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# PRIORITIZATION OF WATERSHEDS IN WULAR CATCHMENT FOR SUSTAINABLE DEVELOPMENT AND MANAGEMENT OF NATURAL RESOURCES

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## Abstract

The resource development programmes are applied generally on watershed basis and thus prioritization is essential for proper planning and management of natural resources for sustainable development. The study area is situated in Sopore, Bandipore and Sonawari tehsils. It lies between 34°12'24.67" and 34°36'26.26" N latitude and 74°26'41.42" and 74°56'02.90"E longitude. The present study is an attempt to carry out the prioritization on an integrated approach utilizing, land use/cover, drainage morphometry and socio-economic data. The indicators included in prioritization are man- land ratio, population growth, average annual fuel wood consumption, drainage density, forest cover, built up, barren land and agriculture.The prioritization is carried by assigning ranks to the individual indicators and a composite score is calculated. It is revealed from the study that eight watersheds fall under high priority zone, eight under medium and three under low priority zone. The Watershed 1EW2b has attained the highest priority level. The prioritized watersheds are in dire need of management and planning so that the problem of environment degradation in them can be addressed.

**Keywords**: Wular Catchment, Watershed, Prioritization, Sustainable development, Land use

## Introduction

The environmental deterioration of watershed is a common phenomenon in most parts of the world. Amongst several causes, the major ones are improper and unwise utilization of watershed resources observed in developing countries (FAO, 1985). Intensification of food production is a key activity in the development of modern society. The modern techniques have made it possible to produce more food on less land. Increasing agricultural exploitation of landforms and associated land use changes have often led to soil degradation and loss of soil by erosion. The increasing population along with the poverty and restricted options for alternative sources of livelihood added to the problem by forcing people to over exploit natural resources for basic subsistence requirements. The technological innovations and high consumption rates have made the matters worse in most of the developed world.

Catchments and watersheds have been identified as planning units for administrative purpose to conserve the land and water resources (Honore, 1999). It is not possible for the administration to implement watershed development and management programmes in all the areas at a time. The concept of prioritization plays a key role in identifying areas which need immediate attention.The resource development programme is applied scientifically on watershed basis and thus prioritization is essential for proper planning and management of natural resources for sustainable development.

The Wular Lake is an important fresh water ecosystem of the Kashmir valley with substantial ecological, aesthetic, recreational and biodiversity value. However, due to high anthropogenic pressure in the catchment, the economic and aesthetic value of the lake is declining. It is in this backdrop that the prioritization of watersheds in the Wular Catchment is being undertaken for sustainable management of natural resources.

## Study Area

The study area falls in the three tehsils namely Sopore, Bandipore and Sonawari of Kashmir Valley. It has an area of 1200.36 km$^2$ and accounts for 7.6% of the total area of Kashmir valley. The study area lies between 34°12'24.67" and 34°36'26.26" N latitude and 74°26'41.42" and 74°56'02.90"E longitude. The altitudinal range of the Study area is from 1580 meters near Wular Lake to about 4500 meters in Harmukh range. The location map of the study area is depicted in Fig.1. The major rivers apart from Jhelum in the study area are Madhmatti and Erin.

The landscape is mountainous and rugged in the north-eastern side, while it is mostly plain in south-western side. Two world famous freshwater lakes namely Wular and Mansbal fall in the study area. The major crops grown in the study area are Paddy and

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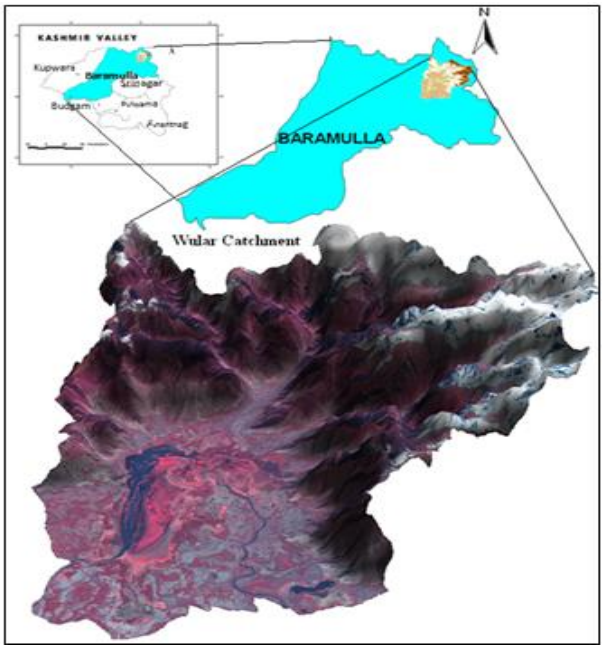
Maize (Kharif) and Sarson (Rabi). Fish and water nuts are an important produce of these lakes. The Wular Catchment has got a great tourist potential, in terms of its virgin landscape, lakes and historical places. It is one of the most enchanting and picturesque resort of Kashmir Valley.

Fig. 1: Location map – Wular Catchment




## Methodology and Database

The prioritization of the watersheds was done involving the delineation of watersheds using Survey of India toposheets on 1:50,000 scale, drainage morphometry utilizing the same data source and determination of land use/ land cover using IRS-1C LISS III, 2004 satellite data. Socio economic parameters from both primary and secondary sources were also determined. The study area has been divided into nineteen watersheds, Wular Periphery and Wular Lake (fig.2.), by employing the modified AIS & LUS codification of Kango and Qadri, 1982 (Table 1).

Fig. 2: Watershed Map-Wular Catchment

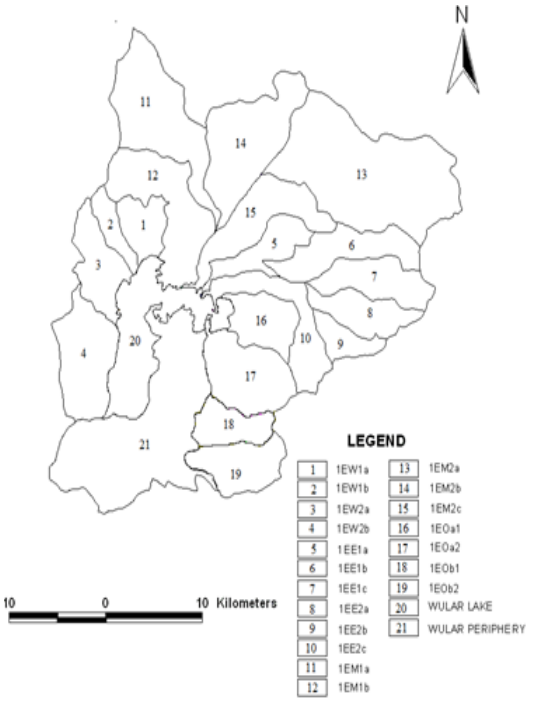



Table 1: Watershed Level Codification Scheme of Wular Catchment.

| S.No. | Catchment | | Sub Catchment | Watershed |
|---|---|---|---|---|
| 1. | Wular I | 1EW | W1 (Nagmarg)<br>W2 (Zaingir) | W1a, W1b<br>W2a, W2b |
| 2 | Madhmatti | 1EM | M1 (Tragbal)<br>M2 (Bodnar) | M1a, M1b<br>M2a, M2b, M2c |
| 3 | Erin | 1EE | E1 (Erin Nar)<br>E2 (Astar Nar) | E1a, E1b, E1c<br>E2a, E2b, E2c |
| 4 | Wular II | 1EO | Oa (Dudh. Nar)<br>Ob (Rang Nar) | Oa1, Oa2<br>Ob1, Ob2 |
| 5 | - | - | - | Wular Lake |
| 6 | - | - | - | Wular periphery |

Source: Modified from Kango and Qadri, 1982

The prioritization was carried out by assigning ranks to the individual indicators and a composite score was calculated. Watersheds with highest score were of low priority while those with lowest were of high priority. Thus an index of high, medium and low priority was produced. The various indicators which have been used in the Prioritization of Wular Catchment are described in table 2.

Table 2: Indicators used for Prioritization of Watersheds in Wular Catchment

| S.No. | Parameter | Source | Factors of Prioritization |
|---|---|---|---|
| 1 | Population | Modified from Census of India, 2001 | Population has a direct relationship with the resource utilization and if the population or their requirements exceed beyond a thresh hold commonly known as carrying capacity; it may cause degradation or even extinction of resources leading to environmental instability in the region. *More the Population, Higher the Priority* |
| 2 | Population Density | Modified from Census of India, 2001 | The areas of high population density are more susceptible to degradation then those with low population density. *More the Population Density, higher the Priority* |
| 3 | Agricultural Density | Modified from Census of India, 2001 | The relation of the number of agricultural people to cultivated area or agricultural density is an important index of man – land ratio indicating the level of development in the region. *More the Agricultural density, higher the Priority* |
| 4 | Average Annual Rate of Growth | Modified from Census of India, 2001 | It expresses, the pace with which the population is growing, indicating threat of population explosion which may result in acute crisis of land and water resources and environmental degradation. *Higher the Average Annual Growth Rate, higher the Priority.* |
| 5 | Magnitude of Fuel wood Consumption | Field Survey by the authors | The magnitude of fuel wood consumption reflects the level of development and the dependence on the forest resources of the region. *More the Magnitude of Fuel wood Consumption, higher the Priority* |
| 6 | Built-up Land | Derived from IRS LISS III, 2004 | It is an important human impact indicator expressing the level of land modification and urbanization, both of which have a direct bearing on the environmental stability. *More the Built up land, higher the Priority.* |
| 7 | Agriculture | Derived from IRS LISS III, 2004 | The intensification of agriculture and its extension to ecologically fragile areas has led to the land degradation, particularly the pressure to increase rice production to meet food needs, induces land degradation. *Larger the extension of Agriculture, higher the Priority.* |
| 8 | Barren land | Derived from IRS LISS III, 2004 | It is a direct resultant of human interference in environmentally fragile areas. *More the Barren land, higher the Priority.* |
| 9 | Dense Forest | Derived from IRS LISS III, 2004 | Since vegetation is a crucial natural resource that can also function as an environmental indicator, the dense forest cover of a region is an important indicator expressing the level of human impact. *More the Dense Forest, lower the Priority* |
| 10 | Drainage Density | SOI Toposheets, 1961 | Drainage density has a direct bearing on soil erosion leading to highly dissected landscape. *Greater the Drainage Density, higher the Priority* |

## Results and Discussion

The watershed wise priority indicators and the composite score have been given in table 3 and 4 respectively. The Watersheds have been broadly classified into three priority zones according to their composite scores - High (<90), Medium (90-120) and Low (120 and above) and are depicted in figure 3.

## High Priority

The watersheds which have been assigned high priority are 1EW1a, 1EOb1, 1EM2c, 1EE1b, 1EOb2, 1EW2b, 1EM1b and 1EOa2. The highest priority has been attained by 1EW2b. It is mostly attributed to its low dense forest cover (31ha) constituting only 0.5% and high population density (5 persons/ha). The land use of this watershed is mostly dominated by agriculture (2724 ha) and built-up land (425 ha) sharing 46.5% and 7.3% respectively. 1EW1a has a high population density (4.9 persons/ha) and agriculture (51.2%). This watershed has attained second highest priority. In 1EOb1, barren land, spread on 519 ha constituting 19.3% has a high proportion; while as dense forest cover (23 ha) is minimal and constitutes only 0.9% of the watershed. Population density (5 persons/ha) is also very high in 1EOb1. 1EM2c has a highest population density of 6.3 persons per hectare. The high population density is attributed to the presence of urban centre of Bandipore in this watershed. The average annual rate of growth (4.13%) and built up extension on 450 ha ( 8.3%) are also of high magnitude. 1EE1b has attained high priority mainly due to high agricultural density (3.4 persons/ha of cult land) and moderate dense forest cover of 653 ha constituting 14.2% of the watershed. 1EOb2 has a highest proportion of barren land (19.1%) and dense forest cover is totally absent. 1EM1b has highest built up extension of 617 hectares, constituting 8.4% of the watershed. 1EOa2 has been prioritized in the high category as the proportion of land under cultivation is very high of the order of 44.9%.

## Medium Priority

The watersheds which come under medium priority are 1EW1b, 1EM2b, 1EM1a, 1EM2a, 1EW2a, 1EOa1, 1EE1a, 1EE2c. The medium priority is mostly attributed to the substantial forest cover; moderate to low extent of built up, agriculture and barren land and low population density in most of the watersheds. 1EW1b has attained a medium priority as most of its indicators like the average annual rate of growth (2.35%), daily average consumption of fuel wood (17.5 kg/household) and the land use indicators like built up land (95 ha) and agriculture (520 ha) constituting 6.2% and 33.7% respectively are of moderate level although it has got a higher population density (5.1persons/ha), and drainage density (3.29 km/km$^2$) leaving the watershed in the medium category. 1EM2b and 1EM1a have very low population densities of 1 and 0.6 persons per hectare respectively. In addition, 1EM2b has got a comparatively higher extent of barren land (272 ha) constituting 3.4% and its daily average consumption of fuel wood is also of greater magnitude (26 kg/household). While as, 1EM1a has got a highest agricultural density of the order of 5.2 persons per hectare which reasons out its position in medium priority category. 1EM2a, has very low population density (0.06 persons/ha) and built up land (9 ha), constituting only 0.05%, while as it has got the highest average annual rate of growth (4.2%) and daily average consumption of fuel wood (39.2 kg/household) 1EW2a, has attained medium priority as all of its

indicators are of a moderate level with an exception of drainage density (3.12 km/km$^2$), which is high. 1EOa1, has got a very low extent of barren land (39 ha) covering only 1.1% , while its agricultural extent is 1529 ha, constituting 44.9% of the watershed. 1EE1a, has a higher built up area of 298 ha, covering 9.8% of its total area, but the average annual rate of growth (1.68%) is low. 1EE2c have attained a medium priority due to moderate land use.

## Low Priority

The watersheds which are assigned low priority are uninhabited and include 1EE2b, 1EE2a and 1EE1c. Land use is of negligible magnitude and dense forest cover is substantial.

Table 3: Indicators of Watershed Prioritization

| S. No. | Watershed code | Population (2001) | Population Density(per/ha) (2001) | Agricultural Density(per/ha cult.) (2001) | Average Annual Rate of Growth (%) | Daily average Fire wood Consumption Kg/sample household | Built up(ha) (2004) | Agriculture (ha)(2004) | Barren (ha) (2004) | Dense Forest(ha) (2004) | Drainage Density Km/km$^2$ Length/area) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1EW1a | 12140 | 4.9 | 2.5 | 2.6 | 21 | 178 | 1258 | 205 | 286 | 2.74 |
| 2 | 1EW1b | 7925 | 5.1 | 3.5 | 2.35 | 17.5 | 95 | 520 | 89 | 303 | 3.29 |
| 3 | 1EW2a | 9574 | 2.5 | 1.9 | 2.66 | 16.6 | 176 | 1405 | 90 | 1073 | 3.12 |
| 4 | 1EW2b | 29707 | 5 | 2.2 | 2.7 | 19.5 | 425 | 2724 | 101 | 31 | 0.45 |
| 5 | 1EM1a | 5353 | 0.6 | 5.2 | 2.76 | 32.5 | 91 | 230 | 560 | 3313 | 2.88 |
| 6 | 1EM1b | 16785 | 2.3 | 2 | 1.36 | 17.7 | 617 | 1922 | 268 | 2180 | 2.66 |
| 7 | 1EM2a | 986 | 0.06 | 2.3 | 4.2 | 39.2 | 9 | 486 | 267 | 1525 | 2.70 |
| 8 | 1EM2b | 8003 | 1 | 2.7 | 2.84 | 26 | 166 | 1075 | 272 | 1985 | 2.59 |
| 9 | 1EM2c | 34353 | 6.3 | 4.5 | 4.13 | 16.5 | 450 | 1010 | 59 | 2300 | 2.44 |
| 10 | 1EE1a | 8357 | 2.7 | 2.1 | 1.68 | 15.6 | 298 | 998 | 134 | 735 | 2.59 |
| 11 | 1EE1b | 8934 | 1.9 | 3.4 | 3.2 | 28.3 | 280 | 805 | 175 | 653 | 2.61 |
| 12 | 1EE1c | - | - | - | - | - | 11 | 90 | 211 | 819 | 2.31 |
| 13 | 1EE2a | - | - | - | - | - | 1 | 33 | 80 | 603 | 3.02 |
| 14 | 1EE2b | - | - | - | - | - | 0 | 0 | 177 | 471 | 2.78 |
| 15 | 1EE2c | 10286 | 2.3 | 2.4 | 2.75 | 15.7 | 250 | 930 | 161 | 1598 | 2.02 |
| 16 | 1EOa1 | 16461 | 4.7 | 1.7 | 2.7 | 14 | 257 | 1529 | 39 | 669 | 2.46 |
| 17 | 1EOa2 | 17260 | 3 | 2.8 | 3.12 | 27.5 | 283 | 2539 | 32 | 778 | 1.94 |
| 18 | 1EOb1 | 13602 | 5 | 1.8 | 2.78 | 20.1 | 227 | 1334 | 519 | 23 | 1.30 |
| 19 | 1EOb2 | 15333 | 3.9 | 1.2 | 2.4 | 11 | 298 | 2182 | 747 | 0 | 1.03 |

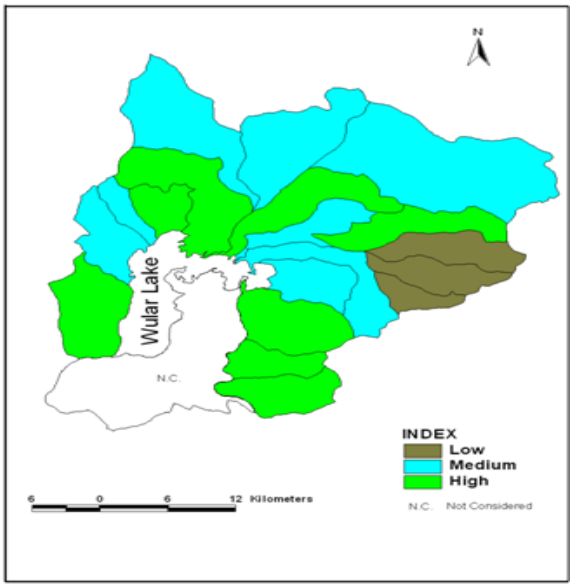
**Source**: Computed from SOI Toposheets, 1961, IRS LISSIII, 2004, Census of India, 2001, Field Survey, 2007

Table 4: Priority Ranks of Watersheds

| S.No | Watershed code | Population (2001) | Population Density (2001) | Agricultural Density (2001) | Average Annual Rate. of Growth | Daily Average Fire wood Consumption | Built up (2004) | Agriculture (2004) | Barren (2004) | Dense Forest (2004) | Drainage Density | Total Composite Score |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1EW1a | 8 | 5 | 7 | 12 | 6 | 11 | 8 | 8 | 4 | 6 | 75 |
| 2 | 1EW1b | 14 | 2 | 8 | 14 | 10 | 14 | 14 | 15 | 5 | 1 | 92 |
| 3 | 1EW2a | 10 | 10 | 13 | 11 | 11 | 12 | 6 | 14 | 13 | 2 | 102 |
| 4 | 1EW2b | 2 | 8.5 | 10 | 9.5 | 8 | 8 | 1 | 13 | 8 | 19 | 72 |
| 5 | 1EM1a | 15 | 15 | 1 | 7 | 2 | 15 | 16 | 2 | 19 | 4 | 96 |
| 6 | 1EM1b | 4 | 11.5 | 12 | 16 | 9 | 1 | 4 | 5 | 17 | 8 | 87.5 |
| 7 | 1EM2a | 16 | 16 | 9 | 1 | 1 | 17 | 15 | 6 | 14 | 7 | 102 |
| 8 | 1EM2b | 13 | 14 | 6 | 5 | 5 | 13 | 9 | 4 | 16 | 10.5 | 95.5 |
| 9 | 1EM2c | 1 | 1 | 2 | 2 | 12 | 2 | 10 | 17 | 18 | 13 | 78 |
| 10 | 1EE1a | 12 | 9 | 11 | 15 | 14 | 4.5 | 11 | 12 | 10 | 10.5 | 109 |
| 11 | 1EE1b | 11 | 13 | 4 | 3 | 3 | 7 | 13 | 10 | 8 | 9 | 81 |
| 12 | 1EE1c | 18 | 18 | 18 | 18 | 18 | 16 | 17 | 7 | 12 | 14 | 156 |
| 13 | 1EE2a | 18 | 18 | 18 | 18 | 18 | 18 | 18 | 16 | 7 | 3 | 152 |
| 14 | 1EE2b | 18 | 18 | 18 | 18 | 18 | 19 | 19 | 9 | 6 | 5 | 148 |
| 15 | 1EE2c | 9 | 11.5 | 8 | 8 | 13 | 9 | 12 | 11 | 15 | 15 | 111.5 |
| 16 | 1EOa1 | 5 | 6 | 15 | 9.5 | 15 | 8 | 5 | 18 | 9 | 12 | 102.5 |
| 17 | 1EOa2 | 3 | 8 | 5 | 4 | 4 | 6 | 2 | 19 | 11 | 16 | 88 |
| 18 | 1EOb1 | 7 | 3.5 | 14 | 6 | 7 | 10 | 7 | 3 | 2 | 17 | 76.5 |
| 19 | 1EOb2 | 6 | 7 | 16 | 13 | 16 | 4.5 | 3 | 1 | 1 | 18 | 85.5 |

**Source**: Computed from SOI Toposheets, 1961, IRS LISSIII, 2004, Census of India, 2001, Field Survey, 2007

Fig. 3. Prioritization Map: Wular Catchment




Source: Computed from SOI Toposheets, 1961, IRS LISS III, 2004, Census of India, 2001, Field Sur

## Conclusion

The increasing impact of anthropogenic alterations and the rate of changes are imposing threats to the adaptive capacities of fragile ecosystem of Wular Catchment. This emphasized the need to prioritize the watersheds with an impending impact of increasing human activities on their environment and resource base.

The prioritization on the basis of socio-economic, land use/ land cover and hydrological variables has revealed that eight watersheds fall in high priority zone, among which highest priority has been achieved by 1EW2b, while the others fall in moderate and low priority zones. The highest priority has been attained mostly by the watersheds which have high population pressure, high agricultural extension and meager forest cover. The prioritized watersheds are in dire need of sustainable management and planning so that the problem of environmental degradation in them can be addressed.

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