# Active and Paleo floodplain mapping of Palam Cauvery using Geospatial Technology

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***Abstract*****:** ***This paper presents precise active floodplain and paleo floodplain mapping of the Palam Cauvery in its deltaic region implementing various Geospatial Techniques, as well as a comparative analysis to comprehend the changes that have occurred to the river course in the past. False Colour Composite (FCC), Normalized Difference Water Index (NDWI), Principal Component Analysis (PCA), Synthetic Aperture Radar (SAR) ALOS PALSAR L- Band and Digital Elevation Model of ALOS PALSAR has been used to carried out the detailed mapping. The active floodplain and paleo flood plains are mapped using the method proposed above and ten separate cross-sectional profiles were obtained along the river course, revealing that the paleo flood plain has an aerial extent that is 86% broader than the present flood plain. This clearly shows that the principal river was formerly running along the Palam Cauvery in this course and has progressively shifted or migrated.***

***Keywords*****:** **Cauvery Delta, Paleo floodplain, Remote Sensing, Digital Elevation Model**

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## I. INTRODUCTION

Mapping of floodplain, terraces, and their associated sub-environments gives insights to build understanding, how river systems work [5], [7], [9], [16]. It is fundamental in decisions about geographical planning, flood vulnerability assessments, surface flood control, and river basin management programmes [6]. Furthermore, the floodplains of significant tropical and subtropical rivers systems are home to a distinct species that has incorporated to floods e.g. [32] and It is essential to map morphologies and surface fluvial deposits in precision in order to forecast potential landscape changes with relevance for biodiversity protection e.g. [8]. These investigations were conducted from the standpoint of process-form connections in order to aid in the understanding of ancient fluvial patterns [30]. The paleochannels are recognized as the source of possible aquifer deposits, mineral deposits of placer and also the mystery of archaeological perseverance. These characteristics include host hydrocarbons, precious metals, high-grade silica sand and economic mineral deposits [15], [28].

Many researchers have been conducted a detailed study on the Cauvery delta, the most notable of which are by [4], [17], [18] for understanding the neotectonics; [2], [3], [7], [13], [27], [29] for elucidating the Quaternary fluvio-marine interactive processes; [1], [10] for its hydrocarbon prospects. In addition, the groundwater problems, geomorphic evolution and paleochannel have also attracted many geoscientists and agencies to study this delta [14], [19], [20], [21], [22], [23], [24], [25], [26], [31], [33], [34].

The current study was conducted in addition to the previous research in the Cauvery delta, which focused on the precise delineation of the active floodplain and paleo floodplain of Palam Cauvery, as well as a comparative analysis of their size and shape employing various Geospatial techniques.

## II. STUDY AREA

The Cauvery River originates in the Brahmagiri Hills of the Western Ghats and runs eastward eventually shaped into arcuate type delta then draining to the Bay of Bengal. Its distributaries stretch south to north in an arc towards the east from its apex in Tiruchirappalli, forming a fan shape and are now understood as paleochannels, along with the parental channel Cauvery. The present study focused on the deltaic portion of Palam Cauvery from Papanasam, Thanjavur district to Poompuhar, Mayiladuthurai district which lies in between latitude $10^{o}$ 53’N to $11^{o}$ 15’N and longitude $79^{o}$ 14’E to $79^{o}$ 54’E (figure 1). Deltaic sediments predominate of alluvial sand, conglomerate sandstone, calcareous sandstone, ferruginous sandstone, ferruginous grits, fossiliferous limestone, shale and clay stones.

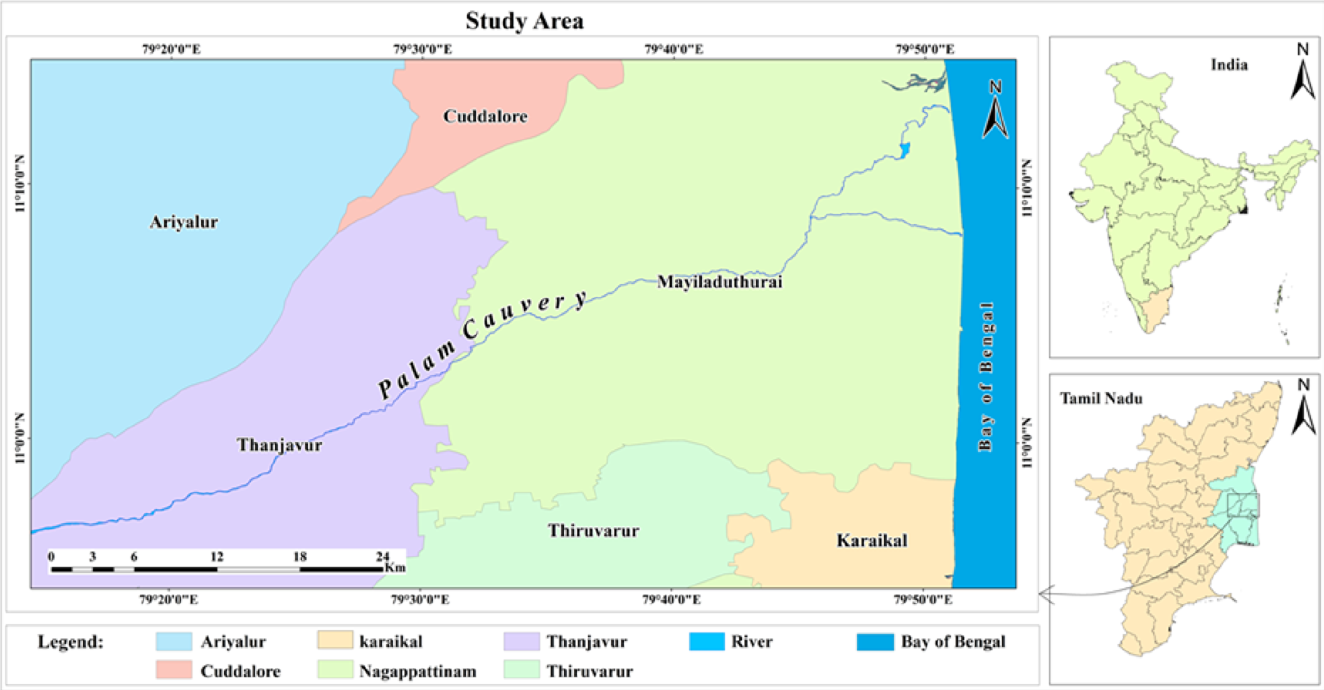


Fig. 1. Study Area map.

## III. Materials and Methodology

To identify the active floodplain and Paleo floodplain of Palam Cauvery, sentinel-2A of 10-meter resolution (https://scihub.copernicus.eu/) and ALOS PALSAR Radiometric Terrain corrected Digital Elevation Model (DEM) of 12.5 meter have used. In addition to Radar Remote Sensing ALOS PALSAR L- Band have been utilized; Both DEM and Synthetic Aperture Radar (SAR) data of ALOS PALSAR collected from the Alaska satellite Facility website (https://search.asf.alaska.edu/). The SAR image was processed using ASF Mapready and ENVI software before being transferred to GIS software for Paleo floodplain mapping.

River, Active floodplain and Paleo floodplains are mapped using optical, microwave and DEM derivatives. Detail comparative study has been made on width of river, active and paleo flood plain in 10 cross-sectional profiles. To map the Active and Paleo flood plain, the following techniques adopted.

### A. *Paleo floodplain mapping*

Paleo floodplain were distinguished by their distinctive dark tone, the unique curving pattern of the river in conjunction with the cropping pattern, high reflectance of NIR bands and related disjointed water bodies. False colour composites, Normalized Difference Water Index, and Principal Component Analysis were used to determine the precise boundaries of the paleo floodplain. Each technique has advantages that are being utilized to determine distinctive characteristics of ancient floodplain.

a) False colour composites:

The use of Near Infra-Red in FCC, improve data interpretability with green and red band of visible spectrum; this composite is highly useful in deciphering variables like drainage system, lithology, and land use/land cover [12].

Green, Red and Near Infrared bands of Sentinel-2A has taken to into ArcGIS platform and Image Analysis tool performed to generate the FCC composite (figure 2), which used to further use in interpretation of Paleo floodplain and accurate digitization.

b) Normalized Difference Water Index:

This Normalized Difference Water Index (NDWI) index is intended to optimise water reflectance plant and soil features. When compared to Normalised Difference Vegetation Index (NDVI), NDWI is more suited for tracking Paleo floodplains in the area under study, having results ranging from+1 to -1. NDWI image (figure 3) has generated by using Map Algebra tool of Arc Toolbox (1) and takes the input as green and NIR bands of sentine-2A.

$$NDWI = (GREEN-NIR) / (GREEN+NIR) \qquad (1)$$

c) Principal Component Analysis:

Principal Component Analysis (PCA) is a well-known mathematical method for decreasing data complexity while maintaining as much variability in Features. Four spectral bands of 10m resolution Sentinel-2A processed in ERDAS Imagine to create the PCA image (figure 4). Moreover, a cluster of bands is blended in the PCA depending on the correlation matrix. The band combination of most diversity among the matrix is used in ArcGIS platform to digitize the boundary of Paleo floodplain.

d) Microwave Remote Sensing:

Unlike optical Remote Sensing, microwave images are complex and contain variety of noises that required pre-processing. In this study, L-Band of (Advanced Land Observing Satellite Phased Array) ALOS PALSAR has processed for Amplitude Calibration, co-registration, terrain correction, geocoded and exported to GeoTIFF format using ASF Mapready software. The resultant GeoTIFF has been treated for speckle noise with the help of Lee flitter in ENVI software. Finally, the orthorectified L-Band image was used to map the Paleo floodplain. It reveals buried shallow alluvial curvilinear paleo floodplain boundary in magenta colour (figure 5).

### B. *Active floodplain mapping*

a) DEM and Hill Shade Analysis

A digital elevation model is a collection of data that may be used to supplement remotely sensed satellite imagery. The ALOS PLASER DEM (12.5m resolution) was used to generate the derivative maps such as slope, aspect and Hillshade.

Utilization of DEM in the study gives an elevation variation between the natural levee and the active channel courses (low elevation within natural levee) which represented in figure with gradual changes in colour. Use of Hillshade gives rise to 3D artistic image of the study area; where the linearity of continuous depression along with active river noted. By superimposing both image and putting transparency to Hillshade with DEM helped in understanding the profile as well and chances of active flooding has been digitized.

In the current study, to obtain the Hillshade the azimuth and altitude of light source has given as 350 and 10 degrees respectively (figure 6).

## IV. RESULT

River and flood plains are mapped using different Digital enhancement techniques like False colour composites (FCC), Principal Component Analysis, Normalized Difference Water Index DEM and Hill Shade Analysis and finally the width of the Active and Palaeochannels are compared in 10 profiles. The results of the individuals are discussed below.

### A. *False colour composite and floodplain mapping*

Presence of alluvial sediments carries excess moisture, which results in higher amount of vegetation growth and urban growth has noticed along the Paleo floodplain compared to the adjacent areas. Disjointed water bodies noticed along with the Paleo floodplain with a curvilinear coverage of vegetation which helps in differentiating with adjacent features. In figure 2 many zoomed out portions of FCC image has shown in six sections, in which A and B represents urban settlement growth along Palam Cauvery has noticed with loads of disjointed water body. Significant vegetation growth has noticed in A, D, E and F. whereas the dark tone in South east part of the Section-F has noticed, which represents the flooded water spill from the river goes out of Paleo floodplain.

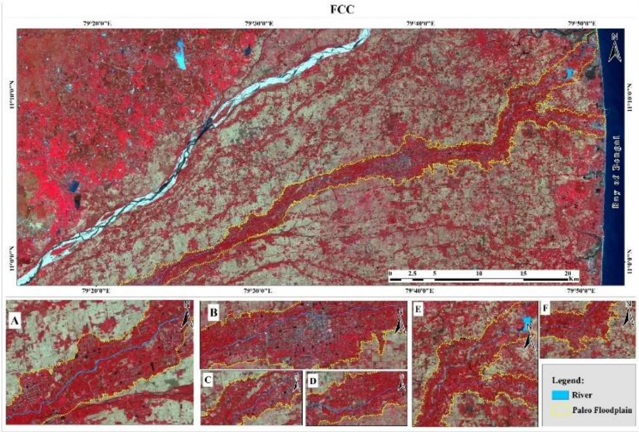


Fig. 2. FCC and flood plains.

### B. *Normalized Difference Water Index and floodplain mapping*

It is magnificent to see the NDWI outputs show a great connectivity between the Paleo floodplain and active channels floodplain, by using this method differentiation in dry and moisture land got clear. In figure 3, section-A shows a clear distinction between a patch of paleochannel of Palam Cauvery with its Paleo floodplain. Where as in B, C, D and F sections the maximize moisture features clearly differ with adjacent features. significant thing to notice in section-E is the upper limb of Palam Cauvery has less moisture contain than the lower limb, indicating the less active limb or older limb of Palam Cauvery with a greater Paleo floodplain than currently active floodplain towards Poompuhar.

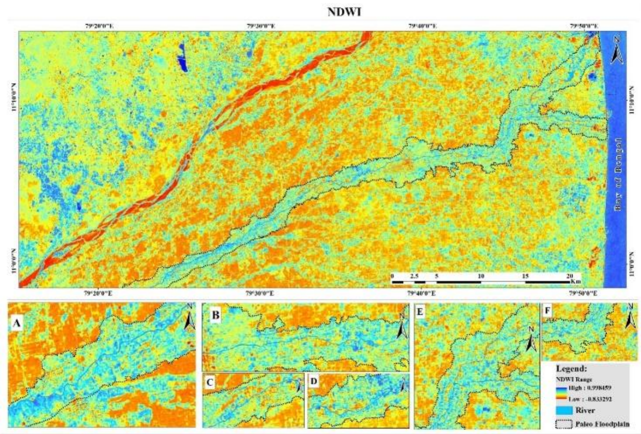


Fig. 3. NDWI and flood plains.

### C. *Principal Component Analysis and floodplain mapping*

Principal component analysis has shown with Band combination with most diversity matrix of sentinel image to enhances the Paleo floodplain characteristics. PCA analysis helps in verification of maintained digitization accuracy. The variation creates in the PCA image surely improved delineation of the Paleo floodplain boundary of different sections of A, C, D and F figure 4. whereas the beautiful urban growth of Mayiladuthurai town has noticed along the Paleo floodplain in section-B. In section-E the distinct sinusoidal paleo course of Palam Cauvery has noted in the upper limb.

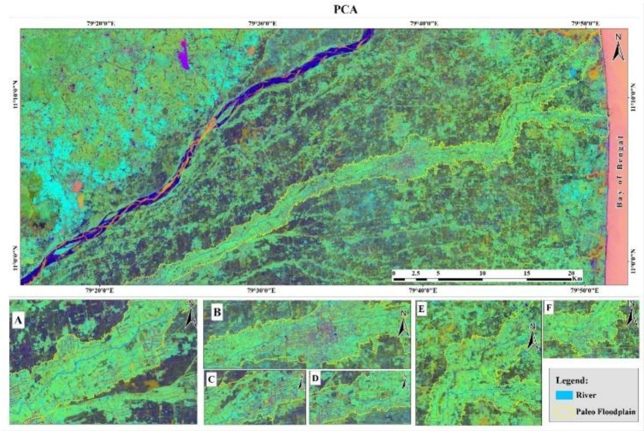


Fig. 4. Principal Component Analysis and floodplains

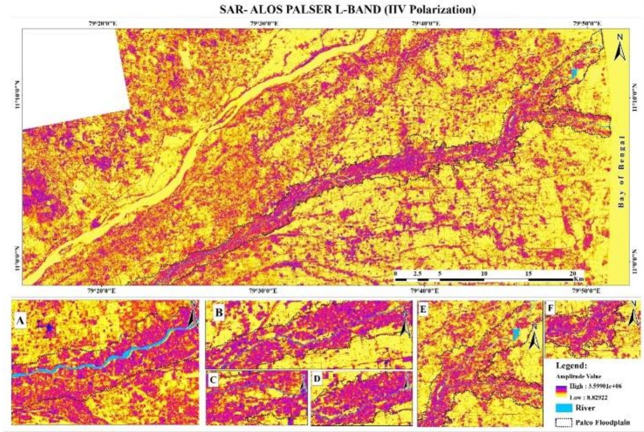


Fig. 5.SAR and flood plains

### D. Orthorectified Synthetic Aperture Radar image and floodplain mapping

Utilizing microwave Remote sensing longer wavelength L-band gave us advantages revealing the buried Paleo floodplain detection which has ground penetration pixel value to some extent. As the delta lies in low elevation with dielectric properties of water put forward into a magnificent orthorectified image of HV polarization. Due to the substantial growth of vegetation along the Palam Cauvery with time SAR orthorectified image gives a clear distinction between the water body with curvilinear vegetation represented in all the sections of figure 5.

### E. Digital Elevation Model, Hillshade and floodplain mapping

It’s an excellent tool for delineating the Active Floodplain when it has superimposed on DEM with transparency effect, certainly discernible image obtained gives advantages over all other methods in order with digitizing the active floodplain figure 6. Hillshade image improves the topographic structure and is quite useful in extracting satellite information dealing drainages and linear and curvilinear depressions. A, C, D, E and F sections of figure 6 has shown the continuity of depressed area adjacent to the active river presented as active floodplain of Palam Cauvery. In Section- B lateral migration shift has observed which imply the lateral migration within the Paleo floodplain towards the south east direction.

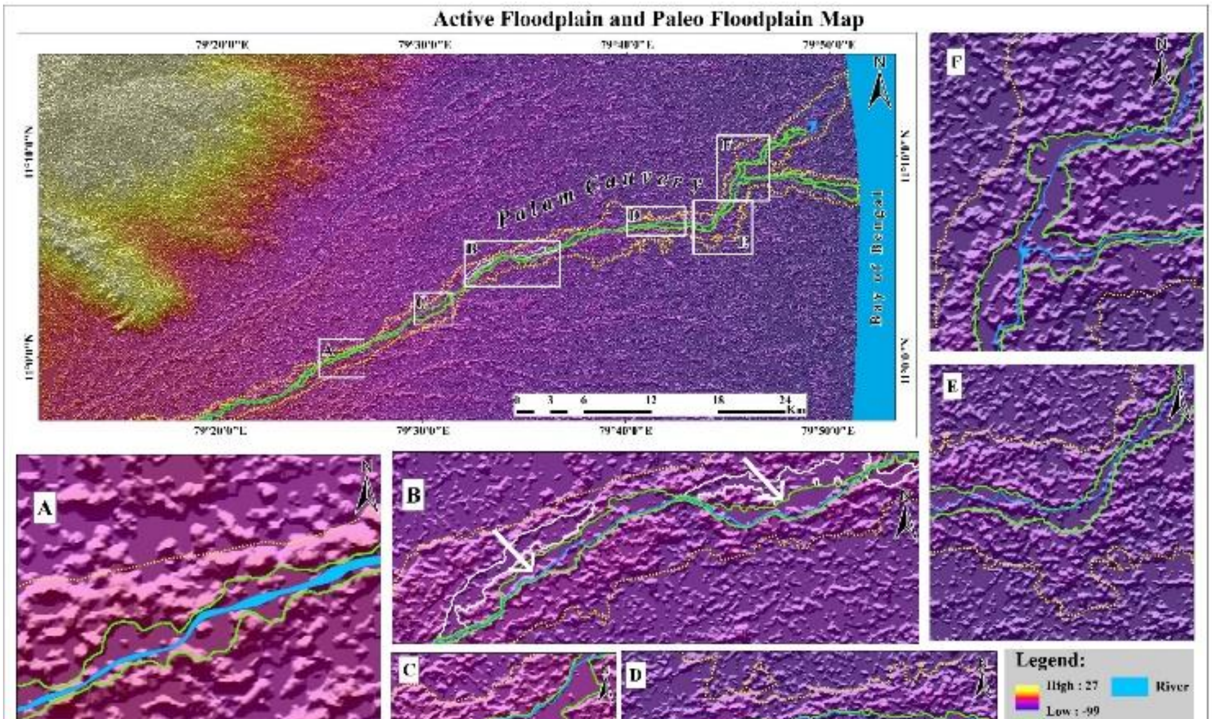


Fig. 6.Active Floodplain and Palaeo floodplain mapping from Digital Elevation Model and Hillshade.

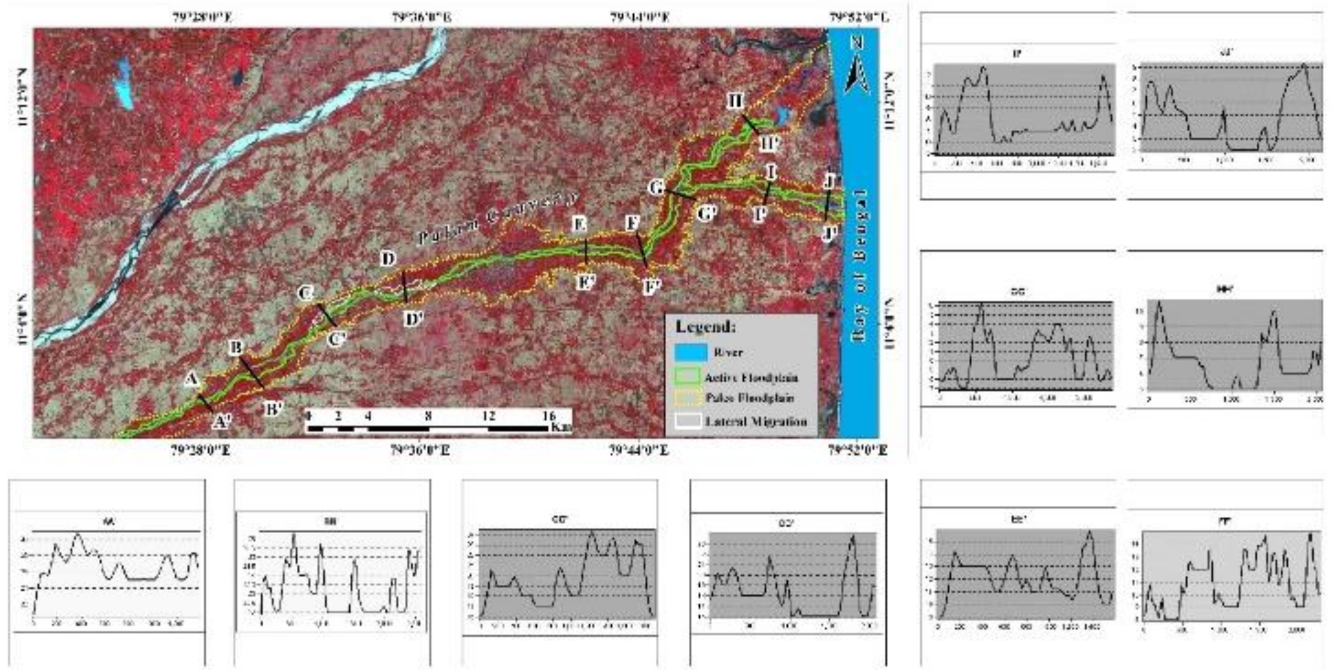


Fig. 7. Width of active and paleofloodplain.

### F. *Comparative Analysis*

To understand the relationship with the active floodplain and paleo floodplain of Palam Cauvery, relative width of both active and paleo floodplains with their cross-sectional profile have made figure 7. The selection of the sites for performing comparative width assessment solely focused on the less disturbed portion of the Palam Cauvery. Certainly from the cross-sectional profiles shows width of the active and paleo floodplain gradual increases showing flatter lines in the profiles towards eastward. Where BB', DD', HH', II' and JJ' profiles shows a substantially higher width of active floodplain. While in CC', EE', FF' and GG' profiles got the vegetation and settlements interferences so it presented in zig zag profiles.

To quantify the amount of spatial changes in between active and paleo flood plain, width of river, width of active flood plain and width of paleo flood plain has calculated along the cross-section of the profile (table.1).

TABLE I. COMPARISON TABLE SHOWING WIDTH OF THE RIVER, ACTIVE AND PALAEO FLOOD PLAIN

| **Sl.No.** | **Sample Cross-section** | **Active River width (meter)** | **Active Floodplain width (meter)** | **Paleo floodplain width (meter)** | **Decrease of floodplain width (%)** |
|---|---|---|---|---|---|
| 1 | AA' | 26 | 278 | 1382 | 79.88 |
| 2 | BB' | 44 | 759 | 2587 | 70.66 |
| 3 | CC' | 22 | 261 | 1906 | 86.30 |
| 4 | DD' | 21 | 441 | 2140 | 79.39 |
| 5 | EE' | 27 | 570 | 1566 | 63.60 |
| 6 | FF' | 22 | 497 | 2279 | 78.19 |
| 7 | GG' | 28 | 548 | 2348 | 76.66 |
| 8 | HH' | 25 | 703 | 2036 | 65.47 |
| 9 | II' | 18 | 322 | 1746 | 81.55 |
| 10 | JJ' | 45 | 1216 | 2144 | 43.28 |

From the table, it has observed that the decrease of the width of the floodplain is significant; which is maximum at the CC' and II' and Minimum at JJ' and EE'. And in rest of the profiles has a decrease of the >70 %.

## V. CONCLUSION

The utilization of Digital Elevation Model, Microwave Remote Sensing and Spectral Remote Sensing has proven the effective delineation of Paleo floodplain and Active floodplain of Palam Cauvery; which reflecting the abundant fluvial activity through Palam Cauvery and gradually decrease its width and discharge volume. The glorious past of Palam Cauvery reveals that it evolved through time as a response to tectonics, changes in climate, and structural and tectonic activity. The study reveals that Area of Paleo floodplain has reduced to 86% as compare with Active floodplain and asper the 10 samples width comparative assessment approximately 72.49% width of paleo floodplain has been decreased to current floodplain. The paleo floodplain is fundamental for modelling groundwater aquifers for agricultural and development work. The utility of radar, sepctral remote sensing and fine resolution Digital Elevation Model in viewing and near surface structures and finding paleo hydrologic system has been provided; these systems are encouraged for further research.

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Fig.7. width of active and paleofloodplain.

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