



Climate Induced Factors Affecting Income Diversification in Flood-Prone Areas of Punjab, Pakistan: An Application of Income Diversification Herfindahl Index

Aneela Naz¹, Dr Dilshad Ahmad^{2*}, Dr Muhammad Irfan³, Dr Bilal Tariq⁴, Dr Asad Abbas⁵

Abstract

Climate change instigating severe threat on global population livelihood more specifically the developing countries like Pakistan. Rural households of Pakistan predominately depend on farming practices where their livelihood is vulnerable due to severe and repeated threats of flood disasters. In view of income diversification as livelihood strategy regarding life-threatening of floods this research work investigated the factors of income diversification in flood prone areas of Punjab, Pakistan. Multistage random sampling method was applied for data collection of 380 flood-affected households where household-based income diversification was estimated with Herfindahl Index while ordinary least square method applied for regression coefficients estimation. Estimates of this research work shown as households with more educated family members, male household heads and more earning numbers of family having more income diversification profile. Moderation analysis indicated households with aged educated members and male household head more likely to income diversification rather than illiterate households. Findings indicated contradiction with literature as insignificant coefficient of poverty with income diversification in Muzaffargarh district highlighting the inadequate awareness and insufficient economic opportunities reason be more significant factor of income diversification rather than wealth. Policy measure to Pakistan and more particular to rural communities as investing human capital, rising economic opportunities access and formulating awareness strategies of income diversification consider essential to developing rural household's livelihood sustainability particularly flood prone communities.

Keywords: Climate Change, Livelihood Strategies, Income Diversification, Herfindahl Index, Punjab, Pakistan

1. Introduction

In recent decades, human livelihood has severely influenced by climate-based disasters like floods, heat waves, landslides, droughts and tropical cyclones (Rana et al., 2023; Ahmad et al., 2024). Climate change is major challenge in worldwide perspective where global economies especially developing countries have recorded the highest number of resources based economic and human losses due to floods (Barros et al., 2017; Recking et al., 2019; Yadav et al., 2023). Frequent and extreme events of climate change have internationally raised matters of food security, livelihood threats and unpredictability in agricultural production (Ahmad and Afzal, 2020; Musyoka and Onjala, 2023). These disasters reason to reduce employment and income level in affected areas which deliberated root source of poverty in rural regions. Inconvenience of social services, inadequate infrastructure, resource acquiring inequality and natural resources pitiable accession causes to lead income diversification (Gul et al., 2022; Zhou et al., 2023). In 21st century climate change poses higher threat to economies with inter-governmental complex challenge of disturbs distinct components of socio-political, ecological, and socioeconomic disciplines (Makate et al., 2019; Feliciano et al., 2022; Leal et al., 2023). Natural disasters badly affected overall global continents like Africa, America, Asia, Europe and Oceania specifically in 2019, 2020 and 2021. Southern Africa region owing to frequent natural calamities like droughts heat-waves and floods severely affected small farming is particularly susceptible to changes in typical weather (Abbass et al., 2022; Ahamd and Afzal, 2024). Climate change enhancing disastrous river flooding particular in the countries of China, Bangladesh, Pakistan, India, Germany and Poland where overflowing has become insistent and enormous because of increased frequency of rain fall and socioeconomic livelihood life style (Jongman et al., 2018; Jamshed et al., 2023).

In Asian region, mostly countries having agro-based economies in which farming community living generally correlated with agriculture where climate inconsistency leading major issues to livelihood (Padhan and Madheswaran, 2023). Farming households mainly inhabited in flood affected areas are higher susceptible to climate change flood disaster which frequently facing major resources losses of livestock, fishing and crops production (Das and Ghosh, 2020; Musyoka and Onjala, 2023). Frequent floods are outcomes of climate change which causes to seasonal structure change and unpredictability in agricultural production (Recking et al., 2019; Yadav et al., 2023). Asian region generally while more particular the South Asian countries like Pakistan, India and Bangladesh considered most susceptible due to flood disasters natural hazards (World Bank, 2022; Ahmad et al., 2024). Pakistan is highly susceptible to climate risk such as storms, heat waves,

¹ MS Scholar, Department of Economics, COMSATS University Islamabad, Vehari Campus, Pakistan

^{2*} Associate Professor, Department of Economics, COMSATS University Islamabad, Vehari Campus, Pakistan. dilshad@cuivehari.edu.pk

³ Associate Professor, Department of Economics, COMSATS University Islamabad, Vehari Campus, Pakistan

⁴ Assistant Professor, Department of Economics, COMSATS University Islamabad, Vehari Campus, Pakistan

⁵ Lecturer, Department of Economics, COMSATS University Islamabad, Vehari Campus, Pakistan

earthquakes, floods and droughts (World Bank, 2022). In 2021, Pakistan was considered 5th most susceptible country of the world (Eckstein et al. 2019; Ahmad et al., 2023). In the most recent eras, a frequent flood has increased human fatalities, damages of crops and destruction of infrastructure and livestock where inhabited population living standard have become worst. Pakistan suffered major losses of agricultural yield and production due to floods and other climatic changes considered declining crops production up to 36% in upcoming era of 2049 (Ali and Rahut, 2019; Memon et al., 2020; Khan et al., 2022). Pakistan regarding to flood calamities have prolonged erect in past around some severe and most important floods subsequently 1950 to 2014 (Rasul et al., 2021; Ahmad and Afzal, 2023). In current era, Pakistan challenged recurrent flood devastations for the dated of 2010 to 2022 but then again 2010 and 2022 floods devastations were more destructive. Flood adversity of 2010, evacuated rounded 20 million overall public, prompted most worrying as damaging 1.5 million houses, instigated 1985 human fatalities toll and approximately 160,000km² destruction of inhabited and cropped areas (NDMA², 2017; Tariq et al., 2024). In outlook of Pakistan, current flood of 2022 formed matchless harsh conditions for the reason that of recurrent severe rains with urban, riverine and flash flooding (Ahmad et al., 2019; World Bank, 2022). Flood of 2022, overstated wide-ranging 33 million general public, death toll of additional than 1700 persons, evacuated 8 million peoples, hard-pressed poverty trap 9.1 million peoples, with wide-ranging predictable damages of US\$15.2billion with record damaging sectors of infrastructure and agriculture (Recking et al., 2019; World Bank, 2022).

Flood disasters frequency consecutively reducing income and employment opportunities to the flood affected inhabitants' communities in flood prone areas where income diversification measures can promote (Parvin et al., 2016 Musyoka and Onjala, 2023). Handling the climate change challenges specifically in flood prone areas income diversification consider significant measure to reducing severe livelihood threats of poverty. Income diversification is switching dependence or smoothing the income and consumption patterns to fulfill neglected needs where household income diversification and livelihood closely associated with resilience, sustainability and flexibility (Kam et al., 2021; Ahmad and Afzal, 2024). Rural communities having to find various economic opportunities according to their competencies whereas in Pakistan, inappropriate utilization of available rural resources and limited access of disasters information causing major obstacles to adopting risk reduction strategies and diversifying livelihood measures (Recking et al., 2019; Shah et al., 2020). Households' education level, age, income, owner of households and location consider more significant factors of risk mitigation plans at the household level (Dimova and Sen, 2010; Ahmad and Afzal, 2020; Shah et al., 2023). Income diversification sources of households have significantly impact food security households' level which benefits small holders' agrarians to report issues of uncertainty and risk (Ahmad et al., 2019; Dai et al. 2020). Diversification of income in non-farming activities ensures food security, its crucial to participate income diversification or engage in non-farm activities that supports to increase livelihood resources in long run and short run (Adem et al., 2020; Musyoka and Onjala, 2023).

In literature perspective, some significant research work regarding worldwide scenario focused on various aspect of climate change regarding natural disasters where some studies focused on climate based sustainability's and vulnerabilities with various economies (Agbola et al., 2008; Islam, 2008; Davis et al., 2010; Thakur et al., 2012; Phukan et al., 2012; Roslan et al., 2012; Arnall, 2014; Bukhari and Rizvi, 2015; Tullio et al., 2016; Bubeck et al., 2017; Ashraf et al., 2018; Török, 2018; Kron et al., 2019; Smith et al., 2019; Ahmad and Afzal, 2021;), off-farm, on-farm activities and livelihood diversifications (Barrett et al., 2001; Dolan, 2002; Ellis et al., 2008; Sarker et al., 2011; Salvioni et al., 2013; Talukder, 2014; Nasiri et al., 2016; Lechowska, 2018; Recking et al., 2019; Ahmad and Afzal, 2020; Memon et al., 2020; Sarker et al, 2020; Maria, 2021), farm based, non-farm based activities and influencing factors in reducing inequality and poverty (Carletto et al., 2007; Florsheim et al., 2008; Jonkman and Vrijling, 2008; Harries, 2012; Dragičević et al., 2013; Cavaillé et al., 2015; Zelenáková et al., 2017; Balgah et al., 2019; Khosravi et al., 2019; Kakinuma et al., 2020; Angelakis et al., 2020), food security regarding on farm income diversification (Schwarze and Zeller, 2005; Agbola et al., 2008; Islam, 2008; King, 2009; Nair, 2012; Kellens et al., 2013; Tsakiris, 2014; Islam et al., 2017; Shah et al., 2018; Glago, 2019; Memon et al., 2020; Kam et al., 2021) household income diversification, risk management strategies and livelihood diversification (Janvry et al., 1991; Barrett, 1997; Douglas et al., 2010; Rahman and Schmidlin, 2014; Islam and Hasan, 2016; Bhuiyan et al., 2017; Solín et al., 2018; Munyai et al., 2019; Biswas and Anwaruzzaman, 2019; Dedehouanou and McPeak, 2020; Bernier et al., 2021). In overhead represented literature considerable studies emphasized global outlook about quite a lot of features of flood disasters livelihood diversification, food security and farm income diversification, off-farm, on-farm income and livelihood diversification and climate change vulnerabilities. In all of these the aspect of climate-based diversification of income factors specifically in flood prone areas not properly addressed in literature and particularly regarding Pakistan not appropriately reflected interconnected to foremost consociate of authors. In obtaining such research gap, regarding this study captivated to investigate

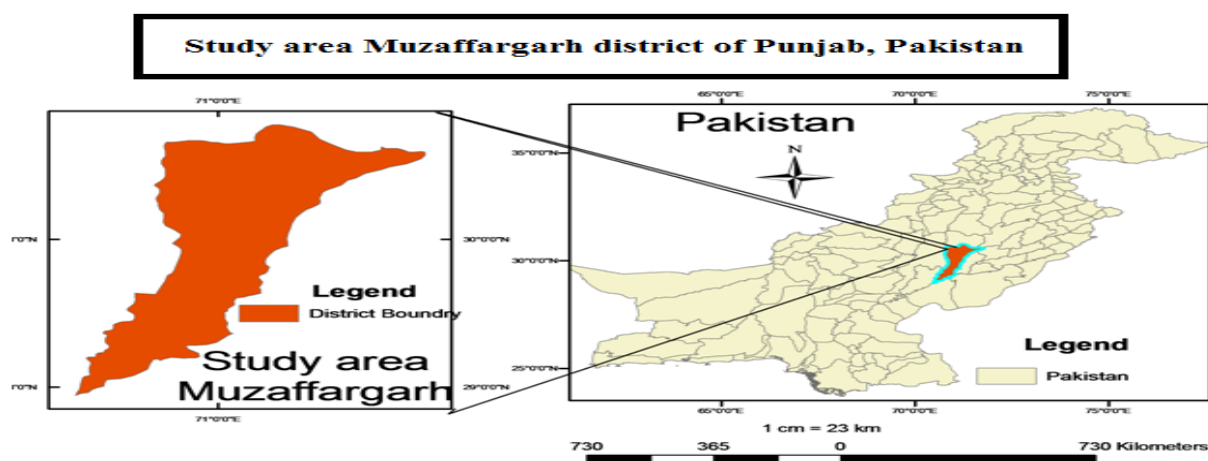
² National Disaster Management Authority

the climate induced factors affecting income diversification in flood-prone areas of Punjab, Pakistan. In this study as classified in to four sections, introduction explained in first section, second section indicated material and method, as the third section elaborated results and discussion while in the last section highlighted the conclusion and suggestions.

2. Material and Method

2.1 Study Area

Baluchistan, Punjab, Khyber Pakhtunkhwa and Sindh are Pakistan's four provinces however regarding considerable ins and outs Punjab mostly chosen for this study. Firstly, in utmost imperative outlook among other provinces Punjab reports recorded populated province distribution of 52% population, representative ¼ area and contributory 53% general country agricultural GDP³ (GOP⁴, 2022). Secondly, this province mostly comprises of most productive lush green lands area and persistent country largest curving river Indus most prone to climate-based hazards, incited recurrent natural adversities like erosion of riverbank, riverine floods calamities and unpredictable rains (PDMA⁵ Punjab, 2022; NDMA, 2023). Thirdly, southern Punjab deliberately chosen purpose to recurrently incited sophisticated hazard of floods and riverbank erosion as to be initiated on equally edges of river Indus (PDMA Punjab, 2022). In fourth outlook, river Indus twisted all over the year reasons recurring erosion of riverbank and repeated floods for river connecting and population of riverine that causes to rises living susceptibility to flood-prone rural inhabitants as was mostly occupied for this research work (BOS⁶, Punjab, 2020; PBS⁷, 2021). To end, district Muzaffargarh considered foremost floods and riverbank erosion affected among fourteen districts of Punjab province (PDMA Punjab, 2021; BOS Punjab, 2022) for the reason that of growing severity of flood devastation and riverbank erosion was favored for such study as detailed in figure 1.



Muzaffargarh district managerially categorized Jatoi, Alipur, Muzaffargarh and Kot addu as four tehsils which comprises of ninety-three union councils, 4.32 million population and 8249 km² area (GOP, 2022; BOS Punjab, 2023). Muzaffargarh is alike sandwich in mutually rivers placed on dangerous position as curving western bank Indus River and eastern bank Chenab River reasons to this area complex susceptible to flood adversities and riverbank erosion (BOS Punjab, 2020; PBS, 2022). This area based average annual rainfall of 127mm with mild winter with 1°C(30°F) and hot summer higher temperature 54°C(129°F) (PMD, 2021). In recent decades, district provoked frequently cumulative unpredictable rains, continuing riverbank erosion and repeated floods subsequently comprehensible losses of valued lush land, human harm of life, pitiless crops damages, infrastructure and livestock devastation (PBS, 2022). Based on social progress index screening lowermost cultural, social and economic magnitudes of district preferred as low-slung socio-economic situation of region in province (BOS Punjab, 2022). In investigation process of this research work primary data of 380 flood affected households was used. PDMA, NDMA and DDMA⁸ based on disaster

³ Gross Domestic Product

⁴ Government of Pakistan

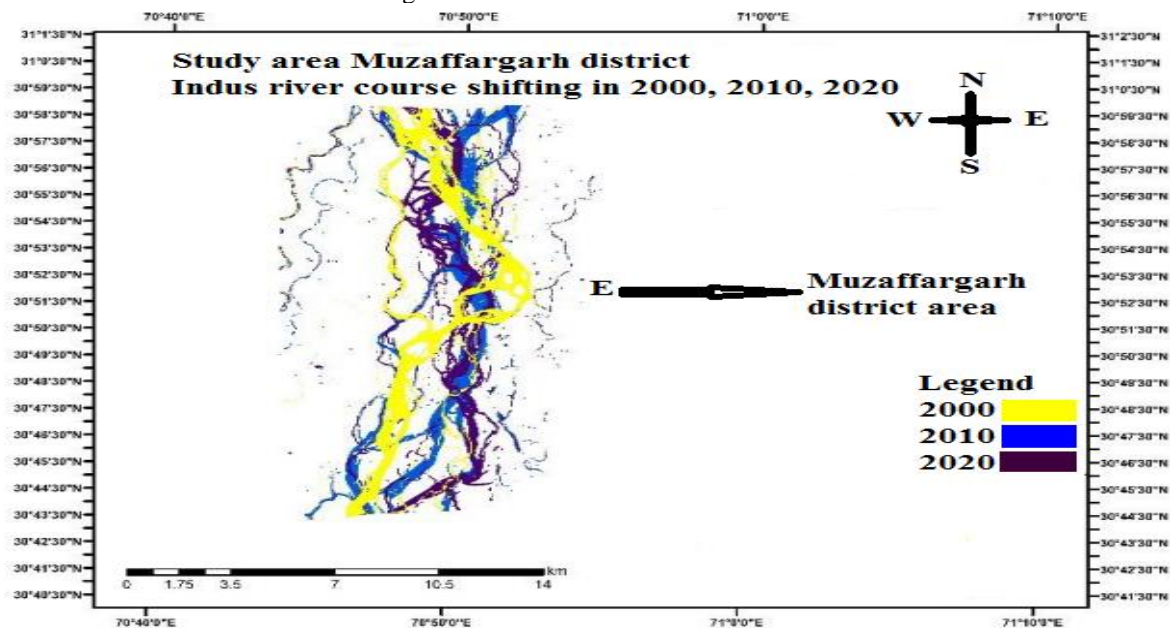
⁵ Provincial Disaster Management Authority

⁶ Bureau of Statistics

⁷ Pakistan Bureau of Statistics

⁸ District Disaster Management Authority

handling, revenue, land and irrigation improvements department were leading bases in gathering the data of this flood affected area as showed in figure 2.



3. Sampling Survey and Collection of Data

In sampling process, method of multistage random sampling was applied in this study for data collection while firstly, southern Punjab region frequently located on Indus River riverbank challenging persistent riverbank erosion and floods so preferred for this study regarding to higher vulnerability status. Secondly, among higher floods susceptible fourteen districts of province Muzaffargarh considered more vulnerable regarding to location preferably selected for this study (PDMA Punjab, 2021; PBS, 2022). Thirdly, from most vulnerable four tehsils of district floods influenced eight union councils Khan Garh Doma, Langarwah, Bait Mir Hazar Khan, Bait Qasim Wala, Rampur, Chak Frazi, Sheikh Ummer and Rangpur mostly were nominated for this study on information sources providing from PDMA Punjab, (2021) District Disaster Management Authority (2023) and NDMA, (2022). In final stage, as of each union council two villages further, if possible, carefully chosen based on losses of flood disasters, higher floods prone and household poor index about basic services access. Furthermore, extra statistics concerning research region were achieved from the description providing that by agriculture officer, patwari (officer of land record) and district baes management authority even however study respondents were favored and randomly interviewed. In process of collection survey data, household head (female/male) were essential respondents whereas simple random sampling method used in this study. In via method of Yamane (1967), sample size of 380 households well-thought-out adequate for empirical estimation of the study as this method endorsement is confirmed from previous research perspective such as various research characteristics Saqib et al., (2018), Ullah et al., (2016) and Ahmad and Afzal, (2023).

$$\text{Sample Size } (n) = \frac{N}{(1 + Ne^2)} \quad (1)$$

Equation 1, where N as demonstrated the study area total households, n as detailed sample size while e places of interest the correctness value as 7%. Preceding in developing questionnaire for data collection focus group discussion, reconnaissance survey and literature review were directed. In respectively nominated most flood prone eight union councils of district focus group discussion was showed where in each focus group discussion having number of respondents from 8 to 10 with occupation of livestock rearing, housewives and farming practices individuals aged 18 to 65 years. In evolving suitable consideration concerning numerous issues of climate change influenced risks and vulnerabilities of Muzaffargarh where substances documented from literature review were reflected to confirm related sub-components a major component following the research objectives. Questionnaire was developed on some significant information related to household income resources, income diversification basis, social networks, livelihood strategies, sociodemographic profile, climatic and natural disasters variability. In the survey procedure, data of households' respondents was collected from January 2023 to April 2023. In data collection process, household respondents were well versed concerning data collection purpose whereas local language Punjabi and Saraiki was used during conversation with respondents for appropriate response. Concerning the obtainability of respondent's suitable

access at farm or home were connected where few of them household respondents those who were not concerned in contribute in data procedure were substituted to others.

4. Model and Methodology Description

Estimating the income diversification and its related factors this research work applied econometric specification-based model as previously applied in the study of Schwarze and Ziller (2005).

$$\ln Div = \beta_0 + \beta_1 EM + \beta_2 Dep + \beta_3 Edu + \beta_4 GHH + \beta_5 Poor + \beta_6 AgrInc + \varepsilon \quad (2)$$

In above mentioned model equation 1 $\ln Div$ indicated income diversification natural log, EM as earning members of household, Dep consider ratio of dependency, Edu mentioned educational level of household head, GHH illustrated gender headship of household, Poor as financial status as poor household, AgrInc as agricultural income of household whereas E term indicated model error term.

Income diversification is estimated through calculating number of non-zero income level sources of households where herfindahl index applied for measuring income diversification. Herfindahl Index is inversely proportional to income diversification which measures higher diversification which was presented via German economist Albert O. Hirschman and American economist Orris C. Herfindahl. In this research work Herfindahl Index used to measure income diversification for three diverse earnings origins like agriculture, livestock and non-agriculture earning where diversification formula as given below.

$$Div = \frac{1}{\sum_{i=1}^n S^2} \quad (3)$$

In equation 3, Div signifies diversification of income, S demonstrations portion of each income source in overall income while summation indicated diversification inverse value. Total earning number member signifies those members of family which are vigorously intricate in earning practices whereas rises in earning members of family then diversification can increase as family member hold various level of education and skills as income diversification determinants description indicated in table 1.

Table 1: Description of determinants of income diversification

Indicators	Description	Reference
Gender status	Household respondent gender status (male =1, female =0)	Loison (2015)
Respondent age	Age of the household head	Mesfin et al., (2011)
Earning members in numbers	How many earning members in family	Roy and Basu (2020)
Dependency Ratio	Size of dependent population to working-age population	Venus et al., (2022)
Education level	Household head schooling level Illiterate = 0, 1 to 4 year schooling=1, 4 to 10 year schooling=2, 10 to14 year schooling=3	Deressa et al. (2010); Kouame (2010)
Household agriculture income	Monthly agriculture income of household Less than 20 thousand = 1, 20 to 50 thousand = 2 50 thousand to 1lakh = 3, 1lakh to 1.5lakh = 4, above than 1.5 lakh = 5	Saqib et al., (2018)
Household poverty line	If the household below the poverty line, then is equal to 1 otherwise 0	Memon et al., (2020)

Dependency ratio indicated ratio the member of family not part of labor force relies on some earning family members showing lower diversification with higher rate of dependency ratio. Education level shows significant determinant of income diversification which develops level of productivity and employment yet enhances adaptive capacity of rural families. Hence, higher educated level more opportunities of diversification of income (Wan et al., 2018). Gender status of household showing major determinant of income diversification while showing mix outcomes of gender status regarding income diversification in global perspective (Senadza and Hodey, 2015; Musyoka and Onjala, 2023). The term "poverty" refers to state of not having enough money to support household's plan of income diversification of income as household having poor status showed mix outcomes of income diversification (Nazir et al., 2024). Agriculture income indicated household earned income by agricultural activities showing discouraging level income diversification with higher income from agriculture (Barrett, 1997; Dercon, 1998; McPeak and Barrett, 2001). Descriptive statistics of the study indicators as explained in the table 2 which is given below.

Table 2: Descriptive statistics of study indicators

Indicators	Percent	Mean	Standard deviation	Minimum value	Maximum value
Log Inverse Herfindahl Index		0.78	1.3	1	8
Very low	68%				
Low	16.08%				
Medium	9.4%				
High	4.92%				
Very high	1.8%				
Gender		0.9	0.3	0	1
Age of the household head		36.5	8.48	19	74
Education level of the household		2.34	4.24	0	14
Illiterate 0 years	54.7%				
1-4 years	8.9%				
4-10 years	27.6%				
10-14 years	8.8%				
Number of earning members in family		2.37	1.4	0	7
Agriculture income monthly		0.38	0.5	3	0
<20thousands	56.33%				
20thousands to50 thousands	19.17%				
50thousands to 1lakh	13.33%				
1lakh to 1.5lakh	9.17%				
Above than 1.5lakh	2%				
Poverty		0.3	0.4	0	1
Dependency ratio		1.3	0.8	1	6

5. Results and discussion

Empirical estimates of the study are reported in table 3, where in data collection procedure those eight household who presented their income zero from various sources were dropped from data. Estimated Variance Inflation Factor value is less than ten as showing no multicollinearity data base issue while assessed coefficients are also clarified in the table 3. Highly diversified income profile was estimated those households having multiple earning members. Mostly members of households having same earning practices while considered less diversified regarding income while those having more family members more diversified income as results are alike with the study of Nazir et al., (2018). Households having large dependency need their profile diversify and have to generating more income sources so higher dependency reduces marginal utility leisure's and should increase risk reduction preference. The study estimated indicated insignificant association in income diversification and dependency ratio so lower dependency households more diversify income rather than high dependency ratio households as conclusions are similar with the research work of Beyene, (2008) and Nazir et al., (2018). Household head age and diversification of income can positive or negative as in positive perspective as aged households well experienced and highly eager to diversification for increasing household income while in the negative perspective aged households more reluctant in diversification of income rather than young ones. Estimate of study regarding household age showing insignificant value illustrating negative association with interaction in two variables as age and education as include in the model. Estimated negative value of household age and income diversification illustrated when household head become aged wants more leisure than work or aged household becomes reluctant to income diversification as findings are similar with studies of Adem et al., (2018).

Table 3: Income diversification determinants in Muzaffargarh district

Study variables	1	2	3	4	5
Earning members	0.185** (0.047)	0.178* (0.043)	0.169** (0.041)	0.158* (0.038)	0.167* (0.042)
Dependency ratio	0.016 (0.061)	0.015 (0.059)	0.012 (0.073)	0.014 (0.069)	0.016 (0.076)
Household head age	0.003 (0.007)	0.002 (0.006)	0.001 (0.004)	0.000 (0.003)	-0.014** (0.005)

Household education	head	0.047* (0.026)	0.054* (0.023)	0.058* (0.031)	0.059** (0.029)	0.137** (0.047)
Household gender status	head	0.283* (0.139)	0.279* (0.154)	0.187* (0.097)	0.243* (0.134)	0.214* (0.131)
Household poverty line	below	-0.026 (0.151)	0.081 (0.156)	-0.039 (0.143)	-0.042 (0.138)	0.006 (0.139)
Household agricultural income in PKRs	head	- (0.149)	- (0.143)	-0.238* (0.137)	-0.267* (0.148)	-0.316* (0.371)
Household education ≠ household is below poverty line	head		-0.039 (0.037)			
Household education ≠ household head agricultural income PKRs	head			-0.046 (0.0338)		
Household education ≠ household head gender status	head				0.106** (0.037)	
Household education ≠ household head age	head					0.003*** (0.001)
Constant		0.139 (0.257)	0.079 (0.231)	0.132 (0.271)	0.171 (0.216)	0.697*** (0.297)
Observation		240	240	240	240	240
R-Square		0.158	0.163	0.169	0.164	0.179
Adjusted R-square		0.128	0.137	0.143	0.134	0.164
VIF		1.21	1.38	1.76	7.21	3.98

Estimations of this research specified positive and significant association in education of household and diversification of income illustrating as educated households are more willing to generating off-farm and on-farm income rather than uneducated households. Educated households more willing to adopt risk spreading strategies by application of income diversification strategy as these results are alike with the studies of Ahmed, (2012), Ullah et al., (2016) and Shah et al., (2017). In research perspective middle aged households more willing to adopting mitigating strategies where in the specific region as south Asia men rather than women more easily adjust in off-farm practices where females having cultural constrains and not capable to adjust in far areas for earning. In rural areas of Pakistan man have dominant role rather than women so major decision are made by men rather than women so more diversification is focused by men rather than women. Estimates of the study are similar with the studies of Reardon et al., (1992) and Dercon, (1998). Poverty can confine the attainment of essential resources to diversify out of crop agriculture wherever poor households may not capably owing to inadequate saving. Inadequate saving considers major issue in income diversification of poor households as estimates illustrated independent status of poverty with income diversification. Government inadequate investment on infrastructure and lack of technical skills major constraints in income diversification of poor households as these results are alike with the research work of Barrett, (1997), Dercon, (1999) and Memon et al., (2020) and in dissimilar with the study of Ahmad et al., (2023). Mainstream population 79% in the study area earning perspective related to farming practices where more earning from agriculture focuses more resources allocated for agriculture mitigation which prevent from income diversification. Estimates of the study indicated significant and negative association income from agricultural and diversification of income showing as agricultural increases diversification of income decreases as these outcomes of study are in line with research work of Reardon et al., (1992) and Sarker et al., (2020).

Insufficient schooling to be suitable for skilled jobs, unaware about business opportunities and employment consider significant possible reasons about incapability of poor households regarding income diversification portfolio. Estimates of the study indicated educate peoples having more employment opportunities so of more focus to income diversification rather uneducated households. The reason related to this is that educated households having more opportunities of employment rather than uneducated households as these results are in line with the studies of Nazir et al., (2018). Household head education and agricultural income diversification interaction showing whether education level of household causes to increase in agricultural income while estimates indicated no significant outcomes regarding this perception. The reason related to such perspective is that education showing no moderate association regarding income diversification and

agricultural income as illustrated in column 3. In table 3 the interaction of household genders status and education level indicated showing purpose whether male educated households likely to diversify. Estimated results in the study illustrated as positive and significant coefficient highlighting male educated household head more likely to income diversification portfolio as these finding is similar with the studies of Dercon, (1998) and Senadza, (2014). Household head age not robustly correlated with diversification of income as highlighted in column 1. Household head age and education can be determined as aged and higher educated household more likely to income diversification sources. Estimated results indicated positive and significant interaction in household head age and education as illustrating educated and aged household having more diversification of income rather than less educated and young ones as indicated in table 3 and column 4 as results are alike with the studies of Dolan and Walker, (2006) and Ahmad et al., (2024).

6. Conclusion and suggestions

This research work particularly focused to investigate the factors affecting income diversification in flood prone areas of Punjab Pakistan. Estimates of the study indicated as households having more family earning members, male household head and more educated family members consider higher income diversification. Household head education positively moderate association of household gender status and household head age related to diversification of income. Moderation examination indicated as households with male educated household head and aged educated household head are more possible to diversify their portfolio of income as strategy of risk- spreading. On the other hand, higher poverty and income from disincentive diversification of income having no substantial association with diversification of income.

In Muzaffargarh district livelihood sources of flood prone inhabited population considered the fishing, livestock rearing and farming practices while manual labor, some technical skill and small based business activities considered other economic opportunities. Small-based business activities and manual labor minimal earning sources while farming practices of crop cultivation and livestock rearing major sources of inhabited population earning which mostly remains under risk due to flood threatened. In job searching and working in industrial areas required more education and technical skills where the inhabited study area having lower schooling level and unfamiliar with technical skills. In the conclusion, inadequate schooling, limited awareness and insufficient economic opportunities considered significant bottleneck to diversification of income in district Muzaffargarh.

In policy perspective, results of the study suggest as their necessity to capitalize in education and formation economic occasions to recover resilience of rural households regarding external shocks. Literate household head are more to be expected to engross communication linked to flood risk and take safety protection utterly. Strategy measures must base meeting the requirement of illiterate households to overcome their susceptibility. Gender bias can moderately be reported for over the as long as education excellence yet there is essential to make occasions precisely for women in labor market to household incentivize to direct their female to schools. This research work also related to some limitations firstly in this study due to financial constraints limited to single district and small sample size of 240 applied which can enhanced to more study areas and sample. Secondly study estimated indicated insignificant association in poverty and income diversification which need to further analysis for understanding insignificant association related to context of income diversification determinants in this district Muzaffargarh.

7. Declarations

Ethical Approval

Ethical approval taken from the COMSATS University Vehari campus, ethical approval committee

Consent to Participate

Not applicable

Consent to Publish

Not applicable

Authors Contributions

AN and DA analyzed data, methodology, results and discussion, conclusion and suggestions and manuscript write up whereas both AN, DA, MI, BT and AA finalized and proof read the manuscript and both authors read and approved the final manuscript.

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Competing Interests

The authors declare that they have no competing interest.

Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

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