Climatic Variability Leading to Loss and Damage to Rural Household's Livelihood in Desert Ecosystem: Evidence from Tharparkar Sindh.

By

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DECLARATION

I, Akbar Khan, 2015PIDEFMPHILENV01 hereby declare that I have produced the work presented in this thesis, during the scheduled period of study. I also declare that I have not taken any material from any source except referred to wherever due that amount of plagiarism is within acceptable range. If a violation of HEC rules on research has occurred in this thesis. I shall be liable to punishable action under the plagiarism rules of the HEC

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Moreover, I especially tribute my parents, who sacrificed their everything to make me a well literate person. Their love care and sacrifice has been the beacon of light throughout my life.

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Dedication

This work is dedicated to my beloved parents, brothers and my best friends, Saba Batool, Danyal Khanzada, Noorullah Jamro, and Ghulam Muhammad Jatoi.

ABSTRACT

Climatic variability is a global threat and its first and foremost impact is at household level. Tharparkar District faced extreme drought in 2014 which was considered as socio-economic drought as it caused serious negative impacts on livelihood sources of households. As majority

of the rural masses rely upon livestock and cropping as their major source of income, households faced loss and damage in their financial assets. This research examines the loss and damage from latest drought that hit Tharparkar in 2014. A household survey questionnaire was developed along with Focused Group Discussions with the farming communities of villages to collect qualitative and quantitative responses from 20 villages of Tharparkar District. A sample of 384 households were randomly selected from the villages for the purpose. The data was collected for both, drought year (2014) and normal year (2016) in order to compare and capture the true picture of loss and damage due to drought. Satellite images were also censored to get the vegetation cover (Normalized Difference Vegetative Index) in both, drought and normal year. We found that the respondents never witnessed such extreme drought before in their life. According to 384 households surveyed, above 5000 animals were died in drought year including: sheep, goats, cattle, and camels. Average monetary loss per household per year in shape of animals died in drought year was 78426 Rupees, whereas average monetary damage per household per year in shape of total medication cost on animals was 5073 rupees. Almost 94% of the respondents reported that their crops were failed and almost 92% reported that their crop seeds were destroyed in 2014 and thus got no income from cropping that year. Whereas in normal year (2016), no such massive destruction was witnessed. The average loss per households in shape of cultivation cost in drought year was 65943 Rupees. Main coping strategies opted by the households against drought were: water storage techniques, migration, selling property, seeking private loans, and solar panels. Coping strategies of the households were not sufficient enough to tackle the negative impacts of drought, although all the households adopted coping strategies to fight against the drought. It was concluded that such droughts firstly affect the water demand, causing low vegetation for human and animals eventually affecting the food availability for households and feed for livestock. This scenario put the households in low resilience group, as their income is disturbed because of the climate stressor. The authorities should compensate the households for their loss and damage.

Pakistan Institute of Development Economic

CERTIFICATE

This is to certify that this thesis entitled: **"Climatic Variability Leading to Loss and Damage to Rural household's Livelihood in Desert Ecosystem: Evidence from Tharparkar Sindh."** submitted by Akbar Khan is accepted in its present form by the Department of Environmental Economics, Pakistan Institute of Development Economics (PIDE), Islamabad as satisfying the requirements for partial fulfillment of the degree in **Master of Philosophy in Environmental Economics**.

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LIST OF ACRONYM:

UNFCCC	United Nation Framework Convention for Climate Change
IPCC	Inter-Governmental Panel on Climate Change
AOSIS	Alliance of Small Island States
ADB	Asian Development Bank
COP	Conference of Parties
WIM	Warsaw International Mechanism
UNU-EHS	United Nation University Institute for Environment and Human Security
PMD	Pakistan Meteorological Department
LDVCI	Loss and Damage in Vulnerable Countries Initiative
FAO	Food and Agriculture Organization
PKR	Pakistani Rupee
HDI	Human Development Index
LDC	Least Developed Countries
DC	Developing Countries
FGD	Focused Group Discussion
NDVI	Normalized Difference Vegetative Index
NIR	Near Infra-Red Rays
GOP	Government of Pakistan
HACI	Household's Adaptive Capacity Index
NGO	Non-Government Organization
RDF	Research and Development Foundation
RO	Reverse Osmosis

CHAPTER 1: INTRODUCTION

1.1 Global Climate Change

The latest body of knowledge on climate change is more clear and evident on the adverse impacts of climatic variation on different ecosystems. The Fifth Assessment Report from the Intergovernmental Panel on Climate Change (IPCC) in 2014 expressed that global mean temperature changes of 2 to 4°C above 1990–2000 levels would surpass the adaptable limit of numerous frameworks and result in a noteworthy increment of individuals' vulnerability. Increase in temperature occurs due to the observed increment in anthropogenic greenhouse gas emissions is the dominant cause of witnessed warming. Climate change have caused impacts on human and natural ecosystem all over the world and across the oceans as well in the recent decades (Pachauri et al.,2015). The surface temperature forecast is witnessed to rise over the 21st century under all examined emission scenarios. Rainfall and drought events will become more frequent and intense in many parts of the world especially South Asia and Africa. The ocean will become warmer and acidified and the sea level to rise along the 21st century (Pachauri et al., 2015). The response to the changing global climate is necessary as it possess potentiality to endanger water availability and food security. South Asia and Southern Africa are most vulnerable to the impacts of climatic variability where major economies are least developed (Lobell et al., 2008).

Increasing temperature, changing rainfall patterns and droughts will cause major crop and livestock losses, which can prove disastrous for developing economies that are heavily dependent on agriculture. Above a certain limit of temperature, seeds may destroy or the pollination ma fail and arable lands may turn into deserts, which will be a permanent loss of livelihoods (Harmeling et al., 2015).

Climate change has adverse impacts on human health as well. Climate stressors caused disease outbreak is a challenging factor to tackle, major of those climate stressor caused diseases are: infectious diseases through vectors such as tick, and mosquitoes, heat strokes, chronic illness, direct deaths and injuries from extreme weather events, mental stress, and diseases born from contaminated food and water (Medical Society Consortium on Climate and Health, 2017).

1.2 Climate Change and Pakistan

Pakistan is most vulnerable to climate change. The country comes under the top ten most affected countries due to climate change from 1996 to 2015 (Kreft et al., 2016). Pakistan is a land of extraordinary topographic diversities and along these lines the climate of the nation has extensive spatial and worldly variety in the climate of places situated in the same latitudinal belts. The vast majority of the ranges of Pakistan are extremely delicate to the progressions in both temperature and precipitation (Salman, 2014). A portion of the region of the country, especially the southern regions are extremely vulnerable against drought and heat stresses. Flood and drought are most essential climate occasions influencing Pakistan in the recent decades. In Pakistan there is general view of this adjustment in the recurrence of event of these climate occasions. Temperature and precipitation have direct impact on agriculture production and different viewpoints, for example, water assets. According to Geest and Dietz (2004), in dry areas a climate risk turns into a catastrophe when it hits vulnerable individuals. Some researchers have proposed that in the Dry regions, atmosphere aggravation is an intense danger to crop and livestock farming, (Okoruwa et al.,1996; Tschakert, 2007; Holthuijzen, 2011).

Examination concerning changes and pattern in the temperature and rainfall are vital for a nation, for example, Pakistan whose economy is subject to agriculture production. Changes have been seen in the seasonal temperature and rainfall over the southern Pakistan. However,

the spatial rainfall pattern demonstrated that some particular territories of southern Pakistan have critical diminishing pattern (Hanif et al., 2013). In Pakistan, crop yields are declining due to low rainfall and if necessary measures are not taken such as introduction of drought resistant varieties, region can be in threat of food insecurity (Ali et al., 2017). A study by Salman (2014) shows that annual average temperature and rainfall projections for 2090 for Pakistan is higher for northern areas, as compared to the southern part of Pakistan.

1.3 Loss and Damage Definition

Losses and damages due to climate change can be defined as the one with the irreversible and severe impacts are the (losses) and the one with reversible impacts are (damages). World Bank (2010) defines damage as total or partial destruction of physical assets existing in the affected area" and loss as "changes in economic flows arising from the disaster"**.** One of the initial works done on loss and damage is of Warner et.al (2013) who gave the working definition of loss and damage as "negative effects of climate variability and climate change that people have not been able to cope with or adapt to". Nishat et.al (2013) gave their definition of loss and damage as "current or future negative impacts of climate change that will not be addressed by the adaptation efforts".

1.4 Loss and Damage and International Negotiations

Loss and damage at United Nation Framework Convention for Climate Change (UNFCCC) started when developing countries (Annex 1) demanded compensation from developed countries (Annex 11), blaming them for the disastrous emissions causing climate change happen. It started when International Insurance Pool by Alliance of Small Island States (AOSIS) was established in 1991 (ADB, 2015).

At the thirteenth Conference of Parties (COP 13, 2007) in Bali, Indonesia, accord on risk reduction, risk management and risk transfer was called. At COP 16, 2010 which was held in Durban, South Africa in 2010 things moved a step further and the Work Programme was established to consider approaches to address loss and damage from climate change in Annex 1 countries that are vulnerable to such climatic shocks. The "International Mechanism" was introduced in seventeenth Conference of Parties (COP 17, 2011) which was considered as an opportunity of developing an institutional structure to address loss and damage. In (COP 19, 2013) held in Warsaw, Poland, the Warsaw International Mechanism (WIM) was established which was considered as a milestone to address loss and damage due to climate change. And this mechanism was kept under the adaptation framework. This mechanism will guarantee the parties to research on risk reduction, risk management, causes of losses and damages due to climate change. To do this practically, WIM has its executive committee that is answerable to the COP. Loss and Damage is now considered as the third pillar of negotiations going equivalent with mitigation and adaptation (ADB, 2015). An initial two-year work plan was developed by the executive committee of UNFCCC which was to be reviewed in 2016 COP 21 in Paris. Parties agreed on a five-year plan to address the Loss and damage issues after reviewing the initial plan, agreement took place in COP 22 in Marrakesh (Kreienkamp & Vanhala, 2017).

1.5 Previous and Current Research on Loss and Damage Due to Climate Change

Loss and damage due to climate change research are not too old. As the recent progress in the UNFCCC's Conference of Parties, resulting "Warsaw International Mechanism" came into act, new projects started working on loss and damage. One of the most known is "Loss and Damage in Vulnerable Countries Initiative". The project conducted studies on sudden on-set

events[1] by Shamsuddoha et.al (2013), slow on-set event[2] by Roberts et.al (2013), legal and institutional responses (Faroque & Khan, 2013). The empirical studies done under this project are: "Loss and Damage from Salinity Intrusion in Sathkira District, Coastal Bangladesh" by (Rabbani et al., 2013). Second study is "Loss and damage due to climate change in nine vulnerable countries (Bangladesh, Bhutan, Burkina Faso, Ethiopia, Kenya, Micronesia, Mozambique, Nepal and Gambia). This study was conducted by United Nation University Institute for Environment and Human Security (UNU-EHS). This study found that the impacts of climate change varies between the households and between the countries and region depending upon vulnerability levels.

1.6 Desert Ecosystem, Tharparkar and Climate Change

Climate change as in many ecosystems, causing adverse impacts on desert ecosystem as well (McCarty, 2001). The increase of 0.5C temperature over the earlier century can be witnessed on different ecological systems including desert ecosystem (McCarty, 2001). Some of the major impacts of climate change on desert ecosystem include, loss in the productivity, decrease in the cultivable land soil erosion and loss of native species, desertification and water scarcity as water is the scarcest resource in deserts (Brown et al., 1997). As the main source of livelihood in the deserts is livestock keeping, population heavily depend on rains for their livelihood sustenance (Degen, 2004). But the rainfall pattern is changed due to climatic variations. This leads toward disturbance of human livelihood, mainly livestock

[1] On-set event is an event in which there is a loss of human life, property and assets. Sudden on-set events are those in which a disaster suddenly hit an area and causes massive destruction e.g. Flood, Drought. Slow on-set events are those in which destruction is a slow and steady process, changes in any natural phenomenon occur frequently which eventually causes destruction e.g. Sea level rise, increasing temperature, ocean acidification, glacial retreat.
[2] Ibid.

keeping (Halepoto, 2014). Climate change also causes desert warming as it further increases the evapotranspiration[3] (Shove, 2010).

Tharparkar is the district which is spread over 19639 kilometres in southern Sindh. Tharparkar district is entirely covered with Thar Desert. The region of southern Pakistan including the "Thar Desert", are to a great degree powerless against drought. Such element of reduced precipitation and expanding temperature are most huge and disturbing for these territories. The reasons of noteworthy changes in temperature and rainfall of Pakistan, is either because of worldwide climate or constrained by anthropogenic exercises.

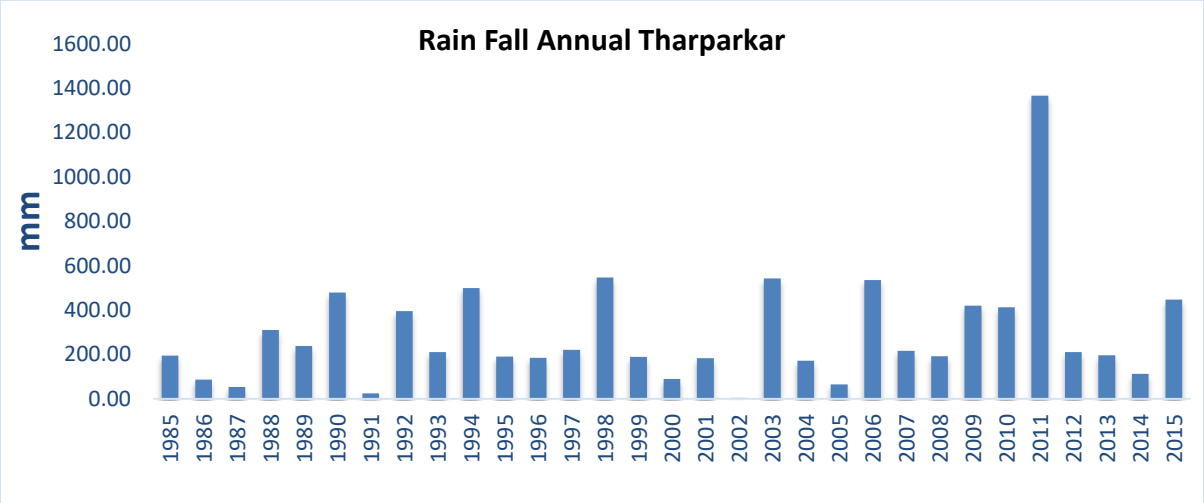
[3] Evapotranspiration is the process by which water is transferred from the land to the atmosphere by evaporation from the soil and other surfaces and by transpiration from plants.

Figure1.1: Study Area Map (Tharparkar District, Sindh)

The territory gets just rainstorm downpours from June to September. Climatic conditions in the Tharparkar District and Thar Desert are harsh, now and then it doesn't rain for a considerable length of time together coming about serious dry season as experienced in the years 1986, 1987, 1991, 2002, 2004, 2005, 2012, 2013, and 2014 (PMD, 2016). This is because of the rainstorm winds originating from the Arabian ocean surpass this desert

without giving any precipitation. Moreover, to worsen off the matter, the region is naturally cut off from any river or water system.

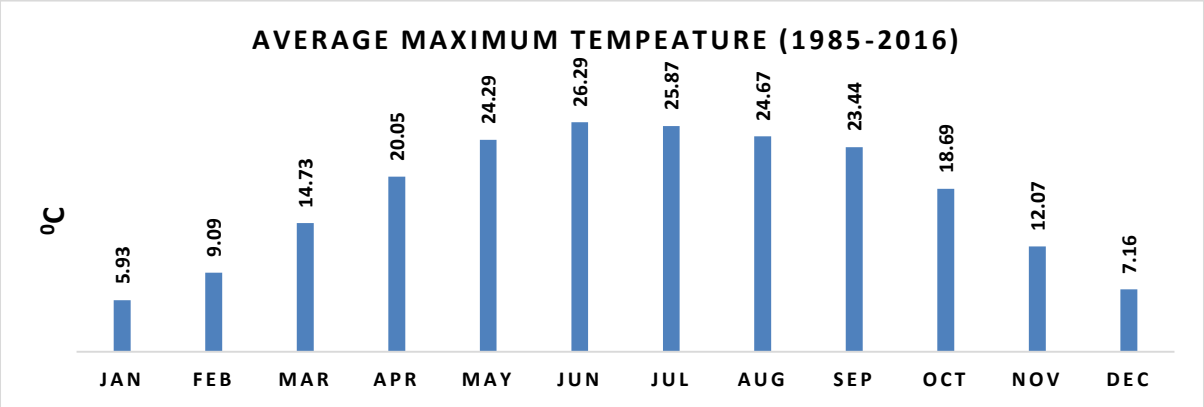
Figure 1.2: Annual Rainfall of Tharparkar (1985-2015)



Source: Pakistan Meteorological Department

This figure shows the rainfall in mm for Tharparkar district starting from 1985 to 2015. The average rainfall according to the data is 290 mm. Where the driest years are 1986, 1987, 1991, 1993, 2000, 2001, 2002, 2004, 2005, 2007, 2008, 2012, 2013, and 2014. The maximum rainfall is witnessed in the year 2011 where the rainfall was 1366 mm, considered as the flood year. Year after the flood year, rainfall declined and was 196 mm in the year 2013 and as low as 113 mm in the year 2014. The graph clearly reflects the uncertainty in the total rainfall per year for the last 30 years.

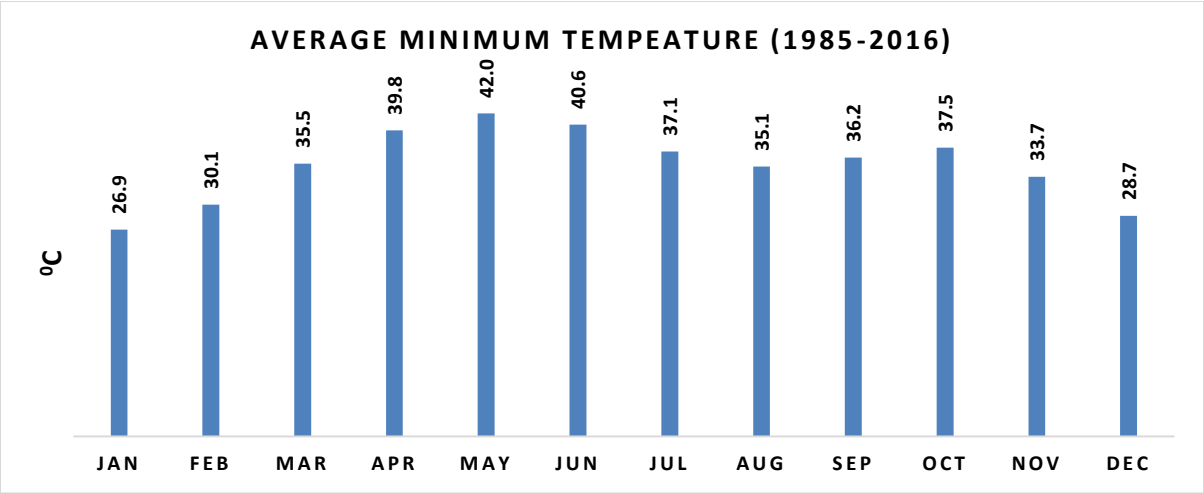
Figure 1.3: Average Monthly Maximum Temperature in Tharaparkar.



Source: Pakistan Meteorological Department.

This figure shows the average monthly maximum temperature for Tharparkar. June and July are the hottest months. The mean monthly maximum temperature of June and July for the past 30 years starting from the year 1986 to 2016 is about 26^0C to 25^0C. The hottest years are 1987, 1988, 2001, 2002, 2004, 2010, and 2014. Where the hottest among all are 2002 and 2014 when the temperature stood up to 36.5^0C and 36^0C respectively.

Figure 1.4: Average Monthly Minimum Temperature in Thaparkar



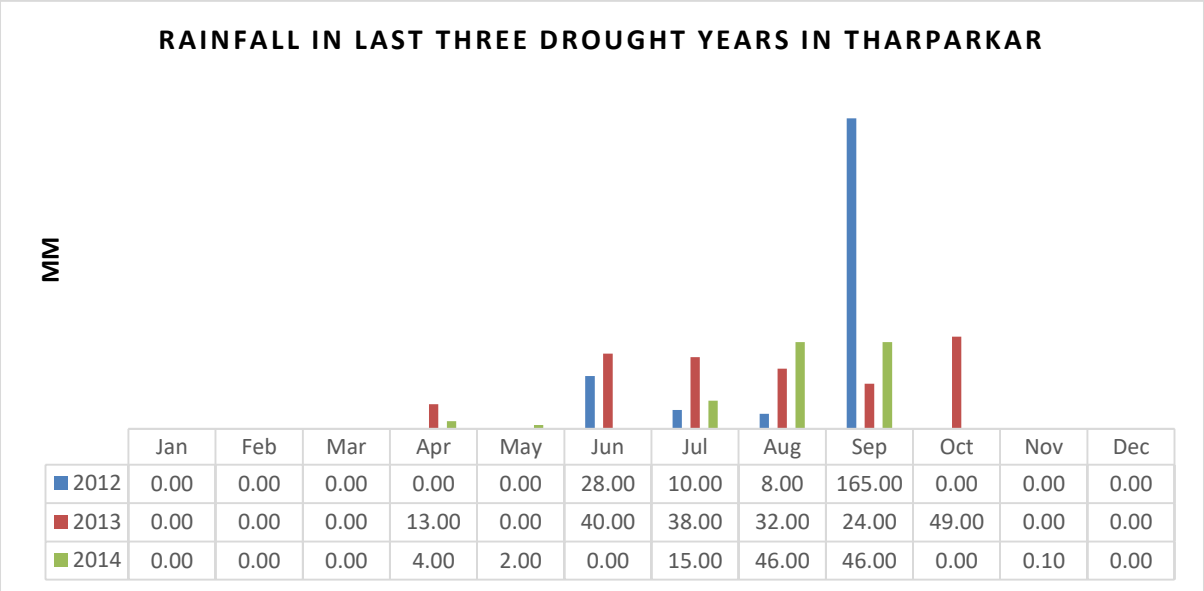
Source: Pakistan Meteorological Department.

This graph shows the monthly average minimum temperature for Tharparkar. The peak months are May and June. Monthly average minimum temperature of May and June for the past 30 years starting from the year 1986 to 2016 is 42^0C and 40^0C respectively. There is little change witnessed in the average minimum temperature started from 17.2^0C for the decade 1986-1996 and now for the last decade, 2005-2015 the average minimum temperature is 19^0C.

Livelihood of Tharparkar depends on rain. Whenever there is rain, livelihood prospers and whenever there is less rainfall, the livelihood suffers. As a Sindhi saying is “it is Thar when it rains, elsewise it is wasteland”. But this rainfall pattern is changed due to climatic variations. (Halepoto, 2014). Extreme events like drought are more frequent and consecutive in current decade (2006 to 2016) than the previous decades (PMD, 2016). Tharparkar faced three

consecutive drought years 2012, 2013, 2014 which affected the majority of the district's population. People of Tharparkar witnessed adverse impacts of those droughts on their livelihood.

Figure 1.5: Rainfall in Last Three Drought Years 2012, 2013, and 2014 in Tharparkar



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2012	0.00	0.00	0.00	0.00	0.00	28.00	10.00	8.00	165.00	0.00	0.00	0.00
2013	0.00	0.00	0.00	13.00	0.00	40.00	38.00	32.00	24.00	49.00	0.00	0.00
2014	0.00	0.00	0.00	4.00	2.00	0.00	15.00	46.00	46.00	0.00	0.10	0.00

Source: Pakistan Meteorological Department.

Figure 1.5 shows the rainfall for three recent consecutive drought years, 2012, 2013, and 2014 of Tharparkar. Table shows the region's rainfall dependency on the monsoon season which usually starts from June till September but in these three years, change in monsoon pattern due to climate change has been witnessed. In 2012 the rainfall started in June with 28 mm rainfall then in July it was very low with only 10 mm which was very low than normal rainfall. Same rainfall deficiency was witnessed in august when rainfall was only 8 mm. September 2012 was the month when abnormal rainfall was witnessed with 165 mm which was against the usual pattern and September was the wettest month for the year 2012. The 2013 started with the monsoon rainfall of 40 mm in June, which was considered better than 2012. It rained better than 2012 in the months of July, August and September when rainfall was 38 mm, 32 mm, and 28 mm respectively. But the change was witnessed in the month of

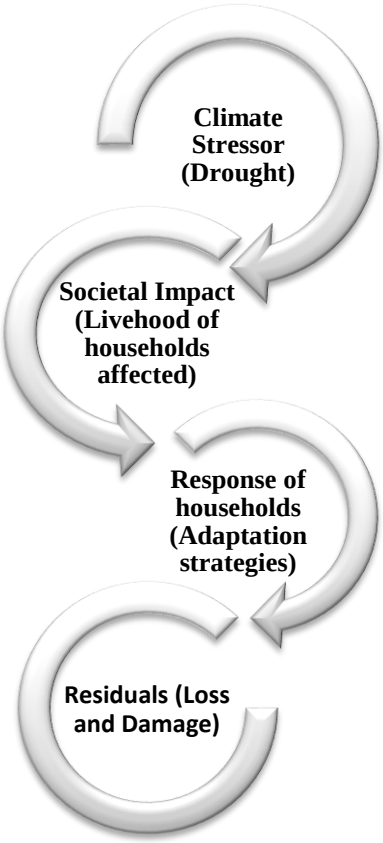
October when the rainfall was 49 mm comparably no rainfall in October 2012. The year 2014 was the driest year of the three years where monsoon pattern was seemed to be largely disturbed. The rainfall started in July instead of the normal trend of June and was as low as 15 mm. in August and September, the rainfall was 46 mm in each month. And that was the whole rainfall for the year.

Life becomes difficult when rainfall is well below average in areas like Tharparkar where whole rural life depends upon rain. Low rainfall puts negative impact on vegetation cover, and drinking water availability for humans and animals. In result, area becomes food insecure, as there is not much to eat for humans and fodder for animals. 2014 was among the worst years Tharparkar witnessed where the rainfall was just under 100 mm, which is well below its average rainfall.

The motive behind this work was to investigate the impacts of recent climate stressor i-e drought in the year 2014[4] on livelihood assets of Tharparkar households. Livelihood assets taken in the study were the education, income from livestock and cropping, health, and environment. And how the households were coping and adapting with this climatic variation, yet witnessed the adverse effects and bear the losses and damages due to this climate stressor. Though most of the area in Tharparkar was affected by the droughts, there is not much research to be found on how the households are bearing losses and damages from droughts even if they are trying to cope with or adapt. Thus, it was important to understand the loss and damage pattern and the monetary losses and damages which the households witnessed in their livelihood assets. Tharparkar is one of the districts where livelihood is heavily dependent on climatic conditions. And when these climatic conditions vary, livelihood of Tharparkar are disturbed greatly.

[4] 2014 was the worst year among the three drought year, receiving the lowest rainfall of all the drought year. And it was the most recent drought year, therefore it was easy to recall the memories of the people as they remembered much about the latest disaster.

Figure 1.6: Loss and Damage Pattern



Source: Koko Warner et.al (2013).

Figure 1.6 shows the pattern of loss and damage where climate stressor that was drought in the case tends to the societal impact that is the livelihoods assets of households. The households responded to the climate stressor by coping and adaptation strategies but those strategies were rather insufficient to avoid the residual effects of the climate stressor due to which households witnessed losses and damages.

1.7 Research Gap

Studies are being conducted regarding Loss and Damage at national level and taking in account the losses and damages causing form slow on-set events or sudden on-set events. Loss and Damage work was started in 2013 under the "Loss and Damage in Vulnerable Countries Initiative" project. This study aimed to contribute in the existing studies on loss

and damage due to climate change by Rabbani et al., (2013); Traore, (2013); and Warner et al., (2013) by adding the livelihood assets: Health, Education, and valuation of monetary loss and damage in cropping and livestock. Another gap which the study aimed to fill was that the study assessed the temporal drought monitoring by using Geo Spatial technique in order to check the intensity of recent drought on vegetation cover.

1.8 Research Problem Statement

Tharparkar is the district of Sindh with harshest environmental condition. The region is mostly covered with desert that consists of sand dunes, barren tracts, some green lands mostly in Nagar Parkar region of the District. Since the area is a desert ecosystem, some of the basic resources are scarce. One the biggest of those resources is water, sweet water is hard to find in the region as the area is also deprive from river water or any major irrigation systems. Tharparkar has a tropical desert climate with summers of extremely hot days and cooler nights where April, May and June are the hottest months.

These climatic conditions make things difficult for the households living in the area. Things are worst for those living in the rural and remote parts as they largely depend upon livestock and cropping for the livelihood sustenance. The agriculture of the area is totally dependent on the rain. The crops are grown on the rain water (Barani Cropping) in the monsoon season and the pastures and green lands also depend upon rain which become the source of fodder for livestock. Drought is a common climate stressor in desert ecosystem.

Tharparkar witnessed three consecutive drought seasons starting from 2013 to 2014 which lead toward massive destruction in agriculture production, losses of animals and livestock, food insecurity and caused acute malnutrition (FAO, 2016). This situation has caused the area to have the lowest Human Development Indicators (HDI) in Pakistan. In the monsoon season of 2014 Tharparkar only received 37% (113 mm) of its normal annual rainfall that is almost

300mm (PMD, 2016). The health care facilities are also a challenging factor for livelihoods as it costs one thousand to four thousand rupees PKR to just reach to the nearest health facility and the travel time is 2 to 4 hours to reach the nearest health facility (WHO, 2014).

Thus the people have low resilience to fight against the climate stressors affecting their livelihoods. Although people are trying to adapt, but that adaptation is either insufficient or requires the socio-economic indicators to be uplifted in order to respond accordingly to the adverse impacts but ultimately when the adaptation is failed, the households suffer and bear the losses and damages in their livelihood assets such as cropping and livestock in the rural areas of Tharparkar. Different studies on Tharparkar showed that droughts have affected the livelihood of the households. The drought period of 1997-2001 in Tharparkar and some parts of Baluchistan severely affected the livestock and crop production of Pakistan (Ahmed et. al., 2004). Tharparkar did not receive sufficient rains in 2013 and 2014 causing losses of lives and animals due to lack of water availability eventually the area was declared calamity affected in early 2014 (Pasha et. al., 2015).

Table 1.1: Families affected due to droughts in 2014

Taluka	**Families affected**	**Person died**	**Cattle head affected**
Mithi	40371	148	14716
Diplo	38124	4	11720
Chachro	46441	19	6628
Nagar Parkar	43692	9	9382

Source: Pasha et. al., 2015

Table no.1 shows the finding of Pasha et. al, (2015), number of families affected, person died, and cattle head affected in Tharparkar during 2014 drought. Chachro has the highest number of families affected with figure of 46,441 families. Whereas highest number of

persons died in the 2014 drought is of Mithi with 148 people. Mithi also bears the highest number of cattle head affected with the figure of 14716.

1.9 Significance of the Study:

Desert ecosystems are largely dependent on natural climate and are highly sensitive to climatic variables such as precipitation and temperature. A small change in precipitation can lead to natural resource depletion and scarcity. Water is the scarcest resource in the deserts as found in the Thar Desert as well. The recent change in the monsoon pattern observed in Tharparkar in 2013 and 2014 (PMD, 2016) lead to massive mass disturbance and causing loss and damage to the households. Rural households that already having low HDI index are more vulnerable to these climatic variations. Therefore, it was important to estimate such losses and damages of those households and most important was to understand how the households are coping with these extreme weather events. And are those coping strategies are sufficient enough to avoid the loss and damage?

Loss and damage itself is a moderately new research space. Researchers are currently trying to fill this knowledge crevice on climate related loss and damage. It was essential to investigate the loss and damage due to climate stressors and to understand the collaborations between livelihood, coping and adapting systems and the negative consequences for families and groups. This area has been studied through different descriptive methodologies but specific to livelihood assets of households like: health, and education, less work has been done and specially on estimating or calculating the losses and damages in monetary term. This study specifically contributed to literature by analysing the impact of climate stressor on different livelihood assets of households. The study also aimed to serve as a medium of information to the authorities dealing with the situation by providing the pattern of loss and damage. And through Geospatial technique, study also monitored the drought intensity in

Tharparkar for a deep insight of loss of vegetative cover and agriculture of the area. One of the main gap which the study aimed to fill was the comparison loss and damage between a drought year (2014) and a normal year (2016), which provided a clear and neat picture of the loss and damage of household assets due to drought.

1.10 Objectives of Study:

- To estimate the loss and damage of livelihood assets (health, education, livestock, and cropping) due to climate stressor (Drought).
- To analyse the different coping strategies opted by households with the factors influencing adaptive capacity of households.
- To assess the temporal drought monitoring using Geo Spatial technique for Tharparkar District.

1.11 Research Question:

- What is the impact of climate change on Tharparkar (Desert) that lead to loss and damage among Households?
- What are the coping strategies of households against the drought?
- What kind of loss and damage is incurred in monetary terms as a result of the impact of drought?
- What is the vegetation cover difference between drought year and normal year?

1.12 Organization of the Thesis

The study is divided in five different chapters. Chapter one describes the introduction and the conceptual framework of the study. Second chapter comprises the literature review, different themes of literature are covered according to the scope of the study. In the third chapter,

methods and techniques applied in the study are discussed. Fourth chapter of the study shows the complete results and findings of the study. Whereas, fifth chapter comprises conclusion and policy recommendations coming out from the results.

CHAPTER 2: REVIEW OF LITERATURE

2.1 Climate Change and Desert Ecosystem

Various studies show that climate change has adverse impacts on the desert ecosystem throughout the world. This include decrease in the cultivable land, loss in the productivity, soil erosion and loss of native species. Such desertification leads toward disturbance of human livelihood, mainly livestock keeping. South-western North America's grasslands converted into desert within 125 years is an evidence of this global change pattern because water is the scarcest resource in such ecosystems. Small changes can have significant effects (James.H, et al., 1997). Same study conducted by McCarty (2001) demonstrates that Global temperature has already warmed by 0.5C over the earlier century. And the results of this variation can be witnessed on different ecological systems. Changes in the recent decades are ostensible at all level of ecological organizations: demographical, shifts in topographical range, changes in the structure and functioning of ecosystems.

Soil moisture reduction is another impact of droughts combined by increased evapotranspiration and lower precipitation caused by desert warming as a result of climate change as desert warming increases evapotranspiration (Shove, 2010). South-western United States also facing impacts of climate change specially the Sonoran Desert where average temperature has climbed about 1.5F when compared to the mid-twentieth century. The area is already facing drought, up to 40% of the desert witnessed drop in the precipitation over a half century. The region will continue to be drier than average as projections are concerned and water stress will be upsetting for the native species (Wildlife, 2009).

Pakistan is also facing the curse of climate change that could lead to water scarcity in the region. Pakistan having diverse ecological zones, comprises Thar Desert which is most thickly populated desert ecosystem in the world. Thar shows low resilience to climate change

as the major indicators reflecting resilience which are education, employment divergence, and social mobility have low measures in this expanse. Such climate changes can worsen off the life situation in Thar Desert which already is facing issues of groundwater depletion (Hanif, 2014).

2.2 Livelihood in Desert Ecosystem

Livelihood is desert ecosystem are largely dependent on livestock or rain water cropping. In Afghanistan's Registan desert, livelihood assets are mainly sheep, goats, camels for milk and meat purposes and donkeys are used for transport. Wells are the source of water for the households and their animals. Livestock of the region was reliant on natural vegetation (Degen, 2004). In Desert Australia, households are largely dependent on income from livestock keeping. And this dependence has led to the decline of pastoral populations (Strong et al., 2008). Livelihoods also depend on some of the nature's gift are observed in every ecosystem Rani et.al (2013) researched on such ecological gift in Rajasthan, India. They elaborated the importance of Prospis Cineraria (L) Druce, a desert tree which support the livelihood in Rajasthan. Rani et.al (2013) identified multi benefits of this tree as it provides healthy fodder, used as a vegetable, and its wood is used as a fuel for domestic uses. This tree also bears an important religious value, so it is protected by the local community. Tharpakar region in Pakistan is a desert like area which almost covers the Thar Desert. Livelihood of Tharparkar depends on rain. Whenever there is rain, livelihood prospers and whenever there is less rainfall, the livelihood suffers. As a Sindhi saying is "it is Thar when it rains, elsewise it is wasteland". But this rainfall pattern is changed due to climatic variations (Halepoto, 2014). This situation forces the herdsmen to migrate towards the rivers where they can find fodder for their animals and when they need extra money for sustenance, they sell their animals. The people of Tharparkar do not enjoy much varietal food, milk is the main consuming food with its by-products like butter and yogurt. (Halepoto, 2014). Farming and

crop growing in Tharparkar region is considered as a lottery, because of the pattern of uncertain rains (Herani & Pervez, 2008).

2.3 Climate Change and Livelihood

Climate change is likely to affect the poor community living in the developing countries. Being dependent on basic sector such as agriculture, developing economies are more vulnerable to climate change. And the capacity to adapt the climate change is limited. Climate change can affect the sustainability of development trail, therefore adaptation to this climatic variation is a necessity (Osbahr et al., 2008). The risk for increased water stress will be felt by 350-600 million people living in Africa by 2050 which is a clear sign of high climate vulnerability. Lack of resources for adaptation will worsen the situation of African people to adapt to climate change (Hahn et al., 2008). In many parts of Africa, the impacts of climate change are being felt in agriculture sector. Increasing temperature and drying will reduce the crop yields by 10 to 20% to 2050. Due to severe losses from climate stressors like increasing temperature, droughts and flooding, many of the households in the remote areas will shift their livelihood activities as an adaptive measure (Jones & Thornton, 2008). In Bolivia, climate change is affecting the Andean ecosystem. In result of this climatic variation indigenous knowledge for dealing with meteorological conditions and climate hazard were failing. The current meteorological models will not work in the case of a topology as Andes bears, so planning a process is needed for developing advanced understanding and awareness to climatic uncertainty that can be helpful in building adaptive capacity (Valdivia et al., 2010). In Pakistan, desert areas like Tharparkar which covers the Thar desert are most vulnerable to climatic variability. The people of Tharparkar heavily depend upon Livestock and rain-fed agriculture. More than 90 per cent of the population of the area is dependent of these sectors which directly are related with the monsoon rains. Climate stressors like drought

reduce the crop productivity which further lead to food scarcity, malnutrition and loss to livestock, wildlife and human health (Halepoto, 2014).

Increasing temperature, changing rainfall patterns and droughts will cause major crop and livestock losses, which can prove disastrous for developing economies that are heavily dependent on agriculture. Some farming methods may be helpful to fight against the situation e.g. crop diversification, early warning systems, building blocking infrastructure against flood etc. However, above a certain limit of temperature, seeds may destroy or the pollination ma fail and arable lands may turn into deserts, which will be a permanent loss of livelihoods (Harmeling et al., 2015)

2.4 Climate Change Adaptation

Climate change adaptation is most important step for the LDCs[5] and DCs[6] where main driver of economy is agriculture, specially the southern part Africa, and South Asia where if adaptation measures not taken immediately, people will face food insecurity in the larger populated regions of the world (Lobell et al., 2008). Climate risk management requires a clear knowledge and information about the intensity and frequency of the stressors, how the climatic conditions are changing, and what can be projected for future witnessing the past and current changes (IPCC, 2014). There is a room available for adaptation to climate change in the field of agriculture in the regions where there are moderate impacts of climate change but not much can be done where it has severe impacts (Howden et al., 2007). When the people are not able to adapt or cope with climate change, they face loss and damage in their livelihood assets (Warner et.al 2013). Adaptation to climate change can bring economies to a level of economic growth in comparison to non-adapting economies, adaptation to climate change economies are predicted to have a global growth rates of about 11% by 2020

[5] Least developed countries.
[6] Developing countries.

(Climate-KIC, 2017). Pakistan's major crops are showing a declining trend against the climatic factors mainly rainfall and if adaptation measures such as: introduction of drought resistant varieties are not taken, country can face food insecurity (Ali et al., 2017).

2.5 Loss and Damage due to Climate Change

Loss and damage due to climate change studies are conducted in different local levels in different developing countries like in Micronesia by Monnereau & Abraham (2013), in Mozambique by Brida & Owiyo (2013), in Kenya by Opondo (2013), in Nepal by Bauer (2013), in Ethiopia by Haile (2013), in Bhutan by Kusters (2013), in Bangladesh by Rabbani et.al (2013), and in Northern Burkina Faso by Traore (2013).

In Bangladesh, the southwest coastal district of Satkhira is one of the most vulnerable area to climate change because of salinity intrusion and poverty. The rice production of the area was affected due to increase in the salinity levels in the soil over past 20 years. Farmers were largely affected by this decline in production of rice. Sea level rise and cyclones were the climatic hazards responsible for this salinity intrusion. The local population introduced saline-tolerant varieties of rice as an adaptive measure to minimize the damages (Rabbani et al., 2013).

Loss and damage from droughts occurred in 2004 and 2010 in the Sahel region of Burkina Faso were accounted as majority of the population experienced negative impact on crop and livestock, furthermore such droughts tend to water scarcity in coming future thus availability of food and feed for animals will also be affected. Moreover, this water scarcity has led to increased interdependency between livestock keeping and crop growing resulting increased vulnerability (Traore, 2013).

Loss and damage will undermine food and sustenance security, social cohesion, culture and identity (Warner et al., 2012). According to Warner & Geest (2013), People in vulnerable countries face loss and damage when: no adaptation measures area unit adopted, or the existing measures don't seem to be comfortable to avoid loss and damage, or the measures have prices that don't seem to be recovered, or the coping measures have negative or erosive effects within the future.

Tharparkar region in Sindh also faces the climatic variability as droughts are frequent phenomenon in the region caused by the uncertain rainfall trends in the monsoon season. Drought lead to deaths of animals and human lives. In the recent droughts of 2013 and 2014, the local evidence is that 20% of the livestock dead but livestock department has yet to come up with the figure of animals dead in the region. The major source of livelihood for the people is their pastures and greenery which is in result of rainfall. Drought caused this greenery to fall and created severe shortage of fodder for livestock grazing. Drought has caused death to 154 children under age of 5 years till 2014 (Halepoto, 2014). The standard of living of Tharparkar fell below poverty line due to the death of their livelihood assets such as livestock and crops in 2014 (IDP, 2014). Extreme weather events like heat waves and droughts, torrential rain and storms are nothing new, however over the last thirty years their frequency and intensity has exaggerated (Hirsch, 2015).

Summary and Research Gaps coming out Form Literature

Climate change as in many ecosystems of earth, causing negative impacts on deserts and from those negative impacts, availability of water is of main concern. Droughts and desertification are the two main climate stressors hitting the deserts which causes destruction of vegetation cover and habitat loss. The livelihood in desert ecosystem largely depend on natural factors. Rain is considered as a blessing, as it is the main source of agriculture

production. Livestock keeping is one of the major occupation in deserts and if rain pattern is disturbed, occupation is disturbed. Households always try respond to the climate stressor hit their area, but in most cases, the respond is not sufficient no avoid the negative impacts. And when the adaptation or coping against the climate stressors fail, households witness loss and damage in their livelihood.

Talks are being held on international level to compensate the vulnerable countries of the world under the UNFCCC umbrella. Initially the voice was raised by the small island states of the world who are most vulnerable to climate change, but the recognition was not that welcoming in the start. After the Warsaw International Mechanism, things somehow went in the favour of the vulnerable as the mechanism assures the undertaking of loss and damage studies and compensation. But on the particle grounds, things are yet to be done. Pakistan comes under the most vulnerable countries of the world and yet, no study to be found working on loss and damage due to climate change in Pakistan.

CHAPTER 3: METHODS AND TECHNIQUES

3.1 Data and Methodology

Study was conducted in the 20 villages of 4 Talukas of district Tharparkar namely: Mithi, Diplo, Chachro, and Nagar Parkar in order to capture the effected population from the climate stressor. A mixed-methods social science approach for evaluating loss and damage at local level used by Warner et.al (2013) has been adopted. For impact of drought on education, method used by Mudavanhu C, (2014) has been adopted and for impact of drought on health, method used by Dey N.C et.al (2011) has been adopted. Both qualitative and quantitative data was gathered including focused group discussions (FGDs), in-depth interviews and questionnaire survey from the households. 5 primary schools in the villages were visited, 1 from each of the 4 Talukas and 1 primary girls school was also visited for data collection on attendance and absentees. A desk-study was also conducted to examine the secondary data available that was helpful to systemize the study. For assessing drought monitoring in the previous five years, Geo spatial technique (NDVI)[7] was constructed for the Tharparkar region which took satellite images of District Tharparkar into the study. The data was collected for 2014 and 2016. 2016 was taken as a normal year as it received above average annual rainfall. For comparative analysis between a drought year and normal year, 2014 and 2016 were taken. The brief sketch of data collection process is given in figure no. 3.1.

[7] Normalized Difference Vegetative Index.

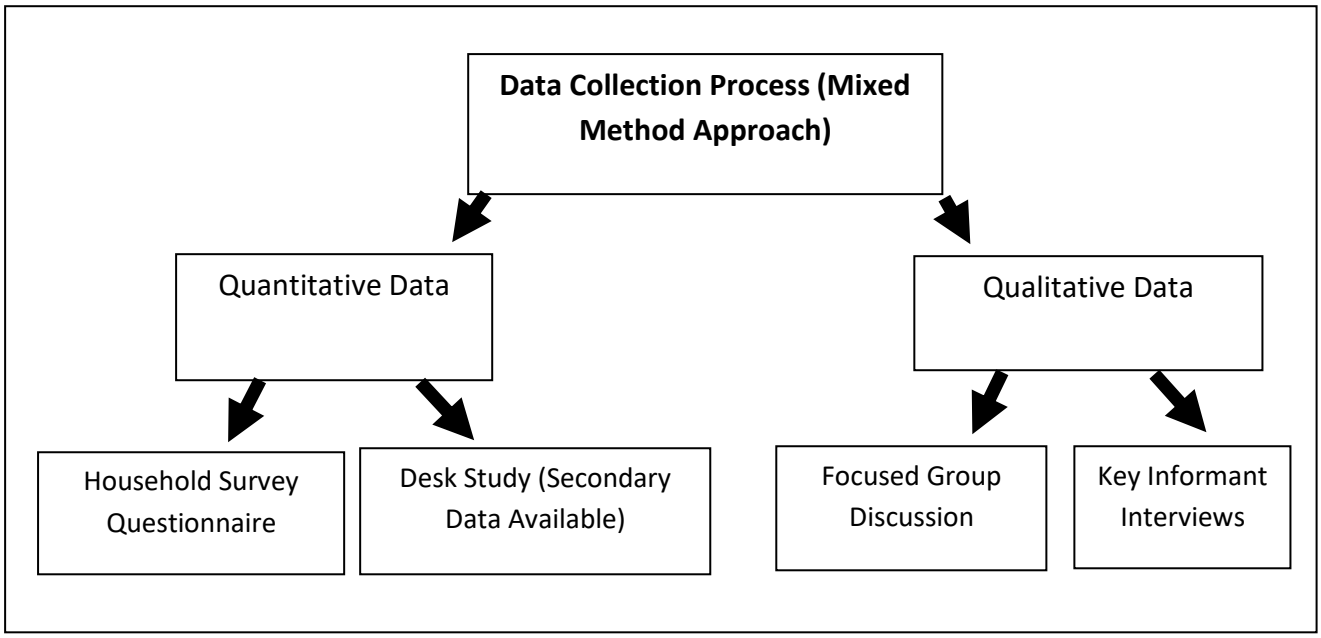


Figure 3.1: Data Collection Process & Sources

- **Household Survey**

A household survey was conducted in the randomly selected villages of district Tharparkar. A questionnaire was designed according to the objectives of the study which included various major sections. First section covered the socio economic and demographic characteristics of the households. Other sections focused on the extreme weather events, its impacts and the coping and adaptations to these variations, and economic loss and damages from these extreme weather events in livelihood assets of household. This design of survey has been adapted from Traore (2013).

- **Focused Group Discussion**

Focused Group Discussions FGDs were organized in order to address the qualitative questions that helped to conduct the study more focused and in-depth. FGDs included farming and livestock keeping community household members of each village. The focus of discussion was on climate change, climate stressor, social impacts, vulnerability, coping,

adapting and residual impacts (Loss and damage). The approach has been adapted from Traore (2013).

- **Key Informant interviews**

Key informant interviews was conducted in order match the results derived from household survey. Key informants included senior doctor from health units in each Taluka, principle or head of the school in the Talukas, head of the environmental protection agency in the area, head of agriculture department in Tharparkar, and head of livestock department in Tharparkar.

3.2 Analytical Tools and Econometric Modelling

To analyse the linkage between the coping strategies of households and socio-economic factors, binomial logistic regression model was constructed. Binomial logistic regression is typically used when the dependent variable is dichotomous and the independent variables are either continuous or categorical. It commonly best suited model for qualitative responses (Park, Hyeoun-Ae, 2013). Furthermore, to analyse the linkage and relationship between climate stressor (drought) and livelihood assets of households: education, health, cropping and livestock, and to estimate and calculate the monetary loss and damage of livelihood assets due to climate stressor, descriptive statistics was used to estimate the results as used by warner, (2012).

Health Loss: The loss faced by the households during drought period in the form of health effect was calculated in this study The data was gathered for both, drought and normal period in order to collect true picture of drought N.C. et.al (2011) used such method in their study to show the impact of drought on human health in Bangladesh. It was intended to calculate the heath cost in rupees through doctor fee, traveling cost, and medication fee but we found that majority of the respondents used government provided facilities which were free of cost. This

made their health cost negligible except very few respondents who visited private doctors. Therefore, those few respondents were not sufficient to take as representative of whole population for calculation of health cost. However, the average cost of private doctor per visit, average travelling cost and average medicine fee is mentioned in chapter no. 4 of the study.

Loss of Livelihood in Monetary Term:

- Drought related Diseases: disease because of which they visited hospital,
- Cholera that usually causes severe Diarrhea and Dehydration
- Malaria
- Fever
- Diarrhoea

Livestock Monetary Loss Calculation: The loss faced by the households during drought period in the form of Animal death or disease was calculated in this study. Those costs are shown by descriptive statistics. The data was gathered for both, drought and normal period in order to collect true picture of drought

Loss of Animal in Monetary Term:

- Number of animals died in the drought period vs normal year
- Which animal (camel, cow, goat, sheep, horse)
- Value of each animal in Monetary term based on Market prices
- Total value (in Pakistani Rupees)
- Number of animals needed medication in drought period (having drought related disease)
- Total medication cost per animal.

Description:

Total loss and damage cost incurred during drought period to households was calculated. Number of animal died in drought period has been taken. Then the total sum is calculated by adding the market prices of those animals in drought period and in normal period as well.

Cropping Monetary Loss Calculation: The loss and damage faced by the households during drought period in the form of crop failure, low yields, less area under cultivation due to water shortages was calculated in this study. These costs are shown through descriptive statistics. The data was gathered for both, drought and normal period in order to collect true picture of drought.

Loss and Damage in Crops in Monetary Term:

- Area Cultivated (Drought vs Normal Period)
- Yield Per Acre (Drought vs Norma Period)
- Seed Rate (Drought vs Normal period)
- Cost of Production Per Acre (Drought vs Normal period)

Description:

Monetary values of losses were estimated according the market prices of crops in drought periods as well as in normal periods due to the fluctuation in the prices according to the time. The other factors which can affect the crops were also taken in order to draw a true picture of loss and damage such as: seed rate, fertilizer rate, method of cultivation, etc.

Education Loss

In order to capture the impact of drought on the education of children, data on attendance and absentees was gathered from the local village schools and was compared for the drought period and normal period. Other factors which can influence the child's education were also

taken such as: Learning environment of the school, distance of school from house, parents cannot afford to send children to school, etc. Moreover, data was also collected from the households in order to capture their perceptions about the children's learning and schooling during drought period. This method has been adapted from the Mudavanhu, (2014) who worked on the impact of flood on children's education in Zimbabwe.

Logistic Regression Model for Coping Strategies:

In order to analyse the linkage between different coping strategies of households and their socio-economic factors, binomial logistic regression model was constructed for each of coping strategy opted by the household during the drought period. Some of the major coping strategies which were also found in Tharpakar were adopted from study of Traore, (2013) who worked on the estimation of loss and damage due to droughts in Burkina Faso.

LOGIT [P (S_1=1)] = β_0 + β_1 (IN) + β_2 (HHS) +β_3 (EHH) + β_4 (NEP) + β_5 (WMH) + μ_i ……EQU. (1)

Where:

- S_1 = Water Storage Techniques 1=Strategy opted, 0= Strategy not opted
- IN = Income
- HHS = Household Size
- WMH = Working members in Household
- EHH= Education of Household Head
- NEP = Number of Educated Person in House

LOGIT [P (S_2=1)] β_0 + β_1 (IN) + β_2 (HHS) +β_3 (EHH) + β_4 (NEP) + β_5 (WMH)+ μ_i ……EQU. (2)

Where:

- S_2 = Migration 1=Strategy opted, 0= Strategy not opted

LOGIT [P (S_3=1)] $\beta_O + \beta_1$ (IN) + β_2 (HHS) +β_3 (EHH) + β_4 (NEP) + β_5 (WMH)+ μ_i ……EQU. (2)

Where:

- S_3 = Selling property 1=Strategy opted, 0= Strategy not opted

LOGIT [P (S_4=1)] $\beta_O + \beta_1$ (IN) + β_2 (HHS) +β_3 (EHH) + β_4 (NEP) + β_5 (WMH)+ μ_i ……EQU. (2)

- Where:
- S_4 = Private loans 1=Strategy opted, 0= Strategy not opted

LOGIT [P (S_5=1)] $\beta_O + \beta_1$ (IN) + β_2 (HHS) +β_3 (EHH) + β_4 (NEP) + β_5 (WMH) + β_6 (GNGH)+ μ_i ……EQU. (2)

- Where:
- S_5 = Solar Panels 1=Strategy opted, 0= Strategy not opted

Justification of Variables used in the model

Coping strategies used in the study are based on existing strategies practiced in the study area. Whereas independent variables used in the model i-e: Household's income, Household size, working member in household, Number of educated person in household, Household head's education, and Government or NGO's help, are taken from the study of Mwamba.O., (2013). He used these variables to derive rural household's adaptive capacity index. Using these determinants in the logit model as independent variables provide us the relationship between coping strategies opted by the households and their influencing factors.

3.3 Use of NDVI for vegetation Cover

NDVI is an environmental remote sensing technique used in vegetation studies to estimate the vegetation cover, pasture performance, crop yields, and rangelands. NDVI was initially used by Rouse et al. in 1973 (Primicerio et al., 2012). Knowing the behaviour of vegetation across the electromagnetic spectrum, NDVI can be derived by focusing on the sensitive satellite bands to vegetation information i-e near-infrared and red. The formula to calculate NDVI is:

$$\boldsymbol{NDVI} = \frac{(\boldsymbol{NIR} - \boldsymbol{RED})}{\boldsymbol{NIR} + \boldsymbol{RED}}$$

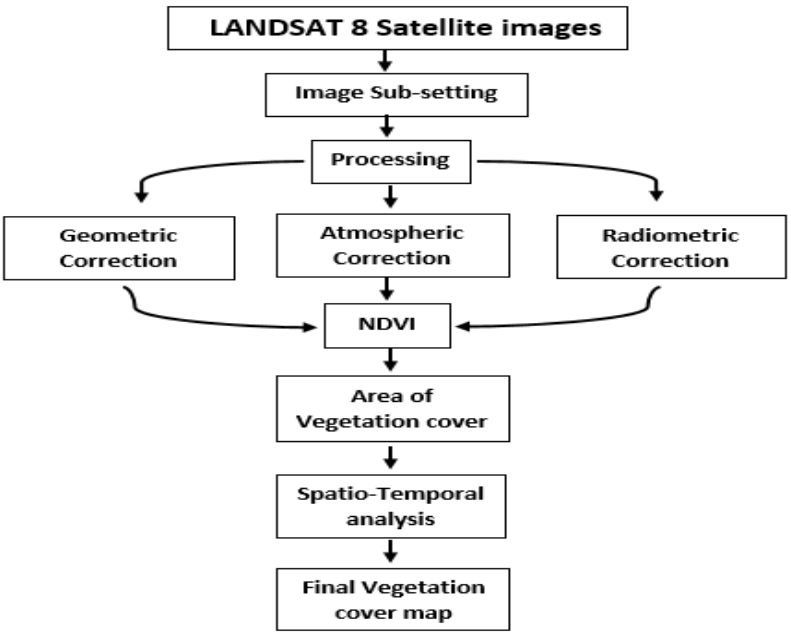
Where:

NIR= Near-Infrared rays

RED= Red rays

The methodology of constructing NDVI has been adapted from Atif and Mehboob, (2016). A total of 18 images were downloaded from (www.earthexplorer.usgs.gov) and processed for the months of September, October, and November of 2014 and 2016. Tharpakar district was covered by collecting and mosaicking 3 different paths and rows of satellite images. atmospheric, geometric, and radiometric corrections were made to get NDVI image using ArcGIS software. Then area estimation of vegetation cover and spatio-temporal analysis were undertaken to get the final vegetation cover map. Process map and methodology is shown in figure 3.2 below.

Figure 3.2: Vegetation Cover Image Processing:



3.4 Sample Size

A total sample of (n) 384 households was selected for household survey according to the population of rural areas of the district Tharparkar with the confidence level of 95% and a confidence interval of 5%. Data was gathered from four Talukas of the district Tharparkar. A total of 20 villages were randomly selected, 5 villages from each Taluka with a total of 19 to 20 households randomly selected from each village.

Table 3.1: Selected number villages and Households for survey

Taluka	Total No. Villages	No. Villages Selected	No. Households Selected
Mithi	43	5	96
Diplo	40	5	96
Chachro	38	5	96
Nagarparkar	36	5	96
Total	157	20	384

Source: Mouza Statistics of Sindh 2008, Agriculture Census Organization.

3.5 Sampling Method

In order to meet the objectives of the study, purposive stratified random sampling method was used. Purpose was to cover the rural area of the district. Tharparkar district was divided into four strata's according to the administrative division of the district which has four Talukas namely Mithi, Diplo, Chachro, and Nagarparkar. 5 Villages were selected randomly from each Taluka to collect a sample of 96 households from each Taluka. A total of 19 to 20 household samples were collected from each village selected.

CHAPTER 4: RESULTS AND DISCUSSIONS

4.1 Socio-Economic Information

Religion and Casts: It was found that almost 91% of the respondents were Hindus, and only 9% were Muslims. Major Hindu casts were: Meghwar, Thakur, Bheel, and Malhi. Whereas major Muslim casts were: Samejo, and Soomro.

Age: Results found that out of 384 respondents randomly interviewed, average age of household heads was almost 43 years. Minimum age of household head was 23 and maximum was 84 years and standard deviation was 11.76 (Table no.4.1).

Table 4.1: Age of household's head

Mean	43.73
Standard Deviation	11.76
Minimum	23
Maximum	84
Count	384

Family Size: Table no. 4.2 shows the descriptive statistics of family size of households interviewed. The average family size in Tharpakar District was found to be about 6 members per household, with minimum of 2 members and a maximum of 22 members per household. Standard deviation was 2.42 and total sum of 384 household family members was 2451. Average number of males in a household is about 3 and average number of females were also about 3.

Table 4.2: Family size of respondents

Mean	6.382813
Standard Deviation	2.420931
Minimum	2
Maximum	22
Sum	2451
No. Males (Average)	3.11
No. Females (Average)	3.26
Count	384

Education: Table no.4.3 shows the education statistics of the respondents. Almost 81% of the respondents were illiterate. Only 7% of the respondents got primary education. And for higher education, figure is as low as 0.78% which is if compared to Pakistan's national literacy rate which is 58% GOP (2015) is very low.

Table 4.3: Education of Household's Head

Level of Education	Number of Respondents	Percentage of Respondents
Illiterate	309	80.46
Primary	28	7.29
Middle	19	4.94
Matric	17	4.42
Intermediate	8	2.08
Graduate or Post Graduate	3	0.78
Total	**384**	**100**

Income: Table no.4.4 shows the income description of the respondents. It was found that almost every household in the village was involved in livestock keeping and cropping on rain water. Agriculture was the only and main source of income for the people living in villages. The average income of sample of 384 respondents was 10562 Rupees with the minimum income of 7500 Rupees and a maximum of 28000 Rupees.

Table No. 4.4 Monthly income of households

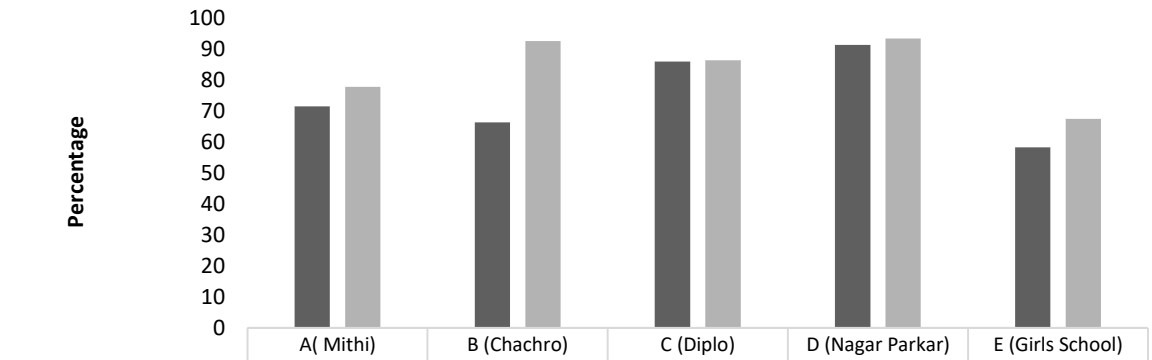
Income Description	
Mean	10562.5
Standard Deviation	3761.14
Minimum	7500
Maximum	28000
Count	384

4.2 Education Loss and Damage

5 primary schools of District Tharparkar were visited for the data collection, 1 school from each Taluka: Mithi, Chachro, Diplo, and Nagar Parkar. And 1 girl's primary school was taken which was found in a working position from Chachro Taluka. Girl's school was hard to find and was not commonly available in most of the villages surveyed. Data on attendance and absenteeism was collected for the years 2014 and 2016. Moreover, the data on other factors (related or not related to droughts) causing absenteeism and dropouts was also collected. 10 teachers, 2 from each school were interviewed along with a total of 30 students of class 3 to class 5 from all 5 schools.

Almost 3 out of 5 schools of the District were found affected due to the drought. Affect was in the shape of increased absenteeism in drought period. The main difference in the attendance between the drought year and normal year was witnessed in the months of August, September and October. As the monsoon season starts from July and end till September, and when the rainfall in these months is below the average then the year is considered as drought year (PMD, 2016). Therefore, the difference in the attendance and absentees due to drought between drought year and normal year is more visible in the months of August, September, and October. July was the month of summer vacations of the schools therefore July is not taken in the comparison.

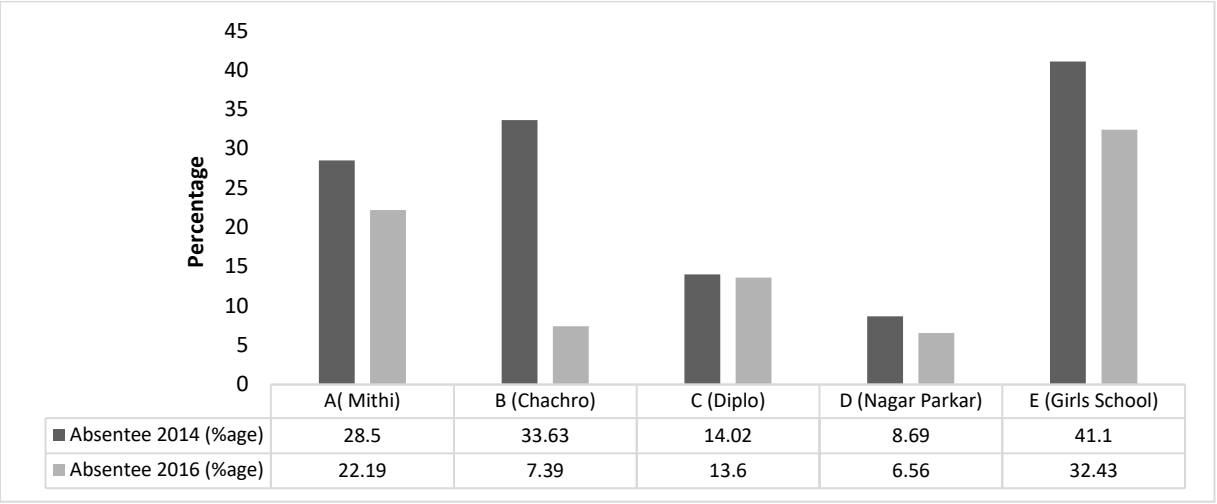
Figure 4.1: Attendance percentage of students in 2014 and 2016



	A(Mithi)	B (Chachro)	C (Diplo)	D (Nagar Parkar)	E (Girls School)
Attendance 2014 (%age)	71.49	66.42	85.97	91.35	58.31
Attendance 2016 (%age)	77.8	92.6	86.39	93.43	67.56

Figure no.4.1 shows the attendance percentage for the years 2014 (drought year) and 2016 (normal year) of 5 different primary schools of District Tharparkar. Each school is the representative of 4 Talukas of the District and is coded in alphabetical order as: A for Mithi, B for Chachro, C for Diplo, D for Nagar Parkar, and E for girl's school which was taken from Chachro Taluka. Major difference in the attendance can be witnessed in the primary school of Chachro which was highly affected in the drought year, where the attendance was 66.42% in 2014 (drought year) and 92.6% in 2016 (normal year) and the difference between two years is 26.18%. Girl's primary school is the 2nd most affected school with the difference of 9.25% between 2014 (drought year) and 2016 (normal year). Whereas less difference can be witnessed in Mithi, Nagar Parkar, and Diplo where the percentage difference between the drought and normal year is 6.31%, 2.08%, and 0.42% respectively. The difference in the attendance percentage between the villages was mainly because of the norms of the specific casts, as some of the casts in Tharparkar are very resistant and do not migrate or displace from there areas and they do not force their children to stop their education due to any disaster or extreme weather. One of those casts include Thakurs. The area or village where Thakurs are in majority, there will be low rate of migrants and low rate of absentees in the children's schooling.

Figure 4.2: Absentee percentage of children



	A(Mithi)	B (Chachro)	C (Diplo)	D (Nagar Parkar)	E (Girls School)
Absentee 2014 (%age)	28.5	33.63	14.02	8.69	41.1
Absentee 2016 (%age)	22.19	7.39	13.6	6.56	32.43

Figure no.4.2 shows the absentees percentage for the years 2014 (drought year) and 2016 (normal year) of 5 different primary schools of District Tharparkar. Absentees are in contrast with the previous attendance figure. Chachro holds the highest number of absentees according to the comparison of both years. In drought year it was 33.63% against the normal year with 7.39%. percentage difference between the two years is the same 26%, as explained in the previous figure of attendance. Girl's primary school is the 2nd with highest number of absentees in comparison of two years. Percentage change between the two years is 8.6%. Whereas less difference can be witnessed in Mithi, Nagar Parkar, and Diplo where the percentage difference between the drought and normal year is 6.31%, 2.08%, and 0.42% respectively.

Table No. 4.5 Number of dropouts of students in 2014 and 2016

School Name	No. of Dropouts 2014	No. of Dropout 2016
A(Mithi)	1	0
B (Chachro)	3	1
C (Diplo)	0	0
D (Nagar Parkar)	0	0
E (Girls School)	6	3

The table no.4.5 shows the number of dropouts from the schools for the years 2014 (drought year) and 2016 (normal year) of 5 different primary schools of District Tharparkar. Highest

number of dropouts can be witnessed in the girl's school where it was 6 students in 2014 (drought year) and 3 students in 2016 (normal year). Chachro holds the 2nd largest figure for the dropouts with 3 students in 2014 and only 1 student in 2016. In Mithi, only 1 dropout was witnessed in 2014 and no dropout in 2016. Whereas no dropouts in both years was witnessed in Diplo and Nagar Parkar.

Table No. 4.6 Other factors affecting children's education

Factors	Respondents	Score				
		SA	**A**	**DA**	**SDA**	**Average % SA or A**
Poor learning environment	**Key informants**	2	3	3	2	50
	Children	6	10	11	3	53.3
Parents cannot afford fee	**Key informants**	0	0	5	5	0
	Children	0	7	17	6	23.3
Time spent to fetch water	**Key informants**	2	5	3	0	70
	Children	8	11	6	5	63.3
Paid or own labour	**Key informants**	3	5	2	0	80
	Children	9	11	7	3	66.6
School too far	**Key informants**	0	0	7	3	0
	Children	0	3	20	7	10

Children, n=30; Key informants, n=10.
SA, strongly agree; A, agree; DA, disagree; SDA, strongly disagree.

Table no.4.6 show the results of other factors related or not related to droughts that contribute to absenteeism and dropouts. The results indicate that other factors like: more time spent to fetch water, poor learning environment, and drought forcing children to paid or own labour were the major factors contributing in the absentees and dropouts. Poor learning environment refers to the non-seriousness of learning environment in the school which include poor infrastructure, lack of punctuality of teachers and students, lack of library or reading materials etc. 50% of key informants and 53.3% children indicated that poor learning environment was the major factor contributing in the absentees. Majority of the key informants and children with an average percentage of 80% and 66.6% respectively indicated that drought put extra pressure on households and force the members to earn extra income,

thus children get involve in paid or own labour. Drought also put pressure on households in shape of water fetching efforts. People fetch water mainly for their domestic use and for their livestock, 70% of key respondents and 63.3% of children indicated that attendance is disturbed by water fetching effort. Fee affordance and school distance were the factors that did not have much impact on the absentees, as all the schools available in the villages were administered by the Government and the tuition fee is very low or almost free, and the schools were built near to the houses and huts of the villages.

4.3 Health Loss and Damage

For health, household interviews were conducted with addition of key informant interviews of doctors from health facilities in the localities. Major diseases which were common in the area and as well as common in the droughts were Diarrhoea, Cholera, Malaria, and Fever. It was witnessed through key informant interviews and FGDs that due to lack of fresh water during drought or normal season, disease outbreak increase for Diarrhoea, and cholera, as these diseases have direct linkage with the drinking water. Basic Health Units were available in most of the villages in Tharparkar except few villages where no health facility was available.

According to the data collected from the households, Change was witnessed in the number of people affected due to noted diseases in the drought year (2014) and normal year (2016). For almost all the diseases, numbers of persons affected were higher in the drought year. Diarrhoea and Cholera with the main difference between drought and normal year, as these two diseases were mainly linked with the water which is difficult to find in the droughts.

Table no.4.8 shows the percentage of persons affected from malaria, Diarrhoea, Cholera, and fever in Tharparkar for 2014 (Drought year) and 2016 (Normal year). For other disease than Diarrhoea, the data was collected from the sample of 2451 persons which included 1197 females and 1254 males. And for Diarrhoea, children were identified in each house aging

from 1 to 10 years. A total of 636 children were found in a total sample of 2451 which completed 384 households. Out of 636, male children were 249 and female children were 387 And these disease increase more rapidly in the droughts then normal conditions. Doctors from civil hospital Mithi indicated that they attend more Diarrhoea and cholera patients in the droughts.

Malaria does not show much difference in the percentage of people affected in drought and normal period with total 2.93% affected in drought year and 2.89% affected in normal year. In Diarrhoea, clear difference can be witnessed between drought and normal year with a total of 20.5% children affected in drought year in comparison to 12.5% in the normal year. Cholera also show a clear difference between the two years with almost doubled figures in the drought year. In normal year 1.5% person were affected and in drought year this figure is 3.1%. Fever does not show any major difference between the two years which is 20.6% with affected persons in drought year and 19.4% in normal year. And it is also witnessed that female population is more affected in all the diseases than males.

Table 4.7 Percentage of persons affected due to diseases in 2014 and 2016

Diseases	Drought Year			Normal Year		
	Male %	Female %	Total Affected %	Male %	Female %	Total Affected %
Malaria	2.23	3.67	2.93	1.75	4	2.89
Diarrhoea	14.47	22.73	20.59	17.26	9.36	12.57
Cholera	2.39	3.84	3.1	1.19	1.83	1.5
Fever	21.4	19.8	20.68	18.5	20.3	19.4

Male, n=1254; Female, n=1197; Total, n=2451; For Diarrhoea: number of Children, n=636; Male Children, n=249; Female Children, n=387.

figure no.4.3 shows the comparison of persons affected due to prevailing diseases between normal year and drought year. Diarrhoea and cholera show a clear difference between the two years as in drought year, the outbreak of these diseases is higher as compare to normal year. While malaria in case of Tharparkar does not show any difference between the two years. Fever is The common disease in any catastrophe, in case of Tharparkar, fever also showed a

higher number of person affected in drought year as compare to normal year. One of the main reason of high fever rate is the way of living of rural people. Rural areas of Tharparkar are exposed to any sort insects and pests and pathogens. Water is limited for washing cooking materials i-e, vegetables dishes, and for bathing or even washing hands or face frequently. Water stored for drinking is not often purified. Moreover, there is no concept of usage of any soap, sanitizers, or detergents, which make the households vulnerable to such diseases.

Figure 4.3: Comparison of diseases between drought year and normal year

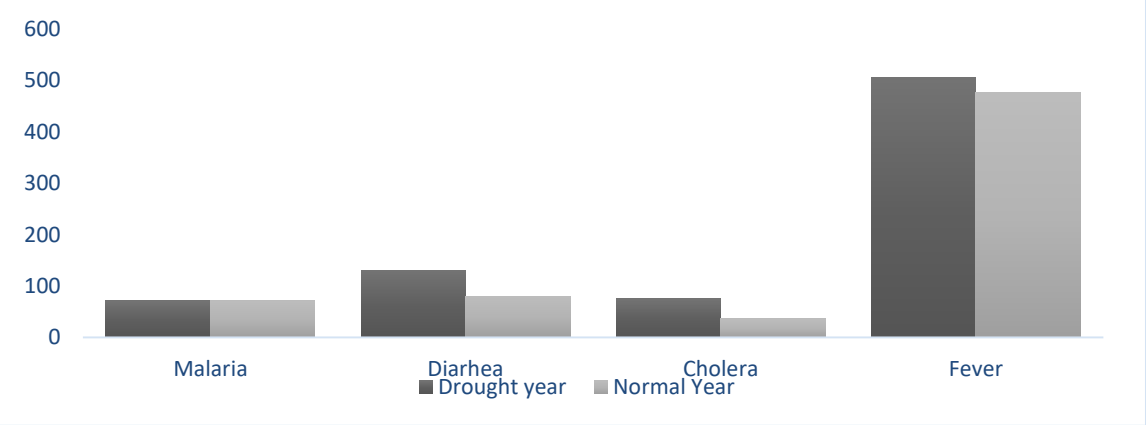
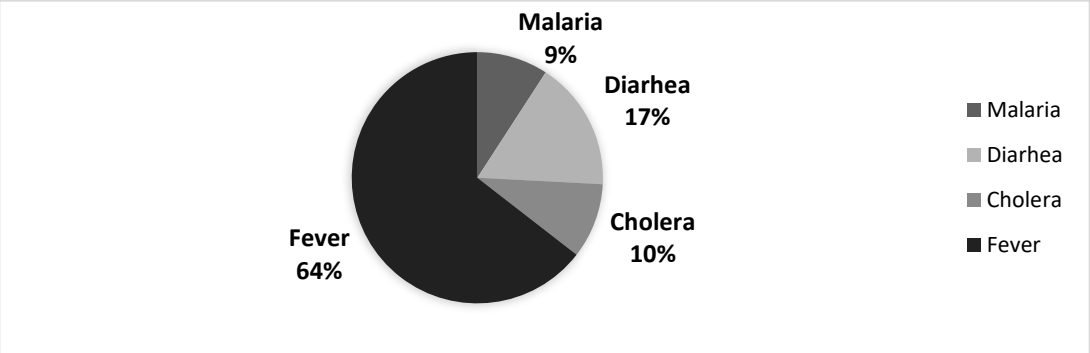


Figure no.4.4 shows the percentage of the person affected from the prevailing diseases in Tharparkar District. Fever is with the highest value of 64% affected people following fever is the Diarrhoea with 17% of the people affected. 10% of the people were affected from cholera and 9% from malaria.

Figure.4.4: Percentage of person affected due to noted diseases



Visitation and consultation to private doctors in case of diseases was not found common in Tharparkar district. Only 18 cases were found in which respondents consulted private health facilities. The statistics of those respondents are shown in table no. 4.8, which shows that average doctor fee for diarrhoea was 288.8 PKR, for cholera was 264.2 PKR, and for malaria was 150 PKR. Average medicine cost in case of cholera was relatively higher i-e, 2071 PKR, for diarrhoea was 590, and for malaria was 400. The average travelling cost in all the 18 cases was 680.5 PKR.

Table 4.8: Descriptive Statistics of respondents consulted private health facility during drought year (2014)

Statistics	Diarrhoea			Cholera			Malaria		
	Doctor fee	***Medicine cost***	***Travel cost***	***Doctor fee***	***Medicine cost***	***Travel cost***	***Doctor fee***	***Medicine cost***	***Travel cost***
Mean	288.88	590	911.11	264.28	2071.4	478.57	150	400	350
S.D	136.42	127.57	594.65	124.88	1017.70	264.35	70.71	141.42	70.71
Min	100	400	200	100	500	200	100	300	300
Max	500	750	2000	500	3500	1000	200	500	400

4.4 Cropping Loss and Damage

For cropping, household survey was conducted which included information about crops grown in the area, cultivated area of each crop, fertilizer usage, seed rate, water requirement and irrigation, and crop yield. And Focused Group Discussions were also conducted with the farming community of the area, including senior farmers of the society. FGDs revealed that almost all the crop seeds were destroyed in the drought year of 2014 due to lack of rainfall required at the appropriate time of cropping season which starts from June for the crops which are grown in Tharparkar desert. The only way of irrigating the crops is rain. Each and every farmer faced huge loss in their crops in 2014. The farmers of the area do not use any sort of fertilizer in their crops. All farmers were growing Guar, Millet, Sesame, Mung Bean, and Moth Bean in their total land. Means of tillage operations mainly are camels and tractors. Table no. 4.9 shows the results of the qualitative responses of households responding to

experience of crop failure and seed destroyed in the drought year (2014). Almost 94% of respondents indicated that they faced crop failure during the drought season of 2014 and almost 92% respondents indicated that their seeds were destroyed.

Table No. 4.9 Crop related responses of households on loss and damage

Crop Related Loss and Damage	Yes	No
Crop Failure	93.8%	6.2%
Seed Destroyed	91.9%	8.1%

Table no.4.10 shows the comparison of crops grown, area cultivated, average cost per acre, seed rate, and crop yield between drought year (2014) and normal year (2016). It was found that the area cultivated was the same in both years. Every farmer cultivated the same amount of land every year and almost every livestock holder bears some piece of land for cultivation. The main crop in Tharparkar according to the area cultivated was Guar with 2341 acres of cultivated area. Millet was the second largest grown crop with 1811 acres of cultivated area. Sesame, Mung Bean, and Moth Bean were grown on an area of 765, 629, and 435 acres respectively. Average cost per acre which include seed cost and tillage operations cost was also same for both the years. It is 4500 Rupees for Guar and Millet, 4200 Rupees for Moth Bean, 4000 Rupees for Mung Bean, and 3000 Rupees for Sesame crop. Seed rate is also the same for drought and normal year. Whereas main difference lies in the crop yield between drought year and normal year. In drought year, whole seed was destroyed and farmers reported that there was no yield received to them that year.

Table 4.10 Cropping description between drought and normal year

Crops	Drought Year				Normal Year			
	AC (Acres)	Avg. CPA (PKR)	SPA (KG)	YPA (Munds)	AC (Acres)	Avg. CPA (PKR)	SPA (KG)	Avg. YPA (KG)
Guar	2341	4500	10	0	2341	4500	10	120
Mung Bean	629	4000	5	0	629	4000	5	105
Sesame	765	3000	3	0	765	3000	3	101.2
Moth Bean	435	4200	4	0	235	4200	4	100

Millet (Bajra)	1811	4500	3	0	1811	4500	3	1200

AC=Area Cultivated, CPA=Cost Per Acre, SPA=Seed Per Acre, YPA=Yield Per Acre

Table no.4.11 shows the total and average monetary loss each household faced in cropping during the drought year (2014). Total area cultivated including all crops was 5981 acres, and on average each household is cultivating 15.5 acres of land. According to this estimation, the total monetary loss of the sample interviewed in Tharparkar was 25322000 Rupees. And on average each household faced the monetary loss of 65943 Rupees.

Table 4.11 Average household's loss estimation in cropping

Crops	**Total Area Cultivated (Acres)**	**Avg. Area Cultivated Per HH**	**Avg. Cost per Acre**	**Total Monetary Loss (PKR)**	**Avg. Loss per HH (PKR)**
Guar	2341	6	4500	10534500	27434
Mung Bean	629	1.6	4000	2516000	6552
Sesame	765	2	3000	2295000	5977
Moth Bean	435	1	4200	1827000	4758
Millet (Bajra)	1811	4.7	4500	8149500	21223
Total	**5981**	**15.5**	**------**	**25322000**	**65943**

4.5 Livestock Loss and Damage

Results found that livestock was the major sector which was affected heavily during the drought year of 2014. Lack of forage and water deficiency both were the major factors that contributed in the loss of livestock. Out of the qualitative responses, table no.4.12 shows that majority of the people reported that there was lack of forage available for the animals during the drought, as the major source of forage is the greenery which grows straight after the rain. 87% people reported that water for animals to drink was also short in the droughts. While selling prices of animals were also affected and were down according to 78% respondents.

Table No. 4.12 Livestock related household's responses on loss and damage

Livestock Related Loss and Damage	**Yes**	**No**
Lack of Forage	87%	13%
Lack of Drinking Water for Animals	87.5%	12.5%
Low Selling Price of Animal	78.6%	21.4%

Table no.4.13 shows the comparison of number of each animal available to the respondents, number of animals died, and number of animals needed medication between drought year and normal year. Households bear major losses in drought years as the number of animals in drought year were 14738 and were gone down to 7129 animals in normal year. Most of the animals died during the drought season and many of the respondents sold the animals to cope with the situation. More than 5000 animals died in the drought year in comparison to 126 animals in the normal year. Sick animals that needed medication in drought year were 5546 and in normal year were 610.

Table 4.13: Comparison of animals between drought and normal year

Animals	Drought Year			Normal Year		
	No. Animals	**No. Animals Died**	**Needed Medication**	**No. Animals**	**No. Animals Died**	**Needed Medication**
Goat	6470	2314	2760	3321	63	210
Sheep	5976	1997	2088	2677	51	354
Cattle	1916	656	576	858	10	33
Camel	331	45	113	248	0	13
Donkey	45	17	9	25	2	0
Total	14738	5029	5546	7129	126	610

Figure no.4.5 shows the comparison of animals died and needed medication between the drought year and normal year. The numbers are huge in drought year for both, number of animals died and number of animals needed medication in comparison to normal year where the bars in the figure are very small.

Figure no. 4.5: Comparison of animals died and needed medication

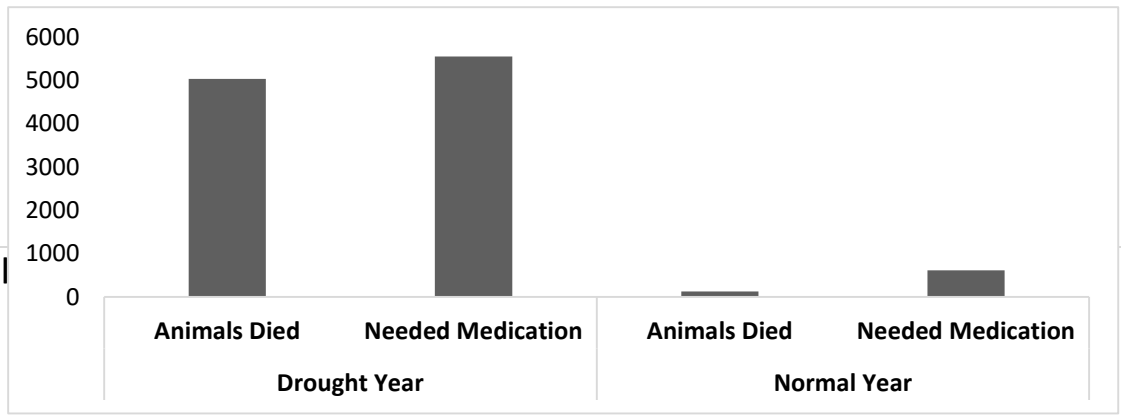


Figure no.4.6 shows the percentage of different animals died in drought year. Goats and Sheep were highly affected animals with the dying percentage of 46% and 40% respectively. In the total animals died, 19% were the cattle and only 1% were camels.

Figure no.4.6: Percentage of different animals died in drought year

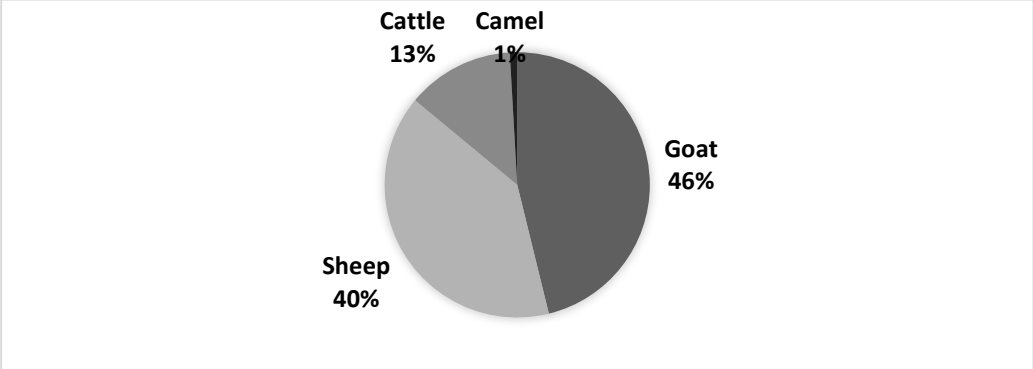


Table no.4.14 shows the medication cost borne by the households during the drought year in Pakistani Rupees. It was found that per animal average medicine cost for cattle was 421 Rupees, for goats and camels was about 330 Rupees and for sheep was 223 Rupees. Doctor was called by any household for all the sick animals. And average was calculated by dividing the total amount of doctor fee on the number of animals he got, and according to this the average per animal doctor fee was 38 Rupees for goat and sheep, and 178 and 141 Rupees for camel and cattle respectively. Total medication cost per animal was calculated by adding the medicine cost and doctor fee. Total medication cost for sheep and goat was 264 and 368 Rupees respectively. And for camel and cattle it was 499 and 562 Rupees respectively.

Table 4.14 Average medication cost incurred per animal

Animals	Avg. Medicine Cost per Animal (PKR)	Avg. Doctor Fee per Animal (PKR)	Avg. Total Medication Cost per Animal
Goat	330	38	368
Sheep	226	38	264
Cattle	421	141	562
Camel	321	178	499

Table no.4.15 shows the average market price of each animal, total monetary loss of the respondents, and average loss per household is Pakistani rupees. Local livestock markets were visited in all 4 talukas: Mithi, Chachro, Diplo, and Nagar parkar and were asked about the prices of animals in normal condition and the prices in drought. It was found that the selling prices of animals in the drought period were below than the normal period prices. The reason behind that was that the animals commonly sold in drought period were sick and were bought mostly for slaughtering for meat purpose. Then these prices were match with the household's revealed prices, who sold their animals during the drought period. Averages of both the prices were almost the same. Average market price for a camel in drought season was 25000 Rupees, for cattle it was 26000 Rupees, for goat and sheep it was 3000 and 2500 Rupees respectively. And these selling prices were almost of half amount of the prices of animals in normal conditions (average or above average rainy seasons). According to these average prices of animals, total monetary loss of respondents was 30115500 Rupees. When this total monetary loss was divided by the number of animals died, average loss per household was found which was 78426 Rupees.

Table 4.15 Average household's monetary loss in livestock

Animal Name	Animals Died	Avg. market Price per Animal (PKR)	Total Monetary Loss (PKR)	Avg. Loss per HH (PKR)
Goat	2314	3000	6942000	18078
Sheep	1997	2500	4992500	13001
Cattle	656	26000	17056000	44417
Camel	45	25000	1125000	2930
Total	**5012**	**56500**	**30115500**	**78426**

Table no.4.16 shows the total monetary damage in shape of diseased animals, medication costs, and average damage per household. Total number of animals needed medication were found to be 5537. Total monetary damage was calculated by multiplying the average total medication cost of each animal by number of animals needed medication. Total monetary

damage in shape of medication was 1948085 Rupees. And when this total monetary damage was divided by number of animals needed medication, average damage per household was estimated which was 5073 Rupees.

Table 4.16 Average households monetary damage in livestock

Animal Name	No. Animals Medicated	Total Monetary Damage (PKR)	Avg. Damage per HH (PKR)
Goat	2760	1015956	2646
Sheep	2088	551858.4	1438
Cattle	576	323827.2	843
Camel	113	56443.5	147
Total	**5537**	**1948085.1**	**5073**

4.6 Environmental Loss and Damage

For environmental loss and damage, qualitative questions were asked from the respondents about the pasture lands affected, productive capacity of soil damaged, animal species other than domestic animals harmed, and plant species harmed during the drought year (2014). Above 80% respondent indicated that the productive capacity of soil was damaged, animal and plant species were harmed during drought season (See Table No.4.17). For productive capacity of soil, question was asked whether the yields of crops were low in the years after the drought year, and whether they observe that this is due to the soil deterioration. Fresh water scarcity was major problem during the drought year almost 79% respondents observed fresh water scarcity. 75% respondents indicated that the pastures available after rain were also damaged due to lack of rain in 2014.

Table 4.17 Household's response to environmental loss and damage

Environmental loss and Damage	Yes	No
Fresh Water Scarcity	78.4%	21.6%
Pasture Damage	75.8%	24.2%
Productive Capacity of Soil	84.1%	15.9%
Animal Species harmed	81.5%	18.5%
Plant Species Harmed	81.3%	18.8%

Among the plant species harmed during drought season, households indicated the following plant species specifically:


Kandi is a native tree of desert. The fruit of Kandi is known as Singri in local language Sindhi and Dhatki. The fruit is used for eating purpose and is a common vegetable of Tharparkar.

2): Calligonum polygonoides

Local Name: Phogg

Calligonum polygonoides is commonly found in deserts. It is the most common local medicine in Tharparkar, commonly used in all stomach related diseases.

3): Calotropis gigantea

Local Name: Akk


Calotropis gigantea is also common plant of deserts and barren lands. It is used for medicinal purposes.

Among the animal species harmed, households indicated the following species:

1): Peacock

Local Name: Mor

Peacock is the most affected bird in Tharparkar. Households indicated that they put water in a pot for peacock to drink in their houses and neighbourhood, but when drought prevail they are not able to do that because of water shortage.

2): Vultures

Local Name: Gijh

According to the household's perception, Vultures are hard to find in Tharparkar. Households indicated that vultures were of good service, as it consumed their dead animals. Now vultures are hard to find and their dead animals are left for decaying, thus more infections and diseases become common.

4.7 Coping Strategies Opted Against Drought

Droughts are a common phenomenon in desert ecosystem and almost all the households were involved or were trying to involve themselves in some coping strategies against such droughts. It was found that fighting against drought in Tharparkar was a bit difficult as majority of the respondents reported that in spite of their coping strategies, they observed the negative impacts of droughts in their numerous livelihood sectors. Some of the major coping strategies in which households were involved are as under:

- **Water Storage Techniques**

Water is a precious resource in Tharparkar. Most of the households have their personal wells in a specific region mostly about 1-2 kilometres away from the villages. Those wells are dug by the households on their own expenses of materials used such as: bricks, mud, etc. Such well water is mostly used for the drinking purpose if the water is potable or sweet, and if the

water of the well is undrinkable, salty or dirty, then it used for the drinking of domestic animals. The only recharge of such wells is the rain. And in droughts, water is hard to find in such wells as well. Numerous households have small water storage tanks constructed in their houses (huts). Those households store water in such tanks and use it when it is required or in dry season. Some of the households had both drinking water tanks and animal drinking and bathing tanks. Such tanks were commonly constructed underground and made up of concrete, and bricks. Other water technique included the purifying of drinking water with the help of cloth and clay pots. It is an indigenous method of purifying the drinking water in such areas where fresh or clean water is hard to find.

- **Migration**

Migration is of the common coping and adaptation strategy opted in Tharparkar. It was found when interviewed to the local NGOs that this strategy is the only strategy that may be the helpful one in case of Tharparkar as surviving against the drought in the middle of a desert is a challenging task. Migration which is opted in Tharparkar is of 3 kinds: Temporal migration, Partial migration, full migration.

Temporal Migration: People migrate towards other cities of Sindh such as: Umer Kot, Mirpur Khas, Hyderabad, Karachi for a period of 6 to 8 months commonly in the drought season and when the conditions get better, they come back to their villages.

Partial Migration: One or few working members of the households migrate to other cities of Sindh in search of labour. Their major source of livelihood gets affected in droughts thus extra pressure forces some of the household's members to migrate and earn extra income.

Full Migration: Some families migrate to other cities with whatever assets they have got and never come back. Such families have less assets to survive or bear the shocks of catastrophes.

Fully migrated households commonly shift their profession and usually found involved in different sort of labour.

- **Selling Property**

Selling of personal belongings and property was also found to be a common strategy in Tharparkar. Most of the households sell their animals, precious ornamental items, and jewellery in order to have some money in hand to fight the situation. The most common property sold were domestic animals. It was found that diseases and mortality of animals increased in droughts. So it is a suitable option or a compulsion of households to sell their animals, as those animals are commonly sick or eventually will die and then will have no value. Such animals are sold at a very low price in the market and households are helpless to sell them. Visits of local domestic animal market revealed that the reason behind purchasing animals at a low price in drought is because of the animal's health. Animals commonly brought to the market are of bad health and physical structure, thus are of low value and usually are not bought for raising purpose but are bought for slaughtering purpose for meat production.

- **Government or NGOs Help**

Government of Sindh took action after the 2014 drought to relief the people of Tharparkar. Actions included improvement of health facilities available in the region, and food provision to the affected families. According to the responses of the households, Non-Government organizations are more active in their villages than the Government. Households though agreed that Government of Sindh has provided them the wheat throughout the year, but it is not enough to meet the challenge. NGOs commonly found active in the villages of Tharparkar District were Thardeep (TRDP) and Research and Development Foundation (RDF). Both mostly working on strategies to fight against the droughts. Projects included

installation of small solar panels in the houses, installation of RO water plants in the villages, construction of water storage tanks, plantation of drought resistant plant species in the villages, skill development programs for women, and financial support of deserving people. With the help of such programs, many households were aided and relieved.

- **Private Loan**

Private loan was commonly in practice in the villages of Tharparkar. People used to take small loans when they were short of budget or were in other sorts of deficits from private money lenders, merchants, or any person who was well-off in terms of money. Private loans were lent on some interest, forced by the lenders, or sometimes if the lender was close to the lending one, knew him very well, or lived in a same village, then no interest was charged by the lenders.

- **Solar Panels**

Solar panels were not that much common as other coping strategies. Small solar plates were used for lighting and other domestic uses which met the voltage criteria of the battery. Solar panels were mostly installed by NGOs in the villages, and where the NGOs had not installed the panels, there the panels were installed by the families with a larger income group or with a large household size.

Table 4.18: Coping strategies opting percentage of Households

Coping Strategies	Percentage HHs Opted
Water storage techniques	72.1
Migration	56.7
Selling property	67.9
Private loan	50.4
Solar panels	21.6
Government or NGOs help	17.7

Table No 4.18 shows the percentage of households opting various coping strategies. Water storage technique was the most opted strategy by the households with 72.1% households opting, 67.9% households sold their property (mainly animals), 50.4% households lent private loans, and 56.7 households migrated during the drought period. Whereas NGOs help and installation of solar panels were least opted strategies by the households with 17.7% and 21.6% respectively.

4.8 Binomial Logistic Regression Results of Coping Strategies and Adaptive Capacity Influencing Factors

Water Storage Techniques

Table no. 4.19 shows the regression results of water storage technique opted or not by the households as a coping strategy. Household size and income has statistically significant impact on water storage techniques opted by the households. While number of educated person in household, household head's education and working member in a household has statistically insignificant impact on water storage techniques opted. Results revealed that households with larger household size and better relative income were more likely to opt water storage techniques. Table no. 4.20 reflects the marginal effects of the variables towards water storage technique opted. Results indicate that for each additional member, households were 6% more likely to opted water storage technique. With the increase in income, households were 23% more likely to opted water storage technique.

Table 4.19 Logit results of water storage techniques

Variable Name	Coefficient	Z	P>[z]
Household size	.6565384	6.98	0.000
Household Head's education	.053818	1.38	0.168
Working member in HH	.0827632	0.59	0.557
No. educated person in HH	.0736847	0.52	0.603
Income	2.291411	3.54	0.000

Table No.4.20 Marginal effects after logit for water storage techniques

Variable	dy/dx
House hold size	0.0684629
Household head education	0.0056121
Working members in HH	0.0086304
No. educated person in HH	0.0076837
Income	0.2389452

Migration

Table No 4.21 shows the regression results of migration opted or not as a coping strategy by the households. Results show that Household size, and income has statistically significant impact on migration, whereas household head's education, number of educated person in households and working members has statistically insignificant impact on migration. Households with larger size were more likely to migrate, whereas the negative sign of coefficient with income variable indicate that with more income, households were less likely to migrate. Though working members has statistically insignificant but the negative sign indicates that more the household head's education and working members in a household, less likely they migrate. Table no 4.22 shows the marginal effects of variables after logit. Results indicate that with an increase of one member in household, they likely to migrate by 2%. with the increase in income, households less likely to migrate by 2%. this is due to the low variation in the household's income (see table no. 4.3).

Table 4.21 Logit results of migration

Variable Name	Coefficient	Z	P>[z]
Household size	.1079387	2.23	0.026
Household Head's education	-.0131847	-0.47	0.638
Working member in HH	-.1434564	-1.56	0.118
No. educated person in HH	-.0136888	-0.15	0.881
Income	-.3116655	-2.25	0.025

Table 4.22 Marginal effects after logit for migration

Variable	dy/dx
Household size	0.0264814
Household head education	-0.0032347
Working members in HH	-0.0351952
No. educated person in HH	-0.0033584
Income	-0.0764631

Selling property

Table no. 4.23 shows the regression results of property sold by the households and adaptive capacity influencing factors. Results indicate that only income of household has statistically significant impact on selling property opted as a coping strategy by the households. Whereas all other variables have statistically insignificant impact on selling of property by households. Households with higher income, less likely to sell their property. Table no. 4.24 shows the marginal effects of variables after logit. Results reveal that with the increase of income, households less likely to sell their property by 10%.

Table 4.23 logit results of selling property

Variable Name	Coefficient	Z	P>[z]
Household size	0.0109098	0.22	0.828
Household Head's education	-0.0465122	-1.59	0.112
Working member in HH	-0.0987536	-1.06	0.288
No. educated person in HH	-0.0252578	-0.26	0.795
Income	-0.5056488	-3.58	0.000

Table 4.24 Marginal effects of variables on selling property

Variable	dy/dx
Household size	0.0023525
Household head education	-0.0100294
Working members in HH	-0.0212941
No. educated person in HH	-0.0054463
Income	-0.1090323

Private Loan

Table no. 4.25 shows the regression results of private loan opted by the households and adaptive capacity influencing factors. Results indicate that income of household has statistically significant impact on private loan opted as a coping strategy by the households.

Whereas all other variables have statistically insignificant impact on private loan. Negative sign with income coefficient show that households with higher income, less likely to sell their property. Table no. 4.26 shows the marginal effects of variables after logit. Results reveal that with the increase of income, households less likely to opt private loan by 6%.

Table 4.25 logit results of private loan

Variable Name	Coefficient	Z	P>[z]
Household size	0.0766381	1.54	0.123
Household Head's education	0.0168559	0.58	0.563
Working member in HH	-0.1303256	-1.42	0.156
No. educated person in HH	0.1481218	1.41	0.158
Income	-0.2962515	-2.12	0.034

Table 4.26 marginal results after logit of private loan

Variable	dy/dx
Household size	0.0176932
Household head education	0.0038915
Working members in HH	-0.0300878
No. educated person in HH	0.0341964
Income	-0.0683945

Solar Panels

Table no. 4.27 shows the regression results of solar panels installed by the households and adaptive capacity influencing factors. Results indicate that income, working members in household and NGOs help has statistically significant impact on solar panels opted as a coping strategy by the households. Whereas all other variables have statistically insignificant impact. Households with higher income, and with NGOs help, more likely to install solar panels in their houses. Table no. 4.28 shows the marginal effects of variables after logit. Results reveal that with the increase of income, and NGOs help households more likely to install solar panels by 13% and 28% respectively.

Table 4.27 Logit result of solar panel

Variable Name	Coefficient	Z	P>[z]
Household size	.0322829	0.55	0.583
Household Head's education	-.0171379	-0.47	0.635
Working member in HH	.514089	4.18	0.000
No. educated person in HH	-.0704785	-0.56	0.576
Income	.8444356	5.43	0.000
NGO help	2.739304	6.65	0.000

Table 4.28 marginal effects of variables after logit of solar panel

Variable	dy/dx
Household size	.0049903
Household head education	-.0026492
Working members in HH	.0794683
No. educated person in HH	-.0108946
Income	0.1305336
NGO help	0.2880424

Summary of Logit Regression Results

Income variable was found to be significant in all the strategies opted by the households. This is because each strategy required some additional income to adapt, mainly: construction of cemented wells (water storage techniques), and installation of solar panels. And additional income was also required for not opting some weak strategies like: migration, selling their property, and private loan seeking. Household size was found to be significant in most of the strategies opted by the households, as the households with greater size needed more water to store thus they opted to construct cemented wells in their houses. Same was the case in migration, households with larger size chose to migrate which was mostly the partial migration in which one or two members of households were forced to migrate for extra earning. Households with larger size had relatively more needs, therefore they opted to seek private loans. Education in all the strategies was statistically insignificant because the educational status of Tharparkar was poor, very few people were literate otherwise majority of the respondents were illiterate[8]. Working members in a household was also found to be statistically insignificant in all the strategies opted by the households. This was because of

[8] See Table No. 4.3, Household's education status

low variation in the number of working members. In Tharparkar, rural household members work together and almost all the members of households work for livelihood sustenance.

Figure 4.7: Overall results summary of findings (Researcher own conclusion)

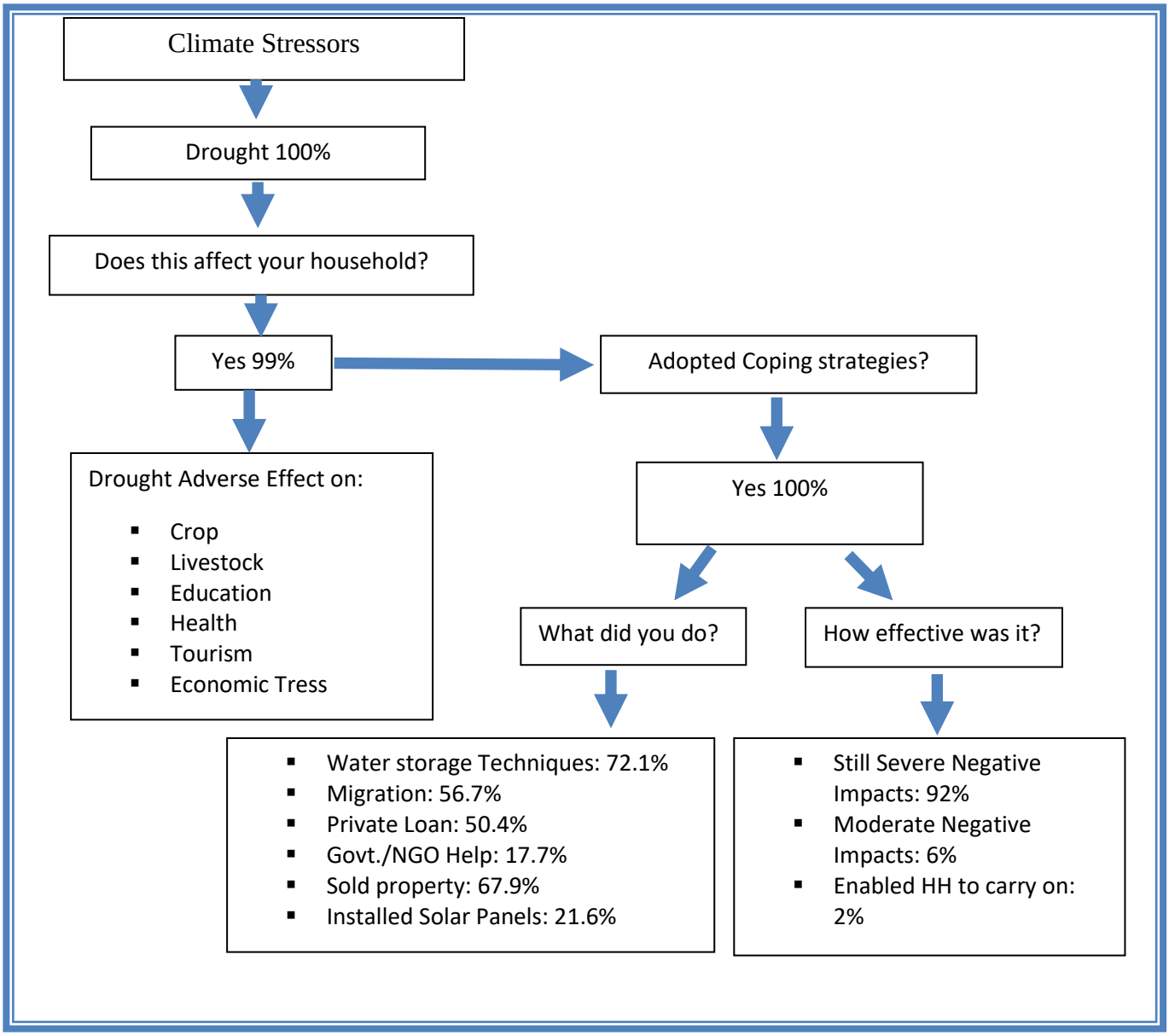


Figure 4.7 shows the overall results summary and findings. The figure also serves as a channel of loss and damage to the households by providing the loss and damage framework i-e: climate stressor causing societal negative impacts, then comes the response of the society and in the last when the households are not able to respond sufficiently, they face loss and damage.

4.9 GEO-SPATIAL TEMPORAL MAPPING ANALYSIS OF THARPARKAR

Satellite images were gathered from (www.earthexplorer.usgs.gov) and censored for the vegetation cover (NDVI) using the ArcGIS software. Images were to be collected for the peak months of vegetation which are July, August, and September, and October for 2014 and 2016 to see the drought impact on vegetation cover. But due to cloudy images for the month July and August, image processing to acquire vegetation cover was not possible, therefore the images were collected for the months of September, October, and November. The images show a clear difference in the vegetation cover as in 2014, vegetation cover is way too less than in 2016. Figure shows the difference in the vegetation cover in 2014 and 2016 of Tharparkar for the months of September, October, and November.

Figure 4.8: Difference in Vegetation Cover NDVI images

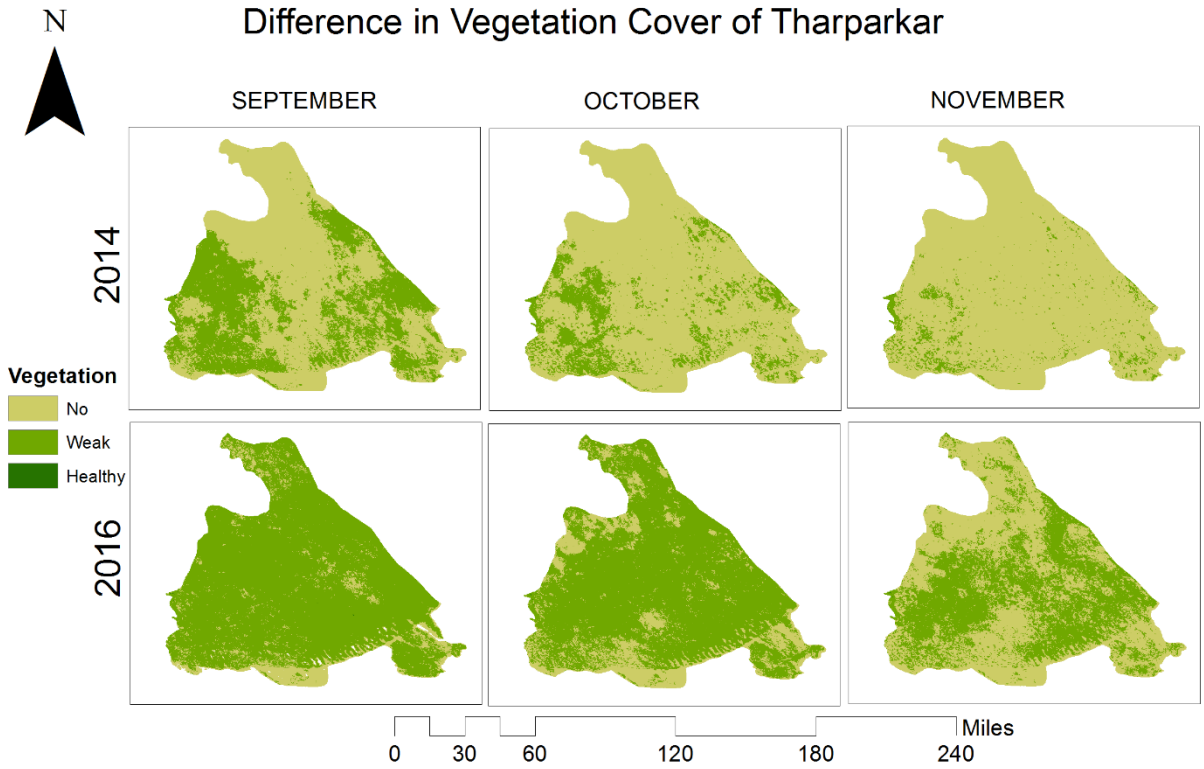
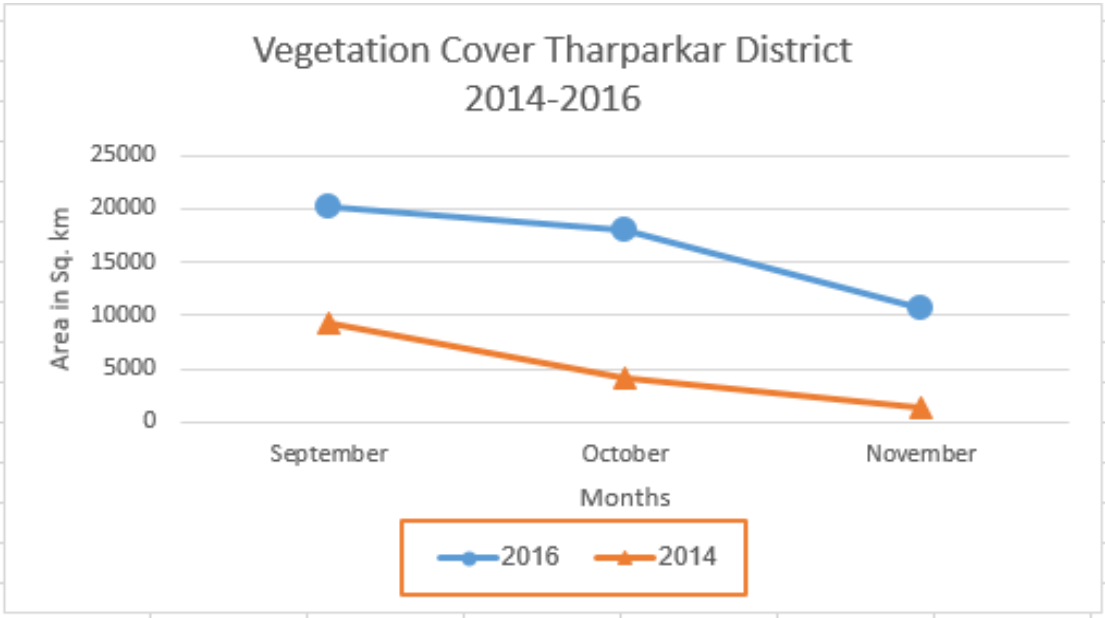


Figure no. 4.8 shows the area of vegetation cover in square kilometres in 2014 and 2016. To take out the area, zonal geometry as a table of spatial analysis tool was used in ArcGIS software. The figure shows a clear difference in the vegetation cover between the drought and

normal period. As in 2014, area covered in vegetation in the month of September was about 10000 Sq. km compared to more than 20000 Sq. km in 2016. In the month of October, vegetation cover went down from 10000 Sq. km to below 5000 Sq. km in 2014, whereas it did not change in 2016 where it remained around 18000 Sq. km. In November, vegetation cover was almost zero in 2014, whereas in 2016 it was almost 10000 Sq. km.

Figure 4.9: Area Vegetation Cover Comparison Between 2014 and 2016



CHAPTER 5: CONCLUSION AND RECOMMENDATIONS

5.1 Summary of the Results

Climatic variability is a global threat and its first and foremost impact is at household level. Tharparkar District faced extreme drought in 2014 which was considered as socio-economic drought as it caused serious negative impacts on livelihood sources of households. This research examined the loss and damage from latest drought that hit Tharparkar in 2014. The major research findings are summarized as the average age of the respondents (household head) was 43 years. The average family size of the respondents was 6. Educational status of the households was poor, almost 81% of the respondents were illiterate. The households were found to be highly dependent on agriculture as their only source of income. The average monthly income of the households was 10562 PKR.

Results from 5 different primary schools found that children's education was affected during the drought year of 2014. Number of absentees was higher in the drought year than the normal year (2016). Data collected on the factors contributing to the absenteeism concluded that poor learning environment of the school, more time spent to fetch the water for household, and involvement in the paid or own household labour were the factors forcing the children not attending the school during the drought year.

For health, data was collected from each member of household thus the sample size became 2451. The major prevailing diseases which were common in the area were Diarrhoea, Cholera, and Fever. And it was witnessed that the number of affected persons was larger in the drought year than the normal year. Malaria showed no difference in both years. For Diarrhoea, the data was collected on the children in the households, thus the sample for the Diarrhoea became 636. In drought year, 20.5% children were affected from Diarrhoea whereas in normal year the affected children were 12.5%. it was also found that the outbreak of Diarrhoea and Cholera in the drought year was because of fresh water shortages.

Cropping in Tharparkar was highly affected due to the drought in 2014. The only source of irrigation was rainwater. Almost 94% of the respondents reported that their crops were failed and almost 92% reported that their crop seeds were destroyed in 2014 and thus got no income from cropping that year. The average loss per households in shape of cultivation cost in drought year was 65943 PKR.

Satellite images were also censored in this research to get the vegetation cover (Normalized Difference Vegetative Index) in both, drought and normal year. Results indicate that if the vegetation is disturbed, it puts negative impact on the livestock production as well. Same was the case in Tharparkar where 5029 animals died in drought year including, goats, sheep, cattle, and camels due to lack of forage and drinking water whereas animals needed medication were 5546. Average monetary loss per household in shape of animals died was 78426 PKR. And average monetary damage per household in shape of total medication cost on animals was 5073 PKR.

Coping strategies of the households against the drought were not sufficient enough to tackle the negative impacts of drought, although all the households adopted coping strategies to fight against the drought. Adaptive capacity influencing factors or socio-economic variables like education of the household's head, number of educated person in household, working members in a household do not have much impact on the coping strategies opted by the households. But income have a significant role in some of the coping strategies opted like water storage techniques, migration, and installation of solar panels. Households with higher income likely to opt water storage techniques, and solar panels as a coping strategy whereas households with lower income likely to opt migration as a coping strategy.

5.2 Policy Recommendations

Study finding based policy recommendations are as follows:

- Droughts are a common phenomenon in desert ecosystems. But the droughts are more frequent and intense in recent years than earlier years, as indicated by the data collected by PMD[9] and local people of Tharparkar. People of Tharparkar witnessed their worst experience of droughts in 2014. The region should be paid special attention by providing special early drought monitoring for the future. Pro-active approach is required to tackle the disaster instead of prevailing lazy and not sufficient re-active approach.
- It was found that socio-economic condition of the people living in the rural areas of Tharparkar is poor. The average monthly income of Households was 10562 PKR, which is not sufficient to survive in any disastrous conditions. Authorities should plan to uplift the socio-economic conditions of Tharparkar. Programs like Benazir Income Support Program (BISP) should specially be initiated for Tharparkar region.
- It was found that in most of the villages, schools were limited to primary standard. And for acquiring middle and higher education, students had to move far from village to cities like Mithi, Chachro, and Diplo. Which is a difficult process as most of the villages do not have the road links to cities. Authorities should provide at least middle or high school in each village and should provide incentives to the teachers to work in such environment.
- Health status of the region was also seemed to be disturbed. although most of the villages had primary health units, but most of them were not in working position when I myself visited and reported by the respondents too. People were found to be helpless against Diarrhoea, Malaria, and Cholera. And for any emergency case, they have to move to city government hospital, which was miles away from the villages. There should be special care units near or in the villages working 24 hours or at least

[9] Pakistan Meteorological Department

current basic health units (BHUs) buildings should be functionalized and staff should force to pay their duties as these diseases outbreak in the droughts and need rapid action and care.

- In the drought of 2014 people faced total destruction in their crops due to lack of rain at appropriate time. Authorities should compensate the household's cropping loss by providing them an appropriate amount of money.
- The point of extreme depression for the households in the drought of 2014 was their loss of livestock. 5546 animals needed medication and more than 5000 animals died. Authorities should compensate the households with an appropriate amount of their losses.

5.3 Limitation of the study:

The study goes through different methodologies adopted from different researches to achieve the objectives, however there were some major limitations which if filled will increase and strengthen the in-depth analysis of each aspect taken in the study. The main reasons for such limitations were

1. Time: to conduct the research which was approximately four to five months.

2. Financial limitations: as it was difficult travel and stay in a remote area being a student without provided financial aid.

3. Recall method: as data collection process was based on recall method, it was difficult to collect data on all the aspects as respondents only remembered main events and figures.

Following are some limitations of the study

1. Comparison between the Talukas is not conducted in the research as District was taken as whole.

2. Regarding health cost, conversion of number of hours' people suffered from any disease into hourly wage rate is not done in this research.
3. Economic value is not assigned to the environmental loss and damage, as such type of loss and damage comes under non-economic loss and damage in the context of climate change, but a value can be assigned to those loss and damage as well.
4. In cropping loss and damage, a value to loss due to zero production (loss of un earned income) in drought year is no taken.
5. Loss and damage are taken for only one year of drought, as the impact of drought can be much longer than only the year it hit the area.
6. Malnutrition is not taken as a disease in health loss, as malnutrition is mainly caused by deficiency of water.
7. In livestock loss and damage, monetary value of milk not produced is not taken.

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APPENDIXES:

Appendix A: Questionnaire of the Household Survey

I am a student of MPhil Environmental Economics at PIDE, Islamabad. This survey being administered to know your perceptions and opinion about the climate stressor drought affecting the Tharparkar area. I would like to ensure that the information/feedback provided by you will be kept confidential and will only be used for academic research purpose. Your cooperation in this regard will be highly appreciated. Thanks.

Questionnaire No: _____

Socio Economic information

Name of Respondent: _____

Name of H.H head: _____

Gender: _____ (Male/Female) *Tehsil: _____*

Village: _____ *Age: _____*

Family size: _____Males: _____, Females: _____,

Years of schooling of HH head (No. of years): _____

No. of educated person in HH_____

No. of Working members in HH_____

No. of non-working member in HH_____

Occupation a) Cropping b) Livestock keeping 3) Own Business 4) Others

Primary sources of income: _____

Secondary sources of income: _____

Total monthly income (Rs): _____

Loss and Damages

How you experienced the recent drought effects?

a) *Severe* ***b)*** *Not severe* ***c)*** *No affects*

Which sector of your financial livelihood you experienced effects?

a) *Cropping* ***b)*** *livestock* ***c)*** *other*

Do you have knowledge about the catastrophe that hit your area most frequently?

Yes: _____ ***No: _____***

Education:

Are your children getting education?

Yes: _____ ***No: _____***

No. of children getting education:

Male_____ Female_____

School available in the village:

Yes: _____ ***No: _____***

Distance from the school (Kms):_____

Transportation available to reach the school:

Yes: _____ ***No: _____***

Do the recent droughts effect your children's education?

Yes: _____ ***No: _____***

If yes, then please mention that which gender of child got effected?

Male_____, Female_____, Both_____

According to your perception, does the number of absentees of your children increase during droughts?

Yes: _____ ***No: _____***

Health

Distance from basic health unit or hospital Kms;_____

Name of Disease	**No. of Person affected (Drought Period)**		**No. of Person affected (Normal Period)**		**Type of Health Facility**	**Total Medicine Cost (One time/One person**	**Travel Cost Per (Visit)**	**Doctor Fee (per visit)**
	Male	**Female**	**Male**	**Female**				
Malaria								
Diarrhoea								
Cholera								
Fever								
Other								

Environment

Did your household observe fresh water scarcity during the recent drought period?

Yes: _____ ***No: _____***

Did you witnessed that the pastures were damaged during the recent drought period?

Yes: _____ ***No: _____***

Did you observed that the productive capacity soil is decreased during and after the recent drought period (means that the soil is not providing that much yield as compared to the pre-drought period)?

Yes: _____ ***No: _____***

Did you witnessed that desertification is increased during and after the recent drought periods (means that the sand particles are now more common in the soil as compare to the pre-drought period)?

Yes: _____ ***No: _____***

Any of the animal species harmed or damaged during the recent drought period?

Yes: _____ ***No: _____***

If Yes, then Specify the names_____; _____; _____;

Any of the plant species harmed or damaged during the recent drought period?

Yes: _____ ***No: _____***

If Yes, then Specify the names_____; _____; _____;

Cropping

Did you felt that the crop production decrease during the recent drought period?

Yes: _____ ***No: _____***

Did you witness crop flier in the recent drought period?

Yes: _____ ***No: _____***

Was your crop seed destroyed during the recent drought period?

Yes: _____ ***No: _____***

Crop Grown	Area Cultivated (Acres)		Yield per Acre		Seed per Acre		Fertilizer Usage NPK Ratio (per acre)		Cost per Acre (Rs)	
	Drought Period	Normal Period	Drought Period	Normal Period	Drought Period	Normal Period	Drought Period	Normal Period	Drought Period	Normal Period

Livestock

Did you experience lack of forage for your animals in the drought period of 2014?

Yes: _____ ***No: _____***

Did you observe that the drinking water for your animals was short during the drought period of 2014?

Yes: _____ ***No: _____***

Did your animals die due to this deficiency in during drought period of 2014 or suddenly after the drought period?

Yes: _____ ***No: _____***

Did you observe that the selling prices of animals decreased during the drought period?

Yes: _____ ***No: _____***

Name of Animal	**No. of Animals**		**No. of Animals died**		**No. Animals needed medication**		**Total Medication Cost per animal**	**Travel Cost Per (Visit)**	**Doctor Fee (per visit)**
	Drought period	**Now (normal period)**	**Drought period**	**Now (Normal period)**	**Drought period**	**Now (Normal period)**			

Economic Impact of Drought (Household's Perception)

Did the recent drought period lead to higher prices of food items?

Yes: _____ ***No: _____***

Did you witness any damage to the crop quality during the recent drought period?

Yes: _____ ***No: _____***

Did you witness any loss from dairy, livestock, and crop production during the recent drought period?

Yes: _____ ***No: _____***

Did any of your household members witness unemployment during the recent drought period?

Yes: _____ ***No: _____***

Do you feel that the recreational/visiting sites and tourism was affected during the recent drought period?

Yes: _____ ***No: _____***

Did you witness that the food items were imported from other localities in higher number in the recent drought periods than normal period?

Yes: _____ ***No: _____***

Do you feel that the low rain fall is the major cause of food shortages in Tharparkar region?

Yes: _____ ***No: _____***

Coping Strategies

Coping strategies applied during the drought period:

Selling property/ Animals _____

Type of property sold_____, selling price _____

Which animal_____, quantity sold_____, price_____

Migration _____

Water storages techniques _____

Earn extra income _____

Help and support from NGO's _____

Plastic mulching to preserve moisture in the soil _____

Modified food consumption _____

Private loan_____

Crop diversification_____

Begging_____

No actions taken _____

If no action taken, then what is the reason;

Lack of financial resources to take any action _____

It's not your responsibility _____

lack of knowledge _____

lack of other resources _____

Do you feel the coping strategies were sufficient to prevent the negative effects?

Yes: _____ ***No: _____***

If yes, then any improvement you felt in the situation?

Yes: _____ ***No: _____***

Appendix B: Logistic Regression Results (Copied from Stata)

---

name: <unnamed>

log: C:\Users\Akbar Economist\Desktop\new estimations.log

log type: text

opened on: 4 Aug 2017, 14:55:36

. logit waterstorage

Iteration 0: log likelihood = -227.20121

Iteration 1: log likelihood = -227.20121

Logistic regression Number of obs = 384

LR chi2(0) = 0.00

Prob > chi2 = .

Log likelihood = -227.20121 Pseudo R2 = 0.0000

---

waterstorage | Coef. Std. Err. z P>|z| [95% Conf. Interval]

---+---

_cons | .9511887 .113824 8.36 0.000 .7280977 1.17428

. logit waterstorage hhs hhed wm nedp inc

Iteration 0: log likelihood = -226.87408

Iteration 1: log likelihood = -169.96982

Iteration 2: log likelihood = -158.72849

Iteration 3: log likelihood = -157.68524

Iteration 4: log likelihood = -157.6384

Iteration 5: log likelihood = -157.63836

Iteration 6: log likelihood = -157.63836

Logistic regression Number of obs = 383

LR chi2(5) = 138.47

Prob > chi2 = 0.0000

Log likelihood = -157.63836 Pseudo R2 = 0.3052

---

waterstorage | Coef. Std. Err. z P>|z| [95% Conf. Interval]

---

hhs | .6565384 .0939936 6.98 0.000 .4723143 .8407625

hhed | .053818 .0390708 1.38 0.168 -.0227594 .1303954

wm | .0827632 .1408788 0.59 0.557 -.1933542 .3588806

nedp | .0736847 .141661 0.52 0.603 -.2039658 .3513353

inc | 2.291411 .6480924 3.54 0.000 1.021173 3.561649

_cons | -4.717278 .825448 -5.71 0.000 -6.335127 -3.09943

. mfx

Marginal effects after logit

y = Pr(waterstorage) (predict)

= .88173467

---

variable | dy/dx Std. Err. z P>|z| [95% C.I.] X

---

hhs | .0684629 .0151 4.53 0.000 .038865 .098061 4.85901

hhed | .0056121 .00423 1.33 0.185 -.00268 .013904 2.68668

wm | .0086304 .01466 0.59 0.556 -.020101 .037361 1.50392

nedp | .0076837 .01476 0.52 0.603 -.021249 .036617 .574413

```
    inc |   .2389452      .03948    6.05   0.000    .16156  .316331   1.40731
------------------------------------------------------------------------------

. *(1 variable, 384 observations pasted into data editor)

. logit migration hhs hhed wm nedp inc

Iteration 0:   log likelihood =  -262.0697
Iteration 1:   log likelihood = -256.61155
Iteration 2:   log likelihood =  -256.6063
Iteration 3:   log likelihood =  -256.6063

Logistic regression                             Number of obs     =        383
                                                LR chi2(5)        =      10.93
                                                Prob > chi2       =     0.0529
Log likelihood =  -256.6063                     Pseudo R2         =     0.0208

------------------------------------------------------------------------------
   migration |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         hhs |   .1079387   .0483311     2.23   0.026     .0132116    .2026658
        hhed |  -.0131847   .0279992    -0.47   0.638    -.0680622    .0416927
          wm |  -.1434564   .0917809    -1.56   0.118    -.3233437    .0364309
        nedp |  -.0136888   .0916147    -0.15   0.881    -.1932503    .1658727
         inc |  -.3116655   .1385981    -2.25   0.025    -.5833128   -.0400183
       _cons |   .4480301   .3074559     1.46   0.145    -.1545724    1.050633
------------------------------------------------------------------------------

. mfx

Marginal effects after logit
      y  = Pr(migration) (predict)
```

```
      =  .56828618

------------------------------------------------------------------------------
variable |      dy/dx    Std. Err.     z    P>|z|  [    95% C.I.   ]      X
---------+--------------------------------------------------------------------
     hhs |   .0264814     .01185    2.24   0.025   .003259  .049703   4.85901
    hhed |  -.0032347     .00687   -0.47   0.638  -.016698  .010228   2.68668
      wm |  -.0351952     .02252   -1.56   0.118  -.079332  .008942   1.50392
    nedp |  -.0033584     .02248   -0.15   0.881  -.047411  .040694   .574413
     inc |  -.0764631       .034   -2.25   0.025  -.143097 -.009829   1.40731
------------------------------------------------------------------------------

. *(1 variable, 384 observations pasted into data editor)

. logit sellingproperty hhs hhed wm nedp inc

Iteration 0:   log likelihood =  -240.4215
Iteration 1:   log likelihood = -231.53515
Iteration 2:   log likelihood =  -231.4773
Iteration 3:   log likelihood =  -231.4773

Logistic regression                             Number of obs     =        383
                                                LR chi2(5)        =      17.89
                                                Prob > chi2       =     0.0031
Log likelihood =  -231.4773                     Pseudo R2         =     0.0372

------------------------------------------------------------------------------
sellingproperty |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
----------------+-------------------------------------------------------------
            hhs |   .0109098   .0503135     0.22   0.828    -.0877028    .1095224
           hhed |  -.0465122   .0292884    -1.59   0.112    -.1039164     .010892
             wm |  -.0987536   .0928612    -1.06   0.288    -.2807582    .0832511
           nedp |  -.0252578   .0974109    -0.26   0.795    -.2161796     .165664
```

```
         inc |  -.5056488   .1412496    -3.58   0.000     -.782493   -.2288046
       _cons |   1.725263   .3305949     5.22   0.000     1.077309    2.373217
------------------------------------------------------------------------------

. mfx

Marginal effects after logit
      y  = Pr(sellingproperty) (predict)
         =  .68539554
------------------------------------------------------------------------------
variable |      dy/dx    Std. Err.     z    P>|z|  [    95% C.I.   ]      X
---------+--------------------------------------------------------------------
     hhs |   .0023525      .01085    0.22   0.828  -.018909  .023614   4.85901
    hhed |  -.0100294      .00631   -1.59   0.112  -.022388  .002329   2.68668
      wm |  -.0212941      .02002   -1.06   0.288  -.060534  .017946   1.50392
    nedp |  -.0054463       .021   -0.26   0.795  -.046612   .03572   .574413
     inc |  -.1090323      .03038   -3.59   0.000  -.168583 -.049481   1.40731
------------------------------------------------------------------------------

. *(1 variable, 384 observations pasted into data editor)

. logit privateloan hhs hhed wm nedp inc

Iteration 0:   log likelihood = -251.45353
Iteration 1:   log likelihood = -246.32683
Iteration 2:   log likelihood =  -246.2954
Iteration 3:   log likelihood = -246.29538

Logistic regression                             Number of obs     =        383
                                                LR chi2(5)        =      10.32
                                                Prob > chi2       =     0.0668
Log likelihood = -246.29538                     Pseudo R2         =     0.0205
```

```
------------------------------------------------------------------------------
 privateloan |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         hhs |   .0766381   .0496909     1.54   0.123    -.0207543    .1740305
        hhed |   .0168559   .0291082     0.58   0.563    -.0401952     .073907
          wm |  -.1303256   .0917886    -1.42   0.156    -.3102278    .0495767
        nedp |   .1481218   .1048064     1.41   0.158     -.057295    .3535387
         inc |  -.2962515   .1398523    -2.12   0.034    -.5703568   -.0221461
       _cons |    .678259   .3147191     2.16   0.031     .0614208    1.295097
------------------------------------------------------------------------------
```

. mfx

Marginal effects after logit

```
      y  = Pr(privateloan) (predict)
         =  .63832398
------------------------------------------------------------------------------
variable |      dy/dx    Std. Err.     z    P>|z|  [    95% C.I.   ]      X
---------+--------------------------------------------------------------------
     hhs |   .0176932      .01146    1.54   0.123  -.004764  .040151   4.85901
    hhed |   .0038915      .00672    0.58   0.562  -.009278  .017061   2.68668
      wm |  -.0300878      .02118   -1.42   0.155  -.071595  .011419   1.50392
    nedp |   .0341964      .02415    1.42   0.157  -.013137   .08153   .574413
     inc |  -.0683945      .03225   -2.12   0.034  -.131609  -.00518   1.40731
------------------------------------------------------------------------------
```

. *(1 variable, 384 observations pasted into data editor)

. logit solarpanels hhs hhed wm nedp inc

Iteration 0: log likelihood = -200.19889

```
Iteration 1:   log likelihood = -175.01259
Iteration 2:   log likelihood = -173.99401
Iteration 3:   log likelihood =  -173.9929
Iteration 4:   log likelihood =  -173.9929

Logistic regression                     Number of obs     =        383
                                        LR chi2(5)        =      52.41
                                        Prob > chi2       =     0.0000
Log likelihood =  -173.9929             Pseudo R2         =     0.1309

------------------------------------------------------------------------------
 solarpanels |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         hhs |   .0322829   .0588713     0.55   0.583    -.0831028    .1476686
        hhed |  -.0171379   .0361459    -0.47   0.635    -.0879826    .0537067
          wm |    .514089    .122936     4.18   0.000     .2731388    .7550391
        nedp |  -.0704785   .1261878    -0.56   0.576     -.317802    .1768451
         inc |   .8444356   .1555821     5.43   0.000     .5395004    1.149371
       _cons |  -3.474743   .4300504    -8.08   0.000    -4.317626   -2.631859
------------------------------------------------------------------------------

. mfx

Marginal effects after logit
      y  = Pr(solarpanels) (predict)
         =  .19110017
------------------------------------------------------------------------------
variable |      dy/dx    Std. Err.     z    P>|z|  [    95% C.I.   ]      X
---------+--------------------------------------------------------------------
     hhs |   .0049903      .00911    0.55   0.584  -.012861  .022842   4.85901
    hhed |  -.0026492      .00559   -0.47   0.636  -.013605  .008306   2.68668
      wm |   .0794683      .01936    4.10   0.000   .041521  .117416   1.50392
```

Appendix C:
FIELD SURVEY

Focused group discussion with local farming community of village Jassar, Talluka Mithi.

Household survey in village Jassar, Talluka Mithi.

Household survey of village Veesasar,Taluka Chachro.

Governemnt primary school of village Bhaosanda, Taluka Chachro.

Visitng primary school of village Bathu sanda, Taluka Diplo

Water storage well constructed for domestic use purpose. This was one of the coping strategies used by the households to store water.