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River restoration

5.1 Meaning and significance

Rivers, a composite arrangement of flowing water draining specific land surfaces, are among the most significant landscape features and prime source of freshwater. Seasonal flow regime fluctuations, erosion, deposition, flooding etc are integral part of their process-response mechanism. However, globally rivers are under enormous stress in the present times. Numerous anthropogenic interventions of diverse magnitudes over rivers and their floodplains have caused severe consequences and in many instances the fluvial processes are disturbed beyond resilience limit [150].

Incessant degradation of river ecosystems and loss of aquatic biodiversity are prevalent in today's world. Hence, river restoration has evolved as an important approach for addressing water resource management issues with an aim to alter past degradation of freshwater ecosystems. River restoration also prioritizes the concerns to diminish the anticipated damage to freshwater from future developmental processes

and resource- extraction activities. Thus, river restoration is presently at the forefront of applied hydrologic science [25].

River restoration is an umbrella term which incorporates activities of river rehabilitation, river reconstruction, river revitalization, river enhancement and habitat improvement. Muhar et al (1995) [151] defined river restoration as the totality of measures which change man-induced alterations to rivers (primarily flood control measures, but also diversions etc.) in such a manner that the ecological functioning of the new state resembles a more natural river. Thus in a broad sense, river restoration aims to re-establish the eco-hydrological integrity of a degraded river system.

Although the concept of river restoration has received widespread attention in recent times, yet proper scientific strategies regarding this is vastly lacking all around the world and most particularly in developing nations like ours. Majority of the river restoration measures are nowadays a site specific activity, driven by a single driver like water quality improvement or flood protection works etc rather than based on scientific strategic planning. Clarke et al (2003) [152] stated that sustainable river restoration can only be achieved if it is carried out under a proper process-driven and strategic framework with impetus from multidisciplinary fields.

Benefits of River Restoration

Streams and rivers that function well with healthy aquatic ecosystems bring benefits to the entire area as well as to the neighborhoods adjacent to streams. Better functioning streams and rivers mean:

- Better flood control
- Less trash in and around local water bodies
- Reintroduction of wildlife species
- Better protection of wetland areas
- Improved aesthetics for clean and well-functioning waterways
- Stabilized stream banks
- Reduced local pollution, and reduced pollution flowing downstream
- Improved habitat for fish, amphibians, insects, and other aquatic organisms that compose a balanced ecosystem food chain
- Cooler waters, which make it easier for fish to survive

5.2 A review of theory and practice

River restoration is accepted by wide section of stakeholders as well as the government agencies as a viable option and a critical complement to conservation and natural resource management. Stakeholders from different fields have different perceptions regarding the meaning of river restoration. The most acceptable definition of river restoration was given by Wohl et al (2005) [27] who defined it as assisting the establishment of improved hydrologic, geomorphic and ecological processes in a degraded watershed system and replacing lost, damaged or compromised elements of the natural system. Here the elements of natural system largely include the hydrological regime, water quality and ecosystem dynamics.

While, the efforts of river restoration have increased exponentially over the last few decades, yet substantial evidence of failure of restoration projects with minimal scientific inputs are a common scenario [38 and 151]Hence, research agenda

related to river restoration should advance on scientific basis [27]. The traditional view of river restoration as a reactive, site specific activity needs to be changed into a framework of pro-active planning where restoration occurs at a landscape and catchment scale. Spatial as well as temporal considerations are fundamental to river science. The natural timing, frequency, duration, magnitude and rate of change in flows (the natural flow regime) are all crucial in governing ecological processes along a stream [22]. Since, all the physical, chemical and biological fluvial processes are interrelated in complex ways across watersheds and across timescales, hence it is assumed that restoration projects are likely to be successful in achieving goals if considered at the context of the entire watershed. The time element has gained importance because of the fact that successful restoration projects should unavoidably take into account the dynamic and temporal processes in rivers like migrations of river beds and even wetland dynamics. Moreover, general background knowledge regarding the river dynamics (discharge regime, sediment transport, lateral and longitudinal connectivity, water quality and ecosystem dynamics) based on historical databases acts as a foundation stone for the science of river restoration.

Lastly, in addition to the hydrological as well as ecological concept of river restoration plan, social undertaking is also of equal importance [153 and 154]. Restoration success is often judged on social considerations and societal perceptions and expectations of ecosystem performance ultimately determine the viability of a river management option. Norton (1998) [155] argued that educating the public about the relations between the operation of a river and its delivery of valued amenities is critical. Currently the participation of stakeholders in restoration decisions is rising and they have varied preferences, institutional mandates and proficiencies. Hence,

river scientists should play a critical role in conveying the recovery trends of a given river restoration plan to the public in a meaningful way so that the stakeholders can evaluate the progress rate and the cost-effectiveness of the same. Hostmann et al (2005) [156] establishes the stakeholder values in decision support for river rehabilitation.

In nutshell, self-sustaining, ecologically successful and sociopolitically acceptable river restoration efforts need to be designed in relation to broad spatial (watershed) and temporal context in order to revive the degraded river systems of the world. Therefore, the overall spatio-temporal concept of river restoration involves the following broad initiatives:

- i. Maintenance of proper discharge regime
- ii. Enhancement of water quality
- iii. Management of riparian zones
- iv. Improvement of in-stream habitats
- v. Improvement of upstream/downstream connectivity
- vi. Establishment of lateral floodplain connectivity
- vii. Stabilization of river banks

5.3 Key limitations to river restoration

Various shortcomings are encountered during the designing and implementation of river restoration processes. The limitations generally encountered in achieving restoration goals can broadly be categorized into two classes (1) scientific limitations and (2) non-scientific limitations [157]. Scientific limitations

include lack of scientific knowledge on watershed-scale fluvial process dynamics, inadequate information on crucial ecosystem conditions, unavailability of consistent temporal data, and inadequate synthesis of available information during restoration model development. Lack of sophisticated institutional structures that support large scale adaptive measures is also a scientific limitation towards achieving restoration goals in developing countries like India. Non-scientific constrains largely incorporate infeasibility of certain desired restorative actions (e.g. eradication of infested exotic species, reintroduction of extinct native species), philosophical differences among the diverse group of stakeholders under direct impact and conflicting interests among them over issues like bearing or sharing the social and economical costs of restoration. Last but not the least, lack of political support and proper fund release acts as a hindrance in accomplishing river restoration goals.

In order to attain a sustainable river restoration outcome, it is therefore necessary to address these issues properly and to establish co-ordination among various sections of the society for implementing the restorative actions.