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HORTICULTURAL FARMERS' LIVELIHOOD VULNERABILITY TO CLIMATE CHANGE IN UPLAND BALOCHISTAN, PAKISTAN

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ABSTRACT

This paper was designed to assess vulnerability to climate change of farm household of major horticultural crops in arid province of Balochistan. A comprehensive field survey was conducted for face-to-face interview from 200 farming households in district Mastung. To assess livelihood vulnerability of the farm household, a Climate Vulnerability Index for Arid Environment (CVI^{AE}) was developed. This index is particularly used to assess the vulnerability level of spatial units to climate change in the context of human dimension. The CVI^{AE} is also a useful tool in assessing the vulnerability of drought-hit regions of Balochistan in specific and in other arid to semi-arid regions in general, with consideration of significant indicators according to the context and area. The results of indices elucidate that the study area is more vulnerable in agriculture, water, health and livelihood major-components. It is plausible to enrich the knowledge of farming community by timely communicating effective early warning system, drought forecasting through district agriculture and extension directorate. These initiatives enable farmers to adjust planting and to avoid further depletion of already scared water resources for irrigation in the study area. Attention on resistant varieties and new crops suited to agro-climatic circumstances and variation of farm and livelihoods is desired.

KEYWORDS: Livelihood Vulnerability, Adaptive capacity, Sensitivity, Exposure, Climate Change, Water Management

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1. Introduction

Agriculture is the backbone of rural population because their livelihoods are directly or indirectly dependent on agriculture and natural resources (Qasim et al., 2011; Myers & Saburo, 2020). Out of the 3 billion rural households in the developing and undeveloped countries, an estimated 2.5 billion households are totally dependent on agriculture (Ahmad et al., 2020; Kantamaneni et al., 2020). It is estimated that with an increase in the world population, the land area under cultivation will also increase. Agriculture systems throughout the world are negatively affected by climate change impacts (Sathyan et al., 2018; Kogo et al., 2021). Climate change has greatly affected the food production in many parts of the world, thereby aggravating food security concerns (Kantamaneni et al., 2020). The climate change has caused erratic rainfall, storms, floods, famine, temperature fluctuations and droughts in both developing and developed countries (Asrat & Simane, 2017; Kantamaneni et al., 2020). All these changes in climatic conditions have affected the crop yields throughout the world. It is expected that the ongoing climate change may cause a decrease in the crop production in both the developing and underdeveloped countries by up to 70% (Kantamaneni et al., 2020). In South Asian countries, the average yield of wheat, sorghum and maize will decrease by 8% in 2050 (Kantamaneni et al., 2020; Ojumu et al., 2020). In Pakistan, it is estimated that since 1960, the average temperature has increased by 0.47 ^{o}C and is expected to reach 3 ^{o}C in the coming few decades (Gorst et al., 2018; Kazmi et al., 2015). Because of arid and hyper-arid situations, the country is expected to face stern challenges due to climate change and global warming issues.

Climate change has severe impacts on agriculture system in the South Asian countries (Hussain et al., 2018). Pakistan is also under severe threat of climate change impacts (Khan et al., 2016). Although, Pakistan ranks 135th in the emission of greenhouse gases (GHGs) per capita in the world but contrary to this it is ranked 8th in terms of vulnerability to global warming and climate change in the world. The rapidly changing trends of climate change have led to an increase in the frequency and intensity of extreme events (Rasul et al., 2012). Climate change has negative impacts on yields of staple crops especially rice and wheat in Pakistan (Gorst et al., 2018). Climate change is evident in the country in the form of increased temperatures, decreased rainfall in dry regions, increased rainfall in monsoon regions and rapidly melting of glaciers (Ahmad & Schmitz, 2018).

Due to agrarian and horticultural based economy, nearly 85% of the population of Balochistan is dependent on agriculture (Naz et al., 2020). Climate change has resulted in recurrent droughts in Balochistan province of Pakistan, which has severely affected its agriculture sector. Climate change induced scarcity of water and persistent drought conditions have created hurdles for farmers in adopting sustainable agricultural development strategies in the province. Prolong drought periods of 1998-2003 and 2015-2017 had badly impacted the economic situation of the country, however severity was much higher in Sindh and Balochistan provinces. Major part of Balochistan is arid and semi-arid with limited surface and ground water sources. Rainfall is highly variable

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in the province with considerable regional variations and in recent past province witnessed two or three or sometimes up to six consecutive dry years mainly due to climate change and environmental factors (Khair et al., 2015). Therefore, the main purpose of this research study is to assess vulnerability to climate change of farm household of major horticultural crops in upland Balochistan. Furthermore, this research will propose approaches that might help policy makers and as well as farmers for effective horticultural farming in Balochistan.

2. Methodology

2.1 Selection of the study area

The Geography of Balochistan province is mountainous in nature and remains dry throughout the year and is located around 30◦ north and 67◦ east. The province have four agro-ecological zones that include deserts, plains, lower and upper highlands. Each zone then has different climates: the lower plateaus have been dry and hot in the summers and excessively cold during the winters, the plateaus with high altitude remains cold in winter and warm in the summer; summers are too hot in the plain areas, and mild in winters, whereas extremely hot and dry in deserts. The summer rainfall in the province is occurred due to monsoon winds while westerly disturbances causes the winter precipitation. Furthermore, due to these westerly disturbances regions with 34◦ to 36◦ north receive extreme precipitation during the winter season. The province receives on average annual rainfall of about 25mm to 500 mm precipitation that which is consisted on summer heavy rains and winter snow (Naz et al., 2020).

Since last two decades, Balochistan had witnessed different dry spells due to climate change and caused a great threat to the livelihood of its population. Balochistan has 12.34 million populations and majority (85 percent) of this population lives in rural areas and their livelihood mainly based on livestock and agriculture sectors. Figures indicate that majority of the districts (26 out of 34) depends on flood water; tube wells, rain and *karezes* water for watering their farms. To achieve the objectives of the study, district Mastung have been selected for extensive field survey. The district is one of the main horticultural crops growing district of upland Balochistan and was extremely affected by recent drought due to climate change.

2.2 Sampling Design

To achieve the objectives of the study filed survey was conducted in district Mastung. Data was gathered from the household head as a sampling unit of this study because in the rural areas household head is responsible for all the major decisions and socio-economic betterment. A total of 200 farmers were interviewed during filed survey in district Mastung. Sample size was determined following (Arkin & Colton, 1963) statistical formula as given in equation 1.

$$n = \frac{Nz^2PQ}{Ne^2 + z^2PQ} \quad \text{Equation 1}$$

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Multistage sampling technique is used in order to select farmers. At the First stage Union Councils have been selected purposively with the prior consultation of district agriculture officer and key informants. From each Union Council, villages were selected at the second stage randomly. Finally, farmers were selected randomly from each village to collect the required data.

Semi-structured questionnaire was used as data collection tool. The first section of the questionnaire generally focuses on the socio-economic profile of the farmers. The second part comprised on questions assessing the farmers' livelihood vulnerability to climate change. Finally, the questionnaire addresses farmers' perception about climate change and their adaptive/coping approaches to lessen the adverse effects of climate change on farmer's livelihood.

2.3. The Livelihood Vulnerability: Composite Index Approach

The livelihood vulnerability index is one of the sustainable livelihood approaches that take into account five assets of a household. These assets include the social capital, financial capital, human capital, physical capital and the natural capital (Chambers & Conway, 1992). In this context, the vulnerability to hunger and famine have been the most critical issues often faced by the inhabitants of worldwide semi-arid lands. These semi-arid regions are subject to excessive climate variations in their limited seasonal and inter-annual precipitations accounting for repeated floods and droughts. In the semi-arid zones natural resources are scarce such as fertile soils, timely availability and supply of water, and vegetation, and the available scant resources can easily be damaged by varying patterns of the precipitations and also by some home actions (Ribot et al., 1996). However, the sustainable livelihood approach is applied to developing programs at community level and has been proven as a handy kit for assessing household's ability to withstand stressful events like epidemics and other disasters. Climate change has added complexities to households' livelihood security. This approach to a restricted extent addresses the issues of adaptive capacities and sensitivities to climate variability and integrates climate vulnerabilities that accounts for adaptation practices of a household.

2.3.1 Development of Climate Vulnerability Composite Index for Arid Environment (CVI^{AE})

There is a bunch of well-established approaches for calculating climate vulnerability, but we have modified the indices existing in the literature according to the local situation having arid climate and where the farming system is completely dependent on ground water for irrigation. We have developed the CVI^{AE} based on the framework presented in **Figure** 1. In order to develop the CVI^{AE}, three dimensions of vulnerability (i.e. Sensitivity, Adaptive capacity and Exposure) have been subdivided into nine main components. The dimension of adaptive capacity is further divided into four main components that include socio-demographics, livelihood strategies, the component of social networks and agriculture. The second dimension of sensitivity has been similarly divided into three main components of food, health and water. Lastly, the dimension of

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exposure incorporates two major components of impacts of natural disaster and climate variability. These major components were sub-divided into 36 minor-components or indicators in the next stage. These nine major components and 36 minor components have been adapted to capture the speculative determinants of vulnerability based on literature review and local situation. After calculating the overall index, we will be able to assess dimensional vulnerability in the arid zone of Balochistan. A detailed explanation of the indicators of the major components can be found in **Table** 1.

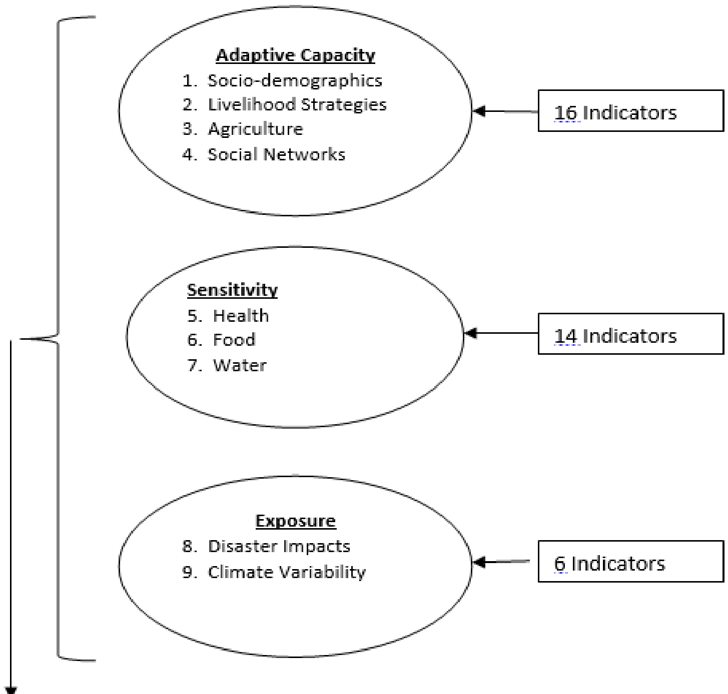

Figure 1: Climate Vulnerability Index for Arid Environment (CVI^{AE})

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Table 1: Dimensions of Vulnerability and nine major components and 36 sub-components/ indicators used for estimating CVI^{AE}, with explanation and source

Vulnerability component	Major Component	Sub-Component/ Indicator	Explanation	Unit	Source
Adaptive Capacity	**Socio-demographics**	Family dependency	Ratio of (population below 15 years and population above 59 years, to the population between 15–59 years)	Ratio	(Sadhak, 2013)
		Farming Experience	Inverse of Farmer's Years of farming experience in years	Number	**New**
		Illiterate HH Head	HH where the head has never attending school	Percent	(Hahn et al., 2009; Pandey & Jha, 2012)
		HH raising orphans	HH that raise at least one orphan in their home	Percent	(Hahn et al., 2009)
	Livelihood Strategies	HH Income	Inverse of HH Income (in Thousands)	Average	**New**
		Migration	HH that report at least 1 family member migrated for better income or work in other communities	Percent	(Pandey & Jha, 2012)
		Solely Agriculture	HH that report only agriculture as a source of livelihood	Percent	(World Bank, 1997)
		Livelihood Diversification Index	Inverse of (the number of non-agricultural livelihood activities +1)	Average	(Sathyan et al., 2018; World Bank, 1997)
	Agriculture	Farm holding size	Inverse of land holding size	Average	(Sathyan et al., 2018)
		New crops	Percent HH that Have not introduced any new verity of crops	Percent	(Pandey & Jha, 2012; Sathyan et al., 2018)
		Decline in farm production	HH reported decrease in farm production	Percent	(Pandey & Jha, 2012; Sathyan et al., 2018)
		Decline in livestock production	HH reported decrease in livestock production	Percent	**New**

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	Social Networks	Cooperation (Receive: Give Ratio)	Ratio of (the number of types of help received by a household in the past month + 1) to (the number of types of help given by a household to someone else in the past month + 1)	Ratio	(Hahn et al., 2009; Sathyan et al., 2018)
		Assistance from community leader	HH reporting they have not asked their local community leader for any assistance in the past 12 months	Percentage	(Hahn et al., 2009)
		Lack of agriculture extension services	Farmers do not visit agriculture extension office or extension worker does not visit them	Percentage	**New**
		Lack of ICT access	Percent of Households with no access to Information Communication Technology	Percentage	(Sathyan et al., 2018)
Sensitivity	**Health**	Access to health facility	Average time to get to the nearest health facility in minutes	Average	(Hahn et al., 2009)
		Family members chronically ill	HH where at least 1 Family members has chronically illness	Percentage	(Hahn et al., 2009)
		family member miss work due to illness	HH that report at least 1 family member who had to miss work due to illness in last month	Percentage	(Hahn et al., 2009)
	Food	Food Insufficiency	number of months households struggle to obtain food (range: 0–12)	Average	(Sathyan et al., 2018)
		Saving Crop	HH that does not save crops from each harvest	Percentage	(Hahn et al., 2009)
		Saving Seed	HH that does not have seeds from year to year	Percentage	(Hahn et al., 2009)
		Staple crop	HH that does not grow wheat	Percentage	**New**

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	Water	TW Service Area	Area of land irrigated by a single TW	Average	**New**
		HH reporting water conflicts	HH that report having heard about conflicts over water in their community	Percentage	(Hahn et al., 2009)
		Water Scarcity	HH that report water is not available every day	Percentage	(Dey et al., 2005; Hahn et al., 2009; World Bank, 1997)
		Paved water pond/channel	HH that do not have paved Water pond/Channels in their orchard	Percentage	**New**
		Distance of orchard from water source	Distance of orchard from pond in meters	Average	**New**
		Availability of solar Tube Well	HH that do not have Solar TW in their field	Percentage	**New**
		Person affected of waterborne disease	HH reporting at least one family member is affected of waterborne disease	Percentage	(Pandey & Jha, 2012; Sathyan et al., 2018)
Exposure	**Natural Disasters**	Death or injury due to natural disasters	HH that reported either an injury to or death as a result of the most severe drought in the past 20 years.	Percentage	(Hahn et al., 2009)
		property damage	HH reported housing or property damage due to natural disasters	Percentage	(Sathyan et al., 2018)
		Early warning	HH that did not receive early warning about the flood and drought	Percentage	(Hahn et al., 2009)
	Climate Variability	Minimum temperature increase	standard deviation of monthly average of average maximum daily temperature (years: 1985–2018)	Average	(Hahn et al., 2009)
		Maximum temperature increase	standard deviation of monthly average of average minimum daily temperature (years: 1985–2018)	Average	(Hahn et al., 2009)
		Erratic precipitation index	standard deviation of monthly average precipitation (years: 1985–2018)	Average	(Hahn et al., 2009)

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Note: New stands for those indicators which have been developed by authors keeping in view the local characteristics of the study area.2.3.2Standardization/Normalization of sub-components or indicators

The indicators were measured on different scales, including numbers, percentages, and indices, thus, there was a need of normalization. These indicators were normalized to a 0-1 transformation developed for Human Development Index (HDI) in calculation of life expectancy index (UNDP, 2007) and also practiced by (Hahn et al., 2009) using Equation (2):

$$Index_S = \frac{S_d - S_{min}}{S_{max} - S_{min}} \qquad \text{Equation 2}$$

Where S stands for indicator or sub-component, and S_{max}, S_{min} are the maximum and minimum values, respectively, and S_d is the average value for each indicator. After standardization process, the indicators were averaged by using equation 3 to come up for an index value of each major component in the following manner:

$$M = \frac{\sum index_{Si}}{n} \qquad \text{Equation 3}$$

Here M is a major component such that there would be nine M values. $Index_{si}$ signifies the sub-components for every major component, while "n" in the denominator is the number of indicators. After calculation of each major-components employing equation 3, it is needed to assign weights. For this, we have followed, balanced weighted approach utilized by Hahn et al., (2009) and Sullivan & Meigh, (2005). In Balanced Weighted Approach, the number of indicators appearing in a major component is used as the weight for calculating the CVI^{AE}. Here, for evaluating all the three dimensions of the vulnerability the equal weights are given to each indicator because all the dimensions included in the CVI^{AE} are equally desirable and important. In the last step, we take the average of weighted scores of the major components calculated in equation 3 to calculate the final CVI^{AE} of district Mastung. The overall CVI^{AE} for vulnerability can then be expressed in Equation 4 as follows;

$$\mathrm{CVI}^{\mathrm{AE}} = \frac{\sum w_{Mi} M_i}{\sum w_{Mi}} \qquad \text{Equation 4}$$

Here, $\mathrm{CVI}^{\mathrm{AE}}$, is the Climate Vulnerability Index for the Arid Environment of the study district Mastung. W_{Mi} are weights discussed earlier and M_i is the average value of each major component. The CVI^{AE} developed ranges from 0, (least vulnerable) to 1 (most vulnerable).

3 Results and Discussion

3.1 Comparison of Climate Vulnerability Index for Arid Environment (CVI^{AE})

Table 2 depicts the average, minimum and maximum CVI^{AE} sub-component/ indicators values for the surveyed district. The table also elucidates indices for major-and minor-components and that of CVI^{AE}.

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3.1.1 Adaptive Capacity

Overall, district Mastung showed higher vulnerability index (0.28) in terms of major-components of socio-demographic profile. Main difference comes from sub-component of farmers' literacy status in the study area, where more than three-fifth of farmers had never attended school as compared to some neighboring districts (for instance two-fifth in Pishin district). The study area has also higher vulnerability incidence in terms of family dependency ratio and farming experience (in years) of the farmers. Almost 17 persons on average were living in a household. This large number is due to the prevalence of joint family structure in the study area. This characteristic makes the farming household more vulnerable in terms of family dependency ratio as on average 7 family members were belonging to active (between 14 and 60 years) age. On the other hand, a farming community with higher experience may reduce vulnerability as they can swiftly cope with climatic events such as droughts, efficient pest infestation, timely application of fertilizers and pesticides, better crop management, and most probably having contacts with whole sale fruit markets. These positive dimensions of farming experience have also been highlighted by previous research in the study area (Murtaza & Thapa, 2015, 2017).

Over 11% of the farming households in district Mastung reported that they are raising at least one orphan at their home, making it more vulnerable (Table 2). The study area also witnessed significantly greater vulnerability in terms of second component of livelihood strategies (0.513). Household income has been considered as an indicator encountering climatic-induced vulnerability. As the data suggests that Mastung is dominant by small to medium farmers, thus they have very limited land and income and have no room for diversifying their income opportunities due to lake of available/usable land. Thus farmers were vulnerable in terms of sub-component of household income with sub-component values of 0.22. Huge difference comes in terms of sub-component of migration in the study area as compared to others parts of the province. Majority of the sampled farmers (89%) in the district reported that none of their family members has migrated to nearest City of Quetta or to other community for better income opportunities. This could be due to the fact that HHs in Mastung have relatively large farm size (22.3 acres on average) compared to rest of highlands of Balochistan, and most of HH members work on family farm as free labor. Contrary to Hahn (2009) argument where he has assigned higher vulnerability scores to households with migrated family members, this study has rather considered migration as a coping strategy to fulfill immediate income needs against climate induced draught impacts, thereby lowering livelihood vulnerability and enhancing adaptive capacity.

One third of sampled farmers were dependent solely on agriculture making them more vulnerable to climate induced water scarcity and drought impacts. Rest of the farmers had less sources of income yet some of them were engaged in raising livestock such as goats, sheep, cows and buffaloes. Therefore, due to these adaptive practices, sample farmers may reduce vulnerability in terms of livelihood strategies than Mastung. Singh (2015) and (Sathyan et al., 2018) have also emphasized the importance of migration,

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diversified livelihood Strategies and income diversification for enhancing the adaptive capacity of Indian farmers.

The sampled farmers in Mastung were most vulnerable (0.738) in terms of agriculture component among four major-components of adaptive capacity dimension. A significant number of farmers in the districts have not introduced any drought resistant crop. In addition, more than 90% farmers reported loss in agriculture and livestock production due to climate-induced drought impacts in the districts. Nonetheless, the significant difference could be seen in terms of average farm holding size. Figures indicate that farmers in Mastung have an average landholding size of 22.3 acres, thereby making the farmers less vulnerable (0.29). Since large farmers are less vulnerable due to their income and crop diversification opportunities/ capabilities. A recent study by (Murtaza et al., 2021) also confirmed that limited landholding was a key barrier in adopting sustainable and drought resistant agricultural practices.

Table 2: Climate Vulnerability Index for Arid Environment (CVI^{AE}), summary statistics, index values and overall CVI^{AE} for Major- and sub-components for Districts Mastung.

Dimension of Vulnerability	Major Components	Sub-Components	Min	Max	Mean	Sub-Component Index	Major Component Index
Adaptive Capacity	**Socio-demographic Profile**	Family dependency	0.14	8.00	1.47	0.17	**0.277**
		Farming Experience	0.01	0.25	0.07	0.22	
		Illiterate HH Head	0	100	11	0.11	
		HH raising orphans	0	100	61	0.61	
	Livelihood Strategies	HH Income	0.001	0.120	0.027	0.22	**0.513**
		Migration	0	100	89	0.89	
		Solely Agriculture	0	100	37.50	0.38	
		Livelihood Diversification Index	0.25	0.50	0.39	0.57	
	Agriculture	Farm holding size	0.01	1.00	0.30	0.29	**0.738**
		New crops	0	100	83	0.83	
		Decline in farm production	0	100	90	0.90	
		Decline in livestock production	0	100	93	0.93	
	Social Networks	Cooperation (Receive: Give Ratio)	1.00	2.00	1.04	0.04	**0.485**
		Assistance from	0	100	93	0.93	

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		community leader					
		Lack of agriculture extension services	0	100	87	0.87	
		Lack of ICT access	0	100	10	0.10	
Sensitivity	**Health**	Access to health facility	5	95	59.63	0.61	**0.519**
		Family members chronically ill	0	100	45	0.45	
		family member miss work due to illness	0	100	50	0.50	
	Food	Food Insufficiency	0	6	1.82	0.13	**0.338**
		Saving Crop	0	100	50	0.50	
		Saving Seed	0	100	45	0.45	
		Staple crop	0	100	27	0.27	
	Water	TW Service Area	0.33	20.00	8.56	0.42	**0.585**
		HH reporting water conflicts	0	100	87	0.87	
		Water Scarcity	0	100	66	0.66	
		Paved water pond/channel	0	100	55	0.55	
		Distance of orchard from water source	30	1200	678.65	0.55	
		Availability of solar Tube Well	0	100	59	0.59	
		Person affected of waterborne disease	0	100	45	0.45	
Exposure	**Disasters Impacts**	Percent of Households with death or injury due to natural disasters	0	100	2	0.02	**0.483**
		Percent of Households reported housing or property damage	0	100	46	0.46	
		Percent of households that did not receive a warning about the pending natural disasters	0	100	97	0.97	
	Climate Variability	Mean standard deviation of monthly average of average maximum daily temperature	0.89	3.90	1.80	0.30	**0.345**

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		(years: 1985–2018)					
		Mean standard deviation of monthly average of average minimum daily temperature (years: 1985–2018)	1.26	3.38	1.90	0.30	
		Mean standard deviation of monthly average precipitation (years: 1985–2018)	8.09	39.30	21.53	0.43	
Climate Vulnerability Index for Arid Environment (CVI^{AE})							**0.499**

Within vulnerability dimension of adaptive capacity, the major-component of social networks is assessed by four sub-components or indicators. These include average receive-give ratio, number of visits to community leader in case of help, access to Agricultural extension services and access to information and communication Technologies (ICT). Overall, in this major-component of social networks, the vulnerability index is 0.485 (see Table 2). This is due to the fact that majority of sampled farmers in had never visited their community leader for help. Similar results are also witnessed in sub-component index value of access to agricultural extension services where some 87% farmers had neither visited office of agriculture extension nor any extension officer visited their orchard, which arises a big question mark on the role and functioning of research extension wing of Agricultural department. Almost 90% of respondents have access to ICT in the form of mobile phones which is a positive sign. Household's ratio of receiving to giving help from/to their fellow farmers was also assessed under social networks major component. Some 40 farmers in Mastung reported receiving help from fellow farmer or relatives compared to 15 farmers who did help their fellow farmers in-kind or cash, medical care, selling produce to wholesale market or during installation of tube Wells. As this major-component of social network is design to assess the level to which farm household rely on relatives and fellow farmers for in-kind help and financial assistance. The intuition behind is that a farmer that offers cash or in-kind help and receives less help from others is less vulnerable. The reason behind very less number of farmers receiving help in-cash was due to the fact that orchard farming in Northern Balochistan is dominated by contractors who buy/contract the orchard in the beginning of the season on predefined soft terms and conditions (Murtaza, 2019; Murtaza & Thapa, 2017). These (contractors) pay cash to the farmers in two to four installments. Such informal sources of credit have become very dominant in the study area and have solved much of farmers' cash issues. As a consequence, the role of formal credit institutions like *Zarai Taraqiati Bank Limitted* (ZTBL) is almost

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negligible. Therefore, much focus of this indicator was on in-kind help of farmer community members to each other.

3.1.2 Sensitivity

Under the vulnerability dimension of sensitivity, three very basic and essential elements have been analyzed, namely health, water and food. Mastung shows the highest vulnerability towards water major-component (0.585) followed by health (0.519) and food (0.338). It is now a well-known fact that groundwater decline and increased drinking water shortage are major concerns in upland-Balochistan (Ashraf et al., 2014, 2021). Water scarcity is a serious issue in the Province due to continuous drought spells and a strong groundwater decline. Overall, 66% of farming households in Mastung agreed that water scarcity problem persists in the region as the farmers are not able to water their field every day. A study in India has also found that water vulnerability in rural areas was primarily due to high dependency on natural resources and agriculture for living (Pandey & Jha, 2012). District is also more vulnerable in terms of tube well service area (0.42) as figures suggest that farmers have on average larger farm size. Thus a single tube well is irrigating on average 8.56 acres of land in Mastung. Similarly, due to large farm areas, the pond to farm distance in Mastung is on average 679 meters. Long distance of pond to farm and unavailability of paved pond and water channels cause waste of water through absorption and evaporation leading to high water vulnerability in already water-stressed study area. Farmers in Balochistan have come up to a solution for continuous long hour electricity load-shedding by installing solar tube wells. Almost 41% in Mastung claimed of having solar TWs thereby minimizing their water vulnerability.

Figures indicate that farmers in Mastung reported longer time-distance of 59.63 minutes to the nearest health facilities. This has resulted in high sub-component vulnerability index values of 0.61. At the same time some 45% farmers in Mastung reported themselves or other family members chronically ill. Almost all of the chronically ill reported respondents claimed stomach-ache and gastric problem. Some 50% of farmers reported that at least one of their family members missed work due to illness in the past month. During discussion with farmers, it was realized that they believe that such chronic stomach issues are water-borne as they consume same water pumped by tube wells from as below as 800 to 1000 feet and in most instances the water has gaseous bubbles. A detailed analysis of water for drinking is needed in the study area that might help uncover reasons for water-borne diseases. Within the major-component of food, farmers in study area are vulnerable with an index of (0.34) as 73% of the farmers do not grow wheat, which is the main staple food of the country. At the same time, almost half of the sampled farmers do not save seed or crop for future cultivation. Farmers in the study area reported that they struggled for attaining sufficient food for their family members for at least two months. They further added that the most important factor due to which this particular situation occurs during winter season in the months of January and February within which there is no farming activity (focus group discussion).

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3.1.3 Exposure

The dimension of exposure comprised of two major-components, i.e., Disaster Impacts and Climate Variability (Table 2). Study area shows vulnerability index of 0.48 and 0.35 in the major-components of natural disaster impacts and climate variability, respectively. Based on the average reported number of drought events in the past two to three decades, the percent of households receiving no early warnings about such devastating events is quite high (97%). Similarly, it is found that disaster impacts perceptions were more pronounced in Mastung district where the households were more concerned about the rise in temperature, hot months and decrease in rainy days. Nearly half of the sampled farmers claimed property or farm damage due to water shortage and extreme climate events (e.g. drought). Small farmers, in particular, were worried about decrease in production due to erratic rainfall and the occurrence of continues droughts. People opined less financial and physical assistance from government institutions during disaster emergencies. One of the solutions for this might be strengthening and equipping the local informal associations and formal institutions to tackle natural disasters. Residents participating in community-based adaptation actions are both knowledge holders and users.

4 Conclusion and Recommendation

This paper was designed to assess vulnerability to climate change of farm household of major horticultural crops in upland Balochistan. Furthermore, this research has suggest strategies that might help farmers as well as policy makers for sustainable horticultural farming in the province. To assess livelihood vulnerability of farm household, a Climate Vulnerability Index for Arid Environment (CVI^{AE}) was developed. The results indicate that the study area is more vulnerable in agriculture, water, health and livelihood major-components. Within vulnerability dimension of adaptive capacity, farmers are highly vulnerable in terms of major components of livelihood strategies, socio-demographics, and agriculture. While under sensitivity dimension, they are vulnerable in major components of health and water. Lastly, under vulnerability dimension of exposure, farmers are more vulnerable in the context of natural disaster impacts. The findings of this research study can provide a platform for policy makers and stakeholders with relevant information to act and address the identified gaps and problems. It is crucial in restructuring the existing Agricultural Development Policies through concerted research and development efforts for documenting indigenous adaptation strategies. Attention on resistant verities and new crops suited to agro-climatic circumstances and variation of farm and livelihoods is desired. An accurate and timely weather forecasting system, drought early warning system, and timely communication with farming communities would enable them to adjust in input use, selection of crops resistant to stress conditions etc. This can be achieved with the proper help and continuous support of government extension services. An effective awareness campaigns and disaster management on the natural resource seem to be emergent needs of the farming community. Since the study area is prone to frequent droughts and also there is high variability in rainfall in the province, there is great need of adjustment in the existing water resource management strategies in the context of changing climate to avoid further depletion of already scared water resources for irrigation in Balochistan. Furthermore, social capital that include farmers-to-farmers extension could also enhance adaptive capacity of the farming community, therefore policy intervention in this regard is needed.

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