



Examining the Role of Livelihood Diversification as a Part of Climate-Smart Agriculture (CSA) Strategy

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ABSTRACT: Climate change poses a severe threat to agricultural livelihood due to the increased intensity of environmental shocks and weather variability. Livelihood diversification plays an important role to cope with climate variability and diminishing food insecurity. This study investigates the main drivers of livelihood diversification such as crop production, livestock farming, and off-farm income diversification, particularly focusing on the part of climate-smart agriculture (CSA) strategy and its impact on farm households' welfare. Data were collected from 420 farmers in 35 villages located in different agro-ecological zones (AEZs) of Punjab province, Pakistan. We used the Seemingly Unrelated Regression (SUR) model to regress a system of equations consists of the crop, livestock, and off-farm income-generating livelihood activities. Estimation shows that crop, livestock and off-farm diversification on average have a positive and significant impact on welfare when farmers adopted it as an adaptation strategy to mitigate the impact of climate change and earned more 9.3 % income than nonadopted farmers. Moreover, positive and significant determinants of assets endowment such as human, physical, natural, social and financial capital confirmed that well-endowed farmers were enabled more to adopt livelihood diversification than other farmers. Based on the findings, we suggest the policy implications regarding the institutional interventions aimed at strengthening the most important livelihood diversification drivers, to support for improving the household strategic assets endowments.

Keywords: Assets endowment, Climate change, Driving factors, Households' welfare, Sustainable livelihood

İklim-Akıllı Tarım (CSA) Stratejisinin Bir Parçası Olarak Geçim Çeşitliliğinin Rolünün İncelenmesi

ÖZ: İklim değişikliği, çevreye ilişkin ani şokların yoğunluğu ve havanın değişkenliği nedeniyle tarımsal geçim kaynakları için ciddi tehdit unsuru durumuna gelmiştir. Geçim kaynaklarındaki çeşitlilik iklimin değişkenliği ile baş etmede ve gıda güvenliğini artırmada önemli bir rol oynamaktadır. Bu çalışma, özellikle İklim-Akıllı Tarım stratejisinin tarımsal hanehalkının refahı üzerindeki etkisine odaklanarak, bitkisel üretim, hayvancılık ve tarım dışı geçim kaynaklarının çeşitliliğini belirleyen temel faktörleri araştırmaktadır. Bu amaçla Pakistan'ın Punjab bölgesindeki farklı tarımsal ekolojik bölgelerinde (AEZ) bulunan 35 köyde 420 çiftçi ile anket yapılarak veri toplanmıştır. Bitkisel üretim, hayvancılık ve tarım dışı gelir getirici faaliyetlerden oluşan bir denklem sistemini geliştirmek için Görünürde İlişkisiz Regresyon (SUR) modeli kullanılmıştır. Tahminler, hayvancılık ve tarım dışı faaliyetlerin çiftçiler üzerinde iklim değişikliğinin etkisini hafiflettiği ve iklim değişikliğine uyum sağlayamayan çiftçilerden % 9.3 daha fazla gelir sağladığı için, refah üzerinde ortalama olarak olumlu ve önemli bir etkiye sahip olduğunu göstermektedir. Buna ek olarak, sermaye varlığının (insan gücü, fiziksel sermaye, doğal kaynaklar, sosyal sermaye ve ekonomik güç) pozitif ve önemli belirleyicileri, iyi donanımlı tarımsal hanehalklarının diğer tarım işletmelerinden daha fazla geçim çeşitliliği benimsemelerine olanak sağladığını doğrulamaktadır. Bulgulara dayanarak, kurumsal katkıların işletmelerde geçim çeşitliliği sağlayan en önemli itici güçlerini artırmayı ve hanehalkının stratejik mal varlığını iyileştirmeyi destekleyen politikalar şeklinde olması önerilmiştir.

Anahtar Kelimeler: Sermaye varlığı, İklim değişikliği, İtici güç, Hanehalkı refahı, Geçimin sürdürülebilirliği

INTRODUCTION

Climate change poses the gravest threat to the whole world and development concern. There is a

consensus that climate change is altering the temperature, rainfall pattern, and other climatic

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parameters. Studies find that climate change, weather variability, and extreme environmental shocks have different impacts on different countries (Lipper et al., 2014). This hypothesis states that the consequences of climate change and extreme weather events have a more severe impact on poor countries than richer countries (Stern and Stern, 2007). These differences in the impact of climate change among the countries are defined as adaptation deficit. Literature suggested that adaptation deficit depends on the number of exogenous factors, for instance, geographical location and vulnerability of the population in hazard zones, lack of institutional support, farm household demographic and socio-economic characteristics. It is thus clear that farm household who has weaker adaptation response such as having poor institutional support, poor farm household demographic and socio-economic characteristics, their livelihood is more climate-sensitive due to the reduced ability to deal with adaptation measures than other farmers. Climate anomalies and environmental shocks are posing the most serious challenges to livelihoods, especially to the agriculture sector such as crop and livestock production. According to the study (Sardar et al., 2016), Pakistan is listed among the most impacted countries due to the adverse impact of climate change.

Punjab is the largest province with fertile land in Pakistan. It contributes to 74% of the total agricultural production and 56% of the total cultivated land area in the country. The agriculture sector contributes approximately 21% to the gross domestic product (GDP) and around 42% of employment to the rural population in Pakistan. Punjab province has experienced many negative impacts of environmental shocks and climate variability due to the increasing frequency of floods, drought, uneven patterns of rainfall and rise of the temperature. Thereby, it poses a major threat to the agriculture-based economy of Pakistan (FAO, 2013).

However, a growing concern for the increasing population and rising risk of climate variability call for the adoption of livelihood diversification options at the farm level in Pakistan. Thus, the adoption of livelihood diversification can enhance the farm household resilience against the environmental shocks and climate change which depends on the strategic assets endowment that farm households hold. These strategic assets represent the capacity of the farmers to adopt their sustainable livelihood (Skaf et al., 2019). Combined with disrupting weather patterns and climatic shocks with the challenges of the projected increasing food demand and to diminish the poverty is threatened. Therefore, studies such as (Thornton et al., 2018) suggested a comprehensive and integrated approach, namely climate-smart agriculture (CSA). Since its inception as a concept of CSA, it is included in the international policy agenda for building

resilience against climate change, and to ensure food security. It is necessary to mention that CSA is not a set of practices. It is an approach, that is used with the site-specific requirement to get the food security, adaptation, and mitigation potential of the practices. There are many livelihood diversification strategies and agricultural practices that are used to mitigate the impact of climate change and it can be treated as climate-smart if it is contributed to the CSA objectives in order to guide policy. In some studies, livelihood diversification is adopted as an alternative strategy to increase food security and to shape the resilience against environmental shocks and climate change (Jiao et al., 2017). Therefore, it may be considered as a potential strategy for the adaptation pillar of the CSA. For this purpose, the present study investigates livelihood diversification as a part of CSA strategy and its impact on the farm households' welfare at the farm level in Punjab. To the best of our knowledge, there is no study that identified this issue and addressed it in rigorous manner for Punjab province. This study contributes to the literature by identifying how determinants explain the adoption of livelihood diversification to building resilience against environmental variability at the farm level. And also, it examines livelihood diversification impact on farm households' welfare

MATERIAL AND METHOD

Livelihood is defined as the means of earning activities undertaken to fulfil the basic needs of his own and his family members to sustain the survival and development (Skaf et al., 2019). Following the literature (Kurukulasuriya et al., 2011), we illustrated farm livelihood diversification behaviour in the context of the economic theory. A farmer who wants to maximize his utility through the adoption of livelihood diversification for sustainable livelihood under the risk aversion by utilizing its strategic assets endowment that farm household holds. The literature described livelihood as sustainable and resilient when it not only copes with stress and shocks but also maintain or enhance its assets capabilities, and natural resource base to fulfil the needs of the present generation without compromising the future generation requirement. Based on this assumption, studies for instance, (Xu et al., 2015) have worked on the concept of sustainable livelihood framework (SLF). SLF contributed the rich understandings to determine the livelihood strategies for sustainable agriculture. Therefore, we adopted SLF in our study following (Jiao et al., 2017; Nielsen et al., 2013). The essential content of this framework consists of three main components such as assets pentagon endowment (financial, physical, natural, human and social capital), activities *i.e.* livelihood strategies, and the livelihood outcomes (Nielsen et al., 2013; Su et al.,

2018). Within this context, it is essential to examine the socio-economic factors to determine the livelihood diversification by using the SLF (Arslan et al., 2015; Kassie et al., 2017). Livelihood diversification is determined from the vulnerability status and degree of the risk aversion which is linked to the endowment of the assets that farm households hold. The endowment of different sets of assets can be seen as a vector of capital K as follows,

$$K_j = [K_j^N, K_j^P, K_j^F, K_j^S, K_j^H] \quad (1)$$

where, K_j^N is the natural assets (*e.g.*, agriculture land), K_j^P is the physical assets (*e.g.*, livestock, tractors and machinery). K_j^H represents the human capital (*e.g.*, education attainment, working family members and farming experience) while K_j^S and K_j^F indicate the vector of social assets (*e.g.*, access to the market and weather information; assistance from relatives) and financial assets (*e.g.*, credit access) respectively. In the context of SLF, we can find the adoption of livelihood diversification impact on the farmers' welfare that is determined and affected by the set of livelihood assets endowment and the environmental shocks. The farmers' welfare is W . It can be represented in the livelihood diversification strategies (L_j^d) that is adopted by the farmers to mitigate the impact of climate variability and to cope with climate shocks (C_j^S), in accordance with the vector of assets K_j and unobserved factors U_j for household j (where $j = 1, 2, \dots, N$), which can be shown as a random variable in the following equation

$$W_j = f[L_j^d, C_j^S, K_j, U_j] \quad (2)$$

Farm households may choose to adopt livelihood strategy one for others to maximize their utility if the utility from this particular livelihood strategy is more than the previous one (Kassie et al., 2017; Nielsen et al., 2013).

In the specified form equation (2) can be written as,

$$W_{dj} = C_j^S + K_j + I_d + U_j + \varepsilon_j \quad (3)$$

where, $j = 1, 2, \dots, N$ is the farm households. While $d = 1, 2, \text{ and } 3$ is the livelihood diversification strategies represented by the vectors L_j^d ; C_j^S is the vector of the climatic shocks *i.e.* plot level disturbance index¹; K_j represents a vector of assets endowment that households hold; I_d is the vector of the institutional role that determines the assets' endowments and livelihood diversification. U_j is a vector of exogenous dummies and instrumental variables used in the model. While ε_j is the error term.

To examine the drivers and effects of the livelihood diversification, it is necessary to account for its simultaneous factors that can affect the livelihood diversification. As explained earlier, separate estimations would not give consistent findings for deriving the reliable information from the entire covariates, representing possible correlation existing among the error terms of livelihood diversification equations where $d=1, 2, \text{ and } 3$. So, in this context, we employed a robust empirical approach as a system of equations. It is the well-known robust empirical approach developed by (Zellner, 1962) that gives efficient estimates considering the error correlations between equations, named as Seemingly Unrelated Regression (SUR) model. This approach has been successfully applied in some studies to analyse the diversification strategies (Rosenstock et al., 2016). Thus, the SUR model allows us to study the livelihood diversification drivers and their impact on farmers' welfare to shed insights on the institutions' role through the assets endowment that households hold (Terza et al., 2008).

This study was conducted in the Punjab province because Punjab is the largest province with fertile land. It is categorized into four agro-ecological zones (AEZs) based on different attributes of environment, geography, and cropping patterns (Abid et al., 2016). We collected survey data from 420 farmers following the multistage sampling technique. A pre-tested questionnaire was used containing all the necessary information related to assets, demographic characteristics and livelihood diversifications. The enumerators were graduated and well trained for collecting the survey data about the objectives of the study. We treated farm household as diversified farmers who adopted ex-ante or ex-post livelihood diversification to cope with environmental shocks and climate change, for instance, changing planting dates, planting a crop or variety mix or shifting or combining livestock and crop operations, while off-farm income such as differentiating the income sources through other sectors than agriculture, starting their work in non-agriculture sectors, or your own work, or the farmers who migrated.

The richness and the relevance of this dataset allow us to investigate the drivers of livelihood diversification and its impact on welfare outcomes. Detail of the variables used in the study and their explanation are given in Table 1.

¹We constructed plot level disturbance index by simple count. Primary data were collected from the farmers who experienced drought, floods, animal and human diseases due to the weather variability.

Table 1. Variable descriptions

| Variable Name | Definition | Explanation |
|--|---|--|
| Welfare | Total income (in rupees per year) | Total income earned from all sources such as on-farm and off-farm income |
| Crops diversification (LS^1) | Share of crop income to the total income earned (in percentage) | Total net income earned from the production of the crops |
| Livestock diversification (LS^2) | Share of livestock income to the total income (in percentage) | Total net income earned from the livestock activities |
| Off-farm income diversification (LS^3) | Share of off-farm income to the total income (in percentage) | Income earned from the non-agricultural activities |
| Human capital | | |
| Working family members (Working_members) | Working family members in a household (in numbers) | |
| Education (Edu) | Education attainment | |
| Experience (Exp) | Farming experience (in years) | |
| Physical capital | | |
| Distance to extension centre (Dist_ext) | Distance from farmland to the nearest extension centre (in kilometres) | |
| Agriculture technology assets (Agri_tech_assets) | Agriculture technology assets such as tractors and machinery. | |
| Livestock ownership (Livestock_own) | Total livestock owned (in numbers) | |
| Natural capital | | |
| Size of landholding (Land_size) | Size of landholding by the farmer own or rented for cultivation (in hectares) | |
| Financial capital | | |
| Credit access (Credit_acc) | Do you have credit access (1 = yes; 0 = no). | |
| Social capital | | |
| Relative assistance (Relative_assis) | Availability of relatives and friends for your assistance such as seeking money or equipment sharing (1=yes, 0=no). | |
| Market Information (Market_info) | Market information (1 if a farmer had access, 0 otherwise) | Formal institutional support or having ICT technologies access such as (TVs, mobiles, radios, computers, etc.) |
| Weather information (Weather_info) | Weather forecasting information (1 if a farmer had access, 0 otherwise) | |
| Climate shocks | | |
| Climate_shocks | Plot level disturbance index | |

Note: Livelihood diversification strategies are defined as the farmers who have diversified their livelihood due to the experience of climate shocks, and perceived changes in climate during the last ten years.

RESULTS AND DISCUSSION

In the study area, most of the farmers were engaged in crops, and livestock production. However, a variety of non-farm livelihood activities in the study districts was also prevalent, including small trade, and small-scale employment in industries such as agro-

processing, sugar, cotton, etc. Table 2 shows a summary of the variables used in the study. We examined farmers' socioeconomic characteristics based on the category who adopted livelihood diversification and who did not adopt.

Table 2. Summary statistics of the farm household data used in the study

| Variable | Adopters | Non-adopters | ² Difference |
|--|------------|--------------|-------------------------|
| Welfare (W) | 1165562.49 | 814643.87 | 350918.62 |
| Crops diversification (LS^1) | 42.67 | 26.47 | 16.20 |
| Livestock diversification (LS^2) | 23.70 | 17.10 | 6.60 |
| Off-farm income diversification (LS^3) | 33.72 | 56.43 | 22.71 |
| Human capital | | | |
| Working_members | 2.40 | 1.84 | 0.56 |
| Edu | 7.42 | 5.46 | 1.96 |
| Exp | 23.44 | 18.35 | 5.09 |
| Physical capital | | | |
| Dist_ext | 22.98 | 35.40 | 12.42 |
| Agri_tech_assets | 1.21 | 0.64 | 0.57 |
| Livestock_own | 12.50 | 9.71 | 2.79 |
| Natural capital | | | |
| Land_size | 5.78 | 4.31 | 1.47 |
| Financial capital | | | |
| Credit_acc | 0.43 | 0.30 | 0.13 |
| Social capital | | | |
| Relative_assis | 0.64 | 0.26 | 0.38 |
| Market_info | 0.61 | 0.44 | 0.17 |
| Weather_info | 0.72 | 0.46 | 0.26 |
| Climate shocks | | | |
| Climate_shocks | 1.68 | 1.16 | 0.52 |

²It is measured by subtracting averages of non-adopters from averages of adapters who diversified their livelihood.

Three types of livelihood diversification strategies (LS^1 ; LS^2 ; LS^3) were absorbed in the study area. Table 2 shows that farmers who altered their livelihood diversification such as crop income,

livestock income were earned more share of income than the other farmers, but it was reported opposite in non-farm activities case, which is shown in figure 1.

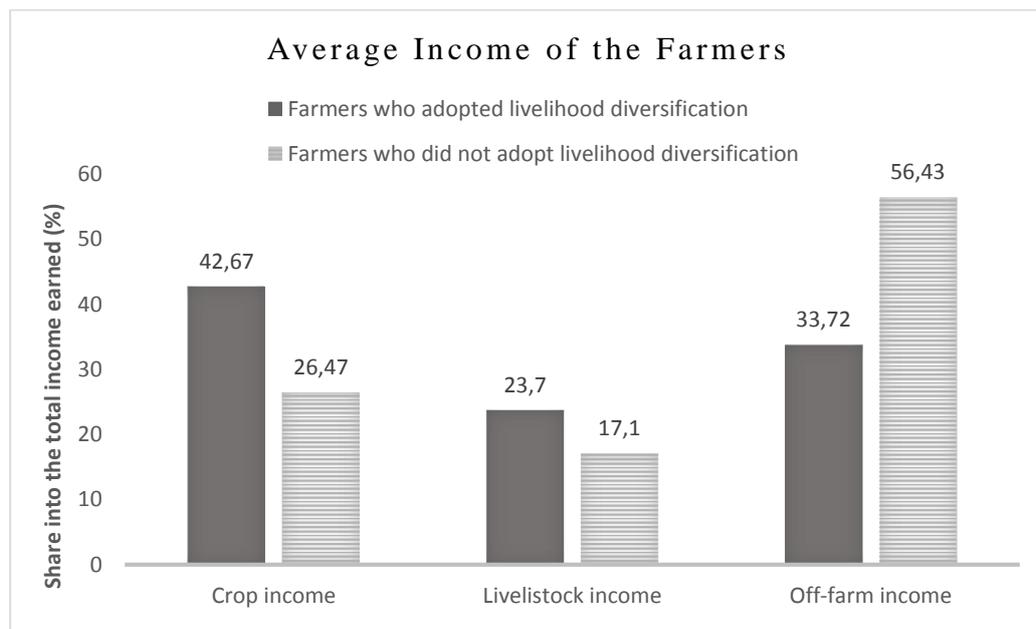


Figure 1. The income share of the farmers in the study area.

It may be pointing that agricultural diversification activities were climate-sensitive and impacted more by the changes in climate than non-farm activities. Likewise, the farmers who have adopted livelihood diversification to cope with the changes in climate have earned more income than their peers (*e.g.*, who did not adopt). Therefore, on average the farmers who adopted livelihood diversification enjoy comparably more welfare (in terms of total income) than non-adopted farmers.

Similarly, the farmers who adopted diversification have more human capital such as more education, working family members and experience than their counterparts (*i.e.* non-adopted farmers). Likewise, adopted farmers were better-off with higher physical capital, financial capital, social capital and natural capital comparably non-adopted farmers. Our findings are in line with the study (Williams et al., 2018). This study describes that the farmers who have higher assets endowment have more capability and capacity to respond against the ongoing occurrences of the climate shocks and weather variability. Therefore, better financial, social, human, physical, and natural capital enable the farmers to diversify their livelihood to cope with climate change. The socioeconomic characteristics of non-adopters may imply that poor conditions of farmers' assets endowment limited the farmers' capacity and capability to respond against climate change and to mitigate its impact on their livelihood. These findings are similar to the study (Skaf et al., 2019).

Determinants of livelihood diversification

The results obtained by using the SUR model are shown in Table 3. The outcomes of livelihood diversification are reported in column (1), (2), and (3) of Table 3. We estimated the impact of livelihood diversification on farmers' welfare by using the income earned by the farm household who adopted livelihood diversification and who did not adopt. We measured livelihood diversification in three categories namely crop income diversification, livestock income diversification, and off-farm income diversification. The estimates showed robust evidence for increasing the income share by those farmers who diversified their livelihoods than other farmers. We estimated this impact by using a dummy variable. A positive and significant coefficient of livelihood diversification (dummy variable) shows that farm households who adopted livelihood diversification to mitigate the impact of climate variability earned more income (0.714 and 0.289) from crop and livestock activities respectively than non-diversified farmers. However,

we had an insignificant impact on the non-farm activities case. It may be pointing that non-farm activities were not more sensitive to climate change impact as compared to the agricultural activities because the agricultural output is totally dependent on the natural environment. Study findings are consistent with the literature (Brown et al., 2018; Xu et al., 2015). Another important findings related to the determinants of livelihood diversification, as expected, was that the assets endowment was found as a significant and positive driver for the adoption of all three livelihood diversification (Sardar et al., 2019).

It is interpreted as the framers who have higher endowments of physical, social, financial, human, and natural capital were better to adopt the perceived changes in climate. Indeed, higher human capital, for instance, more working family members, more education, higher experience, better financial condition as access to credit, and large cultivated land area that provides the advantage of economies of the scale and helps the farmers to adopt livelihood diversification. These instruments constitute as precious tools that enable the farm households to take a better decision about the livelihood diversification. Therefore, these assets positively affect the adaptation of livelihood diversification outcome.

Apart from these assets, the role of social capital was very important. It can play an effective role by providing timely information to the farmers such as weather information, market information for making rational decisions about agricultural production and seeking relatives' help, especially for financial purposes when they need to cope with climate shocks by adopting livelihood diversification. The results of this study confirmed that higher assets endowment better off the farmers to adopt livelihood diversification and earned more income than less endowed farmers. The findings of this study suggested that livelihood diversification is a deliberate strategy adopted by the proactive well-endowed farm households who were well informed, educated, more experienced, having a better knowledge of weather variability and were impacted by climate shocks. These findings confirmed the importance of the institutional role to improve the farmers' capacity of the strategic assets endowment that farm households hold. Because farmers' capacity to adopt livelihood diversification was totally dependent on the household assets endowment. Therefore, institutional support either it is related to government or private can develop the household capacity to respond against climate change by improving the farm household assets endowment.

Table 3. SUR model estimates of livelihood diversification and its impact on farm households' welfare

| Regressors | Dependent Variables | | | |
|--|---|--|---|-----------------------------------|
| | Diversification in crops cultivation (LS^1) (1) | Diversification in livestock production (LS^2) (2) | Diversification in off-farm activities (LS^3) (3) | Welfare (Total Income earned) (4) |
| Human capital | | | | |
| Working_members | 0.117*** (0.015) | 0.273*** (0.056) | 3.361*** (0.955) | 0.095*** (0.024) |
| Edu | 0.029* (0.015) | 0.571*** (0.188) | 0.728** (0.319) | 0.035*** (0.008) |
| Exp | 0.091*** (0.021) | 0.128* (0.069) | 0.662*** (0.118) | 0.004** (0.002) |
| Physical capital | | | | |
| Dist_ext | -0.266*** (0.053) | -0.024 (0.037) | 0.291 (0.393) | -0.018** (0.008) |
| Agri_tech_assets | 0.346* (0.196) | 1.121 (1.381) | 0.648 (0.985) | 0.091* (0.051) |
| Livestock_own | 0.101* (0.053) | 0.319** (0.157) | -0.587 (0.452) | 0.017*** (0.003) |
| Natural capital | | | | |
| land_size | 1.198*** (0.132) | 0.424 (0.445) | 0.774 (0.685) | 0.054*** (0.014) |
| Financial capital | | | | |
| Credit_acc | 0.412* (0.221) | 0.347** (0.169) | -0.742** (0.336) | 0.095* (0.054) |
| Social capital | | | | |
| Relative_assis | 1.626*** (0.291) | 1.317*** (0.471) | 0.601 (0.701) | 0.015** (0.007) |
| Market_info | 2.141 (3.180) | 1.432* (0.753) | 1.623*** (0.514) | 0.082* (0.042) |
| Weather_info | 0.416** (0.187) | 2.189 (2.391) | 0.629 (0.946) | 0.033*** (0.012) |
| Climate shocks | | | | |
| Climate_shocks | 0.905** (0.367) | 0.208 (0.759) | 1.135** (0.562) | 0.039 (0.033) |
| Livelihood diversification (Dummy = 1, if adopted otherwise 0) | 0.714*** (0.207) | 0.289*** (0.099) | 0.311 (0.551) | 0.093*** (0.022) |
| Jhang (dummy =1 otherwise 0) | 0.796*** (0.211) | 0.651** (0.323) | 0.016 (0.024) | 0.091*** (0.024) |
| Sialkot (dummy = 1 otherwise 0) | -0.171 (0.987) | -0.311* (0.169) | 2.343** (1.042) | 0.128 (0.297) |
| Constant | 1.091* (0.599) | 0.821*** (0.225) | 0.953 (1.482) | -0.077* (0.042) |
| R^2 | 0.69 | 0.52 | 0.46 | 0.63 |
| N | 418 | | | |

Breusch-Pagan test of independence: $X^2 = 400.076***$

Note: ***, ** and * indicates the significance of probability levels at 1%, 5% and 10%, respectively. Standard errors in parenthesis.

Effect of livelihood diversification on welfare

In this section, we showed the impact of the adaptation of livelihood diversification on farm households' welfare. Here, we presented the livelihood diversification impact on farmers' welfare by using the proxy, namely as total income earned by the farmers. Results of the diversification outcome *i.e.* welfare are presented in column (4) of Table 3. The coefficient of welfare (in total income) was shown in the log form. The principal and robust findings of livelihood diversification outcomes were reported. The farmers who prefer to adopt livelihood diversification were earned more 9.3% of total farm income than non-adopted farmers. Results showed that adopters of livelihood diversification were better, as the impact showed, with increasing the total income earned. By comparing the adaptation of livelihood diversification impact on farm households' welfare, we can conclude that agricultural diversification (*i.e.* crop and livestock production) were the mainly benefited livelihood activities than off-farm livelihood diversification. Vulnerable farm households adopted these diversification activities to decrease climate risk and the adverse impact of environmental variability as well as adapting it for their sustainable income. Ultimately, the increase in farmers' income will enable them to raise the welfare of the farmers by adopting sustainable livelihood.

CONCLUSION

This study sheds light on the determinants of livelihood diversification as a part of CSA strategy and its impact on farm households' welfare in Punjab province, Pakistan by using a primary dataset collected from the structured interviews that were conducted in August 2018 and September 2018. We demonstrated that the farmers who adopted livelihood diversification such as crop, livestock, and off-farm income diversification as an alternative strategy to mitigate the impact of climate variability and weather shocks had higher welfare than the farmers who did not adopt. Further, we also identified the determinants of livelihood diversification particularly, in the context of the assets endowment. The study showed that assets endowment was a positive and significant determinant of livelihood diversification adopted by the sample farmers and this adaptation had successfully increased the total income by decreasing the probability of livelihood vulnerability. Therefore, it may provide the potential to increase food security with adaptation to climate change and increasing the farmers' income may be constituted as an adaptation pillar of CSA. The results of the study unveiled that the farmers who adopted livelihood diversification were the well-endowed and more benefited by earning a higher income than less endowed farmers. Broadly speaking, in the context of assets endowment, we

suggested the policy implications for strengthening the most important livelihood diversification drivers. They are the most relevant and efficient instruments that determine the livelihood diversification to mitigate the impact of climate change to increase the farm household welfare. However, this conclusion appears more benefits in the case of agricultural diversification, for instance, crops, and livestock production in the context of climate variability. The findings of the study related to the institutional role such as access to the credit services, information for the market, subsidies, weather forecasting information, and excess to the extension services aimed to reveal that effective institutional support will be helpful to the lower endowed farmers and to make them enabled to adopt.

Therefore, desirable policy implications and institutional interventions are expected to reduce the adaptation deficit gap by adopting the necessary measures to support for increasing the capacity of farm household assets endowment. Although this is the first study, that contributed to the literature by identifying the determinants of livelihood diversification behaviour and its impact on farm household welfare in Punjab, we documented livelihood diversification in the distinct ways in which institutions' role shaped the diversification strategies affecting through its determinants. It is an important strategy for sustainable agriculture that not only increases the farmers' income but also contributes to the adaptation pillar as a part of the CSA approach.

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