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ORIGINAL PAPER

Disaster vulnerability and flood management policy framework in the Himalayas

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Abstract
The Himalayas are one of the most disaster-prone regions in the world and have experienced an increasing number of disasters, particularly floods in recent years that have hampered the socio-economic development in the region. Flood management policies are key in mitigating and managing disasters and are an important part of disaster risk reduction. In the present study, we discuss the disaster vulnerability and policy framework in the North-Western Himalayas, with a focus on the flooding in the Kashmir Valley, which is one of the most vulnerable regions in the Himalayas. Kashmir has a long history of flooding that has affected society and the environment on a wide scale. However, flood management began at the beginning of the nineteenth century. The present work explores the primary sources to make a historical analysis of flood management in Kashmir. The study provides an in-depth analysis of the important policies and proposals for flood management in the region. It discusses the top priorities established by various flood management suggestions and examines how the focus was given to Srinagar city and the reclamation of agricultural land while neglecting other areas. The study highlights the failure of the flood management plans and why the problem of flood management persists in the Kashmir Valley. The study also discusses the vulnerability of the Kashmir Valley to floods and the resultant causes.

Keywords Himalayas · Kashmir · Flood · Jhelum · Policy · Management

Introduction

Regardless of geographic or hydrological regions, floods are one of the most severe and common water-induced disasters, resulting in significant harm to habitat, infrastructure, and properties as well as having an immediate economic impact (Wasko and Sharma 2017; Ibrahim et al. 2017). Flooding is one of the most damaging disasters, accounting for around one-third of all environmental risks (Adhikari et al. 2010). Floods have piqued the interest of academics around the world in recent decades due to their catastrophic nature and capacity to cause major economic damage and life losses (Kron et al. 2012; Nied et al. 2017). Among all natural disasters, floods have generated the greatest proportion of insured losses in recent decades (Aerts et al. 2018) as disasters have myriad effects on the populations (Malik 2021). Developing countries, notably those on the Asian continent, endure approximately 90% of flood-induced disasters and 95% of the related losses (Gupta et al. 2003). Recent floods on the southern slope of the Himalaya (e.g., Pakistan, Bangladesh, India, and other South Asian nations) have killed thousands of people, displaced millions, and cost billions of dollars in damage (Kafle 2017; Kron 2005). From 1985 to 2018, other transboundary flood episodes killed over 6000 people and displaced millions in South Asia, primarily in China, Nepal, and India (Aryal et al. 2020).

The Himalayas are one of the world's largest mountain systems and among the most vulnerable regions (Gerlitz et al. 2012; Pandey et al. 2018). This mountainous region is also known as the "Third Pole" and the "Water Towers of Asia" due to the largest glacier cover outside the polar regions (Banerjee et al. 2021). The lives and livelihoods of Himalayan populations are seriously threatened by climate change, socioeconomic change, high population density,

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poverty, and environmental degradation (Malik and Hashmi 2022; Dimri et al. 2013; Khurshid et al. 2016; Sultan et al. 2022). The Himalayan countries often lack policies, methods, and plans for dealing with severe flooding. Most extant policies are related to riverine floods or disasters in general (Shrestha & Bajracharya 2013).

Flooding is the most recurrent disaster in the Kashmir Valley. It has had a deep impact on the physical, economic, social, and psychological history of Kashmir. The Kashmir Valley is one of the most food-prone Himalayan regions (Malik 2022a). The geology and geography of Kashmir Valley, including the Jhelum River, make it vulnerable to different types of disasters, especially floods, and throughout its history, the frequency of floods has been high (Dar et al. 2014). Historical records testify the occurrence of sixty-four flood events from the early seventh century to 1950 CE. (Ballesteros-Cánovas et al. 2020). The historical records reveal that the Kashmir Himalayan region has suffered heavy causalities and loss of property due to the recurrent floods (Mohammed et al. 2015). Floods affected the Kashmir Valley in 1893, 1928, 1950, 1959, 1992, 2010, 2014, 2015, 2017, and 2019 (Malik and Hashmi 2021), and most recently in 2022. However, for most of history, the steps to contain or lessen the damage caused by floods were entirely neglected. It is because either the floods were thought to be divine punishment or too massive to be challenged at all, and sometimes they struck after decades, thus making people forget that they had any long-term impact on history.

Study area

The Kashmir Valley (Fig. 1) is the study area for the present study. Kashmir Valley lies in the northwestern part of the Himalayas and is a major tourist destination (Malik 2015). Kashmir means "a land devoid of water." It is an oval-shaped valley that spans 15,853 km^2 and lies between the Greater Himalayas in the north and Pir Panjal Range in the south (Malik 2022b) within the latitude and longitude ranges of 33° 55′ to 34^0 50′N and 74° 30′ to 75° 35′E, respectively (Zaz et al. 2019). The climate of Kashmir valley is affected by the southwest monsoon and extratropical cyclones (Ahmed et al. 2022) and has a well-developed river system led by the Jhelum River (Bhatt et al. 2013).

Data base and methodology

The study relies heavily on the primary historical sources. The study also uses a critical analysis approach to analyze flood management policies. Several flood managements plans, and their failures were analyzed to explain the contribution of different plans in flood management of Kashmir Valley. The study area map was made with the help of Arc GIS 10.2. The source material consists of archival material available at the state archival repositories of Srinagar and Jammu. Apart from the files present in the political, revenue, publicity, and development departments of the archival repositories, the important sources are the Harris Report (1929), Uppal Report (1956), Master Plan (1959), and High-Level Flood Committee Report (1977). The annual administration reports of the state also provided information about the flood management including Ghulam Hassan Khan's Irrigation, Flood and Food Problems of The Jammu & Kashmir State (1961), Jarnail Singh Dev's work Natural Calamities of Jammu and Kashmir (1983), and Hakim and Tramboo in Kashmir, The State of Floods (2016). These archival sources were qualitatively analyzed for the policy framework analysis.

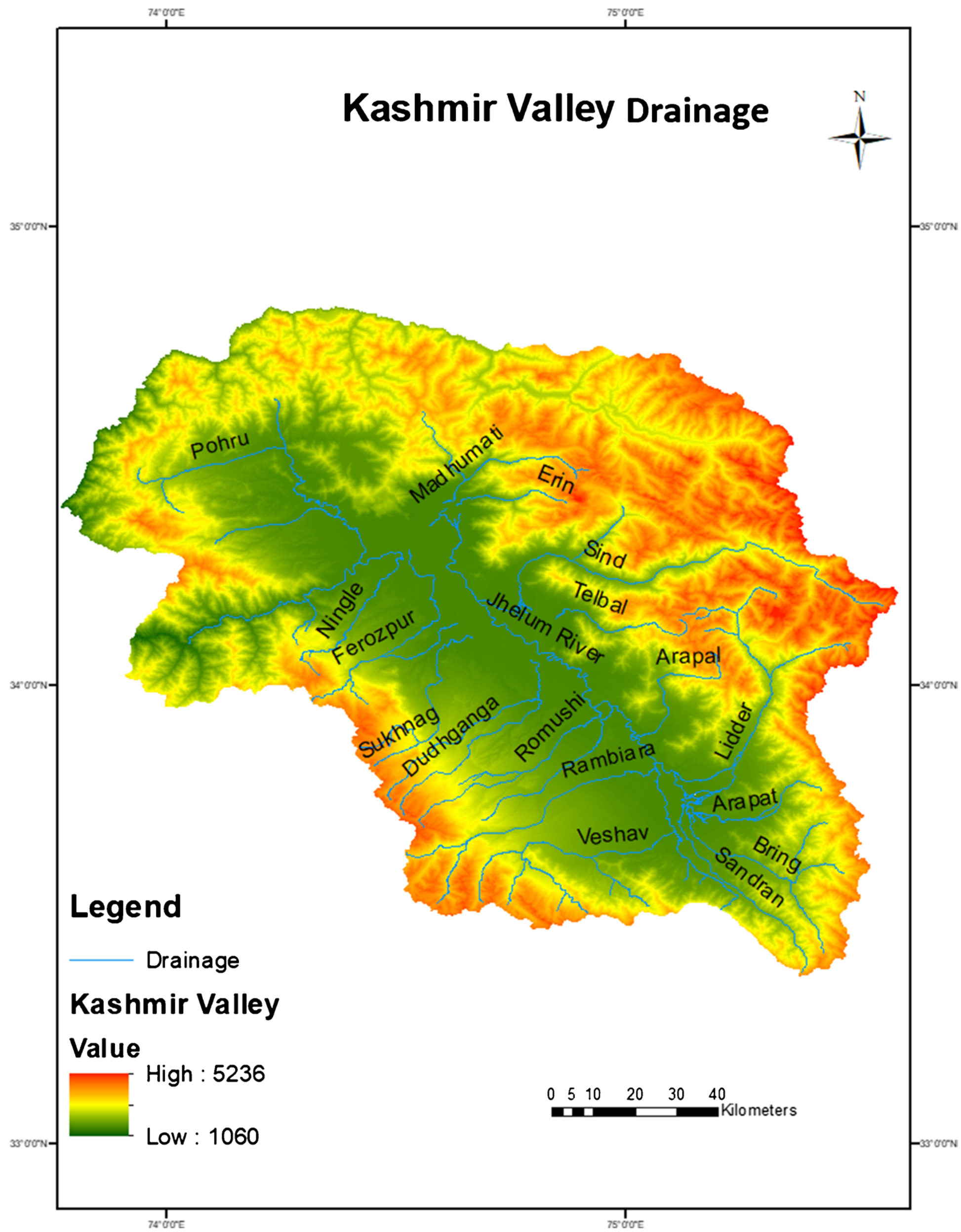
Results and discussion

Flood vulnerability of Kashmir Valley

Due to its geographic, climatic, and geological configuration, the Kashmir Valley is susceptible to all kinds of dangers (Meraj et al. 2015). Low-lying parts of the valley are vulnerable to flooding because of its terrain. Unchecked urbanisation, the building of highways and railroads in the flood basin, a decrease in river carrying capacity, and the rapid extinction of the wetlands and lakes in the valley have all contributed to the valley's increased vulnerability to flooding in recent years (Iqbal 2019). Since the valley took on its current form after draining out of the primordial Karewa Lake, the Satisar, the hydrographic features of the Jhelum River system demonstrate that the frequency of floods has been quite high (Raza et al. 1975; Dar et al. 2014).

Kashmir is a bowl-shaped valley, which also includes some other smaller valleys (High Level Flood Committee Report 1977). The slope is steep, and thus the time lag is very low. The valley is narrow in nature, only 65 miles long and 2–16 miles broad. At Awantipora, it is just 2 km wide (Harris 1929). Once water comes down, it must pass through a single river channel known as Jhelum. Most of the land is on the left bank, and it falls from Sangam to Srinagar (Harris 1929). The water brought by Jhelum has boulders and even big rocks, which it leaves before reaching Sangam. Its water is silted, and this silt comprises the earth washed away in the upper reaches. There are several water bodies known as *numbals*, which were earlier continuous but are now separated by the detritus brought from the upper areas. The water flows into the valley (mostly from Awantipora to Pampore) on the left bank through breaches, and just before Srinagar city, it comes back, flooding the city because the Dudhganga ridge on the left side of the city to the hills causes

Fig. 1 Kashmir Valley map (study area)



obstruction (Harris 1929). There are several smaller lakes and two major lakes, Dal and Wular. Dal Lake does not have any role in either regulating or causing floods in the valley. It is Wular Lake, in which Jhelum drops from one side and comes out on another side, from its southwest corner, which has a role in floods in the valley but not beyond Sher Garhi, which lies in the southern part of Srinagar city. During floods, 60,000 cusecs of water may be entering Wular while only 30,000–35,000 cusecs are leaving (Uppal 1956). From Wular, Jhelum passes through a channel known as the "Outfall Channel" for a length of 13 miles up to Baramulla Bridge. At Baramulla, it enters the gorge, and after flowing for three and a half miles through it, it takes a sharp bend towards the left. At its end, a huge rock spur projects into the river bend from the left side. Jhelum leaves the valley through this single and narrow gorge known as Khadanyar, which is very difficult to widen. This narrow nature of the Outfall Channel and Baramulla Gorge is a major factor in the flooding of the valley (Uppal 1956) as it decreases the velocity of the water.

Kashmiri's preferred low-lying area like Srinagar for settlement which was and is a flood prone area, thus the very decision of choosing lower areas involved risk and disasters. This decision of choosing of such a site for settlement may be attributed to the possibility of boat traffic in Jhelum, which made travel and transport easy and economically viable. Added to this the economic factor of vegetable gardens in Dal and Wular might have been quite attractive in settling around these areas in a food deficient country like Kashmir. It is the human occupation, inhabitation, adaptation, decisions, to be at ease and comfort, to keep themselves sustained which causes floods and floods turn into disasters.

The diminishing capacity of the Jhelum River and wetlands, especially Dal Lake and Wular Lake, contributes to the vulnerability of the Kashmir Valley to floods. This is the result of continuous siltation of Karewas (tablelands), land erosion, sediment, and other materials like soil and boulders brought down by hill torrents. Over the centuries, some of the wetlands have been completely lost. The area of wetlands in Srinagar has decreased from 13,425.90 ha in 1911 to 6407.14 ha in 2004, a loss of 7018 ha in 95 years. Overall, the total area of major wetlands with an area > 25 has decreased from 288.06 km^2 in 1972 to 266.45 km^2 in 2013 (Romshoo et al. 2018). Similarly, the open water area of Wular has been reduced from 89.59 km^2 in 1911 to 15.73 km^2 in 2013, and the total area of the lake has been reduced by 45% from 157.7 km^2 in 1911 to 86.71 km^2 in 2007. The area of the Dal Lake has been reduced from 76 km^2 in the fifteenth century AD to 25.6 km^2 in the nineteenth century AD (Hussain 2000). The open surface area of Dal was reduced from 27.53 km^2 in 1911 to 24.21 km^2 in 2013 (Romshoo et al. 2018). These wetlands and lakes used to be regulators and moderators of floods. With their diminishing capacity, the risk of disastrous floods has significantly increased. Padshahibagh, a food channel on the Jhelum River in Srinagar, had a capacity of 17,000 cusecs but has been reduced to around 6000 cusecs due to encroachment and siltation (Malik 2022c). The area that either used to be the natural course of Jhelum or part of any wetland or lake has been occupied by humans, which has significantly contributed to increasing the risk of disasters. Land use changes have a significant impact on the geography of a region, and during the last 50 years, the impervious cover—land that is covered with roofs, pavements, and cement—has greatly increased in the valley, in the south of the city, due to urban sprawl; it has increased from 34% in 1992 to more than 65% in 2010 (Jamal et al. 2022; Romshoo et al. 2018). The rainwater, instead of getting absorbed in the soil, finds its way into the stream, and increases the risk of flooding. Thus, natural factors like topography and location, and anthropogenic factors like inadvertent land use and haphazard urbanisation and encroachment make Kashmir vulnerable to floods, as a result, the Jhelum frequently crosses its "bank full level."

Historical account of flood management in Kashmir Valley

Prior to 1880, no scientific knowledge was available regarding floods in Kashmir. The single flood control measure in ancient times was Suyya's scheme under the rule of Awantivarman (Kalhana 2013). In mediaeval times, no long-term measures were taken; there are apparently no references to dredging operations manuals or otherwise in the Jhelum. There were no funds allocated for the clearance of its beds, and no alternate channels were provided. The banks of the river were neither repaired nor constructed (Kaw 2001). We only possess references to the construction of a few embankments. Stone blocks from the temple Parhasakeshu, destroyed by Sikander near Sopore, were used by him for the construction of embankments at some unknown place (Khuihami 2015). Zain-ul-abideen also used stones from the temple Chitratama, demolished by Sikander at Inderkote, for the construction of an embankment at Sopore (Khuihami 2015). During Mughal times, we possess a single reference to the construction of embankments by Jahangir and Shah Jahan, called "gunds," to reclaim land from Wular (Lawrence 1895). There is a single reference to the construction of an embankment under Afghan rule by Amir Khan Jawansher to protect Darabagh (Khuihami 2015). Towards the turn of the nineteenth century, knowledge began to be produced, and once knowledge was produced, flood control measures also began to be taken. Thus, structural measures like channelization, levees, dredging, etc. and non-structural measures like warnings, evacuation, first aid, relief camps, and forgiveness money began to be taken.

The European observers were the first to conceptualize the flood problem in Kashmir. Their interest mainly remained confined to the embankments in Srinagar city. It is important to note that initially only the city was under consideration by the state and engineers. The three British engineers, Captain Capper, Fraser, and Lotbiniere, played an important role in conceptualizing and beginning the work on flood management. From 1920 on, it was the local engineers Tulsi Das, Tej Bahadur, and G. H. Khan who played a great role and greatly helped Harris and Uppal comprehend the problem. Walter Lawrence was the first to lay the foundation for making sense of the flood problem in the valley. In his report on the flood of 1893 reported to the government of India, he writes that the existing embankments were faulty and that for a country like Kashmir, there should be two lines of embankments: the first line near the riverbank of a size sufficient to keep out ordinary floods, and the second line at some distance from the riverbank sufficient to keep out all the floods. According to him, this would also secure the cultivation above and below Srinagar. Further, the bank would serve a double purpose as an embankment as well as a road (Lawrence 1895). Walter Lawrence's other contribution was that he identified a flood triangle with an apex at Panznara and a base at Wular. It was further elaborated by Arthur Neve, who identified two flood triangles, the first having an apex at Shalteng and a base at high ground southwest of Shadipur. The lowest portion of this triangle extends from Ranbirgarhi (8th mile from Baramulla Road) to Serai Dangerpora near Shadipur. The second triangle, according to him, is a few miles away from this place, with its apex at the 12th mile on the Baramulla Road base at Hajin and Tarazo (Chief Secretary Kashmir, JK. Pol. No. 92, 1903b).

The flood of 1893 prompted the state to look more seriously into this problem, and bunds were strengthened in the city. Dal Lake was also provided with an iron gate. The most important issue before the administration was to save the capital city from floods. In 1900, Captain Capper prepared a report that became the basis of the Srinagar Flood Spill Channel, which would take 17,500 cusecs of water from Padshahi Bagh into Batmalu Numbal and thus relieve pressure on Srinagar in floods. The work was completed in 1903–1904 (Chief Secretary Kashmir, JK Pol. No. 126, 1900). After the flood of 1909, Maharaja asked the Public Works Department to consult experts from outside the valley to study the flood problem in the valley, and with this started the work on major projects of flood management in Kashmir (Chief Secretary Kashmir, JK Pol. No. 223, 1903c). The state engineers, after a detailed study, found the pier bridges responsible for flooding in the city and asked the state for their replacement (Chief Secretary Kashmir, JK Pol. No. 223, 1903c). Thus, it was first the city of Srinagar that called for attention. This problem of saving the city of Srinagar led to the beginning of conceptualizing the flood problem. However, the overall process should be seen as a stimulus response. Every expert commission, or committee, was called to find a solution to the problem once a disastrous flood struck, like Captain Capper, Harris, and Uppal were called after the floods of 1893, 1928, and 1948, respectively.

All the experts believed that complete immunity from floods was neither achievable nor desirable. Every report written on the floods in the valley discusses the issue of food security, i.e., saving agricultural land and reclaiming the already existing swamps in the context of floods (Uppal 1956). Up until 1928, the proposals revolved around the city. Uppal turned his attention towards Sangam. In addition, it was only after 1950 that the state decided to take steps to save parts of South Kashmir. This should be seen in the context of the establishment of a democratic government in Kashmir, and prior to this, the experts had to work on terms of reference made by the state, and for them, the area above Awantipora meant nothing.

Policies and proposals for flood management in Kashmir Valley

Purves' recommendations (1915)

A serious effort was made by the state government by inviting R. Regeption Purves to investigate the flood problem and propose solutions. Purves carried out investigations from 1913 to 1915. In November 1915, he submitted his recommendations to the government (Uppal 1956). His work was mostly connected with the Wular Barrage Scheme, a barrage proposed to be constructed on the outfall channel of the Wular Lake for maintaining supplies in the upper Jhelum canal during the winter season. Purves work on the hydraulic problems of the Jhelum River is very valuable (Uppal 1956).

The Purves report (1915) suggested improvements in the outfall channel from Sopore to Khadanyar to keep lake levels at R.L. 5174.39 or 5172.83. The actual R.L. would be 5183.32 or 5181.76. This includes the reclamation of R.L. 5167. The outfall channel had been calculated to run a maximum discharge of 38,400 cusecs in 1915 after dredging operations in the previous few years, from 1912 to 1914. A suitable design to make the most of the dredged outfall channel, including the Pohru diversion to Wular, was recommended. At Gagarzoo, he proposed a cut to take water from Jhelum through Anchar Lake and again through Shalbug Swamp to the opposite side of Shadipur. The Jhelum is to be diverted from Asham to Ningli, which means it would not enter Wular through its mouth but from below through Ningli. Purves proposed to separate Barangoura Swamp from other areas as it already received much water through levees. To save the outfall channel, Purves proposed the diversion of Pohru to Wular. The preparation of a contour plan of the valley with a view to attempting a solution to drainage, reclamation, irrigation, and silting problems, particularly in swampy areas, was also recommended.

Purves proposals were mainly concerned with below Srinagar city. No decisive recommendations could be made by Purves because of the lack of required data, especially hydraulic data. None of these recommendations appear to have been implemented, as only partial measures were suggested subject to the collection of further hydraulic data on the river. This is revealed by the miscellaneous recommendations at the end of Purves report, where he has emphasised the need for the collection of further data to observe small changes even in the river regime, which required extreme watchfulness as expressed by him in his report (Master Plan 1959) (Fig. 2).

Harris's recommendations (1929)

After the flood of 1928, the state government decided to hire the services of D.G. Harris, a consulting engineer at the Government of India, to analyse the necessity and method of maintaining the Zamindar river bunds from Khanabal to Srinagar, which were raised after the flood; examine the longitudinal section of the river Jhelum; and consider the possibility of providing an efficient linking channel between the Dal Lake and the Anchar Lake.

Harris made many recommendations regarding river bunds, cuts, channels, outlets, and dredging (Uppal 1956). He submitted his recommendations to the government on

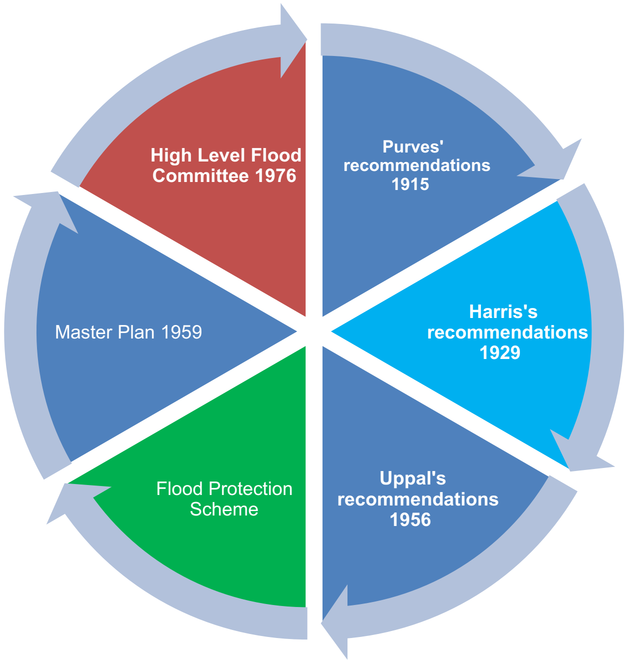


Fig. 2 Policies for flood management in Kashmir Valley

October 18, 1929 (Chief Secretary Kashmir, JK. Pol. No. 135, 1903a).

Harris divided his recommendations into primary and secondary ones. The primary recommendations were those that form part and parcel of the scheme, which should be regarded as a single whole, for mitigation of floods, and the secondary recommendations were those that deal with matters within the scheme but do not form part of it, hence came to light during the investigation (Harris 1929). The primary recommendations include that the embankments on the right of the Jhelum River from Srinagar to Sangam should be taken over by the Public Works Department and raised to a level varying from 3 to 4 feet above the maximum flood level and should be provided with escapes capable of discharging 44,000 cusecs into the valley. It suggested that the right and left banks of the river through Srinagar should be strengthened and brought up to a level two feet higher than that of the 1928 flood. Harris recommended that a cut capable of carrying 16,500 cusecs be made through the Dudhganga ridge to connect the valley above Srinagar with the Batmalu numbal. The report suggested that a new outfall channel should be dug from the Batmalu numbal to the Jhelum, which can carry 12,000 cusecs, and a channel with a capacity of 20,000 cusecs should be excavated from Gagarzoo to the Anchar Lake if need arises and the embankments around the lake raised.

The secondary recommendations include that a navigation lock be constructed near the Dal gate; a linking channel be constructed between the Dal and the Anchar lakes; and the Sumbal bridge be rebuilt (Harris 1929). Harris's scheme aimed mainly at the protection of the city of Srinagar, which was one of the terms of his reference in preference to the safeguarding of agricultural lands from the depredation of recurrent floods. Harris, too, like Purves, did not consider the construction of reservoirs feasible, which have proved quite successful in flood control in China, owing to the threat of catastrophic damage in the event of any failure and the short life span due to siltation.

After 2 years regarding the accepted proposals, a nod was given for execution, and arrangements were instituted. Some spade work was also done on Dudhganga and Anchar Cut but had to be stopped on account of political opposition (Master Plan 1959). In this period, there was also the beginning of a mass movement in Kashmir. The scheme was never executed owing to the opposition of influential landlords, especially regarding the opening of old canals. When the floods struck in 1948, the government thought of executing Harris proposal after two decades, but as things had changed, it called Uppal to frame the flood management policy in Kashmir.

Uppal's recommendations (1956)

The Uppal project was the first major project undertaken by the government. State engineering departments had already collected a massive amount of data over four decades by 1950. Uppal started to work on the project in October 1950, and the report was completed and submitted in 1954. A sediment survey was made of the river in 1951–1952, and an aerial survey, the first in the history of Kashmir. The report gave new life to the issue of flood management in Kashmir, as this problem was now thought to be insoluble.

Recurrent floods in 1948 made the revision of Harris's proposals necessary. H.L. Uppal was entrusted with the re-examination of the Purves and Harris schemes in 1951 and to suggest reorientation of these schemes after their reappraisal in the light of changed conditions as manifested by the flood of 1950. Uppal's recommendations are in two volumes. The first volume deals with Control of floods above Wular and second volume with floods from Wular to Khadanynar. Efforts had been made to solve the problems keeping all their different aspects in view and considering recent advances made in the methods and techniques of flood control and drainage (Uppal 1956).

The Uppal report envisioned investigating the protection of the rich cultivable land in the valley above and below Srinagar against devastation by the floods; the protection of Srinagar city and other inhabitants on the banks of the Jhelum River against floods; and proper drainage of the valley, resulting in the reclamation of about 116 sq. miles of swampy areas called numbals for cultivation. The recommendations are in two volumes. The first volume deals with the control of floods above Wular Lake, and the second volume deals with floods from Wular Lake to Khadanynar.

The Uppal report recommended the maintenance of embankments or bunds of suitable height to confine the river in between the embankments up to low or medium-sized flood stages only, and no effort should be made to raise the bunds so high to confine the highest flood discharge in the channel (Uppal 1956). It recommended the construction of a regulated supplementary channel taking off from the left bank below Dogripora that can carry 30,000–35,000 cusecs of water from the river. It was thought to be the second track of the river joining the Wular Lake directly. The Bud kul, Romshi, Dudhganga, Sukhnag and Ferozpur nallah all shall join the supplementary channel. With navigation locks and other minor arrangements, it would not be difficult to convert the supplementary channel into a navigable channel. Uppal called for measures to be adopted in the catchment area of the Jhelum River and its tributaries to stop the huge quantity of coarse sediment that the river is unable to transport (Uppal 1956).

Uppal proposed diversion of tributaries like the Ningli nallah and the Pohru River into the Wular Lake to prevent the inflow of stone gravel and coarse sand into the outfall channel. The continuous deterioration in the capacity of the outfall channel was attributed to the inflow of heavy sediment brought in by its tributaries. To get rid of this source of trouble, he proposed the diversion of the Ningli nallah and Pohru river into the Wular. According to him, the outfall channel required all the clear water but not the sediment, while on the contrary, the Wular lake required all the sediments to rise to the bed and help its early reclamation (Uppal 1956). Uppal called for stabilization of the five hill torrents joining the river below Baramulla with boulders, bars, and wires across them. According to him, no other single factor works in a more detrimental manner towards imparting the capacity of the outfall channel than the torrents which dump heavy stones at the riverbed (Uppal 1956). plantations on the banks of outfall channel between Ningli and Sopore caused considerable obstruction to the river flow especially during the floods. Uppal called for removing this obstruction (Uppal 1956). According to Uppal, the Sopore dam had no influence on the river levels during high stages. Similarly, the Chatabal weir offered no obstruction to the flow of water during floods. Suitable positions of gauges for different stations were also proposed (Uppal 1956).

Uppal thought that through these measures, food security could be achieved. He believed that the flood problem would end for all time as, due to siltation over time, the low-lying marshlands, jhils, and Wular Lake would be reclaimed. The rich alluvial silt brought by Jhelum through the supplementary channel would reclaim marshy areas, and the silt brought by the Pohru River, the Ningli nallah and other effluents will have Wular reclaimed, and yield harvests secured from the floods (Uppal 1956).

Uppal did not give any specific recommendations regarding the capacity of the outfall-channel as he presupposed that the silt free water will emerge from Wular lake after diversion of Pohru river into the lake. It will tend to pile up the silt in the outfall channel and retrogression of levels will ensure and thereby the capacity of the outfall channel will improve automatically.

Flood protection scheme

After various deliberations, the first phase of the Kashmir Valley Flood Control Scheme was given practical shape. In Phase I, steps for immediate execution included enlarging and excavating spillway channels from Padshahi Bagh to Wular and marginal bunds around numbals and lakes; strengthening and retirement of river Jhelum bunds above and below Srinagar (from Sangam to Banyari); and construction of drainage channels and flood gates in the valley. By these measures, it was proposed to increase the capacity of the Jhelum River by retiring bunds to 50,000 cusecs and allowing the excess discharge to spill over into the low-lying area between Dogripora and Padshahi Bagh; to carry a discharge of 17,000 cusecs to a series of lakes and numbals between Padshahi Bagh and Wular; and to limit the discharge in the river channel below Padshahi Bagh to 33,000 cusecs. It was also planned to provide drainage facilities to the areas above Srinagar inundated by floods so that these areas are quickly drained off by the subsidence of the floods. This was supposed to be completed in the second plan, but the disastrous floods of the 1950s compelled the state to take up Phase II according to a Master Plan. The work done under Phase I fully responded during the flood of 1957; the banks above Padshahi Bagh withstood a discharge of 50,000 cusecs, and the enlarged Flood Spill Channel carried nearly 20,000 cusecs and was responsible for saving large tracts of land on the left bank of the river below Padshahi Bagh (Master Plan 1959).

Master Plan (1959)

The Master Plan suggested a more radical solution for informants to outfall channel by dredging and diverging of its major tributary Pohru, as any delay according to Master Plan in taking the former work in hand would create disastrous consequences for the entire economy of the state (Master Plan 1959). In this respect, the Uppal's suggestion of wait and watch the results of Pohru diversion to Wullar as usual was manifested on the outfall channel in respect of natural regimentation of regime (Khan 1961).

The Master Plan (1959) envisaged that the river embankment between Sangam and Padshahi Bagh would be made suitable to carry the discharge of 50,000 to 90,000 cusecs of water in various reaches. It planned to establish large absorption basins [Basin A (left/right Dogripora-Koil) and Basin B (Kandizal-Pohru-Lasjan-Shalina-Nowgam-Padshahi Bagh)] on the left bank of the river in this reach for absorbing 25,000–30,000 cusecs, and flooding of the basins will be done in a controlled manner. It was suggested that the spill channel from Padshahi Bagh to Wular will be further developed to carry an ultimate discharge of 20,000 cusecs, while the level of the Wular will be maintained between R.L. 5178 and R.L. 5181 and the outfall channel will be developed to 45,000 cusecs to attain this end. An attempt to increase the capacity beyond this figure entails high costs, as well as difficulties in the operation of the scheme. Soil conservation in the catchments of Pohru and Ningli nallah was contemplated to be executed to improve the regime of these tributaries (Master Plan 1959).

While the Master Plan dealt with the overall problem in three parts, namely [1] from Sangam to Padshahi Bagh, [2] from Padshahi Bagh to Wular, and [3] from Wular to Khadanyar, priority was given to the third part, as this was the crux of the entire problem. It was thought that the existing spill channel could reasonably absorb the flood discharge in the river. It was also thought important to restrict the level of Wular Lake to reduce the intensity of the floods in the valley by enlarging and improving the outfall channel. The work on parts I and II was suggested to be carried out simultaneously, and the work on part III was executed in 1960–1961 and reassessed in 1973.

Under the Master Plan, the outfall channel was given the focal point, and some areas around Sonawari were also decided to be developed as Model Block. The idea of a supplementary channel was given for the time being to prevent premature reclamation of low-lying land (Master Plan 1959).

High level flood committee (1975–1976)

The work on Master Plan 1959 started immediately, and the work on the outfall channel was given the highest priority. A major part of the work was confined to the improvement of the outfall channel, and a very limited number of resources were available for flood control above Wular. On this account, the flood hazard above and near Srinagar could not be mitigated to any appreciable extent. So, the government appointed a High-Level Flood Committee (HLFC) to evaluate the physical work done so far and the benefits that have occurred compared to the expenditures; examine and reappraise the proposals in depth and suggest modifications or improvements, if any; and examine the present organisational set-up and suggest changes, if any, considered desirable therein (High Level Flood Committee Report 1977).

The committee made an evaluation of work done from 1950 to 1960 and reported that the main work done was raising and strengthening embankments both above and below Srinagar that were more susceptible to breaches and overflow. It suggested that there was a need for extension and improvement of the flood spill channel to restore it to its original capacity of 17,000 cusecs and the construction of marginal bunds around numbal lakes en route (High Level Flood Committee Report 1977).

The HLFC re-examined and re-appraised the Master Plan 1959 and held that the ultimate solution to the flood problem will be the diversion of excess water from the Jhelum River from Dogripura to Wular through a supplementary channel, as proposed by Uppal (1956). It believed that the silting up of low-lying areas of the left bank of the river above Srinagar is a precursor to such a channel. It held that since the capacity of the river through the city and flood channel is not of the order of 90,000 cusecs, there is no alternative but to provide detention basins as a purely interim measure (High Level Flood Committee Report 1977).

The High-Level Flood Committee Report, 1977, suggested that the embankments from Sangam to Srinagar were to be strengthened and raised with a top width of 12 to 15 feet and a free board of 5 feet. The design capacities in the various reaches were to be:

Sangam to Dogripura — 90,000 cusecs
Tokina to Kandizal — 60,000 cusecs
Kandizal to Padshahi Bagh — 50,000 cusecs
Flood spill channel — 17,000 cusecs
City channel — 33,000 cusecs

The Committee noted that improved discharge in the flood spill channel should be below 57,000 cusecs. It was recommended that embankments from Srinagar to Wular should be raised and strengthened under a capacity of 33,000 cusecs from Srinagar to Shadipur and 42,000 cusecs from Shadipur to Wular, with a free board of 4 feet for the left bank and 2 feet for the right bank and a top width of 6 feet. Further, spillways at Krishibal into Anchar Lake and at Hakbarn into Malgam numbal need to be provided for silting up low-lying areas on the right bank. Through the city, the committee recommended the prevention of further encroachments and the renewal of the existing canals. The river and channels in this reach were observed to be largely improved, and greater attention was paid to their maintenance (High Level Flood Committee Report 1977).

Quarry work in Baramulla should be prohibited. Hill torrents should be further stabilised. The dredger should then be deployed for extension up to Sheri. If possible, all shoals from Baramulla to Khadanyar should be removed. A suction dredger should not be deployed for further dredging in the O.F.C. until after the cunettes in the seer are cut off and that between the two bridges is completed. The dredgers should then be deployed for excavating the cunettes, and thereafter the effect shall be watched for a few years (High Level Flood Committee Report 1977).

The proposals were divided into four stages and total cost was estimated to be Rs. 33.59 crore (4,083,643 USD).

1. Project for flood detention basin	Rs.5.512 crore
2. Project for improvement to river Jhelum above Srinagar from Sangam to Padshahi Bagh	Rs.17.14 crore
3. Project for improvement to river Jhelum through Srinagar city from Padshahi Bagh to Gagarzoo	Rs.3.28 crore
4. Project for improvement to river Jhelum below Srinagar from Gagarzoo to Banyari	Rs.7.66 crore
Total	**Rs. 33.59 crore**

Recent developments in policy framework

Dredging activities were suspended in 1986. It was halted owing to a lack of sufficient resources and backup facilities. Tonnes of silt have accumulated in Jhelum since then due to the gradual degradation of its catchments. This has lowered Jhelum's outflow channe's flood routing efficacy and charge carrying capacity from 35,000 cusecs in 1975 to 20,000 cusecs at present (Wani 2018). Despite eight floods in the 1980s and 1990s, the state didn't take any significant action. It is because of the outbreak of the insurgency, political instability, and the instability of responsible governments in Kashmir. After the flood of 1997, S. C. Sud, Commissioner [Indus] Ministry of Water Resources, Government of India, and Commissioner cum Secretary to Government, P.W.D. J&K, took an interest in flood control in Kashmir, and national-level tenders were invited for the preparation of Master Plan for flood control in the valley. The proposal was approved by the Contract Committee subject to the approval of the Ministry of Irrigation, which dumped the document in 1999 without any comments. The proposal prepared was a holistic one that was to involve 41 experts related to various fields, but due to the non-serious approach of the government, the opportunity was lost (Hakim and Tramboo 2016).

The government recently made two failed attempts in 2009. In the initial effort, it chose Halcrow India Limited to commission a comprehensive Jhelum Basin Management Plan. The contract was signed for Rs. 15 crore (1,822,597 USD), but it could not be completed because it was awarded after the offer's validity term, which was unacceptable to the company (Hakim and Tramboo 2016). The second attempt was made by Mir Najibulah, Chief Engineer, Irrigation and Flood Control Department. He prepared a detailed project report for various districts for various project works such as restoration works such as improving Jhelum's existing capacity, dredging of the outfall channel, anti-erosion works, increasing hydraulic efficiency, beautification of bunds, dredging of rivers, flood protection bunds, and water transport. This project encountered numerous challenges. One of these was the Central Water Commission's (CWC) request for the creation of a digital hydraulic model of the river to estimate inundation levels for various flood releases. Thus, the Central Water Ministry approved only a portion of a Rs. 2,000 crore (243,108,000 USD) project to facilitate immediate interventions, including the procurement of machinery and dredging in Jhelum, particularly the Flood Spill Channel in Srinagar and the outfall streams at Dobbagh and Ningli in Baramulla (Wani 2018). Kashmir, as a conflict zone, lacks an effective disaster management plan and policy, which is one of the key reasons for its devastation by the recent floods especially 2014 flood.

Impediments to resolving the flooding problem

Economic compulsions and implications

Economic compulsions and implications have been the most important reason for not carrying out the high-cost projects. Almost every time the state put forward its weak economic conditions to carry out these projects, be it Harris, Uppal, or Najibulah recommendations. Moreover, rising prices made it more difficult for the state with every passing day to carry out these recommendations. Besides, there were legal issues involved in the acquisition of land. The economic conditions of the state can be understood from the fact that the machinery required was to be imported from abroad, which was very costly. After Harris report, the state brought into existence a sanitary department, a hydraulic division, and an engineering department, but owing to the economic depression of 1928, these departments were axed, and all the machinery was sold at a very low price (Khan 1961). The weak economic conditions in Kashmir have made it difficult for the state government to carry out these costly measures, and this has made it excessively dependent on the central government for flood management, which has continued up to this time.

Social compulsions and implications

The flood management in Kashmir required the dislocation of a huge section of the population (Khan 1961). There was also the threat that if a reservoir or supplementary channel developed a breach, it could put a huge section of the population in danger. There has always been interference on the part of short-sighted big landlords. The land mafia-bureaucratic-political nexus has, in the last few decades, encroached on much of the flood plain and created further problems for any possible solution in the future (Hakim and Tramboo 2016).

Lack of political consensus and successive changes of governments

The people at the helm of affairs could not build a consensus on the issue of flood management. From 1880 to 1915, there was a difference of opinion between residents, British officials, and members of the state council, including the Maharaja. The recent governments found it more difficult to reach a consensus on the issue.

Lack of consensus among experts

One of the issues has been the difference of opinion among experts regarding flood management, especially between those commissioned (mostly out of state) and local engineers. This has a bearing on convincing administrators and legislatures, who have little knowledge of engineering-related matters.

Knowledge production and application

Knowing and applying one of the important issues in flood management was that the flood problem was not studied completely at once due to the absence of hydraulic data, flood routing studies, contour maps, etc. Thus, knowledge production and its application went hand in hand. This lack of a priori knowledge stretched the time to arrive at a unanimous solution and, in the end, hindered finding a lasting solution.

Conclusion

Flood management started in the Kashmir Valley in the last two decades of the nineteenth century. The reason for this was the continuous devastation of the capital city of Srinagar and revenue losses to the state. The availability of knowledge in the form of European experts also played a role. It started with saving the city, and then attention was given to the area below the city to ensure quick drainage of water. After that, parts of Kashmir above the city were also brought into consideration. Due to the non-availability of data and socio-economic hindrances, the problem was never completely addressed. No short-term measure worked, and no long-term measure could be taken into hand. Further, the problem was not continuously worked on, as sometimes it was put aside for decades. The topography and anthropogenic factors continued to make it more complex, and with every passing decade, frequent floods continued to strike Kashmir. The successive plans and policies proved ineffective in flood management due to social, economic, and political factors. The formulation and implementation of a proper policy for flood management is the need of the hour to save people and the economy.

Declarations

Conflict of interest The authors have no relevant financial or non-financial interests to disclose.

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