Chapter 5
Watershed Management[7]

Watersheds are rich in natural resources and are often exploited for subsistence farming, economic interests, and tourism. Some activities, when unmanaged, have impacts that degrade the environment in the long term. These factors exacerbate flood hazards by increasing the quantity and velocity of flash floods. It is very important to incorporate the dynamics of exploiting natural resources in terms of natural disasters. Integrated watershed management is needed to suppress the processes that trigger flash floods. Proper uses of land, forest, and water resources are primary acts of mitigation. The role of the community in properly managing watersheds is paramount. This section provides some suggestions on watershed management measures targeted towards reducing flash flood hazards.

5.1 Land Use Management

Overexploitation of resources has adversely affected the land's resilience. Proper management of land use in vulnerable areas is essential to ensure the minimum loss of life and property. Management of land use in a watershed can include two major activities to reduce flash flood risk: a) management of settlements, and b) management of agricultural land and forests.

Management of settlements

Numerous social, economic, and environmental benefits of living near water have historically outweighed the risk of floods (FAO 2005). Settlements near flood zones not only put people at risk, they also alter the natural flow of water. Extension of settlements in floodplains must be restricted, and existing settlements near riverbanks must consider special housing designs that minimise interference with the natural flow of water.

Management of agricultural and forest land

Rapid population growth and poverty have compelled people to overexploit resources. They are forced to convert forest and pasture land to farmland to feed their families.

Since landholdings in high mountain areas tend to be very small, more people rely on livestock for their livelihood. Overgrazing of pasture land adversely effects soil stability. Overgrazing destroys plant cover, leading to a decrease in both interception and infiltration of rainwater, and, thus, enhanced surface runoff. Further, as there is no humus layer, the water-holding capacity of the soil is greatly reduced, and there is no vegetation to retard the flow of water carrying large quantities of sediment in its wake. As a result, a flash flood can be triggered. It is, therefore, important to manage both agricultural land and forest land properly to reduce the effect of disasters. Table 3 provides some tips for the management of agricultural land and forests.

Table 3: **Tips for the management of agricultural and forested land**

Agricultural land	Forested land
Proper soil management activities to enhance the infiltration capacity of soil (for example, certain types of soil tillage, increase of the organic fraction, etc.)	Increase the intensity of forest land
Favourable agricultural practices to minimise soil loss (crosswise tillage, grass covering, etc.)	Increase community participation in conserving forest
Introduction of agroforestry	Increase the multifunctional use of woods (productive, protective, recreational, ecological, landscape functions)
Proper drainage channels to overcome inundation of fields	Maintain stability of woods from the ecological point of view (mixed woods, woods of different age, etc.)

[7] Contributed by Mr. Keshar Man Sthapit, ICIMOD.

How to make land-use planning effective in reducing vulnerability to natural disasters

- Be subject to stakeholder participation and scrutiny to ensure that its role and purpose are understood.
- Mobilise adequate resources in terms of finances, people, skills, and equipment.
- Enact legal status and power to enforce plans, codes, and legislation.
- Coordinate with other mitigation methods.
- Raise awareness of measures, benefits, and limitations.
- Monitor and evaluate the success of the plans.

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5.2 Remodelling Agriculture

Agriculture in flood-prone areas should be planned to mitigate the possible flood damage to crops. Agriculture in Assam, where floods are a regular feature, is a good example. The successive floods from the Brahmaputra and Barak rivers and from their tributaries cause extensive damage to agriculture, for example:

- damage to the Ahu crop (rice) before the harvest
- damage to the sali (the main rice crop), which cannot be transplanted in time as the seedlings are damaged either in the nursery or after transplanting, or sometimes even destroyed in the field
- damage to the jute crop or quality is adversely affected

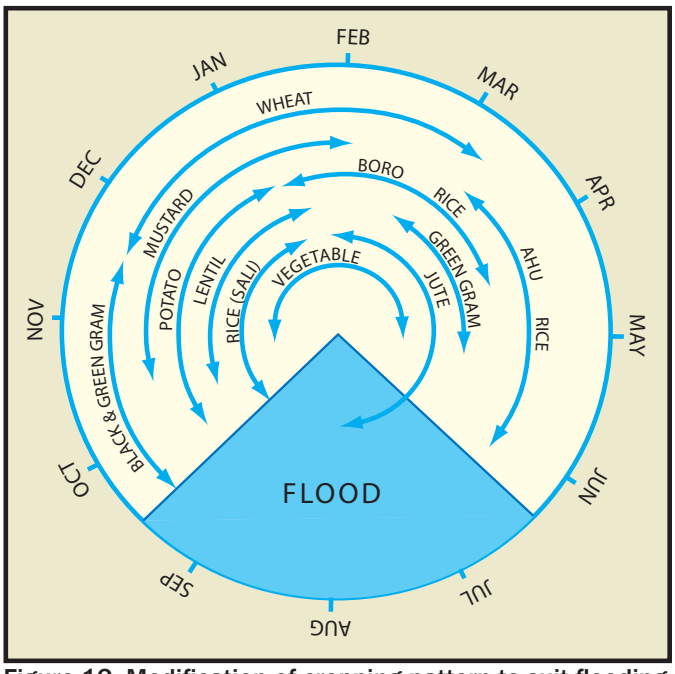
The strategies concerning remodelling of land use proposed to minimise the adverse effects of recurrent floods include (Swaminathan 1980):

- **Multiple cropping:** Cropping of medium-tall Ahu rice with deep-water rice in low-lying areas as an insurance so that if the Ahu rice is damaged there will be some production from the deep-water rice.
- **Restructuring of the cropping pattern[8]:** The safest way to assure crop production in flood-prone areas is to grow more crops in the flood-free period.

The flood-free period and the potential for growing crops in this period are shown in Figure 12.

5.3 Maintenance of Watercourses[9]

Maintenance and restoration interventions along natural (e.g., rivers, streams, nullas) and artificial (e.g., canals, drainage channels, pipelines) watercourses are necessary to assure discharge capacity during strong flood events. Watercourses often change their paths, and human activities like mining river materials (sand, stone, water itself) can intensify this meandering process. It is wise to leave a watercourse in its natural state, but if this cannot be achieved, certain precautionary measures should be taken.



Source: Modified from Swaminathan 1980

Figure 12: Modification of cropping pattern to suit flooding period

[8] The strategy suggested here is more applicable for flash flood-prone areas in the central part of the Himalayas of Nepal and India where rainfall-induced flash floods occur mainly from mid-June to October. In other areas, the scheme might be applicable with appropriate modifications.

[9] Many of the measures listed are beyond the capacity of communities and CFFRMCs; however, they must be aware of these measures so that they can create an enabling environment for external agencies and the government to implement them.

Some general maintenance measures to attain acceptable conditions in watercourse areas are listed below.

- delineate a buffer zone in the floodplain and restrict settlement and agricultural activities
- develop the floodplain as an ecological corridor
- non-interference with natural water conditions
- upkeep watercourse reaches that are still in their natural state
- protect specific habitats
- undertake structural interventions to improve ecological functions (activation of old branches and creation of biotopes where necessary to comply with the ideal conditions established by environmental models)
- undertake flood damage prevention measures (e.g., local bank protection, constant stabilisation interventions, and rechannelling of course deviation into the original bed)
- take measures to counter harmful influences on the whole system originating from the neighbourhood (e.g., protection against deposition of erosive materials and promotion of water-friendly exploitations)
- upkeep and activation of floodplains
- maintain natural depressions that act as natural retention during floods

5.4 Bioengineering

Bioengineering is the integration of vegetative methods with simple engineering practices, and can be a very effective watershed management measure using local resources (Bhatta et al. 1999). Bioengineering measures are effective in protecting unstable slopes. In bioengineering systems, vegetation provides additional strength to the engineering structures with which they are integrated. Commonly practised bioengineering techniques that can be used for slope stabilisation and minimisation of runoff include the following (Wagley 1999; Li 1999).

Planting trees, shrubs, and grasses: Trees, shrubs, and grasses can be planted on degraded slopes, either alone or in combination. A dense network of roots in the soil and a canopy overhead helps to protect the slope from erosion, which in turn prevents river-damming landslides. Methods of planting should be selected depending upon the purpose, site condition, and availability of resources. On hill slopes, contour-line planting at regular intervals is the general practice (Wagley 1999).

Planting stumps/woody stems: Stumps can be cut or woody vegetation planted along the contour to trap soil particles and debris falling down the slope (Wagley 1999).

Seeding grass, trees, and shrubs: Seeds of grass, trees, and shrubs can be sown directly on site either alone or in combination. Methods and timing for seeding depend upon site conditions and availability of resources. Seeds can be broadcast to cover large areas in a short time at low cost. This method can be used on steep, rocky, and unstable slopes where seedlings and cuttings cannot be planted directly.

Bamboo/broom grass planting: Rooted culm cuttings, rhizomes, and wild seedlings of bamboo and broom grass can be planted directly on slopes. Bamboo and broom grass perform slope stabilisation work effectively once they are established.

Wattling: Bundles of live branches with buds are put into a trench along the contour and covered with a thin layer of soil. When the branches put out roots and shoots, a strong vegetative barrier is formed that is effective in holding soil particles moving down hill slopes. This technique is not popular as it is expensive and works only on gentle slopes.

Brushwood check dams: Brushwood check dams of bamboo and wood are commonly used to stabilise gullies on slopes. After construction of the check dams, grass and shrubs are planted on side slopes and on the gully head.

Vegetated riprap: Side slopes of gullies and gully beds are sometimes protected by constructing dry stone walls, after which grass seeds are sown or planted in the gaps between the stones to reinforce toe walls and gully beds.

Loose stone and gabion check dams: Constructing loose stone and gabion check dams is a very common method for stabilising slopes. After the construction of check dams, seedlings of trees, shrubs, and grasses are planted either separately or in combination on gully heads, side slopes, gully beds, and in and around the structure for reinforcement.

Jute netting: Jute netting is another way to protect slopes using grass slips or seedlings. Jute, being a biological product, decomposes into the soil and functions to support the seedlings during their early growing period. This method can be useful on steep and hard slopes where establishing vegetation is difficult.

Integrated watershed management (IWM) is essential to ensure sustainability of risk management (Bhatta et al. 1999; APFM 2004a). For any land use planning and development, certain guidelines must be followed to reduce the risk. The wish to obtain optimal utilisation of natural resources often results in a devastating hazard like flash flood. Reducing overgrazing of pasture and introducing stall feeding, and introducing bio-friendly methodologies like biogas or solar power for household activities, can reduce the dependency on natural resources. Good governance, transparency, and proper grip and unity in a community are fundamental requirements to ensure that the activities in a watershed do not increase hazards, CFFRMCs can play an important role here.