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Understanding and Assessing Flood Risk Management in Balochestan Iran: With Integrated River Basin Approach, Future Direction

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Abstract: A holistic perspective on changing rainfall-driven flood risk is provided for the late 20th and early 21st centuries. Balochistan is exposed to different types of floods that cause severe economic losses, damage to infrastructures, and loss of lives. Reliable information on the drivers, patterns and dynamics of flood risk is crucial for the identification, prioritization and planning of risk reduction and adaptation measures. Here, we present a systematic review of existing flood risk assessments in Balochistan. We evaluate the current status, persisting gaps, and challenges regarding the understanding and assessment of flood risk in this large province. A society well-aware of risks must not only give attention to the prevention of flood risks but must also consider disaster management, i.e. minimizing casualties and flood damages, and enhancing recovery. Balochistan has No solid network of levees along any of the rivers that protect the many low-lying polders from flooding, however the government trying to build few in Sarbaz river from Shirgwaz to Kolani and in Kajo river from Kalat to Dalgan. Well, nature is unpredictable, extreme events may happen, and absolute protection against flooding cannot be offered. It is common practice to perform technical and economic analyses to determine the feasibility of flood protection plans and also institutional and administrative aspects are addressed. But how the people that live in the polders feel about the flood risk and protection plans seldom gets attention.

Keywords: Disaster risk reduction, Flood, integrated flood risk management, risk assessment, vulnerability

1. Introduction

The study was conducted at Damen and Bampur rivers in Iranshahr district, Kajo river in Kaserkand district, Sarbaz River, Rapch and Kahir rivers in Chahbar district. Thus location up on which this study concentrates is bounded by the coastline of southern Iran and Western Pakistan, approximately, by the line of latitude 25˚ to the South and the line of longitude 60˚ to the west. The area consists of an inland chain of steeply sloping bare rock (mountains) which drain onto a coastal alluvial plain. The analysis is based on a multi-sites analysis approach, since the five rivers locations are not considered sufficiently similar to be pooled together. The Study Area might be classified as “Tropical Triple season Moderate Climate Zone”, which is characterized by single rainfall season from July-September and its moderating influence in temperature. The river flow and rainfall temperature pattern of the area based on the record of data obtained from the Iranian Meteorological and water resources organization department. Iran continues to suffer from natural hazards that threaten to affect the lives and livelihood of its citizens. Due to its unique geo-climatic conditions, Iran is one of the most disaster prone countries in the world and undergoes natural disasters including floods, earthquakes and drought. A location plan is shown in Figure 1.

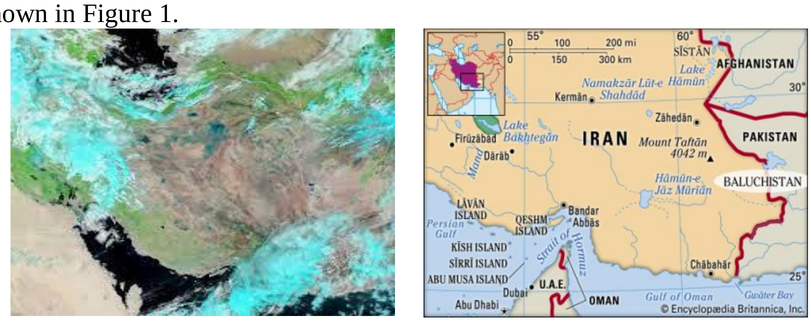

Figure 1: The area of study Rivers Damen, Bampur, Rapch, Kajo and Sarbaz.

2. Materials and Methods

The area of the study is near the border of Iran and Pakistan. The study was conducted in six different and the biggest rivers in Balochistan are Damen, Bampur, Kajo, Sarbaz and Kahir. The area is located near the borders of Iran and Pakistan. Thus location up on which this study concentrates is bounded by the coastline of southern Iran and Western of Pakistan, approximately, by the line of latitude 25 degree to the South and the line of longitude 60 degree to the west. The area consists of an inland chain of steeply sloping bare rock (mountains) which drain onto a coastal alluvial plain. The analysis is based on a multi-sites analysis approach, since the five rivers locations are not considered sufficiently similar to be pooled together [1, 22].

Data for in this paper has been obtained from the Water Resources Department of the Islamic Republic of Iran Meteorological Organisation (IRIMO) and relates to the Province of Sistan and Balochistan. It is noted that there is also a neighbouring Province of Balochistan to the west in Pakistan. The climate of the region varies from subtropical arid and semi-arid to temperate sub-humid in the plains of Sistan and Balochistan. The river discharge rate of flow data studied in this paper comes from the southern part of the region including the port of Chahbar [1].

The study was conducted at Damen River in Iranshar District, Kajoo River in Dashtyari District and Sarbaz River in Bahu and Dashtyari. The analysis is based on a multi-sites analysis approach, since the two rivers locations are not considered sufficiently similar to be pooled together. The Study Area might be classified as “Tropical Triple season Moderate Climate Zone”, which is characterized by single rainfall season from July-September and its moderating influence in temperature [21]. Therefore, flash flood disasters occurred in Iranshar district on cities on 20/7/ 2019 which is illustrated in figure (2).

Figure 2: Illustrates human effects on riverine flood risk disasters River Damen and Bampur Overtopped levee during the flash flood in July 2019

3. The Level of Flood Protection

The level of flood protection along rivers in the Balochistan is among the highest in the Iran. According to the Iranian Law on flood protection, dikes along the main rivers must all be built for 2014 year design flood. This uniform high level of protection has been realized in the last decades by reinforcing the hundreds of kilometers of levees along the rivers. This way of protecting city from flooding seems to have been effective: the last river flood causing dike breach and flooding several cities occurred in 2019 as a result of the highest Damen river discharge ever recorded with about 4025 m^3/s. In 2015 and 2019 again huge floods occurred, although the discharge remained well below that of 2012. Still, in 2014 the cities along the Damen River experienced a narrow escape from being flooded. Since then, the gradually neglected levees have been heightened and strengthened at full speed [12, 14].

The 2014 and 2019 floods raised flood risk awareness again. At the same time, the debate about the – primarily technical –flood protection philosophy in Iran was resumed [4]. Of course, Iran can cope with the increasing frequencies and levels of floods due to climate change by heightening and strengthening the levees. But with flood levels in the rivers going up and the population and economy in the low-lying cities growing at a steady pace, a dike breach may turn into a disaster. A change in protection philosophy can already be observed as, firstly, the government received, accepted and adopted a *room-for-the-river* policy aimed at lowering flood levels by giving more room to the rivers instead of heightening dikes and let the flood levels go up, and as, secondly, the government now seriously considers the purposeful inundation in order to protect downstream polders from accidental flooding [3, 16]. The 2014 and 2019 floods made many people feel uneasy, but the present planning of room-for-the-river measures and calamity cities provokes real commotion among the people involved. People living in the would-be calamity polders, for example, are very worried about the plans and protest. And although it is common practice to perform technical and economic analyses to determine the feasibility of measures, and whilst also institutional and administrative aspects are often taken into account, the question of how the people involved feel about the plans get only little attention. Therefore, this paper discusses some psychological aspects which are relevant for practical flood risk management and risk communication. It addresses questions such as how people – especially in the this particular region in Balochistan – feel about living along rivers, whether they are concerned about flood risk at all, and how do they expect a flood will affect their lives. We address these issues, as flood risk management for a modern society requires that social and psychological issues are seriously taken into account in decision making. Based on the discussion, elements are identified that should be considered in the further development of a flood risk management strategy for Balochestan [4].

4. Flood Problems in General Perspective in Balochistan

It is recognized world over that floods are the most destructive of natural hazards and the greatest cause of large-scale damages to lives and properties. Over the years, major floods have occurred in almost all the South Asian countries, causing huge loss of life and properties. Despite the investment of millions, even billions of dollars in efforts to tame the rivers of the region, the frequency of occurrence of major flood disasters has actually increased over the past 25 to 30 years. Consequently there is a growing consensus that the impacts of climate change may well lead to an increase in both the frequency and the magnitude of floods. Nevertheless mankind has to live with the floods and devise measures to better manage them to minimize the losses and harness benefits [1].

Seven major floods that have hit the country since 1980 caused economic losses and damages estimated as $2.0 billion US dollars. Recorded Flood Peak Discharges between 1980 and 1920, floods of various magnitudes occurred. These floods affected the basins of the rivers in Balochistan. In Khuzestan and some areas of Bandar Abbas also, damage is caused mainly from hill torrents in which rains generate flash floods in monsoon season. In upper to mid reaches of Sistan river Basin, generally tributaries like Hamoon and Kajaki are mostly the cause of flooding. River floods particularly hit Sistan and Balochistan while hill torrents tend to affect the hilly areas of Balochistan and Northern areas. Districts of Hamoon, Iranshar and Dashtyari are exposed to risks from flooding. In recent years, vulnerabilities of large cities to flooding have increased. Cities like Mazendaran, Shiraz and Awaz have experienced flooding due to inability of sewerage system to cope with heavy rains [10]. Therefore, flash flood disasters occurred in Iranshar district in July 2019 which is illustrated in figure (3).

Figure 3**:** Illustrates human effects on riverine flood risk disasters occurred in Iranshar district overtopped levee in July 2019

5. Causes of Floods in Balochistan

The major cause of floods in Balochistan is heavy concentrated rainfall in the river catchments; generally result into floods in rivers during the monsoon season. Occasionally, Monsoon currents originating in the Bay of Bengal (India) and resultant depressions often result in heavy downpour in the additionally affected by the weather systems from the Arabian Sea (Seasonal Low) and from the Mediterranean Sea (Westerly Wave) cause destructive floods in one or more of the main rivers in Balochistan basin System. However, in some cases exceptionally high floods have occasionally been caused by the formation of temporary natural dams due to soil erosion transportation. There are large seasonal variations in almost all the river discharges, which further aggravate the river course and morphology [7]. The major rivers cause flood losses by inundation of areas along their banks by damaging irrigation and communication facilities across or adjacent to the rivers and by erosion of land along the riverbanks. In the upper part of the Iranshar Basin System floodwater spilling over the riverbanks generally returns to the river. However, in the lower part of Iranshar district, the River, which is primarily flowing at a higher elevation than adjoining lands, spills do not return to the river. This phenomenon largely extends the period of inundation resulting in even greater damages. Although flood protection by embankments has been provided along almost the entire length in Sistan and Balochistan Province and at many locations in the upper areas, the bund breaches can still occur. Such breaches often cause greater damage than would have occurred without the bunds because of their unexpected nature and intensification of land use following the provision of flood protection [5].

The inadequate existing discharge capacity of some of the important structures like: Barrages, Roads and Bridges in Balochistan Rivers like Damen and Sarbaz. During exceptionally high floods this results in afflux on the upstream side, which sometimes results in breaches in the flood embankments. At times, the flood embankments have to be deliberately breached at pre-selected locations to save the main barrage structures and other vital settlements and installations in the vicinity. The encroachment of village population in riverine areas has also increased the quantum of flood damages and losses to humans and livestock. As there is no proper regulatory frame work in the country regarding the settlement in riverine areas, most of the poor people have constructed their shelters along the vulnerable river banks and become victims to devastating floods. Some people are making the most of these areas for business purpose through promoting agriculture and cattle Ghats/dairies. All such activities are extending beyond the safe limits of riverine areas to achieve more economic benefits but in fact are posing a great threat to unprecedented and unruly flood; the losses due to which may be in hundred multiples of such small scale economic profit. The river catchments and flood plains are to be kept as prohibited area for the riverine community especially during the flood season [16].

6. Flood Control Objectives & Need

Flood management planning and practices in Balochistan aim at achieving the following objectives:

I. Reduction of flood losses in an economically sound manner.
II. Prioritizing of areas of greater economic hazards.
III. Protecting the cities and vital infrastructural installations.
IV. Exploring the possible use of existing flood control facilities.
V. Promoting appropriate land use in flood hazard areas.
VI. Minimizing adverse effects on national ecosystem and environment.
VII. Creating flood awareness and adaptability in the riverine areas.

7. Why Flood Management is imperative

Flood remains as an annual unwanted visitor in many countries. It often takes the shape of a disaster and badly affects people lives as well as the economic activities in the affected areas. Even experienced administrators and engineers are often caught by surprise under the emerging situation in taking decisions concerning necessary emergency measures. Floods affect agricultural and industrial production, services, and marketing systems adversely and directly by damaging and/or destroying physical infrastructure, floods also disrupt passage/flow of goods and services to the flood affected communities [7].

People living in marooned areas become extremely distressed. Unfortunately, these people often do not find adequate and appropriate shelters; quality food and drinking water; adequate and hygienic sanitation; privacy for women, particularly for the lactating mothers and adolescent women etc. Floods often force the students out of academic activities since their learning centers are often used as makeshift flood shelters in affected areas. These disasters not only affect micro- and household-level activities but also have macro-economic/budgetary implications. As resources are required to address the relief and rehabilitation requirements, budgetary reallocation becomes necessary, adversely impacting on development activities from which resources are transferred. Moreover, contribution to national exchequer may be reduced, as people may be unable to pay their taxes as well as utility services. Floods also create health hazards for the affected people. Widespread water borne diseases may loom large. Paradoxically, although there is excess water, potable water becomes very short in supply. The traditional potable water sources suddenly disappear or become dangerously contaminated [6]. After shelter, the most sought after commodity in a flood situation is the potable water. Shelters often become congested with people of all ages, exhausted, in ill health, and suffering from water and vector-borne diseases. Sometimes due to disruption of communication, doctors are not available in the marooned villages.

In order to provide better services to flood victims during and after floods it is necessary to examine existing flood management capabilities and identify gaps with a view to develop and introduce a better flood management system. The cultural context of the affected people is an important aspect and should therefore be considered in developing the approach/ approaches to flood management [18].

8. Integrated Approach in Flood Management

In the past, floods were considered as a hydrological reality; only structural and non-structural measures were adopted to deal with this phenomenon, but now well-being of the people of the flood prone areas, their economic growth; and social urgency for alleviating poverty prevailing in these floods affected areas, are over riding concerns.

Enough hard work is required to address these concerns from both national and regional perspectives. The regional approach is of particular significance as activities undertaken in one country may affect, positively or negatively, the extent of floods in the other regional countries, particularly the downstream ones [18].

To make full use of the experiences gained from flood management activities in the regional countries there is pressing need for exchange of views and experiences, data and information sharing, and working together to develop approaches and methods to address pertinent flood management issues, nationally and regionally, in an open and trusting atmosphere [17].

9. Flood & Disaster Protection Works for Disaster Risk Reduction (DRR)

Flood is a natural disaster and demands continuous improvement in our existing structural and non-structural measures in order to reduce losses from such eventualities. In order to fulfill Government of Iran commitment to save fertile lands and adjoining agricultural land from recurring floods and to fully incorporate the aspect of disaster risk reduction (DRR) in the planning, site selection & implementation in the flood protection and river training infrastructure, there is a need to launch a flood protection project with emphasis on safe construction accounting for DRR strategies to better fight/mitigate flood hazard [6].

The project envisages construction and provision of structural and other non-structural interventions for flood mitigation on various rivers and streams spread throughout the country. The proposed river training and flood control works for major rivers are located mainly in the province of Sistan and Balochistan along river Damen and its major tributaries i.e. Bampur, Shahrdaraz, and Abter including some other secondary and tertiary rivers. Flood protection works along the hill torrents have been located in the province of Sistan and Balochistan.

10. Suggested Response

There are vital global lessons to learn from the ongoing flood catastrophe in Iran. The main lesson is that mismanagement of river systems for the benefit of short-term gain, such as along the Balochistan, has major long-term costs, some other valuable lessons include:-

1. The pre-flood planning seems to be absent. There is an immediate need to build water reservoirs which would hold the excessive water. This would help Balochistan in two ways; frequency and level of floods can be controlled and water can be utilized for agriculture and hydro power [14].
2. NWMO has emerged as merely a policy organ which lacks the administrative capability. There is a need for capacity building of it.
3. Political differences and lack of coordination between federation and provinces have added insult to injury in flood situation. A coordinated approach was absent and it has been felt that political are exploiting the floods card for their personal gains. Synchronized federal approach for disaster management is the need of hour.
4. Breaching of water channels by changed the course of flood causing numerous looses to life and property. Judicial inquiry against the law breaker must be carried out to control the human factor of the disaster.
5. The rise in the planet temperature has reached a tipping point and people are now in a scary new era of extreme weather. Therefore, every effort should be made to cut greenhouse gas pollution.
6. Stop weather disasters to become catastrophes. It means increasing the resilience of infrastructure, economies and communities. Greater resilience in Balochistan would include better emergency warning and evacuation systems, better flood protection for key infrastructure and plans to help communities recover once the water recede [15].

11. Stability Analysis on Inundated Flood Plain Based on Flow Characteristic

Recent years have seen an increase in the intensity of extreme rainfalls and the frequency of floods caused by climate change. As a result, South Iran (Sistan and Balochistan province) is facing an ever-increasing risk of flooding due to monsoon and typhoons in the summer season. In South Iran, since the implementation of the Five Major Rivers Restoration, a variety of eco-friendly riverfront facilities, such as ecological parks as well as sports and recreation areas have been constructed on floodplains [18]. These riverfront facilities have a high risk of damage due to inundations during the rainy season. To perform hydraulic analysis and stability assessment of these facilities, accurate numerical modeling is necessary. First and foremost, it is crucial to address the dry/wet (DW) phenomena caused by rising and falling water level [12].

Extreme precipitation events are likely to become more frequent and more extreme under a changing climate. It follows that monetary damages from flooding would also increase relative to baseline, yet this relationship has not been quantified at the scale of the entire Balochistan. In this paper, we quantify how climate change could affect monetary damages from flooding in the coterminous Balochistan. With publicly available historical flooding and river flow data, we estimate region-specific logistic regression models of the probability that severely damaging floods will occur under baseline conditions [14].

We then use future river flow projections driven by climate model outputs to estimate the probability that damaging floods could occur under a business as usual ‘climate change scenario. Our results project an increase in monetary damages from flooding in nearly all regions of the Balochistan and a total increase in damages by the end of century of approximately 30% (assuming no change in built infrastructure or values). However, these changes vary between regions due to differences in the mechanisms driving flooding and general circulation model precipitation projections [16]. Thus, the significant of the figures illustrated for different wet months shown the rate of flow for the region under study and a good translation lagging behind river Damen during entire periods of the year 2019.

In the light of the storms and flood monthly maximum the calibration of river Damen basically illustrated during month of December 2019 has been tested by computer the peak discharge was 4025m^3/s ,whereas during month of December 2014 was tested 3722m^3/s, for the February 2019 was tested 256m^3/s, for the March peak discharge has been tested by excel was 854m^3/s where as for the same river on the month of April suddenly rate of flow dropped to 4 m^3/s even though for other months during summer rate of flow for Damen river is completely drought or nil discharge accordingly to the dry months when there is no rainfall in the all-region, this is the link between rainfall and storm characteristics and its effect on monthly maximum discharge have been dealt with in the past also the storms characteristics mainly considered were the storm pattern, might be speed and direction of rainstorm moving in the downstream direction produces a higher peak flow than storms moving upstream which can be concluded that storms moving at the same speed as the stream velocity have more impact on peak discharge than rapidly moving storms [12]. Thus peak discharges are shown during flash flood which is illustrated in figures number (4 and 5).

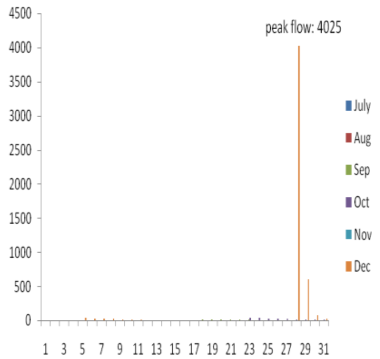

Figure 4: Monthly Maximum Rate of flow during flash flood from July to end of December 2019

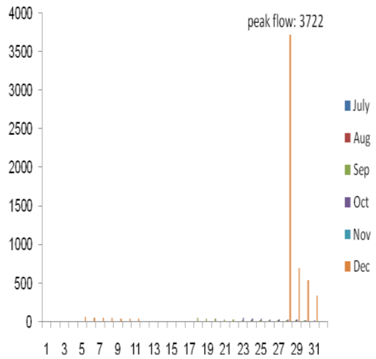

Figure 5: Monthly Maximum Rate of flow During flash flood from July to end of December 2014

12. Result and Discussions

Both discharge data from stream gauge stations and from post-flood analysis were available in the study. Discharge data from stream gauge stations were available for two cases, whereas data from post-flood analysis were used in the remaining four cases. Post-event analysis methods include a range of procedures for indirect estimation of peak discharges, generally encompassing the following steps: identification of the flow process (which was categorized into the following classes: 1- liquid flow 2- hyper concentrated flow 3- debris flow), high water marks identification, post-flood river geometry survey, and application of appropriate hydraulic methods for peak flood computation [8]. With regard to the classification of the flow process, only liquid flows were considered in this study. Together with peak discharge values, post flood analysis methods were used also to derive time of the raising flow, flood peak time, and rate of recession. Timing estimates were obtained based on eye witness's interviews and accounts. A standardized method for post-event analysis was used throughout the study. Estimates of flood peak for the earlier events were reviewed considering the original field notes, photographs, reports, and documentation, and conducting field visits to the flood locations [16]. Discharge data from stream gauges were obtained based on extrapolation of rating curves from smaller observed flows. The rating curves were checked to evaluate the degree of extrapolation required and to assess the quality of the final estimates [12].

Although great care was devoted to the various steps of discharge estimations, we should note that all the peak flood data should be regarded as affected by considerable uncertainty. An accuracy of 15–20 min has been reported for the timing estimates obtained by means of eyewitnesses interviews. The large percentage of discharge data obtained from post-event analysis underlines the importance of indirect discharge estimates in setting up catalogues of flash floods. This is particularly the case for events which impact small catchment areas. Categorizes catchment areas according to the method used to derive the peak flood data (stream gauge versus post-event analysis). Discharge data from gauging stations generally concern catchments which are significantly larger than those for which estimates are obtained from post-event analysis. This is not an unexpected finding: larger scale flash floods events have higher probability to be recorded by stream flow measuring stations, whereas events with smaller spatial extent generally impact ungauged basins. An implication of this finding is that systematic survey of flash floods is particularly important in the region where these events are climatologically characterized by smaller spatial extent, such as in the sub-continental areas. Without systematic post-event analysis, it may be unlikely to develop reliable flash flood catalogues in these areas [12, 14].

Focusing the river Damen for the purposes of water flow and gauged at two gauging station called Damen and Bampur gauging stations though the catchment for Iranshar station is $750km^2$ and the catchment area for the Damen hydrometric station is $460km^2$ however, the river network is a complex inter relationship of a historically. A conceptual approach that allowed some degree of perception of the hydrological processes to be expressed in mathematical form. The establishment and development of distributed monthly maximum flow analysis that account for the spatial variability of hydrological processes is appropriate to achieve river discharge in Balochistan, thus the different monthly maximum discharge m^3/s are illustrated in Figures (6, 7, 8, 9,10 and 11), which indicated various rate of flow for Damen River during wet months [16].

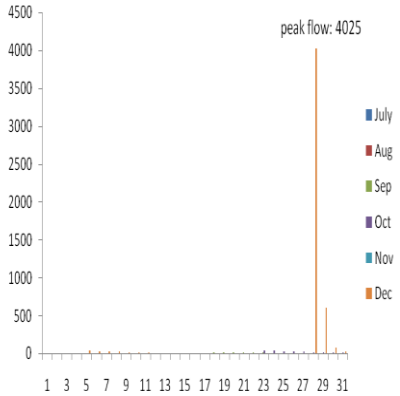

Figure 6: Monthly Maximum Rate of flow During flash flood from July to end of December 2019

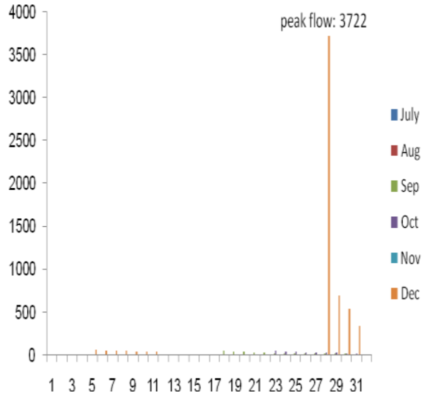

Figure 7: Monthly Maximum Rate of flow during Flash Flood from July to December 2014

The significant of the figures illustrated for different wet months shown the rate of flow for the region under study and a good translation lagging behind river Damen during entire periods of the year 2014. In the light of the storms and flood monthly maximum the calibration of river Damen basically illustrated during month of April 2019 has been tested by computer the peak discharge was $4025m^3/s$, for the February 2019 was tested $632m^3/s$, for the March peak discharge has been tested by excel was $523m^3/s$. Whereas for the same river on the month of April suddenly rate of flow dropped to 5-10 m^3/s even though for other months during summer rate of flow for Damen river is completely drought or nil discharge accordingly to the dry months when there is no rainfall in the region, this is the link between rainfall and storm characteristics and its effect on monthly maximum discharge have been dealt with in the past also the storms characteristics mainly considered were the storm pattern, might be speed and direction of rainstorm moving in the downstream direction produces a higher peak flow than storms moving upstream which can be concluded that storms moving at the same speed as the stream velocity have more impact on peak rate of flow than rapidly moving storms [12, 14].

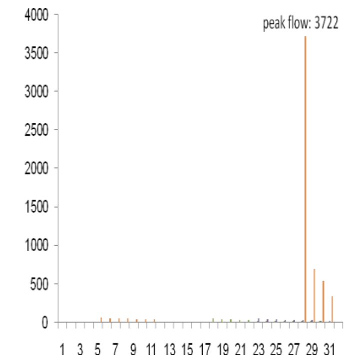

Figure 8: Monthly Maximum Rate of flow During Flash Flood from July to Dec. 2019

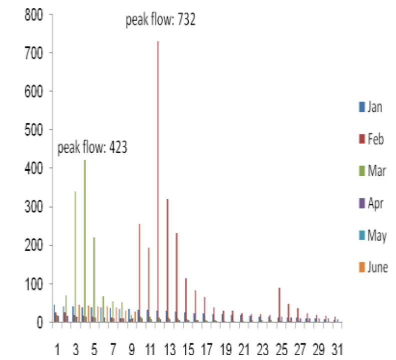

Figure 9: Monthly Maximum Rate of flow during Flash Flood from Jan to June 2019

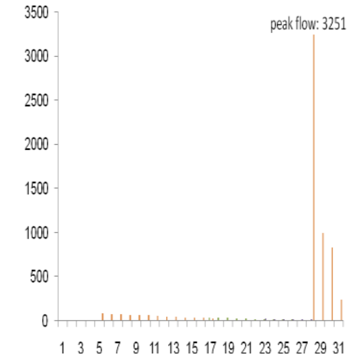

Figure 10: Monthly Maximum Rate of flow During flash flood from July to Dec. 2012

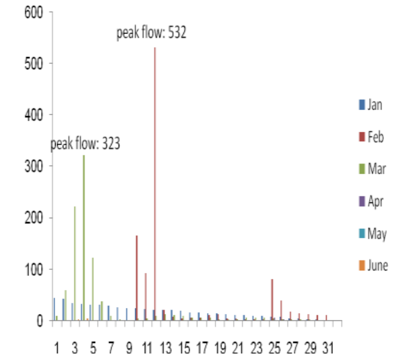

Figure 11: Monthly Maximum Rate of flow During flash flood from Jan to June 2012

13. Conclusion

Devastating floods 2019 have caused a huge loose to the people of Iranshahr and Bampur and economy of Balochistan in general and it has also posed serious questions on the mismanagement and governance issues of the country. Since floods have become almost annual phenomena, there is an immediate need to relook the flood management strategy of Iran. It is also evident from the study that huge flaws in disaster response system of Balochistan have aggravated the situation and resultantly country suffered a historical damage both in term of lives capability of National Water Organization and empower it for managing the future disasters at the war footing. It is to be remembered that only quality of the response can reduce the consequences of any disaster. Flood risk management is gaining importance in order to mitigate and prevent flood disasters, and consequently the analysis of flood risk components is becoming a key research topic. The components of the methodology are tested in floodplain areas in Balochistan recently affected by floods. The results show that the methodology can provide an original and valuable insight of flood susceptibility and vulnerability processes.

There are several approaches to assess flood vulnerability as a proactive measure to reduce the risk of flooding. The indicator-based approach is primarily practiced from a policy point of view through the use of composite indicators. Composite indicators can be built from very easy to very complex and sophisticated methods. However, there are two complications that arise with this issue. On the one hand, the flood vulnerability index should be fairly simple, taking into account the interdisciplinary nature of various stakeholders involved in flood risk management. While on the other hand, addressing the issue of subjectivity or prejudice should be scientifically defensible. As there is no a single universally “best” methodological approach for the construction of composite indicator due to its data-specific nature for each individual study.

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