Tail End Aberrations of the Rivers of the East Coast of Central and Southern Tamil Nadu, India

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Abstract
The drainages have well defined life histories with youthful, mature and old stages. Such well carved out life histories and the related courses of the drainages are interfered and aberrated by the lithologies, tectonics, geomorphology and their processes. Along the coastal zones, the courses of the drainages are often disturbed and modified by the physical oceanographic processes. In this context, the tail end aberrations and the modified courses in the form of preferential migration, deflected drainages, eyed drainages, compressed meanders and other similar drainage anomalies were studied along the Tamil Nadu coast in some rivers using IRS LISS III FCC data. The studies revealed that the preferential northerly migration of Vaigai, Manimuttar and Pudukkottai Vellar rivers are due to E-W cymatogenic arching and the course of Tamirabharani is due to complementary E-W cymatogenic deep/graben.

The preferential northerly migration of Cauvery river and Eruvadi rivers is due to active N-S northerly hinging faults. The S shaped drainages observed in some rivers are due to NE-SW sinistral faults, the Z shaped drainages do signify dextral faults. Thus, even such minor drainage aberrations confirm the post collision tectonics of the South India inferred by the earlier workers.

Keywords: Drainage aberrations, Active tectonics, South India.

Introduction

The drainages have characteristic life histories. The drainages have three stages in their life viz. youthful stage, mature stage and old stage. In the Youthful stage, they flow in hilly and the upland catchment regions with short and straight drainages having erosion as the dominant process; Whereas in the Mature stage in the plains, the rivers flow with oscillatory courses having both erosion and deposition; in the old stage in the coastal regions, they have noodle flow and sluggish courses with deposition of sediments as the dominant process[24]. The rivers have carved out such well-defined life histories because of the base level of erosion or Mean Sea Levels (MSL). The drainages start their life in the hilly or upland catchments, as they lie very much above the MSL/ base level of erosion. In order to reach the MSL as quick as possible, they flow as short and straight drainages causing deeper erosion forming V shaped gullies. Such vibrant process of erosion is called as youthful stage. When the drainages climb down the hills and reaches the plains, though they comparatively reach the MSL but however lie above the MSL, the drainages flow with oscillatory and sinuous courses causing both erosion and deposition on their either bank. So, this is called as 'watch and walk' phase or mature stage.

In contrast, when the drainages reach the coast, since they attain the MSL, flow in sluggish and over printed pattern, do not have energy to carry the sediments, which they have carried all along, and hence deposit the sediments and develop deltas. So, this is called as 'Brownian phase' or old stage.

Material and Methods

Though the life histories of the rivers are overall controlled by the base level of erosion, their flows are interfered by the geology and the geological processes and cause varied drainage anomalies.[1-5,7,8,16-19,21-23,26]

In addition, along the coastal zones, the physical oceanographic processes too interfere with the flow of the drainages and cause anomalies along the coastal zones.[6,8,11,20] In this context, the drainage aberrations or anomalies seen in the tail end or the coastal regions have been studied in some rivers in parts of central and southern Tamil Nadu (Fig. 1) and their significance has been brought out. In the study, digital image processing of IRS LISS III data was carried out using ENVI Image Processing software. The IRS LISS III FCC data gave the better contrasts of the terrain features and the same was used extensively in the present study.

Results

Tail end aberrations of the rivers

Eruvadi River (Fig. 2A): The Eruvadi river which is flowing south easterly all along has taken south southeasterly turn in the coastal zone from Mittatharkulam (2, Fig. 2A) in the north northwest to Koothankuzhi (3, Fig. 2A) in the south southeast and met the sea. It seems to have migrated later, towards northerly (4, Fig. 2A) and now meets the sea near Thisayanvilai (5, Fig. 2A).

This migration is clear from the defunct morphology of the river in the satellite data along Mittartharkulam and Koothankuzhi (Fig. 2A).

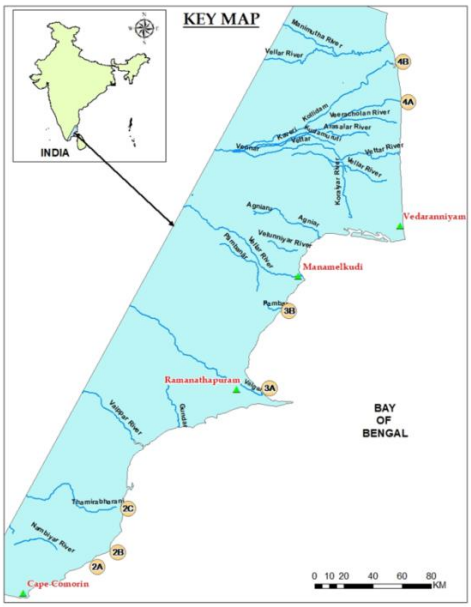

Fig. 1: Key Map; 2A- Eruvadi river; 2B- Thandavankadu river; 2C- Tamirabharani river; 3A- Vaigai river; 3B- Manimuttar-Pudukkottai Vellar rivers; 4A-Palam Cauvery (Kaveri) river; 4B- Coleroon (Kollidam) river.

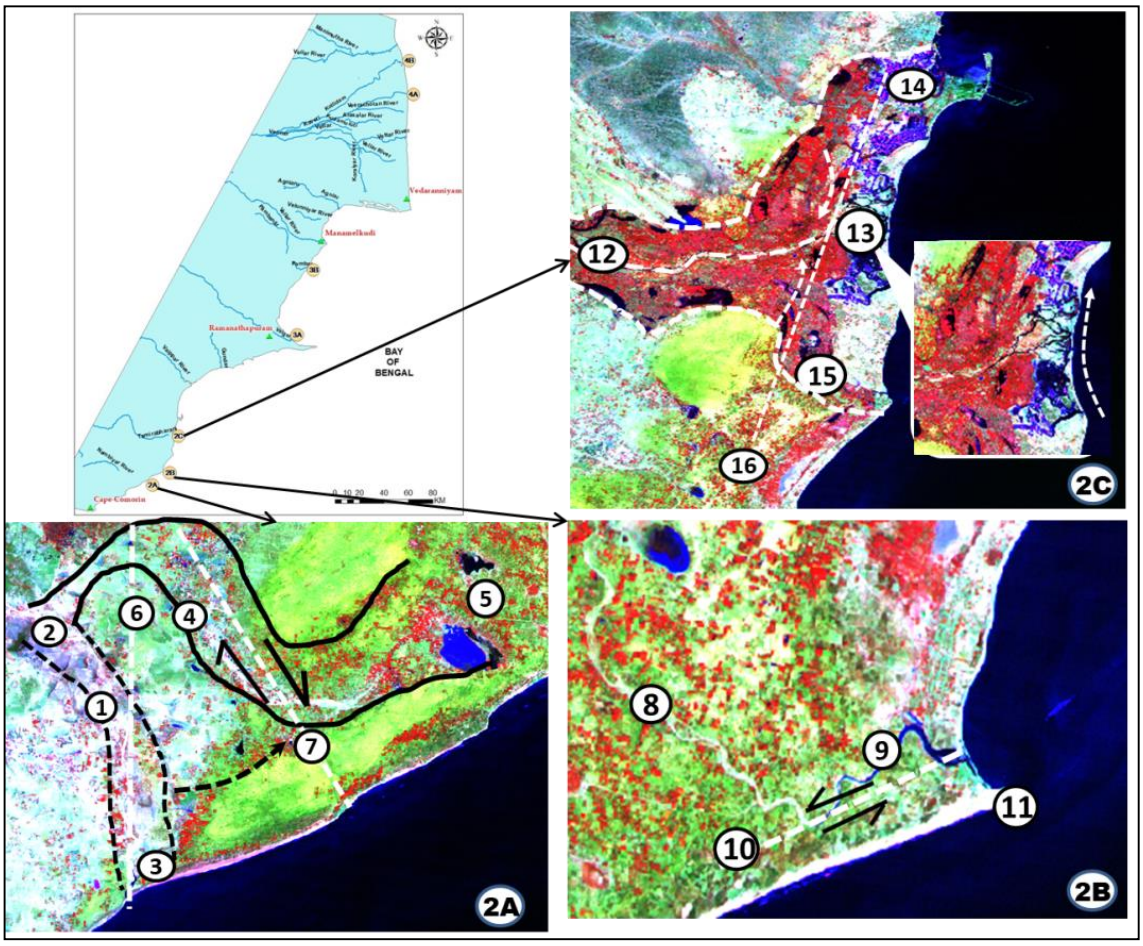

Fig. 2: Drainage aberrations in Eruvadi, Thandavankadu and Tamirabharani rivers:
Fig. 2A: 1-Eruvadi river; 2- Mittatharkulam; 3- Koothankuzhi; 2-3 old course of Eruvadi river along Mittatharkulam-Koothankuzhi; 4- present Z shaped course of Eruvadi river along Mittatharkulam- 5- Thisayanvilai; 6- N-S hinge fault; 7- NW-SE dextral fault.
Fig. 2B: 8-Thandavankadu river; 9- Deflected 'S' shaped compressed segment of Thandavankadu river; 10- ENE-WSW/NE-SW sinistral fault; 11- Manappadu
Fig. 2C: 12-Tamirabharani river; 13- Punnakkayal; 14- Tuticorin; 15- Tiruchendur; 16- NNE-SSW active fault.

N-S lineament coincided with defunct course of the river (6, Fig. 2A). Ramasamy[16] has observed that the N-S faults are the regional extension and also block faults in morphology in parts of Tamil Nadu related to the post collision tectonics of the Indian plate. Ramasamy and Saravanavel[19] have further observed that the N-S faults are also hinge faults with their hinges in the north. So, such N-S lineament/ fault (6, Fig. 2A) must be a northerly hinging fault and because of such earth movements, the Eruvadi river might have been pushed towards northerly.

The new course of the river flowing along Mittatharkulam - Thisayanvilai (2-5, Fig. 2A) showed a Z shaped compressed meander and also this course is coinciding with another NW-SE lineament (7, Fig. 2A). Ramasamy[16] and Ramasamy et al[17] have observed Z shaped compressed meanders in number of rivers in parts of Tamil Nadu and advocated dextral earth movements along them. Hence, such Z shaped compressed meander of the Eruvadi River must be due to the dextral movement of the land along the NW-SE fault (7, Fig. 2A).

Thandavankadu River (Fig. 2B): The Thandavankadu river (8, Fig. 2B) which flows south easterly, as soon as it reaches the coast line sharply and abruptly got deflected towards north easterly (9, Fig. 2B) and meets the sea near Manappadu (11, Fig .2B). This has been deflected along the NE-SW lineament (10, Fig. 2B) which shows that this lineament is active. In addition, it seems to be a sinistral fault as seen in the sharper projection of the land in Manappadu area (11, Fig. 2B). Further such deflected drainage has the compressed meander morphology with S shaped pattern (9, Fig. 2B). Such S shaped compressions were observed to reflect the NE-SW sinistral faults in several parts of Tamil Nadu[16,17,19]. This indicates that this sinistral fault not only caused sharper deflection but also the S shaped meandering. The present fault causing deflection of the Thandavankadu river along with S shaped morphology indicates that the NE-SW sinistral fault is active and it confirms the still active post collision tectonic compression advocated by Ramasamy[16] earlier.

Tamirabharani River (Fig. 2C): The Tamirabharani river flows as a straight E-W drainage in the southern part of Tamil Nadu (Key map: 12, Fig. 2C) and meeting the sea near Punnakkayal (13, Fig. 2C). In the coastal zone, it has developed a wide estuarine delta from Tuticorin (14, Fig. 2C) in the north to the Tiruchendur in the south (15, Fig. 2C). There is a NNE-SSW lineament (16, Fig. 2C) upto the east. The wide spread estuarine delta has also developed.

Ramasamy and Saravanavel[18] have observed that the N-S, NNE-SSW and NNW-SSE lineaments are block faults related to post collision tectonics. Varadharajan and Ghanju[25] have interpreted several such faults from the airborne geophysical data along the Tamil Nadu coast. So the delta to the east of such NNE-SSW fault must be subsiding along the lineament/ fault facilitating the wide spread growth of the estuaries and thus the estuarine delta. The Tamirabharani river is unique with well-developed flood plain all through its youthful, mature, and old stages. Ramasamy and Saravanavel[18] attributed these anomalies to two subparallel E-W faults to the North and south of the river forming the graben and hence the Tamirabharani River which flows within the subsiding E-W graben, has developed flood plain all through. So this must also be the reason for the broad delta from Tuticorin to Tiruchendur. Then because of the depleted flow, the river must be now flowing along the axis of the delta along Punnakkayal. Again, in Punnakkayal the river Tamirabharani shows northerly migration in the tail end region (insert, Fig. 2C). This northerly migration in the tail end region may be due to the vibrant littoral currents which are moving northerly/ clock wisely throughout the year in the Gulf of Mannar region Ramasamy[15].

Vaigai River (Fig. 3A): The Vaigai river is one of the major rivers in Tamil Nadu (18, Fig. 3A) showing well carved out life history with youthful, mature, and old stages. This southeasterly flowing river has developed a unique and huge lobate delta with thousands of lobes and interlobal depressions. To its south, there was observed a defunct or a palaeo river course which is misfit by Gundar river. This indicates that this must be the old course of Vaigai and the same would have subsequently migrated towards northerly to the present course (18, Fig. 3A). Ramasamy[16] has inferred a cymatogenic arch between Cochin (Kerala) in the west coast and the Rameshwaram (Tamil Nadu) in the east coast of India, which falls in between the Vaigai's old course in the south and Vaigai in the north (19, Fig. 3A). Hence because of such E-W land arching, the Vaigai River which was flowing along the present path of Gundar, might have migrated towards northerly.

Manimuttar- Pudukkottai River (Fig. 3B): Similarly, the Manimuttar River is yet another southeasterly flowing river. This river too shows signatures of aberrations along the coast. It has developed a large lobate delta with its apex near Devakottai (20, Fig. 3B). In the deltaic region, the river has developed bundles of old courses in the southern parts from Devakottai in the North West to Thondi (21, Fig. 3B) in the south east. The present course of the Manimuttar is found with an easterly flow from Devakkotai in the west to Mimisal in the east (22, Fig. 3B) almost fringing in the northern most rim of the delta. This shows that this river which has flowed along Devakottai- Thondi, has migrated towards northerly along the Devakottai-Mimisal. Such northerly migration may be due to the effect of the Cochin-Rameswaram land arching, as Manimuttar is found along the northern slope of such uplifting arch.

Similar aberration is found in Pudukkottai Vellar river which is flowing in the north of Manimuttar river (Fig. 3B). The Vellar River shows bundles of Paleochannels from Kanadukathan (23, Fig. 3B) in the Northwest to Kottaippattinam (24, Fig. 3B) in the southeast.

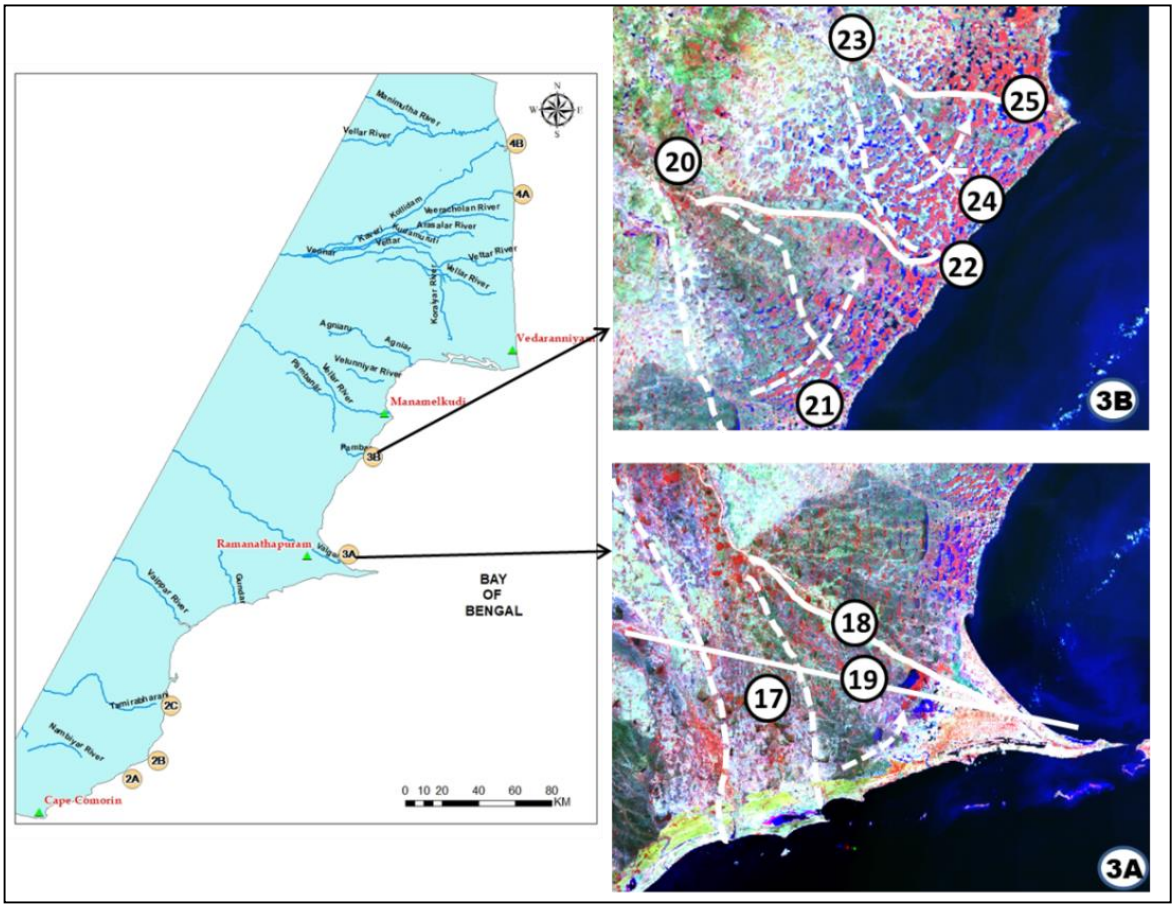

Fig. 3: Drainage aberrations in Vaigai, Manimuttar and Pudukkottai Vellar rivers:
Fig. 3A: 17-Gundar river flowing over the old course of Vaigai; 18- present course of Vaigai river; 19- axis of Cochin-Rameshwaram cymatogenic arch.
Fig. 3B: Old courses of Maimuttar along (20) Devakottai- (21) Thondi; present course along Devakottai- (22) Mimisal; (23) Apex of Vellar delta in Kandukathan; old courses of Vellar river along Kanadukathan (24) Kottaippattinam; present course of Vellar along (23) Kanadukathan- (25) Devipattinam.

But its present course again is found in E-W direction along Kanadukathan in the west to Manmelkudi (25, Fig. 3B) in the east and thus now flowing along the northern fringe of the Vellar delta. Such preferential northerly migration of Pudukkottai Vellar can be attributed to Cochin-Rameshwaram cymatogenic arching as this river is also found along the northern slope of the above said uplifting cymatogenic arch of the land.

Cauvery River (Fig. 4A): In Kumbakonam-Poompuhar area, the river Cauvery displays a wide palaeo course which is called as Palam Cauvery river (26, Fig 4A)**.** There are bundles of Palaeochannels both to the south as well as to the north of the Palam Cauvery River (27, Fig 4A). These palaeochannels are spectacularly seen with red ribbon like bands in IRS LISS III FCC because of the vegetation packages along them.

Generally, in Cauvery delta, there are large number of radiating palaeochannels from east of Tanjore upto the coast and over which the later rivers like Vennar, Vettar, Arasalar, Kudamurutti, Cauvery and other rivers are flowing now. Such display of the palaeochannels and the present palaeochannel Palam Cauvery shows that earlier the river might have flowed in the south eastern end in Vedaranniyam area and later on migrated anticlockwise.

In the process of migration, it would have flowed along Palam Cauvery and then finally moved towards northerly and stabilized as Coleroon in the northern most rim of the delta. Ramasamy et al[10] have developed a migratory model for Cauvery River in which also they have inferred such anticlockwise rotational migration of the river. Such anticlockwise migration of Cauvery was attributed by Ramasamy[16] to the uplift of the southern part of Cauvery delta in Vedaranniyam area in the recent years along the N-S block faults. These block faults were related to post collision tectonics by Ramasamy[16] whereas Ramasamy and Saravanavel[19] explained them as hinge faults. These N-S faults have also been observed to be due to post kinematic drifts[9].

Ramasamy and Ramesh[12] and Ramasamy and Ravikumar[14] inferred the huge building of beach ridges in Vedaranniyam area in the southern part of Cauvery delta and inferred that the land must be rising at the huge rate since last 5000Yrs.

So such block faulting-hinge faulting and the uplift of the south part of Cauvery delta in the Vedaranniyam area must be responsible for the northerly migration of Palam Cauvery.

Coleroon River (Fig. 4B): The Coleroon River (Kollidam) flows all along the NE-SW major lineament (Fig. 1). The NE-SW faults have been inferred to be a regional sinistral faults[16]. Such Northeasterly flowing Coleroon River has anomalous compressed meandering east of Vallampadugai (28, Fig. 4B). In addition to compressed meandering, it also shows the eyed drainage morphology. Ramasamy and Kumanan[13] have observed several eyed drainages in parts of Tamil Nadu and inferred them to be due to tectonic subsidence along the faults that are cutting/ crossing the eyed drainages. The said compressed meanders are also bisected by a NW-SE lineament (29, Fig. 4B), the tectonic subsidence must be responsible for the eyed drainage morphology.

In addition, this compressed meander shows S shaped dragging effect along its NE-SW flow which confirms the still active nature of the NE-SW sinistral faults as demonstrated by Ramsamy[16] in the post collision tectonic model. Immediately after such compressed meanders, the river has taken the east-southeasterly turn due to NW-SE sinistral fault which is visibly seen in the shift of beach ridges along which the spit is also growing in Coleroon mouth.

Discussion

The study of the IRS LISS III FCC data shows that the tail end regions of the rivers show anomalous aberrations. The Vaigai river shows the northerly migration due to the E-W trending Cochin-Rameshwaram cymatogenic arch (1, Fig. 5) whereas the vide delta of Tamarabharani river is observed to be due to its flow along E-W trending faults bounded graben (2, Fig. 5) which appears to be cymatogenic deep complementary to the Rameshwaram cymatogenic arch. Again the wide spread of delta at the mouth of Tamirabharani is due to the cymatogenic subsidence.

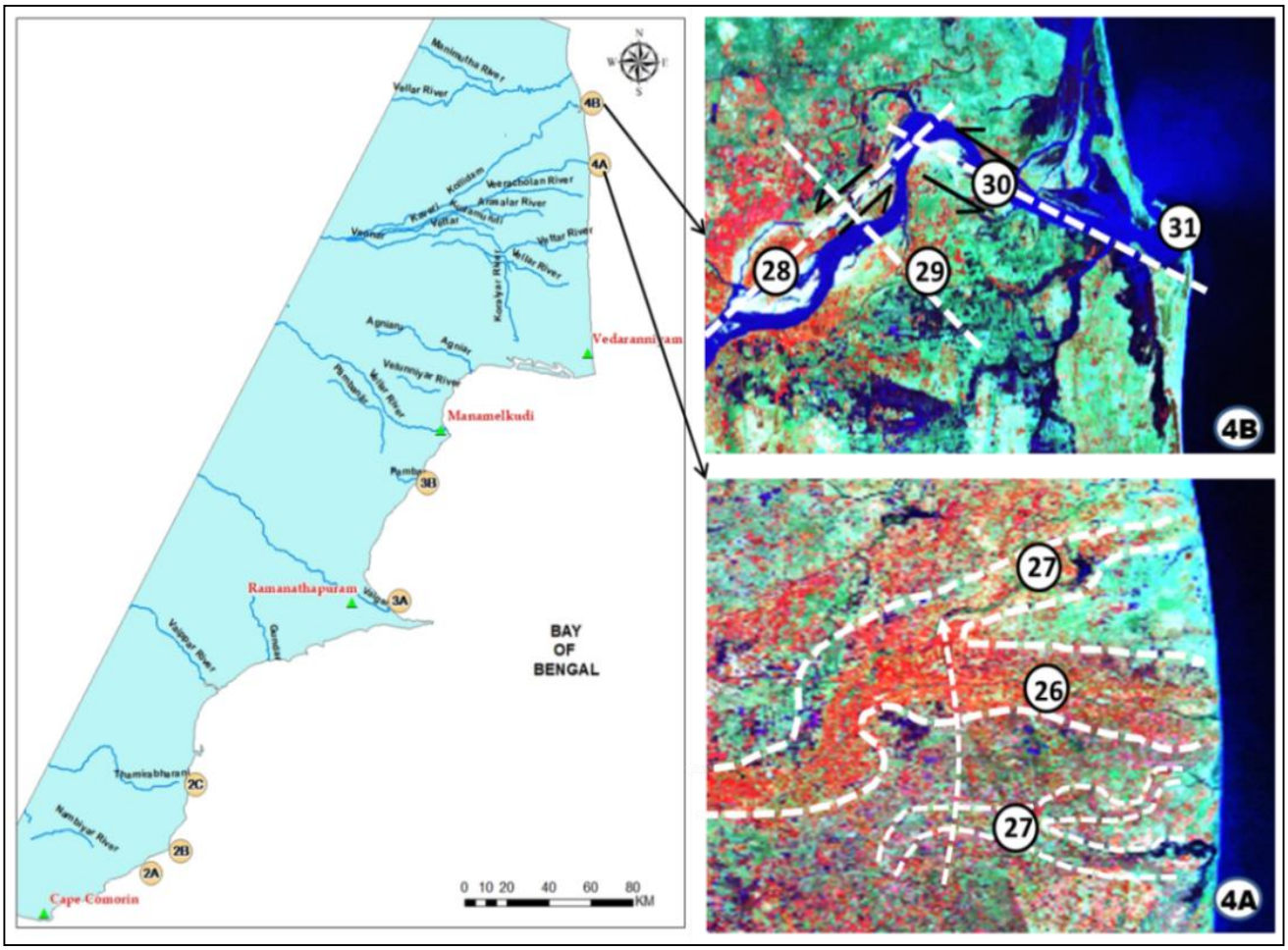

Fig. 4: Drainage aberrations in Palam Cauvery and Coleroon rivers;
Fig. 4A: 26- old course of Cauvery called 'Palam Cauvery' presently flown by Cauvery river; 27- Old courses of Cauvery driver in Cauvery delta; Arrow showing the direction of migration of Cauvery.
Fig. 4B: 'S' shaped compressed meander in Coleroon river due to (28) NE-SW sinistral fault; Eyed drainage in the compressed meander zone, due to land subsidence caused by (29) NW-SE fault; sharper deflection of Coleroon (30) in WNW-ESE direction; sinistral movement along WNW-ESE fault displayed by the land shift in the shoreline and the growth of a (31) spit.

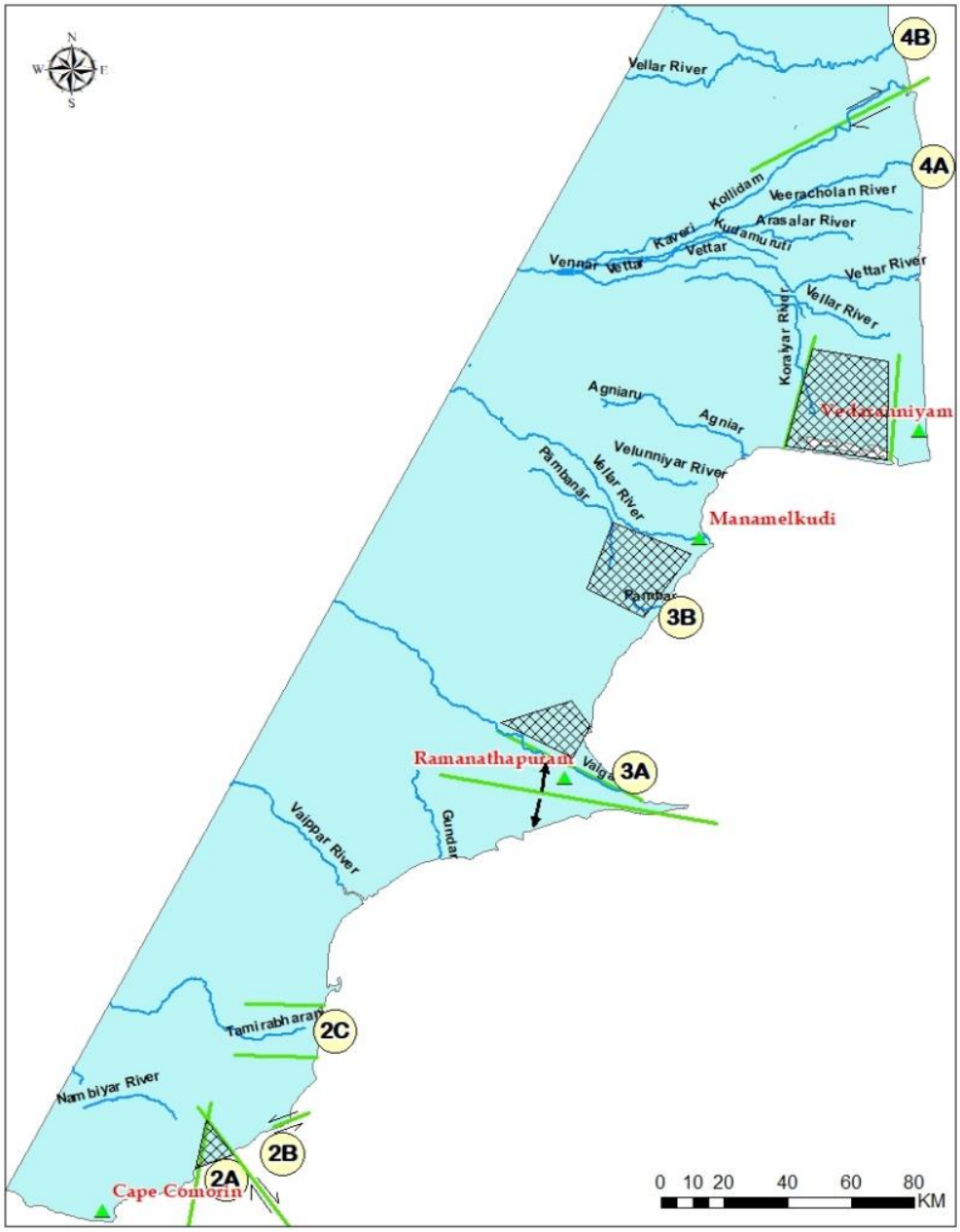

Fig. 5: Drainage aberrations and active tectonics; (1) Vaigai's northerly migration and the cymatogenic arch; (2) Tamirabharani aberrations due to E-W grabening; (3) Northerly migration of Manimuttar and Pudukkottai Vellar due to Cochin-Rameshwaram cymatogenic arch to their south; (4) Northerly migration of Eruvadi river due to northerly tilting of land along N-S fault; (5) Cauvery's migration due to land upliftment in the southern part of Cauvery delta along Vedaranniyam; (6) NE-SW sinistral faulting along Coleroon river; (7) NW-SE dextral faulting along Eruvadi river.

The preferential northerly migration of Manimuttar and Pudukkottai Vellar is observed to be again due to the Cochin-Rameshwaram cymatogenic arch along the northern slope of which these rivers flow in the coastal area (3, Fig. 5). The Northerly flow of Eruvadi river (4, Fig. 5) is due to the active northerly tilting N-S hinge fault again. The northerly migration of Cauvery/ Palam Cauvery (5, Fig. 5) is due to the uplift of the land in the Vedaranniyam area whereas the E-W deflection of the Thandavankadu river (4, Fig. 5) and its S shaped compressed meandering and also the S shaped compressed meander in Coleroon river near Vallampadugai (6, Fig. 5) are due to the still active NE-SW sinistral strike faults. Further the Z shaped meandering in Thandavankadu river (4, Fig. 5) and its coincidence with NW- SE fault are due to the dextral movements.

Conclusion

The tail end migrations of these rivers show the E-W cymatogenic arching and grabening, N-S block faulting and hinge faulting, NE-SW sinistral strike slip faulting and NW-SE dextral faulting confirming the post collision tectonic model developed for south India by the earlier workers Ramasamy[16].

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