CHAPTER I

INTRODUCTION

1.1 Scope of study

Abandoned channels are a geomorphologic testimony of channel movement in the river valleys, (Willem H.J. Toonen, et al., 2012). They are recognized as depression in the landscape and located at the position of a formerly active channel, though typically of considerably reduced width and depth. An abandoned channel is an inactive channel, defined as a former stream channel through which water no longer flows**.**

Rivers have tendency to meander with their floodplains to balance the transport of water and sediments. As a result, both the neck and chute cut offs that occur are considered the main processes of abandoned channel formation. The neck cut off occurs when the river sediment is deposited continuously on the convex bank and sediment are eroded from the concave bend. This causes the sinuosity of the meander to increase and form a narrow neck of the land. Eventually, the neck disappears and a straight channel is formed, thus creating a cut off. When the cut off is sealed from the main channel by sediment deposition, an ox-bow lack is formed and left as abandoned channel. On the other hand, chute cut-off usually occurs when successive high-water flows develop a chute across the inside of a point bar and decreases the sinuosity of the main river channel. As a result, channel forms a bar in the river valleys and the river starts to flow as straight channel and the former channel becomes as an abandoned channel (Pierre Y. Julien et al., 2011). In this regard, it is mentioned that such channels reduce sinuosity and increase velocity gradient in flow and discharge through chute and neck leaving cut-offs which lead to the development of abandoned channels.

Abandoned channels are also the results from the channel shifting processes at various scale and channel bed avulsion (Willem H. J. Toonen, et al.,2012). On the one hand, channel abandonment occurs through stream capture when overland flow from the main channel accelerates and directs headword erosion of smaller channels heading on the fan surface (John Field, 2001). On the other hand, abandonment of channels occur where stream bed aggradations

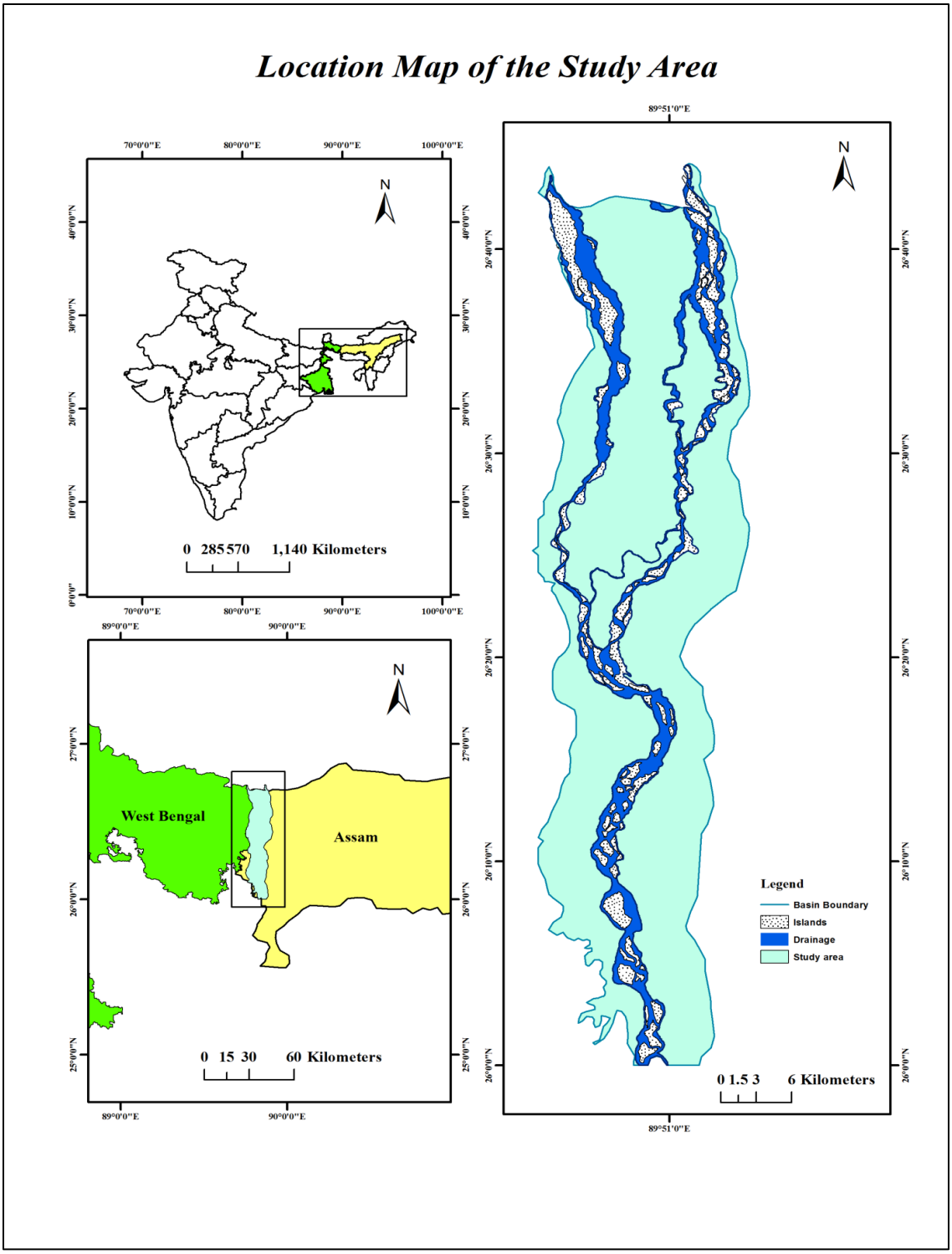
cause the stream to overflow due to climatic (Schumm, 1985) and human interferences. So, the occurrences of abandoned channel involve intricate mechanics of fluvial geomorphic processes which leave wide scope for investigation.

Abandoned channels are also important elements of alluvial river systems because these abandoned channels provide huge resources for habitation of some organisms having much economic value, e.g., the cultivation of fishes can be taken one of the examples. Moreover, abandoned channels areas and the substrate can be used for agricultural production of necessary crops. If managed in a scientific way, abandoned channels can be used as the source of irrigation. On the other hand, human habitation on the abandoned channels area can invite hazards to the cultural environment if they are not used in a scientific manner. Therefore, the study of abandoned channels and their socio-economic importance in the Sankosh river basin in India has been the focus of investigation.

Present researcher seeks to undertake detailed study of the fluvial processes of the abandoned channel formation with their associated problems and to make a value-added appraisal of the socio-economic importance of the channels' surrounding areas with some recommendations for sustainable management.

1.2 Study Area:

Sankosh River is one of the major rivers of North Bengal and Assam in India. This river system has covered up its mountainous parts of Bhutan, flowing through undulating plains of North Bengal and Assam and finally entered into Bangladesh to find its confluence in Brahmaputra River. In Bhutan, it is called as the Puna Tsang Chhu, Sankosh in India and Gangadhar in Bangladesh. The northern limit of the study area started at $26^0$44'24" North latitude where it creates boundary between India and Bhutan, and the Southern limit ends with the boundary shared between Bangladesh and India at $25^0$58'48" North latitude. The longitudinal extension ranges from $89^0$43'48" East to $89^0$55'12" East. The study area covers an area of 1012 sq.km (Map 1.1). The portion of this river basin falling within West Bengal and Assam is constituted of lower alluvial courses having significant dynamic fluvial characteristics for which frequent changes and abandonment of courses are manifested in the channel system which



Source: Compiled by researcher based on topographical map 78F/15, 78F/15 and US Army Map NG 45-8

Map 1.1: Location Map of the Study Area

counts for adequate academic importance. Such changes of the river system have also sufficient social importance from the socio-economic point of view.

On the basis of the Index map of Sankosh river catchment area delineated by Irrigation and Waterways Department, Government of West Bengal (www.wbiwd.gov.in, 2016) and the extent of the distribution of the tributaries and distributaries of the river Sankosh on the topographical maps (78F/14, 78F/15) of Survey of India (SOI) and US Army Map (NG 45-8) as well as field observations on selected sites over the adjacent areas, the study area has been finally delineated for the present study.

1.3 Review of the Related Literature

Abandoned channels are the important geomorphologic features in the alluvial river systems. They have existed in a complex geometry. Their processes of formation with related causes is an important part of the research work and at the same time, utilization of different resources surrounding the abandoned channels area and as well as their socio-economic importance and problem- related measures are also the keen interest in this research work.

Till today, some studies on the core area of abandoned channels along with few peripheral research works are found. But no Ph.D. work and research paper or book publication has been done so far on the study of abandoned channels and their socio-economic importance on the Sankosh river basin in West Bengal and Assam, India. Therefore, an attempt has been taken to fill up this gap. Following literature have been found which shows a few major and peripheral instances of the work taken under study:

1. C.W. Carlstone (1965), has studied “the relation of free meander geometry to stream discharge and its geomorphic implications”, published in American journal of science volume -263 in 1965. This article attempts to highlight that “in the study of the ancient fluvial systems one of the basic approach is to locate and investigate abandoned channels still detectable on the surface.” These provide information primarily on the late Pleistocene and Holocene changes in the environment. In this regard, it is said that based on the various morphometry and sedimentary structure of these channels various

conclusion can be made on the discharge of the forming river and the quality and quantity of its sediments.

2. Zheng Ren Xie Shunan (Qinghua university) *et al*. (1985), have studied the process of longitudinal profile adjustment of abandoned channel of the lower Yellow river in the period from 1149to 1855 which published in the Journal of Sediment Research Vol.(3) in Sept. 1985 as "The depositional profile of the abandoned channel and the main cause of continuous aggradation of the Lower Yellow River". They have mentioned two processes of longitudinal profile adjustment of abandoned channels. In the first one, the river channel adjusted its slope to meet the need of transporting the large amount of sediment coming from the Middle Yellow River and in the second stage, the whole channel profile rose continuously in order to balance the effect of the extension of the river course. Moreover, they have also explained the close relationship between the profile rising and the river courses extension which the retrogressive effect upon the river. As result, the profile of the lower yellow Rivers is quite similar to that of abandoned channel and relatively stable in the past forty years.
3. Holubova et al., (1999), in their research paper " Restoration of Slovak Morava River meanders" Phrase Project Report, Water Research Institute, Bratislava Slovakia has mentioned numerous restoration projects to connect the upstream and downstream ends of abandoned channels to the main flow to re-established connectivity". In this regard, the morpho-dynamical behaviour of the entrance and exit of the abandoned channel plays an important role in the success of such reconnection measures.
4. John Field., (2001), has studied the "channel avulsion on alluvial fans in southern Arizona"; published in American journal of 'Geomorphology' volume no-37, September 4, 2000. He stated that "An uninterrupted sequence of sediment-charged small flows, however, will eventually begin to back-fill the wide channels as vegetation growth stabilizes the bank. The stabilized and back-filled channels are now prone to abandonment during large floods because the decrease in the channel's capacity leads to the generation of overland flow beyond the margins of the shallower channels.

In this regard, it is found that the action of the small aggrading floods is critical in the avulsion process since the greatest amount of overland flow is generated where bank

heights are low. As a result, both small and large floods are effective agents of landscape charge on the fans.

5. J.Steiger , A.M Gurnell and G.E. Petts (2001) have studied " Sediment deposition along the channel margins of a reach of the middle river Severn" published in the journal "Regulated Rivers: Research and Management", volume-17. Authors stated that "In channel deposition not only causes shallowing, but importantly also narrowing of the abandoning channel. This is caused by sedimentation at higher rates at the boundaries of the abandoned channel, which with help of establishing vegetation converts from a lacustrine environment into a terrestrial environment at accelerated pace".

6. C. Amoros and G. Bornette (2002), has explained the "Connectivity and bio complexity in water bodies of riverine floodplains" in their book "Freshwater Biology" and explained the hydrological connectivity of the abandoned channels to the main channel flow. In this regard, it is mentioned that the hydrological connectivity of the abandoned channel usually decreases in due course of time due to fast complex sedimentation process occurring in the upstream entrance and downstream exit of the abandoned channels.
7. J.C Rowland *et al*. (2005), have explained in title "Tie channel sedimentation rates, ox-bow formation age and channel migration rate from optically stimulated Luminescence (OSL) analysis of floodplain deposits ", published in the journal "Earth surface process and Landforms" volume-30. This article attempts to highlight "Downstream plug bar growth into the abandoned channel depression can be compared with delta propagation, as some of the discharge remain directed into the abandoned channel and produces distinct fore sets in the plug bar body". As mentioned above, it is found that the maturity of the plug bar greatly influences the sedimentary process in the distal part of the abandoned channel, as well as sedimentary processes and accumulation rates of channel fill during the next stages of disconnection.

8. WANG Yuan-ying (2007), have studied the Identification and application of abandoned channel in Meander River which published in the Journal of Daqing Petroleum Institute.

They have developed the logging model micro-facies and the method for identification and area grouping of abandoned channel.

9. ZHOW Xin-mao et al.(2010) have published their research work on the Journal 'Natural Science', Journal of Xi'an Shiyou University as the title "Analysis on the types and the sedimentation mechanism of the abandoned channel in meandering river and they explained the sedimentation mechanism of the abandoned channel based on the analysis of sedimentary evaluation characteristics Yakeshi segment of Hailaer river".

10. Willem H.J Toonen *et al*. (2012), published an article as the title "Sedimentary architecture of abandoned channel fills" in the journal "Earth surface processes and Landforms" volume-37, on 27 January in 2012. The author stated that "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". In this regard, it is mentioned that cut-off did lead to full abandonment of a meander channel.

11. John D. Horn, Robert M. Joeckel And Christopher R.Fielding (2012), have published their research paper as the title "Progressive abandonment and plan form changes of the central Platte River in Nebraska, Central U.S.A over historical timeframes" in the Journal entitled Geomorphology, Vol.139-140 and they explained that the Central Platte River was stabilized and abandoned during the period 1858-2006 due to the process of channel filling. They also mentioned that on the decadal scale, the channel morphology of the river system has been significantly affected by creation of dams, irrigation system by land use changes since 1900.

1.4 Hypothesis

1. Abandoned channels occur where stream bed aggradations cause the stream to overflow with rain storms.
2. Channel abandonment has positive relation with instability threshold of bank erosion.

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 channel areas.

1.5 Objectives:

The present study has been conducted with the following objectives:

1. To identify the different types of abandoned channels resulted from various fluvial processes associated with them.
2. To study the occurrences of sedimentary features associated with the abandoned channel fills.
3. To identify the problems of human practices surrounding the abandoned channel areas.
4. To manage the problems and bring out the socio-economic importance of abandoned channel areas.

1.6 Materials and Method:

The present work is divided into three successive parts:

A. Pre-field work
B. Field work
C. Post field work

A. Pre- field work:

1. Reviewed available literature from different libraries and offices regarding the abandoned channel formation and re-constructional planning of the study area.
2. Topographical maps from Survey of India (SOI) on 1:50000 scale – 78 F/14, 78F/15, 78F/16 of the year 1980-81 and on 1:25440 scale – G 45-L of the year 1927-30 and US Army Map No-NG 45-8 of the scale 1:250000 of the year 1930-33 have been used for identifying abandoned channel, preparing base map of the entire study area.
3. Historical data of rainfall from different farmhouse namely Kumargram farmhouse of Alipuduar district and Barokodali farmhouse of Coochbehar District, 2016 and sediment discharge and water discharge data had been collected from CWC offices

from Barobisha and Jalpaiguri to analyse rainfall variability and annual discharge of water and sediment.

4. The satellite images had been collected from NRSC to find out various abandoned channels in the study area and their processes of abandoning and formation along the Sankosh river over the time and space.
5. Geological data of the study area had been collected from the Geological Survey of India (GSI) to interpret the geological formation of the study area.
6. Geomorphological information's were collected from Bhuvan Geomorphological Map of West Bengal, (2005-2006).
7. Collection of others secondary data from the Department of Irrigation and Waterways, Agricultural offices and B.L.R.O offices of Coochbehar and Jalpaiguri districts of West Bengal has been included to interpret various socio-cultural aspects of the study area.

B. Field Work:

Primary data were generated by-

1. The field survey with various instruments has been conducted to generate primary data on river bank erosion, cross profile measurement, bank and bed materials, flow velocity, measurement of the area of abandoned channels etc. at various reaches of the study area.
2. Identification and mechanism of abandoned channels formation of the river Sankosh in the study area has been identified and mapped by using remote sensing data and topographical maps and then verified through field checks by collecting fluvial evidences. In this regard various satellite images of the RESOURSE SAT-1, LISS III (2016); LAND SAT-7, ETM(2017-18); LAND SAT-8, OLI-TIRS(2017-18); NBSS and LUP(2016); USGS Aster DEM (2017) have been used for preparation of maps and interpretation of data. On the other hand, land use and land cover maps of various abandoned channels had been prepared by using LISS II, BHUVAN (2018).

Table No. 1.1: List of Satellite Data used in the Present Study

Sl.No.	Satellite	Sensor	Year
1.	ASTER	Aster DEM	2017
2.	LAND SAT-7	ETM	2017
3.	LAND SAT-8	OLI-TIRS	2018
4.	RESOURCE SAT-1	LISS III	2016, 2018

3. Household survey by using questionnaire had been successfully conducted to collect various primary data relating to socio- economic conditions of the people inhabited surroundings the abandoned channels.
4. Mapping of the resulted landforms associated with the abandoned channels has been carried out by using Satellite images and Google Earth maps and verified through field checks and with the help of ground control points by using Global Positioning System (GPS).
5. Terrestrial photographs were taken during field survey to support and analyze the findings.

C. Post field work:

Geo-referencing of the topographical maps to integrate or incorporated a whole or partial with the satellite images have been made and at the same time enhancement and the digital processing of satellite images for various applications have also been done with the help of different licensed and open source of GIS packages, global positioning system(GPS) has been used for locational studies as a technique of data input and enhancement method of data interpretation wherever applicable and needful. However, some important statistical techniques have also been applied for the interpretation of primary as well as secondary data collected from the field and other sources.

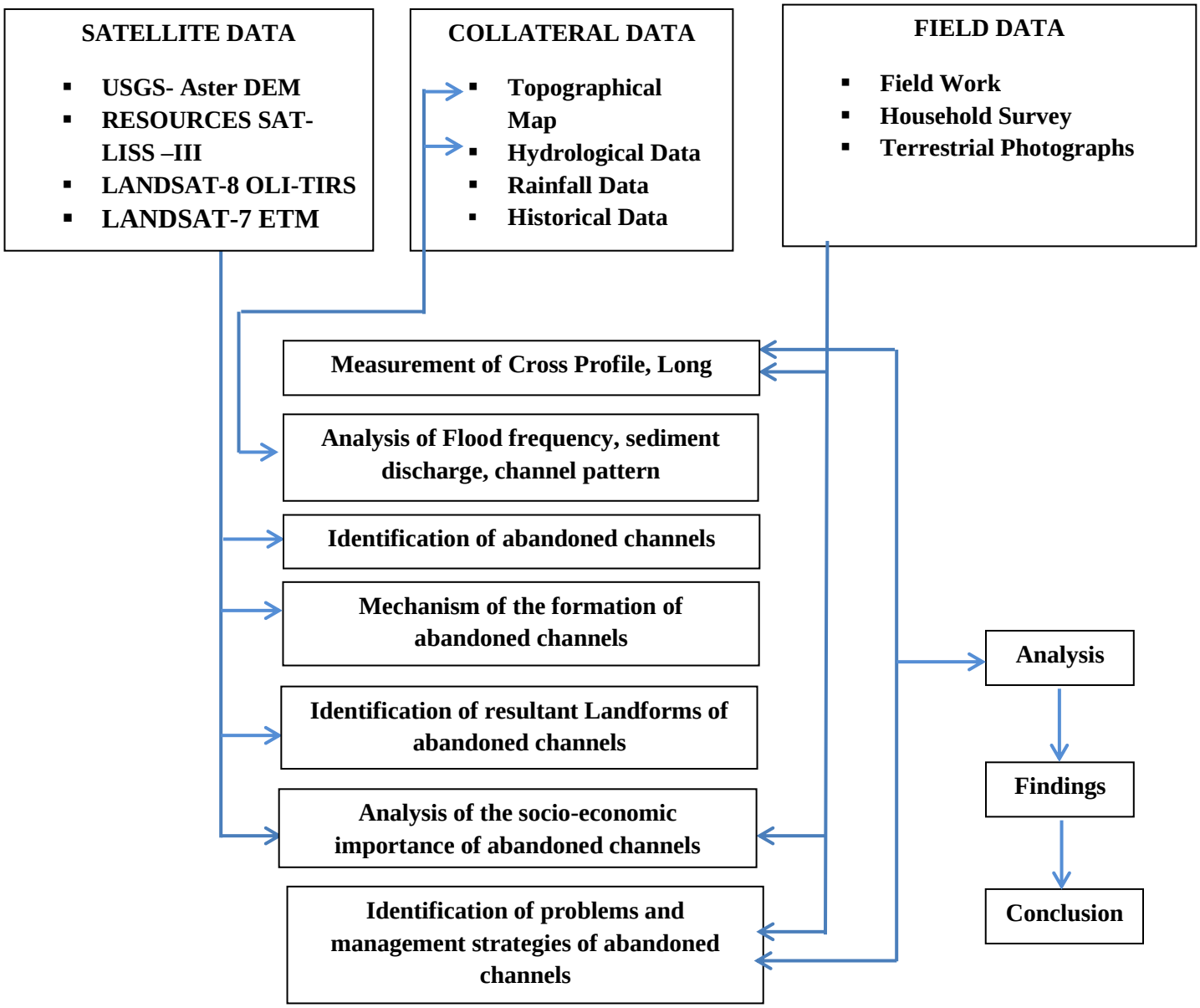


Figure 1.1 Flow Chart of the Methodology Adopted for the Present Study

To explain the methodology adopted for the present study, a flow chart has been prepared and shown in the (Figure 1.1) which provides an overview of the steps followed to complete this research work. These steps are-

1. Measurement of cross profile during field survey.

2. Analysis of water discharge, sediment discharge, channel patterns of the river Sankosh at various gauge station.
3. Identification of various abandoned channels after delineating of the study area.
4. Mechanism of the formation of abandoned channels in the study area.
5. Identification of resulted landforms associated with the abandoned channels.
6. Socio-economic importance selected abandoned channels.
7. Identification of problems and management strategies of the abandoned channels.
8. Major findings and conclusions.

1.7 Overview of Chapterisation:

The entire research work is divided into Seven chapters to fulfil all objectives of the present work. The **chapter I** includes a brief introduction of the research work with hypothesis, objectives and methodology along with the review of literatures. Physical and cultural set up of the study area has been discussed in the **chapter II** whereas the **chapter III** contains a brief morphometric analysis of the Sankosh River in the study area and also discussed about the identification of the abandoned channels. A thorough discussion about the mechanism of the formation of the abandoned channels has been analysed with the help of Remote sensing and GIS platform in **chapter IV**. In **chapter V**, various resulted landforms of the abandoned channels have been identified and explained with maps. Socio-economic importance of the abandoned channel has been investigated through field survey with the help of questionnaire in **chapter VI** and finally in **chapter VII**, various methods has been suggested for sustainable management of abandoned channels in the study area and enlisted major findings of the research work.

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