Volume : 3 | Issue : 3 | March 2014 • ISSN No 2277 - 8179

Research Paper

Delineation of Flood Hazard Zones Using Geomorphological Features in S.p.s. Nellore District: A Study Based on Remote Sensing And Gis

GEOGRAPHY

KEYWORDS :

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ABSTRACT

The Geomorphological studies through Spatial information technologies play a significant role in flood disaster assessment, preparedness, relief, rescue and management. The present study is attempted with the objective of delineating flood hazard zones by interpreting the landforms from the satellite geocoded data of IRS-IC, LISS III imageries and is correlated with the Survey of India Toposheets. The S.P.S. Nellore district of Andhra Pradesh is lying adjacent to Bay of Bengal with a lengthy coastline of 165 kms is not only affected by tropical cyclones, depressions and storm surges but also severely affected due to floods. Due to frequent recurrence of severe cyclonic storms and floods causes greater damages to agricultural crops, settlements, communications etc., resulting into totally upsetting the ecological balance and socio-economic conditions of the people. The landforms identified and interpreted from the satellite data has been integrated with analysed data of RADARSAT-2 images of flood inundated areas to delineate the flood hazard zones in S.P.S. Nellore district. The individual flood events and subsequent damages are integrated with the geomorphological features to arrive flood hazard zones in the district. The flood hazard zones are identified and categorized into two zones i.e., 1. Areas highly prone to floods and 2. Areas moderately prone to floods. The flood hazard zone map is of immense use for effective implementation of prevention measures to reduce the intensity of disasters caused due to floods in the district.

INTRODUCTION

Floods are temporary inundation of large areas resulting due to the incapacity of the river to carry the increased volume of water in its course and hence resulting in overland flow causing inundation of neighbouring lands. Floods are recurrent frequently in Andhra Pradesh causing huge losses of lives, properties, livelihood systems, infrastructures and public utilities. Sri Potti Sreeramulu Nellore district (S.P.S. Nellore district) is the southern most district of Andhra Pradesh lying adjacent to Bay of Bengal but also severely affected due to floods. Among all the coastal districts of Andhra Pradesh, the S.P.S. Nellore district has witnessed more number of cyclonic storms of severe intensity accompanied by storm surges. The district was affected by 22 cyclonic storms with in a period of 100 years (1911-2010) which is highest among all the coastal districts of Andhra Pradesh. The Principal river flowing is Pennar with its large catchment area receive inflows forming floodplains causes inundation. Due to frequent recurrent of cyclonic storms and floods causes greater damages to agricultural crops, settlements, roads, communications etc., totally upsetting the ecological balance and socio-economic conditions of the people.

The S.P.S. Nellore district is one of the nine coastal districts of Andhra Pradesh lies in between 13° 25' and 15° 06' of the Northern Latitudes and between 79° 09' and 80° 14' of the Eastern Longitudes (Fig.1). The total geographical area of the district is 13076 Sq.kms. Administratively the district has 46 mandals. Physiographically the district is occupied by Velikonda hill ranges on the western side and plains on the eastern side. The principal rivers of the district are Pennar and Swarnamuki and the other rivers flowing in the district are Kandleru, Bogeru, which are occasionally torrential in character during rainy season. There are number of tanks which overflows during rainy season causing floods and damages to the neighbouring villages.

Pennar is the major river originating from Chennakesava hills of the Mysore plateau and flows through the Kadapa basin and forms a deltaic plain in the district and joins the Bay of Bengal.

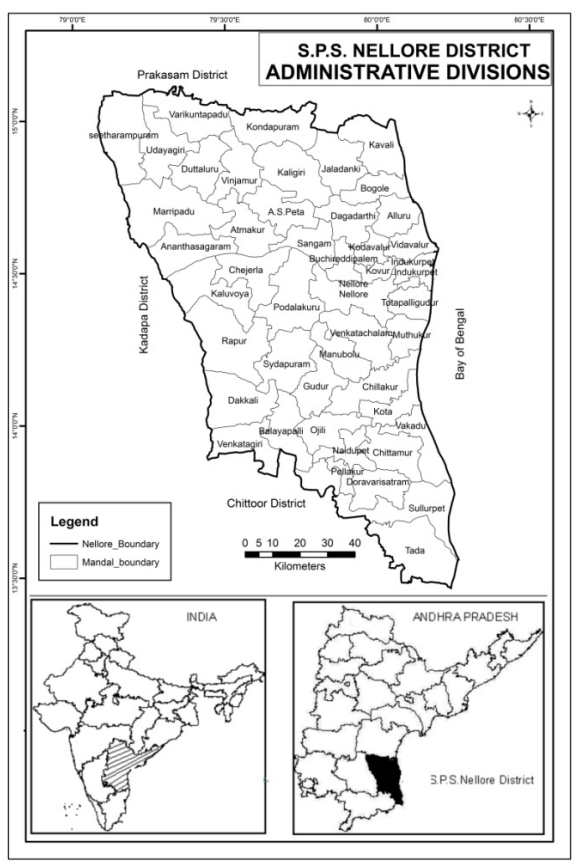

Fig.1: Location and Administrative divisions of S.P.S. Nellore district

Volume : 3 | Issue : 3 | March 2014 • ISSN No 2277 - 8179

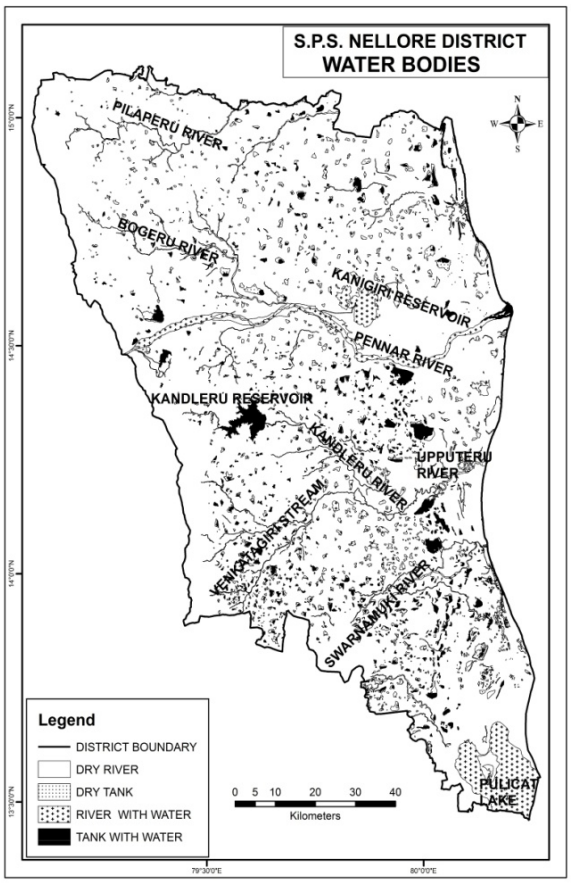

Fig.2 : Water Bodies in S.P.S.Nellore district.

The length of river Pennar from source to its confluence is 560 kms characterized with a host of different landforms/ geomorphic units have a certain bearing with the vulnerability to flood damage. The other rivers such as Kandleru, Venkatagiri, Upputeru, Bogeru and Swarnamuki causes floods in their lower courses (Fig.2).

DATA BASE AND METHODOLOGY

The present study is attempted with the objective of delineating flood hazard zones with the help of geomorphological mapping, which forms the major input for flood disaster management. The satellite data of IRS-1C, LISS III aided with topographical maps on 1:50,000 scale with field checks were used to identify and interpret the various landforms of the study area. Suitable flood alleviation measures are suggested based on the drainage characteristics, geomorphology of the terrain. Geomorphological studies are the only means of providing the required historical background for flood and sediment control. By incorporating the field information various geomorphic units and landforms identified in the study area are presented. The flood inundation areas map generated from the RADARSAT-2 data of 2nd November 2010 has been integrated to delineate the flood hazard zones in S.P.S Nellore district.

DELINEATION OF LANDFORMS IN S.P.S.NELLORE DISTRICT

The landforms are broadly discussed as fluvio-colluvial, denudational, structural and depositional landforms. The erosional and depositional landforms in the district are identified and are related to sequential evolutionary stages during the quaternary period. These are the landforms derived by fluvial processes aided by mass wasting are grouped under fluvio-colluvial landforms. The geomorphological features/landforms identified from the IRS satellite data has been represented in fig. 3.

Valley Fills: The unconsolidated materials partly filling a valley are called as valley fills which are formed by the depositional processes at the youthful stage of a river consisting of loose sediments having pebbles, gravel, sand and silt brought by the streams. These valley fills are found on the northwestern parts of the district along the river courses of Udayagiri mandals. In marripadu and Anantasagaram mandals the valley fills are noticed along the Bogeru river course which is a tributary to river Pennar. In the upstream side of Venkatagiri stream valley fills are identified in Venkatagiri, Dakkili and Balayapalle mandals. Some of the valley fills are found in the upstream side of Kandleru river passing in Rapur mandal.

Natural Levees: These are the depositional landforms built by a river during floods where huge quantity of suspended load is deposited adjacent to the river course. These levees tends to raise river banks above the level of the surrounding flood plains. These natural levees are found mostly along the Pennar river course attaining a height of 2 to 3 mts and are prominently developed in the villages of Sangam, Buchireddipalem, Kovur and Nellore mandals. The natural levees are also developed adjacent to the Venkatagiri, Upputeru and Kandleru river courses. The flood basin is elongated and wider on the northern banks merges with the paleochannels on the eastern side of the Pennar river course. The deposition of point lass is seen mainly at the river bends, the thickness of which varies from 0.5 to 1.25 mts from present bed level of the river. The valley fills and Natural levees occupy linearly with limited horizontal areas and hence it is not possible to show these features in the small scale map of the district.

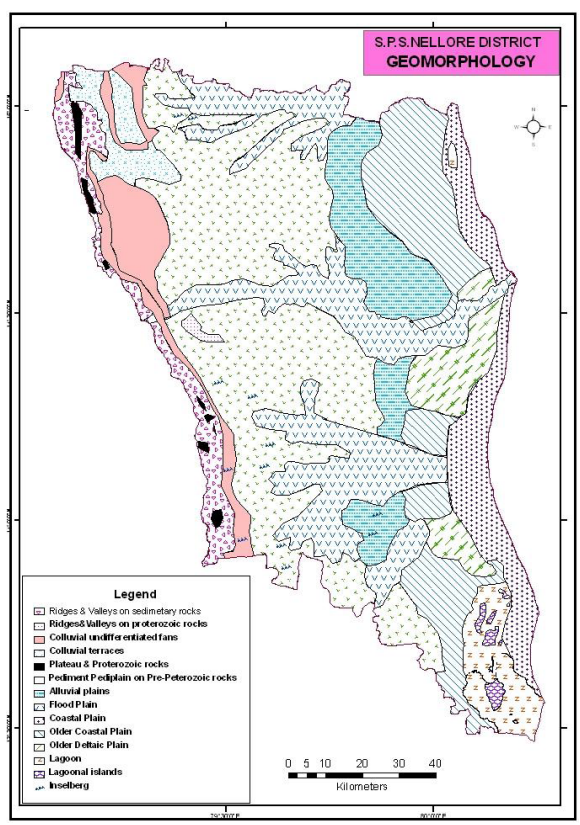

Fig.3 Geomorphological features in S.P.S Nellore district.

Denudational Hills: The steep hills formed by denudation under tropical climate are know as Velikonda ranges of Eastern Ghats lying on the western margin of S.P.S.Nellore district. These erosional remnants are at an elevation ranging from 250 to 1100 mts above mean sea level. These ranges are composed of ridges and shallow valleys on sedimentary rocks, proterozoic sediments of Cuddapah basin. Adjacent to these rocks colluvial undifferentiated fans and colluvial terraces are noticed. There are some isolated plateaus consisting of proterozoic rocks in the hill ranges of eastern ghats.

Inselbergs: The isolated hills are identified from the imageries of the region which are at an elevation ranging from 75 to 600 mts occupying with a limited horizontal area. Based on the accordance of summit levels and other evidences, these inselbergs are considered to be the remnants of 3 cycles of erosion. These inselbergs are generally composed of quartzites, amphibolites, granites and gneisses. The hills are mostly barren rocks with debris accumulation at the break of the slopes.

Piedmont plains: These are the gently undulating surfaces located on the western side of the region characterized by NNW-SSE direction running almost parallel to the denudational hills of the western margin. They are formed due to coalescence of a number of pediments formed under tropical climate during the cycle of erosion. The zone between the denudational hill ranges and the piedmont plain is called piedmont zone. In the early stages streams carried material from the hill ranges and deposited on the low lying adjacent regions. Soon the streams became graded at their lower courses and started cutting laterally forming the piedmont rock benches. Erosion is still active in these regions and weathering extends along the joints, fractures and faults.

Alluvial plains:
The alluvial plains usually consists of unconsolidated sediments. The central part of the district extending up to the eastern side is identified as a zone of Alluvial plains. These plains are occupied by unconsolidated schistose rocks, phyllites, ortho-amphibolities and para amphibolites. They are imperfectly drained alluvial plains with unconsolidated silt, sand and clayey cover. The alluvial plains are noticed in Jaladanki, Dagadarthi, Kodavalur mandals on the northern side of the Pennar river and Nellore, Venkatachalam and Ozilli mandals on the southern side of river Pennar.

Older Coastal plains: The older coastal plains characterized by the occurrence of a series of strandlines spread adjacent to the coastal plains. These alluvial plains are at an elevation of 4 mts made up of black clays to silty muds. From the trend of the beach dunes consisting of medium or fine grained sand predominantly made up of quartz, magnetite, amphibolites, garnet, mica etc., indicate emergence of coast due to lowering of sea-level. These coastal plains of older origin are found in Kavali, Bogole, Allur, Vidavalur, Muthukur and Kota mandals.

Coastal plains: This is gently sloping plain lying adjacent to the alluvial plains on the eastern margin Bay of Bengal. The sediments are transported by rivers to the sea usually spread broadcast over the ground surface. These plains consists of loosely compacted layers of muds, sands and clayey deposits inclined gently towards the sea. But because the surface remains close to the base level, little down cutting is possible and the loose sediments often discourage tributary development. These plains are likely to remain very smooth and poorly drained. The coastal plains are prone to flooding and the villages lying in this zone are affected more frequently due to cyclonic storms.

Delta plains: The Pennar deltaic plain has five abandoned older channels. Some of the abandoned channels have been recognized by Seetharamaiah and Nageswara Rao (1987) based on the study of Landsat imageries. Among the five paleochannels only one is active providing the main outlet to the sea. The remaining four channels are abandoned. The present active channel found to the north of Nellore forms the main outlet bringing sediments and contributing to the growth of the delta. The shape of the delta is cuspate and the deltaic area falls in a tropical cyclone belt. The basement for the deltaic sediments is composed of Dharwar supracrustal rocks comprising volcano-sedimentary sequence with NW-SE trend. The Proterozoic cuddapah sediments are present on the western side of the delta. The deltaic sediments are underlain by the mio-pliocene Cuddalore sandstone consisting of conglomeratic and clayey sandstones. The laterites are overlain by deltaic sands and clays of 50 to 70 mts thick.

The trend of the ancient ridges and abandoned channels reveals the possibility to reconstruct the stages in the evolution of the Pennar delta. Based on the orientation of the beach ridges three strandlines were surmised in the delta. A strandline represents a major change in the coastal configuration which was stationary for quite sometime earlier. When the coastline advances the ridges maintain parallelism unless cut out obliquely by coastal erosion (Nageswara Rao and Vaidyanathan, 1978). The three strandlines suggest the stages in the advancement of delta fronts. The position of ancient abandoned distributaries and their possible points of discharge conform with the position of strandlines. The geomorphic study of the deltaic plains indicate two different physical setups for their growth. The beach ridges and tidal mudflats along the coast and the terrace along the Pennar River indicate emergence of land perhaps due to neo-tectonic activity. The deltaic environment exhibits varying susceptibility to flooding depending upon the conditions of the drain prevailing in the district. The amount of damage depends upon the intensity of rainfall, storm surge, wind velocity and direction, vegetation cover etc.

Lagoon and Lagoon islands: A lagoon is an elongated feature of shallow water lying parallel to the coast and separated from the open sea by sand or shingly barriers built by the sea waves. On the extreme south-eastern tip of S.P.S.Nellore district, Pulicat lake is the shallow water body separated from the Bay of Bengal coast is the largest lagoon. Most of the lagoon area is in Tada mandal extending towards north covering Sullurpet mandal. The length of the Pulicat lake is 55 kms and the width varies from 5 to 16 kms. There are some islands formed in the Pulicat lake by river-borne sediments with a limited brackish water. The only lagoon on the eastern coast of India is the Pulicat lake having salinity waters due to the sea water enters the lagoon at high tide. The salinity of the Pulicat lake increases during the period of north-east monsoon. This lagoon is fed by three rivers namely Swarnamuki, Kalangi and Arani. When the lagoon receives adequate water supply from the rivers, the salinity of the Pulicat lake decreases.

Flood plains: Flood plains are the land areas adjacent to rivers and streams that are subject to recurring inundation. Flooding is a natural and recurring event for a river or stream, is the result of heavy or continuous rainfall exceeding the absorptive capacity of soil and the flow capacity of rivers, streams and coastal areas. This causes a water course to overflow its banks on to adjacent lands. Flood plains are therefore 'flood-prone' and are hazardous to developmental activities. Geomorphologically, it is landform composed primarily of unconsolidated depositional material derived from sediments being transported by the related river.

The flood plain areas are interpreted from the IRS satellite image for the rivers which are flowing in the S.P.S.Nellore district. Pennar is the major river which forms major flood plains in the region. In the northern bank of Pennar river, flood plains are identified in the Anantasagaram mandal. Similarly in the southern bank, the river Pennar developed flood plains with a width ranging from 2 to 4 kms in Chejerla and Podalakur mandals. In the northen bank of river, flood plains are noticed in Sangam mandal with a width ranging from 2 to 5 kms. Flood plains are also developed in the southern bank of river course of Nellore mandal. In the northen bank of Pennar river, flood plains are identified in Buchireddipalem mandal. Generally the flood plains are developed all along the Pennar river course in most of the mandals lying adjacent to the river. The development of flood plains are also noticed at the confluence of Pennar and Bogeru rivers in Atmakur mandal.

Similarly, flood plains are developed by other rivers such as Kandleru flowing in Sydapuram and Manubolu mandals. Such floodplains are also seen on the northern bank of Upputeru river flowing in Manubolu mandal. Flood plains are also seen adjacent to Venkatagiri river flowing in Balayapalle and Gudur mandals. Some of floodplains are developed by Swarnamuki river flowing in Pellakur, Naidupet, Kota, Vakadu mandals. On the northern side of the district the floodplains are also noticed adjacent to the Pillaperu river flowing in Kondapuram mandal.

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DELINEATION OF FLOOD HAZARD ZONES IN S.P.S.NELLORE DISTRICT

The Geomorphological features delineating the various landforms are the most important and essential inputs for flood hazard zonation.

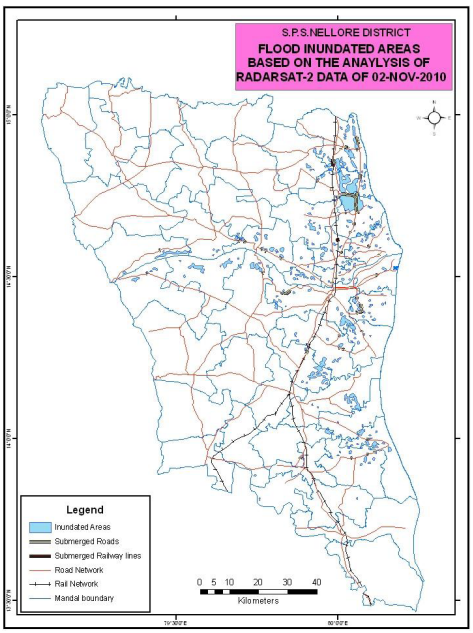

Fig. 4: Flood inundated areas of S.P.S.Nellore district (2010).

The individual flood events and subsequent damages are integrated with the landforms to arrive flood hazard zones in the S.P.S. Nellore distict.

The map of flood inundated areas based on the analysis of RADARSAT-2 data of 2nd November 2010 (fig.4) has been integrated with geomorphological map to prepare the flood hazard zone map. This is of immense use for management of floods and to prevent the damages to a considerable extent in the district.

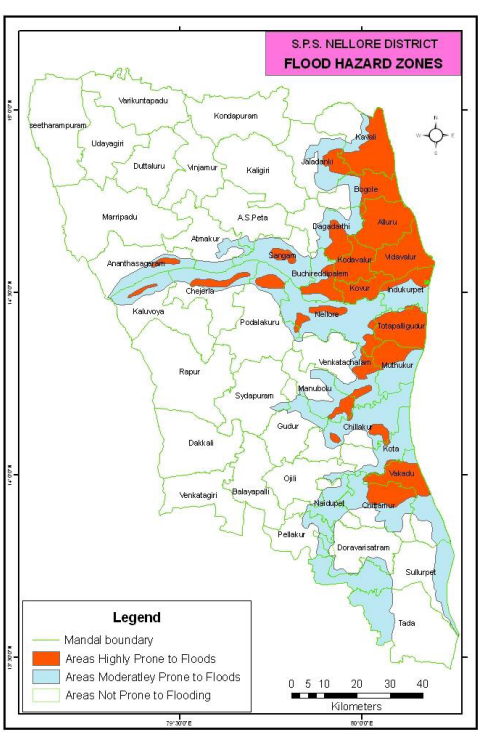

Fig. 5 : Flood hazard zones in S.P.S.Nellore district.

The river Pennar with its large catchment area is the major river with broader flood plains responsible for the occurrence of floods in the district. By integrating the multilayered data the flood hazard zones are identified and categorized into two zones. They are 1. Areas highly prone to floods and 2. Areas moderately prone to floods (Fig.5).

Areas Highly Prone to Floods

These are the areas prone to be affected more frequently either due to tidal waters or heavy rainfall. These areas are highly concentrated along the coastal mandals and significantly noticed in the Pennar delta lying adjacent to the coast. Due to the formation of cyclones in the Bay of Bengal and the resultant heavy rains are responsible for the occurrence of floods more frequently in these regions. The villages located in Chittamur, Vakadu, Kota, Chillakur, Manubolu and Venkatachalam mandals are usually affected by floods. Flood hazard zones are concentrated all along the coastal plains between Muthukur and Kavali mandals. Most of the villages located in the coastal mandals are prone to flooding due to high intensity of rainfall coupled with severe cyclonic storms. The high concentration of medium irrigation tanks in Kavali, Bogole, Kota, Vakadu, Vidavaluru, Allur and Indukurpet mandals when they exceed their storage capacity leads to overflow causing flooding. Most of the tanks in these mandals are silted, covered with weed and are reclaimed with agricultural practices. The tank bunds are also eroded and some of them are weakened. These factors are also responsible to reduce their storage capacity and hence leads to flooding. The highly vulnerable areas to floods are also found on the downstream side of Kanigiri reservoir located in Sangam, Kodavalur, Buchireddipalem and Dagadarthi mandals. The villages located in the upstream side of Kanigiri reservoir are also vulnerable to floods.

Areas highly prone to floods are also noticed in the floodplains lying adjacent to river Pennar. Floodplains are in general vulnerable areas to floods and therefore hazardous due to frequent recurrence. On the northern side of Pennar river course flood hazard zones are identified in the villages of Ananthasagaram, Sangam, Buchireddipalem, Kovur and Indukurpet mandals. The flood zones are also noticed in the floodplains located on the southern side of river Pennar. The villages vulnerable to floods are found in Kaluvoya, Chejerla, Podalakur, Nellore and T.P.Gudur mandals.

Areas Moderately Prone to Floods

These are the areas which are affected due to intensive rainfall with severe cyclonic storms causing less damage to crops and environment. The spatial extent of these areas are more concentrated all along the coastal mandals extending into the villages which are located in the interior mandals of the district. The villages located on the western part of Tada, Sullurpet, Doravarisatram, Pellakur, Naidupet, Ozili, Chillakur, Gudur, Manubolu and Venkatachalam mandals are vulnerable to floods. Similarly moderately flood areas are also extended to the villages located on the western side of coastal mandals located on the northern side of Pennar river. These areas are concentrated in the Kavali, Jaladanki, Bogole, Dagadarthi and Buchireddipalem mandals. Significantly the floodplain areas are found all along the Pennar river course and the Pennar delta are the areas prone to floods moderately. The floodplains covering Anantasagaram, Atmakur, Sangam,Buchireddipalem, kovur and Indukurpet mandals on the northern side and Kaluvoya, Chejerla, Podalakur, Nellore mandals on the southern side of river course are the vulnerable areas to floods.

The villages located in Atmakur mandal are prone to flooding which are found at the confluence of river Bogeru with Pennar. Similarly in the villages of Sydapuram, Gudur, Monubolu and Chillakur mandals are prone to floods at the confluence of Kandaleru and Venkatagiri river courses. These areas are vulnerable to floods mostly because of the presence of tanks and when exceeds the storage capacities leads to flooding.

CONCLUSION

The Geospatial databases developed with the integration of Remote Sensing data has tremendous scope and plays an impor-

tant role in flood disaster prevention and management in the district. The Geomorphological features such as coastal plains, deltaic plains and alluvial plains are the areas prone to flooding more frequently in the district. Flooding is a natural and recurring event in the floodplain land area which are lying on either side of the river courses. The flood hazard zone map of the district helps to carryout flood prevention measures. The Government can take up several initiatives and administered a setup for effective implementation of the prevention and preparedness is built to reduce the intensity of disasters caused due to floods in the district.

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