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# Watershed Prioritisation with Reference to Drainage Characteristics and Land Use Land Cover Change for Sustainable Development of Mountain Regions: Parvati Basin, Himachal Pradesh

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**Abstract:** *Parvati river basin is one of the most ecologically fragile watersheds of Himachal Pradesh. Prioritisation and management of this type of watershed is very helpful as it helps to access the biotic and non-biotic components of ecosystem for improving the structure and implementation of programs for sustainable development. It primarily targets on using natural resources in more productive and sustainable manner. Hence a quantitative morphometric analysis and land use land cover change analysis was carried out for the prioritisation of the watersheds of Parvati basin. The quantitative morphometric analysis was performed, for both linear as well as areal aspects to get a compound value that was used for final ranking of the sub-watersheds. To analyse changes in land use and land cover area and its spatial distribution pattern over time, different time perio d remote sensing satellite imageries were acquired for the years 1973 (Landsat MSS) and 2008 (IRS P6 LISS III). The final prioritisation of watershed was done by combining the priority results derived from morphometric and land use land cover analysis. The study shows that Parvati basin with its significant topographical and land use land cover variation requires in depth watershed prioritisation study for implementing better planning and sustainable development programmes. The high priorities areas mostly lie on the southern bank because of its location in the hilly terrain with undulating topography and intensive land use of the study area.*

## Introduction

The management of natural resources is on the forefront of the struggle for more sustainable and equitable development. The balance between needs of a rapidly transforming global economy and sustainable development has become all the more urgent in recent decades. In India, the process of economic development is accompanied by deteriorating environmental conditions due to misuse of natural resources like water, soil and forest.The significance of the concept of watershed for environmental sustainability is well recognised (Murty, 1998). Different characteristics of watershed, like- size, shape, slope, drainage morphometry, vegetation, geology, soil, climate and land use land cover are considered important for prioritisation of drainage basin (Kathuria, 1978). The type of land, altitudes and physical characteristics are significant for watershed management. Slope, for example, is one of the major controlling factors for the rain water movement and its distribution, land use/land cover pattern and watershed behaviour. [The order, pattern, density and other morphometric properties have a significant impact on infiltration, runoff, land management of the watershed and determine the nature of flow and the erosional behaviour of the stream (Murty, 1998)]. The assessment of interrelationships between different morphometric variables helps in explaining the hydrological and terrain characteristics of river basin, which is helpful for the watershed development and planning (Rekha *et al.*, 2011). The analysis of land use/land cover pattern provides vital information about many facets of watershed system, including altered drainage regimes, valued natural and built features which form a basis for prioritisation and management of watershed (Heathcote, 2009). In this paper an attempt has been made to undertake a quantitative morphometric analysis and land use/land cover change analysis for the prioritisation of the watersheds of Parvati basin in Himachal Pradesh.

## Study area

The Parvati basin is located in the Kullu district of Himachal Pradesh (Fig.1). The watershed is bounded by the Pir Panjal range in the north

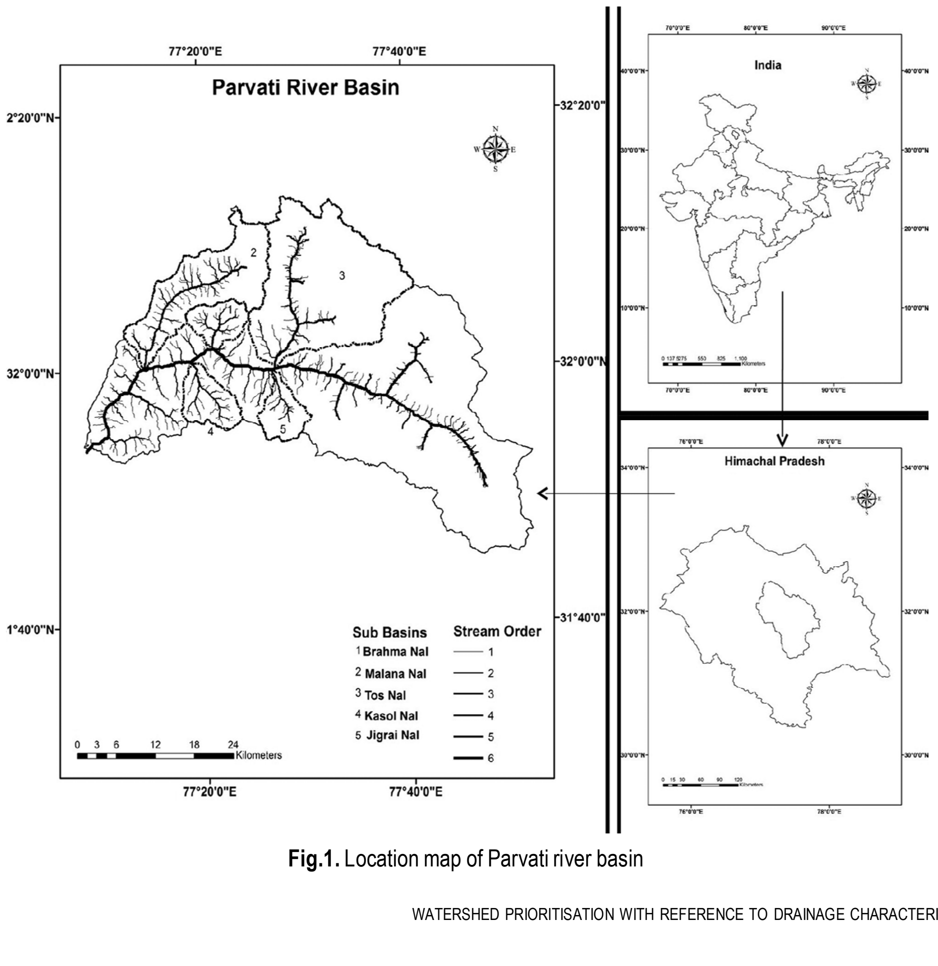


**Fig.1.** Location map of Parvati river basin

and north-east and by the Dhauladhar Range in north-west, south and south-east. The total areal coverage of the Parvati basin is around 1760 km$^2$. Melt water from thirtysix glaciers forms an important source of run-off in the Parvati basin (Kulkarni *et al.*, 2005). The average relief of Parvati basin is 2,500 m. Parvati basin has extremely complicated, fractured and crumbled rock strata of central crystalline and sedimentary formations of Tethys zone. Parvati river watershed presents a typical combination of moderate to high rugged topography with numerous mountain peaks with height over 5,500m and characteristic geomorphic features like narrow valley, steep slopes, ridges, hills, deep gorge, spurs,incised meanders, narrow cultivated terraces, precipitous cliffs, spurs, rocky crags, and escarpments.

### *Climate, geology and soils*

The climatic conditions in the valley vary from hot and moist tropical conditions in lower part of basin during summer to cool temperate at 1,500–2,000 m. Areas above 4,000 m have polar type of climate. Due to large difference between temperature and elevation the seasonal snowline is highly variable, which decreases to about 2000 m in winter and reaches to around 5,000 meters in summer.

The metasedimentaries formation of the 'Kullu-Rampur window' has been classified into three sub units: Green Bed Member, Bhalan Member and Manikaran Quartzite which are categorised under Banjar Formation (Misra and Tewari, 1988). The Manikaran Quartzite sub units are generally gritty, fine grained, at some places and has been recrystallised into a fine-grained mosaic of quartz (Sharma, 1977).The Green Bed Member consists of metamorphic rocks like-green phyllites, schists and metabasics. This sub unit exists as a thick mapable unit besides a few interbedded bands with quartzite. The Bhalan Member consists of slates and phyllites intercalated with metabasics and flaggy quartzites. Glacial and periglacial processes are mainly active in the upper and higher slopes while the main valley corridor is dominated by the fluvial processes. Tectonically, the Parvati river basin is active which is evident from the presence of a number of seismically active faults/lineaments.

The soils of Parvati river basin vary from very shallow to moderately deep and very deep, yellowish brown to dark brown in colour. The texture varies from sandy loam to silty clay loam and clay. Both calcareous and non-calcareous soils are found in the basin.

## Material and methods

The Survey of India topographic sheet (1:50,000) used in the study was registered to UTM projection (WGS 84 North, Zone 43). The drainage network of Parvati basin, Brahma *nal*, Jigrai *nal*, Kasol *nal*, Malana *nal*, and Tosh *nal* (*nal* stands for stream in local parlance) was delineated by digitising drainage lines in GIS environment from the topographic map. Quantitative morphometric analysis for Parvati and different sub-watersheds was carried out, for both linear and areal aspects. The fundamental basin parameters like area, perimeter, basin length, stream length and number of streams were obtained from the drainage morphometric analysis. The values of morphometric parameters like mean stream length, mean bifurcation ratio, stream length ratio, drainage frequency, drainage density, form factor, shape factor, length of overland flow, drainage texture, circularity ratio, constant of channel maintenance and elongation ratio were estimated. Prioritisation rating for all the five sub-watersheds of Parvati watershed was examined by assigning a rank to each variable and then estimating the compound parameter values. The sub-watershed having the lowest compound parameter value was given the highest priority and vice-versa. ASTER stereoscopic data (30-

meter resolution) was used to determine different relief features of the basin.

To analyse changes in land use and land cover area and spatial pattern variations over the study period, different remote sensing satellite images were procured for the years 1973 (Landsat MSS) and 2008 (IRS LISS III). Original satellite images were resampled to make a quantitative comparative assessment of the images in the present study.In addition to this, Survey of India topographic sheets for the year 1969 (52 H/4,H/8, H/12, 53 E/1, E/5, and E/9) and GPS for ground truth verification were used for the ground survey to access the accuracy and proper land use land cover classification. The orthorectified Landsat satellite data (UTM/WGS 84 projection) was obtained from Global Land Cover Facility (GLCF: www.landcover.org). The geometric correction of IRS LISS III datasets was done using Landsat images. After that several band combinations were used to produce falsecolour composites (FCC). Unsupervised classification was carried out for the study area based on the detailed information generated from these data sets. Subsequently, on the basis of texture, colour, pattern, tone etc. The satellite images were classified accordingly, based on their spectral signatures using Erdas Imagine 9.2 software into different land use land cover classes. The quantitative spatial statistics of land use land cover of 1972 and 2008 was calculated to determine the rate of change between two time periods. Finally prioritisation of land use land cover was done from the rank that was estimated on the basis of area falling under each land use category or class. Apart from the ERDAS Imagine, the other softwares used for the present study are ARC GIS -9.3, Microsoft Excel and SPSS.

## Results and discussion

*Morphometric Analysis: Linear Parameters*

STREAM ORDER:Stream order is a useful indicator of stream size, discharge, and drainage area (Strahler, 1964). Stream order analysis shows that the main basin is of sixth order as per the Strahler's scheme of stream order. Similarly Brahma, Malana, Kasol, and Tosh *nal* are of fifth order (Table1). Streams generally follow the path of least resistance, thereby forming valleys where rock is easily erodable. Stream pattern in the sub-basins varies from dendritic in general to parallel in the Jigrai *nal* and sub dendritic in the Malana and Tos *nal*.

BIFURCATION RATIO (Rb): It is defined as the ratio between number of streams of any given order (Nu) to the number of streams in the next higher order (Nu+1) (Horton, 1945). Computed values of Rb of all the five sub-basins are less than 5, which specify that the control of drainage network is mainly marked by geomorphology. The Rb of Parvati river basin is 5.06, which demonstrates the significance of structural control on the evolution of drainage network.

MEAN STREAM LENGTH (Lu):According to Strahler (1964), the Lu is a dimensional property related to the drainage network components which reflect the hydrological characteristics of the underlying rock surfaces and its associated surfaces. The mean stream length (Lu) is minimum (1.44) in the Brahma *nal* and maximum (3.74) in the Malana *nal*. It is noted that the Lu is minimum in the case of first-order streams of all the sub-basins, and maximum in highest order of watersheds (Table1). This shows geological control over the development of streams.

STREAM LENGTH RATIO:The stream length ratio is described as the ratio of the average length (Lu) of a stream of any given order (u) to the average length of a stream of the next lowest order. The stream length ratio in the study area varies between 0.40 and 0.80. The strong correlation between stream order and stream length ratio shows that stream length ratio increases as the order of stream increases.

*Morphometric Analysis: ArealParameters*

FORM FACTOR (Ff): It is the ratio of the basin area (A) to the squared value of the basin length (L) (Horton, 1945). Manu and Anirudhan 2008 stated that the form factor value ranges from zero (in highly elongated shape) to 1 (in perfect circular shape). Average form factor value of the Parvati basin is 0.26. In sub-basins of Brahma, Kasol and Tosh *nal* the Ff are above 0.60, indicating that these sub-basins are of circular shape.

ELONGATION RATIO (Re):It is calculated as the ratio between the diameter of a circle of the same area as the basin (A) and maximum basin length (L) (Schumm 1956). The high value of Re shows dynamic denudational processes with high infiltration capacity and low run-off in the basin, whereas, low Re values point to higher elevation of the basin liable to high headward erosion along tectonic lineaments (Reddy *et al*. 2004). Parvati River, Malana, Tosh and Brahma *nal* confirms that the basins are associated with high relief and steep slopes.

SHAPE FACTOR (BS):Basin shape factor is the ratio of the square of basin length (Lb) to the area of the basin (A). Shape factor (Bs) present a measurement of basin shape irregularity. The calculated value of Bs of the Parvati river basin is 3.78. Brahma *nal* and Kasol *nal* have shape factor below 1.50 that shows these basins have sharply peaked flood discharge.

CIRCULARITY RATIO (RC):According to Miller 1953, it is expressed as the ratio of the basin area and the area of a circle with the same perimeter as that of the basin. It is affected by the geological structures, land use and land cover, slope and climate of the basin. Brahma *nal* and Kasol *nal* have higher Rc values and are circular in shape, whereas rest of the sub-watersheds have elongated shape, since they have lower Rc values.

STREAM FREQUENCY (FS):Stream frequency (Fs) is defined as the total number of stream segments of all orders per unit area (Horton 1932). The stream frequency of a drainage basin is associated with infiltration capacity, permeability, and relief of the sub-basins (Vijith and Sateesh 2006). In the study area, the Brahma *nal* and Kasol *nal* have relatively higher Fs values which reveal that these sub basins have relatively higher relief and low infiltration capacity of the bed rock (Table1).

DRAINAGE DENSITY (DD):It is used to express the closeness of spacing between channels within a basin (Horton 1932). Brahma *nal* and Kasol *nal* have high drainage density that indicates these basins consist of sparse vegetation and impermeable subsurface materials. Whereas, Tosh *nal*, Jigrai *nal* and Parvati basin have low drainage density which is characteristics of highly resistant subsoil materials under dense vegetation cover (Nautiyal, 1994).

DRAINAGE TEXTURE (T):It is defined as the ratio between total numbers of stream segments of all orders to the perimeter of the basin (Horton 1945). Smith 1950, had classified the basin based on the values of drainage texture very coarse (>2), coarse (2–4), moderate (4–6), fine (6–8), and very fine (<8). Drainage texture of the entire Parvati river basin is coarse. Among sub-basins Brahma and Kasol *nal* have closely spaced streams so, these basins have fine drainage texture resulting in high surface runoff.

LENGTH OF OVERLAND FLOW (LO): Horton, 1945, defined it as the length of water over the ground before it gets concentrated into definite stream channels. The higher Lo values of Kasol *nal* (1.28), Brahma *nal* (1.22), Malana *nal* (0.85), Jigrai *nal* (0.69) and Parvati basin (0.62) indicates the late mature and old stage of basin (terrain) development. Tosh *nal* (0.39) have low values due to hilly terrain having steeper valley side and ground slope. This basin is in late youth to early mature stage.

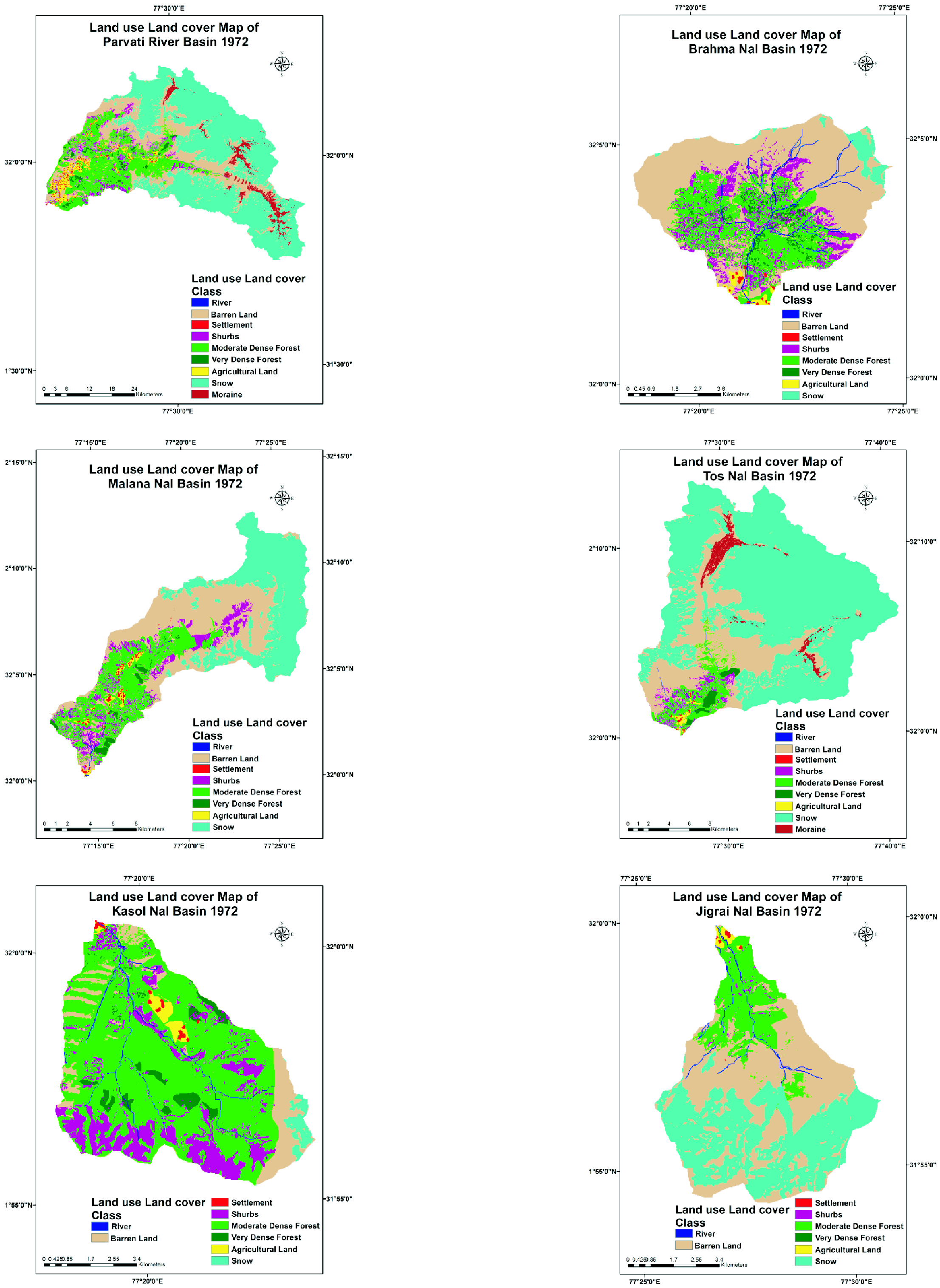


**Figure 2**. Land use and land cover analysis of Parvati basin and sub-basins based on MSS 1972.

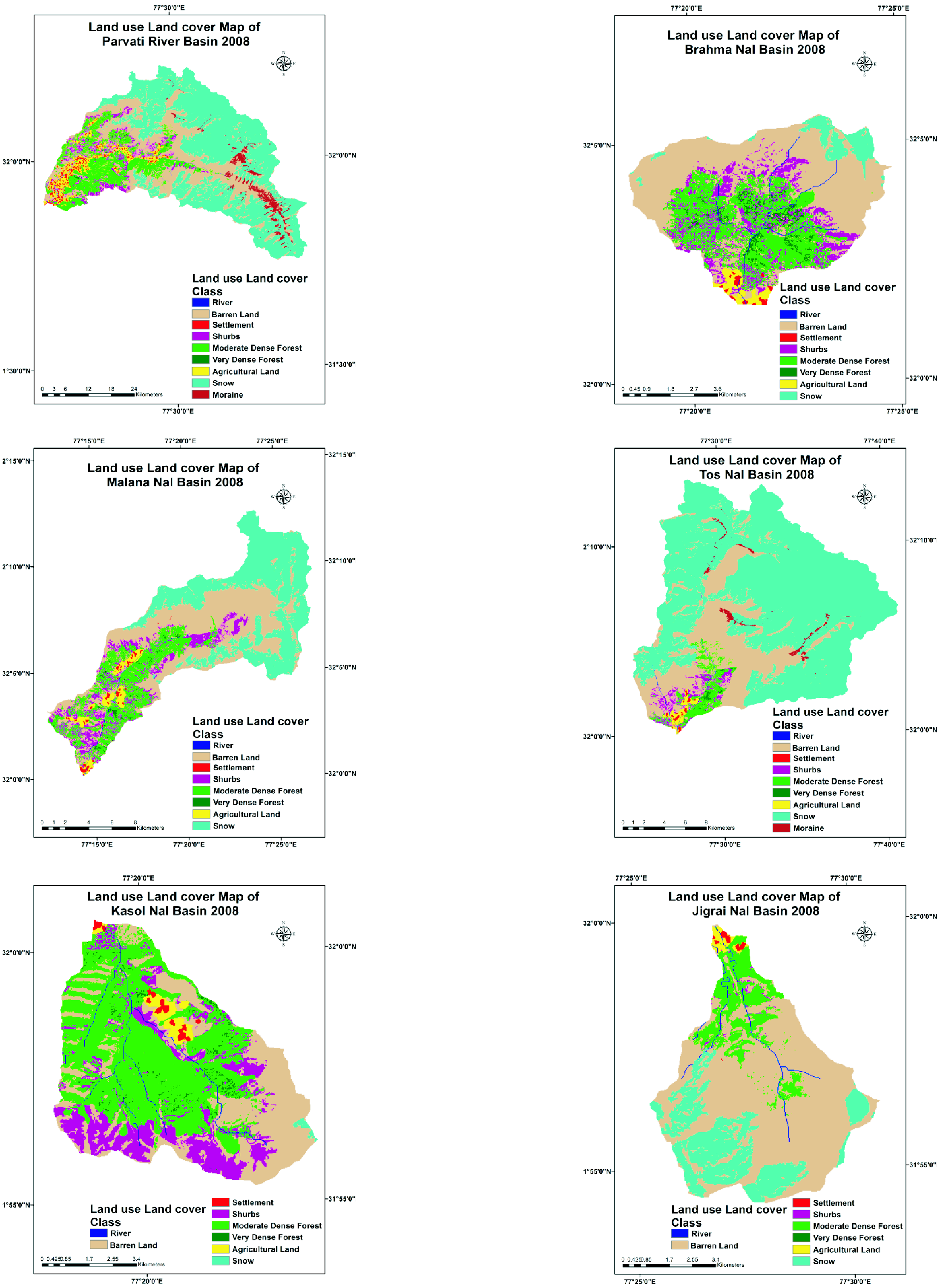


**Figure 3**. Land use and land cover analysis of Parvati basin and sub-basins based on LISS III-2008.

Constant of Channel Maintenance (C):Schumm (1956) had employed the inverse of drainage density to define the constant of channel maintenance. Tosh *nal* and Parvati basin have high value of C that denotes, the high permeability of the rocks of that basin whereas other sub-basins have low value of C that shows less permeable rocks in those basins (Subba Rao 2009).

### *Relief Parameters*

Basin Relief (R): Basin relief is the difference in elevation between the highest and the lowest point of the basin. Parvati basin (5533) has highest and Kasol *nal* (3181) have lowest basin relief values.

Dissection Index (Di): Dissection Index (Di) is defined as the ratio of the maximum relative relief to maximum absolute relief. It is a significant morphometric indicator of the nature and magnitude of dissection of terrain. It is highest for Parvati basin (0.84), perhaps because of high fluvial erosion and high surface runoff and lowest in Jigrai *nal* (0.60).

### *Land use/land cover change analysis*

Land use/land cover change is among the most important socioeconomic forces that induce changes and degradation of ecosystems by influencing important ecosystem processes and services. Over the past four decades agricultural land has increased considerably in the Himalayan region at the costs of other land uses, particularly forests (Sharma *et al.*1992).With the expansion of road network, area under agriculture and horticulture and other anthropogenic activities such as tourism, the Parvati basin has also undergone significant land use and land cover changes.

The land use land cover classification of the study area delineates the spatial distribution of different classes under following heads – built up area, agricultural land, forest land, barren land, water body (river) and snow cover. The land use/land cover map prepared from the Landsat satellite images of 1972 and IRS P6 LISS-III for 2008. It was established through time series analysis that there has been a considerable land cover change, particularly the change of dense forest to scrub and agricultural fields as shown in Table 2. Dense forests are mainly found in protected and reserved forest areas. Moderate dense forests are widely spread in the lower part of basin, whereas shrubs are found mostly at high altitude areas.

Moderate dense forests are more prone to deforestation as they surround the lower part of basin surrounding human settlements and agricultural land. In 1972, the dense and very dense forest cover reported for Parvati basin was about 26704.45 ha (15.17%) and 2819.69 ha (1.60%) out of the total study area of 176026 ha (Fig.2). Within a period of thirty six years, by 2008, dense and very dense forest was reduced to 20775.86 ha (11.80%) and 1539.19 ha (0.87%) of the total area (Fig.3).

Among the sub-basins Kasol *nal* experienced huge change in area of dense and very dense forest, with respect to other sub-basins. However, there is increase in very dense forest area (3.06 ha) from 1972 to 2008 in Brahma *nal* basin. The land use/land cover change analysis shows that the remarkable changes had occurred in the proximity of agricultural lands due to high anthropogenic pressure (Fig. 3). Agricultural lands are mainly found near the Parvati river course and on the alluvial land along the tributaries. Agricultural practices are restricted mostly in lower part of basin where relative relief and slope is low. The agricultural land area increased from 4797.56 ha (2.73%) to 5508.17 ha (3.13%) from 1972 to 2008 in Parvati basin. About 710.61 ha of agricultural area were increased over the period of study. There has been a significant land cover change, particularly the conversion of dense forest to scrub and agricultural land in Malana *nal* basin from 1972

**Table 1.** Morphometric parameters of the Parvati drainage basin

| **Linear parameters** | **Brahma** *Nal* | **Jigrai** *Nal* | **Kasol** *Nal* | **Malana** *Nal* | **Tos** *Nal* | **Parvati River** |
|---|---|---|---|---|---|---|
| Mean stream length(Lsm) I | 0.42 | 0.42 | 0.44 | 0.44 | 0.42 | 0.42 |
| Mean stream length(Lsm) II | 0.42 | 0.70 | 0.63 | 0.74 | 0.59 | 0.63 |
| Mean stream length(Lsm) III | 1.09 | 1.08 | 1.43 | 1.50 | 1.83 | 1.61 |
| Mean stream length(Lsm) IV | 1.98 | 7.38 | 5.27 | 4.82 | 7.39 | 5.60 |
| Mean stream length(Lsm) V | 3.30 | | 4.26 | 11.21 | 12.23 | 9.76 |
| Mean stream length(Lsm) VI | | | | | | 40.71 |
| Mean stream length(Lsm) | 1.44 | 2.39 | 2.41 | 3.74 | 3.06 | 8.14 |
| Stream length ratio (RL) II/I | 0.44 | 0.36 | 0.35 | 0.43 | 0.35 | 0.39 |
| Stream length ratio (RL) III/II | 0.40 | 0.33 | 0.43 | 0.38 | 0.45 | 0.43 |
| Stream length ratio (RL)IV/III | 0.54 | 1.70 | 0.82 | 0.64 | 0.81 | 0.56 |
| Stream length ratio (RL) V/IV | 0.56 | | 0.40 | 0.58 | 0.55 | 0.41 |
| Stream length ratio (RL) VI/V | | | | | | 0.83 |
| Mean stream length ratio (Rlm) | 0.48 | 0.80 | 0.50 | 0.51 | 0.54 | 0.52 |
| Bifurcation ratio (Rb) I/II | 2.25 | 4.74 | 4.10 | 3.85 | 4.01 | 3.84 |
| Bifurcation ratio (Rb) II/III | 6.50 | 4.75 | 5.33 | 5.35 | 6.93 | 5.98 |
| Bifurcation ratio (Rb) III/IV | 3.33 | 4.00 | 4.50 | 5.00 | 5.00 | 6.29 |
| Bifurcation ratio (Rb) IV/V | 3.00 | | 2.00 | 4.00 | 3.00 | 4.20 |
| Bifurcation ratio (Rb) V/VI | | | | | | 5.00 |
| Mean bifurcation ratio (Rbm) | 3.76 | 4.49 | 3.98 | 4.55 | 4.73 | 5.06 |
| **Areal parameters** | | | | | | |
| Form factor (Ff) | 1.06 | 0.46 | 0.74 | 0.27 | 0.65 | 0.26 |
| Elongation ratio (Re) | 2.96 | 2.4 | 2.87 | 3.01 | 4.47 | 5.23 |
| Shape factor (Bs) | 0.95 | 2.19 | 1.35 | 3.71 | 1.54 | 3.78 |
| Circularity ratio (Rc) | 0.62 | 0.54 | 0.63 | 0.31 | 0.48 | 0.32 |
| Drainage density (Dd) | 2.44 | 1.37 | 2.56 | 1.70 | 0.79 | 1.25 |
| Stream frequency (Fs) | 5.01 | 2.51 | 4.55 | 2.87 | 1.42 | 2.26 |
| Drainage texture (T) | 12.24 | 3.45 | 11.64 | 4.88 | 1.12 | 2.82 |
| Length of overland flow(Lo) | 1.22 | 0.69 | 1.28 | 0.85 | 0.39 | 0.62 |
| Constant of channel maintenance (C) | 0.41 | 0.73 | 0.39 | 0.59 | 1.27 | 0.80 |
| **Relief parameters** | | | | | | |
| Basin relief (R) | 3461 | 3271 | 3181 | 4584 | 4253 | 5533 |
| Dissection index (Di) | 0.67 | 0.60 | 0.67 | 0.77 | 0.66 | 0.84 |

to 2008 (Table 2). The built up area of Parvati basin increased from 0.68% in 1972 to 1.13 % in 2008. Over all change analysis from 1972 to 2008 with reference to dense and very dense forest cover indicates, negative changes (loss of forest area) in basins during 36 years. The change of land use land cover between 1972 and 2008 has been comparatively rapid in agricultural and settlement land class. This growth is result of increase in orchard farming in the basin, flow of tourists and infrastructure developments. These changes are mainly contributed to some diversification of forested land towards agricultural land or for horticulture. Majority of dense orchards lie in elevation range 2000-3000 m. Orchard cultivation is mostly practiced on hills having north-east and south–east slopes. Majority of orchards are located on slopes of 21-40 degrees. More than 40 per cent of areas are covered with snow and glacier. Snow line heights are mainly found above 3500 m and are mainly confined to upper parts of the basin. Barren land is second most dominant land cover class in the basin which covers poor, rocky and rugged terrain in basin.

**Prioritisation of watersheds on basis of morphometric parameters**

The morphometric parameters i.e., Mean Stream Length (Lsm), Mean stream length ratio (Rlm), Mean bifurcation ratio (Rbm), Form factor (Ff), Elongation ratio (Re), Shape factor (Bs), Circularity ratio (Rc), Drainage density (Dd), Stream frequency (Fs), Drainage texture (T), Length of overland flow (Lo), and Constant of channel maintenance (C) are also termed as erosion risk assessment parameters and have been used for prioritising sub-watersheds (Biswas, *et al.* 1999; Javed, *et al.* 2009; Panhalkar, *et al.* 2012). The linear morphometric parameters– Mean Stream Length (Lsm), Mean stream length ratio (Rlm), Mean bifurcation ratio (Rbm), drainage density (Dd), stream frequency (Fs), length of overland flow (Lo) and drainage texture (T), have a direct relationship with erodibility, i.e. higher the value, more is erodibility. Therefore the highest value of linear parameters was ranked 1, second highest value was ranked 2 and so on, and the least value was ranked last for prioritisation of sub-watersheds. Whereas, shape parameters like Form factor (Ff), Elongation ratio (Re), Shape factor (Bs), Circularity ratio (Rc) and Constant of channel maintenance (C) have an inverse relationship with erodibility, i.e. lower the value more is the erodibility. Hence the lowest value of shape parameters was ranked 1, next lower value was ranked 2 and so on and the highest value was ranked last. Thus, by conveying the highest priority based on highest value in case of linear parameters and lowest value in case of shape parameters, the ranking of the sub-watersheds has been performed (Table 3). Then the compound value (Cp) was calculated by adding the ranking values for all the linear and shape parameters of every sub-watersheds. The final priority was assigned on the basis of compound value of each watershed. The highest priority was given to watershed having the least compound value, second priority was given to next highest value and so on. The watershed was then classified into three class– high (below 3), medium (3.0–3.5) and low (above 3.5). As per the classification, Kasol and Malana *nal* comes under high priority class, whereas Jigra and Brahma *nal* fall in medium priority class and Tosh *nal* falls under low priority class (Table 3).

**Prioritisation of watersheds on the basis of land use and land cover change analysis**

Seven major primary land cover types were delineated using satellite data viz., barren land, built up area, scrub, dense forest, very dense forest, agricultural land and snow cover. The change in land use land cover area under each class between 1972 and 2008 has been converted into percentage. Each class in the study area was allotted rank on the basis of area under each land use category (Javed, *et al.* 2009). Land use land cover change class that has recorded highest change in area during the study period was assigned rank 1; next higher value was assigned rank 2 and so on. Thus highest ranking was allotted to the land use land cover class showing highest negative change and vice-versa. Finally the compound value was estimated by summing the rank of each land use land cover class of watershed. The final priority for every watershed was determined by classifying the maximum and minimum values of Cp. So, three classes were made– high (below 3), medium (3.0–3.5), low (above 3.5). Kasol and Tosh *nal* fall under the category of high priority, whereas, Malana *nal* and Jigra *nal* are in medium priority category and Brahma *nal* is under the category of low priority (Table. 4).

The final prioritisation of watershed was done by taking average values of the Cp derived from morphometric and land use land cover analysis. The result shows that Jigrai (3.08), Tosh (3.01) and Brahma (3.36) *nals* come under medium priority class, whereas Malana (2.83) and Kasol (2.72) *nal* are under high priority class.

## Conclusion

The prioritisation of watershed based on morphometric and land use land cover analysis can be used for monitoring and estimation of the watershed programmes. The study reveals that Parvati basin with its significant topographical and land use land cover variation offers an appropriate site for watershed prioritisation study. Areas within the watershed with different morphometric and land use land cover classes have been assessed with a view of adopting appropriate conservation measures for sustainable development of the watershed. The high priority areas mostly have higher erosivity values because of their location in the hilly terrain with undulating topography of Parvati basin. Parvati basin has experienced significant land use and land cover change because of rapidly changing socio-economic scenario of the basin. Construction of road infrastructure, growing population pressure, expansion of agricultural area and other anthropogenic activities has significantly altered the local ecology. The removal of a forest cover from a steep slope often accelerates surface erosion. The result shows that there has been significant expansion in settlement and agricultural areas from 1972 to 2008 at the cost of forest and clearing areas. Moderate forest cover has decreased due to deforestation done for settlement and agricultural purposes. Majority of changes has occurred in lower and middle part of basin where settlements and orchards were increased more in comparison to upper part of the valley. Among the different classes of forest cover, moderate dense forest has been mostly affected, because this class of vegetation cover is situated in close proximity to human habitation zone. The study reveals that Malna and Kosal *nals* are under high prioirity areas and both these areas have experienced significant tourism activities and infrastructure development through hydel-power project. The parts of Parvati basin that come under high priority class may be taken up for implementation of soil and water conservation measures.

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