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# BARRIERS TO UPTAKE OF CLIMATE-SMART AGRICULTURE PRACTICES: A CASE STUDY OF DANO AND OUAHIGOUYA FARMERS, BURKINA FASO

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## ABSTRACT

Integrating statistics and visualization analysis, this paper identifies and analyses the key barriers to farmers' effective adoption of Climate-smart agriculture (CSA) practices in Dano and Ouahigouya areas, Burkina Faso. The data used in this study were collected, in May 2016, from 147 households in the two different agro-ecological zones; these data were supplemented by information from focus group discussion (FGD), interview with institutions, and direct observation. It came out from this study that a better adoption of CSA practices requires a strong understanding of barriers and mechanisms (appropriate policies, strategies and actions) that may facilitate these practices by all actors involved in the diffusion, transfer and implementation process. The inaccessibility of inputs, credit constraints, water shortage, uncertainty in market condition, and climate risk appeared to be among factors that hindered farmers' ability and willingness to adopt CSA practices. Therefore mechanisms (such as index based crop insurance and property and procedural rights frameworks) that protect farmers from these hazards and shocks could encourage them (especially, risk-averse farmers) to take on more risky and more technologies that have high potential to maximize their profit.

**Keywords:** climate change, climate-smart agriculture, barriers, adaptation

## INTRODUCTION

As in the other countries of the Sahel, smallholder farmers in Burkina Faso are faced with a number of serious challenges due to climate change/variability, heavy reliance on rainfed agriculture, poverty, weakness of basic rural infrastructure and food insecurity. Climate change

  

ISSN: 2455-6939

Volume:03, Issue:04 "July-August 2017"

puts an extra constraint on food production systems (Liniger, Mekdaschi Studer, Hauert, & Gurtner, 2011), with serious implications for food security and economic development. Moreover, change in climate will most likely impact every type of natural resource. However according to the Intergovernmental Panel on Climate Change (IPCC) latest report, its major impacts in rural areas will be felt through water supply, food security and agricultural production (IPCC, 2014). Rural Africa's smallholder farmers, who are already bearing the brunt of climate vagaries, are among the most exposed to the risks associated to climate change. An overwhelming majority of *Burkinabe* rural population lives in extreme poverty with little access to basic services; an important part of this population (72%) is engaged in subsistence agriculture (characterized by the use of rudimentary tools and family labour force) with farm size less than 5 ha (MAFAP, 2013).

The relationship between climate change and agriculture is bi-directional: agriculture contributes to climate change and is in turn affected by climate change. On the one hand, agriculture contributes to global warming through emissions of greenhouse gases (GHGs) (crop and livestock production), and by the conversion of non-agricultural land into agricultural land. On the other, climate change is one of the limiting factors for agriculture production and threatens to exacerbate existing threats to food security and livelihoods in a number of ways. This includes the reduction of crop yield due to changing climate conditions, increasing frequency and intensity of extremes events (heat waves, drought, flood…), stress on livestock (changes in pests and diseases) and increasing water scarcity (IPCC, 2007). As result, agriculture must undertake a significant transformation in order to meet the related challenges of achieving food security and responding to climate change (FAO, 2010).

Climate-smart agriculture (CSA) is an emerging concept originally put forward in 2010 by the UN's Food and Agriculture Organization (FAO); it integrates the three dimensions of sustainable development (economic, social and environmental) by jointly addressing food security and climate challenges. As defined by the FAO, CSA refers to agriculture that sustainably increases productivity, resilience (adaptation), reduces/removes GHGs (mitigation), and enhances achievement of national food security and development goals (FAO, 2010). Thus, CSA is neither a new agricultural system nor a set of practice, but is a new approach, a way to guide the needed changes of agricultural systems, given the necessity to jointly address food security and climate change (Faurès et al., 2013). Specifically, it is a means of identifying which activities within production systems are best suited to respond to the challenges of climate change for specific locations. The aim of this new approach is to maintain and enhance the capacity of agriculture to support food security in a sustainable way. Supporting smallholder farmers in adoption of CSA practices would help to increase farm productivity and incomes, improve their resilience to climate risks, and mitigate climate change by reducing GHG emissions.

  

ISSN: 2455-6939

Volume:03, Issue:04 "July-August 2017"

At current situation, there is a large deficit of information on CSA practices (including available technology, knowledge, resources and policies) and known barriers to their implementation and diffusion. Yet, the implementation of adaptation measures faces a number of barriers. These include both the inability of natural systems to adapt to the rate and magnitude of climate change, as well as formidable environmental, economic, informational, social, attitudinal and behavioural constraints (IPCC, 2007). Until now, little study has attempted to identify factors that hindered farmers' ability and willingness to adopt CSA practices. To fill the gap, this case study uses data from a 2016 household survey carried out in two areas located in different agro-ecological zones of Burkina Faso. The overall objective is to appraise the current status of CSA practices and to identify and analyse the key barriers to the adoption in order to guide policymakers on ways to promote uptake of CSA practices.

Technologies used in agriculture can be broadly classified into three types: hardware, software, and orgware. Hardware (hard technologies) refers to physical tools, the technology itself; software (soft technologies) refers to the capacity and processes involved in the use of the technology and spans knowledge and skills; and orgware (organisational technologies) refers to the ownership and institutional arrangements of the community or organisation where the technology will be used (Christiansen, Olhoff, & Trærup, 2011; UNFCC, 2014). It is necessary to determine barriers associated to each type of technology adoption in order to establish a sufficient basis for developing measures to overcome them. Furthermore, analysing the nature of specific barriers and relationships between barriers could also facilitate the transfer, adoption and diffusion of technologies. In this paper we define hardware, software and orgware barriers as barriers associated to each aspect technology transfer/adoption.

The rest of the paper is organized as follows. The next section examines previous empirical studies on constraints to adopting new technology. Section three outlines the CSA practices considered in the study. Section four presents the methodology, the fourth section discusses the results and fifth section gives limitations of the study and areas for further research, followed by conclusions.

## OVERVIEW OF LITERATURE

Barriers are factors, conditions or obstacles that reduce the effectiveness of adaptation strategies. According to Ekstrom et al. (2011), barriers can be overcome with concerted effort, creative management, change of thinking, prioritization and related shifts in resources, land uses, and institutions. Most agriculture-based practices and technologies, which fall under the CSA framework, were also identified as climate change adaptation strategies. For Drechsel et al. (2005), the adoption of these technologies is a function of the characteristics of the technology

  

ISSN: 2455-6939

Volume:03, Issue:04 "July-August 2017"

proposed, farmers' perception of its advantages and need, as well as availability and distribution of production factors (i.e. land, labour/time, capital, knowledge, skills, etc.). They further argue that more barriers that impede technology dissemination are more often socio-economic factors (social, cultural and economic) than the bio-physical requirements. Empirical literature on barriers to farmers' adaptation indicated that lack of credit facilities (Acquah, 2011; Maddison, 2007; Nhemachena & Hassan, 2007), lack of information on adaptation options (Acquah, 2011; Deressa, Hassan, Alemu, Yesuf, & Ringler, 2008; Maddison, 2007; Nzeadibe, Egbule, Chukwuone, & Agu, 2011), lack of access to water (Acquah, 2011; Maddison, 2007), labour shortages (Deressa et al., 2008; Sofoluwe, Tijani, & Baruwa, 2011) and irregularities of extension services (Gbetibouo, 2009) constitute the major factors that challenge adoption of practices. McCarthy et al. (2011) showed that up-front investment costs, opportunity and transactions costs across a wide range of investments and practices can be significant barriers to adoption CSA practices. Moreover, according to the authors, potential synergies between the three main pillars of CSA (food security, adaptation and mitigation opportunities), as well as costs, can differ substantially across different agro-ecological zones, climate regimes, and historical land use patterns. Neufeldt et al. (2011) proposed seven key points to overcome hindrances that impeded the successful adoption of CSA practices by poor; these are: provide an enabling legal and political environment, better access to market, improve access to decision-making process, improve access to knowledge and training, improve tenure rights, overcome the barriers of high opportunity costs to land, and improve access to capital. For Barnard et al. (2015), factors that prevent adoption of CSA practices can be classified under two broad categories: hardware barriers (including physical inputs such as land; human resources; equipment; infrastructure and finances) and non-physical or software barriers (institutional, cultural, policy and regulatory environment; information, knowledge and skills; technologies and innovations; and governance among others). According to Peterson (2014), the main barriers to CSA practices adoption were lack of sufficient financial capital, difficult access to or low availability of the necessary agricultural inputs (tools, seeds and fertilizers), and in some cases insufficient labour to carry out the practice. Water scarcity was also a major hurdle for practices such as micro-irrigation, dry season gardening and agroforestry (farmers reported that tree seedlings often died due to lack of water). Descheemaeker et al. (2016) argue that major institutional barriers (such as access to markets and relevant knowledge, land tenure, insecurity and the common property status) limit the adoption potential.

**CSA practices use in this study**

There is no exhaustive list of CSA practices; but rather all agricultural approaches that promote these three primary goals are classified as climate smart. In the current case study, six broads

  

ISSN: 2455-6939

Volume:03, Issue:04 "July-August 2017"

groups of CSA practices are considered. The table below describes these practices and the related advantage to their adoption.

  

ISSN: 2455-6939

Volume:03, Issue:04 "July-August 2017"

**Table 1: Description of broads groups of CSA practices use in this study**

| CSA Practices | Description | Benefits | Benefit-cost ratio[1] | |
|---|---|---|---|---|
| | | | **short term** | **long term** |
| Farmer managed natural regeneration (FMNR) | Farmer-Managed Natural Regeneration (FMNR) involves supporting the regeneration of trees and their sustainable management to produce sustainable supplies of fuel-wood as well as non-timber products[2]. | Creates an enabling environment; Increases biodiversity; Reduces erosion; Enriches soils; Increases water availability; Offers new income opportunities via carbon credit revenues, sale of tree products), medicines... | – | ++ |
| Conservation agriculture (CA) | Crop rotation of cereals and legumes; Mulching/leaving crop residues on farm; Minimum tillage with ox plough/hand hoes. | Reduces labour; Increases organic matter and soil biological diversity; Traps soil moisture to improve water availability and water use efficiency; Reduces soil erosion; Sequesters carbon in soil; reduces production costs. | + | +++ |
| Climate smart rice production | Alternate wetting and drying of paddy fields | Triple-win situation: sustainably increases rice production and farmer incomes; Strengthens crops' resilience to climate change and; Reduces rice production's contribution to climate change. | **No data** | **No data** |
| Crop-livestock integration (CLI) | A system where crops and livestock interact to create synergies, making optimal use of resources. The waste | Increases crop yields; Improves soil biological activity and health; Builds up fertility through nutrient recycling, the planting of leguminous crops and trees; | + | ++/ +++ |

[1] Adapted from Liniger et al. ( 2011)

[2] http://www.ecosystem-alliance.org/meetings/livelihoods-and-ecosystems-land-resource-use-planning-ecosystem-based-adaptation-local , retrieved on July 22, 2016

  

| | | | | |
|---|---|---|---|---|
| | products of one component serve as a resource for the other: manure from livestock is used to enhance crop production (improve soil fertility), whilst crop residues and by-products (grass weeds and processing waste) are supplementary feed for the animals. | Reduces erosion; Intensifies land use, improving profits; Improves livestock productivity and health. | | |
| Integrated water resource management (IWRM) | Non indigenous rainwater harvesting techniques (Plowing, ridge tillage, hilling, soil scarifying...); Traditional micro-catchment runoff harvesting (contours bunds, zaï, half-moon, straw mulching...); Macro catchment runoff farming technologies (micro reservoirs...) | Reduces runoff loss; Restoration of degraded lands; Increases agricultural production (available of water for dry spells); Positive impact on local micro climate; Promotion of biodiversity. | – /+ + | ++ / +++ |
| Agroforestry | Agroforestry is intensive land management system that “intentionally combines agriculture and forestry to create integrated and sustainable land-use systems[3]”. | Increases land-use efficiency; increases production of wood and other tree products; restores the soil fertility; controls soil erosion; provides growing space for medicinal plants; carbon sequestration; enhances or maintains wildlife habitat... | – /+ + | ++ |

– – negative ; – slightly negative ; – /+ neutral ; + slightly positive ; ++ positive ; +++ very positive

[3] http://nac.unl.edu/practices/index.htm, retrieved on July 25, 2016

ISSN: 2455-6939

Volume:03, Issue:04 "July-August 2017"

## MATERIALS AND METHODS

### Survey Design and Study Area

### Sampling procedure, data collection and analysis

A four-stage sampling technique was employed to select 147 households. Two study areas, Ouahigouya and Dano, were purposely selected in order to compare the effects of different weather conditions (climate variability and change) on practices adoptions. In the next stage, three (3) rural communes out of eight (8) and four (4) rural communes out of thirteen (13) rural communes that comprise respectively the Ioba and Yatenga provinces were purposively selected. In the third stage of clustering, twelve (12) villages were also purposely selected, based on biophysical conditions and presence or absence of irrigation facilities (presence or absence of reservoir with irrigation scheme). In the last stage, a total of 74 and 73 households were selected in Dano and Ouahigouya areas respectively.

Data were collected in May 2016 through four complementary research tools (approaches): direct observation, household survey, focus group discussions (FGDs) and interview with government officials and project implementers. Collected data were digitalized using CSPro software package version 5.0. The statistical software SPSS (IBM SPSS Statistics for Windows, Version 20.0) was used for analysis.

### Description of the study area

The study was conducted in two provinces (administrative division) located in two different agro ecological zones: Ioba province (Dano area) and Yatenga province (Ouahigouya area). As the others part of the country, the study zones are characterized by tropical climate with an unimodal rainfall curve, a short rainy season and a long dry season (5 to 6 months in Dano and 7 to 9 months in Ouahigouya).

The study areas are located respectively in the south-western and northern part of the country and cover a total area of approximately 10,279 $Km^2$. Dano area is among the better-watered areas of Burkina Faso; the area's landscape is portrayed by rugged topography, composed of chains of hills with, plateaus, and plains drained by rivers. The second area is characterized by a relative rough climatic condition (Figure 1); its topography, illustrated by plains and plateaus, is subjected to strong environmental degradation.

  

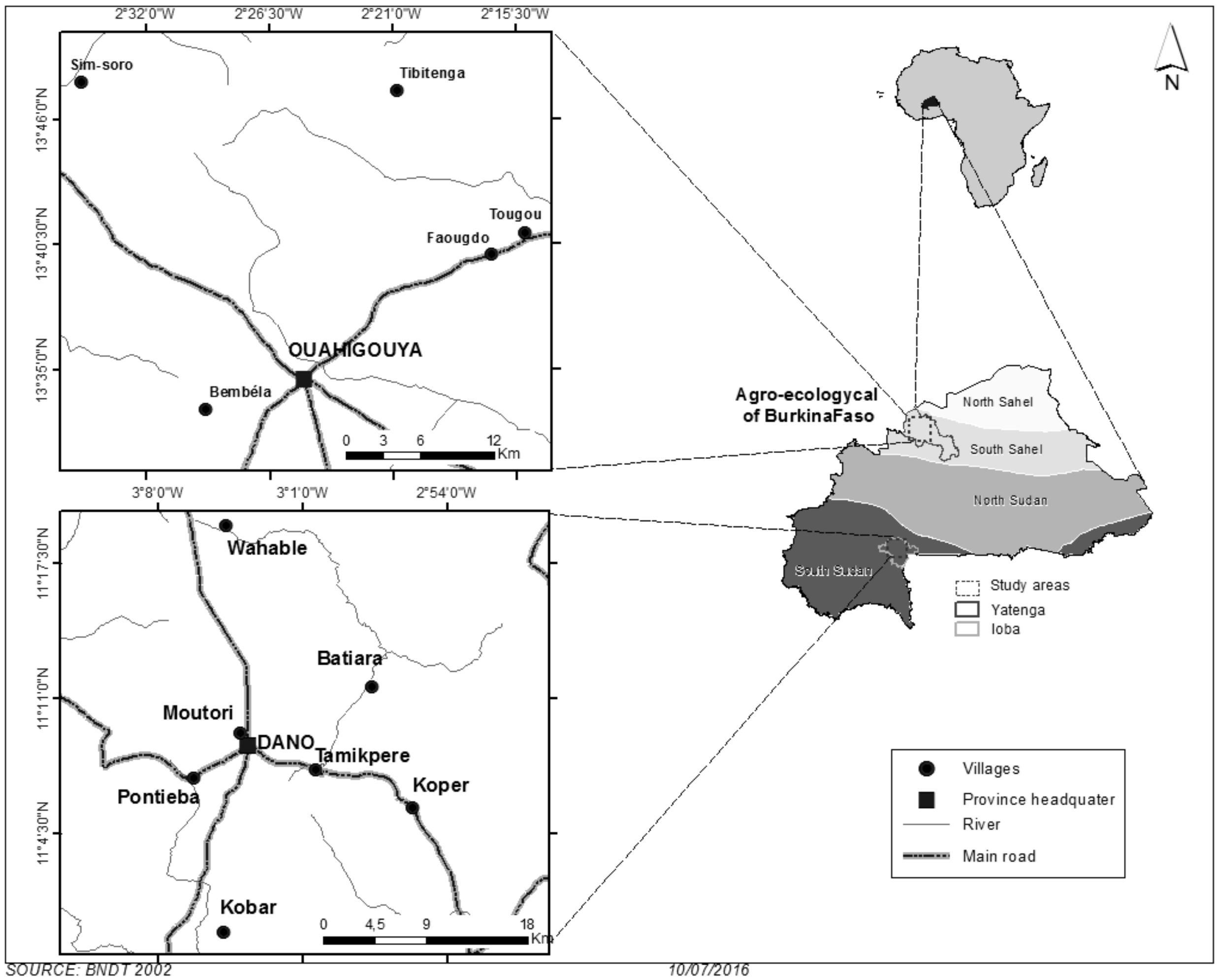


**Figure 1: Location of the study areas**

## Statistical Analysis

### Weighted average index (WAI)

Weighted average index (WAI) was used to transform farmers' self-assessment measured on a nominal scale into numeric scores. WAI Was applied to analyse respondents' opinions. In the literature authors used it for analysing farmers' perception on farming systems activities (Tanthaphone, 2007), farmers' local Knowledge in farming Systems (Chowdhury & Khairun, 2014), the importance of climate change adaptation practices (Ndamani & Watanabe, 2015), farmers' self-assessment on technical and ecological knowledge (Miah, 1993; Zhen, 2002 cited in Chowdhury and Khairun, 2014), fishers' perceptions on the aquatic resources and fisheries management (Sakset & Gallardo, 2013).

  

ISSN: 2455-6939

Volume:03, Issue:04 "July-August 2017"

Farmers were asked the question, *"What kind of barriers do you experience in carrying out improved/climate-smart practices?"* They were also asked to indicate the intensity of barriers (low barrier, moderate barrier and high barrier) in the adoption and/or implementation of the practices. Responses were scaled using a four-point Likert scale (0=not a barrier, 1=low barrier, 2= moderate barrier, 3=high barrier).

The index was computed using following equation:

$WAI = \frac{\sum f_i W_i}{\sum f_i}$, where $W_i$ = the weight assigned to $i^{th}$ in the scale of barrier (0=not a barrier, (1/3) =low barrier, (2/3) = moderate barrier, (3/3) =high barrier), $f_i$ is the frequency of the respondents who select $i^{th}$ in the scale of barrier, $\sum f_i$ is the total number of respondents.

**Statistical test**

The ***t*-test** was applied for a comparison of WAI mean values between the two study areas at a 95% confidence level ($p$-value <0.05). Statistical relationships between barriers and adoption CSA practices were assessed though **chi-square tests** and the degree of association was measured using phi-correlation. The **phi coefficient** of correlation for binary variables suggested by Yule (1912) is a measure of the degree of association between two binary variables. A phi coefficient of 0 indicates independence (no association) between variables; a phi coefficient of 1 indicates complete dependence (association) between the variables.

**Empirical Results and Discussion**

**Barriers to adoption of climate smart agriculture practices**

The most frequently identified factors constraining farmers from adopting CSA practices were hardware barriers (Figure 2). Roughly 78% ($n$ = 114) of respondents mentioned a high cost of inputs as main barrier; and among these farmers, almost 86.8% of them cited this constraint as a high barrier. Absolute majority of surveyed farmers (55%, $n$ = 81) reported the lack of financial resources (lack of capital, lack of access to credit) as one of the main barriers to uptake of CSA technologies. Among farmers who cited the lack of financial resources as a limiting factor to CSA adoption, approximately 65% rated this constraint as a serious barrier; only 2.7% classified it as a low barrier. Market problems and lack of government support were identified as among the main obstacles impeding adoption by approximately 39% ($n$ = 58) and 37% ($n$ = 55) of the interviewed farmers respectively. The results indicated that 35% ($n$ =51) of the surveyed farmers perceived water scarcity as a major factor that challenge adoption of practices such as irrigation

  

ISSN: 2455-6939

Volume:03, Issue:04 "July-August 2017"

and climate smart rice production; whereas according 33% (*n* =49), absence of knowledge, not access to information, and/or familiarity with CSA practices acted as obstacles to CSA practices and technologies adoption or that are complicating they effectiveness and efficiency. About 27% (*n* = 40) and 26% (*n* = 38) of the respondents pointed out respectively labour constraints and climate risks as serious obstacles. The study further found that less than 10% of surveyed farmers identified the small size of the farm and the flexibility of the practices as limiting factors which affected uptake of CSA practices.

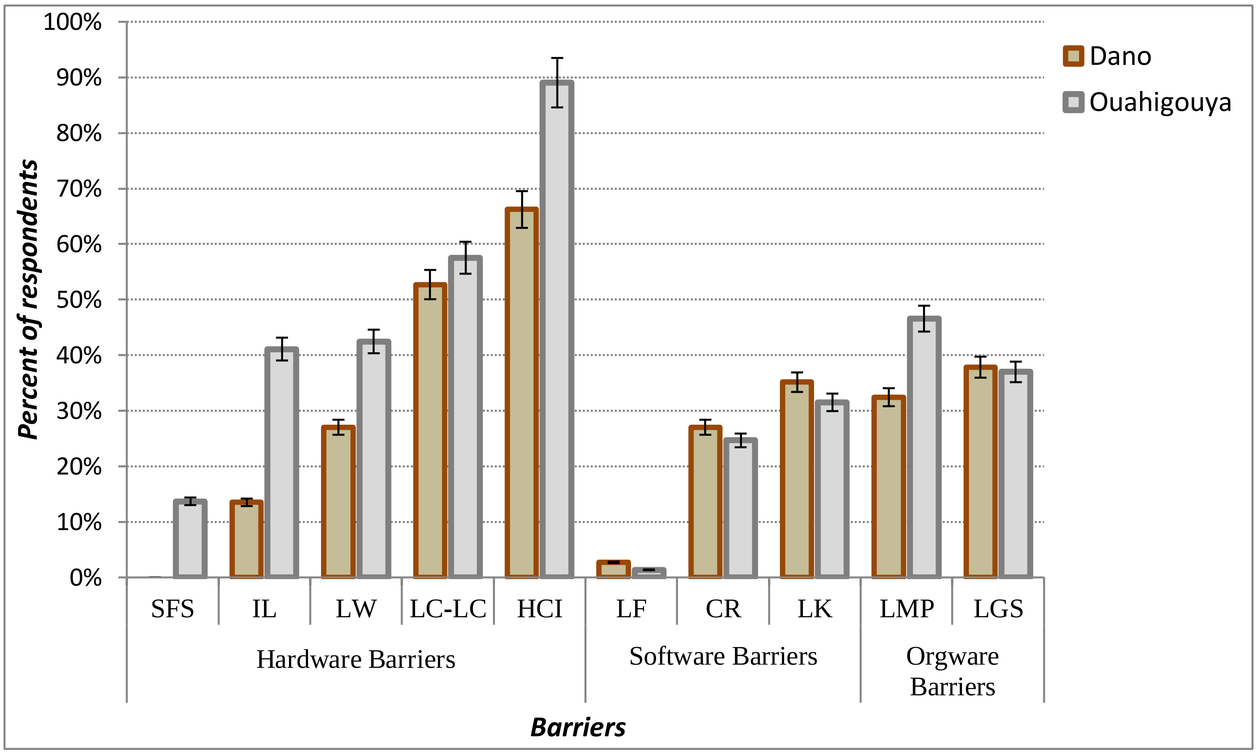


**Figure 2: Barriers to CSA practices adoption**

The ranking of barriers based on farmers' perceived importance is displayed in Table 2. Highest index value ranging from moderate to high barrier was associated with barriers such as the lack of market *(WAI = 0.35)*, the lack of capital/ shortage of credit *(WAI = 0.48)* and the high costs of inputs *(WAI = 0.74)*. The analysis further showed that, in both areas, farmers' opinions of factors that hindering their decision to adopt/implement CSA practices differ greatly (Table 2). For instance, the effect of the major barrier (costs of inputs) on CSA adoption/implementation was high in Ouahigouya area *(WAI=0.85)* and moderate in Dano area *(WAI=0.63)*. Similarly, the difference between the WAIs of the shortage of labour and the lack of knowledge in Ouahigouya *(WAIs=0.31 and 0.35, respectively)* and Dano area *(WAIs=0.12 and 0.23, respectively)* was

  

ISSN: 2455-6939

Volume:03, Issue:04 "July-August 2017"

statistically significant. Although, the study revealed a little effect of the farm size on the adoption/implementation of CSA practices in Ouahigouya area *(WAI=0.10)*, this barrier had no effect on Dano area's farmers decision *(WAI=0.00)*.

**Table 2: Weighted average index of barriers associated with CSA practices adoption**

| | Dano (n=74) | | Ouahigouya (n=73) | | Total (n=147) | |
|---|---|---|---|---|---|---|
| | WAI | Ranking | WAI | Ranking | WAI | Average of ranking |
| ***Hardware Barriers*** | | | | | | |
| High costs of inputs (HCI) | **0,626** | **1** | **0,854** | **1** | **0,739***** | **1** |
| Lack of capital/access to credit (LC-LC) | 0,477 | 2 | 0,479 | 2 | 0,478 | 2 |
| Lack of water (LW) | **0,230** | **7** | **0,352** | **4** | **0,290*** | **5** |
| Insufficient labour (IL) | **0,122** | **8** | **0,306** | **5** | **0,213***** | **8** |
| Small farm size (SFS) | **0,000** | **11** | **0,100** | **9** | **0,050***** | **9** |
| ***Software Barriers*** | | | | | | |
| Lack of knowledge (LK) | 0,279 | 5 | 0,242 | 7 | 0,261 | 6 |
| Climate risks (CR) | 0,270 | 6 | 0,242 | 7 | 0,256 | 7 |
| Lack of flexibility (LF) | 0,027 | 9 | 0,014 | 11 | 0,020 | 10 |
| ***Orgware Barriers*** | | | | | | |
| Lack of market for products (LMP) | 0,297 | 4 | 0,406 | 3 | 0,351 | 3 |
| Lack of government support (LGS) | 0,329 | 3 | 0,297 | 6 | 0,313 | 4 |

Notes: Weighted average index: 0 = not a barrier; 0.01–0.33 = low barrier; 0.34–0.66 = moderate barrier; 0.67- 1 = high barrier; ***, **, * = the difference in the means from the two groups were significant at 1%, 5%, and 10% probability level, respectively.
Source: author

## Relationships between barriers and adoption CSA practices

This section seeks to assess if there are significant relationship among the CSA practices and barriers faced by farmers. Since we have binary variables (0 or 1 values), the chi-square test is more appropriate. It shows whether or not differences between proportions are statistically significant. The null hypothesis is given by: H0: no relationship between CSA practice adoption and the barriers faced by farmers in their activities. The degree of association was measured using phi-correlation and depicted in the elaborated diagram (figures 3). This diagram only shows variables in which $0.01 < p < 0.05$. Positive relations are shown as solid lines and negative as dashed lines.

  

ISSN: 2455-6939

Volume:03, Issue:04 "July-August 2017"

Based on the Chi square tests, the results indicated that the incidences of barriers such as high costs of inputs *($\chi^2$ (1) = 27.842, p =0.000, $\phi$ = 0.435)*, insufficient labour *($\chi^2$ (1) = 5.292, p =0.021, $\phi$ = 0.190)*, lack of market for products *($\chi^2$ (1) = 7.452, p =0.006, $\phi$ = 0.225)*, climate risks *($\chi$2 (1) = 13.660, p =0.000, $\phi$ = 0.305)*, small farm size *($\chi^2$ (1) = 5.043, p =0.025, $\phi$ = 0.185)* and lack of water *($\chi^2$ (1) = 3.887, p =0.049, $\phi$ = 0.163)* on the adoption of FMNR practices are statistically different between adopters and no-adopters. The Phi coefficient denoted a very little to weak correlation relationship between these barriers and decision to use FMNR (Figure 3). Adoption of conservation agriculture practice was influenced by lack of market for products *($\chi^2$ (1) = 4.459, p =0.035, $\phi$ = 0.174)*, small farm size *($\chi^2$ (1) = 7.692, p =0.006, $\phi$ =-0.229)* and lack of water *($\chi^2$ (1) = 5.035, p =0.025, $\phi$ = 0.185)*. The Phi coefficient indicated the strength of the relationship was very little. Climate risks had weak effect on the adoption of IWRM *($\chi^2$ (1) = 14.285, p =0.000, $\phi$ = -0.312)*; while its effect on the adoption of CLI *($\chi^2$ (1) = 14.649, p =0.000, $\phi$ = 0.516)* and agroforestry *($\chi^2$ (1) = 11.373, p =0.006, $\phi$ = 0.278)* was very little. The test showed a very little and significant association between the lack of government support and the use of IWRM techniques *($\chi^2$ (1) = 3.901, p =0.048, $\phi$ = 0.163)*.

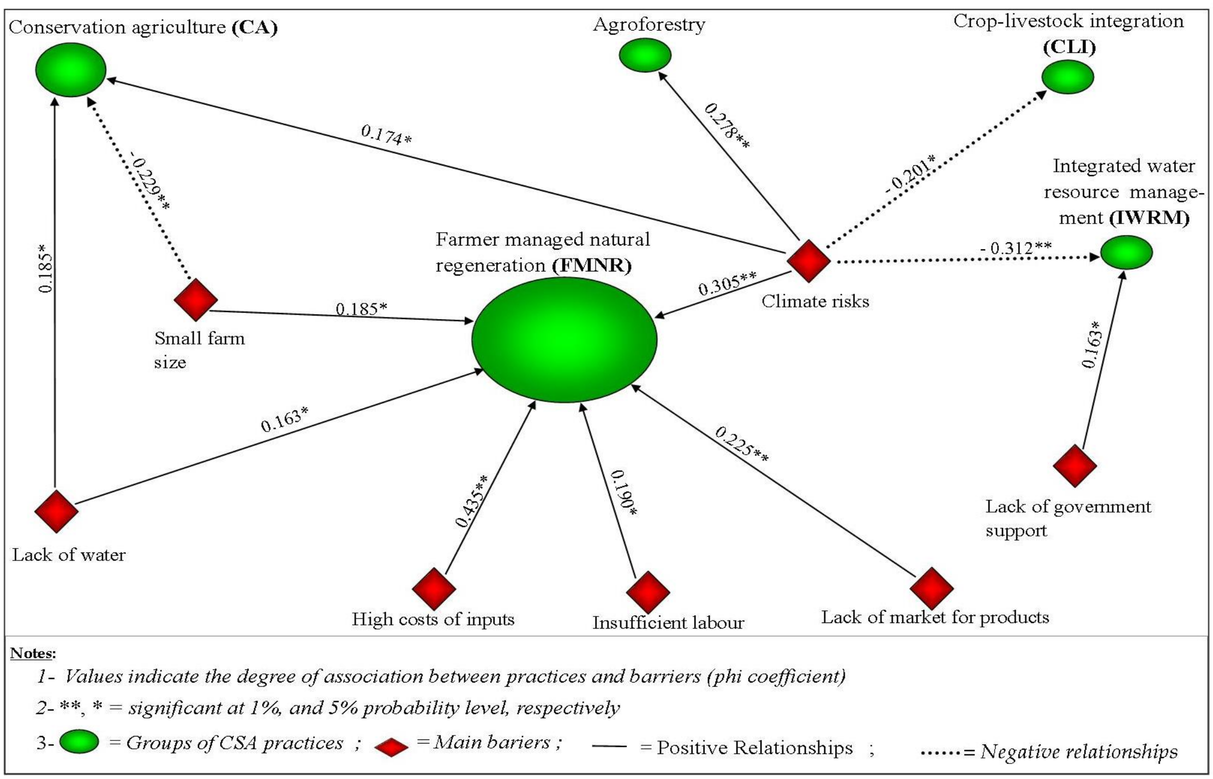


**Figure 3: A path diagram of the statistical relationships between barriers and adoption CSA practices**

  

ISSN: 2455-6939

Volume:03, Issue:04 "July-August 2017"

**DISCUSSION**

A variety of possible barriers were identified in this study, including high costs of inputs, lack of financial resources (capital, credit...), market problem, lack of government support, water scarcity, lack of knowledge about CSA practices, the risks associated with climate change/climate variability, and shortage of labour. It came out that, the main constraints to the adoption of CSA practices are the high costs of inputs (improved seeds, fertilizers, pesticides), and limited access to physical and financial resources.

Regarding to the high costs of inputs (improved seeds, fertilizers, pesticides) farmers, in both areas, pointed out the delays in the supply of subsidized/ improved seeds, and their unavailability at local level. Authors argued that limited access to equipment and other inputs (inorganic fertilizers, pesticides, and herbicides) represent a significant constraint to the adoption of CSA practices such as CA in a maximally productive manner (Barnard et al., 2015; Milder, Majanen, & Scherr, 2011). Food insecure farmers, in the instinct for survival, would first seek to increase their food production by using affordable technology even if this latter is environmentally-unfriendly. For example, a study conducted among food insecure and food secure farmers in Kenya showed that poorer farmers were not investing in improved farm management practices, because they were entirely focused on activities that contribute to their household food supply (source). In this case, reducing the cost of improved seeds, fertilizers, and pesticides may create incentives to expand from food production, and help to achieve the food security.

To successfully adopt CSA practices, smallholder farmers often need financial resources and/or credit for acquiring agricultural inputs (land, equipment, labour, seeds and other farm inputs); and farmers may fail in their activities when any or all of these inputs is absent or available in limited quantities or volumes. Most farmers, in Dano and Ouahigouya, raised the problem of access to physical and financial resources (weak financing mechanisms, lack of access to credit or long and complex procedures link to credit access). Vulnerable farmers are especially risk averse due to household food security concerns (Milder et al., 2011), and some CSA are generally more profitable in the long-term compared to conventional farming (Barnard et al., 2015); therefore, assistance for establishment of certain measures may be needed for small-scale subsistence farmers if costs are beyond their means and if quick benefits are not guaranteed (Liniger et al., 2011). Actions aiming at relaxing credit or others financial constraints (easing farmers' access to credit by reducing the conditions, local insurance-warrantage systems, safety net programs…) would potentially hearten risk adverse farmers to try other suitable options.

Limited access to markets and capital are among the main constraints for smallholder farmers, and limit their ability to innovate and raise their income (Neufeldt et al., 2011). Approximately

  

ISSN: 2455-6939

Volume:03, Issue:04 "July-August 2017"

39% ($n$ = 58) of surveyed farmers, in this study, indicated local market failure (inconsistent distribution system, corruption in the distribution chain, presence of many intermediaries in the market, prices fixed by buyers…) as one of the main barriers preventing them for adopting CSA practices. To this, add a disorganized marketing system (farmers are not well organized in the market), poor roads and infrastructures, shortages of outlets for crop/ livestock production, an absence of post-harvest treatment and storage infrastructure for off-season products conservation.

The poor understanding of CSA concepts and the lack of information/knowledge on existing practices were identified by farmers as main obstacles that impede adoption of CSA practices. Access to information/ knowledge plays a major role on CSA adoption. As stated by AGRA (2014), "CSA is clearly knowledge-intensive and for it to be effectively implemented, well designed, inclusive, and innovative knowledge management systems are essential". As cited by farmers in the study areas inadequate knowledge of CSA concepts, lack of contact with extension services, limited technical assistance constitute limiting factors to the adoption of CSA practices. In a case study done in Western Kenya, Neufeldt et al.(2011), revealed that improve access to knowledge and training significantly improve farmers' willingness to plant more trees. For Thorlakson (2012), educational farm visits to successful management practices can increase adoption rates.

Farmers also raised the lack of government support as factors that impede or slow down the adoption of CSA practices. As noted by Barnard et al. (2015), physical (water management structures, transport, markets...) and social infrastructures (farmers' organizations and cooperative societies) play central roles in any economic activity. Poor and inadequate infrastructure limits adoption of technologies, particularly for smallholder farmers. Investments in physical infrastructures (roads, water retention, irrigation ...) are often beyond the capacity of local communities and small-scale farmers and require heavy investments; these investments may only be undertaken by government, NGOs and donors. Barriers such as the size of the farm area and the lack of flexibility (ability to manipulate the practices) were not ranked by farmers as factors affecting non-adoption or low adoption of CSA practices.

## CONCLUSIONS

This paper aimed to appraise the current status of CSA practices and to identify and analyse the key barriers to the adoption in order to guide policymakers on ways to promote uptake of CSA practices. The study revealed that farmers' adoption was influenced by a variety of possible barriers, including high costs of inputs, lack of financial resources (capital, credit...), market problem, lack of government support, water scarcity, lack of knowledge about CSA practices,

  

ISSN: 2455-6939

Volume:03, Issue:04 "July-August 2017"

the risks associated with climate change/climate variability, and shortage of labour. From this study, it came out that, the main constraints to the adoption of CSA practices are the high costs of inputs (improved seeds, fertilizers, pesticides), and limited access to physical and financial resources. The study also revealed that barriers such as the size of the farm area and the lack of flexibility (ability to manipulate the practices) were not ranked by farmers as factors affecting non-adoption or low adoption of CSA practices. Mechanisms such as index based crop insurance and property and procedural rights frameworks that protect farmers from climate hazards and shocks could encourage them (especially, risk-averse farmers) to take on more risky and more technologies that have high potential to maximize their profit.

**Limitations of the study and areas for further research**

Our findings should be interpreted within the context of some limitations. One limitation concerns the data collection methods used in this study. This study relied mainly on cross-sectional and self-reported data; the use of such data may have led to an overestimation of the relationships considered due to common method variance.

A second limitation is in regards to the data collected itself that may lack detail and depth on the subject and accuracy or honesty issue may occur in the responses given by the respondents. Finally, another limitation is noted to be the lack of homogeneity of the sample in term of gender (gender imbalance) could skew the results.

## RECOMMENDATIONS

Kristjanson et al. (2012) have shown, with evidence, that uptake of CSA practices is proportional to the level of household food security; meaning that the most food insecure households are the most reticent to take up new CSA practices. CSA to be effective and fully accepted by local population must be an accessible option for the large majority particularly: the most food insecure; therefore, promoters (donor, research institutes, government, NGO, and others stakeholders) should target their effort toward programs and actions such as safety net programs in order to allow poor and food insecure communities to invest in CSA measures.

The inaccessibility of inputs, credit constraints, water shortage, uncertainty in market condition, and climate risk appeared to be among factors that hindered farmers' ability and willingness to adopt CSA practices. Therefore mechanisms (such as index based crop insurance and property and procedural rights frameworks) that protect farmers from these hazards and shocks could encourage them (especially, risk-averse farmers) to take on more risky and more technologies that have high potential to maximize their profit.

  

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**COMPETING INTERESTS**

The authors declare that they have no competing interests.

**Authors' contributions**

All authors were involved in the design of the study, and participated in field data collection. Y.B.T. had primary responsibility for analysing the data. All of the authors were involved in interpreting results from the analyses. All authors read and approved the final manuscript.

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