Chapter - 6

FLUVIAL SYSTEM

Saurashtra region is affluent in account of rivers, reservoirs and lakes. The drainage system of Saurashtra is characterized by a radial pattern with the rivers flowing in all the directions along tectonic slopes from the central highland (Merh, 1995). The major rivers draining in the present study region are Hiran, Somat, Singwada, Sangawadi, Rupen, Machundri, Rawal, Malan, Raidi and Dhantarvadi. All the rivers, in general, follow channels with steep banks in the hilly regions and show significant deflections as they meet the Arabian Sea. Overall, the drainage pattern shows dendritic, trellis and parallel type of channel form in the upland and pediment area. The older tidal flats in the coastal zone are dominated by distributary channels of small streams. To understand the physical characteristics of rivers and their drainage basin, several factors are defined based on topography, geology, structural attributes, climate and vegetation (Horton, 1932). The topography of the drainage basin obstructs the channel gradient that is represented from the study of longitudinal river profile (Hack, 1973; Kirby and Whipple, 2001; Radoane et al., 2003) which is commonly a smooth curve rising upstream. A river is supposed to ultimately remove topographic irregularities by second last stage and to develop smooth curve from source to mouth (Whipple, 2001). The profile shows breaks in river course and numerous distinct breaks may indicate knickpoints or heads of rejuvenation responds to the present bedrock type, the topography, structures and the source of sediments (Lee and Tsai, 2010). The rivers flowing in morphotectonic domain-I and domain-II are showing varied drainage basin characteristics and drainage pattern. The drainage basin and its stream characteristics are explained with longitudinal river profiles for both the domains to understand the fluvial system of the present study area.

6.1 DRAINAGE BASIN MORPHOLOGY

The morphotectonic domain-I consists of three major drainage basins flowing towards SSE viz., Dhantarvadi, Raidi and Malan River from east to west (Figure 6.1). Overall, the drainages on the upland zone shows dendritic and trellis pattern due to structural features like conjugate joint pattern, faults, shear zones, dyke ridges and strike (cuesta) ridges and valleys. However, the rivers flowing on Tertiary covered terrain show parallel pattern and trellis type of drainage pattern at few places. The detail fluvial system for each drainage basin is described further.

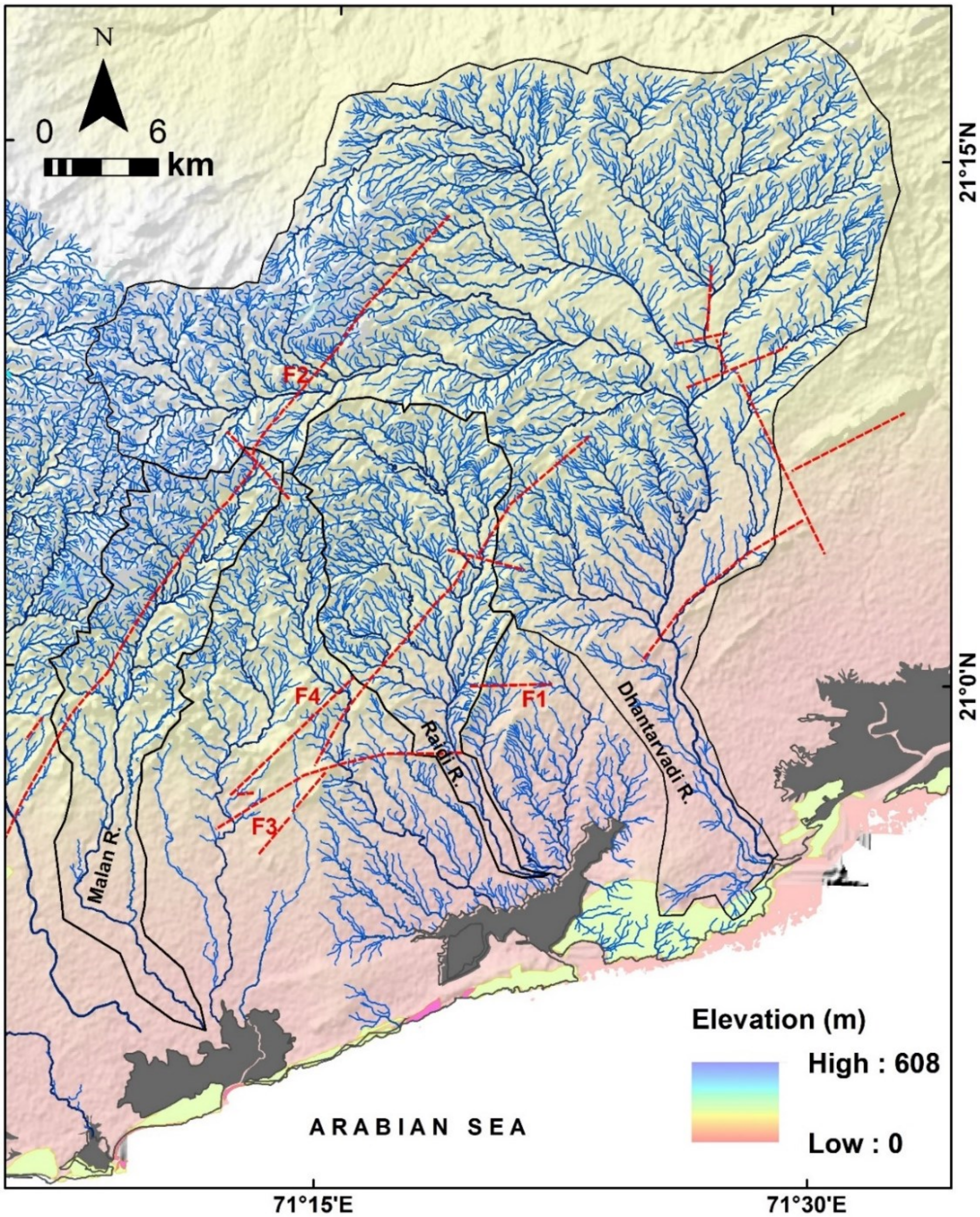

Figure 6.1 Drainage map of morphotectonic domain-I showing faults in the upland zone, mudflats and aeolianite ridges in the coastal zone. Note the parallel drainage patterns over pediment surface flowing towards the southward regional slope.

6.1.1 Dhantarvadi River

The largest drainage basin in the easternmost margin of the domain-I covers the basin area about 864 km^2. The drainage basin is covered by upland zone comprising the southwest tilted trappean lava flows, cuesta ridges, dyke swarms, brittle shear zones and faults (Figure 6.2a-c). The course of the river changes from source to mouth with several sharp meanders over the trappean bedrock. The river originates from the trappean covered undulating terrain incising the lava flows forming small rapids and knickpoints (Figure 6.2b). The fault (F2) trending NE-SW crosses the eastward flowing main trunk stream forming a deformation zone where small channel offset is observed. Towards the east of the fault zone, the river flows over the NE trending dyke swarms with several abrupt channel bends. Majority of the tributaries meeting the trunk channel is flowing from N to NNE towards the SW regional slope. The tributaries in this reach flows parallel drainages following the trend of the dyke ridges with NW facing escarpment (Figure 6.2c). The drainages are showing dendritic to parallel pattern over the dyke swarm covered terrain. The uniform southwest slope in the high relief topography and uniform lithology controls the drainages in this part of the upland zone. There are several dyke ridges with northwest facing scarps offset by other dykes are noticed showing dextral strike-slip nature with the help of satellite imageries. Streams are controlled by several structural attributes forming parallel type of drainage patterns. The deep incised valleys formed over the rugged topography exhibits dendritic drainage patterns. The river flowing over the pediment surface follows shows straight channel with few meanders at places.

The main channel turns southward near the confluence of its large tributary flowing from the north along the regional slope. This confluence was significantly observed with anomalous channel bend, drainage pattern variation and abrupt gradient change to the left side of river looking upstream. At this confluence, the pediment cover is observed where river cliff section shows sharp contact of fine grained alluvium overlying coarse grained alluvial deposits. The middle course of the river comprises of extremely eroded trappean rocks and dyke ridges and southward flowing parallel tributaries. The distinctive appearances of these drainages were only observed at this zone where the channel shifts abruptly towards east where no tributaries were witnessed. The pediment surface entirely consists of Tertiary deposits with orthogonal and conjugate joint sets overlying trappean basalt which are exposed at few river sections (Figure 6.2d). The lower reach shows south flowing straight channel where the drainage boundary narrows with very few streams over the gently southward sloping pediment surface. At the coastal zone, the mouth of the river merges the mudflat and to the sea where marine coastal cliff is exposed at higher altitude with prominent cross-bedding dipping landward.

Figure 6.2 Field photographs of river characteristics and bedrock lithology of river flowing in morphotectonic domain-I. a) Dhantarvadi River flowing eastward over trappean lava flows showing brittle fractures. Channel is ~10m wide incising trappean basalt and forming several rapids. b) River flowing eastward along with the trend of dyke ridges forming rapids over trappean rocks. c) Cuesta ridges swinging in the middle course of Dhantarvadi River shows prominent NW dipping escarpment. d) Dhantarvadi River flowing over coastward gently sloping Tertiary limestone in pediment surface shows prominent orthogonal joint sets. e) Raidi River incising miliolitic deposits up to ~2m in the lower reaches of the channel forming ~150m wide valley. f) Mouth of Raidi River near Jafarabad coast. ~12 to 15m high coastal cliff showing prominent depositional phases with cross-bedding, trough cross-bedding and planar beds. g) Middle reaches of south flowing Malan River showing exposed Quaternary section with Alluvial deposits overlying trappean bedrock lithology. h) Malan River flows along dykes with protruding brittle shear planes and feebly developed striations.

6.1.2 Raidi River

The drainage basin of Raidi River is the most significant basin covering an area of ~162 km^2. The source of the all the channels is NE-SW trending dyke ridges, south of the upper reach of Dhantarvadi River. The drainage patterns observed are trellis, parallel and rectangular type with dendritic pattern at few places. The rectangular channel patterns is due to the presence of dyke ridges, faults and highly eroded trappean lava flows. The brittle shear zones are observed at places resulting in rectangular drainages. The river flows along the slope is towards south and southwest forming parallel type of drainage pattern. The straight courses of the tributaries and main trunk stream towards sea exhibits such pattern. The E-W trending Katar Fault (F1) offsets NE trending dyke ridge in the middle river course over the upland zone. Various cuesta ridges were found on the tilted lava flows and the dip of the flows extends in the direction of the scarp which were long and steep in nature. The cuesta ridges shows NW facing scarps, several parallel running dyke ridges and faults that control the drainages of Raidi river basin. The middle reaches of the channel over the buried pediment zone forms very broad channel valley incising sheet miliolites (Figure 6.2e). The river merges with vast intertidal flat in the coastal zone near Jafarabad creek where the present shoreline has rocky and cliffy coast. The cliff height was around 15-20 m and at some places up to 25 m which gives the evidence of marine erosion (Figure 6.2f).

6.1.3 Malan River

The Malan river basin covers an area of about 153.46 km^2 flowing along fault (F2) towards south at the westernmost margin of the domain-II. The main trunk stream marks the limit of the NE trending dyke ridges in the east and trappean hills in the west. The contrasting topography on either side of the basin midline is prominently observed. The drainages are trellis, parallel and rectangular at few places. The fragmented region due to trappean hill covered upland zone shows trellis pattern. Along the fault and over the dyke swarm, drainages parallel and rectangular patterns due to NE trending parallel ridges over southwest regional slope. At few places, exposed Quaternary sections showing the deposition of alluvium overlying Deccan trap on the left bank of the south flowing river (looking upstream) were seen (Figure 6.2g). The fault evidences are observed on the trappean lava flows near Bediya with brittle fractures forming sigmoidal fracture patterns (Figure 6.2h). The sharp right angle bends are predominantly observed at pediment surface. The fault (F2) might have buried under the Tertiary deposits. However, the channel and tributaries show straight NNE-SSW channel course incising these deposits up to coastal zone.

6.2 LONGITUDINAL RIVER PROFILES

The longitudinal river profiles extracted from the morphotectonic domain-I shows three concave-up profiles with very minor convexity and few slope breaks (Figure 6.3). The Dhantarvadi river profile shows moderate to steep slope in the upland zone over trappean lava flows and NE trending dyke ridges. The main channel drains eastward crossing fault (F2) forming gradient change near the fault zone. Step like rapids to the upstream of the fault zone shows sudden gradient variation. The steep gradient up to 45 km from source where river flows over tilted lava flows, cuesta and dyke ridges. The slope breaks in the middle reaches are due to east flowing channel cutting dykes. Over the pediment surface comprising Deccan Trap and Tertiary deposits, channel flows towards coast over gentle southward slope. The ~35 km long Raidi River shows irregular, moderately coastward sloping bedrock surface and relatively concave upward profile (Figure 6.3). The abrupt breaks in the profile due to the presence of faults show moderately slanting landscape. There is a presence of Katar Fault (F1) and few other local faults observed over trappean lithology controls the drainages (Figure 6.3). The Tertiary rocks are incised over the pediment surface by SSE flowing channel depositing alluvium.

The profile of the ~43 km long Malan river shows uneven and concave upward profile as it flows along the fault (F2) up to coastal zone (Figure 6.3). The profile shows the presence of two small rapids and a knickpoint along its upper course. The change in river course is mainly affected by the presence of several faults, undulating trappean hills and dyke ridges. The reason for few slope breaks might be due to several E-W and NW-SE trending dykes crosses the river transversely. The evidence for development of such knickpoints reveals that may be some type of tectonic activity has taken place during its course in previous time. The drainage characteristics, channel patterns, geomorphic features, structural attributes and river longitudinal profile of morphotectonic domain-I shows that the river and its tributaries are structurally and tectonically controlled.

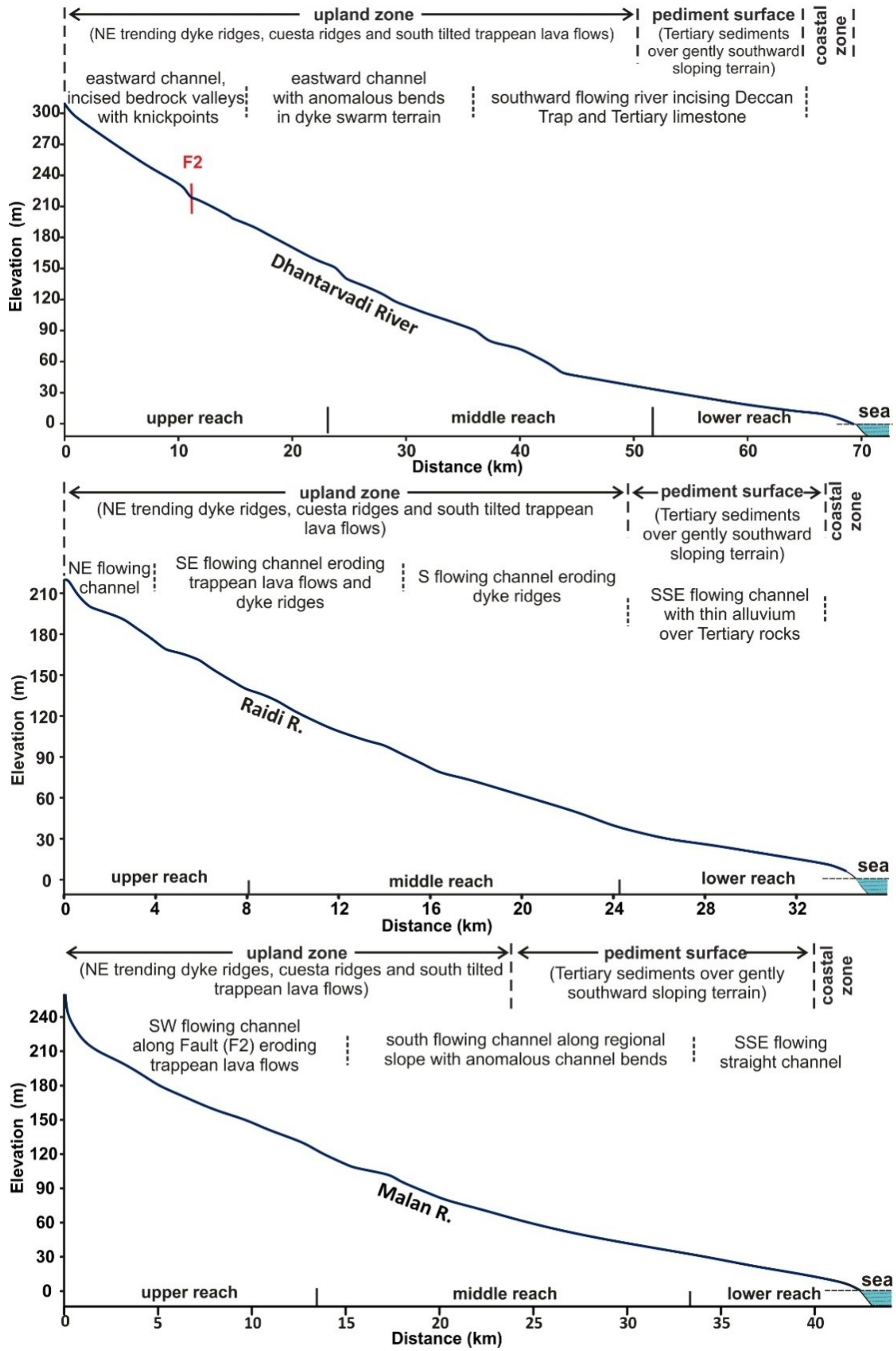

Figure 6.3 Longitudinal profile of Dhantarvadi, Raidi and Malan River showing steeper gradient and concave-up wavelength in upper reaches and gentler slope in lower reaches. Note that the river covers maximum area consisting of dyke swarms, cuesta ridges and southward tilted trappean lava flows.