2. RATIONALE AND SCOPE

2.1 River Jhelum Basin

Wular and associated wetlands form a part of River Jhelum Basin, which is a sub basin of Indus River. The trans-national basin extends to an overall area of 33,300sq km within India and Pakistan and covers 3% of the overall Indus Basin area. Khadanyar Gorge, a geological fault zone and location of distinct changes in hydrological regimes within the basin divides the entire area into two segments. The upper segment of the basin extending to an area of 12,777 sq km drains the entire Kashmir Valley.

View of River Jhelum

The basin is bowl shaped forming an elongated depression between the Great Himalayas in the north east and the Pir Panjal ranges in the south west. The Pir Panjal ranges separate the basin from the great plains of Northern India whereas the Great Himalayas separate the valley from Ladakh. The highest mountain peaks enclosing the basin have an elevation of more than 5,300 amsl on the Great Himalayan side and more than 5,500 amsl on the Pir Panjal side. Important peaks surrounding the basin are Nanga Parbat and Tosh Maidan in the north; Mahadev, Gwash Brari and Amarnath in the South; Kazi Nag on the north west and Harmukh on the east.

The physiographic features of the basin change rapidly with the altitude. At the topmost fringe of the basin are the glaciers which serve as the main source of water for the basin. Several glaciated lakes including Tar Sar, Mar Sar, Kaunsernag, Sheshnag, Gangbal etc are located till about 4500 amsl which serve as source of the streams and rivulets draining into Jhelum.

Forests are mainly located between 1650 – 3500 amsl, with distinct species changes along with the altitudinal gradient. Deodar – kail forests are located within 1650 – 2600 amsl, followed by the fir forests found within 2600 – 3500 amsl. Tree line on the upper fringes of southern and south western forests is dotted with alpine pastures locally termed as margs. Gujjers and Bakkerwals, nomadic tribes raising livestock for sustenance dot these pastures. Tangmarg, Gulmarg, Khilanmarg and Sonmarg are the principal pastures within the basin. During the spring when the snow melts, flowers of all colours appear in the margs creating a stunning panorama of colours.

The rest of the basin area forms a vast plain consisting of Kashmir valley and its four side valleys, namely the Lolab, Lidder, Sind and Kishenganga. With an area of 4,865 sq km and altitude ranging from 1400 – 1650 amsl, the Kashmir Valley is the demographic and economic hub of the basin, inhabited by more than 85% of its total population The Karewas (Wudars) are the unique physical feature of the Kashmir Valley. These are flat topped terraced features, developed in morainic deposits of the Pleistocene glaciation. Primarily freshwater deposits found as low flat mounds or elevated plateaus, the Karewas are formed of clay, sands and silt of lacustrine origin. The Karewas account for nearly 50% of the overall valley area and extend from Kulgam in the south east to Baramulla. The Karewas on the left bank of River Jhelum are extensive and massive till the Northern west end, whereas they are quite few in number and smaller in extension on the right bank. These alluvial land features provide conducive environment for growth and development of temperate fruits including apple, almonds and walnuts, as well as saffron. The Karewas on the right bank are mostly flat topped, whereas those on the north west and west are sloping along the flanks of Pir Panjal range (Map 2.1).

The Jhelum basin bedrock comprises gneisses, granites, schists, shales, phyllites, quartzites, and limestone dating from pre Cambrian to lower Miocene, with all rock units folded and faulted during the tectonic movements of the Himalayan uplift. The valley is a tectonic basin filled to a great extent with essentially alluvial deposits. The valley is believed to be a lake in tertiary era, named Satisar. Occurrence of an earthquake led to formation of a gorge at Khadanyar, leading to draining of the lake waters and formation of the valley. The wetlands were formed due to geological depressions which could not drain out completely in the process.

The basin has four distinct seasons, namely Spring (March –May), Summer (June - August), Autumn (September – November) and Winter (December –March). Precipitation patterns within the basin vary with orography. The Pir Panjal range being in the direct pathway of the south west monsoon has more rainfall in its southern slopes than the valley facing the northern slopes. Contrary to it, the valley facing slopes of Himalayas receives more rainfall as compared to inner slopes. The higher altitudes of the basin, in general, receive more rainfall than the lower altitude. Sonmarg has the highest rainfall within the valley (1800 mm) whereas Srinagar receives only around 650mm. During the winter season, most of the precipitation is accumulated in the form of snow.

There is a wide spatial variation in temperature patterns within the basin. January is the coldest month whereas July the warmest. In the valley, the temperature ranges from -5^{0}C to +30^{0}C. At higher altitudes, the snow remains on the peak for maximum part of the year. Lakes above 3000 amsl remain covered with ice for about eight months in a year, whereas those at 2000 amsl for around four months.

Drainage

The Jhelum basin is drained by River Jhelum and its tributaries. River Jhelum, a part of the Indus River system, is a transnational river flowing through India and Pakistan. The river flows for 992 kms before merging with the Chenab and subsequently into Indus River before draining into Arabian Sea through the Indus Delta. Along its course, the river within its upper reaches is also known as Vyeth and Koshur Darya.

River Jhelum arises within the Pir Panjal ranges located near Banihal from Verinag spring. Several freshwater streams arising from the south eastern part of Pir Panjal mountains meet together with flows of River Arpat from the north east and Bringi and Sanderen from the south east to from River Jhelum at Khanbal. Lidder River, arising from Lake Sheshnag and flowing through Pahalgam Valley joins the Jhelum at Gur near Anantnag. At Sangam, the Jhelum is joined by two of its tributaries in the left bank, namely the Visav and Rambiara. Both of these rivers arise from the Pansal mountains. Vishav arises from the Konsarnag Lake and before joining Jhelum carries the flow of all the streams arising from the northern slopes of Pir Panjal Mountains between Sidau and Banihal Passes. The Rambiara arises from the Nandansar and Baghsar Lakes of the Pir Panjal mountains. Jhelum is next joined by tributaries Arpal on its right bank at Charligund and Romshi on its left bank.

The River at Srinagar is joined by Tsunth Kul, which connects the Dal Lake receiving flows of Tarsar through Telbal Nullah. River Dudhganga, arising from the eastern slopes of Pansal Mountains meets River Jhelum on its left bank at Chhatbal. Below Srinagar, River Sind joins Jhelum at Shadipur. River Sind, rising from the Ganga Lake on Harmukh Mountains and flowing through Zojilla and Amarnath peaks, is the longest tributary of River Jhelum. It braids into numerous branches at Durham, forming extensive lakes and marshes of which Anchar is the largest. Sindh joins River Jhelum after leaving Anchar. Jhelum thereafter flows through Wular Lake, entering at Baniyari and exiting at Sopore. Between Asham and Baniyari the river is connected through several small streams draining the Asham and Malgom marshes. Upstream of Sopore, the river is joined by the tributaries of Sukhnag joined by Ferozepur Nullah. These tributaries rise at Palas and join Trikulabal. The stream then joins Ningal which rises in the Apharwat peak above Gulamarg, and thereafter finally meets Jhelum at Ningal.

Beyond Sopore, the first tributary to join Jhelum at its right bank is Pohru. Pohru River is formed by the Junction of Kahmil and Lolab streams at Moghulpur village, and meets river Jhelum at Doabgah. About 15 kms Doabgah, Jhelum is joined by Mundri and Buniyar streams along the left bank and Limber nullah on its right bank. After this, the river enters the Khadangar Gorge, where it supports run of the river schemes for hydropower generation at Ghantmulla. The river thereafter follows a westerly course for 120 kilometers joining Kishenganga at Domel in Muzaffarabad. Kishanganga rises from the eastern end of Tilail valley and flows through Gurez valley and Drawar before meeting Jhelum. Below Muzaffarabad, the Jhelum turns south, and after being joined by Kunihar River continues upto the town of Jhelum in Pakistan. It is thereafter joined by River Poonch on its left bank. River Jhelum joins Chenab at Jhang Maghiana in Pakistan. The Chenab River thereafter continues to flow till Panjnail in Pakistan, where it meets Indus. The river finally falls into Arabian Sea after braiding and forming the Indus Delta, known for its rich mangroves forests extending to over 6,000 square kilometers.

Land Use

Forests dominate the land use pattern of the River Jhelum basin accounting for 42% of its total area. Twelve percent of basin area is under glaciers. Agriculture and horticulture account for 38% of the basin area, the rest being under settlements and wetlands.

Forests

Forests account for 5,348 sq km area of the River Jhelum catchment. The forests, being temperate, are dominated by coniferous trees. Deodar (*Cedrus deodara*), Kail

(*Pinus excelsa*), Silver fir (*Abies webbiana*), Kachil (*Picea morinda*) and Birch (*Betula utilis*) are the key species found in these forests. Excessive harvesting and over exploitation of Deodar has led to its virtual elimination, and it presently comprises less than 0.4% of the total area. The area under Deodar is presently colonized by Kail, propagated through the Forest Department in the last two decades. Kail forms the principal species on the lower altitudes whereas fir dominates the higher reaches and shady ravines. The conifers form the dominant component of the canopy throughout except in certain moist patches where deciduous species viz walnut, ash, bird cherry, Aesculus occur in abundance. The tree growth ends with birch and junipers. Alpine pastures fringe the tree line at higher altitudes.

Forest Area within Wular Catchment

Forests of Jhelum Basin are highly degraded. Very dense (canopy area > 70%) and dense forests (canopy area > 40%) form only 8% and 49% of the total area, the rest classified as degraded forests. The primary reasons for the degradation are high degree of dependence on forest resources for sustenance. The average annual per capita consumption of fuelwood (949 kgs for rural population and 163 kgs for urban population) is one the highest levels in the country, next only to the northeastern states. The annual availability of fuelwood from forests was estimated to be 1.5 million tonnes for Jammu and Kashmir State as compared to the projected annual consumption of 7.8 million tonnes in 2006. Forests have also been under pressure due to extensive grazing, with number of livestock within the state increasing two and a half times within the last 50 years (40 lakhs in 1956 as compared to 98 lakhs in 2003). Kashmir, with only 16% of geographical area accounts for more than one fourth of the total livestock population of the state. Forests have also been converted for agriculture due to increasing demand of food for the rapidly rising population.

Agriculture and Horticulture

Agriculture and horticulture account for 38% of the basin area. Rice is the primary food crop of the basin grown cultivated in 35% of the gross cultivated area. There is a single cropping pattern within the entire basin. The other important crops grown in the valley include oilseeds, mainly mustard and pulses. Horticulture accounts for 18% of the gross cropped area and is the mainstay of the economy of the state. Maize, the staple food of Gujjers and Bakerwals is cultivated in the hills and accounts for 26% of the area. Maize is a kharif crop sown during May – June and harvested in

September – October. Application of heavy dose of animal fertilizer supports a rich harvest of this crop. Horticulture is the mainstay of the economy. The total area under horticulture within the basin extends to 1,749 sq km, of which 65% is under fresh fruits primarily apple and rest under dry fruits (walnut and almonds).

Agriculture within the basin is dependant on the River Jhelum and its tributaries which irrigate 79% of the cropped area in the valley. Kulgam, drained by Vaishav, a tributary of Jhelum is also known as the 'Rice Bowl of Kashmir'. Besides providing water, the Jhelum is also source of rich silt which supports high productivity in the region. The average productivity of paddy within valley at 22.44 quintals / ha is much higher than that of Jammu (16.12 qtls/ha) or the state average (19.71 qtls/ha). However, with the onset of high yielding varieties, the application of fertilizer has increased more than 12 folds since 1970.

Settlements

The Jhelum Basin is inhabited by 5.4 million population living within its 34 towns and 2846 villages. The population concentration is within the valley, which accounts for 84% of the total population, with the rest sparsely distributed within the hills. Consequently, the population density of the valley at 947 persons per square kilometer is nearly 8 times higher than that of the hills. Based on the census estimates of 2001, 91% of the urban population lives besides River Jhelum.

There has been a rapid increase in population within the Jhelum Basin, registering a five fold increase within the last century. While the rate of growth was nearly constant till the sixties, it has attained an exponential progress path particularly after the 1960s. Nearly 70% of the population growth has taken place within the last 40 years. The number of towns has also doubled from 17 in 1971 to 34 in 2001. The valley population density has registered an increase of 88% during 1981-2001, which was only 45% for the hilld during the corresponding period. Anantnag and Baramula districts have experienced the most rapid growth in the last decade.

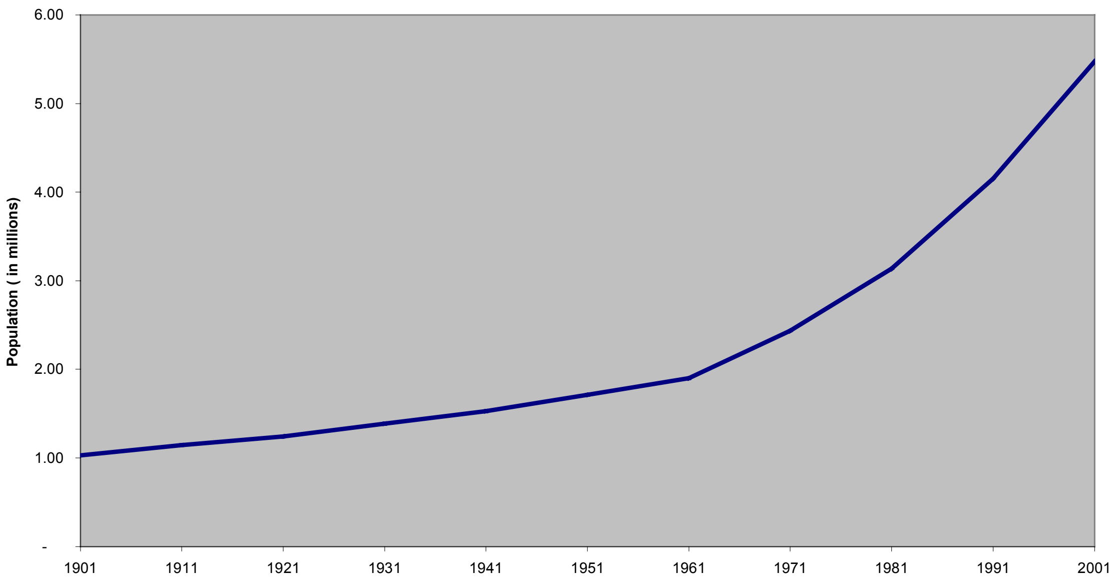


Figure 1 : Population Trends of River Jhelum Basin

Wetlands

The Kashmir Valley with an average elevation of 1600 amsl is dotted with wetlands, which play an enormous role in maintaining the hydrological regimes of the entire valley. There are varied assessments on the extent of wetlands within the valley owing to difference in interpretation of definition of wetlands. The present assessments ranging from 236.5 sq km (Space Application Center, 1998) - 256 sq km (National Wetland Inventory, Salim Ali Center for Ornithology, 2001) , are significantly underestimated considering the comprehensive definition of wetlands on hydrological basis. Dal Lake, Anchar Lake, Manasbal and Wular Lake are some of the larger wetlands of the basin. Extensive marshes have been also formed in lower areas through catchment drainages, particularly between Srinagar and Sopore Rakh Asham, Naugam, Malgam, are some of the major marshes of the valley, a large portion of which has been drained and reclaimed for agriculture and settlement.

2.2 Ecological Features

2.2.1 Catchment and Hydrology

Wetland Catchments

The catchment area of Wular Lake extends to 12,777 sq km and comprises 24 watersheds. Based on drainage; the entire catchment can be broadly classified into following three segments (Map 2.2).

a) Wular upstream catchment comprising 14 watersheds of River Jhelum prior to its entry into Wular, extending to 8,627 sq km
b) Wular direct catchment comprising 6 watersheds directly draining into Wular extending to 1,144 sq km.
c) Wular downstream catchment comprising 3 watersheds of River Jhelum below Wular extending to 3,066 sq km.

Sustainable management of Wular Lake essentially involves minimizing impacts of developmental activities within catchments and implementing strategies for effective land and water resources management. Management of the entire catchment of the Wular Lake is essential for regulating flow regimes. However, in terms of priority, the catchments directly draining into Wular needs to be taken up within the ambit of the current management plan, which should be augmented by conservation efforts in the remaining catchments in the subsequent periods. The present section provides an assessment of the characteristics features of the direct catchment area of Wular to provide a basis for management planning.

The direct catchment extending to 1,144 sq km comprises 6 watersheds (Map 2.3). Madhumati and Erin watersheds located on the northern periphery of Wular, account for 32% and 20% of the catchment area respectively. Madhumati or Bod Kol as it is called in the higher reaches rises from the northern slopes of Harmukh glacier with its feeder streams spread over vast areas between Nagmarg in the west and Sarbal Nag in the east. It is a closed valley till village Bonakut where it spreads laterally into an alluvial triangle where a number of villages and hamlets have settled. Vija Nar and Harpat Nar join Bok Kol at Panar. Madhumati drains into Wular near Dacchigam passing through Kalusa Bridge. Erin catchment is contiguous to Madhumati on its northern side. The nullah is formed from the drainage of Shir Sar and Sukha Sar draining through Chitrar Nala, Titwan Kain Nullah, Kubnai Nar which meet at Isrur tar to form Erin. Erin watershed can be further delineated into 5 sub watersheds and 33 microwatersheds. Similarly , Madhumati watershed can be classified into 5 sub watersheds and 43 microwatersheds.

The southern tip of Wular is enclosed by Ningli and Gundar watersheds. Ningli drains highly erodible Karewas whereas Gundar watersheds are influenced by the drainages of Tangmarg and Apharwath, the famous alpine pastures of Kashmir. The lake is flanked on the left and right by a series of short and flashy drains. The western flank drainage forms the Wular 1 watershed, whereas Wular 2 is formed of the right bank drainage. Wular 1 is separated from Pohru catchment by a ridge , and is also called the Zaingeer Illaqa , after the name of an old irrigation canal that drains the irrigated agricultural lands of the watershed. Wular 2 is drained by Gurthajan Nar, Rang Nar, Kol Nar, Bod Nar, Gujjar Nar and Dudh Nar. These drains form extensive marshes on both sides of River Jhelum and play an important role in governing hydrological regimes, apart from sustaining rich biodiversity. Wular 1 and 2 watersheds can be further classified into 4 and 5 watersheds and 20 and 13 microwatersheds respectively.

Land Use

The catchment land use is dominated by forests which account for 39% of the overall area. Agriculture and horticulture account for 30% and 10% of the overall area respectively. Pasture account for 8% of the total area. Eleven percent and three percent of the watershed area is under glaciers and high altitude lakes (Table 2.1).

Table 2.1: Land use of direct catchment of Wular Lake

Watershed Name	Total Watershed Area	Glaciers	Forest	Agriculture	Horticulture	Pasture	Wetland
Wular 1	14,647		2,000	8,600	2,500		1,547
Erin	23,161	6,300	10,400	4,500	800	1,161	
Madhumati	36,868	6,000	19,110	4,500	3,500	3,758	
Wular 2	8,939		2,000	5,300	839		800
Ningli	14,591		4,000	5,000	1,500	4,091	
Gunder	16,195		7,000	6,000	1,800		1,395
	114,401	**12,300**	**44,510**	**33,900**	**10,939**	**9,010**	**3,742**

The following are the key features of Wular catchments:

- Forests extend to 445 sq km of the direct catchment area. The forests, being temperate, are dominated by coniferous trees. Deodar (*Cedrus deodara*), Kail (*Pinus excelsa*), Silver fir (*Abies webbiana*), Kachil (*Picea morinda*) and Birch (*Betula utilis*) are the key species found in these forests.

- Alpine pastures, extending to 8750 ha, located above the tree line are unique features of the catchment. Several ethnic groups as Gujjars , Bakkerwals, Pohloos (shepherds) and Doombs (herdsmen) use the pasture lands as grazing areas for sheep and other cattle. Of the seven recognized nomadic routes, Bakkerwals enter the direct Wular catchment through route 5 and spend part of their summer in the alpine pastures before proceeding to Gurez and beyond. Some of the important alpine and sub alpine pastures in the direct Wular catchment are:

From Chewa to Gurura Village: Hamwas, Lundi, Dakbat, Rangdori, Sarwas, Larmarg, Zadsar, Kanidalan, Aragan, Salban, Kanzdor, Sarbalsar, Seonar, Kubbi

Gurura to Nadihal: Jaban, Gangbal, Hapatnak, Salnai Nar, Gugurwain, Dadan, Mukarpathri

Bandipora and Ashtangu: Chitarnar, Semthan Tsochalpather, Chitrikain, Sarebal, Rangdaur, Razdhainangar, Chandafi, Nangmarg, Gobaidehak, Traghal, Lashkut, Viji Gali, Madhumatisar, Nunwan, Koraginal, Kanzalwan, Gurez

- Agriculture land are spread over 339 sq km. Of the total area, only 55% is provided with irrigation facilities, the rest being entirely rainfed. Rice is the main crop grown in the irrigated areas; while maize and oilseeds are grown in the rainfed areas with very low agricultural yield. Presence of perennial sources of water from Erin and Madhumati Nullahs has facilitated development of an effective irrigation system in the entire area. Aragam and Garura canals irrigate inner valleys of the two important areas of Gurura and Aragam downstream. Similarly Jinder canal system emanates from Erin and runs across the barren slopes to irrigate sizeable areas of the catchments. The canal system supports rich paddy cultivation in the forms of well laid out terraces, which also lend scenic beauty to the hinterland. Above the irrigated areas, dryland farming is practiced in 15,350 ha, primarily under maize and pulses.

  Catchments of Wular Lake are highly degraded. Against more than 50% of very dense forests in the 1950s, presently only 30% remain under dense forest cover. Approximately 30% of the catchment area is bare and denuded. The following key factors have been identified based on assessment of land use changes:

- **Conversion for agriculture and horticulture development :** Rapid increase in population has increased the need for bringing more area under agriculture and horticulture development at the cost of forests. As per assessments carried by the State Department of Environment, the forest area has declined by 6.24% during 1950 – 1997, with a concomitant 13% increase in area under agriculture.

Conversion of the Lake Area

- **Increasing dependence for energy:** Kashmir valley has one of the highest dependence in forests resources for meeting their energy requirements. The average annual per capita consumption of fuelwood in Kashmir is one of the highest levels in the country. However, the regenerative capacity of the forests has come down sharply owing to the degradation, and at present the forests are capable of meeting only 20% of the fuelwood demand. The forest line therefore has shrunk along the margins. For example, in Kuhnis village situated at the banks of Wular, the forest line has receded by 0.8 km during last 30 years, whereas the women of nearby Panzgam village trudge 2 km more to reach the forests.

- **Adoption of erosion intensifying agropractices in catchments:** Nearly, 30% (4,600 ha) of the area under dryland agriculture is under severe erosion as these are ploughed across the contours. This has resulted in creation of channels, nullahs and gullies contributing high sediment load into the lake. High fertilizer intensity in horticultural lands contributes to overall nutrient enrichment of the water sources, which ultimately flow into Wular.

Degradation within Wular Catchment

- **Degradation of high altitude pastures:** The pastures under the Wular direct catchment are under constant pressure of the nomadic grazers with enormous number of low yielding cattle and sheep moving from meadows to meadows in search of grass. Over use of pasture land has resulted in spread of weeds like *Euphorbia wallichi, Senecio chrysanthemoids, Slipa sibrica, Sambucus wightiana* and rumux spp. This has led to reduction in grazing area as well as fodder production. Presently, 2000 ha of the pasture land is identified as severely eroded, 2,500 ha as moderately eroded and 4,100 as under slight erosion.

- **Quarrying:** Quarrying is an intensive activity in the direct catchment, particularly along the Bandipora – Srinagar road in the Sadarkote Sector. During the course of survey, 78 stone quarries were identified of which 69 were concentrated in Sadarkote Bala. These quarries run throughout the year and throw tremendous quantity of loose stones, pebbles and slush which enter into the lake bed during the monsoon seasons. Besides, sand and bajri mining is also taken intensively within the Madhumati Nallah catchment near Kaloosa. These activities severely alter the natural siltation profile of the catchment.

Quarrying Activity

Degradation of the catchments has contributed to high levels of erosion. Assessment of erosion intensity carried out by the Forest Department using 1997 remotes sensing imagery integrating information on slope, aspect, and land use reveals that 43% and 19% of the catchment area falls under high and moderate erosion categories (Table 2.2):

Table 2.2: Erosion intensity classification for Direct Catchment of Wular Lake

Watershed Name	Total Watershed Area	Erosion Intensity Class 1 (Low Erosion)	Erosion Intensity Class 2 (Moderate Erosion)	Erosion Intensity Class 3 (High Erosion)
Wular 1	14,647	3,000	1,000	10,647
Erin	23,161	16,000	6,161	1,000
Madhumati	36,868	19,600	9,980	7,288
Wular 2	8,939	939		8,000
Ningli	14,591	3,700	2,200	8,691
Gunder	16,195		2,295	13,900
	114,401	**43,239**	**21,636**	**49,526**

Hydrological Regimes:

There is a marked absence of detailed information for assessment of hydrological regimes of Wular. The present assessment is based on analysis of the following information made available through the weekly discharge records of State Irrigation and Flood Control Department:

- River Jhelum at Baramulla from 1922 to 1993
- River Jhelum at Sopore from 1985 to 2003
- River Jhelum at Asham from 1990-2003
- Nallah Madhumati from 1990-2003
- Erin Nallah from 1990-2003

In addition to the above, historical records on Wular Lake collected through State Archives for the period 1900 –60 were analyzed for trend analysis. Concomitant flow observation periods have been used to analyse trends in water inflow, outflow and water holding capacity.

Water Inflow and Outflow
Hydrological regimes of Wular are mainly influenced by the catchment drainages from the following sources:

- **River Jhelum** which till Asham carried the flows of its 8 tributaries. Between Asham and Baniyari , the river flows are also influenced by the marshes drained by Gurthajan Nar, Rang Nar, Kol Nar, Bod Nar, Gujjar Nar and Dudh Nar. These marshes are connected to the wetland through Naz Nallah of the right side and Haritar Nallah and other channels on the left.

- **Erin Nallah** formed from the drainage of Shir Sar and Sukha Sar draining through Chitrar Nala, Titwan Kain Nullah, Kubnai Nar which meet at Isrur tar to form Erin Nallah.

- **Madhumati Nallah** formed as a confluence of Madhumati Sar, Nichnai Nallah, Gagar Sar, Sanspal Nallah, Kutch Nallah, Sinai Sar, Yaml Sar drained through Baripat Nallah. Bod Nar is a major stream joining Madhumati Nullah at Khayyar.

Inflow Channels

- **Kinusa - Watlab areas** drained by seasonal storm water rivulets directly draining into lake.

Besides the above, rainfall and flows from adjoining marshes contribute to the total inflows into the wetland system. The lake outflows are mainly through River Jhelum, which emerges from Wular at Sopore. A limited portion of water is also abstracted for human uses. Water inflow and outflow indicate the following trends

- River Jhelum contributes annually 88% (6,596.73 MCM) of the inflows into Wular. The contribution of Erin and Madhumati are 229 MCM and 436 MCM respectively. Kinusa Watlab and precipitation contribute 204 MCM into the lake. In term of outflows, Jhelum accounts for the 96.9% of the total outflows (7,883.83 Mcum). The rest is accounted for by human abstractions (1.7%) and evapotranspiration (1.4%).

- River Pohru, which meets River Jhelum at about 18 kms downstream of Sopore town at Zab near Doabgah has a considerable impact on the hydrological regimes of the wetland system. The 60 km long river with an overall catchment area of 2,030 sq km has an insignificant lean season flows. However, the river becomes flashy during floods and the flood flow currents cut across the main River Jhelum flow in a manner that the Pohru flow acts as a temporary water barrier to impede flow of River Jhelum and consequentially there is a back afflux in the upstream portion of River Jhelum. Such a situation has been observed during flood flows in both the rivers and has been posing a problem from the flood control view point. This has also been corroborated through the community consultations carried during the course of formulation of action plan.

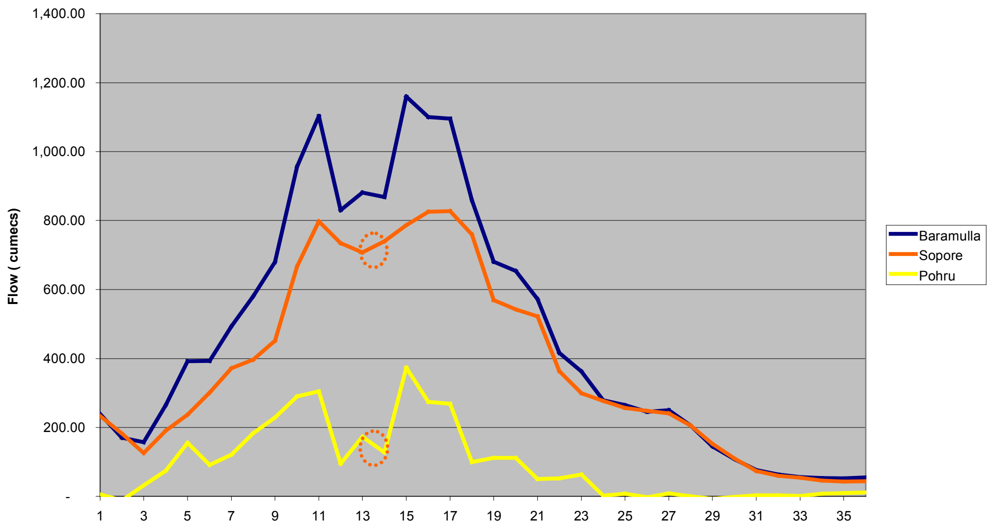


Figure 2: Effect of River Pohru on Flows of River Jhelum in flood years

An assessment of the impact of Pohru was attempted through the mean 10 daily hydrographs of rover Jhelum flows at Sopore, location upstream of confluence point and Baramula, a downstream location. The only contributing flows in the mid course is through the Pohru River. It can be observed that during mid April – early May period, the flows of River Jhelum at Sopore indicate a decreasing trend, whereas they increase at Baramulla. This can be attributed to a hydrological wedge created due to fast flowing currents of Pohru. This would therefore also help maintain water levels of the lake during these periods despite situations of quick drainability created through dredging of the downstream sections.

- There is a high temporal variability in inflows and outflows. While 80% of the inflows take place within the summer months corresponding with melting of snow processes as well as high rainfall; 86% of outflows is also concentrated within these months. As can be seen in the Fig 3, the period March to September has high flows, with only 20% contributed in the remaining months.

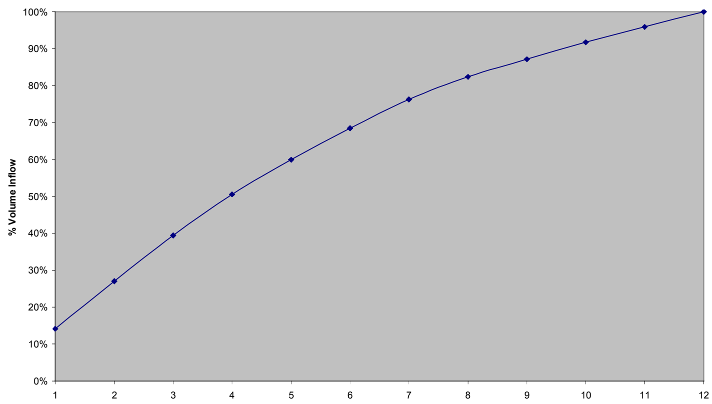


Figure 3: Temporal distribution of wetland inflows

- The net outflows from the Wular as measured at Sopore are higher than the inflows, indicating contribution of the Wular and its adjoining marshes in the overall hydro period. In a normal year, the inflows bear two distinct peaks, which is in difference to the rainfall distribution. The wetland system is a net absorber of water from September – February, which is then released during

March – June. During a flood year, the net outflows from the wetlands system are positive, which is reverse in the case of a drought year. The storages are therefore built during the winter months, when the flows are already in the lean phase.

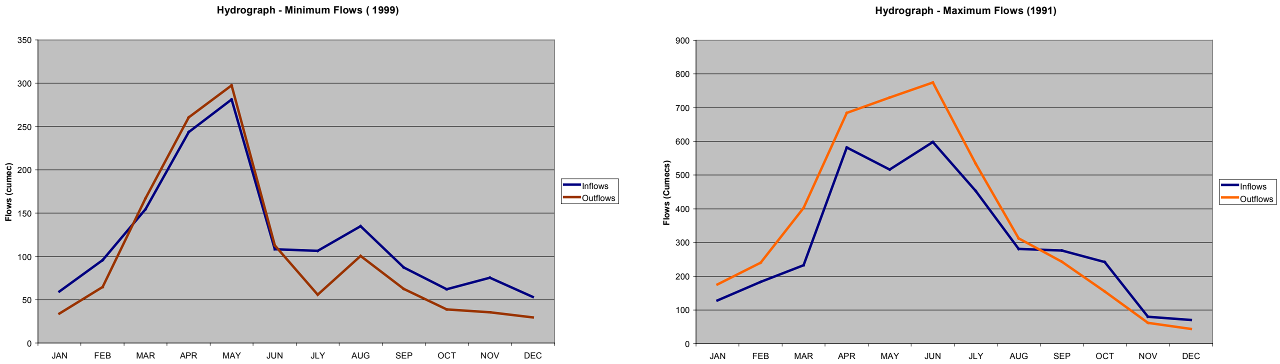


Figure 4: Trends of inflows and outflows for drought and flood years

- Assessment of flow trends of River Jhelum at Baramulla indicate that the lowest discharges occur during October to February, when 1 – 5% of the annual runoff is discharged every month. At the maximum discharge during May and June , more than 15% is discharged very month with the maximum peaks exceeding 1500 cumecs. Despite a moderate mean discharge, high peak flows of above 1000 cumecs also occur during August. This trend is in difference to the rain fall patterns of the upstream Baramulla and Srinagar stations, which peak in March and subsequently hover at around 50 mm. Flows appear to be strongly correlated with temperature which shows a rising trend from March – July, thereby inducing melting of the glaciers and corresponding high flows till June. The secondary peaks may be attributed to the hydrological flow regulation function of the wetlands and their associated marshes, which have been historically observed to absorb high flows and discharge during the lean seasons.

- Mean monthly flows at Baramulla indicate a significant narrowing of peak flows. The peak flow periods during 1922-40 were distributed across the months of April to July, which has reduced to a high flow during May. The flows start building up as early as late February, which was delayed till March during 1922 – 40. Secondly, the secondary peak has also started smoothening, as the marshes as well as the catchments have gradually deteriorated losing their absorption capacity. The variability of flow has also increased during this period. The number of years with high flows (mean + 2 Standard Deviation) increased from 1 during 1922 – 40 to 9 during 1980 – 2000. The number of low flow periods (mean – 1 Standard Deviation) increased from 18 to 31 during the same period. These changes in the hydrographs are indicative of changes in hydrological regimes caused due to loss of marshes, degradation of catchments and wetlands, climate change.

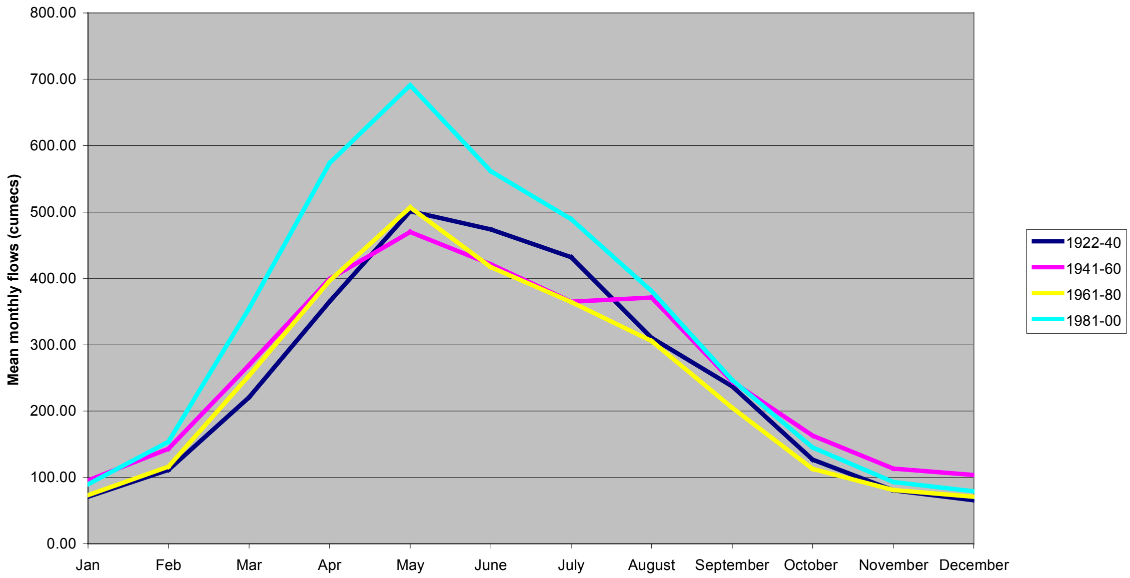


Figure 5: Trends of mean monthly flows of River Jhelum at Baramula

Assessment of inflow and outflow patterns indicate a progressive reduction in the capacity of the wetlands to regulate flow regimes. This has led to enhanced flooding and quick drainability within the basin. The high flows largely remain untapped due to reduced retention capacity of the basin attributed to loss of upstream marshes and wetlands. This trend is likely to enhance situations of hydrological extremities , viz droughts in the lean seasons and floods in the high flow seasons.

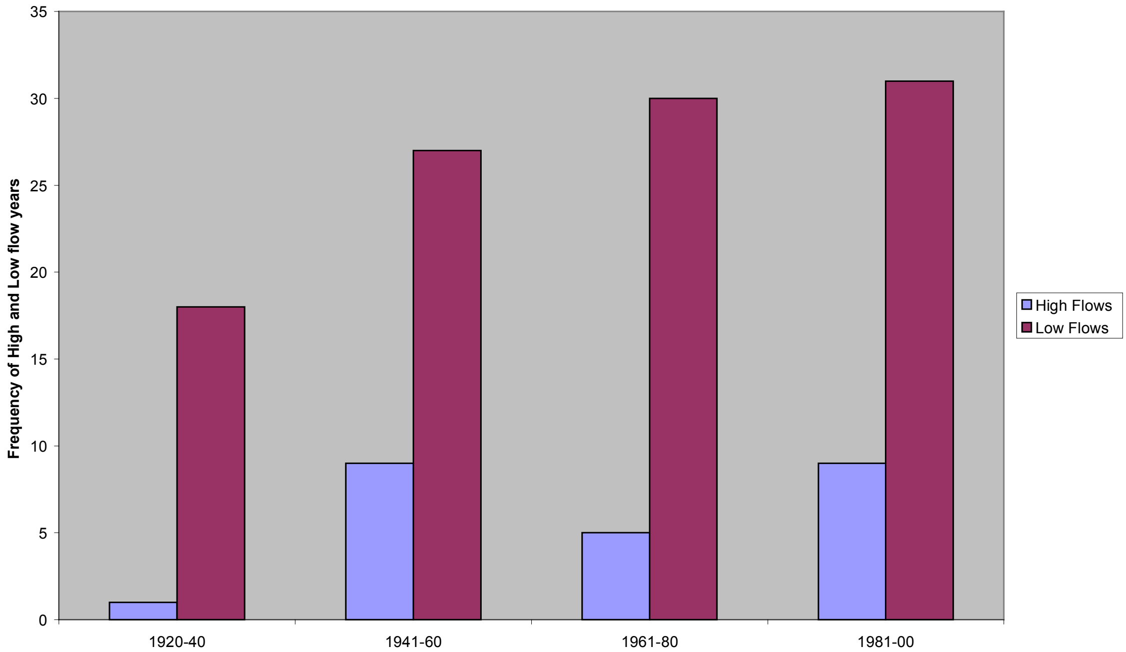


Figure 6: Trends in high and low flow years of River Jhelum at Baramula

Water Holding Capacity

No systematic baseline surveys and its evaluation is available to assess the overall water holding capacity of the Wular system. Assessments based on ground surveys and spot elevations obtained through satellite data, indicate the following:

- The total water holding capacity of the Wular at normal lake levels (1576 meters) is 340 Mcum. The storage available between the average winter levels and summer levels is of about 170 MCM. The lake waterspread undergoes a significant fluctuation between the summer and winter months. The average area has been estimated as 54 sq km, which declines to 24 sq km during the lean period and increases to 89 sq km during summer months. Maximum part of the storage is achieved when the lake levels reach beyond 1574 meters amsl (Fig 7).

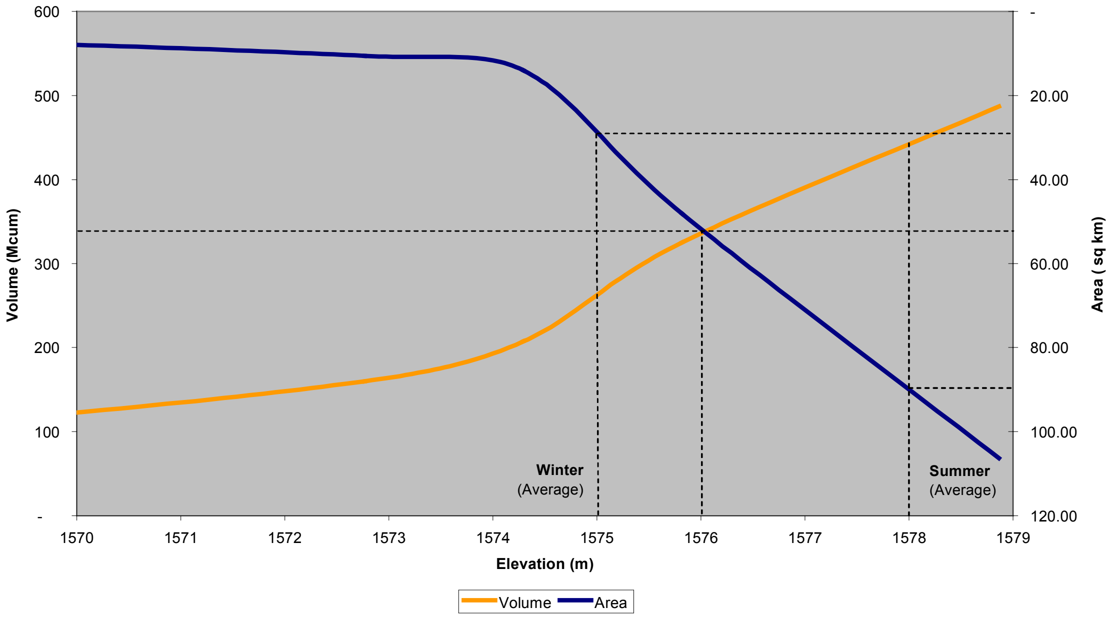


Figure 7 : Area Capacity curve for Wular Lake

- The average lake depth varies from less than 3 feet in the southern segment of the lake to more than 16 feet in the northern segment. The lake has less than 1 meter depth in the north eastern portion where the river Jhelum enters the wetland and in the southern section, between Baniyari and Shahgund (Map 2.4).

- A comparison of the stage volume relationship derived for the Ningli Barrage project, indicates a loss of 91.56 MCM of capacity at 1579 amsl elevation (maximum water level) during a period of last 30 years. Thus about one fifth of the water holding capacity has been lost over the last three decades. This is equivalent to an annual lake sedimentation rate of 2,470 acre feet. This loss of capacity is attributed to the following factors:

  ◊ **Shrinkage of lake area:** A comparison of the SOI toposheet of 1911 and imageries of 2007 indicates an overall reduction in wetland area by 45% (157.74 sq km to 86.71 sq) during this period. Changes between various land use categories within wetland and associated marshes is presented below:

Table 2.3: Land use changes in and around Wular

Land use categories	Area (sq km)		Net change in land use
	1911	2007	
Water	91.29	75.23	-16.06
Marsh	66.45	11.48	-54.97
Plantation	0.66	27.30	26.64
Agriculture	0.38	44.25	43.87
Settlements	0.43	0.95	0.52
	159.21	159.21	
Associated Marshes	58.67	17.67	-41
	217.88	176.88	-41

Receding waterspread areas has led to shifting of the marshes inwards towards the shallower zones. The entire lake marshes have been converted to plantations and agricultural lands through construction of embankments. The area under settlements, located primarily within areas where Jhelum enters the lake, has also doubled. The marshes have also been under considerable alteration, with their areas reduced by 41 sq km during 1911-2007 (Map 2.5 and 2.6).

◊ **Catchment degradation:** The direct as well as the indirect catchmnts of Wular are highly degraded. Presently, dense forest forests (canopy area > 70%) and dense forests (canopy area > 40%) form only 8% and 49% of the total area, the rest classified as degraded forests. The degraded catchment contributes a high amount of silt load into the wetland. Sedimentation is enhanced by intensive quarrying carried out in the periphery of Wular Lake.

◊ **Construction of embankments** within the floodplains of River Jhelum, particularly between Asham and Baniyari which prevents the fanning of silt and thereby leads to its deposition into the lake. The recent satellite imageries indicate a clear northwards shift of the river course after Baniyari, due to heavy silt deposition in the inlet.

The above information however is based on limited data and depicts the broader trends commensurate with the physical observations made during the field visits. Detailed and systematic investigations are recommended to arrive at the actual values.

Water Use

Irrigation and water supply are the primary water uses linked with the hydrological regimes of Wular. In the downstream reaches, the water from the river is used for hydropower generation. Details of the water use are as follows:

- **Irrigation:** Water from Madhumati Nullah is withdrawn through the Zainagair Canal in its head reaches and is further augmented by lifting lake waters at Watlab to irrigate the entire agricultural area situated in the Zainagir block of tehsil Bandipora and Sopore. This canal is designed to carry 10 cumecs flow. However, this is utilized to an extent of 7 cumecs at present during irrigation season. This scheme therefore utilizes 128.81 MCM of water annually form overall lake water availability.

  Besides the Zainagir Canal, there are numerous lift irrigation schemes operational in the reclaimed marshes in the southern lake fringes. The same pumping stations are also used for dewatering purposes in the periods of inundation. At present there are 47 pumping stations, of which 14 stations having capacity of 470 cusecs are operational lifting water from the river Jhelum and / or the marshes.

Zainagir Cannal

- **Water Supply:** A 4 MGD lift water supply installation at Watlab draws its raw water requirements from the lake to supply drinking water needs of Sopore town and Villages between Watlab and Sopore. Another rural water supply scheme at Tarzoo Sopore also utilizes 0.17 MGD of lake waters for its raw water requirements. Water supply schemes lead to withdrawal of 6.94 MCM of lake waters annually

Water Lift Station at Watlab

- **Hydropower:** The outflows from the lake are also utilized for generating hydro electric power in the series of run off the river installations, namely Lower Jhelum Hydro electric Project (105 MW capacity located at Ghantamulla) , Uri Hydro Electric Project Phase 1 (480 MW capacity located at Uri,) and Uri Hydro Electric Project Phase 2 (240 MW capacity also located at Uri). The former two projects have already been commissioned, whereas the third is under construction. These installations, being of run off the river type function as per the availability of water of River Jhelum in the downstream reaches. The present patterns of storage in Wular have a direct bearing on the availability of water in the river for hydropower generation. The loss of water holding capacity in the Wular has also adversely affected power generation, as the availability of discharge during the lean winter months increases the idling period of the machine in the power house.

Flooding

Flooding in and around wetland is more prominent in the eastern periphery of Wular, in both sides of the River Jhelum before it enters the wetland. The area is marked by the presence of series of flood protection embankments, constructed in 1957 – 76 to protect the agricultural lands from flooding from Wular Lake. The most prominent of the embankments is the third line of defence having a height of 1580 feet amsl which hydrologically isolates the marshes from the main lake.

Flooding within Wular Lake is primarily attributed to the changes in inflow patterns, loss of water holding capacity , and conversion of marshes. River Jhelum has insufficient capacity to accommodate the peak summer flows, and therefore a large inundation occurred all along the river course, inducing the state government to construct flood spillway around Srinagar to protect the settlements. These additional flows were absorbed by the marshes, which used to release water during the lean seasons after monsoons had receded. However large scale conversion of marshes were undertaken under the Grow more Food Campaign initiated in 1949, wherein nearly 135 sq km of marshes were converted. This has led to peaking of inflows during monsoon and consequent larger inundation. Construction of embankments retards the evacuation of floodwaters, thereby creating prolonged inundation and waterlogging.

Water Quality

The discharge of solid, liquid and other wastes from human settlements all along the River Jhelum are finally deposited in the Wular Lake. The carcasses of dead animals thrown directly into River Jhelum finally get accumulated in the Wular Lake creating health hazard conditions. Heavy dosages of fertilizers and pesticides used in agricultural fields besides spraying chemical in orchards for pest control are ultimately washed into Jhelum flowing into Wular Lake. There are no regulations or guidelines for disposal of solid wastes including carcasses throughout the River Jhelum. The sewerage system is generally lacking throughout the valley except in some parts of Srinagar. All the channels, streamlets and other aquatic bodies directly or indirectly draining into River Jhelum deposit heavy load of pollution in Wular Lake.

State Pollution Control Board has been monitoring water quality at 10 locations within the River Stretch covering mainly Anantnag and Srinagar districts. The downstream of Srinagar including Wular Lake has been totally neglected. A two year study carried out by National Institute of Aquatic Ecology (NIAE) under J&K Lakes and Waterways Development Authority highlights that heavy load of pollution is from Srinagar followed by Anantnag. Srinagar is the major city which discharges the maximum solid and liquid wastes followed by Anantnag, Sopore and Baramulla (Map 2.7). Similar trends have been observed in BOD and COD. Overall heavy load of domestic pollutants lead to increased concentrations of BOD, COD and drastic reductions in dissolved oxygen levels. The other physical and chemical parameters also reflect deteriorated condition of water quality.

The State Government has formulated project feasibility report involving IRAM consultants for restoration of water quality focusing on Anantnag, Srinagar, Sopore and Baramulla districts under the Jhelum River Conservation Plan (JRCP). The proposal formulated was submitted to Ministry of Environment and Forests (MoEF) which has not been yet approved for financial support, although it has been accepted in principle. Commitment for the sewage treatment has also been made in 10^{th} Plan by the State Government. Economic Reconstruction Authority is proposing to include sewerage treatment for urban and rural areas under a major plan being formulated for economic reconstruction of Jammu & Kashmir state, which is likely to be supported by Asian Development Bank (ADB).

Kashmir University particularly through Centre for Research and Development has been collecting information on water quality of Wular and some parts of River Jhelum. The physical and chemical characteristic of the Wular and its associated marshes has been studied extensively by Kundangar et al (1992), and Kaul & Trisal (1984). The analysis of information of various parameters studied highlights the following characteristics of the water quality:

- Water transparency measured as Secchi disc showed in general low values due to high turbidity caused by heavy turbulence
- Lake water is alkaline as indicated by alkalinity and pH values
- Dissolved oxygen values vary considerably within the lake; extremely low concentrations have been recorded in some pockets receiving domestic effluents from the lakeshore households
- Concentration of divalents is high with bicarbonates being most abundant forms among inorganic anionic components
- Nitrate nitrogen is the most abundant nitrogen source. The concentration of nitrate nitrogen increases during winter and spring which may be attributed to the combined effect of nitrification at the mud-water interface
- Overall water quality corresponds to similar pattern in other valley lakes.

The water quality has deteriorated over a period of time and there has been a progressive increase in specific conductivity, orthophosphate and total phosphorus with a decline in transparency and dissolved oxygen. However, no measure shift in the pH of the lake has been recorded (Table 2.4). Systematic monitoring of water quality over a long period would reflect trends in water quality changes. Based on the analysis of water quality parameters, overall Wular lake water falls within category C as per CPCB's designated best use criteria.

Table 2.4 Water quality changes in Wular Lake during 1992 to 2006

Parameter	units	1992	2006
water temperature	^{0}C	3.1 - 25	6.3 - 27.3
Transparency	m	0.1 - 1.3	0.16 - 0.73
pH		7.1 - 9.8	7.2 - 7.7
Conductivity	µs/ cm,	57.0 - 429	118 - 3.5
Dissolved oxygen	mg/l	1.3 - 15.2	4.5 - 8.0
Chloride	mg/l	11.0 - 81.0	11.8 - 28.0
Calcium	mg/l	4.6 - 73.8	20.5 - 62.3
Magnesium	mg/l	0.8 - 35.6	12.2 - 30.1
Ammonia	µg/l	1.0 - 205	64.0 - 101
Nitrate nitrogen	µg/l	9.0 - 580	205 - 419
Ortho phosphate	µg/l	0.0 - 31.0	79 - 131.7
Total phosphorus	µg/l	0.0 - 103	180.0 - 292.5

The following key issues were identified based on assessment of hydrological regimes :

- ***Changes in hydrological regimes***

  The hydrological regimes of the wetland have undergone drastic change. The wetland presently builds storages during the winter months, when the flows are already in the lean phase. This is markedly different to the earlier trends, wherein the storages were been built during the excess flow periods and were released in the lean flow periods, thereby providing uniformity to the flow regimes. The above trend is also an indicator of quick drainability as the high flows in summer do not get an opportunity to build up storages which could be subsequently available during the lean season. Loss of marshes and catchment degradation have further reduced the capacity of the wetland to regulate hydrological regimes. The present stage of Wular is a contribution of the water resources development projects which have aimed at enhancing the outflows from the Wular Lake to achieve flood moderation in the upstream areas, and conversion of marshes for agriculture development.

- ***Loss of water holding capacity***

  The water holding capacity of the lake has declined by one fifth over the last three decades. This is a major factor leading to high drainability and reduced capacity of the wetlands to regulate flow regimes. The capacity has been further reduced due to willow plantation. Additionally, conversion of marshes which augment the overall holding capacity of the wetland system particularly in its upstream reaches has led to further deterioration of water quality.

- ***Deterioration of water quality***

  The water quality of Wular has deteriorated drastically due to discharge of high levels of untreated sewage / sewerage into the wetland. Wular Lake, due to its geomorphological setting becomes a recipient of entire wastewater of the basin. Despite a rapid increase in population, there has been no upgradation of the civic infrastructure leading to an increasingly higher proportion of wastes being dumped into the waterbodies. Presently none of the settlements have been provided with sewerage treatment facilities.

Discharge of Sewage

- ***Water allocation focused on human uses without considering the ecological requirements***

  The entire focus of water management in the Jhelum basin is on human uses, particularly irrigation and hydropower development, ignoring water allocation for maintenance of biodiversity and overall ecological integrity of the wetlands.

Water is critical to the maintenance of biodiversity and overall wetland ecosystem processes and functions. Though the Indus water treaty has prevented creation of any large water storage structures on the upstream reaches of the River Jhelum, expansion of developmental activities, would gradually crowd out the water availability for maintenance of ecosystem functions. A balanced approach to allocate water for human uses and ecological requirements is critical to sustainable management of wetland.

2.2.2 Biodiversity

Waterbirds

Waterbirds in Wular

Strategically located at the western extremity of the Himalayan range in India and south of the Pamirs, Kashmir wetlands serve as important staging grounds for medium and long distance migratory geese, ducks, shorebirds, cranes and other species that breed in the northern latitudes of Central Asia and Siberia. Many of these wetlands are of international and national importance, due to the large population and diversity of waterbirds and other wetland associated birds that they support. Of these, Wular Lake and Hokersar have already been included under Ramsar Convention considering their importance based on biodiversity and socio economic aspects. More recently Wular Lake and associated marshes viz., Haigam, Hokersar, Mirgund and Shallabugh have been included in the network of Important Bird Areas (Islam and Rahmani 2004), all of which are not formally protected.

The wetlands within the Jhelum Basin are nationally and internationally renowned for rich bird life particularly in regard to migratory ducks and geese. The Valley acts as an important staging ground for many of these species. At least 45 of the 213 waterbird species and 66 of the 118 wetland associated bird species have been reported in the region. The basin has records of 7 of the 53 globally threatened and near threatened waterbird and wetland bird species reported in the country, although none of these species are regularly observed here in recent years. Eight of 43 waterbird species are listed under the appendices of the Convention on the Conservation of Migratory Species of Wild Animals (Bonn 1982) to which India is a Contracting Party. Forty-three of the waterbird species are covered under the Central Asian Flyway Action Plan (CMS 2006).

Based on the analysis of information collected from various sources, an action plan has been developed for management of water birds and their habitats, which is briefly discussed in the chapter. The management of the wetland associated birds will largely be covered by activities prescribed for the management of the waterbirds.

Species composition and population estimation

Waterbirds can be broadly categorized into resident and migratory species. Resident species spend entire year in the valley while, as the migratory species may be seasonal or international migrants. The seasonal migrants nest in the valley during

April to August and then move out during August to other parts of the country. The international migrants, nest in the northern latitudes of Central Asia and Siberia (Russia, Kazakhstan, Uzbekistan, Tajikistan, Kyrgyzstan, Turkmenistan, China, Mongolia). These species may stop or stage in the valley during southward migration to wetlands in the subcontinent and/or during northward migration to the breeding grounds. Further, some of these international migrants are non-breeding or wintering birds that spend entire period in the valley.

Waterbirds utilize the Wular Lake and satellite wetlands on a daily basis for different purposes. It is observed that the birds visit Wular during the night time to feed when there is no disturbance from fishing boats and hunters. During the daytime they seek refuge in the Hokersar, Haigam, Shallabugh and other adjoining wetlands. The great importance of the Wular Lake for ducks, geese and other waterbirds can be only appreciated from some of the census work undertaken by the State Wildlife Department at Hokersar and Haigam since the early 1990s (Figure 8 and 9). The peak counts of 2000-2001 are of 511,755 waterbirds, though in other years, the counts are usually between 260,000 and 450,000. However, as these counts only cover two of the sites used by the waterbirds in the day, the total abundance of waterbirds is expected to be much higher.

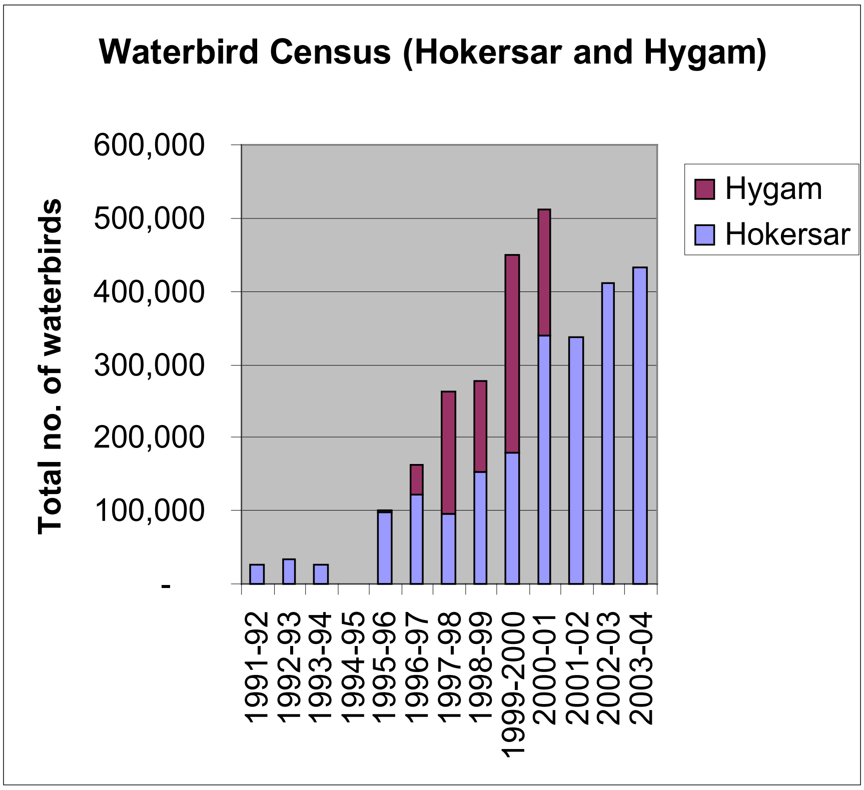


Figure 8: Estimated total population of waterbirds during January-March annual census at Hokersar and Haigam (1992-2004) based on information provided by the State Wildlife Department.

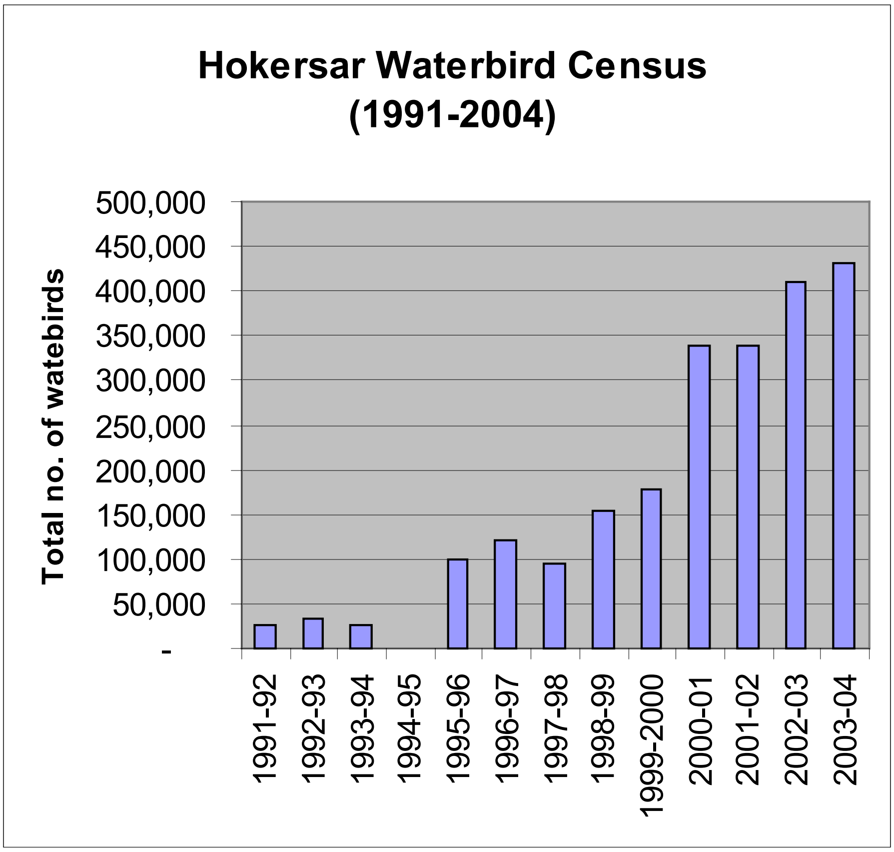


Figure 9: Estimated total population of waterbirds during January-March annual census at Hokersar Ramsar Site (1992-2004) based on information provided by the State Wildlife Department

The latest census data collected by the Wildlife Department on waterbirds provides an indication of the predominance of some waterbird species (defined as species comprising more than 5%) include Northern Pintail, Mallard, Gadwall, Northern Shoveller, Eurasian Wigeon and Common Teal (Table 2.5). Census data from in the early-mid 1990s (Bacha, 1992; 1994) provides a comparison to recent information, and indicates that during in past the predominant species were also roughly the same, although there are variations in the proportion of species between these two decades. From the data in 1992 and 1994 (Fig 10), it is also evident that there are changes in numbers of a species between the years, for example, Mallard dominated in 1994 and formed 40% of the total population, although it, was less than 5% in 1992. Similarly, Eurasian Teal dominated in 1992 with over 25% of the total population whereas in 1994 the population was only 7%. The reason for these annual fluctuations may be attributed to census timing, habitat changes and food availability and weather conditions. This reiterates the need for long term data collection to understand annual variations and their linkages with habitat, climatic, hunting and other factors.

Table 2.5: Census conducted by Wildlife Protection Department for three wetlands (February 2006)

Common name	Hokersar	Haigam	Shallabug	Total	%
Northern Pintail	67,790	180,000	44,330	**292,120**	**21.0**
Mallard	130,435	85,000	45,150	**260,585**	**18.7**
Gadwall	88,941	80,000	37,950	**206,891**	**14.9**
Northern Shoveller	68,400	85,000	31,572	**184,972**	**13.3**
Eurasian Wigeon	86,830	60,000	36,650	**183,480**	**13.2**
Common Teal	7,760	5,000	5,950	**178,710**	**12.9**
Common Coot	44,285	2,000	1,670	**47,955**	**3.4**
Red Crested Pochard	2,920	50	17,577	**20,547**	**1.5**
Greylag Goose	10,054	100	240	**10,394**	**0.7**
Common Pochard	2,590	400	5	**2,995**	**0.2**
Garganey	690			**690**	**<0.01**
Ruddy Shelduck	285		15	**300**	**<0.01**
Others	500			**500**	**<0.01**
Grand total	**571,480**	**577,550**	**241,109**	**1,390,139**	**100.0**

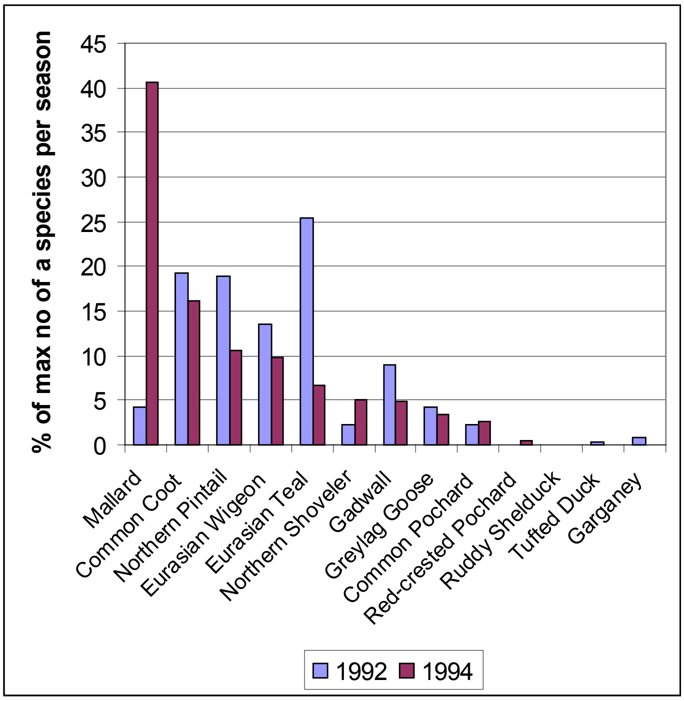


Fig 10. Annual variations in selected waterbird species in Jhelum River Basin based on Bacha (1992, 1994)

Most long-distance migratory waterbirds (ducks and geese) arrive in the valley during September-October**.** Their numbers decline during February to April depending the migration patterns of different species, with most having left by May. Few individuals of some species, constituted by juveniles or injured adults may continue to stay during the northern summer months as well.

Historic census data (1992 and 1994) collected by the Wildlife Department (Bacha 1992, 1994) on waterbirds collected over part of the northern winter provides an indication of the period of northward migration of different species. Counts undertaken during 1994, from January to April indicate that the total number of waterbirds peak in February with a decline in April (Fig 11). A similar pattern emerges for counts undertaken in 1992 (Fig 12).

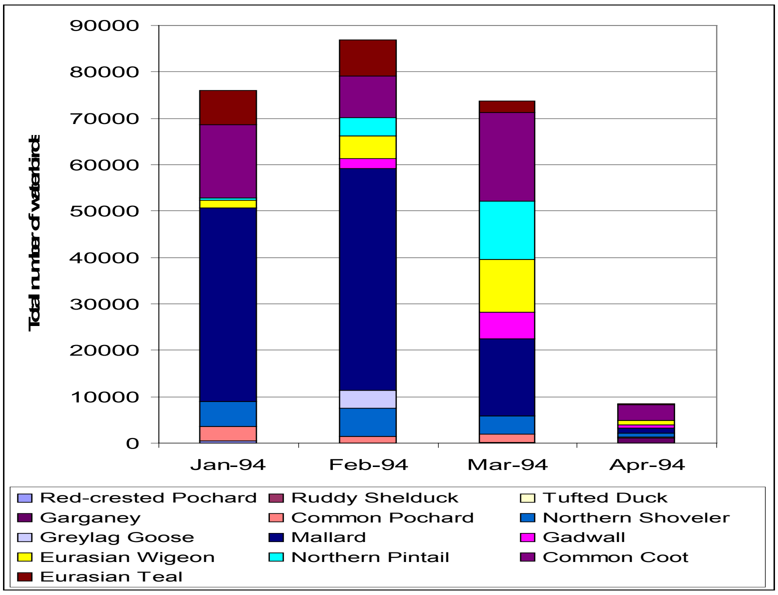


Fig 10 : Estimated monthly totals of waterbird species during January- April 1994 in the Jhelum River Basin wetlands (based on information provided by the State Wildlife Department)

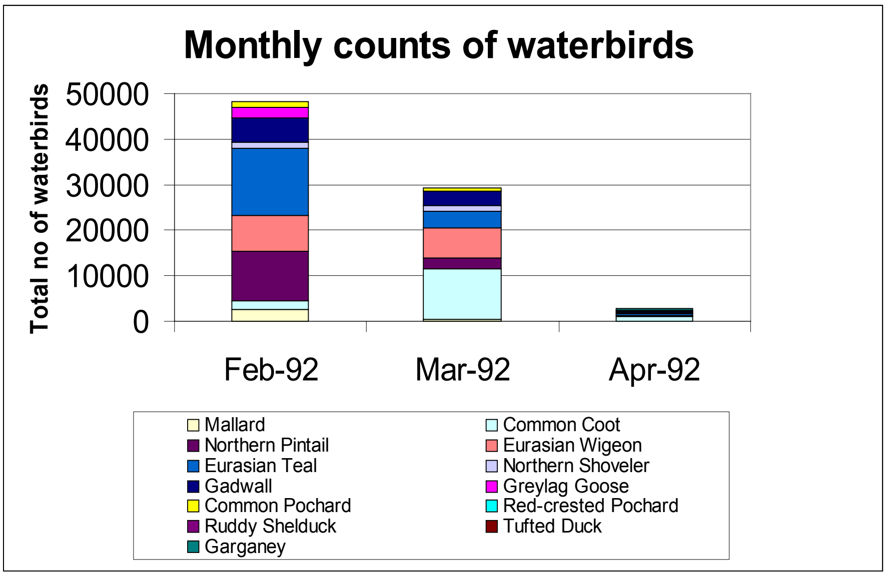


Fig 11 : Estimated monthly totals of waterbird species during February-April 1992 in the Jhelum River Basin wetlands (based on information provided by the State Wildlife Department)

Information on the southward migration patterns of waterbirds is needed while information on northward migration patterns needs to be validated for the current wetland conditions. This reiterates the need for long term data collection to understand migration patterns.

Breeding waterbirds

Twenty-two species of waterbirds, including the globally threatened Ferruginous Duck, are recorded to breed in the valley wetlands (Table 2.6). In addition to these, a range of reed and tree nesting birds (e.g. warblers and raptors) also breed in these wetlands. The historic importance of the Wular Lake and satellite wetlands as a breeding ground for waterbirds can be appreciated from references to boatloads of eggs collected numbers of birds (Mallard, coot, moorhen, etc) for sale in Srinagar and other markets in the late 1800s (Ali and Ripley 1983).

The Wular Lake mostly consists of the open water areas and the areas with submerged and floating vegetation. The open water area is largely disturbed due to anthropogenic interference and the boating. During the March-June period, large areas of Wular covered with floating vegetation serve as breeding sites for the birds like Indian whiskered tern, Pheasant-tailed Jacana and Little Grebe. The peripheral shallow areas with longer grasses like *Typha sp*., *Phragmites sp*., etc. serve as the breeding sites for the birds like Moorhen, Little Bittern, Purple Moorhen, Indian Great Reed-warbler, etc. The associated marshes of Wular Lake like the Mukhdoomyari and Saderkote act as breeding grounds for a number of bird species especially Mallard. Besides, the peripheral wooded areas of Wular Lake serve as nesting sites not only for many upland species but also for a number of wetlands.

Important baseline information on the breeding biology of the some of the breeding species has been collected by the University of Kashmir. However, the current status of the nesting populations of the different species in the different wetlands is not properly known. The main breeding seasons of the waterbirds is from March to October, with a peak during May to August for many species (Table 2.6).

The preferred nesting habitats vary between species and can be categorised into 4 main types:

a. preferring marshes where floating nests are built in vegetation on water,
b. reed beds and tall grasses,
c. trees and bushes, and,
d. on the ground around streams and river channels

Four species are mainly colonial nesting species; three species of heron require trees or undisturbed reed beds; and one species (Whiskered Tern) requires marshy areas, including *Singhara* beds and other floating vegetation. All the other species are largely solitary nesters.

Table 2.6 : Summary of breeding requirements and preferences of waterbirds in the Jhelum River Basin.

Sr. No	Species	Preferred habitat types[1]	Food habits	Preferred nesting habitat[2]	Nesting habit[3]	Nesting season[4]
1	Little Grebe *Tachybaptus ruficollis*	LO,LV,M	F,Ai,C,M	Marsh (Singara beds)	S SC	April-Oct
2	Little Egret *Egretta garzetta*	LV,M,C,R	F,Ai,I,C,A	Plantation bushes/trees (around Wular)	C	July-Sept
3	Grey Heron *Ardea cinerea*	LV,M,C,R	F,Ai,I,R,M	Chinar and tall trees	C SC	March-June
4	Cattle Egret *Bubulcus ibis*	LV,M,C,R	Ai,I,A	Plantation bushes/trees (around Wular)	C	June-Aug
5	Indian Pond-heron *Ardeola grayii*	LV,M,C,R	Ai,I,F	Large reedbeds and bushes	SC	May-Sept
6	Black-crowned Night-heron *Nycticorax nycticorax*	LV,M,C,R	F,A	Chinars, large reeds	C	April-May
7	Little Bittern *Ixobrychus minutus*	LV,M,C,R	F,A,Ai,I,M, C	Large reeds and bushes	SC	June-Aug
8	Mallard *Anas platyrhynchos*	LV,M,C,R	Co,S,L,Se, C,M,Ai,A	Large reed beds and bushes	S	July-Sept/Oct
9	Ferruginous Duck *Aythya nyroca*	LV,M	Co,S,L,Se, C,M,Ai,A,F	Reed beds	S	May-July
10	Water Rail *Rallus aquaticus*	LV,M,C,R	S,Sn,P,M, AI,W	Reed beds, grasses	S	May-Aug
11	Baillon's Crake *Porzana pusilla*	LV,M,C,R	Se,I,W,M	Reed beds, grasses	S	May-Aug
12	Ruddy-breasted Crake *Porzana fusca*	LV,M,C,R	AI, M,Se,S	Reed beds, grasses	S	June-Aug
13	Purple Swamphen *Porphyrio porphyrio*	LV,M,C,R	Se,S,L,I,M, P	Reed beds, grasses	S	May-Aug
14	Common Moorhen *Gallinula chloropus*	LV,M,C,R	Se,S,M,A, A,F	Reed beds, grasses	S	May-Aug
15	Common Coot *Fulica atra*	LV,M,C	V,S,Se,P, W,I,M,F	Reed beds	S SC	May-Aug
16	Pheasant-tailed Jacana *Hydrophasianus chirurgus*	LV,M,C,R	Se,V,Ai,M	Marsh (Singara beds)	S	May-Aug
17	Little Ringed Plover *Charadrius dubius*	LV,M,C,R	I,Ai,W	Dry stream, river bed, sand bank	S	April-May
18	Eurasian Woodcock *Scolopax rusticola*	M,C	W,G,Se,S	Wooded streams	S	April-July
19	Common Snipe *Gallinago gallinago*	M,C,R,LV	W,La,M	Marsh or wet boggy area	S	late Apr-mid June
20	Common Sandpiper *Actitis hypoleucos*	LV,M,C,R	M,C,I	Ground along streams	S	May-June
21	Black-winged Stilt *Himantopus himantopus*	LV,M,C,R	M,C,I,W, Se	Marsh or wet boggy area	S SC	Apr-Aug
22	Whiskered Tern *Chlidonias hybrida*	LV,LO,M, C,R	I,Ai,F	Marsh (Singara beds) and other floating veg	C	June-Aug

Notes:

1 - Preferred habitat types – LO - lake with open water, LV – lake with submerged/emergent vegetation and drying margins, M - marsh (vegetated body with some open channels), C

– river or canal, R - rice fields, P - plantation/forest (submerged/surrounding wetlands) - information extracted from Ali and Ripley (1983) and provided by Dr. C.M.Seth and Dr Shah.

2 - Food habits: (a) Vegetation – Co – corms, L - leaves, P – paddy, S - shoots, Se – seeds of aquatic plants, V – vegetable matter; (b) fauna - A – frogs, AI – aquatic insects, C - crustacea, F – fish, G- grubs, I – insects, La – larvae, M - molluscs, R – rodents, W - worms. - information extracted from Ali and Ripley (1983) and Dr Shah.

3 - Preferred nesting habitat - information extracted from Ali and Ripley (1983) and provided by Dr. C.M.Seth and Dr Shah.

4 - Nesting habit - S – solitary/single, C – colonial, SC - semi-colonial - information extracted from Ali and Ripley (1983) and Dr Shah.

5 - Nesting season - information extracted from Ali & Ripley (1983) and provided by Dr Shah.

A number of factors that influence the breeding success of waterbirds include both man made/natural changes of water levels during the breeding season. While no time series estimates of breeding populations and breeding success of waterbirds are available, it is quite apparent that reclamation of marshes has seriously affected nesting of breeding birds. The absence of nesting of Whiskered Terns and other species are quite visible impacts due to alterations of waterbird habitats.

The food habits and feeding styles of these breeding species depend on a variety of aquatic vegetation (including seeds, stems, leaves, corms), aquatic and terrestrial insects and their larvae, small to large sized fish, amphibia, molluscs and slugs, crustacean, worms and even rodents (Table 2.7). An assessment of the abundance and availability of the different prey species throughout the year at the different wetlands is required to manage these waterbirds.

Table 2.7 : Major feeding habitats and prey types of migratory waterbirds

Waterbird guild	Preferred habitat types[1]	Feeding style[2]	Food types[3]
Ducks, geese and coot	LO,LV,M,C,R	S,D,G	Co,S,L,Se,C,R
	LO,LV	B	M,Ai,A,F,Se
Shorebirds	LV,R	S	M,Ai,A,F,C,G
Gulls and terns	LO,LV,M,C,R	A,S	F,A,I,Ai,F,M,C,G

Notes:

1 - Preferred habitat types – LO - lake with open water, LV – lake with submerged/emergent vegetation and drying margins, M - marsh (vegetated body with some open channels), C – river or canal, R - rice fields, P - plantation/forest (submerged/surrounding wetlands) - information extracted from Ali and Ripley (1983)

2 – Feeding styles: D – dabbling, G – grazing, S- surface (with some digging), B – diving, A – from air

3 - Food types: (a) Vegetation – Co – corms, L - leaves, P – paddy, S - shoots, Se – seeds of aquatic plants, V – vegetable matter; (b) fauna - A – frogs, AI – aquatic insects, C - crustacea, F – fish, G- grubs, I – insects, La – larvae, M - molluscs, R – rodents, W - worms. - information extracted from Ali and Ripley (1983)

Important breeding sites

Historically, it is believed that the waterbirds were breeding widely across the wetlands. There has been no attempt to map their distribution. A preliminary map of the breeding locations of waterbirds of the Wular Lake is presented in Map 2.8. Information of the breeding distribution of waterbirds across the other wetlands and the current status of the breeding populations of the waterbirds is unknown.

The information on waterbirds from various sources clearly indicates a lack of information on species and breeding site locations, preferences, prey abundance and habitat relationships.

Threats to waterbirds and their habitats

The threats to waterbirds in general include heavy poaching, loss and modification of habitats. Decrease in wetland area leading to loss of food and cover plants have led to decline in waterbird populations.

The specific threats to waterbirds are:

- Lack of formal conservation status (such as protected areas) for most sites leading to poaching. Thousands of geese and ducks are hunted by the poachers in the unprotected areas leading to their movement to protected areas such as Haigam during day and their reverse movement during night
- Collection of eggs and chicks of nesting waterbirds constitutes a loss to breeding success.
- Degradation and destruction of the immediate forested catchments causing increased siltation, eutrophication, excessive weed infestation and degradation of water quality.
- Spread of aquatic vegetation over open water areas leading to habitat loss of birds that prefer open water.
- Heavy grazing lead to destruction of breeding and feeding grounds of birds.
- Unregulated and over fishing in some wetlands resulting in loss of fish and invertebrate prey and disturbance to migrants, seasonal migrants and resident waterbirds.
- Encroachment by agriculture and urbanisation, resulting in the decrease in the size and functions of many wetland areas affecting waterbirds.
- Discharge of domestic waste from point and non-point sources leading to habitat modifications.

The key issues identified based on assessments:

- Absence of comprehensive base line information for trend analysis and planning
- Intense poaching in unprotected areas leading in decline in waterbird populations
- Habitat modifications due to changes in natural water regimes and human activities
- Lack of infrastructure and trained technical staff for monitoring and evaluation
- A recent risk to waterbirds and mass deaths of different migratory species to a highly pathogenic avian influenza virus (strain H5N1) from domestic poultry or other sources in east, southeast and north-central Asia, has highlighted the need for greater attention to understanding the impact of the virus on waterbirds and of the potential role of waterbirds in its spread. As the state shares international borders with Pakistan and China, countries in which the virus has been recorded, there is a high risk of incursion of the virus to the waterbirds of the valley.

Fish diversity

Wular Lake with its large expanse of water is an important resource for fisheries. The fisheries of Wular Lake is a combination of capture and culture fisheries. The annual requirement of table fish for Kashmir is 37,000 MT as per standard nutritional requirement of 11 kg / capita / annum consumption of the fish. The current production of the state from culture and capture fisheries is 19,500 MT / annum thereby indicating a deficit of more than 50% of fish requirement. Present status of fish and fisheries of Wular Lake is briefly highlighted in the chapter.


Fishing in Wular Lake

Heckel published two volumes on taxonomic enumeration of fishes in Kashmir. He reported occurrence of 16 species all of which were then considered new to the science. Later Das and Subla (1963-64) produced a new list of 36 species based on field work between 1961 and 1964. Saxena and Koul (1966) listed 39 species based on literature compilation. Further Nath (1986) listed 42 species for which no proof is available to permit assessment of the status or originality of the work. Some of the reported species have never been subsequently recorded and their presence in the valley is rather doubtful. Recent surveys carried out by NIAE, J&KLWWDA (2000) indicate occurrence of 13 species from Jhelum and associated lakes including Wular. As the taxonomy of many species is still under scrutiny the total number may increase or decrease with further investigations in the field. However, whatever the number, it is clear that several species of schizothoracinae are endemic to the region are declining both species and population.

An analysis of fish fauna reveals that three species are endemic to Kashmir valley viz. *Schizothorax niger* (Snow trout) *Triplophisa marmorata* and *T. kashmiriensis*. They feed on detritus, attached plant (including algae) coating of stones and rocks and the associated invertebrate fauna. They grow slowly and attain maturity at the age of 2 years. The River Jhelum has lost at least one migratory fish species, Mahaseer (*Torpi*) due to construction of Mangla dam in Pakistan. Earlier Mahaseer used to migrate upstream of Jhelum for spawning.

The first attempt to introduce trout was made in 1898 by getting fish samples from Scotland for tourist attraction. Subsequently six trout fish hatcheries were established by 1912 and two species viz. *Salmo trutta fario* and *S. gairdneri* got established in different streams. Three varieties of common carp viz. mirror (*Cyprinus carpio specularis*), scale carp (*C. c. communis*) and leather carp were introduced in 1956 and they got quickly established due to their adaptive advantages to thrive under eutrophic conditions and breeding / spawning on vegetation. The commercially important fish species in Wular Lake are listed in Table 2.8.

Table 2.8: Economically important fish species of Wular

S.No	Name of the fish species	Local name
1.	*Schizothorax esocinus*	Cherru
2.	*Schizothorax curvifrons*	Sattar gad
3.	*Schizothorax micropogon*	Chattir gad
4.	*Schizothorax niger*	Aile gad
5.	*Schizothorax longipinus*	Dape gad
6.	*Schizothorax richardsonii*	Khont
7.	*Nemacheilus sp.*	Shud gurun
8	*Cyprinus carpio communis*	Punjabi Gad
9.	*Cyprinus carpio specularis*	Scale Carp

Breeding and spawning

The breeding migration starts in March / April and the spawning takes place in April / May and even upto June (Jyoti et al 1992). All species of the group except *S. niger* exhibit spawning migration to the incoming streams and rivers and lay eggs in shallow pools amidst gavel and sand. Further *S. niger*, which prefers clean and cold pockets of water is the only species which has adapted itself completely to lacustrine habitat, not even showing the spawning migration towards the upper reaches of the streams (Raina et al 1985). *S. niger* being a lacustrine fish does not show any spawning migration out of lake in comparison to other schizothoracine fish but shows a very low absolute fecundity which seems to be related to its non-migratory behaviour, as in migratory fish high fecundity compensates for the high mortality during the migration of both adults and juveniles. However, despite the lowest absolute fecundity, *S. niger* has the highest relative fecundity among the schizothoracine fish. This indicates the impact of the environmental stress on the fish. The exotic species such as *Cyprinus carpio* has adoptive advantages to utilize lake resources for its growth and dominate over other species due to its high fecundity (Table 2.9).

Table 2.9 Growth, feeding habits and fecundity of important fishes

Species	Feeding Habit	Growth attainment (mm)	Fecundity/kg body weight	Peak breeding season
Schizothorax niger	Bottom detritus (Illiophagic herbivore)	1+yr - 80mm 4+yr - 200mm	8000-23000	March-April
S curvifrons	Illiophagic Herbivore Occasionally column feeder	1+yr - 130mm 4+yr - 305mm	25000-40000	May-June
S. longipinis	Herbivore Detritophagus	1+yr - 95mm 4+yr - 288mm	25000-32000	May-June
S. micropogon	Herbivore (bottom feeder)	1+yr - 110mm 4+yr - 280mm	20000-25000	May-June
S.esocinus	Herbivore Omnivore (bottom feeder)	1+yr - 135mm 4+yr - 400mm	35000-40000	June-July
S. richardsonii	Herbivore Typical bottom feeder on rocks & stones	1+yr - 130mm 4+yr - 350mm	25000-30000	May-June
Cryprinus carpio	Detritus bottom Sediments	1+yr - 280mm 4+yr - 455mm	239000-285000	May-June

This is quite evident that common carp, which was introduced in 1959, has invaded all the meandering rivers and water bodies including Wular and has driven out the endemic schizothoracids. Common carp usually spawns from May to June in beds of aquatic plants. The planktonic peaks from March to April and July to August concur with the spawning activity of summer and autumn spawners, suggesting that this adaptation in reproduction is closely related to the availability of food to young ones as well as reducing the chances of competition between the young ones of different fish species.

Feeding Habits

The feeding habit and key biological features of major commercial fish species of Wular Lake indicates that *Cyprinus carpio* has high fecundity and grows at a much faster rate compared to the other species. A study on the food of some cyprinids has revealed that most of the cyprinids of the valley are omnivorous in habit. However, the share of different food items varies significantly in different species. Crustaceans and insects are important and preferred food items. In case of *S. esocinus* the fish-remains forms the most dominant component of the food. Macrophytes being dominant component of Wular Lake, form the bulk of the plant matter present in the gut content of the fish. Numerically algae contribute a large proportion of the food items. Segmented worms contribute to the food of the common carp and also to *S. niger* and *Orenius plagiostomus* that feed on the bottom organisms including sessile algae. *Crossocheilus diplochilus* has been found to be a mixed feeder while trout species are carnivorous in nature and feed on insects, molluscs and even on small fish (Yousuf 1992).

Aijaz (2006) during his research studied seven fish species and analysed gut content on Wular Lake assessed the dependence of fish population on the available plankton. According to him variation in the feeding habits of fish seems to be related to the availability of the choicest food. The Bacillariophyceae was the preferred food item among phytoplankton, while it was Cladocera that formed important component of food of fish. The most preferred food item was Amphora sp., Navicula sp., Cymbella sp. among Bacillariophyceae, while amongst Cladocera the most favoured food was Chydorus sp., Alonella sp., Graptolebris sp., Macrothrix sp., and Pleuroxus sp.

Fish Yield

Overall seven native species and two exotic species are commercially important. In commercial catches the exotic carps contribute 72-75% and the local fishes (*Schizothorax* sp.) and other miscellaneous fishes of less economic importance like *Barbus conchonius* (Button), *Gambusia affinis* (Maih Gad), *Carassius carassius* (Ganga) contribute 25 – 30% of total fish catch. (Fig 12)

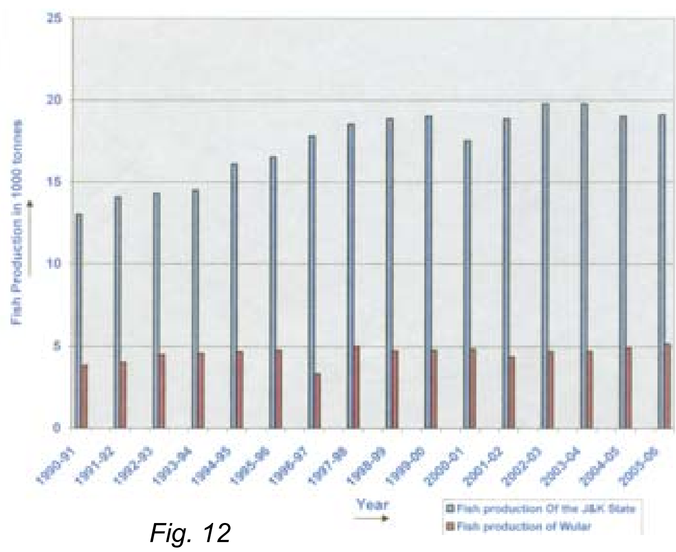
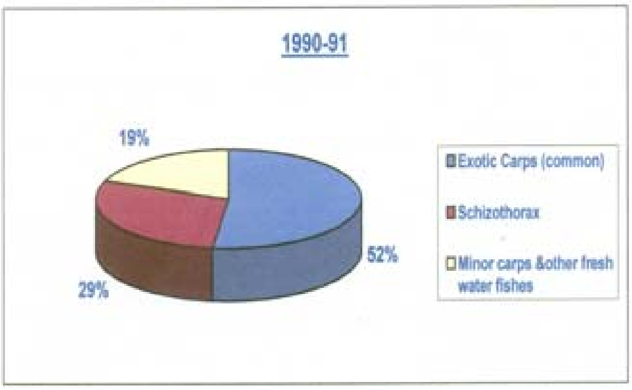
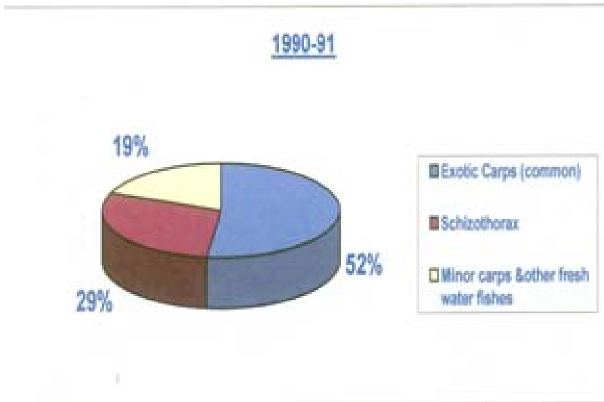


Fig. 12

The state government Fisheries Department has established nine landing centers at different locations of the lake (Map : 2.9). These landing centres lack adequate infrastructure and facilities and even proper road connectivity. They serve merely as connecting points. Middlemen, and money lenders collect fish harvested from the fishing boats directly. As per the fisheries statistics of 2004, of Government of India, Ministry of Agriculture the fishery production of Wular Lake from 1990 – 91 ranges between 3340 to 5150 mt / annum. The estimates are based on ten fish landing centres. The overall trend indicates increase in production with some fluctuations. Wular Lake contributes 23 to 26% of total fish production to the state of Jammu and Kashmir. Further analysis of the contribution of various groups indicates that exotic carps contribute 52 to 67% as compared to other species (fig.13).





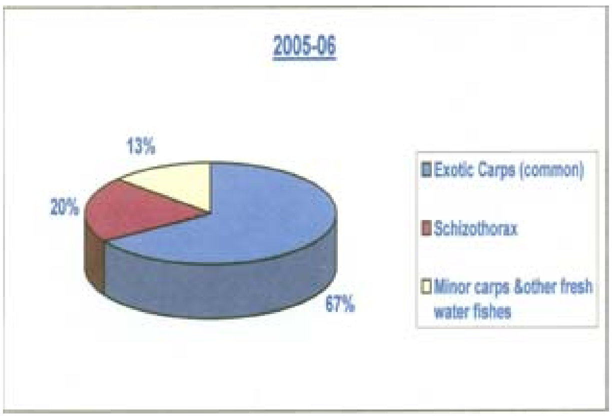


Fig. 13

A rapid survey of nine villages using PRA exercises indicated that average annual production at present is 563 kg. The annual yield of 1476 mt was calculated based on the information extrapolated to ten rural and three urban agglomerations with overall population of 17,421 located in the lake area. This clearly indicates a huge gap of approximately 20% between ground level realities and overestimates of the fisheries department. The figures need to be reconciled based on regular monitoring and developing an appropriate mechanism for monitoring and evaluation. The fish landing centres are not properly equipped with basic infrastructure for collection of fish catch from different pockets of the lake.

Crafts and Gears

Fishing Gears

Several types of fishing gears are traditionally used in Wular lake for fish harvesting, the main being cast nets, bag nets (Khurijal), dip nets, multiple head spears (Panzri), long lines (Wal raz) single / double pronged spear (Narchoo), and gill nets. However, due to decline in fish productivity, the fishermen have resorted to use of nylon nets with mesh size of 10mm and mesh bar of 0.5mm to catch fish of all sizes. The gill nets locally called *Thani* are 15 to 40m long and 1.5 to 3m wide. The use of these nets has seriously affected the regenerative capacity of the fish fauna.

During the participatory appraisals, it was highlighted that the communities themselves had imposed restrictions on the use of lower mesh size nets due to decline in fish catch. Promotion of gill nets was also undertaken by the State Government Department at select locations. Wooden primitive boats of varied dimensions of 5 - 10m length, 0.5-0.75 m width are exclusively used for fishing, transportation of fodder, trapa etc as well as navigation. Wooden boxes have been constructed in the middle of the lake to store catch. At Zurimanz village, the fishers have constructed ponds on the lake periphery to store surplus catch, and regulate fish supply for better price recovery. However, the structure of these ponds is very irregular and needs interventions for optimum us of space.

Information on Wular fisheries is highly fragmented and inadequate to support systematic management planning. There is absence of systematic inventorization and assessment of overall species richness and diversity. Limited research conducted by Kashmir University and some affiliated colleges as well as some other professional universities lack authentic information and have often published contradictory results. There is no proper monitoring mechanism to assess fish yield using appropriate methodology and long term assessment. Based on the information available, the following key issues have been identified:

- **Decline in fish diversity and yield** due to changes in hydrological regimes and loss of critical habitats. Construction of hydraulic structures particularly hydroelectric projects has seriously impacted migration of fishes.
- **Changes in species richness:** Large quantities of sewage discharge from the Srinagar city and major towns flows into the lake thereby leading to increased eutrophication which has adverse impacts on the growth and development of the fisheries in general and sensitive species including schixothorax in particular. Increased pollution levels are favourable for the prolific growth of aquatic vegetation, which seems to be more favourable for hardy species thereby altering the balance of species richness.

Vegetation

Vegetation of Wular Lake is an important component of the lake ecosystem providing both ecological and economic benefits. The communities within the lake area have been utilizing aquatic vegetation for various purposes particularly food, fodder and other purposes. However, dense growth of some species has chocked the lake area thereby reducing water flow and overall potential to provide ecological and economic benefits. Species composition, distribution, economic importance and role of vegetation in the lake ecosystem is briefly highlighted in the chapter.

Aquatic Vegetation

Species composition and distribution:
Vegetation has not been comprehensively studied, hence the information is scanty. Overall, 13 plant species have been reported to be present in the Wular lake (Kundangar, 1993). However, 24 species have been reported in the in the satellite wetlands (Kaul & Trisal, 1985). Species richness is higher in satellite wetlands

compared to the lake itself, thereby indicating the importance of satellite wetlands in maintenance of aquatic plant diversity.

In general, vegetation forms well defined zones distinguishing emergents, rooted floating leaf, free floating and submerged belts which are essentially adapted to water level fluctuations of the lake besides other environmental factors. The distribution of macrophytic species within the lake is shown in the map 2.10. The general sequence of the macrophytic species indicates occurrence of submerged species towards the center followed by mixed zones of submerged and rooted floating leaf types and emergents towards the lake shore.

The key features of the distribution of vegetation are:.

- *Trapa* is distributed throughout the lake but the maximum concentration is found on the eastern side towards right shoreline of the lake. Kanibathi on the north-west and Garoora – laharwalpora towards north east are also thickly colonized by this species
- *Nelumnbo* species is mainly found in some pockets of Ashtangu to Kanusa in the southwest and Lunkershpura, Kolhama and Garura area in northeast.
- Emergents, *Nymphoides* and *Nymphaea* species form large belts in the Garoora- Laharwalpora portion of the lake

Invasive Species

Among the emergent macrophytes *Phragmites communis* and *Typha aungstata* are the dominant species while *Trapa* sp., *Nymphoides* sp. dominate among rooted-floating leaf type. The submerged vegetation comprising associations *of Ceratophyllum-myriophyllum-potamogeton* species occur in deeper portions of the lake. Overall submerged vegetation is greatly reduced due to enhanced turbidity.
Exotic species such as *Salvinia natans*, *Lemna* sp. and *Azolla* sp. have profusely grown in the lake area and have assumed invasive character reaching to nuisance proportions. Proliferation of *Azolla* in the lake is the recent phenomenon and has

been also reported profusely growing in the upstream lakes and the river channel. River Jhelum contributes significantly to the explosion of these species besides various channels dropping into the lake.

Economically important species

Lake vegetation includes some economically important species utilized for food, fodder and fuel by the communities. A brief account of vegetation utilized for food, fodder, fuel and small-scale enterprises is briefly highlighted below:

Food

Several plant species in the Wular lake and associated wetlands have significant food value and are used either by the local communities for their own consumption or marketed to the neighboring towns or Srinagar city. Water chestnut (Trapa sp.) locally called singhara and Nelumbium sp. (locally called nadru) are the two major food resources plants derived from these plant species. Water chestnut has two species viz. *Trapa natns* and *T. bispinosa* which occupy large belts in the lake area. These two species are of great economic value to the people living in the area particularly economically disadvantageous group. Lawerence (1897) has elaborately mentioned about *Trapa* cultivation in Wular Lake. He has reported that essentially there are a number of varieties of Singhara in the Wular lake, viz. Basmati, Dogru and Kangar. Basmati with small nut and a thin skin is a superior variety named in honour of variety of rice. This variety gives one third of Kernel for two thirds of shell. Attempts to propagate basmati have generally failed as the inferior varieties often assert and provide stiff competition to the basmati variety. Dogru has comparatively a larger nut with thicker shell. The Kangar variety has a very thick shell with long projecting horns, and gives the least Kernel of all.

Water chestnuts occupy an overall 21.20 sq km of lake area representing 49.8 % of the lake vegetation. It is distributed throughout the lake but the maximum concentration is found on the eastern side near right shoreline (13.03 sq km) which relatively deeper area. The other chunks of the species are confined to western side (1.50 sq km), north-west near kanibathi (4.98 sq km) and towards garoora – laharwalpora (1.69 sq km).


Harvesting of Trapa

Harvesting of Trapa is an interesting feature in which a boat is moored to a pole on the *Singhara* ground, and two men rake the bottom of the lake with long poles to which are attached crescent shaped hoes. They work in a circle around the pole by which the boat is moored, and scrap up a heap of nuts and mud. The mud is then beaten with a pole called *Chokdan* and a net called *Khushabu*, put down and the nuts are dragged into the boat.

It has been reported by Lawerence that in an around the Wular lake an enormous weight of the water chestnut (*Singhara*) is gathered every year. Bates (1974) reports that about 96,000 *Kharwars* or ass loads of the nuts are harvested annually for five months in the year. It forms the main support of thousands of the poor people. The harvesting of the *singhara* is usually done when the water level is low. The Kernel which is white and mealy, is either taken roasted or fried. The kernels are also ground into flour and eaten as porridge and gruel. No attention has been paid to propagate the best varieties of water chestnut by the botanists or any agriculturist till date in or around the lake.

Nelumbium nucifera, with large floating leaves and underground rhizomes is used as a vegetable and sold in the markets of surroundings villages and towns. The flowers as well as fruits of the plant are used for religious purposes. The species is spread from Ashtangu to Kanusa and a few patches confined to Lunkershpura, Kolhama and Garura covering a total area of 0.49 sq km representing 1.14% of the total vegetation. Earlier this species used to be found all along the lake from Aidipur to Baniyari. The quality of the rhizomatous portion has also deteriorated as the fragility of the stem has increased due to reduction in the fiber content. The floods during recent years have severely impacted production of the species thereby impacting livelihoods of the people.

Fodder

Phragmites-Nymphoides-Nymphaea are the main species utilized as fodder by the communities living in and around the lake. These species form large belts in the Garoora Laharwalpora portion of the lake occupying 10.81 sq km. This portion of the lake is swampy and shallow due to heavy load of silt brought in by River Jhelum and its deposition due to thick strands of willow plantation, which choke the inlet area. Overall, fodder plants cover an area of 18.60 sq km of the lake represent 43.69 % of the total lake vegetation.

Utilization of Aquatic Weeds

Fuel:

Willow plantation covering 27.30 sq km in the lake area is utilized for supply of fuel wood mainly to Srinagar city besides its utilization for manufacture of cricket bats.State government departments mainly, Rakhs and farms, forest department, local panchayats and Social forestry have undertaken massive plantation of willows. Besides several plant species or their components such as shells of water chestnuts are utilized locally for fuel purposes.

Willow Plantation

The massive plantations of willows in the lake area has considerably retarded water flows and led to loss of wetland habitat thereby reducing the benefits provided by the wetland through its natural processes and functions. The problems of enhanced lake siltation, reduction in biodiversity is quite apparent.

Small scale enterprises:
Several plant species are utilized for mat and basket weaving, bat manufacturing and other purposes. The yield form Trapa cultivation is further processed and transported through a chain of contractors and finally sold in the markets of Srinagar and other towns.

Ecological importance of vegetation:
Vegetation acts as a biological sink for mineral nutrients implicated for eutrophication. Based on the information available from various sources it has been calculated that annually 141.77 tonns of nitrogen, 8.30 tonns of phosphorus and 111.59 tonns of potassium is locked within plant tissue which otherwise would have added to nutrient pool and led to degradation of water quality. Harvesting of vegetation provides simple method of nutrient removal form the lake ecosystem. Maintaining vegetation within the lake is thus an advantage to improve water quality.

Aquatic vegetation also provides shelter for several aquatic organisms as well as habitat for breeding and spawning for fishes. Dense vegetational cover is more conducive for the spawning of carp species rather than indigenous schizothorax. Vegetational modifications are required for enhanced fish diversity and productivity of native species.

The key issues are

- The conversion of satellite wetlands being the reservoir of biodiversity has led to species shrinkage, loss of habitats of water birds and vegetal diversity.
- Conversion of huge marsh area for agriculture settlements and other purposes has been responsible for water quality deterioration in the lake as they provided sink for key nutrients
- Shift in the vegetational belts from Lake littoral towards the center thereby decreasing open water area.
- Decline in extent and productivity of Nelumbo
- Invasion of exotic species

2.2.3 Socioeconomics Feature

Demographic features

There are overall 127 settlements located around Wular Lake and its catchments located within the district Baramulla in the tehsils Bandipore, Sopore and Sonawari. The total population of these settlements as per 2001 census is 0.46 million, which accounts for 9% of the total population of the state. Of the total population, 18% resides in the 31 settlements around Wular; 70% within 70 settlements within the foothills and the rest within 26 hill settlements. The population is largely rural, with only 22% residing within the 36 settlements. The average household size increases from 6.8 in the hills to 7.48 within the foothills and 7.56 within the lakeshore communities. The location of settlements around Wular is presented in Map 2.11 & 2.12

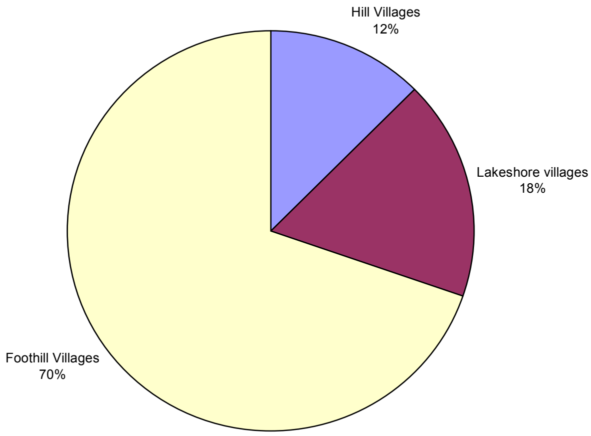


Figure 14: Population distribution in and around Wular

Social Amenities

Social amenities vary across the region, with foothills having relatively better access to facilities as compared to the lakeshore and the hill settlements. Rapid rural appraisals indicated drinking water supply accessible to only 46% and 52% of the lakeshore and hill communities, as compared to 100% coverage in the foothill villages. However, owning to poor maintenance of the water treatment facilities, there are often outbreaks of water borne diseases, particularly in the lakeshore communities wherein 42% of the population was reported to use water from Nullahs / River Jhelum without proper filtration. Adequate sanitation facilities are also very limited in the entire region. Less than 2% of the households in the lakeshore and hills and 8% of the population within the foothills have access to flush toilets, leading to high amount of dumping of untreated sewage in the waterbodies draining the area. Similarly, the access to healthcare is also wanting in the region, 36- 60% % of the settlements have no health care facilities in the village. Fair weather roads are only accessible in the foothill villages, road connectivity becomes severely limited in the high rainfall / snowfall periods.

A comparison of the indicators with those of the state, indicate these settlements being relatively under developed with limited infrastructure as compared to the state. The average access to sanitataion for the whole state at 9% compares with the foothill villages, but his higher than the lakeshore and hill village proportions. Similarly, access to road communication for the state ranges from 60.63% to 82.64% which is much higher than the connectivity within areas adjoining wetland and the hills. In particular, the lakeshore villages have been observed to be completely left out of the development process in terms of access to social amenities.

Economic Activities

Economic activities of the communities are directly linked with access to natural resources. Detailed resource trend and access analysis were carried out in 23 villages and are summarized below for assessment of economic activities and is discussed in the present section:

Lakeshore villages

Livelihoods of lakeshore communities are primarily dependent on Lake Resources, including fish and aquatic vegetation. While all the villages to a varying proportion harvest vegetation, 13 of the 31 villages engage in capture fisheries within the lake.

Fisheries: Capture fisheries within Wular is the main occupation of 2,331 households. There are an estimated 2,621 active fishers in Wular, the rest engaged in trade and / or limited value addition processes including salting and drying. Fishing in the lake is done for 6 months during March – June and then from October – December. Higher catches are realized in the peak summer months of May – June, which corresponds with higher water levels and consequently greater lake spread. While the male members are engaged in fishing, women of the family undertake marketing operations. Fish licenses need to be obtained from the Fisheries Department for fishing into the lake. A license for one year is provided for Rs. 100 / license.

Analysis of the resource mapping trends indicates a steep decline in the fish catch over the last fifty years. The total catch as extrapolated from the catch records from the surveyed villages has declined from 10, 544 MT to 1,476 MT. With a three-fold increase in in population of households dependant on fisheries, and decline in overall catch, the per capita catch has gone down by 20 times (Fig 15). The average annual household income from fisheries is therefore only Rs. 22,528, which is hardly sufficient to feed an average family of seven.

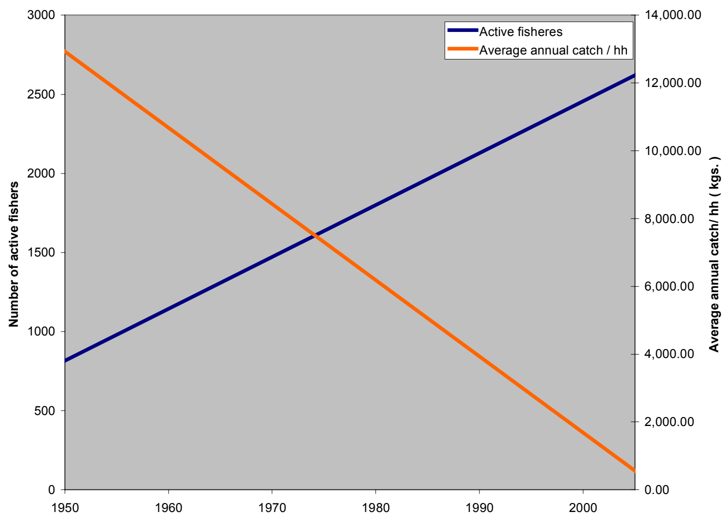


Figure 15: Trends in number of fishers and annual household catch

Economic status of the fisher households is further constrained by lack of access to formal credit mechanism. This has therefore provided an opportunity for a middlemen system, which provide credit on easy terms to the fishermen but undertake a contractual obligation for selling the fish directly to them at prices lower than the market and also pilfering the weighing system.

Lake Vegetation: Lake vegetation provides a significant means for augmenting livelihood base of the lakeshore communities. The key species harvested from the lake for economic purposes are nelumbo (nadru) and trapa (singhara) as food and nymphoids (khur and nar) as fodder. Lake vegetation sustains livelihoods of an estimated 24,150 households forming 29% of the total lakeshore population. Trapa presently is the key commercial crop harvested from the lake.

Analysis of trend data on availability and dependence indicates drastic changes in veegtational resources over the last fifty years. Data collated from the rural appraisal indicated an abundance of vegetation, particularly nelumbo during 1950s, which provided income base to 75 – 80% of the population. However, the availability of nelumbo has decreased by 56% during the last fifty years owing to reduction in lake area, siltation and decline in water quality. On the other hand, the total collection of trapa and fodder has increased by five and three times respectively. Therefore, the communities have gradually switched over from nelumbo to trapa collection, thereby leading to a two fold increase in annual household collection of trapa.

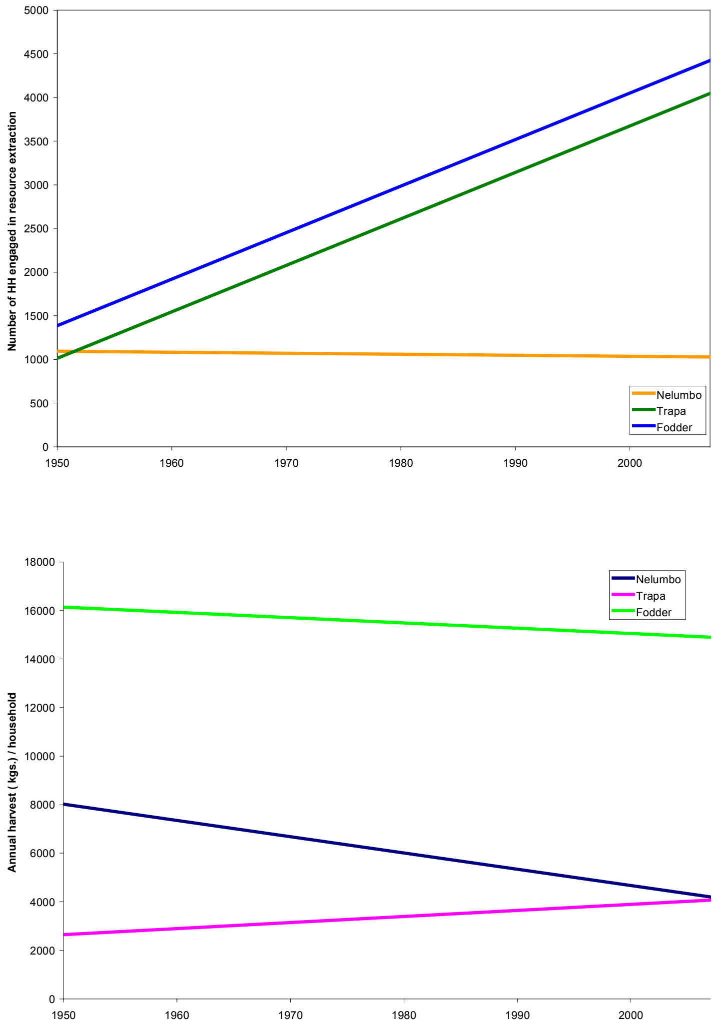


Figure 16: Trends in population dependant and quantity of aquatic vegetation harvested from Wular

Collection of vegetation is primarily regulated by the Revenue Department. Aras for nelumbo are auctioned annually by the Revenue Department. Trapa collection is managed by a separate office of Revenue Department titled Nayab Tahsildar (Malsinghara), Sonawari. Licenses are issued for trapa collection in two phases, a fee of Rs. 25 is charged for three months, i.e. August – October (for immature fruits, locally called *milech gair*) and Rs. 100 for a five months license during November – March (for mature seeds called *kamai gair*). While trapa and fodder collection is carried in 32 lakeshore villages, the activity is concentrated in the northern periphery villages

(Kulhama nadihal, Lankrishipora, Zalwan, Laharwalpora, Aloosa Ghat, Kanibathi, Zurimanz) and within settlements where Jhelum enters Wular (Banyari, Mukhdomyari). The total revenue generated from vegetation of Wular Lake is presented in Table 3.1 :

Table 2.10: Revenue accrued to Government through vegetation of Wular Lake

Vegetation	2002-03	2003-04	2004-05	2005-06	2006-07
Nelumbo	655,000	1,851,000	2,425,000	1,060,000	-Nil (Crop lost due to heavy floods)
Fodder	110,000	181,000	81,000	301,000	280,000
Trapa	80,056	128,320	104,240	125,532	29,508

Based on the annual harvest, it is estimated that incomes from vegetation from Wular contributes annually an average income of Rs. 10 – 13,000, which is critical for livelihood support of the community.

Foothill villages

The foothill communities have a diversified livelihood portfolio. While agriculture and horticulture remain the basic source of income for 43% of the households, business and artisinal crafts are also undertaken by 27% of the population. The rest draws sustenance on dairying and other activities. Several farmers have also raised plantations in the private lands for fuel wood, timber and wood based industries as bats and matchsticks. Availability of irrigation water through canals ensures high productivity. The region also has better road and infrastructural connectivity, and therefore markets are concentrated in this region.

Hill Villages

Communities living in the hills are based on catchment resources and sheep rearing. The primary occupation of the hill communities is collection of firewood and charcoal, which is the main source of energy for the entire valley. Illegal timber felling also provides a rich source of income to the communities. Degradation of the forest resources has led to shrinkage in the resource base of the communities. Several minor forest produce of high economic value [Guchh – used as medicines; Manchren and Ringrish – local tea,; Wupal Hakh, Vulket – used as vegetables] are no longer available within the catchments. Decline in area under certain economically important tree species as Pohu has adversely affected communities engaged in related microenterpise, eg Kangri manufacturing. Availability of firewood and charcoal has also declined by over 10% and 30% respectively in the last five decades. Forests which were the main source of livelihood of 80% of the communities 50 years back can at present support no more than one fourth of the population. Therefore, several households migrate to the valley region to work as agricultural labour in the fields.

Institutional Arrangements

Village Panchayats are the key local self government institutions entrusted with the task of local level planning and management. However, activities of these institutions have been largely limited to political concerns, with little role in development planning within the region. Development projects implemented under Integrated Watershed Development Programme have resorted to formulation of alternate institutions, called

'Village Development Committees' in the World Bank funded Integrated Watershed Development Programmes implemented in the hill catchments. In several villages, user groups (as District Union of Mahigeer wa Singarkash, Dehat Sudhar Committees, Weavers Association) have been formed to cater to the needs of specific groups. Baraderi, or informal elders group play important role in day to day management of village resources and resolution of conflicts. Aukaaf committees are key religious institutions at the local level having significant influence on the village activities.

Impacts of wetland degradation on livelihoods

Poverty

High dependence on natural resources, declining resource base and limited opportunities for occupational diversification have led to high levels of poverty within the communities. Population falling below poverty line around Wular ranges between 41 – 52% as compared to state average of 3.91%.

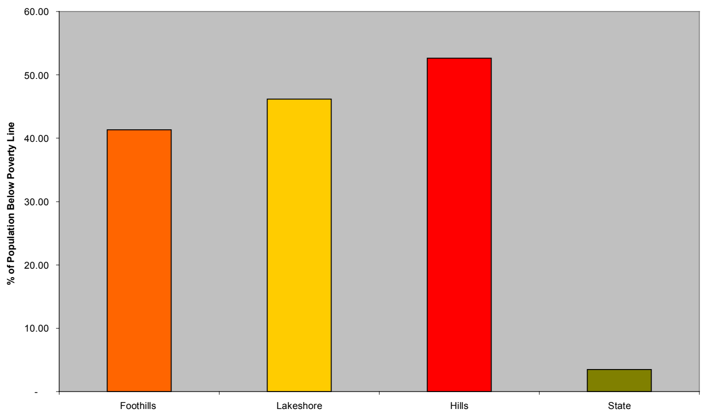


Figure 17: Percentage population living below poverty line in and around Wular

Changes in resource harvesting methods

Declining resources have forced the communities to adopt more exploitative forms of harvesting. This has particularly taken place in the case of fisheries, wherein fishers have resorted to use of nylon nets with lower mesh sizes and long gill nets which drastically affects the regeneration of resources. This has also created conflicts amongst various fisher groups within the lake.

Health hazards

Absence of adequate sanitation and safe drinking water facilities have led to severe health hazards particularly for the lakeshore communities. There is a high incidence of water borne diseases as gastroenteritis, jaundice and diarrhoea. Presently, less than 2% of the households living in the lakeshore villages have access to safe sanitation facilities and 42% use untreated water from Jhelum / Wular for domestic purposes rendering them highly vulnerable to water borne diseases and infections.

Problems in lake transportation

Wular has traditionally been an important mode of communication within villages. However, silting up of large areas and reduction in waterspread has reduced access to and increased travel time for several lakeshore settlements, particularly those living in the eastern periphery of the lake.

The following key issues emerged through the assessment of community profile and resource linkages:

- ***Absence of community participation in resource management***
  Livelihoods of the communities living around Wular is dependant on natural resources. However, they have little participation in management of these resources. The government departments have largely focused on revenue generation through enhancement of resource extraction. The current resource management system is therefore untenable and therefore calls for institutional reorganization with active participation of user groups.

- ***Poverty due to declining resource base and limited opportunities for livelihood diversification***
  There has been a drastic decline in resources both within the lake as well as its catcments leading to decline in incomes and poverty within the communities. There is also limited emphasis on value addition and post harvest management, which present significant opportunities for enhancement of economic returns. Absence of access to economic infrastructure as banking and credit facilities has rendered the communities vulnerable to moneylenders, which lead to lower price recovery pushing the communities into debt trap.

- ***Declining quality of life due to limited access to social infrastructure***
  Lakeshore communities in particular have limited access to social infrastructure, particularly adequate drinking water and sanitation facilities. High incidence of water borne diseases also leads to more frequent loss of working days and morbidity within the communities. This significantly reduces the opportunity for ensuring safer living and better quality of life.

2.3 Developmental Activities and Their Impacts

Jhelum basin is the life line of Kashmir. Ecological and socioeconomic security of the basin is inextricable linked with its rich natural resources including the wetlands. Economic activities of the basin have been traditionally linked with the wetlands. Major settlements emerged along the River Jhelum and wetlands, which were the main water sources. The nutrient rich river sediments supported rich agriculture within the Kashmir valley, the economic hub of the basin. They also sustain livelihoods through supporting tourism and provisioning fish and vegetation and thereby augmenting food security within the basin. The wetlands also acted as natural reservoirs by storing water in high flow periods and augmenting the lean flows, and thereby providing flood protection to the valley population.

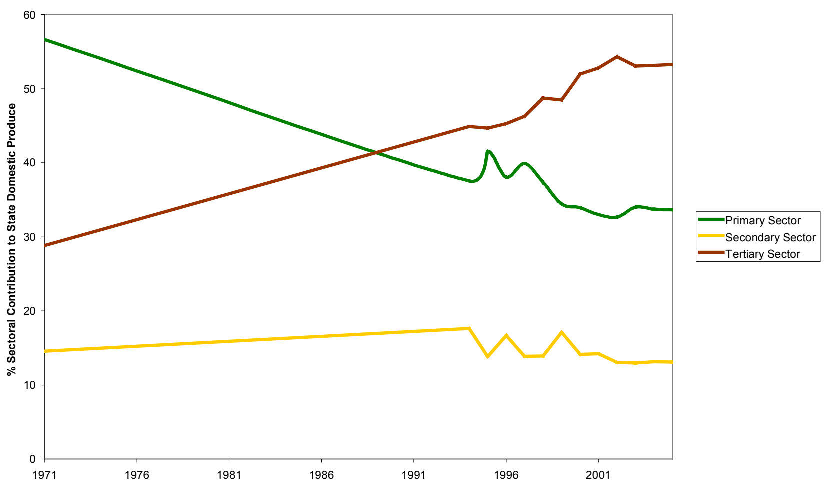


Figure 18: Trends in sectoral contribution of Net State Domestic Product

Developmental activities however completely failed to recognize the immense role of the wetlands within the basin, and thereby led to their large scale conversion, and degradation. Revenue centric approaches led to adoption of strategies aimed short term economic gains but having long term implications on the overall sustainability of the basin. Unsustainable developmental activities within the upstream reaches has created severe downstream changes, threatening the tenability of the overall economy of the basin. Economic activities within the basin have undergone marked changes, with the contribution of primary sector consistently declining and being replaced by a growth in tertiary sector, which is primarily contributed by a growth in nature based tourism (Fig 18). As the returns from agriculture have virtually reached a plateau and are declining, wetlands based livelihoods, including tourism, fishing and allied activities, are the major sectors of growth. Conservation of wetlands thereby is therefore prerequisite for the security and sustainability of the present development pattern. The present section provides a review of the major developmental activities within Jhelum Basin and their impacts on wetlands to provide a basis for management planning.

- *Water resources development*

  Major interventions under water resources development have aimed at flood protection within upstream reaches of basin. As most of settlements within the Kashmir Valley were developed on the floodplains of River Jhelum, they were under a continuous threat of inundation in periods of high flow. Wular Lake, which acted as the flood absorbing basin of the entire valley was the major focus of the flood mitigation interventions and therefore a series of interventions were planned to reduce the lake levels and thereby enhance its floodwater storing capacity (Refer Box : Wular Lake Reclamation – A historical perspective). Dredging was undertaken in the lower reaches of River Jhelum (Sopore – Baramulla) to enhance drainability and lower flooding risk in the major settlements like Srinagar. While the river established its natural regimes within the next four – five decades, the Department of Irrigation and Flood Control undertook dredging of river bed sediment at Pohru for nearly 15 years to address to the effect of heavy siltation caused by the river. Construction of an outfall channel, involving widening and deepening of the downstream reaches was also undertaken as a part of Wular Barrage Project in early 80s. Apart from these large scale interventions, small time and mining is being continually undertaken by the adjoining villages for construction purposes.

  The second major intervention for flood mitigation involved construction of series of embankments for protection of agricultural lands reclaimed from the marshes. Of particular significance was the construction of three embankments, termed as lines of defence, during 1957 – 76 to protect the agricultural lands from flooding from Wular Lake. The present embankment, with height at 1580 feet amsl hydrologically isolates the marshes from the main lake.

  Water resources development has drastically altered the overall hydrological regimes of the wetland. Enhancing outflows has reduced the overall residence time of flows within the wetland critically impairing the hydrological regulation function played by Wular. Construction of embankments and consequent fragmentation of marshes has accentuated sedimentation into Wular and gradual contraction of marshes. This has also enhanced waterlogging on the northern periphery leading to damages to crops and habitation.

- *Agriculture development*

  Rapid growth of population and the need to expand agriculture to support livelihoods of a primarily agrarian economy has been one of the major reasons for conversion of wetlands and associated marshy areas in and around Wular. The first major plan for reclamation of marshes for agriculture development was formulated in 1949 identifying 13,540 ha of area for reclamation through construction of embankments. Intensification of agriculture activities has also promoted the state government to install 7 major dewatering pumps which divert river Jhelum flows for supporting irrigation in these areas and also drain water from these areas when required. Agriculture within these marshes is also fertilizer intensive, runoff of which leads to nutrient enrichment of water and consequent degradation of its quality.

- ***Fuel Wood Plantation***

The forests of Jhelum Basin had been under tremendous pressure for firewood, due to cold climate. Measures were undertaken during early nineties to provide firewood through plantations in Kashmir valley in the available marshy and barren areas. Through a series of experimental plots, willow was found to be most suitable in the marshes and Rubinia on the drier sites. Systematic plantation within the marshes associated with Wular was initiated in 1916. By 1924, the Ningli plantations were established and transferred under the administrative control of the then Sindh Forest Division and subsequently expanded continuously under the Plantation Division of Forest Department, Government of Jammu and Kashmir. However, the local communities, anticipating an impact on the wetland resources which were largely concentrated in the highly productive marshes, protested against their conversion into plantations.

The State Department of Rakhs and Farms, constituted to manage and administer the marshes reclaimed for agricultural purposes further undertook the willow plantation in a major way after the 1950s. The Department promoted plantations in shallower zones of the marshes and water bodies primarily to provide fuelwood and in the later stages to support match and cricket bats manufacturing industries. In the later stages, social forestry division undertook willow plantations within the Wular Lake during 1982 – 2002 under the state government funded scheme on wasteland plantations, covering an area of 0.12 square kilometres. Village Panchayats , encouraged by the immense revenue potential of the willows also undertook plantations in 0.55 square kilometre area.

Following the Jammu and Kashmir State High Court Orders dated 10 October 2006 instructing the State Government to demarcate the territorial limits of the Wular and Manasbal Lakes, an assessment of the area under willow plantation in and around the lake was made by the Revenue Department in three tehsils of Sonawari, Bandipora and Sopore. The survey indicated an area of 34.88 sq km presently under willow plantation in 30 peripheral villages. Of this, the state government departments of Forests, Rakhs and Farms and Social Forestry account for 86% (30.29 sq km) of the willow area.

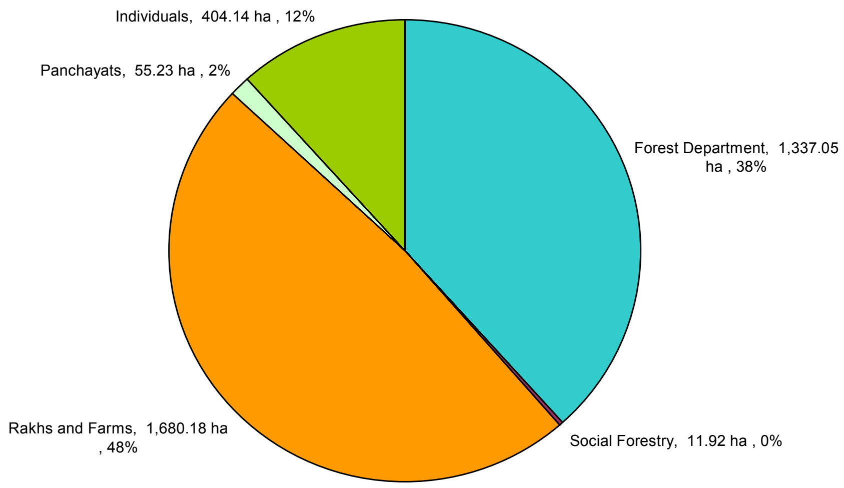


Figure 19:Ownership of willow plantations within Wular Lake

Raising of willow plantation has severely altered the hydrological processes of the wetland. These plantations act as barriers to silt laden waters of the river Jhelum forcing it to discharge the sediment load into the lake and thereby inducing loss of water holding capacity. A spatial analysis of the sedimentation pattern within the wetland clearly indicates rapid siltation along the fringes of the plantation areas. The detritus from the plantations have also accelerated nutrient enrichment of the waterbody leading to water quality deterioration.

- *Urbanization*

The entire Kashmir Valley has undergone a rapid urbanization, with the overall population increasing more than five times during the last century. The number of towns has also doubled from 17 in 1971 to 34 in 2001. Despite an increase in population, there has been no upgradation of the civic infrastructure leading to an increasingly higher proportion of wastes being dumped into the waterbodies.

Rapid increase in pollution has critically affected the waste assimilation capacity of the waterbodies. This is reflected the most in Wular Lake, which due to its geomorphological setting becomes a recipient of entire waste of the basin. Changes in flow regimes, particularly during lean seasons aggravates this problem leading to severe health hazards for the communities living in and around the wetland.

- *Hydropower Development*

Hydropower is the key source of energy for the entire Jhelum basin. The valley suffers a serious deficit of power presently, with the peak power availability being less than one tenth of the demand. Power development in the basin is also regulated through the Indus Water treaty that prevents creating storages on the river and its tributaries for any developmental purposes, including hydropower and irrigation. Therefore, run of the river schemes are the only source of hydropower generation in the basin, which are augmented by gas turbine based schemes for providing power during the winter months. The total installed capacity of the basin is 904.6 MW, 81% of which is accounted for by hydropower. It is also worthwhile to note, that of the total installed hydropower capacity, 80% is accounted for by the two projects on Jhelum, i.e. Uri I and Lower Jhelum Projects.

However changes in the hydrological regimes, particularly lowering of flows during the lean seasons have tremendously affected the power generation capacity of the state. The two downstream projects, i.e. Lower Jhelum and Uri have water requirement of 7,000 and 8,000 cusecs respectively. Lowering of discharges in the lean seasons, particularly during late October to February when the discharge reduces to 2,000 cusecs forces closure of 75% installed capacity of these projects and consequent huge economic loss.

Maintenance of the natural flow regimes is critical to hydropower generation in the basin. However, progressive destruction of Wular and its associated marshes and degradation of catchments have induced quick drainability and higher low flow periods leading to higher standby periods. Conservation of Wular and its catchments is critical to sustainable generation of hydropower in the Kashmir Valley.

Impacts of developmental activities on wetlands

- **Shrinkage of wetland area:** Several wetland of the basin have been converted for alternate purposes. Wetlands complex of Batmaloo – Bemina have been reclaimed for development of housing complexes. A large chunk of marshes along Bad Nambal, Rakh Ajas, Malgom, Haigam, and Nawgam have been reclaimed for agricultural purposes. Within Wular Lake alone, 71.55 sq km has been converted for willow plantation and agriculture development.

- **Fragmentation of wetland regimes:** The connectivity of wetland complexes within the basin is being progressively reduced primarily due to construction of embankments and other structures, siltation of channels and other factors. This has accelrrated the process of shrinkage of wetlands. For example, the large wetland marshes complex adjoining Wular extending to more than 60 sq km in 1911 has been reduced to less than 14 sq km due to construction of flood protection embankments and conversion for agriculture.

- **Changes in hydrological regimes**: The hydrological regimes of the wetlands have been severely altered due to interventions to enhance the outflows and reduce water levels of River Jhelum for flood protection, and loss of natural water holding capacity in the upstream reaches of the basin through conversion of marshes and degradation of catchments. Hydrological assessments for Wular Lake indicate shifts in water storage period from peak summer months to lean seasons, thereby reduced capacity to regulate flow regimes. This has affected the overall water availability within the basin, leading to more frequent occurrence of droughts and floods.

- **Decline in water quality:** The water quality of the wetlands has significantly deteriorated due to uncontrolled dumping of sewage and solid waste by the adjoining settlements. The situation is most glaringly reflected in Wular Lake , which due to its physiographic settling becomes recipient of all wastes dumped into the river upstream, and turns into a cesspool of wastewater leading to high incidence of water borne diseases in the peripheral communities and reduction in biodiversity.

- **Loss of biodiversity:** Alteration of hydrological regimes has severely altered biodiversity of the wetlands. Several native fish species have been reported to be declining due to deteriorating water quality. The waterbird population has also declined due to declining food availability and shrinkage in waterspread area.

- **Poverty in wetland dependant communities:** Wetland resources, particularly fish and economically important food and fodder species form the base of livelihoods of the 31 villages located around Wular. While the peripheral settlements have undergone a rapid growth in population, there has also been a simultaneous decline in resources. Based on the rapid appraisals carried in 8 villages, the most affected resources are the fish and nadroo, which have recorded 87% and 46% decline over the last fifty years. With little opportunities for occupational diversification, this loss of resources has induced high levels of poverty within these communities. With rapid degradation of lake water quality and absence of adequate sanitation and safe drinking water facilities, the quality of life of the communities has rapidly eroded.

Reclamation of Wular : A Historical Perspective

Kashmir valley is essentially a floodplain of River Jhelum and its tributaries located in its upstream areas, a large part of the basin being in Pakistan. Wular and its associated vast swamps played a critical role in maintaining the uniformity of lows in River Jhelum. During the peak summer months with high flows, the swamps would provided storage to the excess flows and thereby prevented lager valley areas from flooding. During lean flow seasons, particularly in the dry months of November to March, the marshes released the stored water, thereby maintaining uniformity of flows and moisture regimes within the valley. The role of wetlands in best described by Lieutenant Colonel A. J. de Lotbiniere, State Engineer, Kashmir Darbar, in a memo dated 6th May 1912 in the following words:

" Kashmir acted as a great sponge at the head of Jhelum which held up the floodwaters and gradually oozed dry during the winter months"

Wular and its associated marshes were identified as important capital assets during the kinship of Maharaja of Kashmir. Their importance was significantly recognized as a) flood reservoir providing protection to life and property in upstream reaches of Srinagar; b) revenue generation through sale of water to downstream Punjab and c) revenue generation through creation of additional acreage through conversion of marshes for agriculture development.

The first early intervention into hydrological regimes of River Jhelum took place in December 1902 with the primary objective of:

- Mitigation of floods in Srinagar and downstream settlements through improving drainage options leading to reduced retention of flood flows in the valley

- Increasing area under agriculture through reclamation of marshes, which were considered to be unproductive wastelands
- Augmenting water availability for irrigation to Punjab State of undivided India for triple canal project contemplated to irrigate Jech, Rechna, and Bari Doab areas. The third objective was envisaged to be achieved by storing of water in Wular Lake through construction of a barrage.

Manipulation of water levels in river and wetland system was therefore identified as central means to achieve the aforementioned objectives. The following activities were envisaged under the Maharaja's Action Plan:

- Dredging of river bed from Srinagar to Wular Lake and thereafter from Sopore to below Baramulla enabling lowering of water levels by 8 – 10 feet leading to flood mitigation in upstream areas
- Providing of narrow and deep drainage cuts from Baranagara Swamp into River Jhelum above Baramulla to drain the pestilential marshes leading to availability of 1,00,000 acres of agricultural land at southern shores of Wular
- Construction of light wooden barrages wherever necessary to ensure river navigation
- Construction of a barrage at the Lake outfall channel for enhancing lake storage for winter irrigation needs of Punjab

The aforementioned activities were expected to significantly enhance the revenue base of the kinship. A review of the proposed plans indicates conflicting objectives of creating storages in Wular for irrigation development on one hand, and decreasing river and wetland levels on the other hand to mitigate floods and drain marshes. This contradiction, as would be expected, resulted in protracted correspondence and deliberation on the scheme of things in which the joint venture economics of the project also became controversial. The matter, therefore, was referred to Government of India which categorically ruled out the propositions of construction of Wular Barrage. The final decision of Government of India was conveyed to Darbar in Residency letter no. 3899 dated 15.12.1905 stating that the Darbar might consider:

"storage scheme as definitely abandoned and may therefore proceed with their over scheme of reclaiming marsh and waterlogged lands in the Kashmir Valley"

Accordingly, dredging works were commenced by the Darbar in the reach from Sopore to Baramulla. During these operations, it was also realized that lowering water levels in Jhelum would require cutting through the rocky boulder below and boulder obstructions below Baramulla. Dredging works led to decline in lake levels at Sopore by atleast three feet. This was accomplished along with the dredging operations, and the results of the change in the river regime started showing in 1912 – 13 onwards when the drainability started increasing with lowering of the lake levels. The lean seasons flows were reportedly declined by 1,000 – 1,500 cusecs.

Reduction of lean flows of river Jhelum also led to decrease in winter water availability in Punjab, and therefore a reconsideration of the above project was warranted by the Inspector General of Irrigation in India, Mr. M. Nathersole, as reflected in the inspection note of the Kashmir Drainage Works of later dated 10 July 1912. The said note recommended the need of artificially regulating Wular Lake at its outfall through a barrage. To be constructed below Sopore and above Pohru River with its sill level at elevation 5150 feet and top up gates at 5161 feet to afford storage of 1500 cusecs for 105 days. This was to compensate the natural storage of the lake lost due to dredging.

The changes in river Jhelum flows , i.e. more flows in Summer and less in winter was also noted with concern as an impact of dredging operations by the Darbar engineers. Measures were therefore sought to regulate the flow regimes to make irrigation water available to Punjab state during the winter seasons. However, construction of barrage also implied inundation of the areas which were reclaimed for agriculture by drainage of the marshes. Therefore construction of embankments around the reclaimed land to a specific height less than the maximum flood levels ever recorded was proposed along with sluice gates which would be operated commensurate with storage of water in Wular during summer months. It was envisaged that the sluice gates would be opened after harvest to enable flooding of the reclaimed lands and thereby an increase in the storage area during high flows of summer months. Winter crop of mustard on the reclaimed land was thereby assumed to be sacrificed for this flood mitigation benefits. A cost sharing formula was worked out for the project keeping all the aspects in view, which was again controversial and deterred the reconsideration of barrage.

After reconsideration, the Durbar realized that revenue maximization through draining of marshes and achieving flood mitigation could not be achieved simultaneously. A revenue sharing formula was therefore worked out for compensation for hydrological regulation. The debate on revenue sharing an mutual interests of Darbar authorities threw up data regarding the benefits and losses of the project which throws a lot of information upon the aspects of values of Wular from the considerations of pasturage, gathering of water nuts and reclamation of culturable areas for agriculture. The debate conclusively stated that in 1919 that completion of dredging works in 1912 and maintained since have *"considerably helped to keep the lands on the left banks of River Jhelum and are now surrounded by embankments dry. These areas used to be flooded at time of fairly high flood and so helped to keep the level of the lake down. But at present, with raised embankments to keep out moderate floods, the water which used to find its way onto these lands now passes direct into the lake and so tends to thereby neutralize the effect of dredging. The greater the area of land reclaimed, the greater will be this tendency. The effect of reclaiming the whole of Baranagra swamps area on the height of water in the lake has never been calculated but this must be great.*" (Remarks contained in the note on Wular Lake storage by the Pubic Works Minister, 25 June 1919).

A structural shift in approach to reclamation of marshes is reflected in the above note. The note recommends reclamation through natural siltation by the flood waters, in moderately bunded areas in segmetized compartmetalization, rather than through embankments and drainage. Physically draining out the waters through nullahs whenever lake levels would permit same. This opinion was reported to be based on experiences in Italy and Egypt.A model of distribution of reclaimed land and lease of same to the beneficiaries was also worked out where considerations were given to resource dependence and lake linkages.

After much deliberation, and apprehensions of loss of reclaimed agricultural areas, assets and socioeconomic implications, the Wular Barrage project was disapproved by Maharaja Inder Mahinder in 1921. However, in the time decision making and beyond the time of this decision , the natural tendency of local farmers to protect their agricultural land from floods resulted in raising up of the moderate level bunds over a period of time and the prospects of reclamation through holding up of silt laden waters in encompassed areas kept on fading.

Water resources development in the post independence period was influenced largely by the Grow More Food campaign. In July 1949, reclamation of lands in Kashmir by bund making, drainage of marshy lands, irrigation and levelling was envisaged under the Grow More Food Campaign, which was duly considered by the state government. Marshes, locally called rakhs / nambals , came under a fresh introspection as potential areas for reclamation. The areas identified for reclamation were as under:

a) southern fringe of Wular Lake below Baniyari, Maqdoomyaari and Shahgund and the islands formed by river Jhelum at its delta
b) part of Anchar lake known as Koojar Rakh
c) areas as Sultanporich Rakh in which water Sukhnag, Ferozepur Nallh and floodflow of sill channel is received
d) Part of Hokarsar NAmbal and Rakhe Harath
e) Gund Akhsa forming part of Batmaloo Nambal

The engineering authorities after exhaustive survey and study of revenue records gave the extent of land that could be reclaimed in the above areas and the money that would be required subject to the following general observation:

- Nambals play an important role in hydrodynamics of the Kashmir valley by acting as storages of flood waters. This was critical to security of life and property of the entire valley as the river channel above as well as below Srinagar did not have sufficient capacity to carry big flood discharges.
- Nambals besides acting as flood storages, regulated the flow regimes by discharging in the lean flow seasons. This function of the Nambals *was reported to be far higher than it could be as arable land.*

However, striking a compromise between the need to support additional food production, the committee recommended reclamation of the nambals around Wular , with the following precondition:

- Regulation of height of the embankments. It was suggested the top levels of the embankments would be such so as to permit inundation by high floods, which could revitalize the soil through deposition of fertile soil as well as contain floods of high magnitude.
- Providing control inlets and outlets within the embankments for proper and quick drainage.

Of the areas recommended for reclamation, certain portions within the periphery of Wular waterline (adjoining Gurura) were included. , specially on periphery of Wular Lake included part of the areas which were within the waterline of the lake , especially near Gurura.

Further implementation of recommendation made the state Government to adopt different alignments of flood protection levies towards the southern shore of Wular Lake. The first came to be adopted in mid fifties which is now known was first line of defence, in which the moderate bunds were raised and strengthened. The floods of 1957 – 59 led to construction of second line of defence in mid sixties. The third line of defence was constructed in 1975 – 76, which marks the present lake boundary. Subsequently the embankment heights were also increased to above 1580 meters, in contravention to the recommendations made by the committee. This therefore led to fragmentation and hydraulic isolation of the marshes from the wetlands. Later 14 pumping stations were also constructed to drain the nambals

2.4 Institutional Arrangement

The State Department of Wildlife Protection is the nodal agency responsible for conservation and management of the Wular Lake. Several State Government Departments including forests, horticulture, soil conservation, social forestry, ecology environment and remote sensing, science and technology, command area development, agriculture, fisheries, public health engineering, rural development, khadi and village industries, tourism, and revenue are involved in regulation and developmental activities. The main activities of these organizations relate to implementation of various programmes for land and water management, socio-economic development and conservation of natural resources.

The earlier focus on Wular Lake was on recreation which over a period of time switched over mainly to revenue generation. Realizing the importance of the wetland for water chestnut cultivation cultivation, Mahla Singhara was established under Revenue Department for regulation and sale of water chestnut, and fodder by auctioning to the contractors. Forest Department, Social Forestry, and Panchayats were mainly involved to supply fuel wood by plantation of willow trees in the lake area. The fisheries department has a stake in the fisheries development which is a major fisheries resources in the state. Irrigation and flood control is involved in providing has developed several schemes for supply of water for irrigation and other human uses. The watershed of Rural Development has several schemes for livelihood improvement of communities in and around the lake area.

Lately, there has been concern about environmental improvement and overall sustainable management of lake ecosystem. Department of Forests and Remote Sensing has undertaken several activities for lake conservation which included catchment conservation and some limited environmental management in the lake area. However, there has been little coordination among the various departments for conservation and management of the wetland. Realizing this recently state government has constituted Manasbal and Wular Development Authority (MWDA) under the aegis of Tourism Department. The MWDA has identified 21 action points for development of Wular and Manasbal Lakes for which no rationale has been provided and at present all these activities seem to be disjointed and lacking long term objectives and vision.

2.5 Current Management Practices and Gaps

Wular Lake was identified as a Wetland of National Importance in 1986 under the National Wetland Programme of Ministry of Environment and Forests, Government of India for intensive conservation and management purposes. A committee was constituted under the chairmanship of the Chief Secretary for formulation of management action plan, with representatives of the concerned state government department including a member for the Ministry of Environment and Forests.

Catchment conservation was identified as priority activity by the committee and therefore an ecological restoration plan for Erin watershed was prepared in 1988 by the Directorate of Ecology and Environment. Activities for treatment of degraded micro watersheds of Erin catchment was supported through the MoEF, which included afforestation , aided regeneration, pasture development and limited soil conservation works , viz contour bunding, bench terracing, stream bank protection and vegetative contour bunding. Limited activities for education and awareness generation were also supported under this action plan. Subsequently, limited funding was provided to continue the various activities, mostly focused on catchment conservation. The focus of all the activities has been on conservation of direct catchments with limited activities in the lake including manual deweeding, desilting in the peripheral areas and monitoring of lake water quality.

The State Department of Environment and Remote Sensing formulated an eco restoration plan for Wular Lake for the period covering 2005 – 15 at an overall cost of Rs. 201.97 crore. The plan envisaged six objectives, including lake protection, land use management, flood control, provision of water for hydropower projects and navigation, control of pollution, and socio economic development of communities living in and around the wetland. However, detailed analysis was provided only for the catchment conservation component, with allocation of 53% of the implementation budget. Remote sensing based delineation of the catchment at sub watershed level, and identification of erosion prone areas based on assessment of land use, aspect and slope were used as basis for planning.

Besides the Department of Environment and Remote Sensing, different schemes are also being implemented, which directly or indirectly influence various features of Wular Lake. The following schemes are outlined in the District Annual Plan for Baramulla for 2006 – 2007:

- **Catchment Conservation:** Rehabilitation of 163 ha of degraded forests through plantation and small scale engineering works. An additional area of 50 ha is proposed to be undertaken through the social forestry division at Bandipora. The department also aims to reduce pressure on forests through development of village woodlots in 29 ha at Pehlipora and plantation within marshes in 17 ha area at Shahgund

- **Irrigation development** through implementation and maintenance of lift Irrigation schemes and upgradation of Tarzoo Weir. Within the Sonawari area, it is envisaged to support lift irrigation schemes at Churthangoo, Veerkhan, Purnibal, Sadarkote, Babdud, Paribal, Garikhan and Baniyari. Dewatering scheme at Wasikhan and Gund Boon have also been planned to support agriculture within the reclaimed marshes. The schemes are being implemented through the Irrigation and Flood Control Department

- **Maintenance of water supply schemes** for 17 villages in Bandipora and urban drainage schemes for Bandipora, Sopore, Baramulla and Hajin through the Urban Development and Public Health Engineering Department

- **Conservation of Protected Area Networks** (Ajas, Hokersar, Shalbug, Haigam, Meergund) through maintenance of species composition, enhancing food availability for flagship species, and protection by the State Wildlife Department

- **Fisheries development** construction of Mahseer fish farm at Boniyar Uri; trout hatcheries at Wanpora (Gurez) and Shokbaba (Bandipora) and restocking of trout streams with 1 lakh seeds.

An analysis of the current management practices reveals the following gaps:

- **Sectoral approaches to development planning:** Presently the schemes in and around Wular Lake are being implemented on an ad hoc basis, without assessment of interlinkages within a definite planning framework. Thus, one hand, the state government is investing into conservation of Wular Lake, schemes for its conversion into plantation and agricultural land is also being proposed through the social forestry and irrigation and flood control divisions.

- **Revenue centric approaches to resource management:** There is an absence of any plan for regeneration of lake resources which sustain livelihoods of local communities. The government on the other hand charges revenue for harvest of all of these resources. The revenue centric approaches are bound to lead to eventual decline of resources.

- **Inadequate targets:** The schemes are mere financial allocation, without any baseline assessment of issues. For example, mere construction of a hatchery is envisaged to lead to enhancement of fisheries. Targets for forestry similarly are not based on achieving a time bound regeneration of forest areas. This sub critical investment is not expected to yield any tangible results in terms of conservation and / or development outcomes.

- **Ineffective institutional arrangements:** No road map has been laid out for participation of local communities in the planning and management of action programmes. In absence of this , any realistic targeting and ownership of the interventions is difficult to achieve , thereby jeopardizing the overall purpose of implementation.

2.6 Key Issues

Based on assessment of hydrological regimes, developmental activities and their impacts on wetlands and assessment of review of management practices under implementation through various agencies, the following management issues have been identified to address conservation and management of Wular Lake:

- **Absence of policies and strategies to guide coordinated actions within River Jhelum Basin**

  The functions and processes of Wular Lake are inextricably linked with the hydrological regimes of River Jhelum, which accounts for over 80% of the overall inflows into the system. Maintenance of natural flow regimes, both in terms of quantity and quality is critical to conservation and management of Wular Lake. However, there is a marked absence of polices and strategies to guide coordinated action at river basin level. Adoption of sectoral strategies without assessing the overall impacts on the wetlands has led to upstream downstream conflicts thereby threatening ecological and economic security of the whole region. Loss of water absorption capacity due to degradation of catchments, destruction of marshes and changes in land use (creation of plantations and expansion of agriculture) has enhanced the risk of flooding as well droughts in the entire basin. Absence of effective waste management in the upstream areas of the basin has converted entire Wular Lake into a cess pool of wastes creating severe health hazards for the communities living in and around the wetland. Regulation of river in the downstream reaches has effected migration of several economically important fish species, particularly mahaseer. Changes in hydrological regimes have reduced the overall capacity of hydropower generation to support economic development, a large proportion of which is supported through the concentration of population and economic opportunities in the upstream reaches of the basin. In the current context, effective conservation and management of Wular Lake is implausible unless measures are undertaken to coordinate actions at the river basin level.

- **Values and functions of Wular and associated wetlands not integrated into developmental planning**

  Wular and its associated wetlands through their natural functioning form the basis of various developmental activities. However, developmental planning has failed to take into cognizance the role played by these systems and therefore adopted measures for short term developmental gain at the cost of sustainability of the developmental process. Wular has long been viewed as a commodity supporting revenue generation, and has therefore been the focus of conversion and degradation, without any concomitant measures for its conservation. The grow more food programme under which conversion of large area under marshes into agricultural land were undertaken led to impairment of the hydrological regimes regulation capacity of marshes , contributing to increase in frequency of droughts and floods. Similarly expansion of settlements in the basin without adequate sewerage management systems have led to the wetlands being used as sink for wastewater leading to water quality deterioration and loss of resources.

  The lack of basic understanding of the nature of wetland ecosystem has led to overall loss of benefits accrued from the wetland through its natural processes and functions. As a consequence of this problems of water quality deterioration, decline in fish productivity and overall loss of aesthetic appeal are quite apparent. An innovative approach needs to be adopted for developmental planning integrating values and functions of the wetland. Such an approach would help to mitigate floods, regenerate water quality, enhance resource base and improve overall quality of life of the marginalized communities.

- **Water allocation biased towards human uses ignoring ecological aspects**

  The entire focus of water management in the Jhelum basin is on human uses, particularly irrigation and hydropower development, ignoring water allocation for maintenance of biodiversity and overall integrity of the wetlands. Water is critical to the maintenance of biodiversity and overall wetland ecosystem processes and functions. Though the Indus water treaty has prevented creation of any large water storage structures on the upstream reaches of the River Jhelum, expansion of developmental activities, would gradually crowd out the water availability for maintenance of ecosystem functions. A balanced approach to allocate water for human uses and ecological requirements is critical to sustainable management of wetland.

- **Lack of baseline information for planning and decision making**

  The current information on Wular Lake is fragmentary and of little use for the practical management of the ecosystem. A few scientific studies carried out are more of academic interests and no attempt has been made to systematically analyze the data for practical implementation. The data collected by various organizations has been for short term objectives and with limited scope. Overall the information collected is grossly inadequate and has not been critically assessed and linked with the defined objectives. There is an urgent need to build up the strong database on ecological, economic and social aspects to develop basis for sustainable resource management.

- **Marginalization of wetland dependant communities**

  The communities depending upon wetland resources have been seriously effected by the degradation of Wular Lake. These communities entirely dependent upon the lake resources such as fish, fodder, fuel and other products of the lake which has drastically declined thereby effecting the livelihoods. The developmental processes adopting structural approaches to poverty reduction has not benefited these communities in absence of resource recovery policy, the wetland dependent communities have been economically marginalized and live under abject poverty.

- **Absence of effective institutional mechanism for coordination and implementation**

  Lack of effective institutional mechanism to coordinate the activities of various state government departments for conservation and development of Wular Lake and its catchments is the major factor for degradation of the lake environment. Although several agencies are involved in implementation of sectoral activities for socio-economic development but often they lead to impacts on regenerating capacity of the lake ecosystem. Further conflicting interests of the stakeholders departments and lack of involvement of local communities in the planning and implementation have lead to intersectoral conflicts and loss of lake resources supporting livelihoods.