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Flood Risk Assessment of Nowshera City and Remediation

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Abstract

The climate change during the year 2010 showed an abrupt change and resulted in catastrophic floods in Pakistan and especially in Khyber Pakhtunkhwa (KPK). Thereby, there is a dire need of identifying the flood-prone areas and emplacement of flood protection structures at Nowshera city to protect the precious lives of the inhabitants and infrastructure. This paper focuses on identification of flood-prone areas, with a view to suggest remediation against flood risk to Nowshera city. A detailed methodology has been adopted and as a first step; field study of the area has been carried out to ascertain the flood limits of flood 2010 to ascertain flood risk areas and in the second step the statistical analysis of hydro-meteorological data has been done with the help of 43 years record of precipitation of Peshawar Basin, 10 years record of snowmelt and 13 years record of discharge of river Kabul, in order to ascertain the reoccurrence period and climatic variability. Based on flood risk assessment, structural measures like construction of flood protection bund/ embankments, bypass channels/inundation canals, dam, breaching sections to dispose of excess water, removal of encroachments/slump settlements, tree plantation in catchment areas and nonstructural measures like implementation of land use laws and preparation of flood risk maps have been recommended.

Keywords*: Climate Change, Hydro-Meteorological Factors, Precipitation, Flood Risk, Structural and Nonstructural Measures*

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BACKGROUND

The occurrence of disasters in the world has increased manifolds since 1970s. Over the last fifty years, Pakistan had experienced more than 150 natural disasters. Since then, more than 58 million people have been affected by various calamities with estimated damages of $ 20 B [1]. Disasters are predominately hydro-meteorological, geological and climatological and comprise of floods, landslides, earthquakes and droughts. Floods being the most frequently occurring calamity and affect many people in the country. It has been calculated that 90% of the worst natural disasters that occurred after 1900 were floods with three of them in last three years i.e., 2010, 2011 and 2012 [2]. Vulnerability is increasing in the region due to climate change, greater occurrence of extreme events and warmer temperatures. This change has caused huge and unpredicted rainfalls in the past four years in all parts of Pakistan especially in KPK. One of the major phenomena in KPK is flooding. However, in the year 2010, the monsoon system resulted in mega floods in Kabul river system. The magnitude was so significant both in scale and destruction in comparison to Earth Quake (EQ) 2005, Tsunami 2004 and Haiti EQ 2010 [3, 4]. This catastrophe will symbolize a day of sorrow and grief for the entire KPK for times to come. The unprecedented event played havoc in a matter of hours. As a result, over thousands of people lost their lives, many of houses were damaged, and a number of small villages and towns were submerged. Almost fours have been passed and protection works on river Kabul at Nowshera were inadequate. There is a dire need of remedial measures against the flood risk to save the people and infrastructure, to evaluate the flood risk data of Nowshera city and determine reoccurrence and climatic variability. The main objectives of this study were to identify flood-prone areas, and suggest possible mitigation and flood routing measures for the flood prevention in the subject area.

RIVER KABUL AND ITS MORPHOLOGY

River Kabul starts from Afghanistan and runs 485 Km before joining River Indus in Pakistan. In Pakistan, the length of the river is 75 Km and the depth varies from 4–7 M and width vary from 200–300 M approximately excluding river playing areas/valleys [5]. There are seven tributaries of river Kabul in Pakistan from Warsak Dam to Nowshera and only Kalpani Nullah exists in the area under study [6, 7].

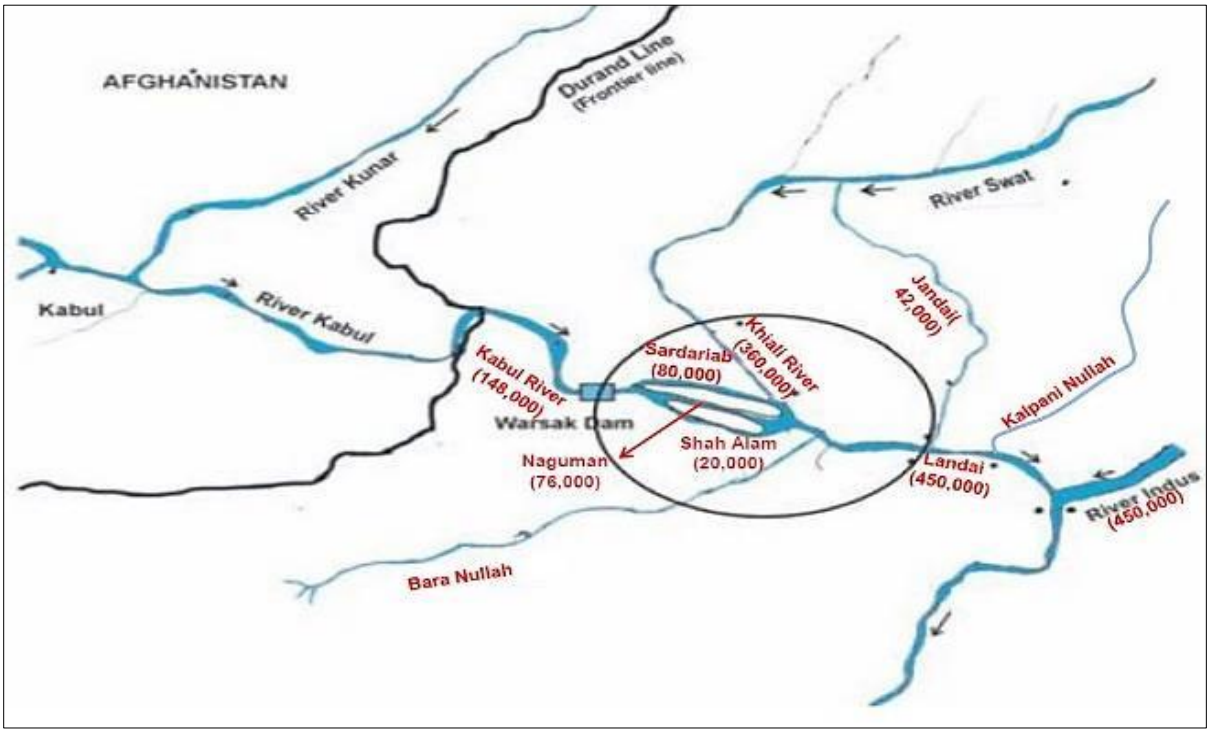

Fig. 1: *The Kabul River and its Tributaries.*

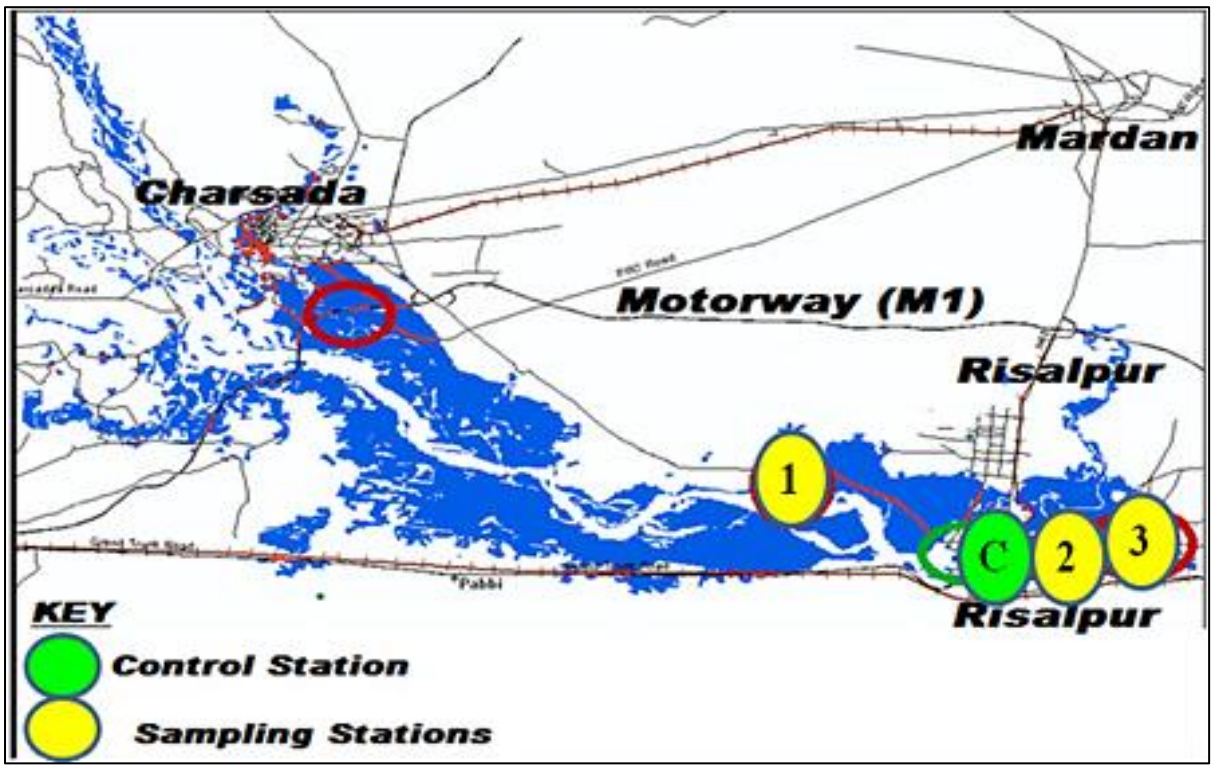

Fig. 2: *Image Showing Scope of Study.*

To recommend structural and nonstructural measures on both banks of river Kabul in Nowshera city, following areas and conditions have been kept in consideration (Figure 2).

a. Area selected for the study is 12 Km along the river Kabul (Kheshgi Bala—Nowshera Kalan and Pir Sabak).
b. Kabul bridge on Mardan-Nowshera road (N45) will be the control point and four sampling stations/node points are Kheshgi Bala, Nowshera Kalan, Nowshera city and Pir Sabak.
c. For pragmatic analysis, 43-year-record of annual monsoon precipitation, 10 years record of snowmelt and 13 years data of discharge of Kabul River has been analyzed.

MATERIALS AND METHODS

Following methodology has been adopted for hazard assessment and indication of mitigation measures at Nowshera city.

Step 1: *Field Survey of Nowshera City—2010 Flood Scenario*

Field study to ascertain the spatial flood limits (flood 2010 scenario) of Nowshera city along the Kabul river has been carried out. Area has been visited along both the banks of the river Kabul from Kheshgi Bala to Pir Sabak and Nowshera city to outskirts of Risalpur (Figure 3). During flood 2010, the discharge was huge and there were no flood protection arrangements along both the banks, therefore devastating flood inundated much of the area. Had the proper flood protection arrangements were in place, there should have been less /negligible damage.

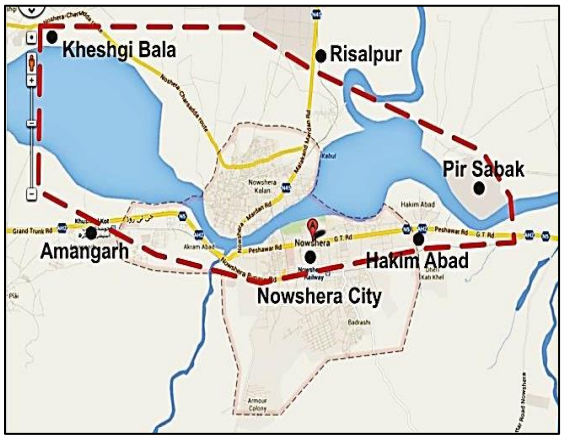

Fig. 3: *Area under Study.*

RESULTS AND DISCUSSION

A. Field Survey

(1) Condition of Area towards North Bank of River Kabul—Flood 2010 Scenario

The water overflooded the banks from Kheshgi Bala to Pir Sabak along both the banks owing to nonexistence of flood protection bund and embankments. Nowshera Kalan and Nowshera city were almost submerged in water.

People took shelter on marble rocks. All the roads were submerged [8]. The villages between river Kabul and out skirts of Risalpur cantonment/city were partially submerged and many buildings were damaged. Almost all inner local roads were impassable; however, the highway route to Mardan N45 was operational.

(2) Condition of Area Towards South Bank of River Kabul—Flood 2010 Scenario

Water overflooded the banks and considerable portions of the Nowshera city was severely flooded from the Kabul river, with a majority of buildings north of the N5 highway were severely damaged / destroyed. Most of the roads were blocked. South of the N5, damages appeared were less severe. Mostly the cantonment area suffered heavy losses. The impact of flood in the towns east of city was less than Nowshera being situated on an elevated ground. Damages were less and all bridges along N5 were intact and functional. However, there were clusters damaged buildings between the Kabul River and the N5.

B. Underpinnings of Field Survey

(1) Flood Risks to Nowshera

The physical layout of river Kabul and densely populated area of Nowshera retard the flow of water which results in water stagnation and back flow of tributaries. Owing to this back flow, adjoining areas become flooded. The inhabitants have made infrastructure right at the river banks both at Nowshera city and Nowshera Kalan [9].

There is a need to identify the river playing areas so that irrigation department is to be cleared that which area is occupied illegally by the inhabitants with a view to plan mitigation strategy at a right place.

(2) Inadequacy of Existing Infrastructure to Withstand Mega Floods

Maximum population of Nowshera was affected during the 2010 floods. This shows that almost two-third areas around river Kabul will remain under threat in times to come, if pragmatic steps are not put in place. Thereby, there is a need of constructing the flood protection structures from Kheshgi Bala to Pir Sabak.

(3) Need of Water Storage through Construction of Dam

The water storage facilities in KPK have been reduced considerably i.e., from 40% to 75%, primarily due to silting, thereby, reducing their flood impact mitigation capacities.

Therefore, the construction of Munda Dam (Power Generation Capacity = 740 MW, Storage Capacity = 1.29 MAF), on River Swat (already approved by the Supreme Court) in addition to power generation can protect up to some extent the Charsadda and Nowshera against peak floods by regulating the flow of the Swat river. Other sites are required to be explored on remaining tributaries of river Kabul to regulate the flow during peak monsoon season.

C. Problem of Water Flow Beyond Designed Capacity—Disposal of Excess Water

It has been observed that during 2010 flood the discharge of river Kabul was more than the designed capacity of 4,50,000 cusecs. This mega flow played havoc due to obvious reasons. With the construction of flood protection bunds, if discharge still crosses the designed capacity then there is a need to identify the dormant areas upstream of Nowshera city where excess water could be diverted through high flow diversions or breaching sections.

D. River Morphology and Land Erosion

One of the prime reasons of lateral inflow of water from river banks during peak flood of 2010 was erosion of banks. Why because, the stratum of bank near Nowshera is loose and no flood protection arrangements exist on the banks, thereby, banks were easily eroded and area astride both banks was inundated. There is a need of protective works (Figure 4).

Fig. 4: *Northern Bank of River Kabul West of Nowshera Kalan—Showing Loose Strata.*

E. Problems of Flood Plain Encroachments

Many inhabitants in the area under study live in river playing area of river Kabul and low lying areas thus susceptible to flood damages. There is a need to identify the right way of river Kabul at Nowshera.

F. Lack of Tree Plantation in Catchment Areas of River Kabul

There is very less tree plantation in catchment areas of river Kabul. Flood water erodes the soil and even normal flows are converted into flash floods. Therefore, there is a need of tree plantation drive in catchment areas of river Kabul.

Step 2: *Evaluation and Analysis of Met Data*

For this purpose, 10-year-record of snowmelt, 43-year-record of precipitation and 13-year-discharge of river Kabul have been used to ascertain flood reoccurrence period. The main purpose of flood hazard assessment in the floodplains of Kabul river at Nowshera is to ascertain and analyze the flood hazard zones [10]. As per the profile, dimensions and current of water of river Kabul at Nowshera city, the discharge of 1,50,000 cusecs can pass easily within the deep channel and discharge more than this will swell over.

A. Monsoon Rainfall and Snowmelt Profile, 2000–2013

From Figure 5 it is anticipated that from the last 10 years, there is a huge increase in snowmelt and monsoon system in the country.

B. Precipitation and Discharge Profile, 1970–2013

Statistical analysis of precipitation data has given clue of high magnitude rainfall events

and their anticipated recurrence period in Kabul river basin (Figure 6).

C. Discharge Profile, 2000–2013

For this purpose, discharge (2000–2013) of Kabul river at its Nowshera gauging station has been deliberated. Variation in the discharge in 13 years has been shown by various peaks in the graph (Figure 7).

From the 43 years precipitation analysis, it is contemplated that the 2010 monsoon flooding event had a probability of occurrence after 75 years. Flood frequency curve has been made on peak annual average precipitation data [11]. The discharge at river Kabul during 2010 was beyond the measurable gauge. Flood-prone areas have been ascertained with the help of above mentioned data.

PROJECT OUTCOME SUGGESTIONS/ RECOMMENDATIONS

A. Structural Measures

Based on current analysis, following mitigation strategy is recommended to save the people of Nowshera (Figure 8):

(1) Section A: Northern bank of river Kabul from Kheshgi Bala to the western edge of Nowshera Kalan:

(a) Construction of flood protection bund at existing road.

(b) Height: 5–6 feet and length: 6 Km approximately.

(2) Section B: Northern bank of river Kabul along Nowshera Kalan:

(a) Construction of embankment (1.5 Km).

(b) Height: 5–6 feet.

(3) Section C: Construction of flood protection bund on both the sides of the river along Nowshera city:

(a) Construction of embankment /Gabion structure.

(b) Height: 5–6 feet and length: 10 Km (approximately).

(4) For pragmatic mitigation strategy to tackle flood hazard at Nowshera, further study and work is recommended in the following areas:

(a) Analysis of each tributary of the river Kabul to control and regulate the flow.

(b) Construction of channel/inundation canal upstream of Nowshera city to connect with Kalpani Nullah to reduce the flood effects.

(c) To identify the dormant areas upstream of Nowshera where excess water could be diverted through high flow diversions or breaching section.

(d) To explore more sites on river Kabul and its tributaries for new dams to contain and regulate the water flow.

(e) Tree plantation drive in catchment areas of river Kabul through the Forest Department.

B. NonStructural Measures

(1) Feasibility study is suggested to be carried out to identify right of way, river playing areas and unplanned settlements, so that it should be clear that which area is illegally occupied and requiring mitigation measures. Implementation of land use laws must be ensured.

(2) Flood risk map of Nowshera city must be prepared and updated every year after the flood.

Fig. 5: *Average Winter Snowfall (Inches) During the Period 2005–2013 in the Months of January–March.*

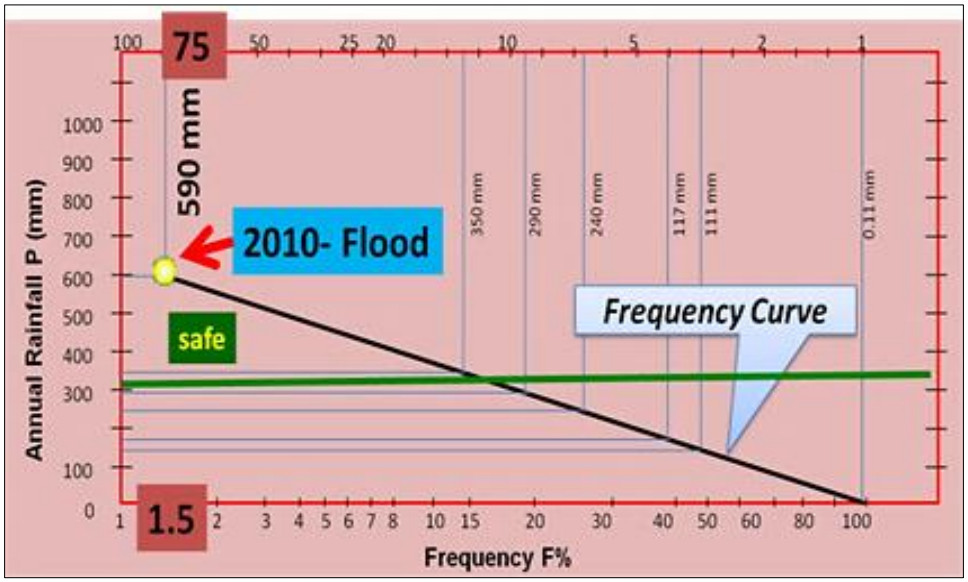

Fig. 6: *Precipitation Data of Nowshera, 1970–2013. Working is based on Hazen Method.*

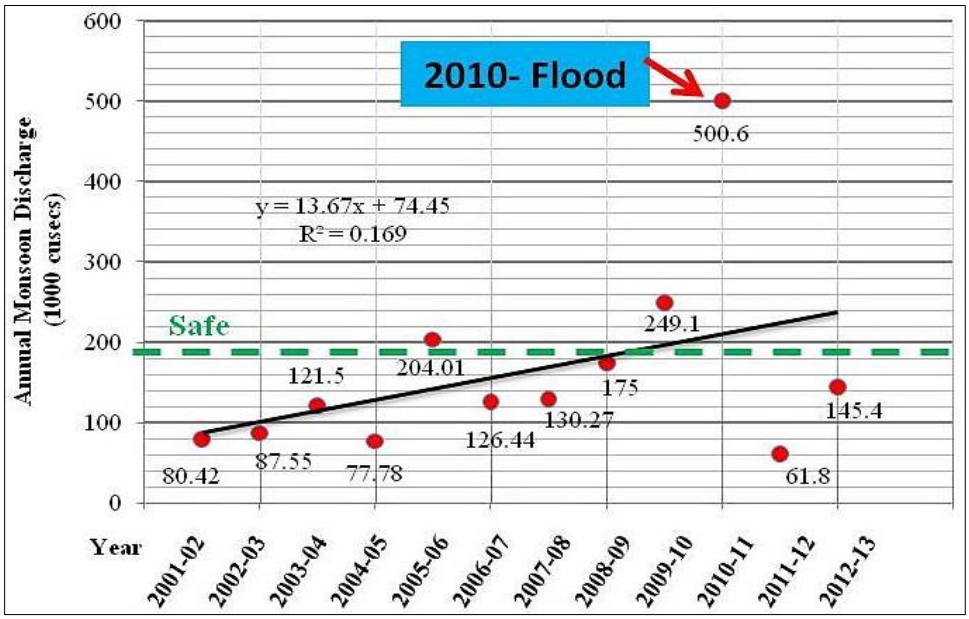

Fig. 7: *Kabul River Discharge Data 2010 (June–Sept).*
(Ranking of Annual Monsoon Precipitation, Probability of Occurrence, and Return Periods for Charsadda and Nowshera).

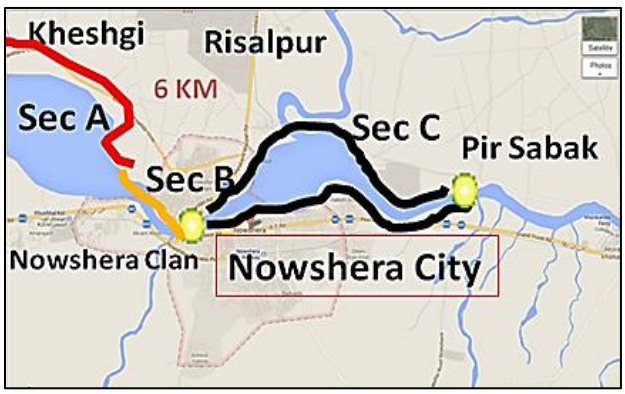

Fig. 8: *Flood Protection Measures from Kheshgi Bala to Pir Sabak.*

CONCLUSIONS

a) From flood 2010, almost four years have been passed and no proper flood protection structures exist at Nowshera and inhabitants are vulnerable.
b) Most of the inhabitants are settled right on the river bank along the Nowshera city. It is difficult to up stick these people; hence some strategy is required to save these people from flood hazard. There is a need to identify the right of way of river.
c) During 2010 flood in river Kabul, most of the areas were flooded due to back flow of tributaries. Thereby, problem needs to be identified.
d) Bypass channels and inundation canals can pay rich dividends in case of peak flood conditions to regulate the water in addition to increase in crop production. These are required to be explored.
e) The construction of Munda dam, on river Swat in addition to power generation can protect up to some extent the Charsada and Nowshera against peak floods by regulating the flow of the Swat river. Other sources must be identified.
f) Upon construction of flood protection bund, still if flow occurs more than designed capacity then, there will be a need to dispose of excess water.
g) Heavy losses occurred in floods 2010 due to huge unplanned settlement in flood-prone areas. Still this illegal construction is being carried out.
h) One of the reasons of flash floods during 2010 was soil erosion due to absence of trees in the catchment areas. Therefore, there is a need of tree plantation drive.
i) Reoccurrence period results will be more precise, if flood frequency curve is made on peak average monthly precipitation record instead of yearly.
j) There were no adequate arrangements in place to forewarn vulnerable communities of flash flooding during flood 2010. This needs to be enhanced.

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