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River Jhelum Ecosystem In Kashmir Valley: Valuation, Degradation And Sustainability Issues

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***Abstract:** Despite numerous ecosystem services/goods, river Jhelum of Kashmir valley has been a victim of continued negligence on the part of authorities and stake holders. The results revealed that river Jhelum provides numerous eco system goods and services that sum up to handsome amount. The valuation of use and non-use values of river Jhelum indicated that water withdrawals for agriculture contributed about half of its total use value, followed by hydel power generation (21%), sand extraction (14%) and houseboat services (12%). Including the minor contributions by fishing, laundry services and water transportation. The total use value of the river was estimated at Rs. 13356 million. Besides, this eco system has non use values which were captured by employing, multiple responses from stake holders. The contingent evaluation of this ecosystem gave an idea about willingness to pay for its restoration, despite its various values, there are growing concerns about its deterioration. Being virtually the dump of sewage discharge from the towns it flows through, the physical and chemical properties of the river water and its associated water bodies have deteriorated. Changing hydrological regimes reveals that since 1980, the river discharge has declined significantly from about 1/4th in first quarter of the year to about 2/3rd in third quarter. Also, the peak flow period was observed to extend from just three months in 1980s to seven months in 2000.Stakeholders were found well acquainted with the ecological and economical values of the river. However, the deteriorating river health is their concern, and seek the restoration of its natural glory for the sake of ensuring continued flow of its services .On the basis of major findings this study suggested policy options for its restoration and emphasizes an integrated ecological approach linking the economic aspects of its changing ecosystem with ecological aspects for its sustainability.*

I. INTRODUCTION

An ecosystem is a dynamic complex of plants, animals, microorganisms and their nonliving environment, of which people are an integral part (UNEP, 2009a). Its components are linked as a functional unit, and the linkage is inseparable as they control their mutual health and vitality. Of all the components, however, water is arguably the most important, as this is driving critical processes and can be regarded as the life-blood of ecosystem functioning. This is an essence for all life forms, and provides us drinking water, sanitation, food and fish, industrial resources, energy, transportation and natural aesthetic amenities, all of which have an increasing demand amid growing population.

Water assumes a much significant role in addressing the priority MDGs of reducing hunger and poverty as it provides food, both directly in its natural state and indirectly by nourishing our landscapes. Despite this, water is one of the main factors limiting future food production particularly in the poorest areas of the world where timely availability and access to water is a problem (UNEP, 2011). The problem is further aggravated as the projections for water availability and demand are alarming. The major manifestation of this problem would be the dried-up and polluted rivers, lakes and groundwater around us. More than 50 per cent of wetlands for example have been lost during the last century (IUCN, 2000). This deterioration of natural resources is a potential threat to the existence of mankind in future which is attributable more to humans itself.

The scenario of water systems, however, may differ widely across different locations/ regions. The Himalayas may have yet more different scenario of this natural resource owing to its natural setting. Water, either in glacial form or in springs/ river form reflects the nature's ultimate beauty in Kashmir. Kashmir valley is an adventurous destination of J&K state. Apart from the glaciated and pine forest lakes in upper altitude of Kashmir, almost all lakes and wetlands downstream are connected to river Jhelum, and are located along its entire course from its origin to its exit.

River Jhelum assumes a great significance in the socio-economic development of Kashmir valley. Apart from irrigating the agricultural fields, the river has an enormous (hydro) power generating potential. Drinking water, drainage, water transport and sand extraction are the other common use values of this river benefiting directly the inhabitants of the Jhelum basin. However, like everywhere, this priced resource has been overexploited and has been a victim of humankind. The uncontrolled discharge of solid, liquid and other wastes from the settlements in its surroundings, and heavy withdrawals for agriculture and the use of chemicals in its catchment has deteriorated the water quality and general ecology of river Jhelum. Apart from the deforestation in the upstream catchments, construction of hydraulic structures and other such anthropogenic activities have also led to the soil erosion and even the loss of critical habitats. This kind of development is ecologically and economically undesirable and demands immediate restoration plans. Such plans, however, require a research based inputs regarding the ecological and economic aspects of restoration and/or conservation.

II. REVIEW OF POLICY AND RESEARCH ISSUES

Human manipulations in nature have become so exploitative that all ecosystems on this planet have virtually been altered to some extent. Trying to quantify these changes, the Millennium Ecosystem Assessment reports revealed that 60 per cent of the ecosystem services accessed by humans are on decline, and the main drivers being anthropogenic in nature (MA, 2003). Many of these global scale changes in ecosystem are feared to have distressing long-term implications (MA, 2005).

Natural Water resources are considered as the bloodstream of the biosphere. Besides supply of freshwater, this hosts a wealth of biodiversity and account for about 45 per cent of the total value of all global ecosystem services, (MA, 2005a). Fisheries and aquaculture, for instance, are very important sources of food from wetland systems (UNEP, 2010), which have been observed to be much more productive than cropland (van der Ploeg *et al*., 2010; TEEB, 2010; Batker *et al*., 2010). Similarly, in parts of Tanzania, these water/agro ecosystems were found to contribute up to 98 percent of the household food intake (McCartney and van Koppen 2004; McCartney *et al*., 2010). The rationale is that the human-ecosystem linkage regarding water resources is fundamental and irrevocable (UNEP, 2009), besides maintaining critical processes (Costanza *et al*., 1997; Falkenmark, 2003).

Water bodies as sensitive barometers of human activities on their surrounding watersheds, (ILEC, 2005), as any unsustainable use of ecosystems is readily visible where water resources are concerned (UNEP, 2009). Experts insist that such changes lead to the disturbances in the physical, chemical and biological properties of water bodies (Alegria *et al*. 2006; Tuan *et al*., 2009; Dong-Oh Cho, 2007; Gregory *et al*., 2002; UNEP, 2006) which in turn result in degraded ecosystem and a loss of biodiversity associated with goods and services. Since the disturbances, of anthropogenic nature, in natural ecosystems have intensified since past century, more than 50 percent of wetlands have been reported to be lost during this period (IUCN, 2000). If the same practices continue, it could result in inevitable degradation or complete destruction of the terrestrial freshwater and coastal ecosystems that are vital to life itself.

Among the various form of water resources, natural rivers are dynamic and physically/ biologically complex (Tockner and Stanford, 2002). Being the focus for human settlement, river waters are perhaps the most impacted ecosystem on the planet (Malmqvist, 2002); possibly because they continue to be heavily exploited for meeting societal needs stemming from urbanization, industry, water-course alterations, etc. (Bae KyungSeok *et al*., 1997; Soontornprasit and Meksumpun, 2008; Hauer and Lorang, 2004). The most reported anthropogenic activities leading to water ecosystem degradation are deforestation (Bunn *et al*., 1999; Falkenmark *et al*., 2007), land-use changes (Rapport and Whitford, 1999; Malmqvist, 2002), Industrial pollutants/pesticides/waste (Rapport and Whitford, 1999; Chambers *et al*., 2006), water withdrawals (Wang and Cheng, 2000; CA, 2007), climate change/temperature increase (Malmqvist, 2002, Jung *et al*., 2010), exotic species (Rapport and Whitford, 1999), overharvesting and overfishing (Thoms and Cullen, 1998, Hauer and Lorang, 2004). Any particular river is likely to be subjected to several types of anthropogenic activities and varying degree of consequent impacts like reduced discharge, river desiccation, groundwater depletion, water pollution and sedimentation, salinization, soil erosion and nutrient depletion (Yamashiki, 2006; Bhowmik *et al*., 2001). The global evidence of degrading and depleting water resources (UNEP, 2011) causing changes in the global water cycle are having far reaching impact on human wellbeing in general (MA, 2005), particularly the poor communities, as their livelihood depends more on land and water based economies (UNEP, 2010), and have less capacity to cope with degraded ecosystems services (WRI, 2005).

Calling for sustainable development, the world community struggles to restore these ecosystems so as to ensure continual flow of their services now and in future. Experts even insist for restoration of headstreams for being critically important to downstream ecosystems (Naiman *et al*., 1987; Gomi *et al*., 2002). Headwater streams provide downstream habitats with a multitude of ecosystem services, including water, nutrients, food, etc (Wipfli and Gregovich, 2002; Compton *et al*., 2003; Gregory et al., 2003), and also serve as refugia and source areas for biodiversity (Meyer *et al*., 2007). Restoration however, may require economic justification through proper valuation of ecosystem services, as it links the ecology with economics. While studying the river restoration, Bernhardt *et al*., (2005, cited in Loomis, 2006), observed that the restoration of rivers and related riparian areas is a billion dollar business a year. However, the proper valuation requires inclusion of entire range of both use and passive use values. Though the inclusion of passive use values and the methodology adopted have been matter of controversy (Portney, 1994 cited in Loomis 2006), the method has shown to be reliable in test-retest studies (Loomis, 2006). In fact, the passive (non-use) value of an environmental resource is often far greater than its use value (Loomis 2006) and their omission can often lead to the impression that the restoration is uneconomic. In this context, (DEST *et al*., 1995) states that the economic values are anthropocentric in nature and relate to anything from which individuals gain satisfaction. Therefore calculating the economic values of restoration including passive use values is necessary so as not to understate the benefits of restoration.

The river Jhelum, its tributaries and wetlands have been the focus of environmental and ecological research in Kashmir, the economic aspects of their use and non-use services have, however, hardly been touched. Studies highlighting long term trends in the physical and chemical properties of water and biodiversity of the river are, however, either scarce or absent. The meagre and scattered evidences available, however, reveal a significant human born changes in the water quality parameters (Yousuf *et al*., 2006; Anon., 2000), biodiversity and hydrological regimes (Anon., 2007) of river Jhelum.

River Jhelum in Kashmir valley is virtually a dump of sewage discharge from the towns that has led to the increased concentrations of BOD, COD and drastic reductions in dissolved oxygen levels, besides deteriorating the other physical and chemical parameters of the Jhelum water (Anon., 2000). Similarly, the loss of marshes, degradation of catchments and wetlands, and climate change has induced major changes in its hydrological regimes. Coupled with progressive reduction in the water holding capacity of the wetlands, changes in flow regimes tend to enhance flooding and quick drainability within the basin (Anon., 2007). Similarly, the reported decline in fish diversity and yield has been attributed to the changes in hydrological regimes and loss of critical habitats through construction of hydraulic structures particularly hydroelectric projects. Mahaseer (Torpi), for instance, is the already lost migratory fish species in the river Jhelum attributed to the construction of Mangla dam in Pakistan. Another indication of diminishing ecosystem services is that the basin has records of seven globally threatened and near threatened water-bird and wetland bird species, although none of these species are regularly observed here in recent years (Anon., 2007).

Together with such ecological implications, the consequent sedimentation and loss of water holding capacity of the river and its associated wetlands is understood to hinder its sustainable developmental efforts by the government. In order to check the trend, the state government has formulated a Jhelum River Conservation Plan (JRCP) which mainly emphasizes on appropriate treatment technologies and resource recovery from sewage. The programme is also addressing the problems of siltation, bank erosion and agricultural runoff containing pesticide and fertilizers with the help of concerned nodal ministries. It is alleged, however, that the plan lacks ecosystem sustainability issues, as it has emphasized more on engineering measures than on integrating ecological aspects in a comprehensive way (Anon., 2007), which may result in further degradation of its ecosystem. The criticism is in tune with (UNEP, 2009) revelation that traditional water management focuses only on specific factors directed more toward individual concerns rather than considering them collectively leading to an unsustainable ecosystem. An integrated ecosystem approach is, therefore, crucial to maintaining both ecosystem health and its sustainability. There is a need to analyze this ecosystem comprehensively in broader policy perspective as emphasized by studies (CBD, 2009). In this direction this paper is an attempt towards valuating ecosystem services/goods provided by Jhelum so as to justify an integrated ecosystem approach for its preservation on sustainable basis.

III. JHELUM BASIN: BRIEF PROFILE

The trans-national basin of river Jhelum extends to an overall area of 33,300 sq km within India and Pakistan and covers 3 percent of the overall Indus Basin area. Khadanyar Gorge, a geological fault zone and location of distinct changes in hydrological regimes divides the Jhelum basin into two segments. The upper segment of the basin extending to an area of 12,777 sq km drains the entire Kashmir Valley. At the topmost fringe of the basin are the glaciers which serve as the main source of water for the basin.

River Jhelum originates from Verinag spring within the Pir Panjal ranges. Several freshwater streams from the Pir Panjal mountains meet with Arpal, Bringi and Sanderen streams to form river Jhelum at Khanabal (Anantnag). The river is joined by about 21 major tributaries on either side of its entire route of 239 kilometers from Verinag to Uri, and flows further 753 kms beyond Uri into Pakistan. The river flow is sluggish in nature and its width varies across its length, from 150 ft at Khanabal to 692 ft at Asham. Jhelum is a backbone of state’s agricultural economy as it irrigates about 83 thousand hectares of land. Drinking water, hydroelectricity, sand extraction, transportation and fishing are the other services provided by the Jhelum.

IV. ECONOMIC VALUE OF RIVER JHELUM

River Jhelum provides a range of direct and indirect services having economic values. Cities and towns have established on its banks centuries before only to avail the services like sanitation, transportation, drinking water, water for agriculture and livestock, fishing and other services. Since then, the added services from Jhelum include hydropower generation and sand extraction plus the modernization of age-old services. Lift irrigation system, for instance, was introduced about three decades ago to tap the irrigation potential of Jhelum. Similarly, sand extraction is understood to have picked up recently owing to the growing demand for it as preferred construction material.

Independent of these direct uses, Jhelum has its ‘existence’ or ‘passive use’ values commonly referred to as non-use values. This is the value placed by any individual on a particular environmental asset simply because it exists and gives him a satisfaction, and/or desires to bequeath this asset for future generation. They not only express their concern towards clean environment but are also willing to pay for assuring continued environmental services (Renzetti, 2010). This study attempts to estimate the total economic value of river Jhelum by calculating its use and non-use values.

As far as the tools of valuation are concerned, under certain circumstances, the market for environmental goods and services do not exist or are not well-designed. A viable alternative could be twin use of the constructed or hypothetical market approach i.e. the direct method and indirect method. This model is based on revealed preference or related/allied market approach to which the visitation rate to river Jhelum for parks, boating, etc. could be taken as indirect measure to the value that people attribute to the river ecosystem. Such valuation approach is known as the travel cost method (TCM). The Contingent valuation method (CVM) elicits consumer preferences of goods and services that are not traded directly to the consumer in the market. Monetary values of the environmental goods and services are established through the setting up of a 'hypothetical' market. A survey question is used to elicit willingness to pay (WTP) for a hypothetical provision of environmental goods and services. CVM is a tool to place an amount or value on goods and services that are typically not exchanged in the market place (Ajzen and Driver, 1992). The CVM tool has been the subject of methodological research and applied in estimating both use values and non-use values of environmental goods (Cummings *et al*., 1986; Mitchell and Carson, 1989). One of the most important concepts in CVM is willingness to pay (WTP), which refers to an amount consumers are prepared to pay for a good or service (ADB, 2007; McConnel, 1985).

USE VALUES

AGRICULTURE: River Jhelum is the backbone of valley’s agricultural sector. Apart from serving directly through irrigating the agricultural fields, the river along with its tributaries and wetlands acts as a natural drain to its catchment areas in times of excessive rains, and as a reservoir in times of dry spells. As per the recent information provided by the concerned directorate, the river Jhelum contributes about 42 percent to the total irrigated area in the valley. Since most of the agricultural fields are on higher elevation than Jhelum, a lift irrigation system has been introduced during 1970s; and has been exploited during these decades to bring more area under irrigation. Currently (in 2010) the river irrigates more than 83 thousand hectares of agricultural land spread in the valley (Table 1). Its importance can be assessed by the fact that since 1980s total area irrigated by Jhelum has increased fourfold. The increase in Kharif season was observed to be almost double than in Rabi.

Division	1980	2010	Fold increase*
Rabi	4609.31	10614.98	2.30
Khariff	15808.91	72489.88	4.59
Total	20418.22	83104.86	4.07

**shows times increase over last reference year available*

Table 1: Changes in area irrigated by river Jhelum (ha)

The economic value of irrigation services by Jhelum has been computed by monetizing the productivity difference between irrigated and un-irrigated agriculture. Our estimates, as shown in Table 2, revealed that Jhelum encourages cultivation of high value and input intensive crops like vegetables, fruits and improved/hybrid varieties of major cereals. The crops have shown significant productivity difference in alternate situations and a consequent income differential as well. The cumulative impact on increase in gross income per hectare of land irrigated by Jhelum amounted to around Rs. 80785. These direct benefits, when computed for whole area irrigated by Jhelum (83105 ha) amounts to about Rs. 6714 million. The approximation was done on the basis of prevailing prices during the study period. The indirect benefits to agriculture like multiplier effects of increased farm income, field drainage and microclimate regulation can push up economic value of Jhelum for agricultural sector much more than our calculated values.

HYDEL POWER GENERATION: Hydel power generation is the most potential aspect of river Jhelum which is being exploited for the generation of electricity. However, the potential remained untapped because of restrictions imposed by Indus Water Treaty signed by India and Pakistan in 1960. Presently, there are 24 power houses in the state including 3 thermal power houses at Ladakh, Gurez and Karnah and 21 hydel power houses. Jhelum basin houses 6 power projects, whereas Chenab, Ravi and Indus basins have 5, 1 and 9 power houses, respectively. Out of about 3722 million units (mu) of hydel power generated within the state, Jhelum contributes about 725 mu (19.5%), though the installed capacity on Jhelum power houses alone is about 33 percent of state’s total installed hydel power capacity. Therefore, lack of capital resource and political will has been a constraint in the prospects of harnessing full benefits from Jhelum’s minimum power generating potential.

Crop	Irrigated (by Jhelum) (1)		Un-irrigated (2)	
	Productivity (q/ha)	**Gross income** Rs/ha	**Productivity** (q/ha)	**Gross income** (Rs/ha)
Rice	70	91000	-	-
Maize	50	51000	35	35700
Fodder crops	650	74750	500	57500
Oilseeds	5.2	2080	-	-
Pulses	140	420000	100	300000
Peas	291	582000	225	450000
Potato	280	280000	205	205000
Onion	330	660000	225	450000
Tomato	420	630000	-	-
Cole crops	395	521400	-	-
Root crops	252	243432	206	198996
Average per hectare		323242		242457
Income differential per hectare (1-2)		80785		
Area irrigated by Jhelum (ha)		83105		
Total income differential (Rs. in Millions)		**6714**		

Table 2: Productivity difference in various crops under different irrigation scenarios

Name of power house	Installed capacity*	Energy generated**	Revenue generated+
Unit	Mega Watts	Million Units	Rs. in Crores
Lower Jhelum	*105.00*	*377.95*	145.89

Hydel Project			
Upper-Sindh Hydel Project-I	*22.60*	*33.89*	13.08
Upper-Sindh Hydel Project-II	*105.00*	*291.83*	112.65
Ganerbal	*15.00*	*11.93*	4.60
Karnah	2.00	1.59	0.62
Pahalgam	3.00	7.93	3.06
Sub-total (Jhelum basin)	252.60	725.1292	279.90
	(33.22)	***(19.48)***	***(19.48)***
Gross total (State)	**760.46**	**3721.8443**	**1436.63**

**For 2008-09; ** For 2010-11; + Rs. in Crores; Figures in parentheses represent percentage of total*

Source: Economic survey (2011-12); Directorate of Economics and Statistics, J&K

Table 3: Installed capacity and hydel power generated by the power houses on Jhelum river basin

On the basis of available information, an approximation was made to account for the revenue generation from hydel power in Jhelum basin by multiplying generated power units to the prevailing power tariff in the state. Since the tariff rates vary from domestic to commercial and agricultural uses as per the state norms, an applicable (average) rate of Rs. 3.86 per unit was used to reach the revenue generated from hydel power houses installed on Jhelum. On the basis of this estimation it was observed that Jhelum hydel power houses alone generate about Rs. 280 crores annually (Table 3). The potential revenue generating capacity of these houses can be as high as Rs. 477 crores annually provided the installed capacity is fully realized. The proper management of the river ecosystem is expected to push up the power potential of the Jhelum considerably.

COMMERCIAL FISHING: Fishing is one of the oldest economic activities in Jhelum. Generally, fishing in Jhelum is done on commercial basis and as leisure pursuit as well. The river can overall be referred to as having low fish population (Yousuf *et al*., 2006). Despite, fishing contributes to both livelihood and food security of this region. Interestingly, womenfolk have a well defined role in the marketing of captured fishes. Though fishing in Jhelum is not a year-round for this community, still the activity contributes substantially to the income and food basket of this community. Our estimates from sampled fishermen revealed that this activity contributes as much as Rs. 102216 to their annual household income (Table 4). The income generated varies over different quarters of the year depending upon the prices and total fish-catch in a particular quarter. It is in place to mention that the fish population varies between quarters depending upon the temperature and water flow, thereby affecting the demand and supply as well.

WATER TRANSPORT: Like fishing, water transport in Jhelum is an age-old activity as well. This mean of transport was common and cheap in ancient times. Though due to expansion of road network and transport the significance of water transport was lost, but the recent campaign by state tourism ministry would rejuvenate the sector by introducing latest water transport system especially for tourist attractions. Nevertheless, sparsely established stands (Ghats) at many places alongside the river could be seen in towns and villages as well, where commercial boatman use to ferry passengers from one end to other end of the river.

Our results have revealed that a single boatman earns an average of Rs. 107280 per annum after adjusting the associated material and labour costs. The earnings are spread almost uniformly among different quarters (Table 4). It can, therefore, be concluded that the water transport in Jhelum is a viable economic activity for resource poor households, as the daily earnings figure around Rs. 300, i.e. more than the much spoken NREGA employment scheme pays a person per day.

LAUNDRY SERVICES: Jhelum water has also been used for laundry purpose at domestic and commercial level. The service is usually availed by those residing on river banks. The commercial purpose laundering cites are termed as 'Dhobi Ghats' in local parlance. The survey of various Dhobi Ghats revealed that this service by Jhelum is linked with more than one thousand crore industry of the valley. The river shore is the ideal place for washing of the prized shawls and carpets being crafted in the valley. This activity provides direct livelihood to hundreds of the people and indirectly to thousands of peoples by establishing strong forward and backward linkages. The direct stakeholders (practicing laundry) were observed to earn a monthly income of around Rs. 14000 after working merely for 5 to 6 hours daily (Table 4).

Services	Q_1	Q_2	Q_3	Q_4	Total
Fishing	10260	6052	7520	10240	102216
Water Transport	8940	8940	8940	8940	107280
Laundry Services	12720	14280	15650	14730	172140
Sand Extraction	165784	55810	173271	259751	654615
House Boat	28061	91938	106286	57041	849976

Q_{1-4} refers to four quarters of the year

Table 4: Average annual value of different services provided by Jhelum (Rs. per stakeholder)

SAND EXTRACTION: Another use value, i.e., sand extraction has emerged as an economically important commercial activity in Jhelum. Its extraction not only maintains the river environment, but also supplies with the important industrial material. The suspended silt load concentration in Jhelum waters is coarse, medium or fine. Usually the suspend silt settles down where the river is wider making flow speed bit sluggish. Stakeholders extract the sand either manually or mechanically from beneath the water and use medium size boats to store it on river banks. At least two persons are required to extract sand from the river. Since the sand is in great demand and the price per unit has more than doubles since recent couple of years, the stakeholders are pretty satisfied with the income derived. In average, a square foot of sand extracted was observed to fetch 11 to 12 rupees; and the total average gross receipts by a stakeholder were estimated to be Rs. 654615 per year (Table 4).

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HOUSEBOAT SERVICES: Houseboats inside the Jhelum and hotels on the banks are the tourist/visitors oriented services; however, they are concentrated in the city only. Few houseboats inside the river are used for residential purpose also. The fleet of about 120 houseboats could be seen in the river passing through central part of city, including about 40 ranked as Deluxe, 25 as 'A' class. The quarterly analysis for hotels and houseboats revealed that second and third quarter of the year are the business peaks generating about around one lakh rupees per quarter (Table 4). The occupancy rate was as high as 98 percent during the peak quarter to as low as about 20 percent in lean quarters. In this way houseboat owners earn around Rs. 0.85 million per year to fixed capital.

TOTAL USE VALUE OF JHELUM: Based on the estimations in table 2 to 4, total use value of Jhelum has been calculated and figures reflected in Table 8. Total average annual income as realized by all stakeholders studied in the entire length (5km) was later averaged on per kilo meter basis to have valuation for the entire river Jhelum. The results revealed that while the urban area contributed the maximum of Rs. 31.58 million, the rural area contributed just 4.96 million, though these does not include the agriculture and hydel power generation, which were calculated for entire length of the Jhelum. It is quite impressive that agriculture alone contributed about ½ of the total revenue generated by Jhelum followed by about 21 percent by hydel power. Contribution of Laundry services, water transport and fishing to total value was just around one percent.

Sector	Urban area	Township	Rural area	Average	Entire Jhelum*
	Per Kilometre				
Sand extraction	8.51	10.47	3.93	7.64	1825
Houseboat services	20.40	0.00	0.00	6.80	1625
Water transport	0.86	0.21	0.21	0.43	106
Laundry services	1.65	0.62	0.00	0.76	181
Fishing	0.16	0.35	0.82	0.44	106
Agriculture	-	-	-	-	6714
Hydel power	-	-	-	-	2799
Total	**31.58**	**11.66**	**4.96**	**16.07**	**13356**

**Length of Jhelum from its origin at Verinag to its exit in Uri is 239 km.*

Table 5: Approximated total value of direct services provided by Jhelum (Rs. In Million per annum)

NON USE VALUE

This section attempts to capture the awareness level among the public towards Jhelum ecosystem, and their enthusiasm towards preserving or enhancing its ecology through their willingness to pay for it. The selected respondents included all types of stakeholders, visitors and residents. The respondents were asked to rate the overall health of the river as poor, moderate good and very good. The results presented in Table 9, reveal that about 96 percent of the respondents rated the health of river as poor. The rating by respondents was actually a comparison between their past and present experiences with the river Jhelum. When asked about the possible causes of degrading health, the negligence on part of government (institutional) and commoners were the frequently reported responses. Climate change was also reported by a significant number of respondents (Table 6).

Health of river	Response	Causes of degradation	Response
Very poor	35.24	Residential/private	32.25
Poor	60.31	Commercial	8.58
Moderate			18.65
Good	4.45	Climate change	
Good	0	Institutional	38.47
Very good	0	Others	2.05

Table 6: Public perception about health of Jhelum and possible causes of degradation (percent)

WILLINGNESS TO PAY (WTP) FOR JHELUM RESTORATION

As reported in economic literature (Renzetti, 2010; Earnhart, 2001) many people show willingness to pay for preserving ecosystem, which pushes the non-use value of ecosystem beyond its use value. The amateurs, who visit the river side quiet frequently, have also shown enthusiasm by revealing their willingness to pay, and increased visitation rate after the river restoration. The respondents were also asked to reveal their WTP for clean water and beautified riverbanks and increased fish population. The results were encouraging as mean willingness to pay was as high as Rs. 930 and Rs. 976 for clean river water and beautified river banks. Fishermen also were willing to pay Rs. 112.50 as extra fee for fish licensing, whereas the visitors were willing to pay an extra trip once the river is restored, i.e. an additional expenditure of Rs. 119 in post-restoration scenario (Table 7).

Parameters	Mean
Average total expenditure per visit	119.25
Pre- restoration visitation rate per week	4.10
Pre- restoration visitation rate per week	5.45
Willingness to pay for transparent water	930.53
Willingness to pay for beautified riverbanks	976.50
Willingness to pay for increased fish population	112.50
House price differential (per 1000 sq. ft plot)	1171855

Table 7: Mean and standard deviation of different variables of WTP (Rs. Per person)

Since the river Jhelum runs through residential areas including the main city of the valley, house price differentials (Hedonic Property Method) will reflect the homeowner's willingness to pay for living by a restored river as compared to a degraded one. The price differential for Jhelum banks was calculated to average to Rs. 1171855 per 1000 sq. ft plot.

An attempt was made to estimate the determinants of WTP for Jhelum river restoration with explanatory variables specified in model of the following structural form:

WTP=f(FMI,SC,RC,FMS,DIS)

The Model was estimated employing OLS procedure in linear form

The regression analysis revealed that the model was overall statistically significant, implying that the specified explanatory variables explained over 80% of variation in the

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endogenous variable (WTP), except family size of stakeholders (FMS) all the variables have significantly contributed to one's desire to pay for restoration of Jhelum ecosystem (Table 8). The coefficients of concerns about the beauty of the river scenery concerns (SC) and restoration concerns (RC) indicated that the improvement of aesthetic appearance of river Jhelum enhance its demand and associated desire to pay.

Variable	Coefficient	S.E
Constant	2.28	-
FMI	0.08*	0.007
SC	1.24*	0.18
FMS	-0.06	1.12
RC	0.19*	0.09
DIS	0.08*	0.02
Adjusted R^2	0.8213	-

** denote significance at 0.05 or better probability levels*

Table 8: Estimated coefficients for model specification

Where, WTP= Willingness to Pay (Amount willing to pay in '000 Rs.); FMI= Family Income (in '000 Rs); SC= Scenic Concern; RC= Restoration Concern; FMS= Family size (No.); and DIS= Distance from residence (in '000 Km)

Despite the fact that Jhelum has immense use and non-use values for stakeholders, there are deep concerns about its deterioration. The findings above provide an ample scope for restoration of the river which, as per the stakeholders and amateurs has lost its decades' old glory. The ecosystem values provided by this river must be balanced by the costs to be incurred for its restoration to its actual form. However, for restoration, a prior knowledge about the extent of degradation of Jhelum and its catchment is therefore must to set our priorities. Following section attempts to capture the extent of degradation of river ecosystem as is reflected through the changes in its hydrological regime.

V. EVIDENCES OF DETERIORATION

The long term trends in the river flows can be helpful in assessing the extent of degradation of its ecosystem. The present study analyses the discharge of Jhelum since 1980 onwards which is based on the records of the department of Irrigation and Flood Control (I&FC), Govt of Jammu and Kashmir. The records of the daily discharge from Jhelum at 6 different sites were used to study the trends in river flows. The results were somewhat in tune with the only study available in the context Anonymous (2007). Our results for changes in average discharge over the period 1980 to 2009 are depicted in Table 9, which revealed an almost uniform decline in water discharge observed through different quarters at different locations. The discharge increases multi-fold from site 1 to 6 as it is joined by about two dozen major tributaries along its course. Assessment of average quarterly discharge of all sites reveals a significant decline in total flows, with about 1/4th to about 2/3rd reduction in Q_1 to Q_3, respectively. However, the temporal variation between 1980 and 2009 is substantial in each quarter and location. Further, the table reveals that the pattern of percentage change in flows over time reveals that the decline has been less in first and second quarter than in third and fourth quarter.

The decreased discharges during latest decade (2001-09) than in preceding decades can well be perceived through the average monthly discharge during three decades as reflected in Table 10. The table reveals that as against the total discharge of 60120 cusecs in 1980-90, the recent decade has shown a total annual discharge of only 39239 cusecs, i.e. about 35 percent decrease in two decades. Nevertheless, the middle decade has shown an increase over previous one, reflecting an irregular trend during the three decades. The table also reflects the distribution of monthly discharge of water as percentage to total yearly discharge. The month of May has been the month of highest flow during these decades. However the number of high flow months (secondary peaks, with 10 or more percent of total annual flow) increase from three months in 1980-90 to five in 1991-00 and seven in 2001-09. Consequently, low flow period has shrunk from 9 months to 5 months during three decades. This finding is in support to early findings by Anonymous (2007).

Year/quarter		1	2	3	4	5	6	Average
Q1	1980	645	1612	3509	3627	7088	10415	4483
	2009	336	2407	3050	3455	4288	5596	3189
	% change	**-47.93**	**49.34**	**-13.08**	**-4.75**	**-39.51**	**-46.27**	**-28.87**
Q2	1980	1525	3133	7565	13590	15437	16839	9682
	2009	811	4137	4810	8082	8145	12930	6486
	% change	**-46.81**	**32.06**	**-36.42**	**-40.53**	**-47.23**	**-23.21**	**-33.01**
Q3	1980	1256	3421	5618	10748	12238	11651	7489
	2009	349	2330	2494	4758	3475	3493	2816
	% change	**-72.22**	**-31.89**	**-55.61**	**-55.73**	**-71.61**	**-70.02**	**-62.39**
Q4	1980	441	1488	2433	1885	2846	3647	2123
	2009	177	996	1052	1657	955	1800	1106
	% change	**-59.80**	**-33.06**	**-56.77**	**-12.08**	**-66.45**	**-50.63**	**-47.90**

(1: Khanabal; 2: Sangam; 3: Ram Munshibagh; 4: Asham; 5: Sopore; 6: Baramula)

Table 9: Trends in discharge of river Jhelum at important sites (cusecs)

The findings over three decades reflect a marked shift in the quantitative and qualitative aspects of river discharge. Relating these changes with climate change will not be an exaggeration. It is pertinent to mention that during these decades the valley has witnessed an unprecedented expansion in mean maximum and minimum temperature. The long summers have resulted in longer duration of glacial melt leading to an extended flow peaks in recent decades. Increase in mean annual temperature melts the snow, thereby building early flows in the river. Once the fresh snow on mountain peaks melts completely, the flow reduces considerably in down streams. That is probably why the decline in Q_3 is almost double than in Q_2. Therefore, the argument by Anon. (2007) can be modified by the fact that the river flow is not only linked with the temperature but snowfall as well.

Months	1980-90		1991-00		2001-09	
	Discharge	%age	Discharge	%age	Discharge	%age
January	1996	3.3	2796	3.7	1301	3.3
February	2866	4.8	3669	4.9	1517	3.9
March	4776	7.9	5719	7.7	3962	**10.1**
April	8106	**13.5**	8979	**12.0**	5304	**13.5**

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May	11735	**19.5**	10276	**13.8**	7281	**18.6**
June	7533	**12.5**	9457	**12.7**	3954	**10.1**
July	5684	9.5	10270	**13.8**	3940	**10.0**
August	5613	9.3	8477	**11.4**	3564	**9.1**
September	3406	5.7	6211	8.3	4883	**12.4**
October	3453	5.7	3585	4.8	1413	3.6
November	2249	3.7	2828	3.8	996	2.5
December	2703	4.5	2329	3.1	1126	2.9
Total	60120	100	74595	100	39239	100

Table 10: Average monthly discharge (cusecs) and expanding peak flow period over three decades

Though the actual causes for such trends across time and space requires an in-depth observation at associated tributaries and catchments, the changing hydrological regime, however, is a concern for everyone. Addressing the issue, therefore, requires development of integrated ecological approach linking the economic aspects of changing ecosystem with its ecological aspects.

VI. CONCLUSION AND SUSTAINABILITY ISSUES

The present study attempted to evaluate the ecosystem services/goods provided by river Jhelum which travels around 239 km from its origin in south Kashmir to its exit in north Kashmir. The extent of degradation and stakeholder's will to conserve the ecosystem has also been studied. The results revealed that river has a vast potential in the socio-economic up liftment of the valley, as it provides food, employment and energy in various other forms of its use values. Presently, the river is being exploited for irrigating agriculture and hydel power generation at macro level, whereas, the minor uses include sand extraction, fishing, laundry services and water transport and hotels (houseboats). The river contributes about 42 percent to the total irrigated area in the valley. Hydel power generation is the next major contributor (Rs. 2799 million) to its total use values, whereas, the fishing, water transport and laundry services contributed just around one percent. Total use value of Jhelum was estimated to the tune of Rs. 13356 million. In addition a huge number of non-use/use value services emerge from the valuable eco-system services. Results further revealed that the stake holders were well aware of the economic and ecological value of the river and showed a deep concern over its deteriorating conditions. In this direction the stake holders were willing to pay handsomely for the restoration of this eco-system with the expectation that they may avail its improved ecosystem services, if it is restored. A linear function was fitted to quantify the various determinants of WTP as a proxy for stake holders demand/desire to its prompt restoration

On the basis of major observation of the study, following policies/ suggestions emerge for the long term sustainability of the Jhelum river ecosystem

Survey results revealed that the stakeholders were well aware of the economic and ecological value of the river, and showed a deep concern over its deteriorating conditions. More than 95 percent people ranked river health from poor to very poor. About 70 percent of respondents attributed the degradation to negligence on part of government and commoners, whereas about 18 percent blamed climate change for degrading river. Being concerned, the visitors and stakeholders were willing to pay for improved and sustainable ecosystem services by Jhelum. It was found that for beautified river banks and clean water people were willing to pay about Rs. 970 and Rs. 930, respectively. House price differential (Rs. 1.17 million) also emerged as major non-use value.

Analysis of river discharge at various locations and in different quarters of river Jhelum revealed a discouraging trend in hydrological regime of the river. Declining discharge and expanding peak flows hints at substantial deterioration in its catchments and possible climate change impacts. On the basis of our findings the study proposes following policies for its restoration/conservation.

- ✓ All though the values of ecosystem services/goods provided by river Jhelum are immense, prioritization of its restoration in economic plans become in evitable. Both short and long term restoration projects should be launched for beautifying river water and its banks. Government.-Stake holder partnership in this regard would help in its sustainability. To launch a knowledge networking campaign to make aware dwellers especially younger people in its vicinity about its gainful externalities of restoration process of this ecosystem needs prioritisation.
- ✓ Since the river had once been a parcel of valley's tourism therefore it should be beautified to its fullest. Encouragement of river tourism and resumption of heritage trip through this river would resume its importance in tourism.

The Govt./planners have more prominent role in enhancing ecosystem services/goods from this ecosystem. Municipal Authorities and Lakes/Waterways Development Authority (LAWDA) should monitor the activities around this ecosystem so that the disposal of domestic wastes is ruled out, however, the provision of sewage and sanitation in its vicinity is equally importantantention.

REFERENCES

[1] Ajzen, I. and B. L. Driver (1992), "*Contingent value measurement: On the nature and meaning of the willingness to pay*". Journal of Consumer Psychology. 1, 297-316

[2] Alegria, H., T. F. Bidleman and M. S. Figueroa (2006), "*Organochlorine Pesticides in the Ambient Air of Chiapas*", Mexico. Environmental Pollution, 140 (3): 483–491.

[3] Anonymous (2000), *Ecological Status and Conservation of River Jhelum*. Technical report, National Institute of Aquatic Ecology, Jammu and Kashmir Lakes and Waterways Development Authority.

[4] Anonymous (2007), *Comprehensive Management Action Plan for Wular Lake, Kashmir*, Final Report by Wetlands International South Asia, Prepared for Department of Wildlife Protection Govt. of Jammu & Kashmir.

[5] Asian Development Bank (ADB) (2007), Retrieved, from http://www.adb.org /Documents /Guidelines/Eco_Analysis/ glossary.asp.

[6] Bae, Kyung Seok., Koo BonKwan, Han SunKyu, Shin JaiYoung, Park SungBae, K.S. Bae, B.K. Koo, S. K. Han, J.Y. Shin and S.B. Park (1997), "*An Ecological Study on the Aquatic Animal Community in Tan Stream",* Korean Journal of Environmental Health Society.

[7] Batker, D., I., de La Torre, R. Costanza, P. Swedeen, J. Day, R. Boumans and K. Bagstad (2010), *Gaining Ground. Wetlands, Hurricanes and the Economy: The Value of Restoring the Mississippi River Delta*. Tacoma: Earth economics. http://www.eartheconomics.org

[8] Bernhardt, E. and 12 others (2005), "*Synthesizing U.S. River Restoration Efforts"*. Science 308: 636-637.

[9] Bhowmik, N., G. M. Demissie, J. C. Marlin, J. Mick, M. A. Marino (ed.), S. P. Simonovic (2001), *"Integrated Management of the Illinois River with an Emphasis on the Ecosystem"*, Integrated water resources management. University of California, Davis,California, USA, April 2000. 365-371; 4 ref.

[10] Bunn, S.E., P.M. Davies, T. D. Mosisch, R. H. Norris (ed.), and M.C. Thoms (1999), *Measures of River Health and their Response to Riparian and Catchment Degradation*. Special issue: River health. Freshwater Biology.

[11] CA (Comprehensive Assessment) (2007), *Water for Food, Water for Life: A Comprehensive Assessment of Water Management in Agriculture*. International Water Management Institute. . London: Earthscan, colombo: international water management institute. http://www.iwmi.cgiar.org/assessment/Publications/books

[12] CBD (2009), *Ecosystem Approach Principles*. Convention on Biological Diversity, Montreal, Canada. http://www.cbd.int/programmes/cross-cutting/ecosystem/principles.

[13] Chambers, P. A., J. M. Culp., N. E. Glozier., K. Cash, F. J. Wrona and A. Noton (2006), "*Northern Rivers Ecosystem Initiative: Nutrients and Dissolved Oxygen–Issues and Impacts",* Environmental Monitoring and Assessment 113:117–141

[14] Compton, J.E., M.R. Church, S.T. Larned, and W.E. Hogsett (2003), "*Nitrogen Export From Forested Watersheds in the Oregon Coast Range: The Role of N2-Fixing Red Alder"*. Ecosystems 6:773-785.

[15] Costanza, R., R. d'arge, R. deGroot, S. Farber, M. Grasso, B. Hannon, K. Limburg, S. Naeem, R. V. O'neill, J. Paruelo, R. G. Raskin, P. Sutton and M. van den Belt (1997), "*The Value of the World's Ecosystem Services and Natural Capital*". Nature, 387: 253–260.

[16] Cummings, R.R., D.S. Brookshire and W.D. Schulze (1986), *Valuing environmental goods: An assessment of the "Contingent Valuation Method*". Totowa, N J: Rowman Allanheld.

[17] DEST, Department of Finance, Resource Assessment Commission (1995), "*Techniques to Value Environmental Resources*", AGPS, Canberra.

[18] Dong-Oh, Cho (2007), "*The Evolution and Resolution of Conflicts on Saemangeum Reclamation Project*", Ocean and Coastal Management, 50 (11–12): 930–944.

[19] Earnhart, D. (2001), "*Combining Revealed and Stated Preference Methods to Value Environmental Amenities at Residential Locations*", Land Economics, 77(1): 12-29

[20] Falkenmark, M. (2003), "*Freshwater as Shared between Society and Ecosystems: From Divided Approaches to Integrated Challenges*". Philosophical Transactions of the Royal Society B 358: 2037–2049

[21] Falkenmark, M., C. M. Finlayson, L. J Gordon, et al. (2007), *Agriculture, Water and Ecosystems: Avoiding the Costs of Going too far in: ca. Water for Food, Water for Life: a Comprehensive Assessment of Water Management in Agriculture*. Earthscan, London, and international Water management institute, Colombo. pp 233–277. http://www.iwmi.cgiar.org/assessment/Publications/books.htm

[22] Gomi, T., R.C. Sidle, and J.S. Richardson (2002), *Headwater and Channel Network – Understanding Processes and Downstream Linkages of Headwater Systems*. BioScience 52:905-916.

[23] Gregory, P.J., J. S. Ingram, I. R. Andersson, R. A. Betts, V. Brovkin., T. N. Chase, P. R. Grace, A. J. Gray, N. Hamilton, T. B. Hardy, S. M. Howden, A. Jenkins, M. Meybeck, M. Olsson, I. Ortiz-Monasterio, C. Palm, T. W. Payn, M. Rummukainen, R. E. Schulze, M. Thiem, C. Valentin and M. J. Wilkinson (2002), "*Environmental Consequences of Alternative Practices for Intensifying Crop Production*". Agriculture, Ecosystems & Environment, 88 (3): 279–290

[24] Gregory, S.V., K.L. Boyer and A.M. Gurnell (Editors) (2003), *The Ecology and Management of Wood in World Rivers*. American Fisheries Society Symposium 37, Bethesda, Maryland.

[25] Hauer, F. R. and M. S Lorang (2004), *"River Regulation, Decline of Ecological Resources, and Potential for Restoration in a Semi-Arid Lands River in the Western USA*", Aquatic Sciences ; 66(4): 388-401

[26] ILEC (2005), *Managing Lakes and their Basins for Sustainable Use. A Report for Lake Basin* Managers and Stakeholders. International Lake Environment Committee Foundation, Kusatsu, Japan. 146 p.

[27] IUCN (2000), "*Vision for Water and Nature: A World Strategy for Conservation and Sustainable Management of Water Resources in the 21st Century"*. IUCN, Gland, Switzerland.

[28] Loomis, J. (2006), "*Importance of Including Use and Passive Use,*Values of River and Lake Restoration", Journal of Contemporary Water research & education, issue 134, pages 4-8, july 2006

[29] Jung, M., M. Reichstein, P. Ciais, S.I. Seneviratne, J. Sheffield, M. L. Goulden, et. al (2010) *Recent Decline in the Global Land Evapo transpiration Trend due to Limited Moisture Supply*. Nature 467: 951–954. http://dx.doi.org/10.1038/nature09396

[30] MA (Millennium Ecosystem Assessment) (2003), "*Ecosystems and Human Well-being. A Framework for Assessment"*. Millennium Ecosystem Assessment, Island Press, Washington, D.C. 245 p.

[31] MA (2005), *Ecosystems and Human Well-being: Synthesis*. Millennium Ecosystem Assessment, Island Press, Washington, DC.

[32] MA (2005a), "*Ecosystems and Human Well-being"*, Wetland and Water Synthesis World Resources Institute, Washington, DC, Island Press.
[33] Malmqvist, B. and S. Rundle (2002) "*Threats to the Running Water Ecosystems of the World*". Conservation Environmental Conservation. 2002, 29: 2, 134-153; many ref.
[34] McCartney, M. P. and B. van Koppen (2004), *Wetland Contributions to Livelihoods in United Republic of Tanzania*. Food and Agriculture Organization of the United Nations (FAO) Netherlands Partnership Programme: Sustainable Development and Management of Wetlands. Rome.
[35] McCartney, M., L. M. Rebelo, S. S. Sellamuttu and S. De Silva (2010), *Wetlands, Agriculture and Poverty Alleviation: Appropriate Management to Safeguard and Enhance Wetland Productivity*. IWMI Research Report: 137, Colombo: International Water management institute
[36] McConnell, K.E. (1985), "*The Economics of Outdoor Recreation"*. Amsterdam, The Netherlands: Elsevier Science.
[37] Meyer, J.L., D.L. Strayer, J.B. Wallace, S.L. Eggert, and G.S. Helfman, (2007), "*The Contribution of Headwater Streams to Biodiversity in River Networks"*. Journal of the American Water Resources Association. 43, DOI: 10.1111/j.1752-1688.2007.00008.x
[38] Mitchell, R.C. and R.T. Carson. (1989), *Using Surveys to Value Public Goods: the Contingent Valuation Method (Resources for the Future)*. Washington, D.C.
[39] Naiman, R.J., J.M. Melillo, M.A. Lock, T.E. Ford, and S.R. Reice (1987), "*Longitudinal Patterns of Ecosystem Processes and Community Structure in a Subarctic River Continuum"*. Ecology 68:1139-1156.
[40] Portney, P. (1994), "*The Contingent Valuation Debate: Why Economists Should Care"*. Journal of Economic Perspectives 8(4): 3-18.
[41] Rapport, D. J. and W.G. Whitford (1999), "*How Ecosystems Respond to Stress: Common Properties of Arid and Aquatic Systems"*. Bio Science, 49: 3, 193-203; 53 ref.
[42] Renzetti, S., D. Dupont and J. Bruce (2010), *Economic Value of Protecting the Great Lakes, Literture Review Report*; Marbek, for Ontario Ministry of the Environment.
[43] Soontornprasit, K. and C. Meksumpun (2008), "*Analysis of Aquatic Ecosystem Response for Zone Management of Ban Pho Town, Chachoengsao Province, Thailand*". Kasetsart Journal Natural Sciences. ; 42(3): 513-521
[44] TEEB (2010), *The Economics of Ecosystems and Biodiversity: Mainstreaming the Economics of Nature: A Synthesis of the Approach, Conclusions and Recommendations of TEEB*. United Nations Environment Program. http://www.teebweb.org
[45] Thoms, M. and P. Cullen (1998), "*The Impact of Irrigation Withdrawals on Inland River Systems"*, Special issue. Water in rangelands. 20: 2, 226-236
[46] Tockner, K. and J. A. Stanford (2002), "*Riverine Flood Plains: Present State and Future Trends*". Environmental Conservation, 29: 308-330
[47] Tuan, T. H., M. V. Xuan, Do Nam, S. Navrud, (2009), "*Valuing Direct Use Values of Wetlands: A Case Study of Tam Giang–Cau Hai Lagoon Wetland in Vietnam*". Ocean & Coastal Management 52 (2): 102–112. http://dx. doi.org /10.1016 / j. ocecoaman.
[48] UNEP (2006), *Marine and Coastal Ecosystems and Human Wellbeing: A Synthesis Report* Based on the Findings of the Millennium Ecosystem Assessment. UNEP, Nairobi. 76 pp.
[49] UNEP (2009), *Water Security and Ecosystem Security-The Critical Connection, A Contribution to the United Nations World Water Assessment Programme* (WWAP), UNEP, Nairobi.
[50] UNEP (2009a), *Ecosystem Management Programme. A New Approach to Sustainability*, United Nations Environment Program. Nairobi, 24 pp
[51] UNEP (2010), "*Blue Harvest: Inland Fisheries as an Ecosystem Service"*. Penang: World Fish Center.
[52] UNEP (2011), *Ecosystems for water and food security*, Background Document, UNEP-IWMI van der Ploeg, S., R. S. de Groot and Y. Wang (2010), *The TEEB Valuation Database: Overview of Structure*, Data and Results. Foundation for Sustainable Development, Wageningen, The Netherlands.
[53] Wang, G. and G, Cheng (2000), "*The Characteristics of Water Resources and the Changes of the Hydrological Process and Environment in the Arid Zone of Northwest China*", Environmental Geology. 39: 7, 783-790; 16 ref.
[54] Wipfli, M.S. and D.P. Gregovich (2002), "*Export of Invertebrates and Detritus From Fishless Headwater Streams in Southeastern Alaska: Implications for Downstream Salmonid Production"*. Freshwater Biology 47:957-969.
[55] WRI (World Resources Institute) (2005), *The Wealth of the Poor: Managing Ecosystem to Fight Poverty*. World resources institute
[56] Yamashiki,Y., T Nakamura, M. Kurosawa and S. Matsui (2006), "*Ecosystem Approach to Mitigate Impacts of Sedimentation on the Hydrological Cycle and Aquatic Ecosystem"*. Hydrological Processes. 20(6): 1273-1291
[57] Yousuf, A. R., F. A. Bhat and M. D. Mahdi (2006), "*Limnological Features of River Jehlum and its Tributaries in Kashmir Himalayan with a Note on Fish Fauna*", J. Himalayan Ecological Sustainability Development. Vol.1.