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APPLICATION OF RS AND GIS FOR SPATIO-TEMPORAL ASSESSMENT OF CHANGE IN CHANNEL NETWORK - A CASE STUDY OF NORTHERN SUB STREAM OF GODAVARI RIVER

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ABSTRACT: Geomorphologically, change in river or stream morphology and network is a continuous and natural process. Now days, such types of natural cycles have disturbed by many anthropogenetic activities. After industrialization and mainly urbanization, causes behind these have growing with fast and huge scope. The present study therefore tried to analyze the spatio-temporal changes in stream channel network, on the basis of topographical set up and allied dynamics of LULC pattern. The techniques of RS and GIS, ground truthing analysis and extensive field survey have been applied for the assessment. On the basis of micro levelled images and data, changes in the stream network have been highlighted with the help of maps. It has commonly observed that the consequence of flat topographical terrain and spatiotemporal developmental process of LULC have been created the drastic morphomatric changes in the stream. It has also observed that some streamslost their source part and some primary ordered streams have totally vanished from the drainage. Averagely, the catchment affected by the urban growth and by agricultural developmental processes at its left and right side respectively. The study concluded that restoration is not the only answer for such changes in natural processes, but it also requires taking extra efforts for safeguarding these system as it is. Otherwise, it has creating complications with unbearable situations both for natural systems and human beings.

Keywords: *Remote Sensing; GIS; Google-Earth; Geomorphology; Morphology; Stream Channel Network*

I INTRODUCTION

Stream is a form of surface water, which flows by slope under the effect of gravity. The stream hydrology has always been interacting with the characteristics of the catchment area related to geography (Poff et al, 2006), geomorphology (Walsh et al, 1998; Knox and Latrubesse, 2016), geology (Mosavi and Arian, 2015), pedogogy, climatology (Vandenberghe, 1995; Schneider et al, 2013) etc. Such interactions go through the process of weathering, erosion, transportation and deposition which design the structural changes in the overall network of the channel. It may also say that the science of stream has also depends with the aspects of hydrology (Chelsea et al., 2012; Wu et al., 2015), ecology (Paul and Meyer, 2001; Isaak et al., 2012; Abbott et al., 2018), and morphology (Leopold and Wolman, 1960; Rosgen, 1994; Huber and Huggenberger, 2015) of the drainage.

Many researchers have trying to focus on anthropogenic activities e.g. water pollution (Wang et al., 2011; Chelsea et al., 2012; Wu et al., 2015), ecological losses (Maddock, 1999; Paul and Meyer, 2001; Isaak et al., 2012, geomorphic and morphometric disturbances (Leopold and Wolman, 1960; Rosgen, 1994; Huber and Huggenberger, 2015; Roy and Sahu, 2018; Lowe et al., 2018) by construction, dumping of debris etc. They are mainly influencing on the channel and concluded that the human interferences are the most critical issue for such extreme transforms. In case of stream morphology, topography is the base of natural set up (Karuppannan et al., 2015), but manmade disruptions create the drastic structural changes in it with temporal succession. The severity of such anthropogenic activities has clearly shown more at urban hydrology than that of rural one. Douglas (1976) opined that the nature and type of hydrological impact very with the developmental process and stages of urbanization. In brief, riparian deforestation (Sweeney et al., 2004), expansion of agricultural land (Jia and Langendoen, 2014), gravels mining (Kondolf, 1997), change in pattern of land use and land cover (Boix-Fayos et al., 2007; Bhunia et al., 2016), urbanization (Hammer, 1972; Li et al, 2007; Zhou et al., 2013), urban sprawl (Graf, 1975; Kim et al., 2016), construction of roads, bridges and dams (Jones et al., 2000; Adib et al., 2016), etc are the basic activities which are affecting the stream morphology. Today, such kinds of activities and changes in channel network creating hazardous and disastrous situations mainly at urbanized zones like urban floods (Yang et al., 2016), surface and ground water pollution (Huang et al., 2016), vanishing the streams, ground water depletion (Hancock, 2002) etc. Shields et al. (2003) and Bernhardt and Palmer (2007) have been devoted to restore such high-risked channels at their study regions. For future planning, management and developments of urban areas, micro levelled restorations will be supportive for long termgrowth (Hansen, 2001; Rinaldi et al., 2016). Field surveys, observations and topographical mapping are the basic methods, which used for the structural micro levelled analysis of the channel morphology (Brasington et al., 2000). In recent trends, change detection models have been developed by many researchers with the application of Remote Sensing (RS) and Geographical Information System (GIS) for the same (Weng, 2001;Leh et al., 2011;Banerjeeet al., 2017; Sarkar et al, 2012; Khan et al., 2018; Rai et al., 2018). On these basic lines of thinking, facts and issues, the present investigation has also been designed. The northern sub-stream of Godavari river, located near the suburban part of Northern Nanded city has been selected as the study area. The sub-stream morphology is the central concept of the present research, which has been trying to assess the spatio-temporal changes. With this prime aim, the following objectives have been designed.

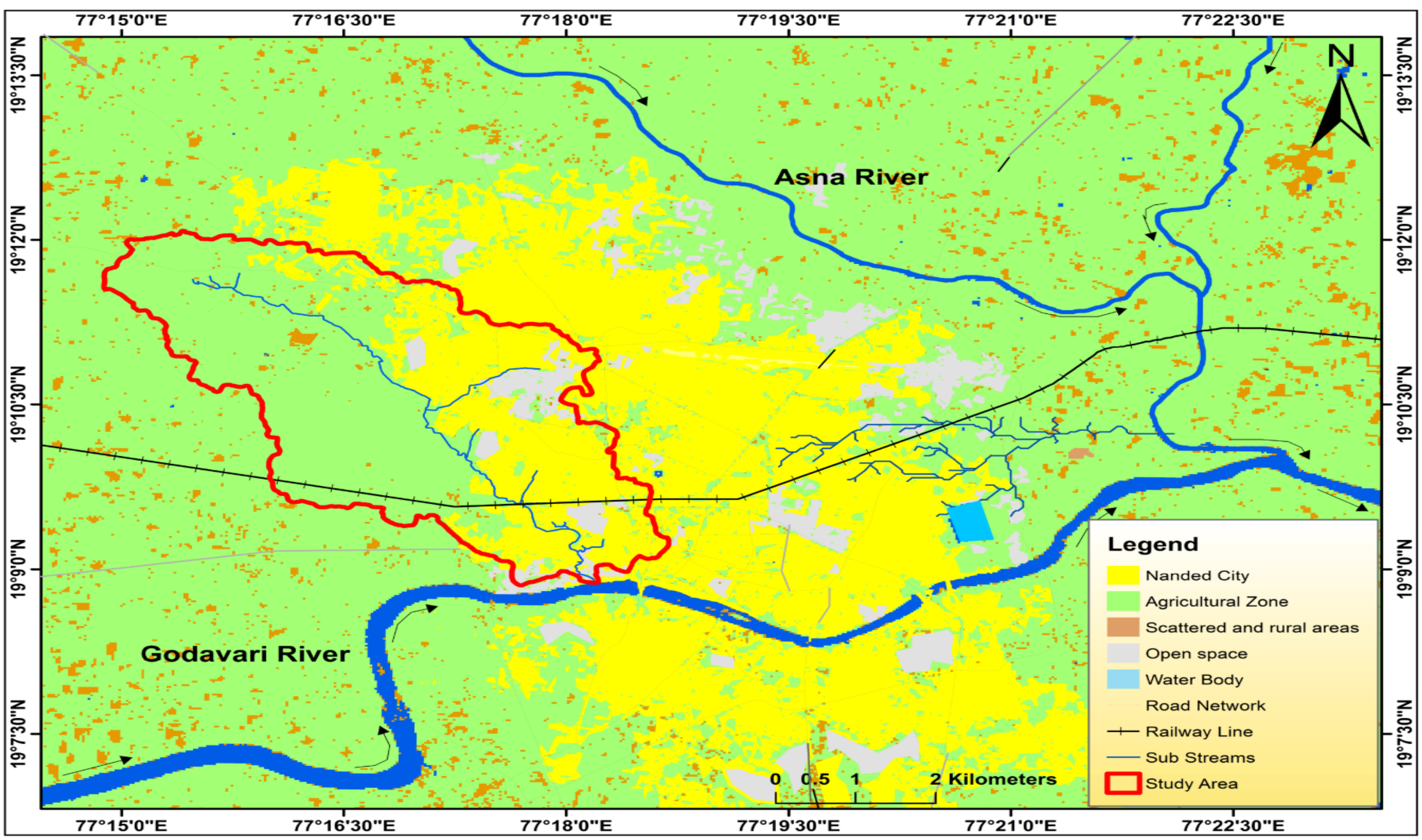
Objectives

- To understand the geographical set up,
- To carry out the morphological analysis of the stream and
- To assess the spatio-temporal changes in the stream channel network.

Study Area

The selected sub-stream is a small northern tributary of the Godavari River, which located on the western direction of the Northern Nanded city, Maharashtra, India (Figure 1). The stream is flowing from north to south direction, from the source region to the Godavari River for the distance of 9.30 km with the average width of 258.26 meter. It is a dendritic drainage pattern. At present, it has 10 first and one second ordered streams along with the main channel.

Figure 1: Location of the Study Area



(Source: USGS, Landsat Image, 2018)

The basin of the stream has occupied 23.37 sq km area, having 4.72 km width and 8.54 km length. It is almost plain area having an average 0.6 per cent slope. Most of the right hand area of the basin engaged by agricultural activities. On the opposite side, it belongs to the urban sprawl area of Nanded city, affecting on the pattern of landuse. This left side area covered mainly by scrubs, open fallow land and some agricultural practices.

II RESEARCH METHODOLOGY AND TECHNIQUES

Mainly the techniques of RS and GIS have been used for the present investigation. The study tries to assess the kind of changes in the stream channel network over the time period at micro level. For this, data and images have been utilised for the years 1972, 1985, 2004 and 2016. In addition to this, Digital Elevation Model (DEM) for the year 2008-2009 has also been used as an additional tool. The details of data have been specified in table 1.

Table1: Description of the data

Sr. No.	Type of Data	Year	Source
1	SOI Toposheet (No. 56 E/8; Scale 1:50000)	1972	Survey of India (SOI)
2	SOI Toposheet (No. 56 E/8/NE; Scale 1:25000)	1985	Survey of India (SOI)
3	Google-Earth Imagery	2004	Google-Earth
4	Google-Earth Imagery	2018	Google-Earth
6	Digital Elevation Model (DEM)	2008-2009	Bhuvan

ArcGIS, the GIS software has been used for the study of channel morphology and micro levelled analysis of the same. The techniques like unsupervised image classification, DEM analysis etc have been applied. The primary data have been collected by the intensive field observations with the help of Geographical Position System (GPS) tool. It has conducted for the purpose of ground truthing.

III RESULTS AND DISCUSSION

The junction of stream network develops within the limits of catchment zone. Such web of waterways creates the specific pattern of flow with respect to the natural setups. In 1972, 1985 and 2004, it has observed that the stream has dendritic pattern of drainage. After 2004 the stream has loosed all its past characteristics of pattern. The micro levelled image analysis have been focused on the changes in number of stream orders, its lengths and vanished part of the same, changes in width and nature of channel bed etc (Figure 2). The details of such quantitative analysis have been summarized in table 2.

Table 2: Stream Orders and Length

Stream Orders	1972		1985		2004		2018	
	Number	Length (km)	Number	Length (km)	Number	Length (km)	Number	Length (km)
1st	27	18.43	13	10.85	20	8.06	12	5.02
2nd	7	4.21	02	5.90	07	7.81	03	7.76
3rd	2	4.90	01	3.45	01	4.95	01	1.37
4th	1	3.29	----	-----	-----	-----	-----	-----
Total	37	30.83	16	20.20	28	20.82	16	14.15

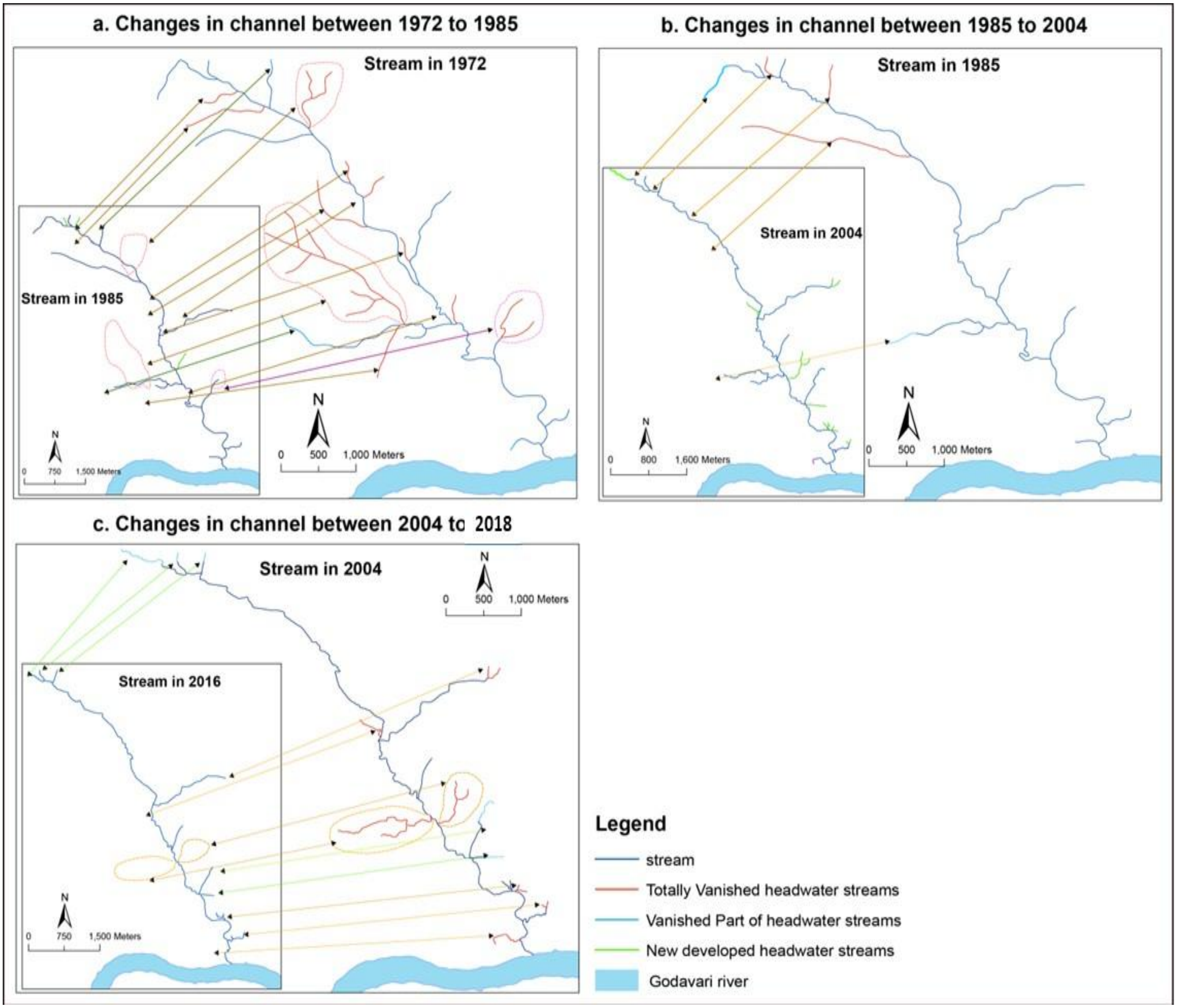
(Source: SOI Toposheets and Google-Earth Imageries)

Strahler's stream ordering method (1952) has been applied for the numbering of the branches of the selected stream. The individual headwater streams assigned as 1st order, the orders succeed as 2, 3, 4…. and so on with confluence of two same order streams. The length of any ordered stream measured from its source to the junction of the next order stream. The main stream length calculated from the source region to the mouth of the course.

a) Vanished and newly developed streams

The present study analysed the images for the year 1972, 1985, 2004 and 2016 and its results have been shown in figure 2. These maps have mainly demonstrating the transformations of streamsat micro level. In 1972, there has a main tributary with its about 8 first ordered streams on right hand side of the selected stream, which has totally vanished between 1972 and 1985 (Figure 2a). From the same side, about 4 first ordered streams have also been disappeared. In addition to this, 6 first and 1 second ordered streams from left side has also been vanished in the period. It results that about 10.63 km length of stream has been reduced by the effects of permanently vanished and removed some part of the headwater streams.

Figure 2: Change in Stream Channel



(Source: SOI Toposheets and Google-Earth Imageries)

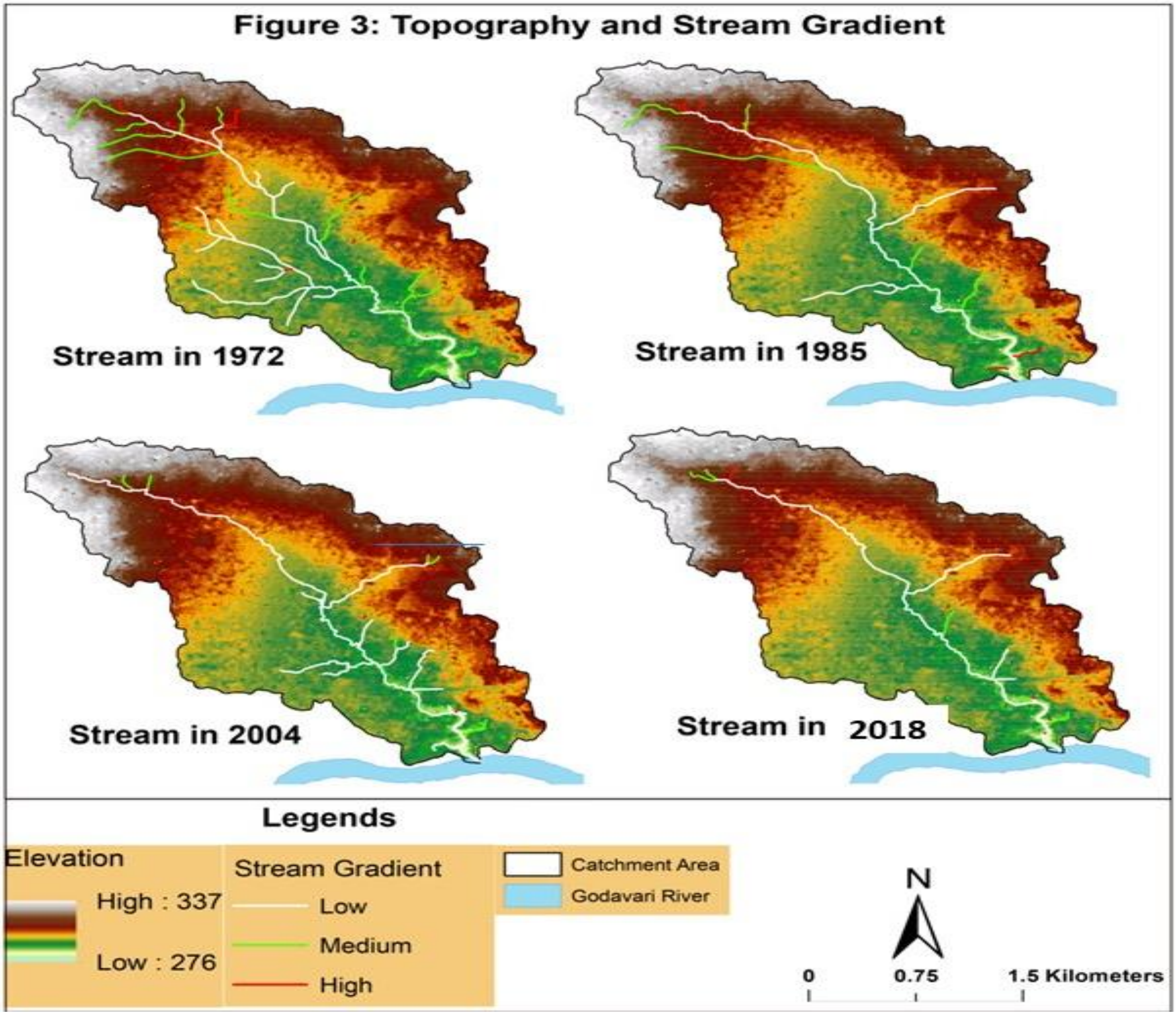
In case of 1985 and 2004, the positive transformation found about the number of stream orders and totallength of the stream (Figure 2.b). This constructive change occurred due the new developed streams on the left side i.e. eastern part of the watershed, which has influenced by the urban sprawls.

Comparing data of 2004 with 2018, the stream drops down all its past features with the depletion of numbers and length of headwater streams (figure 2.c). According to the previous two change detection models, after 2004 the stream neither increased the total length nor created a single new headwater stream.

As already discussed, the present study region has a part of developing urban and suburban areas of northern Nanded city (Figure 1). It results;the land possesses with the dynamic nature of manmade utilizations. The study trying to analyze such characteristics of LULC (land use and land cover) pattern, changes and its sequential impacts on stream channel network. For this, it is necessary to understand the role of topographical set up of the catchment. It has also have an importance to check micro levelled gradient of the stream for the study of channel morphology and bed structure.

b) Topography and Stream Gradient

For the study of gradient, Carto-DEM 2008-2009 image has been analysed. The topographical aspects and associated stream gradient have been calculated and presented with the help of one time digital elevation model.



(Source: SOI Toposheets and Google-Earth Imageries)

The end results have been put forwarded after itgetting correlation with Google-Earth elevation profile, in-depth field surveys and ground truthing analysis. The catchment zone has an very plain landscape with 0.6 per cent average slope, which has great influence on the headwater streams.

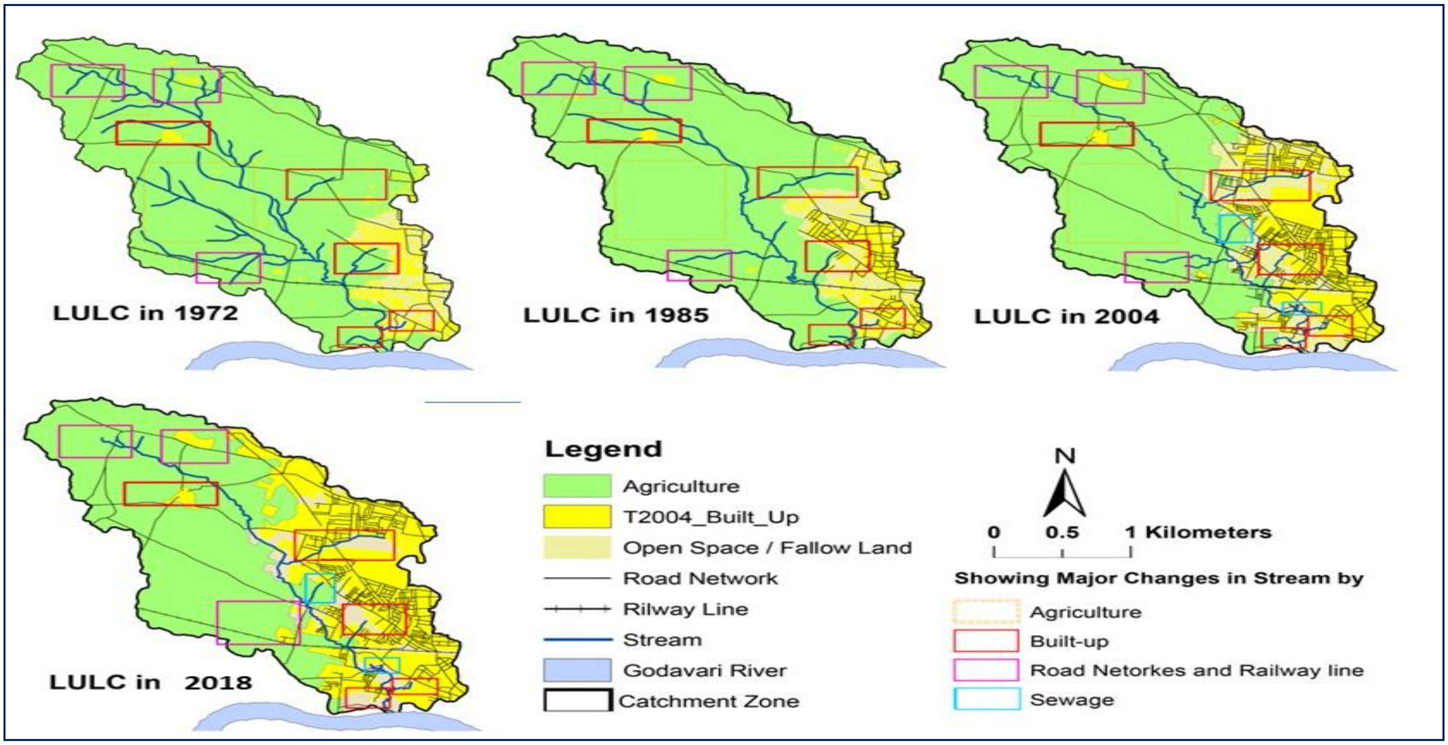
The eastern part of the catchment area has little variation of terrain than that of western (Figure 3). These maps clearly showing the effect of nature of gradient on vanished and newly created streams.

It has therefore these streams have some common characteristics, which are mainly affecting by the natural geomorphological cycle. Such types of changes have observed on right side of the stream, where the influence of urban sprawl has comparatively very low. On the other side, some streams have vanished permanently and some losses their portion of source, caused by dumping for development of plots, roads, and other such urban purposes. In addition, some tiny ponds and new streams have created which are the results of horizontal expansion of the city. Most of them have storing and carrying domestic waste water like open sewage. In short, it happened only because of the type of topography and very low gradient of the area.

c) LULC Analysis

There are four basic manmade activities e.g. agricultural changes, development of roads and bridges, growth of urban build-up area and increase in waste water in open sewage lines, which have vanishing natural or creating new streams.

Figure 4: Change in LULC



(Source: SOI Toposheets and Google-Earth Imageries)

The figure 4 has devoted to present micro levelled spatio-temporal effects of such parameters in the study area. As given in table 3, there is drastic change in LULC from 1972 to 2018.

Table 3 Land Use and Land Cover change from 1972 to 2018

Sr. No.	Types of LULC	Change in Land Use and Land Cover (sq km)			
		1972	1985	2004	2018
1	Built Up	1.05	1.92	4.64	8.27
2	Agriculture	20.75	18.98	15.57	13.29
3	Open space	1.57	2.47	3.16	1.81
TGA in Sq.km.		23.37	23.37	23.37	23.37
4	Number of streams Crossed to Road	10	07	12	14
5	Number of streams Crossed to Railway line	03	02	01	01

(Source: SOI Toposheets and Google-Earth Imageries)

The land under agricultural activities has decreased from 0000 to 0000 sq. km which rate has more in left side than that of right of the stream.As shown in maps, number of streams vanished, particularly from right side; by short or long period agricultural fallow land converted in to regular and developed agriculturalpractices.On the other side, there is a development of road net work and expansion of railway track along with bridges. It happened by the horizontal and vertical growth of the city. The increase in built up has particularly shown in the left southern side of the stream. Both these changes in LULC are responsible to remove the headwater streams. Sometimes, it has also created new streams by the domestic waste water of newly developed built up areas. Such streams are just like tiny cluster of dumped ponds and or very slowly flowing open sewage lines.

IV CONCLUSION

The streams associated with flat topography have relatively small persistent power to live permanently and struggle for smooth flow. In case of streams flowing from urban areas have facing to the natural challenges along the manmade activities with higher rate of resistivity. In the present investigation, both these parameters have been observed as the prime and responsible factors. At the initial stage, urban growth affects on agricultural land use with positive and negative ways. It converts agricultural land in to other urban land uses at the fringe urban areas. At the same time, because of increase in demand of agricultural fresh goods, it supports to the agricultural development at the periphery and alongside areas of the new urban fringes. These effects have also been observed in the present spatio-temporal analysis. In short, permanently removing the streams, shortening some headwaters, shifting the channels, changes in length and width of streams etc have the results of such changes in LULC.

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