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Micro-Level Experimentation And Application Of Geospatial Methods For Rejuvenation Of Cooum Microwatershed

A. Suresh [1], Dr. RM. Narayanan [2*]

Abstract.
Cooum river once a freshwater source gathering surpluses of 75 little tanks of the minor basin and was used as fishing and boat racing, now undergone the burden of the city's populace explosion. Microlevel studies have identified the continuity of the river flow is disrupted by eight bridges obstructing the free flow of the channel. The sinuosity of the meandering channel varies from 1.432 in the upper reach to a 1.001 along with the lower range. The width depth ratio estimated by S. A SCHUMM's equation varied from 0.0772 to 0.100. The ecological flow varied from 0.12 to 3.16 m^3/s. From the digital elevation model, it was found the relief of the Cooum watershed ranged from -1.5m to 29m. The primary source of the pollutant along the river course is comprised of solid wastes, effluent releases from factories and petroleum refineries, sewage etc... and seawater from estuaries. The amount of sludge to be removed is estimated for the micro watershed is 6172 sq.m, and the area extent is 111304 sq.m.

Keywords—*Cooum river, Restoration, Surface water, Water Quality, Discharge, Sinuosity, Bend ratio.*

1.INTRODUCTION

Cooum is a strongl[1]y desecrated waterway which channels into the Bay of Bengal. The Cooum waterway rises up out of the surplus course of the Cooum tank in Tiruvallur Region. It runs east for separation of around 65 KM and gathering with an inlet of Bay of Bengal underside Napier bridge, go through a disjointing of 16 KM inside Chennai city limits [1]. Cooum waterway further supplies water to Chembarambakkam reservoir and acts as flood carrier with its branches towards Otteri Nallah in the north and Virugambakkam to Arumbakkam channel in along south. The study area is represented in the Figure.1 below.

[1] Research Scholar, [2] Professor & Dean
[1,2]Department of Civil Engineering, Dr M.G.R Educational and Research Institute,
Deemed to be University, Chennai -600095.

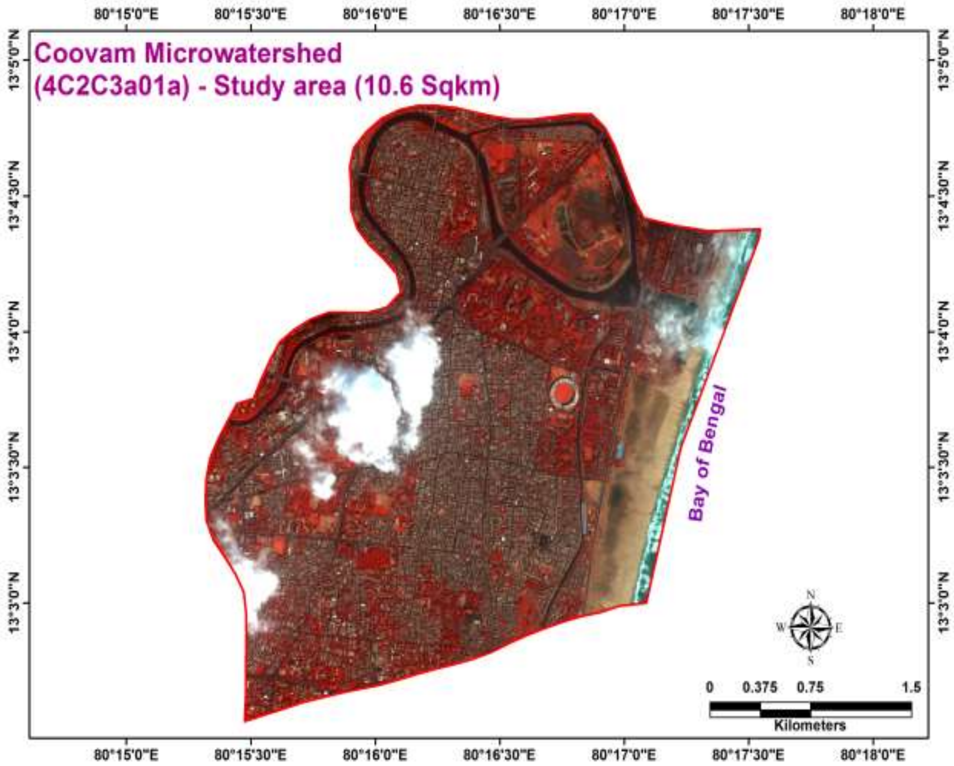


Figure.1 Study area map

1.1 Need for the Study

- Deficiency of water preservation due to the negligence of maintaining irrigation tanks and their supply channels.
- The significant pollution contribution factors are sewage, solid waste, industrial wastes and intrusion [2].
- The means of access of the river channel subjected to obstructed by sand bars coming about because of littoral float making the absence of tidal trade into the stream.
- River system reclamation is to a great extent inspired by the unfavourable economic and ecological effects of corrupted water bodies and related land regions.

1.2 Aim and Objectives

To experiment with the geospatial methods and its significance in the restoration of the Cooum river.

- To check the continuity of the river field, survey is carried out in the study area.
- To estimate the peak discharge and carrying capacity of the river during one of the flooding periods.
- To characterise the meandering, sinuosity, bend radius, variation ratio.
- To perform the topographic survey for the study area and create the slope and gradient map for the study area.
- To characterise the morphology by estimating the amount of silt to be removed for bringing the natural flow of the river.
- To study the water quality of the Cooum river during the year 2015-2016.

2. MATERIALS AND METHODS

2.1 Continuity of river

The potential obstacles of river continuity include dams, weirs, mills, locks cause ecological problems [3]. The continuity of Cooum river is affected by locks and bridges constructed across the Cooum river thence an extensive field survey is carried out to mark the obstruction through GPS and GIS.

2.2 Discharge

The estimation of peak discharge, also known as peak flow, is the most considerable overall economic importance in the application of flood estimation. The point on a stream or river hydrograph representing the highest flow from a single (or cumulative) precipitation event is estimated from the rainfall data of Chennai region. The traditional approach for estimating floods [4] on small drainage basins was estimated using the equation.1

$$Q = CIA \tag{1}$$

Where Q = Peak discharge (ft^3/s)
C = Runoff coefficient (ratio of runoff to rainfall) dimensionless
I = rainfall intensity (in/h)
A = drainage basin area (A)

2.3 Meander Length, Sinuosity, and Bend Radius

The **planimetric geometry of river meanders** is given in equation.2 [5] as

$$\varphi = \omega \sin \frac{s}{M} 2\pi \tag{2}$$

Where φ equals the direction at area s, ω is the maximum angle the meander takes comparative with the general heading of the river, and M is the channel length of a meander.

An approximate algebraic expression is **Variation ratio** and is expressed in equation.3&4 [5]

$$\omega \text{ (radians)} = 2.2 \sqrt{\frac{k-1}{k}} \tag{3}$$

$$\omega = 125° \sqrt{\frac{k-1}{k}} \tag{4}$$

Sinuosity, as assessed by parameter k, as clarified, is believed to be a result of the profile advancement [6], which is just secondarily influenced by the response from the meandering improvement.

As cited by the literature, the **bend radius** [7] is associated with wavelength and is virtually autonomous of sinuosity. Described as in the past, as the average over the 1/6 of channel length for which φ is nearly linearly related to channel distance, bend radius R is expressed as equation.5

$$R = \frac{\frac{1}{6}M}{\Delta\varphi} \tag{5}$$

Since φ ranges from +0.5 ω to- 0.5 ω over this near-linear range. Substituting for ω its algebraic equivalent in terms of sinuosity is given in equation.6

$$\omega = 2.2\sqrt{\frac{k-1}{k}} \tag{6}$$

and since M= kλ, bend radius is given in equation.7

$$R = \frac{\lambda}{13} X \frac{k^{3/2}}{\sqrt{k-1}} \tag{7}$$

Typical values of bend radius in terms of sinuosity reported by literatures are used in the study as given in the Table 1.

Table 1 Bend Radius in terms of Sinuosity

k	Bend radius (R)	Ratio = $\frac{\text{Wavelength}}{\text{bend radius}}$
1.25	0.215 λ	4.6
1.5	0.20 λ	5.0
2.0	0.22 λ	4.5
2.5	0.24 λ	4.2

The sinuosity (P) of these waterways is related with the shape of the channels communicated as a width-depth ratio (F) and to the percentage of silt and clay in the perimeter of the channel (M)as follows:
The relation between the width-depth ratio (F) and sinuosity (P) [5] is shown in equation.8

$$P=3.5F^{0.27} \tag{8}$$

The connection between weighted mean silt-clay (M) in the perimeter of the channel and sinuosity (P) is well created over that for bank material alone and shows that as the sediment dirt substance of the channel, as a whole expands the sinuosity of the channel increases. The relationship is described by the equation.9

$$P = 0.94\ M^{0.25} \tag{9}$$

It shows up additionally that the silt-clay of the channel might be illustrative of the kind of silt load shipped by a stream. It appears to be conceivable that the per cent residue earth in the chain might be identified with the average level of total silt load transported in suspension and is expressed as equation.10

$$F = 255M^{-1.08} \tag{10}$$

2.4 Topographic data collection

Contour map for the study area is essential to demarcate the elevation for finding the flowing river in the graphical representation. A topographic survey was carried out in the study area by using a “Total Station” instrument and ASTER data [8]. The total area surveyed is about 10.4 sq.km with a grid of 30m approximately.

Temporary benchmark at central arm was transferred to the study area. Few Ground coordinates were taken by using GPS Instrument along with topography survey. After that, those data are processed with Auto plotter software and finally prepared the contour map by using AUTOCAD software. Then contour map was Geo-referenced with ground coordinates by GIS. Contour map for the study area is shown in Figure.6.

2.5 Slope/Gradient of the Region

To understand the river behavior slope and aspect is the primary parameter. In this study as per the IMSD/NRSC guidelines [9] the study area has been classified into five different slopes [10] ranging from (0–5°) - Very gentle, (5–15°) -Gentle, (15–25°) – Moderate, (25–35°) - High, and (>35°) -Very high.

2.6 Using Cut Fill for river morphology

Erosion and deposition in a river valley are investigated by characterizing the river morphology with a series of cross-sections should be taken through the valley and regularly surveyed to distinguish regions of sediment erosion and deposition.

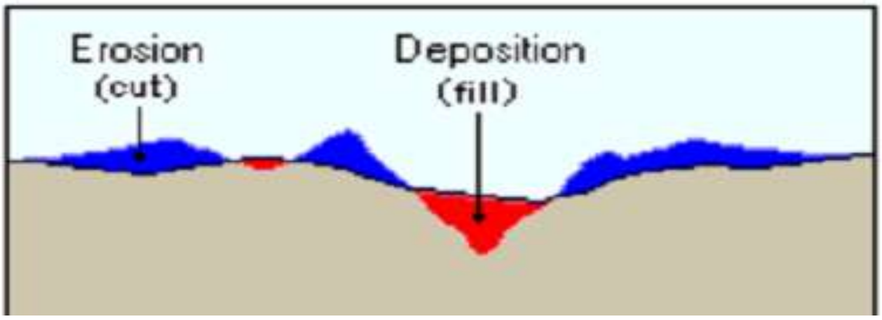


Figure.2 General cross-sectional view of the river

The Figure. 2 & 3 shows how the Cut Fill [6]tool recognizes the regions where the material has been expelled (cut) and where it has been gained (filled). The zone and volume are determined between the reference plane and the surface. The Reference Plane contention decides if these figuring are performed above or underneath the reference, plane using GIS software. Volume is the cubic territory between the plane and the highest point of the surface.

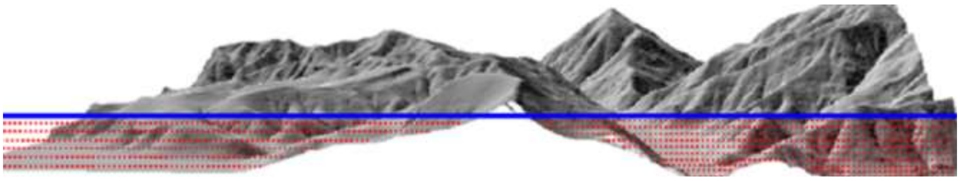


Figure.3 Plane below & above the projected area

2.7 Surface water pollution

Waterways and streams channel falls in upland territories dilute and decomposes pollutants more quickly than standing water. Yet, many waterways and streams are altogether contaminated hence the three crucial stretches of water contaminated in the study area is analysed for three significant sources of contamination [11] (industry, agriculture and domestic) are concentrated along the waterways.

3. RESULTS AND DISCUSSION

In this study, the Continuity of the river is affected by eight bridges: obstructing the free flow of the channel.

- River mouth–Napier Bridge

- Napier Bridge–Periyar Bridge
- Periyar Bridge–Cool ways Bridge
- Cool ways Bridge–St. Andrew Bridge
- St. Andrew Bridge (Arunachala Street)- Harris Bridge
- Harris Bridge–Ethiraj Bridge
- Ethiraj Bridge–College Bridge
- College Bridge–Mc. Nicholas Road.

The discharge estimated along various reaches and also along the college Road Bridge along the Cooum River is given below in Table 2& 3.

Table 2 Discharges for various return periods

Location of Reach	2-year discharge return interval in m^3/s	100-year discharge return interval in m^3/s
Napier Bridge	161	640
Bypass road	119	490
Paruthipattu	115	480

Table 3 Estimated discharge along the College Road Bridge

Date	Time	Level	Discharge
28.10.2006	8.00 A.M	0.40m.	5808 C/S
	6.00 PM	0.60m.	6061 C/S
29.10.2006	8.00 AM	0.90m.	6557 C/S
	6.00 PM	0.50m.	5926 C/S
30.10.2006	8.00 AM	0.40m.	5808 C/S
	6.00 PM	0.30m.	5709 C/S
31.10.2006	8.00 AM	0.20m.	5629 C/S

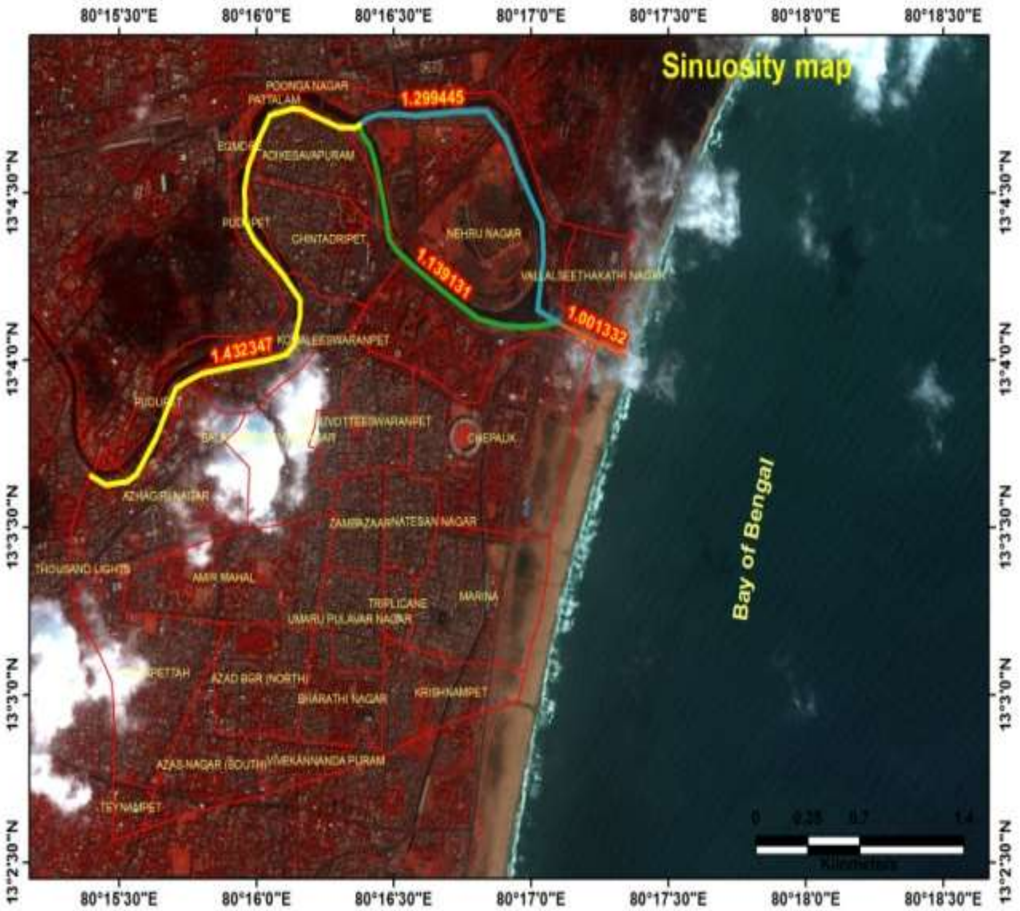


Figure.4 Sinuosity map for the study area

Table 4 Sinuosity, width depth ratio, percentage of silt clay in the meander and banks.

Sinuosity	Width Depth Ratio (F)	Silt-clay in the perimeter of channel. M (%)	Silt-clay in stream banks (%)
1.432	0.087	1.049	38
1.299	0.100	1.084	34
1.139	0.087	1.049	32
1.001	0.077	1.015	30

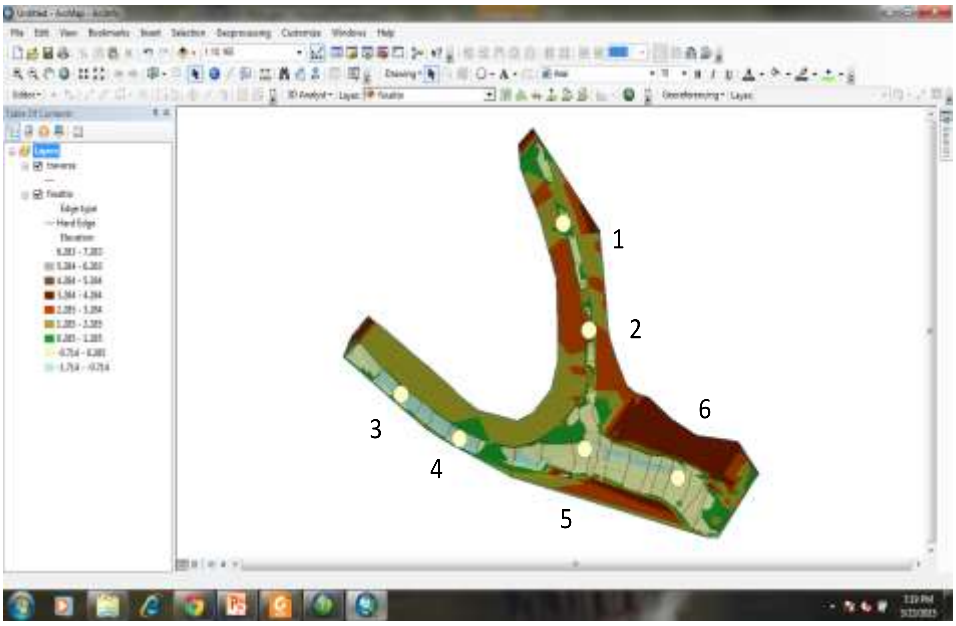
From ARC GIS software the sinuosity calculated for the meandering channel varies from 1.432 in the upper reach to a 1.001 along with the lower range (Figure.4). The width depth ratio estimated by S. A SCHUMM's equation varied from 0.0772 to 0.100 (Table 4). The study indicated the accumulation of silt and clay along the stream banks than the perimeter of the channel. The variation ration of the river channel estimated in this study is comparatively within the permissible standards except for one reach. Sinuosity, bend radius, variation ratio and curve length are showcased in Table 5.

Table 5 Sinuosity, bend radius, variation ratio and curve length

Curve length in m	k	λ	R	VR

0.499	1.0013	0.49	1.04	0.47
0.876	0.87	1	1.2	0.83
3.753	1.43	2.62	0.5	5.24

The downstream water samples are collected across the Cooum river along with six locations, as indicated in the Figure.5 along with latitude and longitude.



80.2773 13.0708 decimal degrees

80.2794 13.0694 decimal degrees

80.2838 13.0691 decimal degrees

80.2871 13.0683 decimal degrees

80.284 13.0727 decimal degrees

80.283 13.076 decimal degrees

Figure.5 Water quality sample locations

Samples collected at 1,2 and 3 of the cities were not suitable for irrigation as they had highly alkaline, and anoxic conditions of dissolved oxygen due to organic loads and high number of dissolved solids. The analysis resulted with identification of microbes which pose health hazards when ingested. The primary source of the pollutant along the river course is comprised of liquid and solid wastes, effluent releases from factories and petroleum refineries, sewage, and seawater from estuaries [12]. The water quality tests undertaken for this plan show the high organic pollution load being added to coastal waters apart from high electrical conductivity [13]. The summary of the general and water quality parameters tested are detailed in the Table 6 below.

Table 6 Water Quality values for the sample locations

Entities	SW1	SW2	SW3	SW4	SW5	SW6	Unit
pH	7.7	7.5	7.85	7.6	7.5	7.6	-
EC	14610	4833	9100	3867	2034	3925	µS/cm
TDS	9820	3360	6270	2740	1456	2775	mg/l
DO	1	1	1	1	1	1	mg/l
Turbidity	35	42	54	60	68	64	NTU
COD	354	256	284	246	218	264	mg/l

BOD3 day 27°C	124	88	98	85	75	92	mg/l

The minimum ecological flow that differs during the time following the pattern the old flow system, which has stamped regular patterns [14]. For the quantification of the operation of monthly minimum ecological flow, the "Range of Variability Approach" (RVA) technique [15] has been applied. This methodology depends on the fundamental role of hydrologic variability on aquatic ecology related to coordination, recurrence, span and the pace of progress with the maintenance of the ecosystems. The following Table 7 shows the quantification of the regime of monthly minimum ecological flow in m^3/s, the "Range of Variability Approach."

Table 7 Monthly minimum ecological flow in m^3/s

Month	**Flow in m^3/s**
July	1.43
August	1.14
September	2.05
October	3.16
November	2.58
December	0.09
January	0.00
February	0.00
March	0.00
April	0.00
June	0.69

From the topographic data (Figure.6) and Digital elevation model (Figure.7), it was found the relief of the Cooum watershed varied from -1.5m to 29m. The slope/gradient map generated for the study revealed that the area falls under a very gently sloping category.

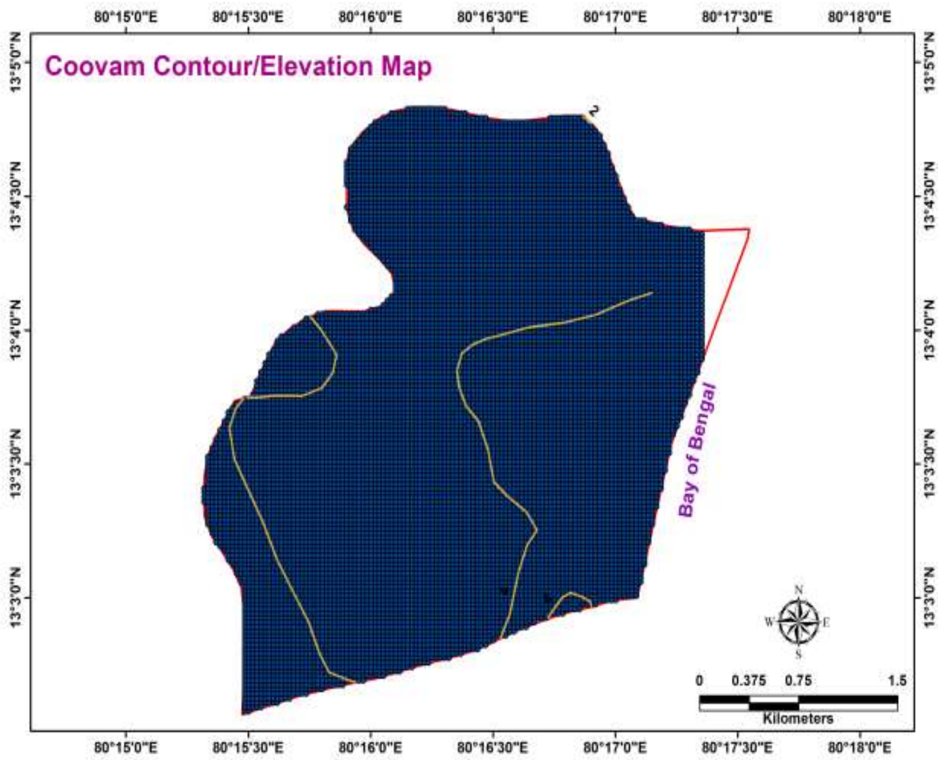


Figure.6 Contour map of the study area

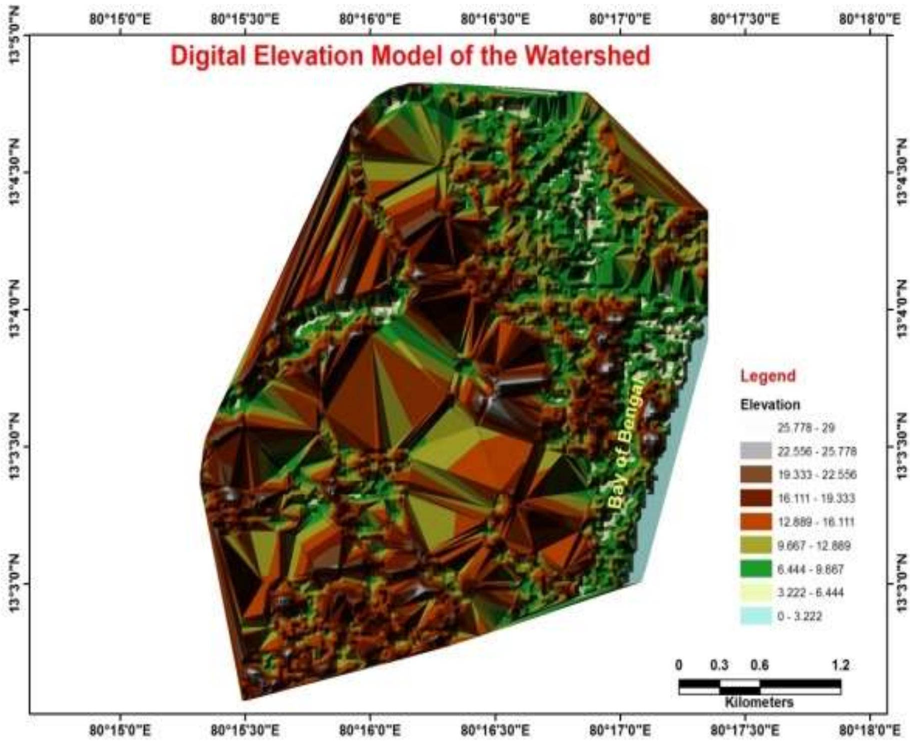


Figure.7 Digital elevation map of the study area

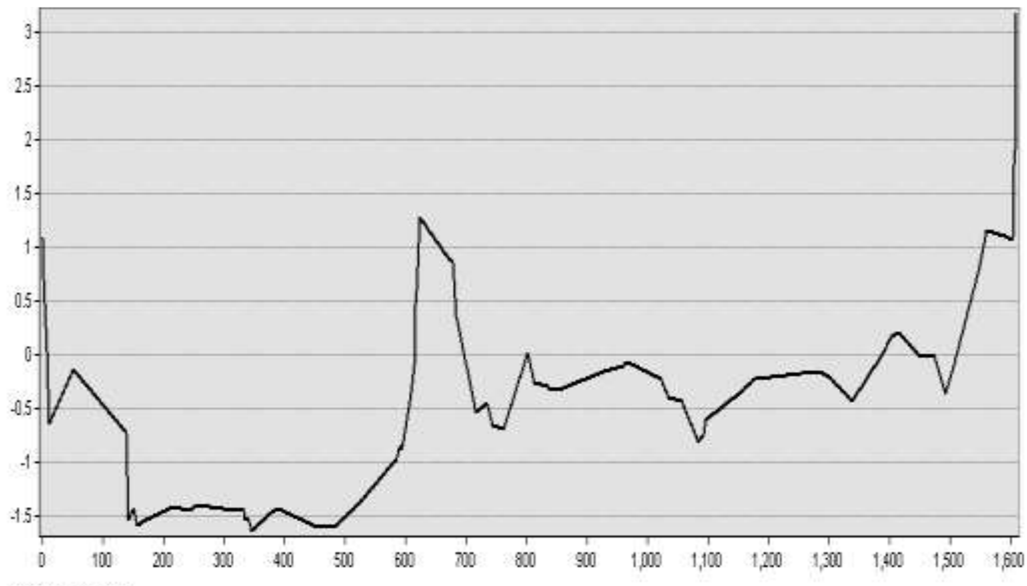


Figure.8 Cross section of the Cooum river transect

Based on the topographic analysis and the Digital terrain model generated for this study indicated that for the free flow of rivers, the amount of sludge to be removed is 6172 sq.m and the area extent is 111304 sq.m from the Figure.8.

4. RECOMMENDATIONS & CONCLUSION

- Dredging to expel the sediment from particular backwaters and side-channel sand to re-establish river habitat.
- Constructing dams and levees to keep sediment loaded water out of prime living space zones and to control water levels for nourishment development for water flow.
- Building islands to diminish wind-produced unsettling influences, in this way lessening turbidity and making living space for little amphibian plants and creatures.
- Altering the progression of water flow to side channels and backwaters towards the streams of silt loaded water during high water for increasing the oxygen levels during low water.
- The elimination of a hydraulic structure permits the return of the natural transport of sediments by the river and their temporary – but renewed – deposition along with the downstream, thus re-establishing a greater variety of aquatic habitats.

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CRediT authorship contribution statement:
A. Suresh: Conceptualization, Methodology, Writing -original draft.
RM. Narayanan: Conceptualization, Correcting draft, Processing and Interpretation of results.

Declaration of competing interest: The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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