# CHAPTER VII

# MANAGEMENT OF ABANDONED CHANNELS

## 7.1 Introduction:

The fluvio-dynamic characteristics of the River Sankosh in the study area and its frequent changes and abandonment of courses counts for adequate academic importance from behavioral point of view of alluvial channels in the zone of sub-Himalayan margin. The areas associated with abandoned courses in the lower course of the basin have significant importance from the socio economic and environmental point of view also. Therefore, an attempt has been made in this chapter to investigate some important unexplored facts about the restoration, conservation and management of abandoned channels which are supposed to be more useful to socio-economic development as well as risk reduction for human habitation and sustainable use of lands of the surrounding channels areas in the studied basin.

## 7.2 Management strategies and recommendations of abandoned channels:

Abandoned channels are recognized as important elements of alluvial river system (Julian, P.et al. 2008). These abandoned channels provide huge natural resources for habitation of some organism having much economic value such as the cultivation of fishes and other aquatic resources. Moreover, surrounding areas of the abandoned channels and the substrate can be used for agricultural production of necessary crops and can also be used as the source of irrigation.

But, abandoned channels of the River Sankosh in the study area are facing different kinds of problems due to huge population pressure, land use change, climatic change and environmental change day by day. In this regard, some major problems of abandoned channels of Sankosh River basin have been broadly summarized as:

I. Shrinkage of channel area due to encroachments, settlements and others.
II. Hydrologic alterations, due to direct surface drainage, de-watering by consumptive use of surface water inflows, unregulated draw down of unconfined aquifer from either groundwater withdrawal or by stream channelization by various anthropogenic activities.

III. Increase of sedimentation, nutrient, organic matter, metals, pathogen and other water pollutant loadings from wastewater discharges from the adjacent areas.

IV. Continuous overexploitation of channels resources and products.

V. Occurrences of more insidious chemical and deposition of various pollutants into water bodies of the abandoned channels mainly by both from the agricultural pollution and bathing of domestic animals.

VI. Changes in characteristics of channel flora and fauna (exotic) due to the change of water quality etc. as a result of change in the adjacent land uses deliberately or naturally.

Based on the above-mentioned problems, appropriate management and restoration mechanism is required to be implemented to regain and maintain sustainability of the abandoned channels of the Sankosh River in the study area. In this regard, some important proposed recommendations and management strategies have been discussed under the following heads.

### 7.2.1 Conceptual Framework for management of abandoned channels:

This study has summarized a number of articles and literature reviews regarding management of abandoned channels with several examples from national and international levels. Abandoned channels need a collaborated investigation involving natural, social and inter-disciplinary study aimed at understanding and analysing various components, such as, monitoring of water quality, socio-economic dependency, biodiversity and other activities as an essential tool for formulating conservation strategies for long term (Kiran et al., 1999).

A developing country like India has an important need to analyze and ensure proper management of abandoned channel due to high population growth and economic development. On the other hand, there have emerged some pressures including resource exploration, expansion of built up area, agricultural development, shifting livelihood patterns by these drivers which make some changing scenario about physical, biological and socio-cultural attribute in the abandoned channels in the study area. There is an urgent need to take some necessary action or management to reduce ecological degradation of abandoned channels and reserve the sustainability of socio-economic development of the local people. In this context, we need long term actions and conservation policies for the sustainable use of abandoned channels and its restoration.

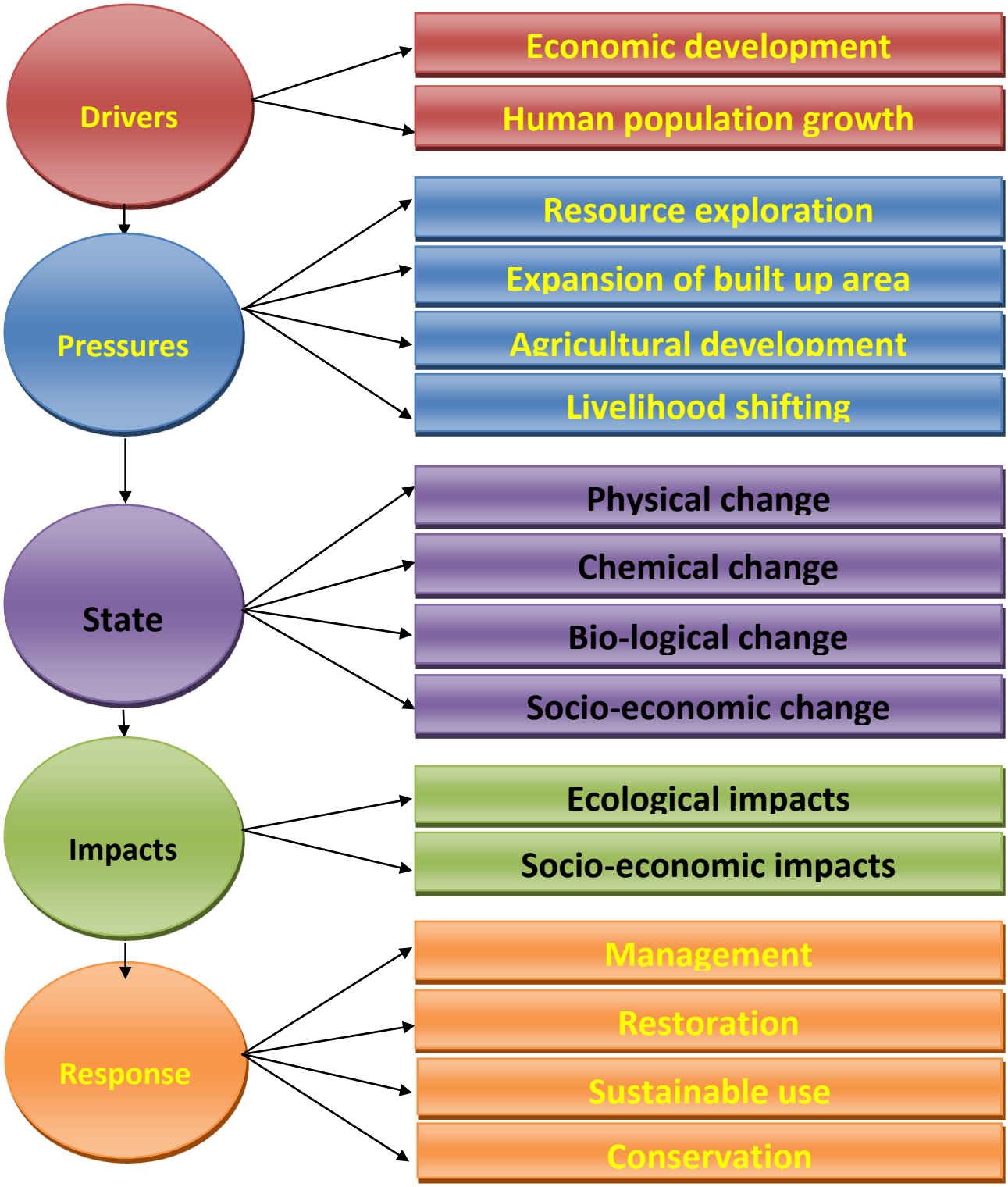


**Figure 7.1 Conceptual Framework for Management of Abandoned Channels**

A conceptual framework has been prepared with the objective that addresses levels of interventions required for prioritisation (Committee on Restoration of Aquatic Ecosystems et al, 1992).

### 7.2.2 Guidelines for Abandoned Channels Management:

The watershed management program generally involves activities to protect, restore, manipulate, and provide for the functions and values emphasizing both quality and acreage by advocating sustainable usage of them (Walters, C. 1986). An intense monitoring, interaction and co-operation among the various agencies (state departments concerned with environment, soil, natural resource management, public interest groups, citizen groups, agriculture, forestry, urban planning and development, research institutions, government, policy makers, etc.) has required for the management of abandoned channels in the study area. Some important guiding principles have been discussed below to manage, restore and conserve the abandoned channels.

I. Management goals should not only involve buffering channels from any direct human pressures that could affect the channels normal functions, but also in maintaining important natural processes that operate on them that may be altered by human activities.
II. Channel management has to be an integrated approach in terms of planning, execution and monitoring requiring effective knowledge on a range of subjects from ecology, economics, watershed management, and planners and decision makers, etc. All this would help in understanding channels better and evolving a more comprehensive solution for long-term conservation and management strategies.
III. In this context, it summarizes that there are multiple formations and problems that are associated with all abandoned channels but it needs some management effort which provides benefit to local people with long-term effectiveness.

### 7.2.3 Restoration:

Abandoned channels are important elements of an alluvial system. These channels can provide habitat for wildlife, biodiversity of aquatic habitat and huge natural resources for the livelihood of the local people. But there are some important problems such as shrinkage of abandoned

channel area, reduction of water level, increase of non-point source pollution that can affect aquatic environment and resources of the abandoned channels. Moreover, these problems also adversely impact the socio-economic life of the local people inhabiting the surroundings of the studied abandoned channels. So, restoration of abandoned channels is essential to solve the above-mentioned problems and to preserve them in the study area.

Restoration is here defined as returning to a pre-disturbance physical state of an abandoned channel. It is also mention that river restoration as assisting the recovery of ecological integrity in a degraded watershed system by re-establishing hydrologic, geomorphic, and ecological processes, and at the same time replacing lost, damages or compromised biological elements. Different types of restoration efforts are to be applied for abandoned channel management. Restoration denotes re-establishment of pre-disturbed aquatic functions and the related physical, chemical and biological features (Cairns, 1988) which aim to emulate environmental and a self-regulating system that is integrated ecologically with the landscape and the functions that the abandoned channels execute.

In this study, it was typically found that most of the abandoned channels along the main stream i.e. River Sankosh has formed due to cut-off (chute cut-off and neck cut-off both) and avulsion also. In this regard there are some management practices to restore the abandoned channels. In this context, engineering solution consists of construction of weir, hydraulic dredging, connectivity with the main river are some most impactful restoration methods to conserve the abandoned channels. Some agronomic methods by BMP include agriculture-stream buffers and bank stabilization, preventing neck cut-off, and erosion control are very important. In all of these cases, all types of restoration have valuable benefits and effectiveness for the entire abandoned channels.

#### 7.2.3.1 Hydraulic Dredging:

Hydraulic dredging is an important restoration process or operation of excavating materials from a water environment for the purpose of improving existing water features. It helps in reshaping land and water features to alter drainage, navigability and use of aquatic resources for socio-economic development of the local people inhabiting the surrounding of the abandoned channels. It also acts to suck up and filter the bottom to remove contaminants and increase the depth of

water level of the abandoned channels. Moreover, as a concern of environmental sensitivity, hydraulic dredging seems to be the more effective method to restore abandoned channels in the study area. Furthermore, the abandoned channels are experiencing undue macro-phytes and algal bloom, thus restoration strategy has been constructed to remove the organic, nutrient rich sediment and deepen channels as experienced through Collins Lake, which is an oxbow lake along the Mohawk River in Scotia, New York restored through hydraulic dredging in 1977 and 1978 (Snow et al. 1979). It is best used for abandoned channel restoration technique. In this regard, it is mentioned that Kamandanga beel (Figure 6.8) and Khalishamari beel (Figure 6.7) need to operate hydraulic dredging to restore the depth of water level and aquatic environment in the study area.

#### 7.2.3.2 Connectivity with Main River:

The hydrological connectivity of these studied abandoned channels usually decreases in time due to fast and complex sedimentation processes occurring in the upstream entrance and downstream sections of the abandoned channels in the study area. In this regard, numerous restoration projects can be applied to reconnect the upstream and downstream ends of abandoned channels to the main river to re-establish connectivity and enhance the quality of ecological habitat (Holubova et.al, 1999; Baptist and Mosselman, 2002). It is also mentioned that the morphodynamical behavior of the entrance and exit of the abandoned channels plays a significant role in the success of such reconnection method in the study area.

Moreover, it is observed that erosional and depositional processes are taking place at the entrance of an abandoned meander or any avulsed abandoned channel, where the exit is still connected to the main channel, but the upstream entrance is closed. In such a condition, this method suitability applied to re-connect abandoned channels with main river to restore them. Here, Nayachhara (Figure 6.10) and other avulsed abandoned channel (Figure 6.12) can be mentioned as being possible to be reconnected their upstream entrance with the main river.

#### 7.2.3.3 Best Management practices (BMP):

The main objective of Best Management Practices (BMP) is to implement edge-of-field practices and agronomic methods including conservation of tillage and winter cover crops to reduce non-point source pollutants from agricultural run-off (Cullum et al., 2006; Knight et. al., 2002). In

relation to this restoration program, BMPs help in correcting point and non-point sources of pollution wherever and whenever possible and to restore aquatic environment including natural resources in the study area. This program along with the implementation of rules, regulations and planning strategy for wildlife habitat and fishes helps in arresting the declining water quality and the rate in loss of abandoned channels. It is also mentioned that intensive planning, leadership financial support and active involvement from all levels of organization (governmental, NGOs, citizen groups, research organizations etc.) are required to achieve the goal of this restoration program in the study area.

In the study area, BMPs can be applied in Khalishamari abandoned channel (Figure 6.8) to reduced sedimentation, nitrogen, phosphorous with the implementation of agronomic methods including crop rotation.

**7.2.3.4 Planning of buffer zones:**

Creation of buffer zones limiting anthropogenic activities around the selected sites of the abandoned channels along the river Sankosh could revive their natural functions. In this regard, Castelle et al., 1994 has mentioned some important criteria for determining adequate buffer size to protect various abandoned channels and their aquatic resources. These are as follows:

- Identify the functional values by evaluating aquatic resources within the abandoned channels in relation to their economic cost.
- Find out the magnitude and source of disturbances, landuse and identify the possible consequences of identify the possible consequences of such stress in long term perspective.
- Buffer characteristics such as vegetation density, structural complexity, soil condition and other conditions are to be taken under consideration.

During the field study it is observed that some areas of Khalishamari beel especially north-western parts are occupied by local people for their agricultural land and settlement. In this regard buffer zone can play an important role to restore the surrounding or peripheral areas of these abandoned channels. On the other hand, western part of Kamandanga beel is also densely settled. So, creation of buffer zones can reduce agricultural land and settlement human impacts by limiting easy access and acting as a barrier.

**Table 7.1: Summary of Problems and Prospects of Abandoned Channels**

| Abandoned Channel | Parent River | Type | Problems | Restoration | Benefits and Effectiveness |
|---|---|---|---|---|---|
| ***Khalishamari beel*** | River Sankosh | Natural chute cut-off | • Sedimentation<br>• Excessive Agriculture | • Construction of weir<br>• Hydraulic Dredging<br>• Agriculture-stream buffers and bank stabilization | • Prevent flow as secondary channel and flood control<br>• Agriculture and fishing |
| ***Kamandanga beel*** | | Natural Neck cut-off | • Built-up encroachment<br>• severe erosion due to neck cut-off | • Prevent neck cut-off<br>• Erosion control | • Agriculture, Livestock grazing and fishing |
| ***Purbachhara beel*** | | Natural Neck cut-off | • Excessive Agriculture | • Agronomic method by BMP | • Agriculture, Livestock grazing and fishing |
| ***Nayachhara beel*** | | Natural Avulsed channel | • Seasonal dewatering | • Construction of weir<br>• Connectivity with main river | • Agriculture, Livestock grazing and fishing<br>• flood control |
| ***Tama Nadi*** | | Natural | • Reduced fishing<br>• sedimentation | • Agriculture-stream buffers and bank stabilization | • Agriculture, Livestock grazing and fishing<br>• flood control |

Source: Data compiled by researcher.

### 7.2.4 Remedial measures for conservation of abandoned channels:

Conservation is the term associated with manipulation of an ecosystem to ensure maintenance of all functions and characteristics of the specific ecosystem. Thus, the balance of an ecosystem of any particular water body is usually accompanied by irreversible loss in both the valuable environmental functions and amenities important to the society.

In this context, a detailed study of channel management, conservation and its implications are required for socio economic development and as well as from the biological and hydrological perspective.

In this regard, it is summarized that some important measures must be taken for the conservation of studied abandoned channels. These are as follows:

**Firstly,** a short-term fix might be providing connection to the main stream by previous path i.e. nearby plug bar of the abandoned channels.

**Secondly,** to determine the sedimentation rates and evolutions along the main stream by collecting sediment core samples.

**Thirdly,** to analyse topographical maps, satellite images and aerial photographs over different time periods.

**Fourthly,** the study area surrounded by abandoned channels needs monitoring with regard to water quality, to improve biological diversity and identify the sources of pollution.

**Fifthly,** restoring the riparian agricultural land adjacent to abandoned channels to reduce inundation and sedimentation and provide bank stabilization.

**Sixthly,** there is an urgent need to assess the aquatic resources i.e. flora and fauna especially and maintain the biological importance.

**Seventhly,** to identify the functional and economic values by evaluating natural resources generated by abandoned channels in terms of the economic costs and its benefits.

**Eighthly,** the study needs some conservation strategies to protect and restore the abandoned channels to its original state.

The discussion done in the chapter 6 and 7 therefore reveals that if abandoned channels are properly managed as discussed above, the socio-economic development of the study area can be possible along with the risk reduction for human habitation and proper utilization of land resources of the study area. Therefore, the hypothesis 3 " ***Management of abandoned channels are supposed to be more useful to socio-economic development as well as risk reduction for human habitation and utilization of lands of the surrounding channels areas'*** is justified for management of the abandoned channels of Sankosh river basin.

## 7.3 Major Findings and Conclusion:

### 7.3.1 Major findings:

This Ph. D. research work has been completed with several remarkable and unknown findings of the study of abandoned channels and their socio-economic importance of the Sankosh river basin in India. There are different objectives to study and identify the several mechanisms of abandoned channel formation and its socio-economic significance. The study has the following findings based on the different objectives which are also dealt with the research issue:

I. Stream ordering and bifurcation ratio of the study area proves that the lower part of Sankosh river has a tendency to overflow or over bank flow in flood season (Map 3.1 and Table 3.1) and which influences the process of channel abandoning.

II. Flood frequency analysis (fig.3.2) and hydrograph shows that the river flow have been diverted or shifted or bifurcated by the process of channel avulsion.

III. Different types of channel avulsions are identified in different parts of Sankosh river of the study area (Map 4.1) and these are considered important processes of abandoned channel formation.

IV. In accordance to *John Field, 2001* sometimes a minor incision with a narrower channel creates channel abandonment by avulsions that are inset into the old channel bed.

V. In the study area, Sankosh River had formed a meander bend cut-off ie, both chute cut-off and neck cut-off. In this connection, sinuosity index is calculated in different parts of Sankosh river (fig. 3.4) within the study area. This mechanism is considered the main process of the formation of abandoned channels in the study area.

VI. An abandoning channel may regain discharge over the courses of next flooding events and develop a new semi-stable channel bifurcation, this occurs often in low-angle split

with a limited difference in gradient advantages and relative long period of abandoning, usually found in avulsion and chute cut-off low sinuous river (Willem H.J Toonen *et al*. 2012)

VII. Braid formation is an important process of channel abandoning and is found in different parts of the study area (Map. 4.5). In relation to this, the braided index is also calculated (table 4.1).

VIII. According to *Friend and Sinha, 1993,* difference in bar area or braided channel ratio would be influenced to changes in channel behavior in terms of aggradation and degradation processes which will have a significant result on avulsion processes.

IX. Different morphological features are also formed by the processes of channel abandoning in the study area which is extensively discussed in the Chapter No. V with suitable maps (Map 5.1)

X. Some resultant landforms are also considered as abandoned channels like oxbow lakes, meander cut-offs and meander scars.

XI. Biological and as well as socio-economic importance of these abandoned channels are also explained in a systematic way.

XII. Sustainable management of these abandoned channels is required to minimize the problems associated with them.

XIII. Abandoned channels restoration methods are suggested for proper utilization or use of abandoned channels for the benefit of local people inhabiting the surroundings of the abandoned channels of the study area.

XIV. Numerous restoration projects are to be taken up to connect the upstream and downstream ends of abandoned channels to the main flow to re-established connectivity in the study area.

XV. The channel morphology of the river system has been significantly affected by creation of dams, irrigation systems and other anthropogenic activity.

XVI. Population pressure over the abandoned channels should be controlled by law and rules governed by the state and central govts.

### 7.3.2 Conclusion

The adopted systematic approach has helped in achieving the basic objectives and research questions to complete this research work. The courses of Sankosh River have been analyzed with the remote sensing and GIS platforms and formation of abandoned channels were quantified from the point of view of fluvial processes. Identification, types and the mechanism of abandoned channel formations have been realized and documented by field investigations. Laboratory analysis and sampling tests of different variables helped to find out the mechanism of abandoned channels formation and their resultant landforms formation in different reaches of the study area. Different morphometric parameters have been calculated and analyzed to know the nature of the River Sankosh. Meander cut-offs, ie both the neck cut-offs and chute cut-offs have been analyzed in relation to the sinuosity index which is considered the fundamental mechanism of abandoned channel formation. The mechanism of channel avulsion has been investigated on the basis of overbank flow during the high flood which is also explained as another important mechanics of the formation of abandoned channels in the study reach. Meander cut-offs, channel avulsion, influences of braid formation have been observed and identified as the main mechanisms of the formation of abandoned channels in the study area.

Different erosional and depositional landforms development with the channel abandonment has been counted and analyzed to fulfill the concern objective of the research work. Abandoned channels are important elements of alluvial river system and these channels provide huge resources for the people inhabited surrounds the abandoned channel. In this regard, the socio-economic importance of these abandoned channels has been analyzed for the benefit of the local people. On the other hand, human habitation on the abandoned channel area has been made different kinds of problem are also investigated in the study reach. For this reason, restoration processes, suggested guideline and a conceptual framework, has been prepared for the proper management of abandoned channels.

Abandoned channels are generally highly productive ecosystems, providing various key benefits to the environment. Records relating to the existing ecological values of the identified abandoned channels along the River Sankosh (main stream) is inadequate in the present era. This necessitates an urgent need to make a record on the types of abandoned channels, its formation and mechanisms, morphometric, hydrological and ecological records, surrounding land use and land

cover, hydrogeology of the main stream basin, surface water quality, and socio-economic dependence, and highlight the pressure these systems are subjected to in the present context. Monitoring of water quality can be done by involving local NGOs and the regulating department of surface water, groundwater and ecology. Such programs and practices help in providing technical support and addressing hydrologic concerns, and consequently, this helps in boosting better consideration of these systems and formulating comprehensive measures regarding their management by restoration and conservation.

In the long run, it is expected that the outcome of this Ph.D. research work has fulfilled all the basic objectives of this research as well as contributed to the field of geomorphology in general and to fluvial geomorphology in particular. The research work has also demonstrated the application of geospatial technology in fluvial geomorphologic investigation.

**References:**

Baptist, M. J., & Mosselman, E. (2002). Biogeomorphological modelling of secondary channels in the Waal river. In *River Flow* (Vol. 2002, pp. 773-782).

Castelle, A. J., Johnson, A. W., & Conolly, C. (1994). Wetland and stream buffer size requirements—a review. *Journal of Environmental Quality*, *23*(5), 878-882.

Cairns Jr, J., & Niederlehner, B. R. (1996). Developing a field of landscape ecotoxicology. *Ecological Applications*, *6*(3), 790-796.

Field, J.(2001). Channel avulsion on alluvial fans in Southern Arizona, *Geomorphology* 37, Elsevier science ltd, pp-93-104.

Fox, G. A., Wilson, G. V., Periketi, R. K., & Cullum, R. F. (2006). Sediment transport model for seepage erosion of streambank sediment. *Journal of Hydrologic Engineering*, *11*(6), 603-611.

Friend, P. F., & Sinha, R. (1993). Braiding and meandering parameters. *Geological Society, London, Special Publications*, *75*(1), 105-111.

Holubova, K., Lukac, M. et. al. Restoration of the Slovak Morava River meanders, *Water Research Institute*, *Brastisalava*, Slovakia.

Julien, P. Y., & Wargadalam, J. (1995). Alluvial channel geometry: theory and applications. *Journal of Hydraulic Engineering*, *121*(4), 312-325.

Kiran, R., et.al., (1999). Status of wetlands in Bangalore and its conservation aspects. *ENVIS Journal of Human Settlements*, *16*(24), 2-10.

Knight, S. S., et.al., (2013). Effects of agricultural conservation practices on oxbow lake watersheds in the Mississippi River alluvial plain. *Soil and Water Research*, *8*(3), 113-123

National Research Council, Technology Board, Environment National Research Council (US). Commission on Geosciences, Resources, Technology National Research Council (US). Committee on Restoration of Aquatic Ecosystems-Science, & Policy, P. (1992). *Restoration of aquatic ecosystems: science, technology, and public policy*. National Academy Press

Snow Jr, T. P., Weiler, E. J., & Oegerle, W. R. (1979). New observations of interstellar abundances and depletions of boron, vanadium, chromium, and cobalt. *The Astrophysical Journal*, *234*, 506-512.

Toonen, W.H.J., Kleinhans, M.G. and Cohen, K.M. (2012) Sedimentary architecture of abandoned channel fills. *Earth Surface Processes and Landforms*,37, 459–472.

Walters, C. J. (1986). *Adaptive management of renewable resources*. Macmillan Publishers Ltd.