IMPACT OF FLOOD DISASTER ON THE PEOPLE'S LIVELIHOOD AND ADAPTATION TO ITS EFFECTS IN THE CHENAB RIVERINE AREA, MULTAN DISTRICT, PUNJAB, PAKISTAN (1992-2015)

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ABSTRACT- The study manages the consequence of the flood catastrophe on the lives and infrastructure of the residents in the Chenab riverine area with reference to weather conditions and public perception. The area is characterized by hot, arid climates having long hot summers and warm short winters. About 616 km^2 study area is consisting of an active flood plain with 33% of the total population. The mean water discharge of the river watercourse rises from January to August and diminished ahead till December. The sum of acreage at risk in Shujabad tehsil is 5.4 TAF as compared to 11.6 TAF (thousand-acre feet) in Jalalpur Pirwala tehsil. During the summer monsoon, the seasonal inundations have been effected the local infrastructure due to deforestation, residential planning, local participation, flood knowledge, population growth, environmental impact assessment (EIA) policy, etc, and required adaptation.

Keywords: Flood, Affects, Preparedness, Management, Vulnerability, Response, Rehabilitation

I. INTRODUCTION

During summer monsoon lows, the water discharge in the Chenab river has an effect on the residents, who are based on either side of the river in respect of their displacement from original settlements, and damages to infrastructure and livelihood. Pakistan's authorities and attached organizations are attempting to overcome the catastrophe problem in the urban and suburban localities of the Multan district, which are located at risk but they are not accomplishing anything to prevail over the problem[1]. The catastrophes are mainly caused by torrential rainfall, cloudburst, glacier retreats, climate change, snow, and ice liquefying and boasted of lakes and dams. The agriculture sector of Pakistan is based on the irrigation system routed from the different dams constructed on the Indus River and its main tributaries. However, the high discharge of the rivers during summer as well as winter seasons are originating catastrophes, since its separation from India (1947) and affected the human settlements, crops productivity, socio-economic sector, hospitals, transportation, communication, food supply chain, gardens, administrative buildings, education, and industrial sector. The flood disaster is not a new science in the Indus basin. Historically, the remains of the well-planned cities of Harappa and Mohen Jo Daro of the Indus valley civilization (2500-1500 BC) show that they were destroyed by a severe flood disaster.

IPCC [2] has stated that the global projected temperature may be raised and will be more effective for the change in the surface hydrology, crop productivity, sea-level rise, and human ecosystem. Furthermore, Pakistan stands at number eight in the list of high-risk climate change vulnerable countries of the world [3]. It is also predicted that in 2050, the declination of fresh water supply will be a critical issue in South Asia and affect more than one billion people. Furthermore, Pakistan is exposed to various natural disasters such as cyclones, floods, intense precipitation, earthquakes, landslides, heat waves, and droughts, which are the result of climate change in the area. Among other disasters, the 60 percent of Pakistan's landmass is at risk for floods, and counts as a major factor of poverty in the area [4]. The UNO [3] has estimated that the failure in the global economy owing to catastrophes is 50 to 60 billion US dollars. The catastrophes originated with estimated damages of 136 billion US dollars and 22800 losses to human lives in the Asian countries.

Multan district is placed between 29^0-22` to $30^0$- 29` north latitudes and 21^0-30` to $22^0$-28` east longitudes over the globe (Fig. 1). In the east, it is covered by Khanewal district; Lodhran, Bahawalpur districts in the South, and Muzaffargarh district in the West. The Chenab River border the study area in the West [5]. The most outstanding researchers who have been studying the flood disaster in Pakistan and at the global level are; [6-14] etc.

II. METHODS AND MATERIALS

The current work discusses the evaluation, impact, adaptation, and mitigation to flood catastrophes with weather conditions in the Chenab riverine area, Multan district for the time duration of 1992-2015. The hypothesis testing during the course of the study is, that "*the flood disaster has affected the lives and livelihood of people residing in the Chenab riverine area in Multan district and required mitigation to overcome the issue.*" The work stands on the examination of rainfall as an independent element, while the temperature, water discharge, accommodations, farming, learning, livestock, water supply, health, transportation, sanitation, migration, atmospheric pressure, humidity, fogs, wind speed, and visibility as dependent variables. The secondary data of mean temperature, precipitation and water discharge, etc of the river have been collected from Pakistan Meteorological Department, Islamabad, and WAPDA Lahore. A total of 100 feedback forms have been accumulated from the locals using a random sampling method. The various investigation tools employed throughout the study consist of observations, field visits, questionnaires, discussions with stakeholders, maps, graphs, mathematical and statistical models, and GIS/RS. A master sheet has been prepared for the field information and the results have been cross-matched with precipitation, temperature, and river flow and presented in the form of a research report.

III. RESULTS AND DISCUSSIONS

The annual mean monthly temperature is 25^0C with a high of 26^0C in 2013 and a low of 24^0C in 1997. The ever recorded high mean daily temperature of 41^0C is noted on 7^{th} June 1994, whereas the lowest of 18^0C on 24^{th} January 2002. The

area remains hot during June and cold in January. The climate of the area is hot continental having high temperatures in summers and warm in winters with arid climates (Table-1, Fig. 1). The ever recorded daily maximum temperature of about 50^0C has recorded on 7th June 1994 and the lowest daily minimum temperature of about 10^0C in January 2001. The summer season in the area lasts for seven months (April to October) and five months of winter (November to March). The area recorded total precipitation of 197.9mm (7.8 inches) and falls in arid climates. The ever recorded precipitation of 2134.2mm (84 inches) was recorded in 2015.

Based, on precipitation the two main seasons of the area are sub-divided into four rainy seasons that is winter (Mid-October to Mid-April), pre-monsoon (Mid-April to June), monsoon (July to Mid-September), and post-monsoon season (Mid-September to Mid-October). The average number of rainy days is 1.8 having the maximum in February and the lowest in November. The number of days with fogs is 1.2, relative humidity 56% with sea level pressure of 1008 MBs, wind speed 5.1 (km/hr), and visibility 4.0 km. Generally, only sea level pressure, wind speed, and the number of rainy days show an increase throughout the series, while there is a decrease in the excluding weather elements (Table-1).

The water discharge capacity of Trimmu Barrage is approximately 600 thousand cusecs, which are declining progressively appropriate to sedimentation and filling up the river bed. Obviously, the river flow increases after May and exceeds 50 thousand cusecs in June and continues till mid-September. Annually, due to high temperature and melting of glaciers in the catchment area, July and August are constituted as the peak flow months (Table-1, Fig. 1).

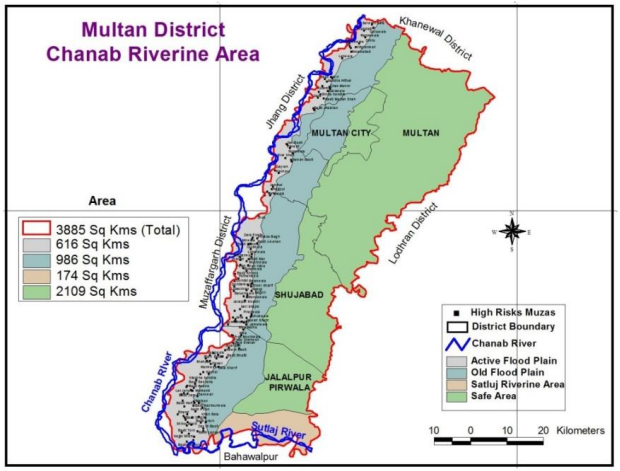

Fig-1 Chenab and Sutlej River Riverine Area, Multan district, Punjab

The river surpasses the heavily colonized areas including Sargodha, Khanewal, Gujrat, Muzaffargarh, Jhang, and Multan districts. These territories are vulnerable to flood catastrophes approximately every year in the summer season. As the flood disaster of the river is pronounced about six hours before the exact time, it is, therefore, hard to take protective measures for emergency response in a short time period. Generally, the flood catastrophe of the river happens owing to torrential rains and snow melting in the catchment area. The input of snow melting in the sum of river flow is 40 percent. The most dangerous flood catastrophes recorded in the Chenab river in the past so many decades were in 2010 that have affected 227 thousand residents, in 2013 (3 thousand) and 156 thousand in 2014 respectively (Fig. 1).

3.1. Flood Riverine Area

The entirety acreage of Multan district is estimated as 4 thousand km^2 per the 2017 census of Pakistan and comprises four administrative units. The sum of the inhabitants of Multan district is 5.20 million including Jalalpur Pirwala tehsil 0.61 million, Multan city 2.61 million, Multan Saddar 1.31 million, and Shujabad 0.71 million. Among the total acreage, almost 617 km^2 areas were declared as a Chenab Riverine in addition to the 175 km^2 of Sutlej river. The total acreage of old flood plains is approximately 987 km^2, which swathes the central part of the district including Multan city. Besides, about 2110 km^2 area, which covered the eastern limits of the Multan district is absolutely protected from flood disasters, however, sometimes it is as well influenced due to overflow in the irrigation canals of both Sutlej and Chenab rivers (Table-1). More or less, one-third of Multan district residents is inhabited the riverine area of both rivers (Fig. 2).

3.2. Chenab River Discharge and Fluctuation

The annual water discharge of the Chenab river is 490, 000 acre-feet with a heaviest of 490,100-acre-feet between 2006-2015 and a lowest of 489,400 acre-feet from 1991-to 1995. Per annum, in January, the average monthly water discharge is 483,100-acre-feet and represents a minimum discharge of the year. The water discharge rises up to 491, 300 acre-feet in August with the increase in summer temperature conditions and considered a high flow month of the year. Throughout, the monsoon season (July, August, and September), the water surge of the river stays lofty owing to intense rainfall and snow melting in the Himalayas and is considered a season of extreme catastrophe in the upper and lower Indus plains. The yearly tendency of river discharge shows that the flow swells commencing January-August and reduces continually up to December (Table-1; 2).

Table-1 Deviation of Annual Flow, Rainfall, and Temperature of Chenab River (1991-2015), WAPDA, Lahore

Year	Flow	Rainfall	Temp	Year	Flow	Rainfall	Temp
1992	0.0	-0.5	-0.5	2005	0.2	0.4	0.5
1993	-0.4	-0.6	-0.7	2006	0.5	-0.6	-0.7
1994	-0.6	-0.3	0.1	2007	0.6	0.9	0.6
1995	-0.7	-0.4	-0.3	2008	-0.2	0.3	0.2
1996	0.4	-0.7	-0.5	2009	0.6	0.1	-0.2
1997	-0.2	-0.9	-0.4	2010	0.1	0.2	0.2
1998	0.0	-0.9	-1.3	2011	0.6	0.7	0.5
1999	-0.1	-0.1	0.0	2012	0.3	0.6	0.1
2000	0.0	0.2	0.5	2013	0.5	0.0	-0.2
2001	-0.7	-0.1	0.3	2014	0.1	1.0	0.2
2002	-0.3	0.1	0.2	2015	0.2	0.3	-0.4
2003	-0.2	0.3	0.6	2016	-0.3	0	0
2004	-0.4	-0.2	0.0	Sum	**0.1**	**-0.3**	**-0.6**

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The yearly tendency of water discharge reveals that from 1991 to 2015 the minimum pour of 489,100-acre-feet observed during 1995 and 2001 and declared the years of lowest flow of the river. The highest flow of 290, 400 acre-feet was recorded in 2007 as well as 2009 and constitutes the heavy water discharge years. During 1991-1995, the water discharge of the river indicates a decrease in the water surge,

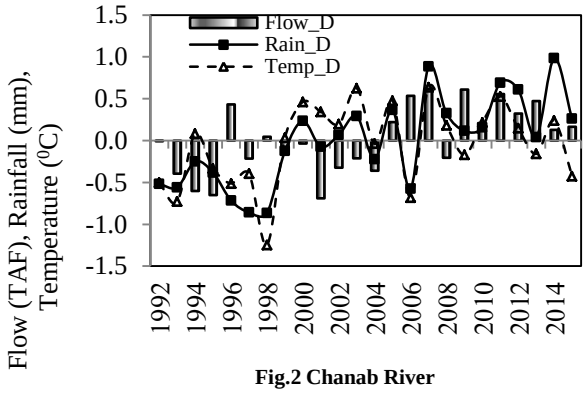

Fig.2 Chanab River Comparison of Water Flow, Rainfall and Temperature (1991-2015)

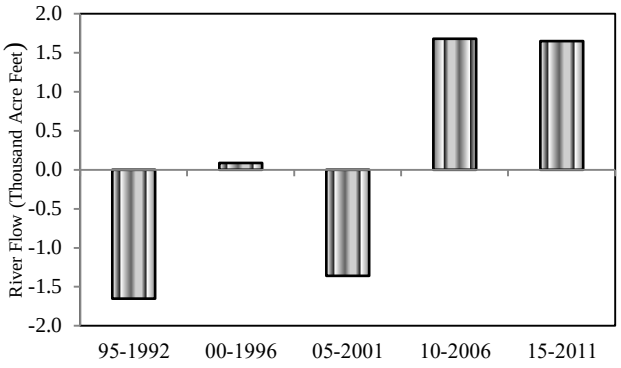

Fig. 3 Chanab River Deviation of Five Years Upstream Flow at Trimmu Headwork

which rises up between 1996 to 2000 with a negative turn in 2001-2005 and remains high till 2012 and falls for a second spell till 2015 (Table-2; Fig.3). Obviously, the annual tendency of water discharge of the Chenab river reveals a linear trend during the time period of 1991-to 2015 with a regression value of 0.226, which is below the normal value. Furthermore, the flow was directly proportional to the precipitation and inversely proportional to the temperature condition in the last three decades. But recently, the trend is inverted and it is mostly based on the melting of glaciers having a directly proportional to the temperature condition in the catchment area of the river.

The departure of mean monthly discharge from the average level recorded over Trimmu headwork during 1991-2015 has been studied and presented in figure-2 and table-2. The annual flow of the river remained low during 2001 and maximum in 2007. The tendency of data indicates that the departure from the annual water discharge of the Chenab river remained below the average line during 1991-2004 excluding a few years, however it remained positive till 2015 having ups and downs in 2008 and 2015 respectively. The total water departure from the average value is 0.1 thousand acre-feet which represents a rise in the water discharge. The statistical analysis of the deviation trend indicates a regression of 0.468 thousand acre-feet and closer to the normal condition and predicted a decrease in the coming decades (Table-2). Normally, the water discharge reveals a direct correlation with the temperature and precipitation condition in the catchment area of the Chenab river (Fig. 2.

3.3. Impact of Floods

During the 2014 inundation, three camps have been established in Multan City, seven in Multan Saddar, and six each within Shujaabad and Jalalpur Pirwala tehsils to rescue the residents at risk and to shift them urgently to the nearby camps during emergency response. The sum of overflow distressed villages in the Chenab riverine area was 121, consisting of 12 villages in Multan City, 49 within Multan Saddar, 27 in Shujabad, and 33 in Jalalpur Pirwala tehsils (Fig-1).

Table-2 Chenab River, Five Years Upstream Flow at Trimmu Headwork (1991-2015), WAPDA, Lahore [6]

Year	Jan	Feb	Mar	Apr	May	Jun	Jul
1992-95	482.1	488.1	489.50	489.60	489.90	490.4	490.9
1996-00	484.5	489.1	489.8	489.90	490.4	491.2	491.4
2001-05	483.2	487.3	489.6	489.6	490.4	490.5	490.8
2006-10	482.5	488.8	489.8	490.4	491.1	491.3	491.6
2011-15	483.3	490.3	490.2	490.3	490.5	491.1	491.3
Average	483.2	488.7	489.8	489.8	490.5	490.9	491.2
Year	Aug	Sep	Oct	Nov	Dec	Ave	Devi
1992-95	491.2	491.3	490.4	489.6	489.7	489.3	-1.70
1996-00	491.3	491.1	488.8	490.1	490.1	489.9	0.10
2001-05	491.1	490.8	490.3	490.6	490.6	489.6	-1.40
2006-10	491.7	491.6	491.3	491.1	490.6	490.2	1.70
2011-15	491.6	491.4	490.8	490.5	490.5	490.2	1.60
Average	491.4	491.3	490.5	490.5	490.3	489.9	0.40

Perceptibly, throughout inundations, the dislocated residents were adjusted in twenty-two emergency camps. The population affected by the 2014 inundation was 0.6 million. The sum of land areas influenced by the inundation was 0.30 million acres consisting of 0.70 million cultivated land having crops and mango gardens. During the 2013 inundation, the sum of affected residents was 3000 people, in contrast to the 157 thousand people in 2014. Moreover, there was only one missing person during the 2013 flood, while there were 12 people missing in 2014. The number of partially/completely destroyed villages in 2013 was 111 in contrast to 121 villages in 2014 inundation. The sum of moderately destroyed residences was 139 in 2013, which reached 4866 residences in 2014. The completely destroyed residences in the 2013 flood were 31 as compared to the 7960 residences in the 2014 flood. It is concluded, that the 2014 inundations were more destructive in contrast to the flood disaster of 2013. Refers to the funding from the Government of Pakistan, the authorities have paid 30.1 million Pakistani rupees to the catastrophe sufferers in 2013, while it was about 1838 million PKR in 2014 for the rehabilitation of their livelihood (Fig. 1).

The satellite images of Chenab river earlier than and later than inundation calamity 2014 reveal that at Muhammad Walla headwork, the sum of discharge covered space of Chenab river was 270.0 meters having 478.0 meters of active merged land in the east and 824.0 meters towards west. Over Muhammad Walla's headwork, the discharge of the river was wrapped by a solitary waterway, whereas it was dispensed

into many waterways and flowed over an enormous land range of 3670.0 meters at the center of the Multan district and 2000.0 meters at the intersection amid Satluj river in the south. Due to erosion, the area covered by the river before the 2014 flood is lesser than the area submerged by the water flow after 2014. Resultantly, due to the rise in the subsurface water and waterlogging, a very big ratio of cultivated land was last by the locals affecting the crops as well as fruit production in the area.

3.4. Public Opinion about Adaptation

The residents of the Chenab riverine plains have been persuaded regarding the pre and post-disaster preparedness and management plan by the government of Pakistan, though, they have stipulated for the advancement and to compose certain the well-being of the inhabitants. The victims expressed that the stakeholders publicized the threats of inundation catastrophe earlier than downpour utilizing the mass communication and to aware the locals. The residents highlighted the lowest satisfaction level about the construction and widening of the river course, as well as embankments having positive expressions about the government monitoring system and demanded the community training programs, provision of safety jackets, first aid boxes, and other lifesaving tools to the locals. Furthermore, the people have recommended adding necessary steps in the disaster planning for the safety of special people, flora, fauna, agriculture, transportation facilities, food, and security issues. For the mitigation, the people have recommended the availability of basic life needs, safety, food, baths, drinking water, toilets, education, and health facilities in the camps.

Most of the victims are residing or shifting during flood season into the active flood plains for the solidarity and grants of the government of Pakistan as well as the national and international community. It is, therefore, recommended to shift all of the people who resided in the riverine area into nearby safe places from the highly vulnerable areas for their safety during the pre-disaster stage and to provide them with life facilities in the refugee camps. They are also demanding a pre-disaster risk survey before the heavy flow in the Chenab river. The residents have the opined that the people of the riverine area are the first to respond the flood catastrophes so; it will be appreciated if the government of Pakistan makes sure their training and facilitate them before the flood. Furthermore, the people are not pleased by the response of government stakeholders, particularly aviation, health, NGOs as well as navigation activities, and demanded the expansion of their services to the high-risk areas and to treat everybody equally.

Every year, the inundation catastrophes destroyed the infrastructure of the residents of the riverine area so; the government is required to make proper planning for the rehabilitation process on an emergency basis as well as to release equal funds to the locals for their damaged assets per market rates so, that the poverty level and economy of the people remained stable. Moreover, the government of Pakistan shall be engaged the local community in the rehabilitation works as well as a monitoring system of the funds for the purpose to make sure the utilization of funds properly and also to shift the people from camps within a limited time period.

IV. CONCLUSION AND RECOMMENDATIONS

The Multan district is characterized by an arid climate with long hot summers and warm short winters. There is a decrease in the temperature, rainfall, relative humidity, number of rainy days, atmospheric pressure, and visibility of the area, while the excluding variables indicate a positive trend throughout the series. Chenab River is 616.0 km^2 compared to 174.0 km^2 riverine areas of Sutlej river and an old flood plain area of 986.0 km^2. Roughly, one-third of the locals in Multan district are inherent in the Sutlej and Chenab riverine lands. The annual water discharge of the Chenab river is 490 thousand acre-feet with an increasing trend from January to August and decrease till December. The yearly water discharge of the Chenab river is directly comparable to the precipitation and temperature conditions in the river watershed areas. Almost, 0.6 million residents were affected by the flood disaster and were rescued from 121 high risks settlements in the district. The locals suggested constructing new dams, barrages, headwork, an extension of the irrigation system, improved the disaster planning and preparedness, community training, socio-economic awareness, health facilities, education, communication network, sanitation, and water supply, river embankments, pre-disaster vulnerability surveys, mass media, alerts system, crops, priority to rescue special people and fauna, and land insurance program, etc to overcome the issue.

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