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Farmers Characteristics in Relation to Soil and Water Conservation: The Case of Yongdeng County, China

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Authors' contributions

This work was carried out in collaboration among all authors. Authors LXL and SA designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors XL and FKY managed the analyses of the study. Author LXL managed the literature searches. All authors read and approved the final manuscript.

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Case Study

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ABSTRACT

Many soil and water conservation technologies have been promoted and spread to encourage the sustainable use of resources by small-scale farmers, but soil degradation continues intensively. The objective of this study therefore, was to identify the measures of Soil and Water Conservation, the factors that inform the adoption and use Soil and Water Conservation measures and evaluate the limitations to realize and maintain of these conservation practices. This study was done in Yongdeng County which falls under the governance of the city-level prefecture of Lanzhou, the capital of Gansu Province. One hundred farmers were randomly selected. Primary data was obtained through interviews and group discussion with farmers, and agricultural extension workers and field survey. The results revealed that the level of education and farm size did not affect the use of SWC measures. Unlike formal education, membership of the group of farmers was significant and had positive correlation with SWC measures. SWC education and training was significant and had a positive impact on the use of SWC measures. The study found that SWC

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structures commonly used by farmers in the study area include terraces (30%), contour ploughing (20%) and the use of drains. The agronomic practices commonly used are agroforestry, crop rotation and the use of grass strips. Farmers identified poverty, ignorance and lack of technical advice as the main obstacles to realizing the full potential of soil and water conservation in the area. Poorly laid out soil conservation structures were also accelerating soil erosion. These results show that, in order to ensure adequate soil and water conservation, particular attention must be paid to institutional and economic factors. Also, to encourage farmers' participation in education and extension training on SWC, it is vital to strengthen the relationship between extension workers and farmers.

Keywords: Soil erosion; adoption; soil and water conservation.

1. INTRODUCTION

A major environmental and agricultural problem faced by human beings is soil erosion [1]. Soil erosion which is a natural gradual process that displaces the upper layer of soil can be as a result of change in the land use practices such tillage, deforestation and arable land expansion [2].

Taking a share of this world environmental and agricultural challenge of Soil erosion is China. National soil and water erosion affects a total area of 2.9491 million km², representing 30.72% of the entire national territory (Ministry of Water Resources, People's Republic of China). According to the Ministry, of the total land affected, 1,2932 million km² suffer from water erosion and 1, 6559 million km² from wind erosion.

Ensuring sustainable food security for the population has over the years become a major concern for policy makers and government officials of China due to the increasing population coupled with rapid urban development and income growth. By the year 2030, the population of China is estimated to reach a maximum of 1.45 billion, with a projected increase of 60% of the people living in urban centers. Beside this, inadequate water resources and cultivated land are shifted to non-agricultural use [3]. Cultivated lands that is intended for production was lost at a rate of 1.45 Mha/year since 2000 and as a result, output in the soil that is left in production becomes increasingly critical to preserve in order to ensure continues food production [4]. Effects of soil degradation include compaction, damage of soil structure, nutrient reduction and soil salinity. Moreover, soil degradation contaminates waterways and also raise bed floor of water bodies through sedimentation which can cause flooding and also affect aquatic organism [5].

In response to the negative impacts of soil erosion on agricultural productivity, the Chinese government, shareholders and other non-governmental organizations have constantly engaged farmers to promote best practices, such as the use of terraces, agroforestry and other agricultural practices aimed at controlling soil erosion at the County, Provincial and National levels. The implementation and use of these practices still remain low notwithstanding these efforts.

One of the places that is of interest with regards to Agriculture is the Yongdeng County located in Lanzhou city of Gansu province. Yong Deng was declared as a national "safe agricultural machinery" demonstration County in 2018 despite the challenges it faces in terms of land degradation. The declaration of this county as a safe agricultural machinery was informed by the role it plays in production of food through agricultural activities and provision of ecological services to the city, province and country at large. with a population of 520,000 (2010) and a growth rate of 4% per annum, the pressure on land resources in Yongdeng county has resulted in agricultural escalation but with inadequate use of soil and water conservation measures and fertility amendments. Therefore, soil erosion caused by land degradation is becoming a severe problem in the area which if left unchecked will lead to serious agricultural and environmental challenges.

With this background in mind, this study seeks to identify (1) the characteristics of the farmers in this area and how they influence the use of soil and water conservation, (2) evaluate the study area to identify the types of soil and water conservation measures that have been implemented by farmers in an attempt to curb the situation, and (3) identify the limitations and constrains to the adoption and use of SWC measures in the area.

2. MATERIALS AND METHODS

2.1 Study Area

The study was carried out in Youngdeng County, Gansu province as shown in Fig. 1. Yongdeng, formerly known as Lingju and Zhuanglang, is affiliated to Lanzhou city, Gansu Province.

It is 102°36' to 103°45' East longitude and 36°12' to 37°07' North latitude. It stretches 107 kilometers from south to north and 101 kilometers from west to east with a total area of 6,090 square kilometers. Yongdeng County's topographical features can be summarized as "three mountains clip two rivers" the formation of loess hilly region and Qin River basin. The landform is characterized by a staggered distribution of stony mountain and loess hills. Terrain located in Qinghai-Tibet Plateau in northeastern and western Loess Plateau transition zone is also the Qilian offshoot eastern extension of the Longxi between sedimentation basins staggered transition region. The mountains in the territory overlap, the hills are undulating, and the river runs through. Towering into the clouds, Wushaoling is located in the north of the county. Flowing through the south of the county is the yellow river and the whole terrain slopes from the northwest to the southeast, with an altitude of 3,000 to 1,600 meters.

Yongdeng County has a continental climate with an annual average temperature of 5.9°C, annual precipitation of about 1,200 to 1,500 mm, annual sunshine hours of 2,659 hours, and an average frost-free period of 121 days. From field tours carried out in the area, bare lands and cultivated lands are the most vulnerable to soil erosion.

2.2 Research Methodology

100 farmers from farming communities in the study area were randomly selected for this study using the compiled village sampling frame. The population of this study consisted of 134 Small and Medium Scale farmers from Linping, Pailou, Xiaolin, Heqiao, Hongun, Xinzhuan, Donggushan and Shuiping community which was based on available data from the farmers register. The study was conducted in the dry season when the farmers were not occupied with their cropping activities. The dry season (October to December) is very good time for protecting the soil from erosion caused by rainfall which is expected after the dry season.

The formula below was used in determining the sample size;

$n = \frac{N}{(1+N(e)^2)}$ Where n= the sample size, N= the population, e=margin of error

From the above formulae, using a confidence level of 95% and a 5% margin of error, we arrived at a sample size of 100.

In each community, farmers were randomly selected and pre-tested semi-structured questionnaire administered to them. The questionnaire administered sought to acquire

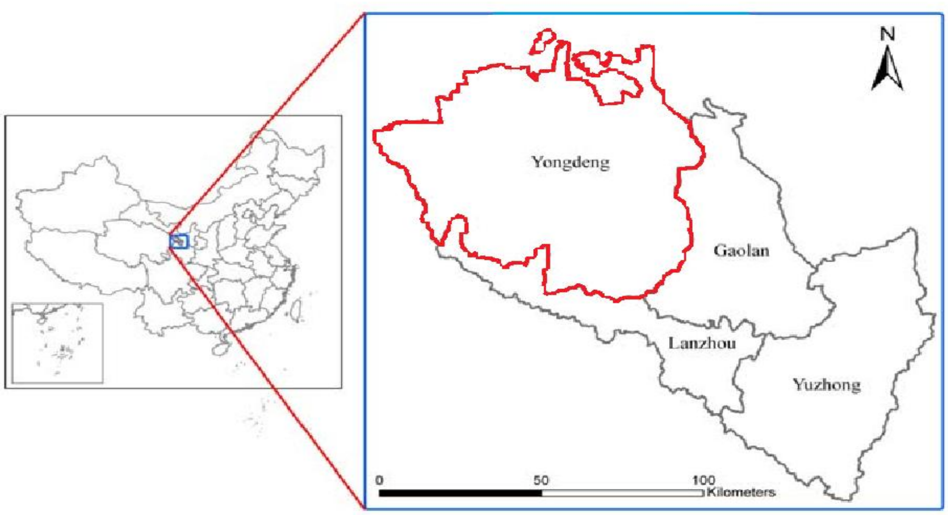

Fig. 1. Study area

information on the demographic features of farmer's households, the perception of the occurrence of erosion and on the conservation of soil and water. Prior to the start of the study, a two-day field tour of the study area was conducted to have an understanding of the area in terms land, soils, land use and vegetation. The field visit was carried out in each community, with the assistance of key informers, who gave their inputs on soil erosion and the diversity of land Management in the area. Further information was obtained through in-depth interviews and group deliberations with farmers. Evidence of erosion and other forms of land degradation were noted during the field tour. Correlations and descriptive statistics, as a minimum, maximum, average, standard deviations, percentages and frequencies, were analyzed using IBM Social Sciences statistical software package (SPSS Version 20.0). Data entry and cleaning was done in MS Excel.

3. RESULTS AND DISCUSSION

3.1 Characteristics of the Respondents

The respondent's age falls between 20 and 89 years with 42% of them falling under the age group of 40–60 years. Males respondents were 85% and females were 15% were. Out of the total respondents 65%, 27% and 5% have acquired primary, secondary and tertiary education respectively whiles 3% of the respondent didn't have any form of formal education at all. The minimum and maximum number of people one household was 4 and 6 respectively. About 2% of the respondents engage in other economic activities apart from farming. Majority of the respondents (80%) have a farm-size ranging between 1-5 hectares whiles the rest (20%) have a farm size above 5 hectares.

Table 1 shows the correlation matrix of variables using IBM Social Sciences statistical software package (SPSS Version 20.0). Correlation differences among variables was found to be significant at 0.01 level (2-tailed), N=100 and 0.05 level (2-tailed).

3.2 Soil Erosion in the Area

The results showed that 75% of the farmers surveyed experienced erosion in their farms whiles the rest did not experience erosion on their farms. 35% and 65% of the farmers indicated erosion on their farms as severe erosion and moderate respectively. During the field tour, common erosion indicators observed included surface water flow and rocky outcrops on the surface, particularly uphill and sedimentation on lower farms. Most farmers reported erosion damage during the first rains when the land is bare. This is in consistent with studies by [6] in which they reported that water filtration becomes difficult when the soil becomes bare and compact and might even worsen due to harsh climatic conditions such as drought.

In the study area, Rill erosion (49%) is the most common form of soil erosion along the boundaries of the farm and watercourses used to remove excess water, followed by gulley and sheet erosions (Table 2). River erosion and splash erosion were not common among farmers. According to farmers, the outflow of surface water on bare surfaces forms rills that widen and deepen to form gullies.

On the causes of soil erosion, farmers identified many. Erratic massive rainfall on bare land, steep slopes, poor and lack of soil and water conservation measures were the highest (Table 2). The reduction of land cover and the expansion of agricultural upward hill in previously forested areas were identified as land uses which led to increased erosion.

Gullies that develop from the conversion of hilly areas into arable land have been identified as the most destructive form of soil erosion. It displaces huge masses of sediment from uphill and become a hazard to farming land and habitations.

3.3 Knowledge and Use of Soil Conservation Measures

In the study area, about 65% of the farmers use at least one SWC measure, with 35% not adopting any at all. The terraces were the highest with 21%, especially among farmers on the upper sides of the area. Agronomic practices, namely agroforestry (16%), mixed agriculture (18%), use of pastures (16%) were also common among farmers. Finally, 16% cut-off drains was the main measure used by farmers because of its effectiveness in the conservation of water on farms and in the control of soil erosion.

Common soil and water conservation structures were terraces and drains, especially on sloppy farms. These structures, according to farmers, contribute to reducing the rate of surface outflow through the slope, retain moisture and also allow water to slowly infiltrate the soil.

Following the Chinese Government's Conservation program which was aimed at eradicating serious soil degradation and its related environmental problems, the Green for Grain program (GGP), one of six key conservation programs was started in Sichuan, Shanxi, and Gansu in 1999. This program has over the years helped farmers adopt agroforestry by incorporating trees in their farms. Farmers admitted to realizing the benefit of trees in their farms, which include increase fertility of soil and protection of soils against erosion as their deep roots hold the soil firmly and also act as windbreakers. Leguminous trees also replenish nutrients as these trees are major sources of nutrients.

Farmers have also made efforts to control gulley erosion by planting grasses along gulley channels and sloppy lands to trap most of the sediments from upstream. Farmers in the study area indicated in this study that they use crops residue or waste and other agricultural materials generated from their farms, as mulch or manure. This confirms studies by [7] who posited that residues of crops that are gathered after harvest and used as manure or fertilizer serve as a source of soil organic matter and also conserve the soil when they are bare and vulnerable to erosion. Notwithstanding this convenient use of residues from the farm, some of the farmers said they faced challenges in deciding how to use crop residue from their farms, thus deciding whether to use it as manure or feeding their animals.

3.4 Factors Influencing the Adoption of Soil and Water Conservation

3.4.1 Age

Table 4 shows that the average age is between forty and sixty years and then followed by twenty and forty years. This indicates that most heads of household belong to the economically active age class. In this study, there was a positive correlation between the age of farmers and adoption and use of SWC measures in this study.

Table 1. Correlation matrix of variables

Variables	Age	Years of farming	Education	Association	Farm size	SWC use	Extension training on SWC
Age	1						
Years of farming	.769**	1					
Education	-0.19	-.244*	1				
Association	0.073	0.149	-.284**	1			
Farm size	.382**	.300**	0.021	0.09	1		
SWC use	0.036	0.226	0.012	0.570*	0.05	1	
Extension training On SWC	-0.05	0.026	-0.044	.273*	0.03	0.643*	1

***. Correlation is significant at the 0.01 level (2-tailed). N= 100*
**. Correlation is significant at the 0.05 level (2-tailed)*

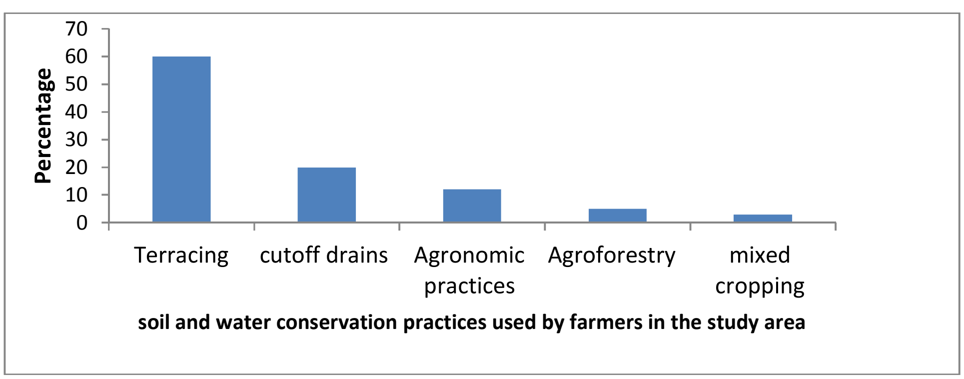

Fig. 2. Soil and water conservation measures used by farmers in Yong Deng County

Table 2. Types of soil erosion in the study area

Type of soil erosion	%
Rill erosion	49
Gulley erosion	26
Sheet erosion	14
River bank erosion	4
Splash erosion	3
Others	4

Table 3. Causes of soil erosion

Type of soil erosion	%
Steep slope	30
Lack of cover	22
Poor constructed structures	20
Lack of SWC measures	20
Heavy rains	8

Table 4. Age of farmers

Age of farmers	%
20-40	32
40-60	42
60-80	19
Above 80	6

Older farmers are more likely to adopt and use SWC measures, because they are endowed with more agricultural experience than young farmers. Similar results was reported by [8]. They found that increase in the age of farmers increases the rate of adoption of SWC measure by about 1.36 times. But [9] reported a negatively significant correlation between the age of farmers and the adoption of SWC measures.

3.4.2 Education

Formal education is an indispensible gauge for literacy levels. Table 6 shows 65 percent of respondents have attained primary education, while 27 percent have acquired secondary education. More than a few studies show an affirmative relationship between level of education and number of SWCPs implemented, consequently signifying that formal education is a vital parameter in clarifying adoption behavior as it helps the individual to make knowledgeable choices [8]. According to [10] farmers accepting innovative ways of dealing with problems on their farms depends to a large extent the level of education of the farmers. Awareness of the exact problems, capacity to identify potential solutions, and capability to obtain required skills to implement remedial measures are indispensible techniques which require some level of education. According to [11] having an education as a farmer and being able to read and understand information enables the farmers to make the right decision in implementing the appropriate soil and water conservation measure on the farm. Exposure to schooling increases farmers' knowledge and understanding of the profits and limitations of SWC. Notwithstanding the convincing view of education in the use of SWC measures, [12], explained that uneducated farmers are better involved in the adoption and use of SWC practices than educated because educated farmers are frequently involved in off-farm activity. But in this study, education was not problem in relation to use of SWC measures.

3.4.3 Size of farm

A lot of the farmers in the area are small-scale farmers. Table 7 shows that over 80% of the size of the farm range from one to five hectares. Based on the results, the size of the farm-holding did not affect the use of SWC Measures. This is in line with the studies of [13] in which they reported that the size of a farm does not influence the decision of a farmer to use of SWC measures. To further support this, [14] reported a significantly negative relationship between farmland size and the decision to adopt and use SWC measures. They argue in their studies that most farmers who cultivate large farm sizes are old aged farmers who have short term plan and does not have the labor required to maintain conservation SWC practice.

W. Geertsema et al. [15] disputed the above reports. They argued in their studies that farm size really did play a significant role in influencing a farmer's decision to use or not use SWC measures. They revealed that farmers who have large farm sizes also have the financial muscle to invest in soil and water conservation measures since they have put a lot of resources into their big farms and expects a lot of return and will therefore employ every means possible to ensure a good yield.

There was a positive correlation between group membership and the use of SWC by farmers. Farmers consider most soil conservation structures laborious and time-consuming. Group farmers tend to work together to build these structures for both soil conservation and water harvesting, reducing time spent and also cost savings. Farmers also share information with each of these groups, so they have access to free and important information.

3.4.4 Extension training and education

The study showed (Table 8) that 33% of farmers have received some form of Extension Training on soil and water conservation, while 67 percent did not receive any extension training or education. The sources of information were from fellow farmers, local groups of farmers (60%), the government agencies responsible for agriculture (15%) and other sources, including media organizations, and researchers (25%), as shown in Table 8.

Information is important to implement innovative SWC practices and technologies. Awareness and information for farmers about soil erosion issues significantly contribute to sustainable use of new SWC practices [16]. Farmers may recognize the available techniques but education and extension services in other areas are needed to improve their practical skills. [17] indicated that farmers who obtain enhanced information from extension agents are eager to adopt innovative SWC practices and continue the prevailing practices. Nonetheless reduced levels of contact between farmers and extension agents result in irrelevant effect. [18] showed that extension services are essential for training new participants (modernization – implementation), for conserving great quality SWC measures (continued- participation), and for applying a wide variety of natural resource management services as well as to SWC practices. This give prominence to the significance of developing human capital, through training and extension services, aimed at increasing implementation and practice of SWC technologies, and for developing schemes that increase extension services for disseminating information. [18] stated that farmers who do not receive frequent visits by extension officials are less likely to adapt to the measures of modern SWR on their farms.

3.5 Land Tenure System versus Adoption of SWC Measures in the Study Area

Land tenure security was one of the important issues raised by farmers as a constraint to investing in SWC measure and practice in the study area. They explained that their unwillingness to invest in SWC measures stems from their uncertainty about the future since their farm lands can be confiscated from them at any point in time due to the nature of the land tenure security in the country. Consistent with this is studies by [19]. They revealed that the important determinant factors which encourage farmers to adopt and practice SWC measures on their farm are Land Tenancy Scheme and Security of tenure. They argued that if the land is owned by the farmer and he/she is guaranteed of using it for extended period of time, the farmer has prospects of gaining profits from the farm for a longer time and therefore, he/she is willing to adopt and use SWC practices and measures on the farmland. But when the farmer is not assured about the security of tenancy, such as when the farm is leased or rented for a short period of time, the farmer might not be eager to adopt and use SWC practices and measures.

Table 5. Years of farming

Years of farming	% of respondents
0-10	25
10-20	27
20-30	35
30-40	5
40-50	3
50-60	2
60-70	0

Table 6. Formal education level of farmers

Educational level	% of respondents
Primary	65
Secondary	27
Tertiary	5
Non	3

Table 7. Farmers farm size

Size of farm (Hectares)	% of respondents
1-5	83
5-10	8
10-15	5
15-20	4

Table 8. Extension training and education on SWC

Extension training on SWC measures	% of respondents
Yes	33
No	67

Table 9. Sources of extension training and education on SWC measures

Source of extension training and education	% of respondents
Fellow farmers	60
Government agency	15
Other source	25

This conclusion is also in agreement with [20], who observed that apart from other influences, plot/land tenure type had a substantial influence on farmer's perception on SWC.

In China, all lands are owned by the state or government. After carrying out the opening policy in 1978, China has converted its intended economy scheme into a communist market economy scheme, and implemented a land usage rights tenancy scheme related to the land leasehold tenancy scheme in Western countries. Under China's Land Management Regulation, which was initially drafted in 1986 and modified in 1998, the Government holds all municipal land, whereas farmer collectives own all countryside land. As the land tenancy scheme was declared in China only after 1986, land use previously in this period is entirely treated as assigned, the user can continue to use them by paying yearly land use levy, or handover the land use right into "approved " by paying the land "approved" premium. The land tenure and land-use rights can be separated, and the government remains the land proprietorship and local administration might transfer the land use rights by regulations on behalf of the government. It likewise states that land and constructions are regarded as two distinct entities. Land users can use the land and own the constructions and developments on it, but the authority of the land remains with the state. Considering the nature of the Chinese land tenancy arrangement, private land tenure does not exist in China.

3.6 Off-farm Activities

As indicated earlier, some of the respondent farmers (2%) engage in other economically-gaining off-farm activities in addition to the farming. The results from this study reveal that farmers that engage in off-farm activities were more likely to adopt SWC measures than full time farmers. They indicated that, the off-farm activities serve as an alternative source of income to support them and their families and they are even also able to use some of the income generated from these activities to purchase farming inputs. In line with this result is the finding of [21]. They revealed that farmers who engage in off-farm activities are more likely to adopt and use SWC measures than farmers who do not because they have extra financial income to support themselves. But opposing results by [22] showed a significantly negative correlation between farmers engaging in off-farm activities and adoption of SWC practices. They stated that making off-farm income reduced the time available for agriculture and such farmers were not much worried about improvement with regards to the quality of natural resources.

4. CONCLUSION AND RECOMMENDATION

Yondeng County experiences soil erosion and this current study has revealed that the farmers in this area are aware of the problem and the detrimental effects it has on production of crops. The rate of adoption and use of SWC measures by farmers in the study area was found to be very low. Contours, terraces and strips are the most commonly used conservation practices, while agroforestry and mixed farming are slowing being adopted by farmers. Among the factors analyzed, age, farm holding size, land tenure security and extension training in SWC were found to influence the adoption of soil and water conservation measures by farmers. Farmers forming associations or groups were found to benefit from training, education and financial assistance. From this study, some of the challenges faced by farmers in adopting soil and water conservation measures were lack of technical skills, land tenure security, poverty and ignorance. These results show that, in order to ensure adequate soil and water conservation, particular attention must be paid to institutional and economic factors. To encourage farmers' participation in education and extension training on SWC, it is vital to strengthen the relationship between extension workers and farmers. Granting subsidies, as was done in the grain for green project will encourage farmers to implement SWC measures and practices in their farms.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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