farmers pointed out indirect effects of SWC practices on livestock by the regeneration and increase of grass, tree and small shrub biomass available to improve animal growth and health. However, some farmers commented that the long-term use of zaï could lead to soil degradation. The study showed that farmers did perceive the beneficial effects of SWC practices and that greater extension and adoption will only be achieved if they could still receive training, financial and equipment supports.

Keywords: Grass strips; Filtering dikes; Half-moons; Stone rows; Yatenga province; Zaï.

1. Introduction

Burkina Faso, like most countries in Sub-Saharan Africa, is facing a continuous degradation of its agroecosystem. In most situations, this degradation of agroecosystem has negatively affected soil organic matter and nutrient levels, thereby reducing water and nutrient holding capacity Sanchez, *et al.* [1]; Mason, *et al.* [2]; Mason, *et*

*Corresponding Author

al. [3]. The consequences are stagnation or decrease in crop yields qualitatively and quantitatively, decrease in biomass for livestock and reduction in ligneous and harvesting products, therefore affecting long-term food security [4]. In 2006, results from a study conducted by the Permanent Secretariat of the National Council for the Environment and Sustainable Development (SP/CONEDD) indicated that about 11% of the country's land was greatly degraded and 34% moderately degraded [5].

Factors affecting the land degradation are mainly the very strong human population grow and economic pressure, the use of unsustainable production practices such as no application of organic as well as mineral fertilizers, overexploitation of natural resources around cities and villages and low use of SWC practices. This leads to a shortening of fallow duration, a decrease in crop yields and a degradation of soil properties [6].

To fight against this degraded agroecosystem, SWC such as stone rows, grass strips, zaï, filtering dikes, half-moons and agroforestry (Figure 1) had been introduced in the Yatenga Province in Northern Burkina Faso several decades ago.

Figure-1. Some SWC practices introduced in the Yatenga Province

Fig-1.1. Stone row

Source: **Agrintalk [7]**

Fig-1.2. Zaï

Source: SPONG [8]

Fig-1.3. Half-moons

Source: Souka [9]

Fig-1.4. Filtering dikes

Source: **Rabdo [10]**

Fig-1.5. Grass strip of Andropogon gagnanus

Source: Rabdo [10]

Fig-1.6. Agroforestry

Source: FAO Food and Agriculture Organization of the United Nations [11]

Past researches on SWC practices that largely focused on field experimentations have been conducted by Brasser and Vlaar [12]; Maré [13]; Zougmoré [14]; Zougmoré, *et al.* [15]; Ganaba [4]; Karen, *et al.* [16]; Kiema, *et al.* [17]; Köhlin, *et al.* [18] and Yougbaré [19] with conclusions indicating beneficial effects of these anti-erosion practices on field productivity. Literature indicated that no studies have focused on surveys to understand farmers' perceptions of the effects of SWC practices on their natural resources such as soils, crops, livestock and vegetation [20].

After decades of SWC/SDR practice, the question of how farmers (first users of improved farming techniques) perceive these techniques remains so far unaddressed so meriting a study. Through a survey, the present study attempts to learn and capitalize the farmers' perception of these SWC practices on soils, crops, livestock and

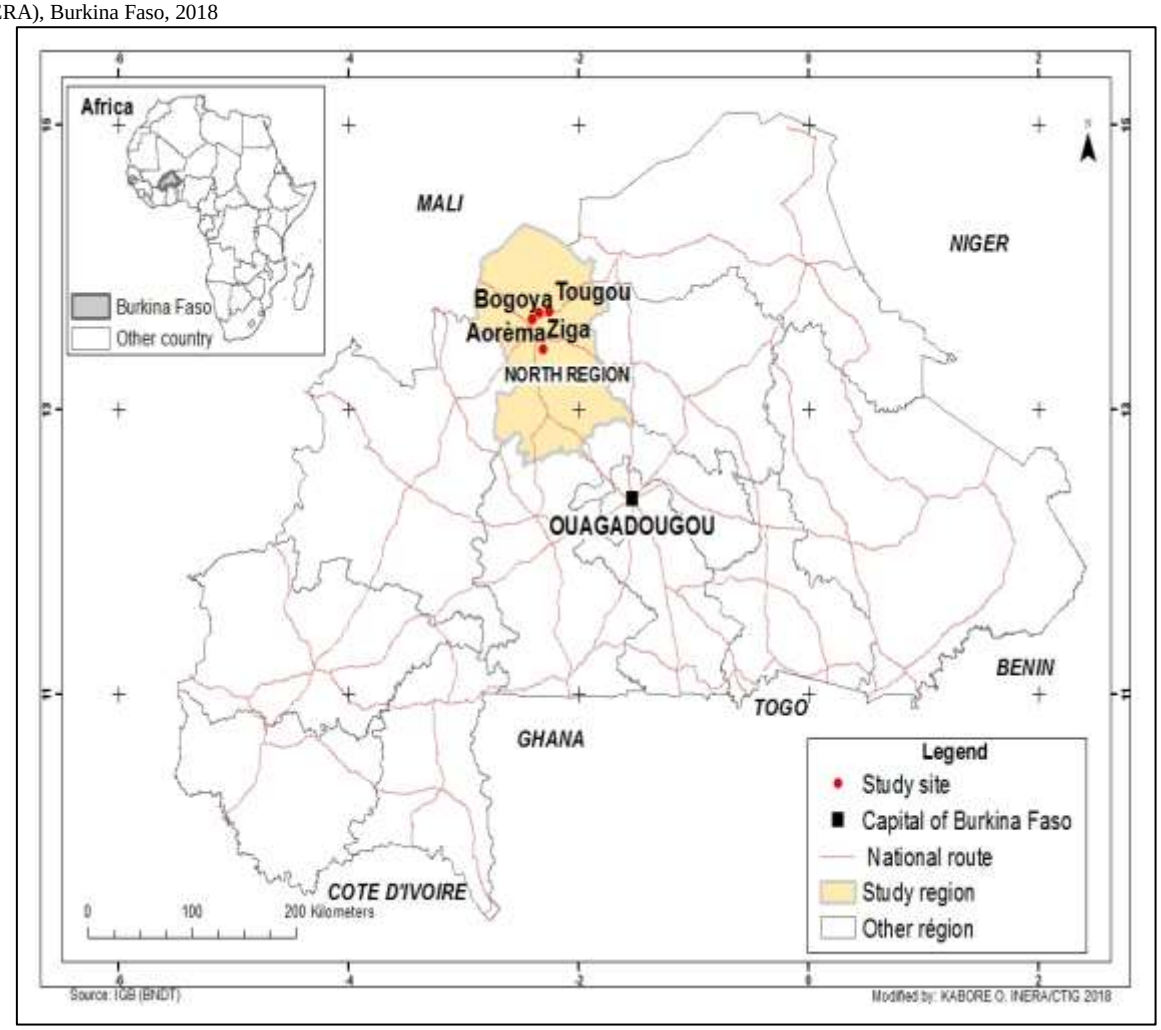
vegetation in Northern Burkina Faso; particularly in the Yatenga Province. More specifically, the study aims to know how efficient are these SWC practices according to farmers from the region.

2. Methodological Approach

2.1. Study Area

The survey was conducted in four villages in Yatenga Province with the capital Ouahigouya (13°35'00'North and 2°25'00'West) having a total population of 762,041 in 2019 [21]. The four villages covered by the survey were Tougou, Bogoya, Aorèma and Ziga located 23, 5, 15 and 25 km from the capital Ouahigouya (Figure 2) [22]. These villages had benefited from the SWC projects that introduced SWC practices such as stone rows, zaï, half-moons, filtering dikes, grass strips and agroforestry selected for the study.

Figure-2. Map of Burkina Faso showing the province of Yatenga and the four survey villages [Source: Geographic Institute of Burkina Faso (IGB); adapted by the Teledetection and Geographic Information Unit (CTIG) at the Institute of Environment and Agricultural Research (INERA), Burkina Faso, 2018



2.2. Data Collection

The data were collected through a questionnaire and from farmers in the four villages covered by the survey. The unit of observation was each household and the respondent was the farmer, responsible of all decisions to be taken in farm management.

Due to the absence of a population data basis giving the list of all farmers practicing SWC techniques in the 4 villages, the sample size was set to thirty (30) farmers per village from different households. The choice of farmers was made taking into account criteria such as the diversity in village populations. An identification of farmers practicing SWC techniques was first carried out with the participation of Village Development Committees (VDC). The VDC helped divide farmers into three random groups. Thirty (30) farmers were selected from each of the 3 groups to give a representative final sample size of 120 total respondents.

2.3. Data Coding, Examination and Analysis

For the coding and analysis of the data collected, the software Excel, [23], Text Mining with R Project for Statistical Computing [24] and IBM Corp [25] were used. SPSS was used to confirm the tests performed with Stata. Text Mining with the R software was used to analyze the responses to open questions related to farmers' perception of the effects of SWC techniques in the questionnaire.

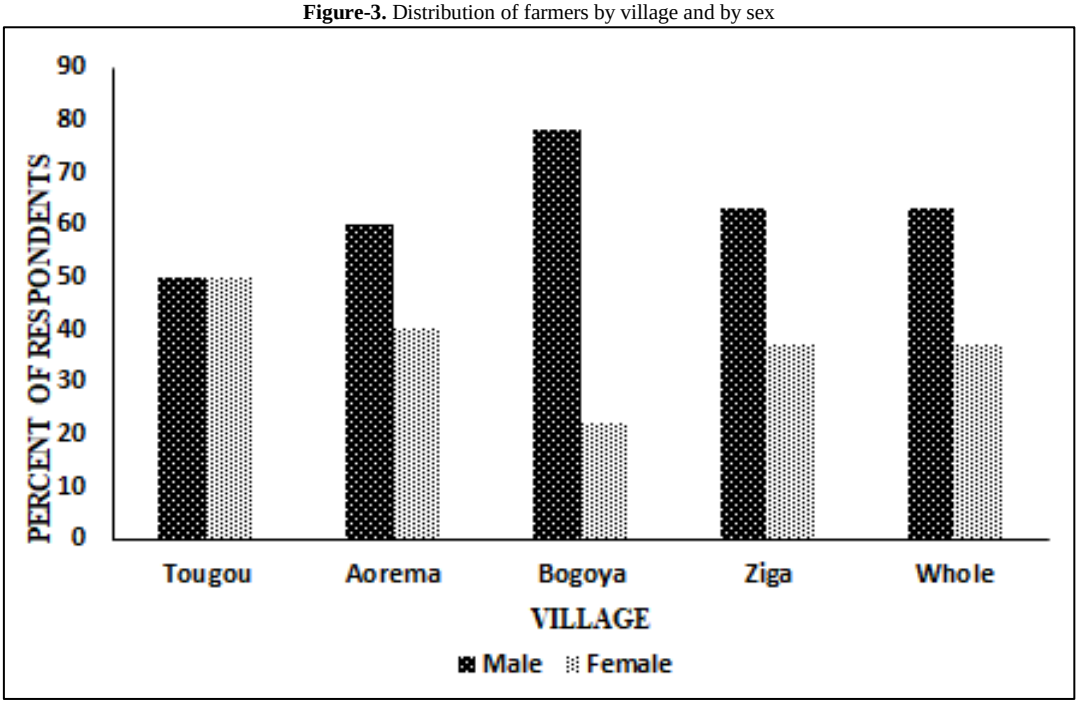
3. Results and Discussion

3.1. Farm Characterization

3.1.1. Distribution of Farmers by Village and by Sex

Results from the survey revealed that in the four villages of the study site, the majority of respondents were men (63%). Separate analyses done for each village indicated higher proportions of men in all villages except for Tougou where the proportions of men and women were equal (Figure 3). The largest difference in proportions between men and women was observed in Bogoya. In fact, in this village, only 22% of the surveyed farmers were women.

Figure-3. Distribution of farmers by village and by sex



3.1.2. Age of Respondent Farmers by Village and by Being Membership of a Farmer Organization

Results from the survey showed that, averaged across villages, the respondents were 53 years old (Figure 4a). Separate analyses for each village indicated fairly high average ages in all four villages with Tougou having younger farmers (40-year-old) and Bogoya older ones (59-year-old). The survey revealed that 57% of respondents were members of at least one farmer organization (Figure 4b). This membership distribution varied from one village to another. In Ziga and Tougou, the proportions of farmers who were members of at least one farmer organization appeared to be the highest with 83% for Ziga and 63% for Tougou. Figure 4b also indicates lowest proportions of 37% of farmers in Aorèma and 44% in Bogoya.

Figure-4. Age of farmer by village and by being member of a farmer organization

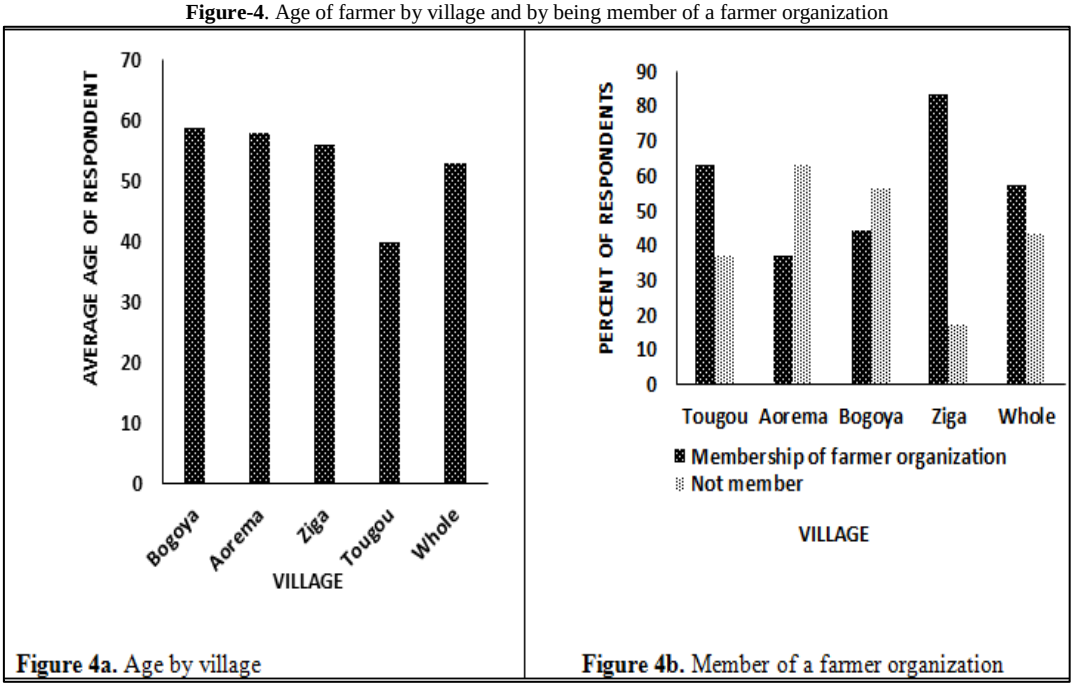


Figure 4a. Age by village

Figure 4b. Member of a farmer organization

3.1.3. Farmer's level of Education by Village and Training in SWC Techniques

The survey results showed that averaged across villages the proportion of educated farmers was 73%. Separate analyses for each village also indicated higher proportions of educated farmers compared to uneducated (Figure 5.a). In this study, educated farmers include all farmers who went to a primary school, a high school, a university or a training center for farmers and functional literacy centers. The greater proportions of educated farmers are observed in Ziga (87%) and Tougou (83%) than the other villages.

Data in Figure 5b indicates that averaged across villages, the proportion of farmers who have received training in SWC techniques was 36%. Nevertheless, separate analyses for each village indicated higher proportion of 53% of farmers trained in SWC in Ziga and lower proportion of 20% in Aorèma.

Figure-5. Farmer's level of education by village and training in SWC techniques

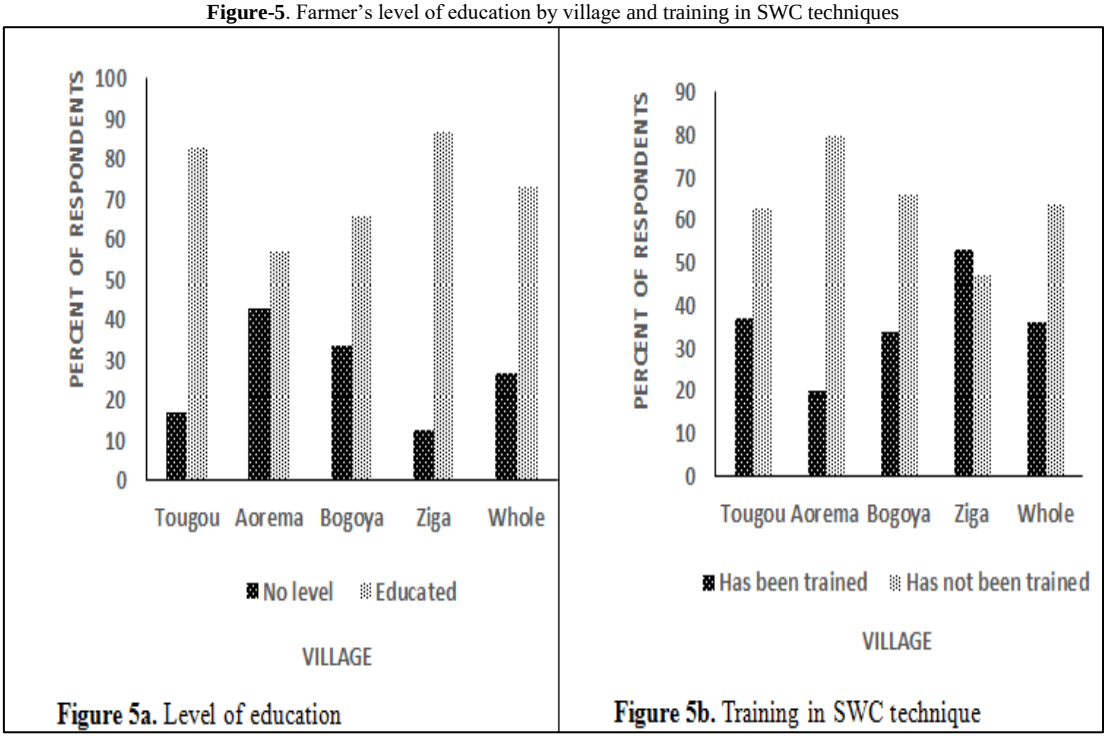


Figure 5a. Level of education

Figure 5b. Training in SWC technique

3.1.4. Crops Grown and use of SWC Techniques

The survey indicated that white grain sorghum and pearl millet were the major crops produced in the four villages. Indeed, these two crops were produced by 95% of farmers. Legume crops were mainly cowpea grown by 89% of farmers and groundnut grown by 75% of farmers (Figure 6a). The other crops grown by less than 30% of farmers were maize followed by sesame and rice.

Results from the survey showed that stone rows and zaï were the most SWC techniques used by farmers (Figure 6b). Indeed, stone rows and zaï are practiced by 77 to 80% of farmers. The other techniques, including filtering dikes, grass strips and half-moons were used by less than 10% of farmers.

Figure-6. Crops grown and use of SWC techniques

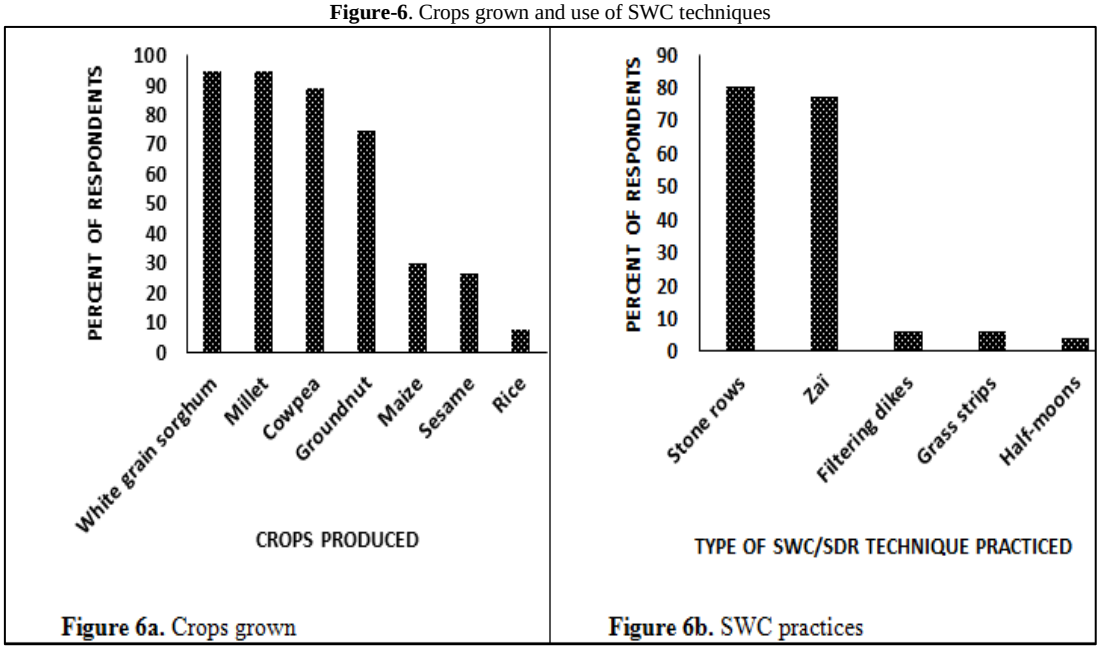


Figure 6a. Crops grown

Figure 6b. SWC practices

3.1.5. Farm Equipment

The survey results indicated that farm equipment encountered included plows, Manga hoes, row markers, sprayers, carts, "dabas" (traditional hoes), pick-axes, shovels and wheelbarrows. The most used equipment was daba that is used by all farmers (Table 1).

Table-1. Statistics for farm equipment

Equipment	Obs.	Mean	Standard deviation	Minimum	Maximum
Plow	76	1.47	1.21	1	10
Manga hoe	18	1.44	1.34	1	6
Row marker	23	1.26	0.54	1	3
Sprayer	21	1.24	0.62	1	3
Cart	61	1.23	0.62	1	4
Daba	122	9.33	5.67	2	40
Pick-ax	42	2.26	1.17	1	6
Shovel	29	2.07	1.33	1	7
Wheelbarrow	8	1.5	0.53	1	2

Note: Obs.: Number of farmers using the equipment

3.1.6. Equipment used for the Implementation of SWC Techniques

Results indicated that dabas, pick-axes, shovels, carts, wheelbarrows, crowbars and small pick-axes were the farm equipment usually used to construct stone rows (Table 2). Crowbars and pick-axes were mostly used to construct stone rows with 67% of farmers using pick-axes and 59% using crowbars. The two first equipment used in zaï preparation were small pick-axes and pickaxes using by 78% of farmers for small pickaxes and 56% for pickaxes. To construct filtering dikes, farmers mostly used pick-axes and shovels (57% of farmers) and crowbars (43% of farmers). Grass strips were realized using only small pick-axes while pick-axes and shovels were the two first tools used to construct half-moons.

Table-2. Main equipment used for the implementation of SWC techniques (in %).

Equipment	Stone rows	Filtering dikes	Zaï	Half-moons	Grass strips
Manga hoe	0	0.82	0	0	0
Daba	0.82	1.64	0	0	0
Pick-ax	67.01	57.14	56.38	100	0
Shovel	22.68	57.14	2.13	80	0
Cart	38.14	14.29	2.13	0	0
Wheelbarrow	27.84	14.29	1.06	0	0
Crowbar	58.76	42.86	0	0	0
Small pick-ax	21.65	28.57	77.66	20	75

3.1.7. Use of Stone Rows and Zaï According to Village

Sone rows and zaï are widely spread in the region and particularly in the study site. Stones rows and zaï were the most SWC practices used at Ziga with 93% of farmers using stone rows (Figure 7a) and zaï (Figure 7b). On the other hand, Aorèma is the village where stone rows and zaï were the least practiced with only 67% of farmers using stone rows (Figure 7a) and 60% using zaï (Figure 7b).

Figure-7. Distribution of farmers by village, according to use of stone rows and zaï

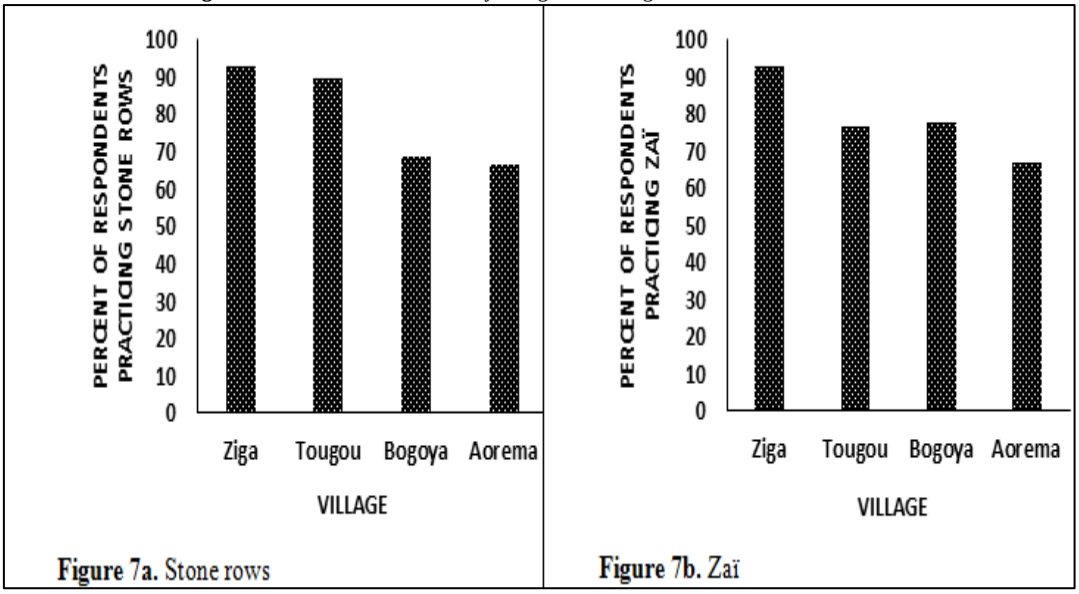


Figure 7a. Stone rows

Figure 7b. Zaï

3.1.8. Practice of Stone Rows and Zaï According to Farmer's Sex

Data in Figure 8a show a greater proportion of 82% for women applying stone rows compared to that of men being 78%, indicating that women in the region are more likely to use stone rows than men. Figure 8b shows a greater proportion of 78% for men practicing zaï compared to that of women being 76%, indicating that men in the region are more likely to use zaï than women who generally cannot access row manure.

Figure-8. Distribution of farmers by sex according to application of stone rows and zaï

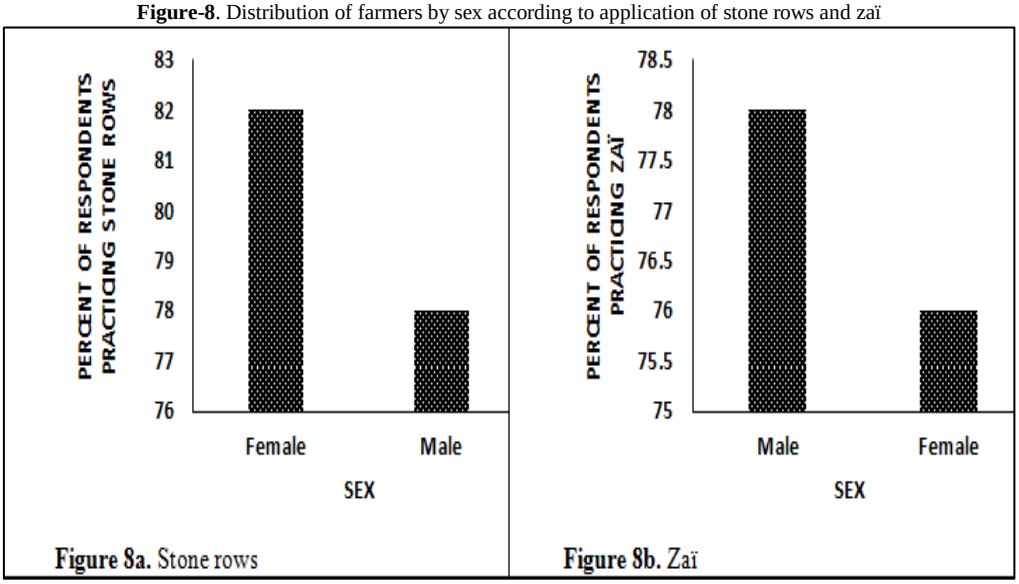


Figure 8a. Stone rows

Figure 8b. Zaï

3.1.9. Livestock Production

In this study, large ruminants included cattle, donkeys and horses, while small ruminants included sheep and goats. Survey results indicated that 79% of farmers bred large ruminants (Figure 9a) and 78% of them had small ruminants (Figure 9b).

Figure-9. Distribution of farmers according to large and small ruminant breeding

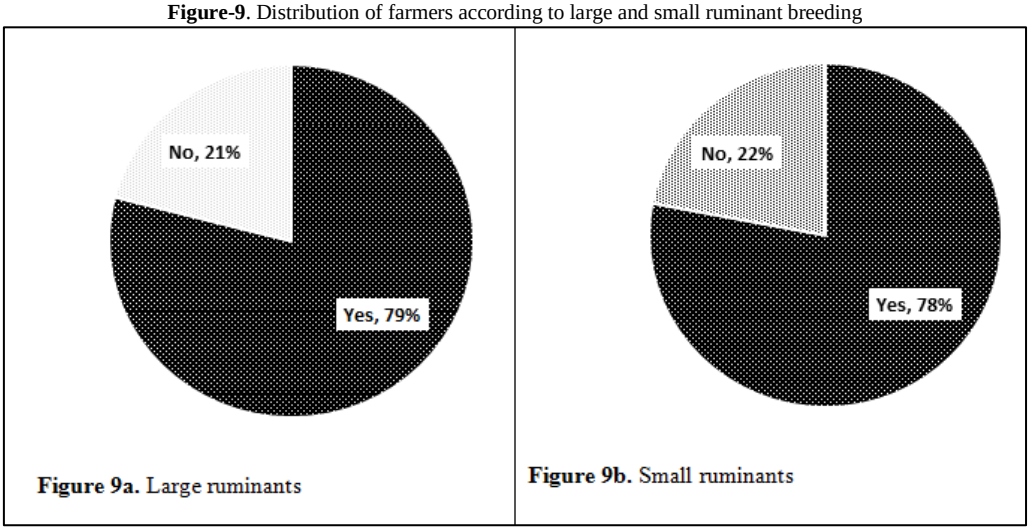


Figure 9a. Large ruminants

Figure 9b. Small ruminants

3.2. Perception of Farmers of the Effects of SWC Practices and Strategies Built Around SWC Practices

3.2.1. Perception of Farmers of the Effects of SWC Practices

3.2.1.1. Effects of SWC Practices on Soil

The effects of SWC practices on soil were numerous and varied from one technique to another. As shown in Figure 10a, the main effect observed by farmers for stone rows was improvement of soil fertility. In addition to this, Farmers indicated that application of stone rows contributed in reducing water runoff, conserving soil moisture and facilitating infiltration and restoring degraded soil, thus improving soil fertility. The benefic effects of zaï technique observed by farmers was its capacity to restore degraded soil and soil fertility (Figure 10b).

However, some farmers commented that zaï can improve soil fertility in the short term, but in the long term this technique leads to soil degradation because manure does not cover the entire field resulting in more nutrients removed than applied. The only effects that have been noted for the filtering dikes were their ability to facilitate water infiltration and to improve soil fertility (Figure 10c). For half-moons and grass strips, farmers indicated that these techniques rendered soil more fertile (Figure 10d). These farmers' perceptions corroborate the experimental conclusions from Maré [13] who demonstrated the positive impact of stone rows when reinforced with grasses on

the increase of soil fertility and the retention of more organic matter, nitrogen, phosphorus and potassium by the soil between two vegetated stone rows. Zougmoré [14], assessing the effects of stone rows and grass strips with urea and / or compost application, concluded that stone rows can significantly reduce water runoff, thus limiting erosion and improving soil water status. Half-moons in combination with well-decomposed organic matter can help restore degraded lands thus supplying nutrients required for crop growth as reported by Zougmoré, *et al.* [15]. [Ghosh, *et al.* [26]] also recommended the use of palmarosa (*Cymbopogon Martinii var*. Motia) as grass strips along with organic amendments to reduce run-off, soil losses and increase crop yields. In 2011, Sawadogo [27] mentioned that soil water conservation practices such as stone rows, filtering dikes, zaï, half-moons contributed to improving soil structure.

Results from the present study indicate that farmers 'perceptions of the effects of SWC practices corroborate the effects observed from field experiments and reported by the above authors.

Figure-10. Scatter of words showing the effects of SWC practices on soil

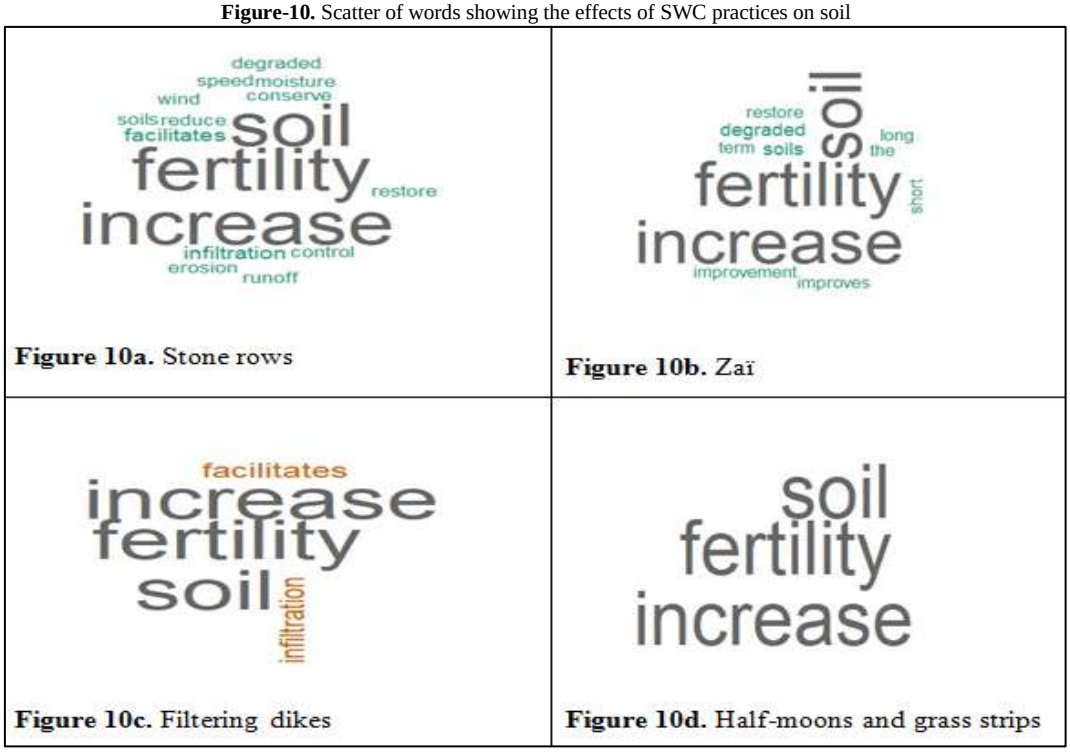


Figure 10a. Stone rows

Figure 10b. Zaï

Figure 10c. Filtering dikes

Figure 10d. Half-moons and grass strips

3.2.1.2. Effects of SWC Practices on the Regeneration of Vegetation and Biomass Production

Various effects of stone rows on the regeneration of vegetation were recorded during the survey. In general, the use of stone rows was perceived to have positive effects on vegetation by accelerating and improving grass, small shrub and tree growth (Figure 11a). Some farmers commented that application of stone rows could lead to area reforestation in the long-term. Others commented that, even if regeneration of the vegetation occurred, this effect was minor. Farmers indicated that the zaï technique improved grass, small shrub and tree growth in the field (Figure 11b) as indicated by Ganaba [4]. However, while a few farmers perceived some effect of zaï on regeneration, others commented that zaï could not lead to regeneration of vegetation. For filtering dikes, half-moons and grass strips, farmers were unanimous that these SWC practices all improve regeneration of the vegetation (Figure 11c).

Figure-11. Scatter of words showing the effects of SWC practices on regeneration of the vegetation

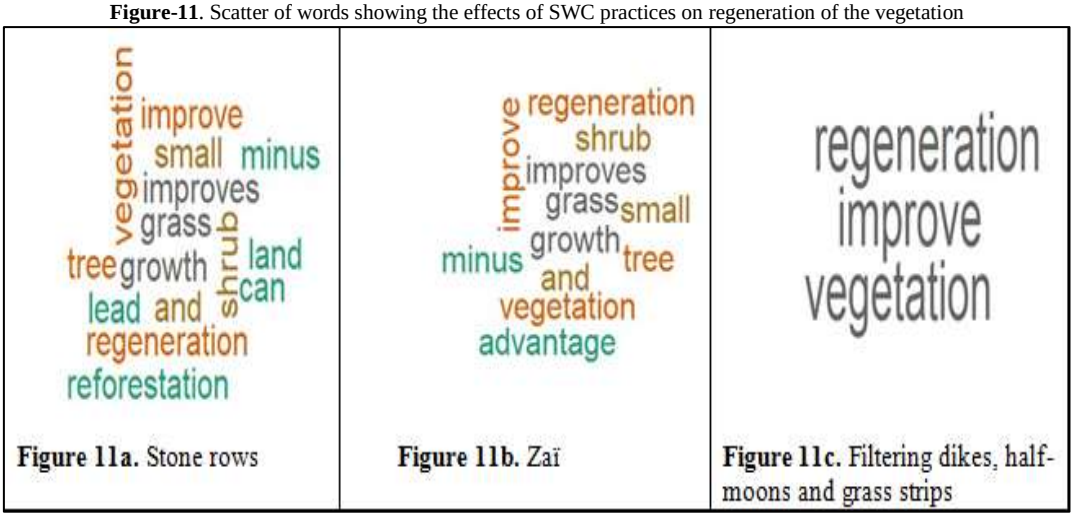


Figure 11a. Stone rows

Figure 11b. Zaï

Figure 11c. Filtering dikes, half-moons and grass strips

Results from the survey indicated the perception that stone rows and zaï allowed an increase in biomass production in general and particularly in plant biomass (Figure 12a and 12b). However, some farmers claimed that this increase in biomass production was small. For zaï users, the increase in biomass was the most effect reported and particularly for grassy biomass (Figure 12b). However, a few farmers declared to have not observed any effect of zaï on biomass production. Application of filtering dikes in the field increased the biomass in general and particularly the grassy one (Figure 12c). For half-moons and grass strips, farmers emphasized the increase in biomass but with no specification (Figure 12d). Farmers' perceptions of the effects of SWC practices in Northern Burkina Faso support experimental findings reported by Ganaba [4] who indicated that the use of half-moons, stone rows and filtering dikes enabled the settlement and development of perennial vegetation, but the best results on density and floristic composition were obtained with application of stone rows. On the other hand, [16] emphasized the vital importance of stone rows in fighting desertification and establishing sustainable agriculture with no negative effects on the sustainability of the practice of stone rows.

Figure-12. Scatter of words showing the effects of SWC practices on biomass production

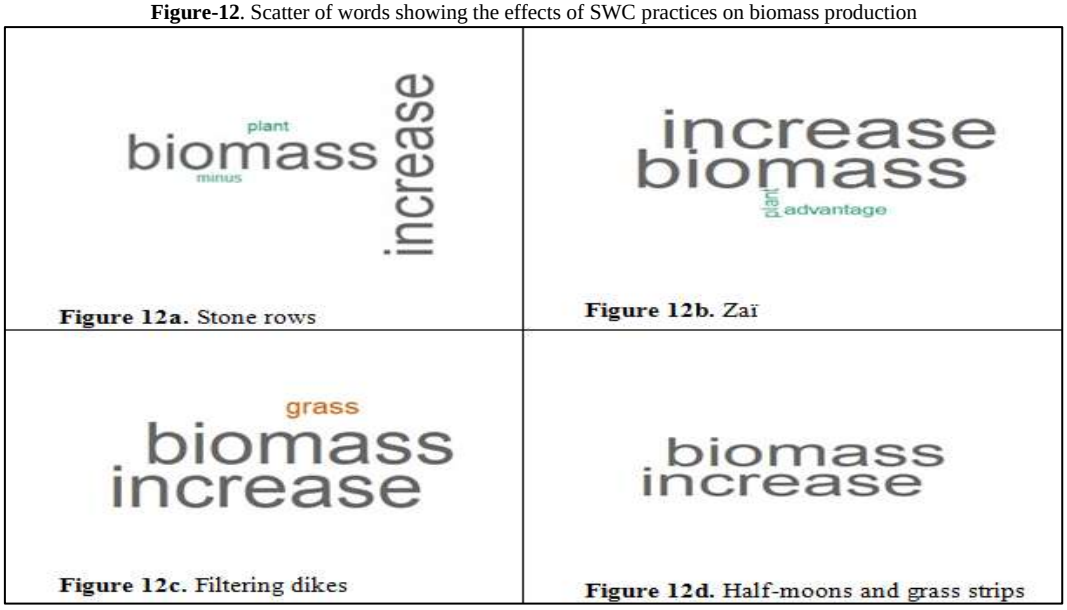


Figure 12a. Stone rows

Figure 12b. Zaï

Figure 12c. Filtering dikes

Figure 12d. Half-moons and grass strips

3.2.1.3. Effects SWC Practices on Crop Yields

For the effects of *SWC* on crop yields, farmers unanimously concluded that crop yields from fields with application of stone rows were greatly improved compared to fields without stone rows (Figure 13a). Although yield increases could not be precisely measured, some farmers perceived significant increases in yields due to stone rows while others perceived increases in yields as average. For zaï (Figure 13b), filter dams (Figure 13c), half-moons and grass strips (Figure 13d), farmers also perceived yield increases. These farmers' perceptions corroborate the increase in grain sorghum yields with application of stone rows reinforced with grasses reported by Maré [13] and Zougmoré [14], especially in years of low and erratic rainfall [14]. Brasser and Vlaar [12], also emphasized the great interest of filtering dikes during dry years in improving crop yields when manure or mineral fertilizer was not applied. Yougbaré [19], concluded that during exceptionally dry years , application of stone rows, half-moons and zaï can ensure the best growth of sorghum plants and thus induce higher crop yields.

Figure-13. Scatter of words showing the effects of SWC practices on crop yields

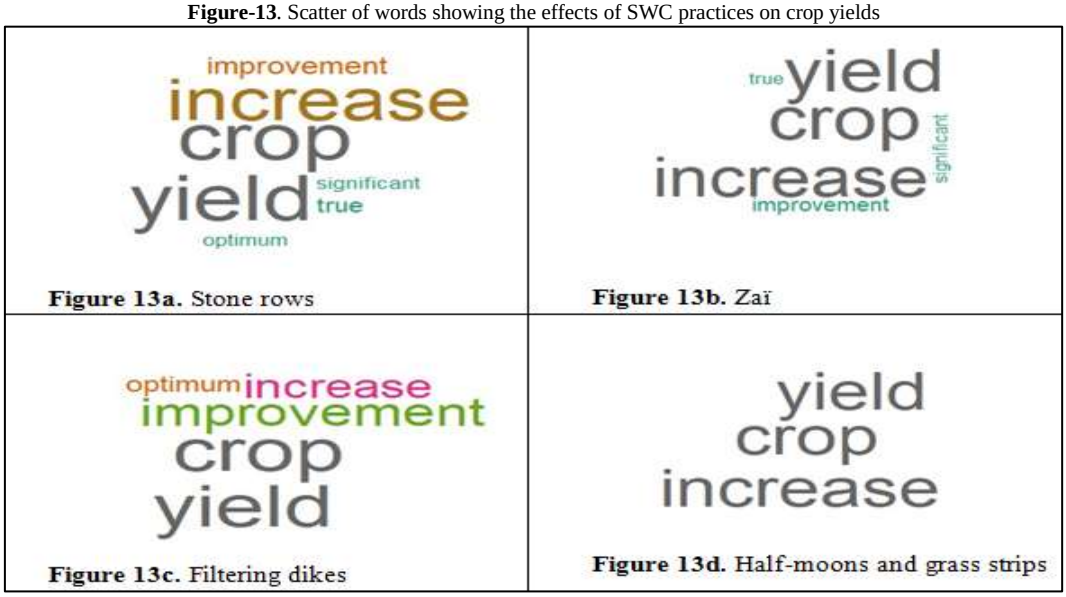


Figure 13a. Stone rows

Figure 13b. Zaï

Figure 13c. Filtering dikes

Figure 13d. Half-moons and grass strips

3.2.1.4. Effects of SWC practices on Livestock

The effects of SWC practices on livestock include (1) effects on fodder availability for animals and (2) effects on livestock growth and health.

3.2.1.5 Effects on Availability of fodder for Animals

All farmers perceived that the use of stone rows, zaï, filtering dikes, half-moons or grass strips resulted in an increase in the fodder availability for animals and commented that this increase was due to the fact that the SWC practices improved grass, small shrub and tree growth and crop residues used as fodder for ruminant livestock. Kiema, *et al.* [17], indicated that using filtering dikes positively affected regeneration of vegetation which can last for up to five years after construction, increased grass and tree biomass, thus increasing biomass availability for livestock.

3.2.1.6. Effects on Livestock Growth and Health

The effects of stone rows on ruminant livestock growth and health were multiple. Farmers indicated that stone rows indirectly contribute to the livestock growth and health by increasing the feed supply, thus allowing animals to eat better and feel better. However, some farmers declared to have not observed any effect of stone rows on their livestock growth and health. The effects of zaï, filtering dikes, half-moons and grass strips were similar to those of stone rows, contributing in ensuring good growth and good health for livestock.

The above results show that farmers have clear perceptions of the efficiencies of SWC/SDR techniques. Indeed, they all stated that fields in which SWC practices were implemented appeared to be more efficient for crop production than fields with no application of SWC techniques.

3.2.2. Strategies around SWC Practices

Various strategies are adopted by farmers to facilitate the implementation of SWC techniques by all farmers in the four villages. The main strategies retained include (1) association of SWC techniques, (2) choice of crop species to grow for each type of SWC, (3) agroforestry techniques and (4) village mutual aid.

3.2.3. Association of SWC Techniques

Results from the survey indicated a great proportion of farmers who combine SWC techniques in their fields to increase soil and crop productivity in the study site (Figure 14a). Farmers from Ziga were 80% likely to use a combination of SWC techniques (Figure 14b). The least proportion of 20% of farmers combining SWC practices in the same field was found in Aorèma. The interesting thing to highlight is the essentially identical proportion of women (51%) and men (49%) combining SWC techniques compared. Farmers who are members of a famer organization had more recourse to the combination of SWC techniques (62%), probably due to the fact that farmer organizations are more equipped.

Figure-14. Distribution of farmers according to the practice of combined SWC techniques

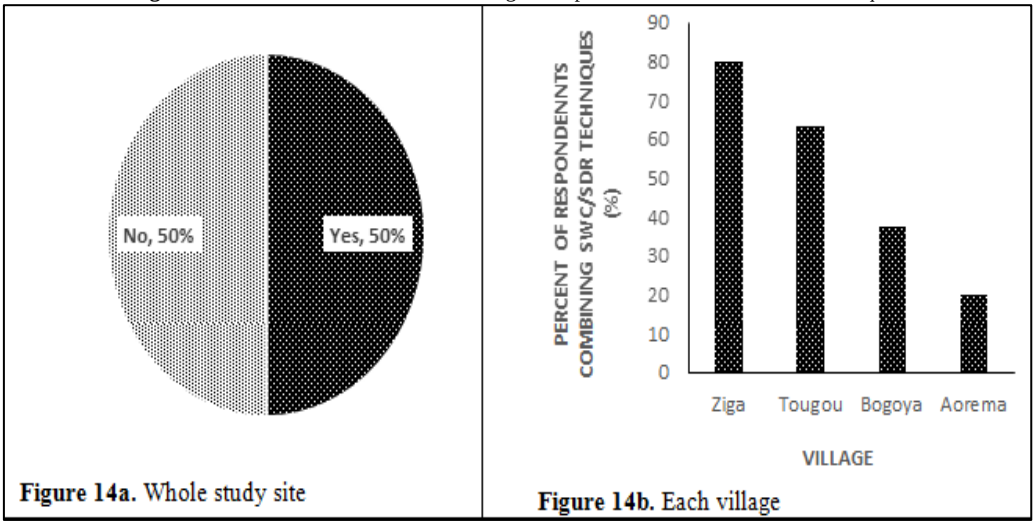


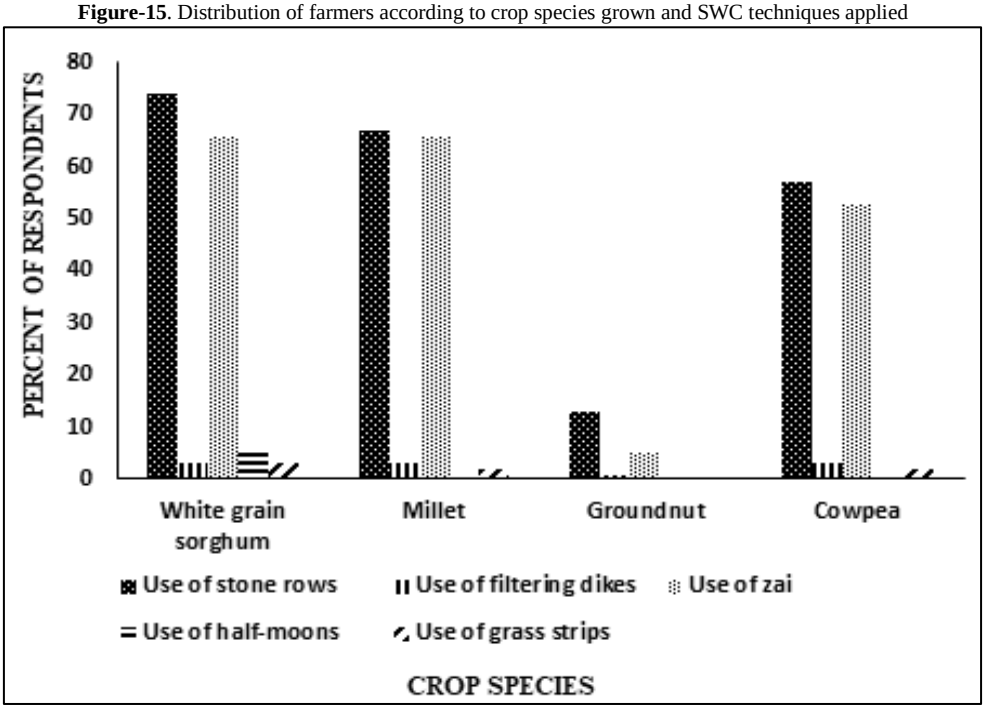
Figure 14a. Whole study site

Figure 14b. Each village

3.2.4. Choice of Crop Species to Grow for Each Type of SWC

Stone rows and zaï were the most practices used for white grain sorghum, pearl millet, groundnut, and cowpea productions. However, the proportions of farmers using stone rows and zaï were higher for white grain sorghum farmers (Figure 15) with 74% of white grain sorghum farmers using stone rows in their fields compared to 67% for pearl millet farmers, 57% for cowpea farmers, and 13% for groundnut farmers. Therefore, it can be concluded that farmers in the study site are more likely to use stone rows in white grain sorghum fields and zaï in both white grain sorghum and pearl millet fields. These higher proportions of farmers are probably related to the fact that white grain sorghum and pearl millet are staple food crops while cowpea (followed by groundnut) is the main income crop for farmers in the study site.

Figure-15. Distribution of farmers according to crop species grown and SWC techniques applied

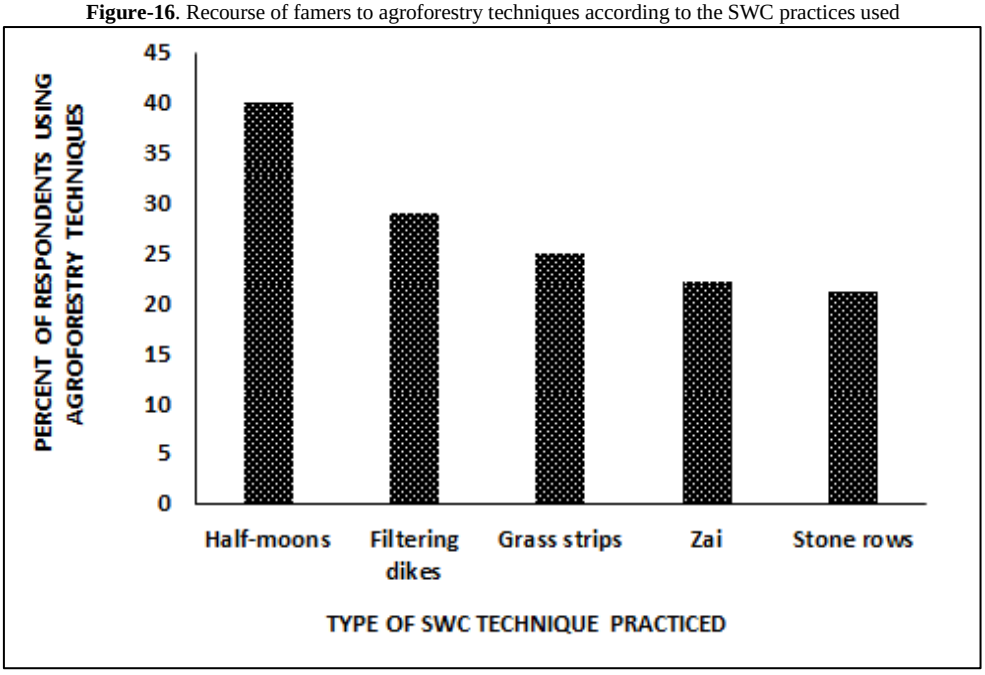


3.2.5. Agroforestry Techniques

The main agroforestry techniques used include the park systems, hedges and windbreaks. Farmers who use half-moon techniques were the most likely to implement agroforestry techniques in their fields (Figure 16). Results showed that 40% of the half-moon users used agroforestry techniques, while only 21% of farmers using stone rows used agroforestry. Farmers commented that the use of half-moons along with agroforestry in a rotational system is a means to rehabilitate bare lands as previously mentioned by Sawadogo [27].

Köhlin, *et al.* [18], investigated the impact of stone rows on crop production value and concluded that the improvement of the productivity impact of stone rows was agro-ecology-specific; therefore, developing and disseminating agro-ecology-specific soil conservation technologies to increase crop productivity is important. Sawadogo [27] demonstrated the agroforestry (widespread in West Africa) benefits that include improved soil structure, helped secure livelihoods, reduced rural poverty, and reduced vulnerability to drought and famine.

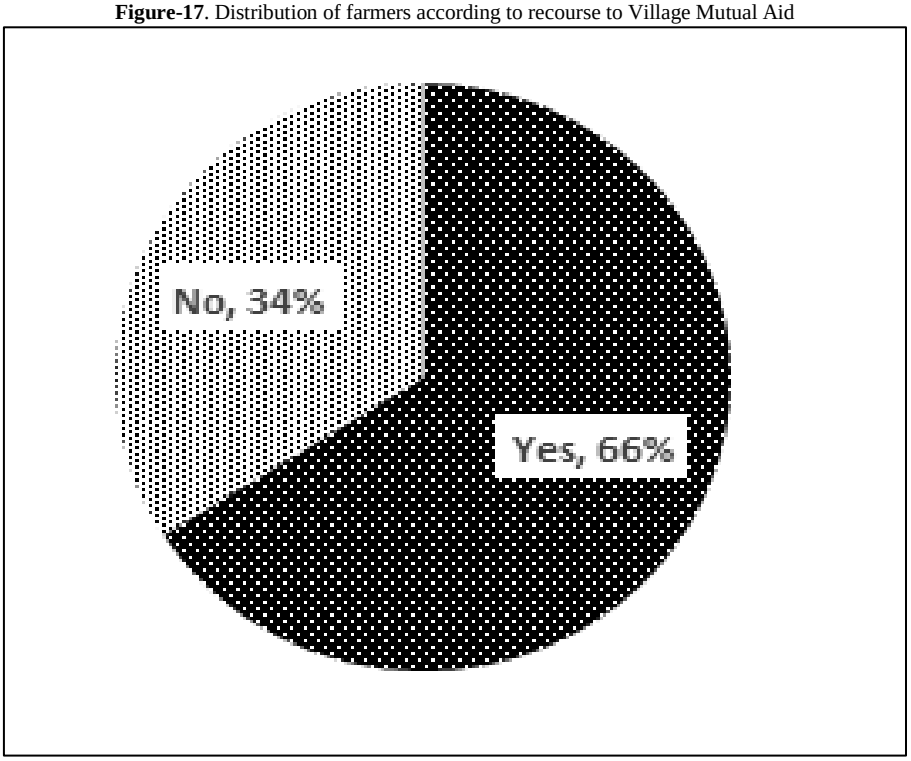
Figure-16. Recourse of famers to agroforestry techniques according to the SWC practices used



3.2.6. Village Mutual Aid

The implementation of SWC techniques often requires certain types of farm equipment such as pick-axes, crowbars, carts, etc. However, not all farmers have adequate equipment to implement the techniques. Thus, the option is to obtain Village Mutual Aid created and managed by farmers. The survey indicated that 66% of farmers used equipment belonging to other individual farmers or to farmer organizations they are members for the implementation of SWC techniques (Figure 17).

Figure-17. Distribution of farmers according to recourse to Village Mutual Aid



4. Conclusion

Results from the analysis of the survey data showed how farmers perceive the positive effects of SWC practices on soils, crops yields, livestock, and vegetation in Northern Burkina Faso. In fact, farmers were unanimous that the main beneficial effects of the SWC practices were their ability to improve soil's structure and fertility, to reduce water runoff thus allowing good water infiltration, to conserve soil moisture that combine to increase crop yields and fodder yields.

The survey results also showed the great willingness expressed by farmers to continue the implementation of all these anti-erosion practices introduced to their villages decades ago. However, the lack of appropriate equipment and reduced labor mentioned by all farmers in the farms make it difficult for farmers to adopt and widely spread the SWC techniques. Therefore, decisions are required by agriculture policy makers to ensure wide spread adoption for sustainable agricultural production systems in Northern Burkina Faso.Those decisions will include development of training programs to build farmers' technical capacities, low interest loans to enhance their equipment and financial levels and availability of inputs in quantity and quality to increase soil productivity for higher production.

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