Chapter 10
Flood Disasters and Land Use Planning in Swat Valley, Eastern Hindu Kush

Atta-ur-Rahman, Farzana, Ghani Rahman, and Rajib Shaw

Abstract This chapter analyzes the flood disasters and effectiveness of land use planning and enforcement in Swat Valley, eastern Hindu Kush, north Pakistan. In Swat Valley, flooding is a recurrently occurring phenomenon. In upper reaches flash flood characteristics dominate, while downstream Madyan river flooding dominates the scene. Downstream Madyan, Swat River enters into a wide basin and braided into numerous channels. The meandering river is frequently changing its course. In Swat Valley, almost every year in summer, the peak discharge overflows the natural levees and in effect causes damages to scarce agricultural land, housing, and other sectors. While in certain areas, deep riverbank erosion is very active and engulfing the farmland and built-up areas. Primarily, the active floodplain of Swat River was a vast grazing land, but with passage of time, the increasing population has used it for cultivation and other developments without taking into consideration risk of floods. This in turn has enhanced the flood vulnerability to various developments. For centuries people lived within the valley of Swat River with the reality of flooding as a natural hazard and with the fact that it has a potential to cause damages to people and their belongings, but so for no attention has been given to land use regulation and zoning. Land use regulations have been widely used as a non-structural flood mitigation strategy in reducing exposure of people and their property. It was found from the analysis that frequent human encroachments onto the flood channel and absence of land use regulations have been identified as the major factors responsible for heavy flood losses. Looking into potential and challenges in land use planning, this is high time to undertake fluvial morphology and rainfall-runoff model for flood risk assessment and spatial land use planning.

Keywords Swat Valley • Land use • Flood • Damages • Regulation and enforcement

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10.1 Introduction

Like other parts of Pakistan, flood is also a serious and recurrent phenomenon in Swat Valley, eastern Hindu Kush (Rahman and Khan 2011). For centuries people live within the valley of Swat River with the reality of flooding as natural hazard (Khan 2003; Rome 2005). Historically, the unprecedented rainfall with heavy melting of snow, ice, and glaciers in the catchment area has always generated high flood peaks in the Swat River. Traditionally, the local inhabitants understand the fact that Swat River has the potential to cause damages to people and their belongings, but so far no attention has been given to land use regulations, zoning and enforcement (Rahman and Khan 2013). It is, therefore, in this chapter an attempt has been made to highlight the issue and mainstream land use regulations and zoning in disaster risk reduction (DRR) planning and policy making.

The flood risk mapping is a complex process, where detailed assessment, zonation and graphical representation of various elements at risk are identified and mapped. In order to find the extent of flood vulnerability, it requires in-depth assessment of exposure plus sensitivity minus adaptive capacity (Yusuf and Francisco 2009). The identification of most vulnerable areas would obviously help in preparation of field based flood mapping and zonation. While working on flood hazard mapping and zonation, the researcher needs to kept in mind both the intensity and frequency of flood hazard. Likewise, in assessing flood risk, the hazard and vulnerability assessment is a pre-requisite. Now-a-days, in Geo-informatics, overlay analysis is the most appropriate and widely used approach for zonation of flood hazard, vulnerability and risk. Risk and vulnerability require effective assessment for devising strategies, demarcating probabilities and enforcing zoning regulations. Generally, zonation process may either suggest change in land utilization, improvement and or abandonment of specific land use (Carter 2005; Kron 2007). In flood hazard zonation, the stress remains on accelerating advantages from the floodplain through minimizing flood damages (APFM 2007).

In Swat Valley, flood is the most recurrently occurring disaster. Almost every year Swat River is flooded due to heavy monsoonal rainfall and excessive melting of snow/ice and glaciers. As a consequence, it recurrently washed away developmental gains and other properties. On average, every third year, the Swat Valley is hit by heavy flood event and as a consequence causes heavy damages to life and property. The analysis reveals that frequent flood events have washed away entire villages, infrastructure, communication lines, standing crops, fruit trees, and livestock. During the past one decade (2005–2015), recurrent flooding has seriously disrupted the socio-economic and physical infrastructure.

The Swat Valley (the study area) roughly follows the district boundary. The total area of the district is ≈5337 km^2. In 2013, the estimated population of Swat District was 2.3 million, and it is growing at a rapid pace of 3 % per annum. According to population census 1998, the literacy ratio was 29 % with 14 % female and 43 % male. In the study area, winter is extremly cold in the headwater region with considerable snowfall, whereas monsoon rain occurs during summer. During field survey,

it was found that frequent human encroachments onto the flood channel and the absence of land use regulations have been identified as major factors responsible for heavy flood losses. Looking into the potential challenges in land use planning, this is high time that the government should undertake study on fluvial morphology, rainfall-runoff modeling for flood risk assessment, and formulation of spatial land use regulation and enforcement.

District Swat is located in the eastern Hindu Kush region of northern Pakistan. Topographically, it is a mountainous area with bumpy land surface and high peaks ranging from 733 m in the south to approximately 5740 m above sea level in the north (Rahman and Khan 2013). Hindu Kush region comprises of a number of fertile valleys drained by rivers and streams. Swat Valley is one of them and famous for its scenic beauty and esthetic value. The valley is elongated with mountains running on both eastern and western sides, Whereas River Swat flows through the middle of this beautiful valley in north-south direction (Fig. 10.1). The eastern mountain forms the watershed between the Indus and river Swat, while the western mountains form the watershed of Swat and Panjkora rivers, which drain Dir valley of northern Khyber Pakhtunkhwa.

Swat Valley has highland climate with cool summer and cold winters. Snowfall usually occurs in the month of February and March. During winter and spring, snow is accumulated in the high mountains which later on become the source of river recharge in summer season. Likewise, summer rain begins in July and continue until September. The summer rain is quite enough to increase river runoff and increase snow melting in the catchment areas. Swat River has a complex drainage pattern. Many streams join the river from both the right and left banks and the main river Swat flows in south direction, and then it takes syntoxic right bend near Mingora. The peak discharge data reveals that in Swat River high-flow season starts in May and continue till the end of August. This high discharge in summer is attributed to heavy melting of snow/ice and glaciers in the headwater region and partly due to summer monsoonal rainfall, resulting into recurrent floods.

Globally land use planning has been marked as one of the effective non-structural mitigation strategies in reducing people exposure to flood hazard. In Swat Valley, the populations are frequently encroaching onto the active floodplain and in effect reducing the channel carrying capacity and multiplying the cost of flood damages. There is lack of land use planning and building codes to regulate the effective utilization of active floodplain.

10.2 The Study Area

Swat District roughly follows the boundary of Swat Valley. Geographically, the study area stretches between latitude 34° 34′ to 35° 55′ north and longitude 72° 08′ to 72° 50′ east (Fig. 10.1). Relatively, it is bounded on the north by district Chitral of Khyber Pakhtunkhwa and district Ghizer of Gilgit-Baltistan province, on the east by Kohistan and Shangla districts, on the south by districts of Buner and Malakand,

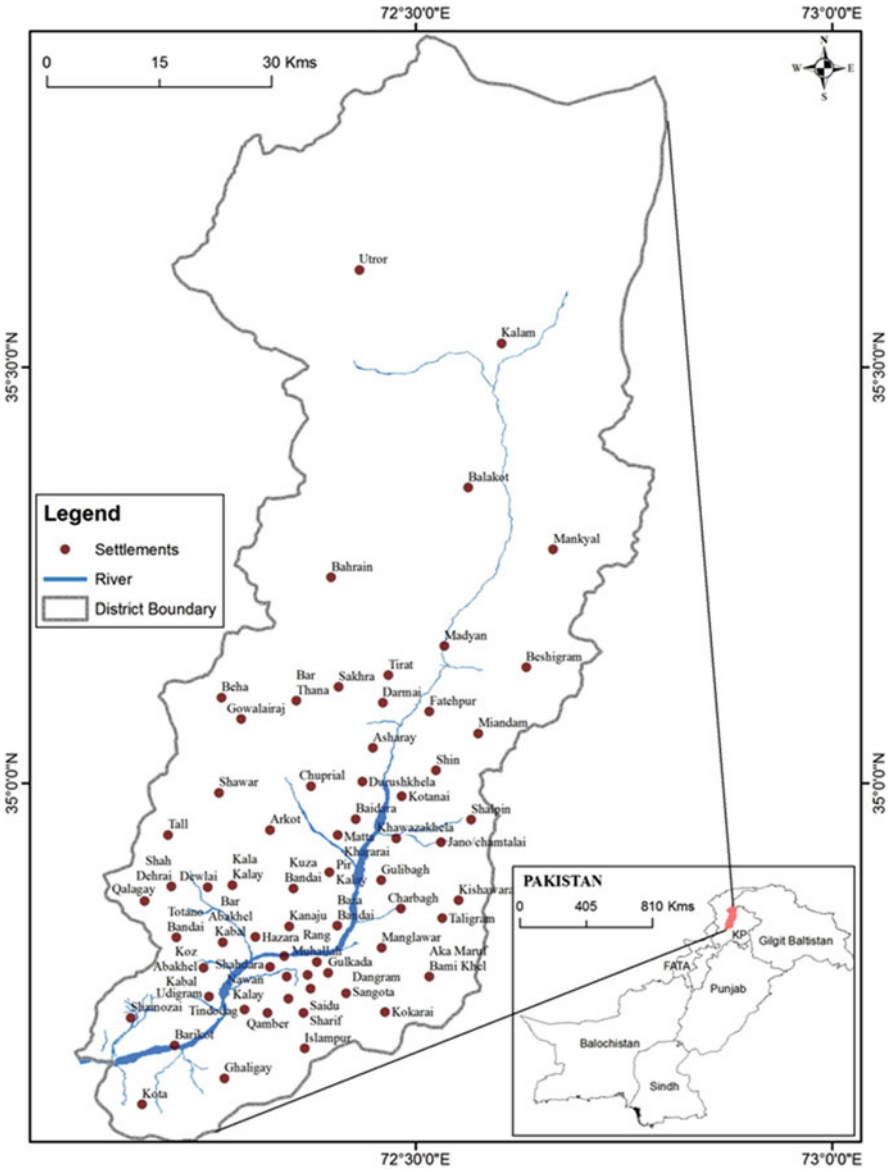

Fig. 10.1 Location map of Swat District

and on the west by Dir Upper and Dir Lower. The total reported area of the district is 5337 km^2. Mingora is the district headquarter. Swat Valley is also called eastern Switzerland. Most parts of the district has a short mild summer, while winter is long and cold especially in the upper mountainous area. Rainfall occurs both in summer and winter seasons. Summer monsoon rain occurs from July to September and

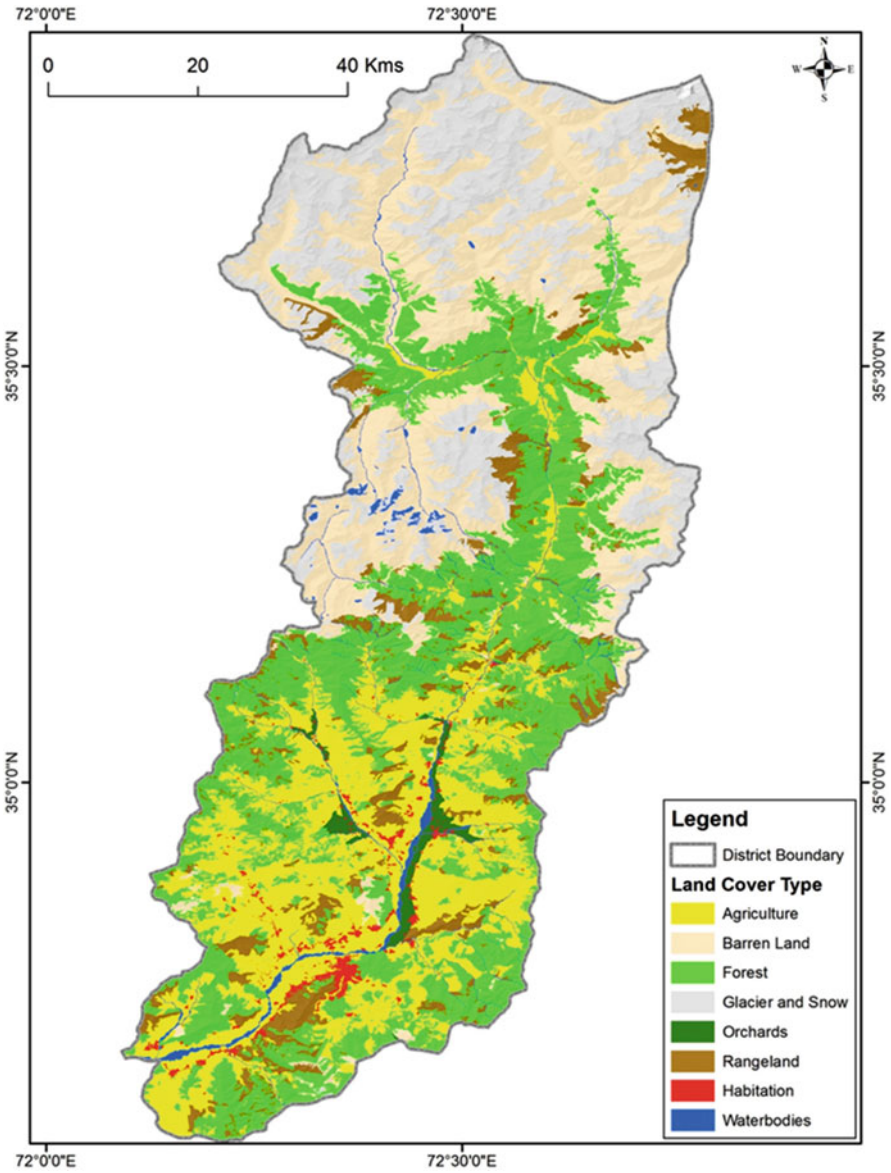

Fig. 10.2 Land use pattern in Swat District

combined with snow melting, which in effect increases the river discharge. In the study area, the economy is predominantly rural and agriculture is the main occupation. Most of the agriculture activities are carried out in the floodplain of Swat River. Out of the total reported area, only 19 % is cultivated, whereas 20 % is under forest cover (Fig. 10.2). According to the 1998 census, the population of the district was 1,257,600 with a population density of 236 persons per kilometer square.

Swat River along with its tributary streams drains the entire district. In the eastern Hindu Kush, Swat River has the largest drainage basin and fed by numerous small and large glaciers. The Swat Valley is elongated and Swat River divides the valley into two equal halves (Ali 1985) and flows through the middle of the valley. The general direction of Swat River is in north-south except a right bank bend at *Fizagat*. Swat River is the right bank tributary of Indus river system. It takes its origin from the northern extreme of Swat District. The two streams Gabral from Gabral glacier and Ushu from Ushu glacier confluence at Kalam, forming Swat River. Downstream Kalam, the river also receives several prominent perennial streams, namely, Harnoi, Deolai, and Daral. Swat River is recharged by rain, snow, and glaciers in the catchment area. The slope is from north to south. From Kalam to Mingora, the Swat River flows southward and then bend westward until it receives the major right hand tributary the Panjkora River. The united stream then flows southwestward and enters into Peshawar vale and joins the Kabul River at Nisatta. A Munda Headworks has been constructed on Swat River when it enters into Peshawar basin.

Swat District almost follows the boundary of Swat Valley (Rome 2007). The general direction of these mountains is north-south (Ali 1985). The valley is bounded on all sides by mountains except to the southwest, which gives an outlet to Swat River (Rahman and Khan 2011). The elevation of Swat Valley ranges from 733 m in the south to approximately 5740 m in the north. Swat District is divided into two major physiographic regions known as Swat-Kohistan and Swat proper. Swat-Kohistan includes the northern mountainous section of the district, while Swat proper is comparatively a low-lying area on either side of the river roughly starting from village Bagh-Dherai to as far as the southern tip of Swat District. Throughout the river course, it is narrow in the upper reaches varying from 35 to 40 m in Swat-Kohistan area, while it reaches to a maximum of 2000 m in Swat proper.

In Swat Valley, the climate is subtropical to temperate. Summers are hot in the lowland, warm in the upland, and cool at higher elevations in the extreme north of Swat Valley. Winter remains cold throughout the valley. There are three meteorological stations, which record weather data at Saidu Sharif (located at lowland in the south central), Malam Jabba (located at the hill station in the south), and Kalam (located at the north central). According to the Pakistan Meteorological Department, in Swat District June is the hottest month with a mean maximum temperature of 33 °C, while in January the temperature falls below dew point (Rahman and Dawood 2016). In the study region, the average annual precipitation ranges from 700 to 1600 mm distributed among three rain-bearing seasons of winter, spring, and summer. In winter season, precipitation mainly occurs due to western disturbance and it starts in December and lasts until the end of March. The higher elevations receive precipitation mostly in the form of snow.

The soil is fertile and suitable for crops, fruits, and vegetables. Wheat, rice and maize, are the chief crops grown in the district. Swat Valley is also a major source of fruits and vegetables. Apples, peaches, persimmons, plums, and apricots are the important fruits. The district is being divided into eight tehsils for administrative purpose. In this study, focus has been made on all eight tehsils.

10.3 Global Pattern of Land Use Zoning and Enforcement

The aim of land use zoning and regulations is to get maximum advantages of active floodplain with meagre damages and less investment on mitigation (Rahman and Khan 2013). The enforcement agency shall ensure that incompatible use of land in the floodplain may not continue and effectively implement the land use zoning and regulations in true spirit. In the floodplain, land use zoning is a non structural risk reduction strategy, to minimize and check the tendency of habitation in the vulnerable zones. In the floodplain management, land use zoning and enforcement of regulation is an effective mitigation strategy through minimizing population density, control over inappropriate use, and effective enforcement of building codes, designation of evacuation routes and replacement of structures that halt the laminar flow. As a preparedness strategy, the flood vulnerable countries in general and Pakistan in particular shall carryout hydrological modelling in a changing climate scenario for effective floodplain zonation and mapping. In Pakistan, the ministry of water and power through federal flood commission has started development of floodplain zoning and regulations in late 1980s but till date no priority has been given to finalize and enforce.

Globally, various land use policies were adopted to regulate land utilization (Tariq and Giesen 2012). It is the job of the local planning authority to allocate the land to development keeping in view that proper flood risk assessments have been carried out, and in some cases it allows developers to construct their infra-structure within the flood prone areas. In certain cases, the already established land use regulations are not respected in true spirit. Di-Martire et al. (2012) highlighted the case of Campania, where population increase has horizontally expanded the urban boundaries and eventually encroached over the flood risk zones.

Land use policies and zoning system is one of the key strategies in reducing exposure and underlying risk factors. Ministers at the fifth AMCDRR in Yogyakarta call on disaster managers and practitioners to enhance capacities and legislative coverage, to infuse and encourage DRR in land use planning at national, regional and local government level (UNISDR Asia and Pacific 2012). In this perspective, so far numerous countries have prepared, enacted and adopted legislative mechanism to enforce land use regulations and building bye-laws for enhancing disaster resilience against the unforeseen events, but it is not that productive due to poor capabilities of its operationalization. In Indonesia, the major challenge in addition to overlapping regulations is poor enforcement, and the efforts to enforce these regulatory and policy instruments have not been so successful. In Afghanistan, limited finances is one of the major reasons behind the poor enforcement of building regulations and resilient structures (HFA National Progress Report 2013).

The physical development and encroachments onto the active floodplain have increased the human exposure to flood risk. So far flood risk assessment and mapping have not been carried out to designate risk-sensitive zoning and enforcement. The Government of Pakistan recognises that there is absence of risk sensitive land use zoning and regulations for coastal areas, floodplain and mountainous

territory (GoP 2012). Similarly, in Turkey construction is undertaken without taking into consideration the building codes (Balamir 2013). Nevertheless, risk communication to the vulnerable community would increase the probability of implementation process.

10.4 Building Codes and Its Implementation in Pakistan

It is the state's responsibility to periodically monitor the infra-structural development in the vulnerable areas and to safeguard that hazard-resilient techniques have been adopted. However, enhancing community awareness in hazard-prone areas is also an effective way of DRR and to follow the approved building codes in structures. The National Housing Authority has already prepared building guidelines for house construction in vulnerable areas. In order to prepare building codes for hazard-prone areas, the Ministry of Housing and Works (MoHW) has developed seismic zone map during the process of formulation of building codes in 2007. According to MoHW, to promote resilient structures in residential areas, the national and local government has been made responsible to guide relevant agencies/organizations to follow building codes and standards.

The Ministry of Housing and Works is responsible for collecting and disclosing information related to earthquake resistance of buildings to show current conditions and expedite efforts in the areas designated to promote disaster mitigation. On the other hand, the existing city governments are not in a position to effectively enforce building bye-laws. Even a city like Quetta, which was devastated by an earthquake in 1935, does not follow safe construction practices. The 1935 Quetta earthquake has ruined the city and since then Quetta building codes are enacted but the developers and urban authority poorly follow bye-laws (Rahman and Shaw 2015). The Quetta building codes include the list of public facilities with results of the building diagnosis, progress of diagnosis, and building strengthening. To ensure strict implementation, the local planning authorities were assigned a task to strictly follow the building codes and secure buildings against disasters.

In this regard, preparation of inventory with specifications need to be utilized. It may be more effective to develop sample house designs, multistorey buildings, and other structures as safe and resilient structures in hazard-prone localities (Rahman and Shaw 2015).

The implementation of building bye-laws is one of the long-term sustainable solution in minimizing impacts of hazards. While infusing disaster risk reduction, building bye-laws should be made mandatory in all new developments and gradual replacement of non-resilient structures by risk-sensitive ones.

10.5 Who Will Formulate Land Use Regulations?

The National Disaster Management Authority should devise land use planning and zoning regulations, and subsequently implement through respective provincial/regional and district disaster management authorities. In order to minimize industrial risk, the ministry of Industries should prepare safety regulations for all types of industrial units and also regularly monitor its enforcement. Similarly, the urban administration should strictly implement building bye-laws, land use zoning and regulations, as the city authorities have institutional capacity as against the rural set-up. Similarly, allocation of financial resources to promote safer construction practices. Likewise, to enhance awareness, enforce pilot programs on risk-sensitive construction in vulnerable areas.

10.6 Land Use/Land Cover Pattern in Swat Valley

In Swat, traditionally, the land ownership is rare of its nature. During the Yousafzai administration in 1600 AD, a unique system of land tenure and ownership called *wesh*/*Garzinda wesh* (mobile allotment of land) was established. In this land tenure system, lands were allotted to main tribe for a period of 5 years by making lottery (Rome 2005). This system has left worst impacts on land development and agriculture improvement. Due to the lack of land ownership, people invest very little to increase the land productivity of a temporary landholding. After 5 years, almost every reallotment resulted into land disputes. The local population once get productive agricultural land was never been ready to shift to less fertile locality. This system has always triggered conflicts and disputes among the local tribes. This system worked until the late 1930s. This system was abolished in 60's, where after a wide range of agriculture reforms and development was occurred. The new system has decisive influence on the development of societies in this mountainous region. Land utilization in appropriate way has resulted into high agricultural production and economic development. With the passage of time, fruit orchard was planted, new crop varieties were introduced, and thus application of chemical fertilizer and other agricultural inputs begun. Presently, fruits are produced and supplied to rest of the country markets.

In Swat District, land utilization varies from area to area depending on physical and socio-economic characteristics (Fig. 10.2). Being a mountainous area, the ratio of plain area is comparatively less. In terms of agricultural return, the most valuable and productive land is located in the floodplain of Swat River. Since the 1981 population census, the encroachment trend toward the floodplain is very rapid. Such land is largely utilized for agriculture, housing, and other infrastructural developments. It is a poor section of the community who prefers to live close to the river with high flood vulnerability as there is no other option but to purchase cheap land and start living in proximity to river with absolutely no resilience and coping capacity.

In Swat Valley, one of the recent studies on change in land use over the past four decades indicates drastic changes (Qasim et al. 2011). In the union council of Kalam, over 30 % of forest cover decreased, out of which 11.4 % deforested area is allocated to agriculture. Similarly, in Malam Jabba agro-forest zone, over half of the forest cover reduced during the past four decades and the same degraded land is allocated to farmland. However, in Barikot region, almost 32 % of forest cover has been reduced over a period of 40 years. Most of deforestation is attributed to extension in agriculture and built-up area, where built-up area increased to 161 %. In the same area, 129 % farmland also expanded at the cost of degraded forest cover (Qasim et al. 2011).

10.7 Human Encroachment and Flood Factors in Swat Valley

River Swat is an active geomorphic agent and it performs the function of erosion, transportation, and deposition of load. The river picks up the sediments and deposit it, where the condition gets favorable. Such heavy influx of sediment deposition in the drainage system is reducing its conveyance capacity. During high discharge, the water overflows the natural levees, resulting into flood and it is active floodplain of river Swat, which has the capability to attract and support population. In Swat Valley, the floodplain is intensively utilized for agriculture, settlement, and other infrastructural purposes.

Forests are vital for the economic development of a country (Khan 2003). According to the state of the world's forest report 2011, only 2 % of the area of Pakistan is under forest cover, and out of the total forest cover, 31 % is located in the province of Khyber Pakhtunkhwa and it is mostly in the districts of Swat and Shangla (Haeusler et al. 2000). In Swat Valley, a large proportion of rural population depends on the forest and other natural resources (Khan and Khan 2009). The land use/land cover data reveals that in Pakistan the state of forest cover is disperse and disappointing (Qasim et al. 2011).

The official records state that there is gradual increase in forest cover due to awareness and afforestation efforts, but the independent source negates this fact (Qasim et al. 2011), and the same is true for Swat District as well. However, deforestation and overexploitation of natural resources is an anguish phenomenon. Since the merging of Swat state (1969) with Pakistan, the forest resources in Swat were ruthlessly cut down (Rome 2005; Khan and Khan 2009). Since 1969, 27 % of the forest cover has been cleared for timber, settlement extension, infrastructure, and agriculture expansion (Qamer et al. 2012). In the study area, emphasis has been given to infrastructure and economic development neglecting the ecological perspective of resource exploitation, which holds numerous threats. Since 2001, the rate of forest degradation is 0.86 % per year (Qamer et al. 2012). In Kalam and

Malam Jabba, the forest area has been transformed into agricultural land, while in the plain areas, forests are cleared for built-up area due to population pressure.

It has been observed that forest is mostly cleared in the catchment area of Swat River. In the study area, the massive destruction of forest cover has been blamed as one of the listed cause of the 2010 flood event (Rahman and Shaw 2014). According to the revenue department, in Swat District 75 % of the agriculture products were damaged by the flood in 2010. If the current trend of deforestation and overexploitation of natural resources continues, there will be increasing flood risk in the entire valley. Plants and trees have the potential to hold the soil and reduce surface runoff by increased ground absorption. That is why with every subsequent flood event, the extent of damages is escalating.

In Swat Valley, early constructions were made up of mud and stones. Roofs were built from wood panels and bushes covered with clay on the top. However, the front and backyards of the houses were bare soil mostly covered with vegetation. Such traditional construction has encouraged soil infiltration and reduced surface runoff, though these constructions were simple but unreliable in the rainy season. In the study area, it has been observed that concrete structures are rapidly occupying the floodplain and reducing the soil infiltration and enhancing the risk of high flood runoff.

In Swat District, Mingora is the main urban center and its population is increasing at a rapid pace. In proximity to Mingora City, the human encroachment onto the natural channel is a regular feature. During the field survey, it was observed that due to high land values, people are illegally encroaching into the natural channel and narrowing the natural course. Similarly, sewerage lines and solid wastes are directly disposed-off in these streams and further reduce its carrying capacity. Natural ground surface is changed to non-pervious artificial surface and reduces the surface water-holding capacity, and when heavy rainfall occurs, the water overflows the surface resulting into pluvial floods. In Mingora, Amankot cluster is the most vulnerable and frequently hit by floods. Amankot is a densely populated cluster and located at the foothill. Almost every heavy rainfall results into a flood in the low-lying areas.

Swat District is largely a mountainous area and such plain area has multiple occupations. With increasing population, human alteration of the floodplain has increased and changed the runoff generation process. Rapid infrastructural development in the floodplain is the major cause of reducing the carrying capacity of Swat River. Likewise, large-scale human development in the floodplain of Swat River, claiming the old river bed, is a serious intervention and offense. This is mainly due to the absence of land use regulations and enforcement, which has encouraged the vulnerable population to encroach and re-encroach onto the active floodplain of Swat River. Throughout the river course, at certain location the government has constructed marginal flood protective embankments to secure the settlement and farmland from the flood impacts.

In Swat Valley, several bridges have been constructed to increase accessibility and reduce remoteness. Usually bridges are constructed where river is found narrow. However, in few cases the channel has been narrowed by filling up and raising

the floodplain at the cost of minimizing the channel carrying capacity. Khwazakhela and Ayub bridges at Kanju are the typical examples were washed away during the 2010 flood.

In the study area, the government has constructed marginal protective embankment to save agricultural land flood effects without taking into consideration its impact on the adjacent land resources. These embankments were built in such a manner that it narrows down the channel, and now a large portion of reclaimed active floodplain is encroached by the local population for housing and other developments. Recently, Qambar bypass road is constructed on the left bank of Swat River and largely occupied by commercial activities. During the 2010 flood event, the same area (Qambar bypass road) was heavily inundated. Due to lack of land use planning and regulation, the local population is frequently encroaching onto the channel without taking into consideration the flood risk.

10.8 Floods and Land Use Planning in Swat Valley

During the past decade (2005–2015), Swat District has experienced many natural disasters and human-induced conflicts leaving everlasting impacts on people, resources, and economy. Among the list of hazards, flood is being the most frequently occurring and more fatal. During the field survey and human perception and response data collection, it was observed that stress has always been made on a short-term structural flood risk reduction strategies over long-term sustainable non-structural approach. In Swat Valley, structural mitigation approach is not a viable solution while dealing with the flood hazard. However, the non-structural mitigation approaches are more effective and sustainable way of reducing flood risk.

In Swat Valley, the place where people construct their houses is also a challenge and increasing vulnerability. Mostly, the houses and roads are built in a location exposed to high flood risk. In the study area, the floodplain of Swat River has been illegally encroached over either by the local population or preferred for government infrastructure with a justification of low-cost land. In Swat valley, construction, new developments, and other built-up properties have been allowed all along the active river channel. In the eastern Hindu Kush region, the local community lacks access to flood-resilient buildings and construction material.

In the study area, land use zoning, regulation, and enforcement have been regarded as technically viable, economically feasible, and socially acceptable strategies in halting the flood losses. Nevertheless, in the past, very little attention has been given to non-structural strategies. In the process of land use zoning and enforcement, few steps are involved including vulnerability and risk assessments, floodplain mapping and zoning, and formulation of land use regulation and enforcement. In Pakistan, such kind of practice is not reported nor a regular feature of flood risk reduction approaches. This is need of the honor to develop land use regulation and mainstream the same as a flood risk reduction strategy.

In Swat Valley, stress has always been made on structural flood risk reduction strategies over long-term sustainable non-structural approach. It has been observed in the post-2010 flood that structural mitigation approach is not a viable solution while dealing with the flood hazard. However, the nonstructural risk reduction approaches are more effective and sustainable in minimizing the flood risk. In the study area, land use regulations and zoning is one of the technically viable, economically feasible, and socially acceptable approaches in minimizing the flood damages. In Swat Valley, traditionally very little attention has been given to nonstructural mitigation. In the process of land use zoning and enforcement, few steps are involved including vulnerability and risk assessments, floodplain mapping and zoning, and formulation of land use regulation and enforcement. In Pakistan, such kind of practice is not reported and need to be mainstreamed in the flood management planning and policy.

In Swat District, land use planning and enforcement is the responsibility of irrigation department, who manages the channel area, whereas District/Tehsil Municipal Administration (D/TMA) is responsible for land use planning in towns and villages. Unfortunately, these departments have not yet undertaken any progress in land use planning and enforcement. Initially, these departments should formulate land use zonation and regulation to limit land utilization in the floodplain and promote disaster risk reduction. The irrigation department has identified limits for the active channel and streams, but the community is consistently encroaching to high flood risk zones without taking care of flooding. Even after the disastrous flood of 2010, the floodwater inundated and washed away all the encroachments throughout the active flood channel. During the post-flood 2010, a number of relief organizations have started interventions and partially compensated the flood victims in early recover, rehabilitation, and reconstruction. However, the community has reconstructed the already washed away buildings in the same location without taking care of past experiences. Similarly, new developments are still in progress in the form of houses, hotels, restaurants, etc. in the active floodplain of Swat River. But none of the government departments are giving any serious attention to this alarming issue.

10.9 Flood Hazard Zonation in Swat Valley

In Swat valley, flood risk may be minimized by changing function of land use or minimize the exposure to recurrent flood events. The land use related departments need to introduce reforms, devise and enforce land regulations through short and long-term stretegies.

In Swat Valley, flood risk mapping still needs to be prepared, and due attention may be given to minimize the flood impacts. A flood risk map is a graphical representation of flood level. Such maps have also risk categorization as high-, moderate-, and low-risk zones on the basis of potential damages to social, economic, and geophysical sectors. A large variety of application of flood risk maps are available in literature and practiced in several countries. Based on these maps, regulations are

streamlines and subsequently implemented for flood risk reduction. In Swat Valley, the floodplain characteristics vary from place to place and region to region depending on the topography and hydrological factors. While demarcating flood risk zones, socioeconomic bound needs to be kept in mind. The field observation reveals that the floodplain dwellers are often attracted by the rivers and offer numerous opportunities.

Regulation for flood zoning needs to be prepared with high safety standard and major focus on getting more benefits from the floodplains rather than merely reducing flood damages. In order to effectively utilize the floodplain, a comprehensive approach is required for the establishment of flood zones parallel to the flood channel. While demarcating various flood zones, proper attention need to be given to past massive flood events and their extent. Contrary to this, sole reliance on prohibition is not a beneficial risk reduction approach.

In Swat Valley, to get a maximum benefit from the floodplain utilization, a rational flood hazard zonation need to be planned to secure minimum flood damages (Fig. 10.3). In this attempt, flood risk can be minimized by changing the functional characteristics of land use practices, which in turn reduce the susceptibility. Generally, in floodplain zoning, it suggests for modification or abandonment of land use. In the active floodplain of Swat River, land is mostly allocated to rice cultivation locally called as *Sholgara*. In terms of investment, the land utilized for rice would cost more as against grass/grazing land and fodder crops.

The utilization of flood risk zones needs to be utilized in a hierarchical order as one proceeds from active channel toward outskirt such as grassland, fodder and rice, etc. Throughout the Swat River course, the zones shall be elongated and narrow in the upper reaches with a steep topographic characteristic and gradually widen as one proceeds downstream from *Khawaza Khela*. For example, the high flood hazard zone is located close to the active channel and needs to be specified for river training with no other utilization. Similarly, the allocation of moderate flood hazard zone is next to high hazard zone. This is a productive land and needs to be specified for agriculture economic activities and would help in getting maximum benefit out of the zone with minimum structural and human casualties. With the same intention and application, the land utilization needs to be extended to next zones.

This is the liability of District/Tehsil Municipal Administration (D/TMA) to apply land use planning in floodplain management of Swat River. It is time that the Tehsil Municipal Administration may take notice of frequent encroachments onto the flood risk zones. Presently, a bypass road has been constructed on the left bank of Swat River to avoid heavy traffic passing through Mingora City and to avoid congestion and development toward the active river channel. Within a year a huge number of resorts and restaurants have been constructed along the bypass road in the active floodplain of Swat River. New constructions are in progress all along the banks of Swat River without taking care of floodplain regulations.

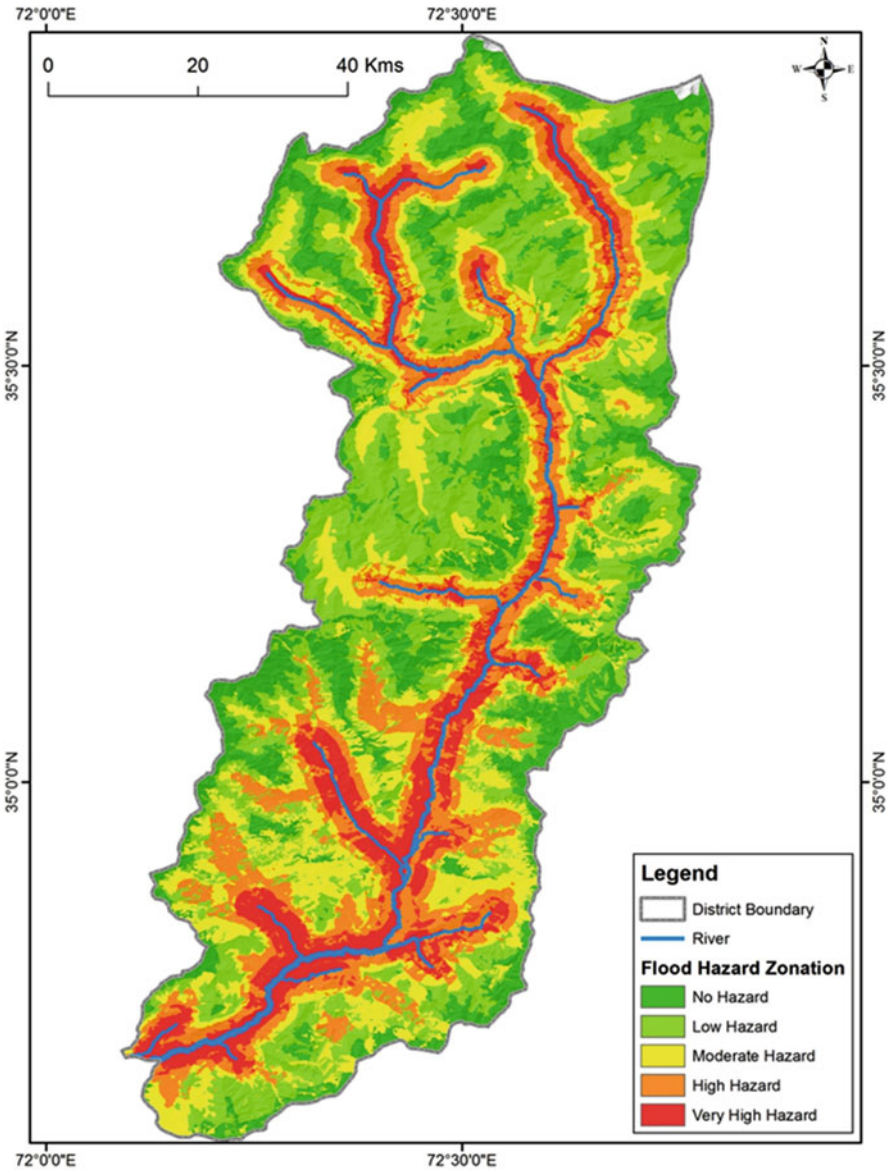

Fig. 10.3 Flood hazard zonation in Swat District

10.10 Conclusion

The analysis revealed that in the study area, flood hazard mapping is not yet prepared by the concerned government organization. It is therefore due attention be given to reduce the impacts of flood events. While managing floodplain, priority be given to get more benefits from the floodplain utilization and a rational flood hazard zones be made with little or no adversaries. It is need of the hour to undertake hydrological modeling, floodplain mapping, and zoning all along the Swat River system in a climate change scenario and to measure flood peaks through projected estimates. Similarly, promoting the use of flood risk information for effective land use planning and zoning programs is also one of the key strategies in disaster risk reduction. Floodplain zoning and management include legislation for land utilization, ban on new construction in the high flood hazard zone, removal of encroachment from the active floodplain of Swat River, and allocation of land to specific use with little or no damages. In addition to this, to enforce effective structural mitigation strategies in the flood-prone localities and also take into consideration integrated flood risk reduction plans. Allocation of funds to promote safer construction practices is another effective way of dealing with flood disasters. Likewise, to implement pilot programs on safer construction in flood-prone areas would help in enhancing awareness in the high-risk zones.

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