# *Chapter - 10*

## FLUVIAL SYSTEM – DOMAIN-II

The domain-II consists of seven south flowing major rivers viz., Rawal, Machundri, Rupen, Singwada, Sangawadi, Somat and Hiran River from east to west (Figure 10.1). The pediment zone shows parallel long drainages due to gently southward sloping plain up to the coastal zone. Therefore, at the regional scale, the pattern looks more of dendritic and parallel type of drainages while in local scale; it is trellis type. The close view shows trellis pattern on the upland area where presence of joints and fractures are observed in basaltic region. The most prominent feature observed in the main trunk stream of majority of rivers is sharp meandering and straight channel. The drainages are divided into two categories: a) Rivers originating in trappean terrain (Rawal, Machundri, Singwada and Hiran) and b) Rivers flowing mostly in miliolitic terrain (Rupen, Sangawadi and Somat).

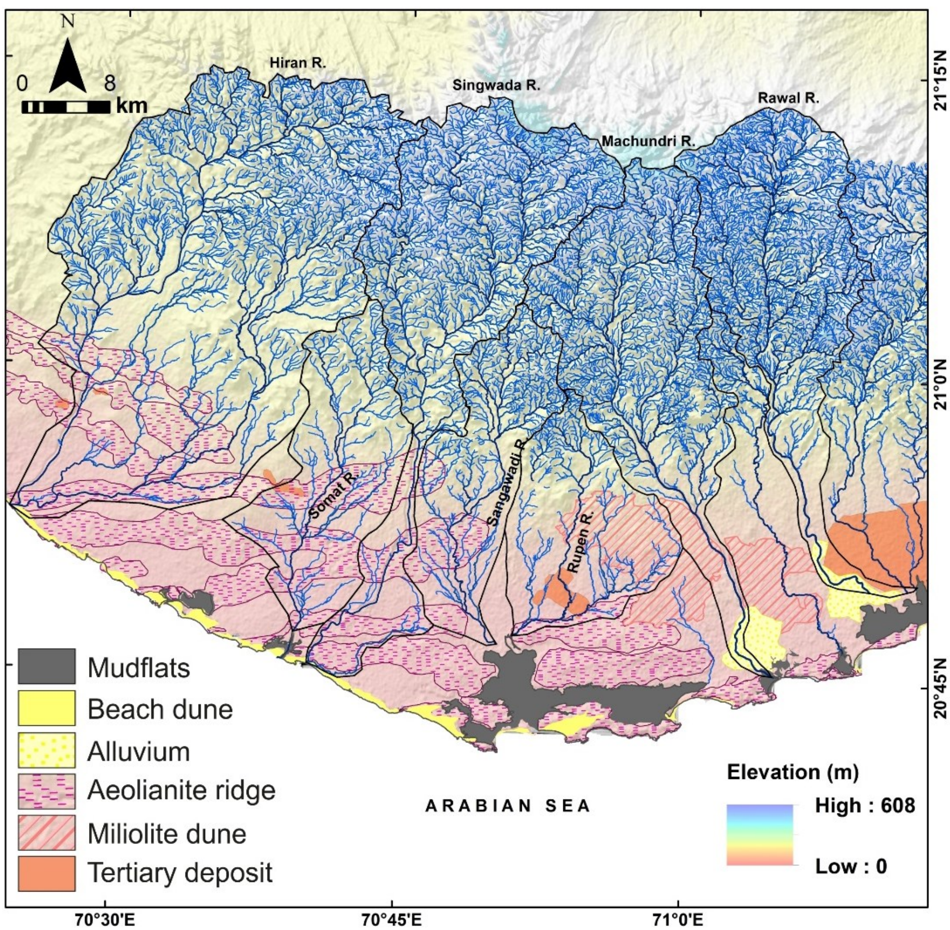


**Figure 10.1** Drainage map of morphotectonic domain-II showing enormous drainages in the upland zone, very few southward flowing parallel drainages in buried pediment zone

and mudflats and beach dune complexes in the coastal zone. Trellis pattern at few places in the upland zone were extracted. Note the anomalous channel bends around aeolianite ridges.

## 10.1 DRAINAGE BASIN MORPHOLOGY

### 10.1.1 Rivers originating in trappean terrain

***Rawal River***

The Rawal River flows at the easternmost margin of the morphotectonic domain-II with basin area of about 371 km$^2$ and length of the main trunk stream is ~56 km. The overall basin exhibits dendritic, trellis and rectangular drainage pattern in the upland zone consisting undulating hilly terrain with linear dykes (Figure 10.1). However, the buried pediment zone shows very less to no tributaries. At the base of the foothills near the contact of trappean lava flows and Quaternary deposits shows few parallel drainages flowing southwest along the regional slope. The main channel slows on a straight path towards south along a structural attribute. The middle reaches shows channel meandering in all the streams flowing over the tilted lava flows. Over the buried pediment zone, the surface exposures of miliolite are found with sudden change in gradient as indicated by the presence of knickpoints (Figure 10.2a, b). The miliolite exposure is overlain by Quaternary sandy alluvium (highly calcretised) further downstream where only main channel flows over the southward gently sloping terrain merging mudflats (Figure 10.2b). The entrenched meander is observed North of Dhokadva village where the surface occurrence of Deccan Basalt is because of the influence of ENE-WSW trending dyke. Hook-shaped meandering at downstream is the result of the presence of miliolite dunes showing low angle planar cross stratification (fluvial gravel) (Figure 10.1, 10.2b). The presence of cross stratified compacted gravelly layer is overlain by semi-compact gravelly sand and that further overlain by less stratified Quaternary alluvium. At this zone, the river incision is very deep up to 15 m at places. The Rawal River also obstructs with several dyke ridges and faults where the presence of rapids and large potholes are witnessed (Figure 10.3c). The abrupt meandering can be explained by lithological transition from miliolite to alluvium, varying thickness of miliolite and also prominent slope towards south.

***Machundri River***

The ~62 km long Machundri River covering an area of approximately 408 km$^2$ shows mostly dendritic to trellis in the upland trappean covered hilly region (Figure

10.1). The presence of several dyke ridges corresponds to the rectangular drainage pattern in the main trunk channel. The river flowing along the dyke ridges at places accompanied by southwest regional slope exhibits right angle channel bends (Figure 10.1). The tilted trappean lava flows parallels with most of the dyke ridges trending southeast and the drainage system behaves accordingly. Minor signature of dyke offsets causes local meanders and straight southward course is because of strong southward regional slope. The channel observed in the upland and pediment zone is broad with incision of trappean bedrock underlain by miliolite up to 20 m. The miliolites deposited over traps are thick sheet miliolites that are estimated to be approx. 10-12m. At one location, the fluvially reworked miliolites are overlain by cross bedded aeolian dune deposits encountered in a quarry section. Sheet miliolites are found to be resting directly on Deccan Trap which are extensively jointed and coastward tilted forming erosional contact. Moreover, river eroding miliolites and depositing large boulders near the sharp meandering (Figure 10.2d). Miliolite dunes, few pocket deposits of Quaternary alluvium between phases of miliolite deposition is observed over buried pediment zone.

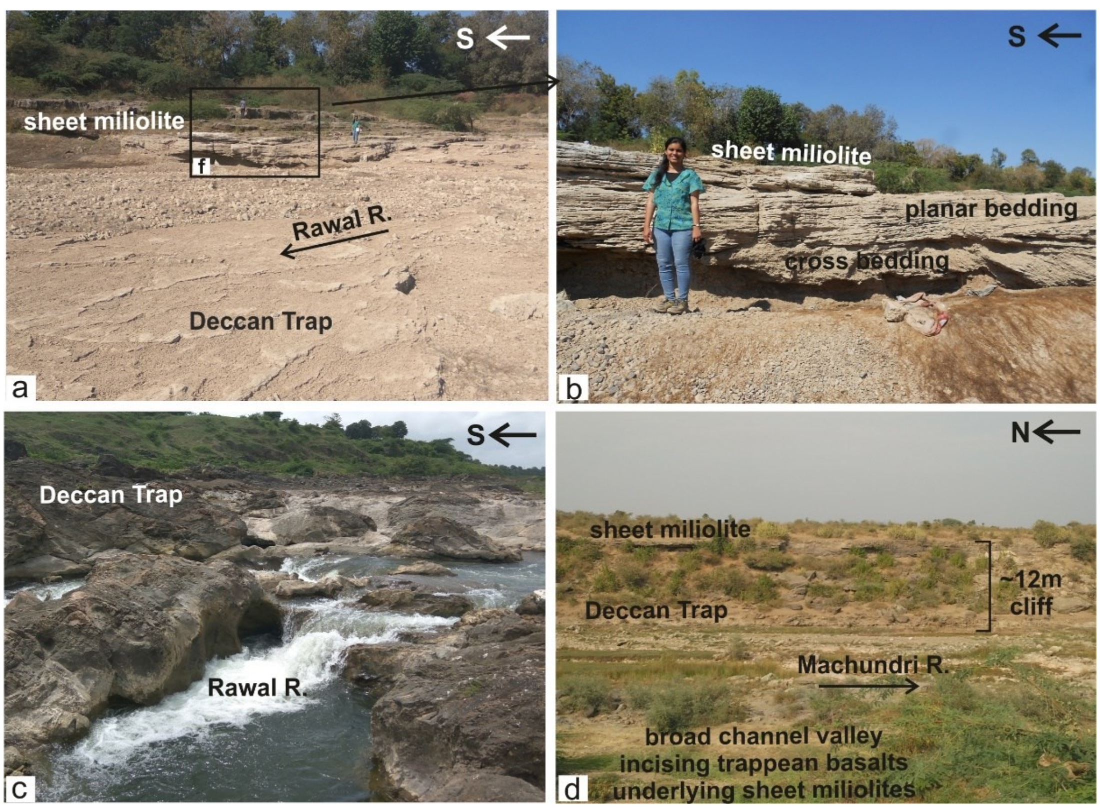


**Figure 10.2** Field photographs of rivers originating in trappean terrain. a) Main trunk channel of Rawal River forming broad valley incising Deccan trap overlain by sheet miliolites. b) Close view of sheet miliolites in Rawal river showing planar miliolite beds overlying the cross stratified miliolites. c) Rawal River downstream near fault (F2)

forming small rapids and potholes over brittle nature of trappean rocks. d) Machundri River valley showing incised cliff of ~12 m with trappean bedrock covered by ~5m thick sheet miliolite deposit.

***Singwada River***

The ~ 71 km long south flowing Singwada River covers the basin area about 480.83 $km^2$in the morphotectonic domain-II (Figure 10.1). The overall drainage pattern shows trellis to dendritic and radial drainage pattern in the upland hilly zone which adjusts to straight channel over buried pediment and coastal zone (Figure 10.1). The main channel corresponds to the trend of dyke ridges and tilted trappean lava flows (Figure 10.3a, b). The river meanders in the upper reaches of the basin and exhibits sharp right angle channel bends. The radial drainages observed around the trappean hills where streams form dendritic to trellis pattern due to dykes (Figure 10.1). The highly fragmented upland region exhibits almost all types of drainage pattern. The trellis and parallel type of drainages at the foothills of the trappean hills and lava flows observed with very few tributaries. The sheet miliolite deposits and E-W trending aeolianite ridges controls the drainages flowing over the southward gently sloping buried pediment cover. The knickpoints and rapids are observed over the trappean bedrock near Jamwala village incising ~7 to 9 m thick sheet miliolite deposits (Figure 10.3a, b). The longitudinal grooves were encountered on the cavernous miliolitic surface that shows few sets of joints with the appearance of the columnar shaped rocks. Such type of miliolitic appearance is not observed at few places in the domain-II over the aeolianite ridge crest. The channel flows on a straight southward course with no tributaries incising deeply the Quaternary miliolites. Several knickpoints observed at this course forms abrupt change in gradient as seen near Ghontvad village (Figure 10.3a, b). The gradient drop is noticed of approx. 6-7 m with Quaternary bedrock incision of sheet miliolites overlying aeolianite ridges showing cross-bedding (Figure 10.3c). No trap rocks or Tertiary rocks are observed further downstream and the sub-horizontal nature of miliolitic limestone with gently southward dip observed (Figure 10.3d). There are erosional terraces cut by river at various levels.

***Hiran River***

It is ~65 km long south-west flowing ephemeral stream originating from the highlands with attitude of ~406 m and drains towards Arabian Sea crossing Quaternary carbonate deposits (Figure 10.3e-h).


**Figure 10.3** Field photographs of rivers originating in trappean terrain. a) Singwada River in upland zone forming ~20m knickpoints at Jamjir waterfall near Ghontvad incising trappean basalt and sheet miliolites. b) Singwada River widens towards downstream incising miliolite deposits overlying Deccan traps. c) Several small rapids observed further downstream of Singwada River incising sheet miliolites forming large potholes. d) South flowing straight channel incising miliolitic limestone. Note the channel widens towards downstream. e) Hiran River near Talala sharply bending westward incising trappean rocks. f) Near Umrethi Dam, Hiran River incising the coast parallel aeolianite ridge. g) Further downstream of Hiran channel incising miliolite forming ~15m high waterfall. Note the thickness of miliolite deposits increases towards downstream. h) Saraswati channel flows westward along the trend of aeolianite ridge (AR-1) forming ~2m knickpoint.

The drainage basin area covers approximately 939.17 $km^2$. The river originates from the undulating terrain of trappean lava flows and dyke ridges. The upland zone is primarily occupied by reserved forest of Gir National Park. The main trunk stream of Hiran River flows southward up to the Veraval coast where Saraswati channel merges draining from northeast (Figure 10.1). The southwest flowing Saraswati channel follows along the aeolianite ridge (AR-1) trending ENE to E. However, Hiran River cuts three coast parallel aeolianite ridges round Hiran River in a straight course towards coast (Figure 10.3e, f). Over the Quaternary deposits consisting of sheet miliolites, Hiran River follows a straight path towards SSW. Before the main stream unites with the sea (~0.5 km inland), two major tributaries viz., Saraswati and Kapila river meets the trunk draining from east and the channel gets widen (Figure 10.3h). The river incising the trappean lava flows forms deep narrow valleys and abrupt gradient change in the upland zone. The drainages are controlled by the trappean rocks at the source region with dendritic and trellis types of drainage pattern. The tributaries decreases as the river crosses the buried pediment zone sloping gently towards coast showing parallel type of drainage pattern. There is almost absence of drainages near coastal zone collecting water and forming marshlands (Pappu and Marathe, 1977). The miliolitic limestone comprising the buried pediment zone and coastal zone has been dated from the exposed cliff sections. The sampled of Paleolithic tools found from the valley and river bank near Talala, Umrethi dam and Sasan has been dated by Baskaran et al., (1986). The river shows sharp meandering and steep gradient change in the trappean highland due to several lineaments trending N-S to NE-SW. The NNE-SSW flowing Hiran River shows typical step-like appearance near the source region covered by basaltic hills and ridges. This river profile shows concave upward shape up to 40 m elevation with gentle sloping bedrock in the middle reaches. The gradient change is due to the presence of large knickpoints (Figure 10.3g). The sudden gradient change observed in the profile is near coastal area. The presence of several miliolitic aeolinite ridges can be the reason of the sudden slope change.

**10.1.2 Rivers flowing mostly in miliolitic terrain**

***Rupen River***

The ~32 km long Rupen river basin covers 223.80 $km^2$ area with mostly dendritic to parallel stream pattern. The river bends in the upland trappean cover zone from flowing towards SE to southward in a straight course. Such sharp meanders were mainly observed near the villages Rewad, Sokhda and Lerka in the buried pediment zone. The river shifts its channel course towards east and flows towards NE up to coastal zone. The Rupen river basin trends south to SSW different from Machundri and Rawal river basin sloping towards SE. The aeolianite ridges extends up to Rupen river basin underlying the miliolite dune deposits. A thin capping of sheet miliolite (fluvial) and Tertiary rocks are encountered along downstream with varying cliff sections. There might have phases of deposition of Quaternary alluvium between phases of miliolitic deposition.

***Sangawadi River***

The ~ 41 km long Sangawadi River flows between Singwada and Machundri River basin covering its basin area about 249.89 km$^2$ (Figure 10.1). Three types of drainage patterns, parallel, trellis and dendritic observed in the river basin (Figure 10.1). The source of the river flows from the upland zone consisting trappean lava flows and dyke ridges of Deccan Trap Formation (Figure 10.1). The dendritic and trellis pattern corresponds to these structural lineaments. The upper reaches of the river shows small tight meanders forming in the trappean bedrock. The middle reaches, however, shows completely different drainage system. Long and parallel drainages flowing towards the coastward slope incising aeolianite ridges overlain by sheet miliolite deposits (Figure 10.4 a-b). The channel changes its course twice over the buried pediment zone. The southward flowing river bends towards southwest at the trappean lava flows receding at foothills. The SW flowing main channel sharply turns towards SSE after flowing along aeolianite ridges (AR-2 and AR-3). The main trunk streams eroded through the ridge trending roughly ENE-WSW placing boulders at the sharp hook shaped meander (Figure 10.4 a-b). The mouth of the channel merges in the large intertidal zone near Diu Island.

***Somat River***

It is ~37 km long ephemeral stream originates from the watershed divide of Hiran and Singwada river (Figure 10.1). The channel drains southwards from the trappean uplands in the Gir reserved forest, north of Bamnasa village, and merges in Arabian Sea near MulDwarka coast. It overpasses the basaltic terrain up to few kilometers and then flows over Quaternary miliolites observed near the coast. The main trunk channel is 37 km long and the basin area covering about 254 km$^2$. The drainages flowing over rugged terrain shows dendritic pattern to parallel stream patterns. The trappean lava flows tilts towards southward regional slope corresponding to the S and SSE draining streams. Due to the moderate sloping terrain, parallel drainages are noticed in the upland region.

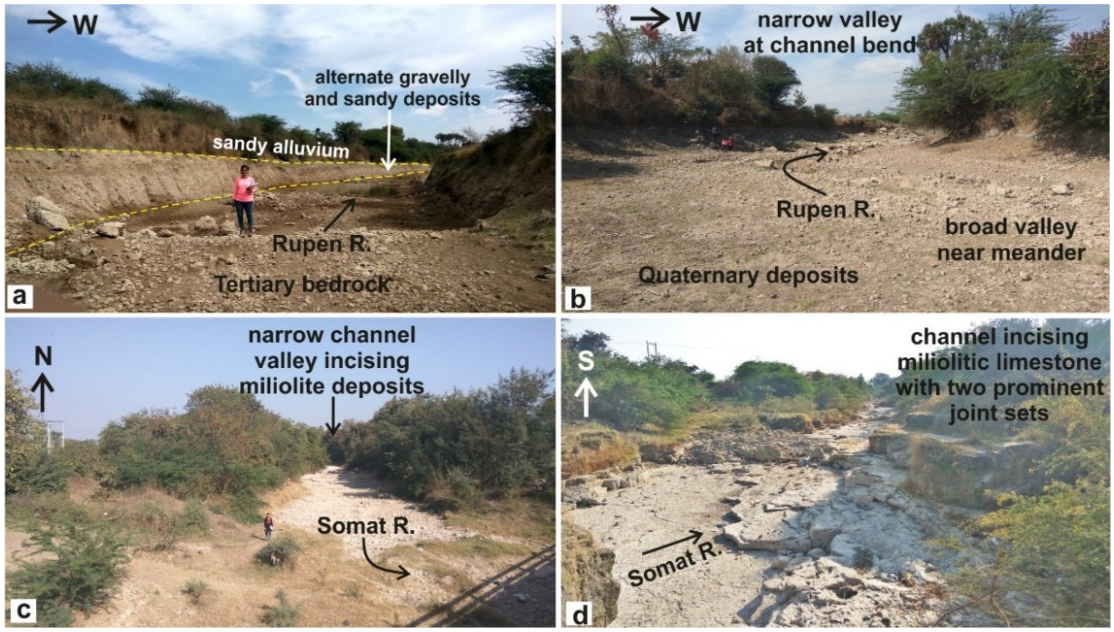


**Figure 10.4** Field photographs showing river characteristics of channel flowing over buried pediment zone in domain-II. a) Rupen river cliff exposing Quaternary alluvial deposits over Tertiary bedrock. Note the channel meanders towards west along aeolianite ridges. B) Rupen river meander incising aeolianite ridge forming narrow valley at channel bend towards west. c) Somat river bedrock showing boulders of Miliolite limestone rocks incised forming narrow valley in the upstream. d) Somat River showing prominent joint sets in miliolitic limestone river bed. ~0.5 to 2 m knickpoints and ~5m miliolite cliff section are also observed. Note the southward straight narrow channel incising miliolites.

At few places, sharp right angle channel bends shows rectangular pattern due to the presence of lithological contact between trappean basalt and overlying Quaternary miliolites (Figure 10.4c, d). Change in river course conforming the southward gently sloping topography over the buried pediment zone. The drainage pattern flows along the E-W trending aeolianite ridges showing rectangular drainage pattern. The fluvial system of the Somat River over the buried pediment zone shows prominent geomorphic features like knickpoints, rapids, deep incised valleys and sudden channel meanders (Figure 10.4d). The aeolianite ridges (AR-1 to AR-4) exposed in the cliff sections shows prominent joint sets that might have appeared due to uplift and cooling effect later. These joints have created blocks with less resistant rocks eroded due to retreating of river. The parallel drainage patterns established due to the coastward gradient observed up to coastal zone. The mouth of the river merges in the intertidal flat near MulDwarka coast.

## 10.2 LONGITUDINAL RIVER PROFILES

The longitudinal profiles of the river flowing in morphotectonic domain-II exhibits variation in drainage pattern and characteristics, topography and geomorphology. The river profiles originating in the trappean terrain shows irregular, concave upward shaped profile showing one major slope break at geomorphic variation (Figure 10.5). The Rawal, Machundri and Singwada River shows almost similar channel patterns over upland zone and buried pediment zone. However, Hiran River relatively shows diverse drainage characteristics. This is because the drainage basin is mainly controlled by aeolianite ridges, sheet miliolites and aeolian dunes deposited over the pediment surface. The E-W trending aeolianite ridges and aeolian dune field corresponds to the sharp right angle channel bends of the major rivers flowing over gently sloping buried pediment zone (Figure 10.5). The presence of knickpoints showing sudden slope breaks are observed at the lithological contact between trappean lava flows and sheet miliolite deposits in Rawal, Machundri and Singwada river (Figure 10.5). The Singwada river profile shows two prominent knickpoints formed waterfall in its middle reaches retreating aeolianite ridges (Figure 10.5). The Hiran River, on the other hand, consists of large tributaries flowing along these aeolianite ridges converge with the main channel covering large basin area. The river also shows large knickpoints around coast parallel aeolianite ridges as the river erodes the aeolianites along with overlying sheet deposits (Figure 10.5).

The longitudinal profiles of rivers flowing mostly in miliolitic terrain shows concave upward profile with wide buried pediment zone covered by sheet/valley-fill miliolites (Figure 10.6). The rivers like Somat, Sandawadi and Rupen flows mostly over the Quaternary covered terrain with long parallel drainages (Figure 10.1). The coastal zone shows very gentle smooth profile from all three rivers. The Rupen river profile shows no such sudden breaks but the gently sloping concave up profile with parallel to collinearly drainage pattern (Figure 10.6). The basin is covered by aeolian dune deposits and sheet miliolites underlain by Tertiary deposits exposed at few places (Figure 10.6). The river anomalously bends towards west along aeolianite ridge (AR-4) near coastal zone (Figure 10.1, 10.6). The Sangawadi River profile shows abrupt slope change at 120 m altitude due to the change in the lithology (Figure 10.6).

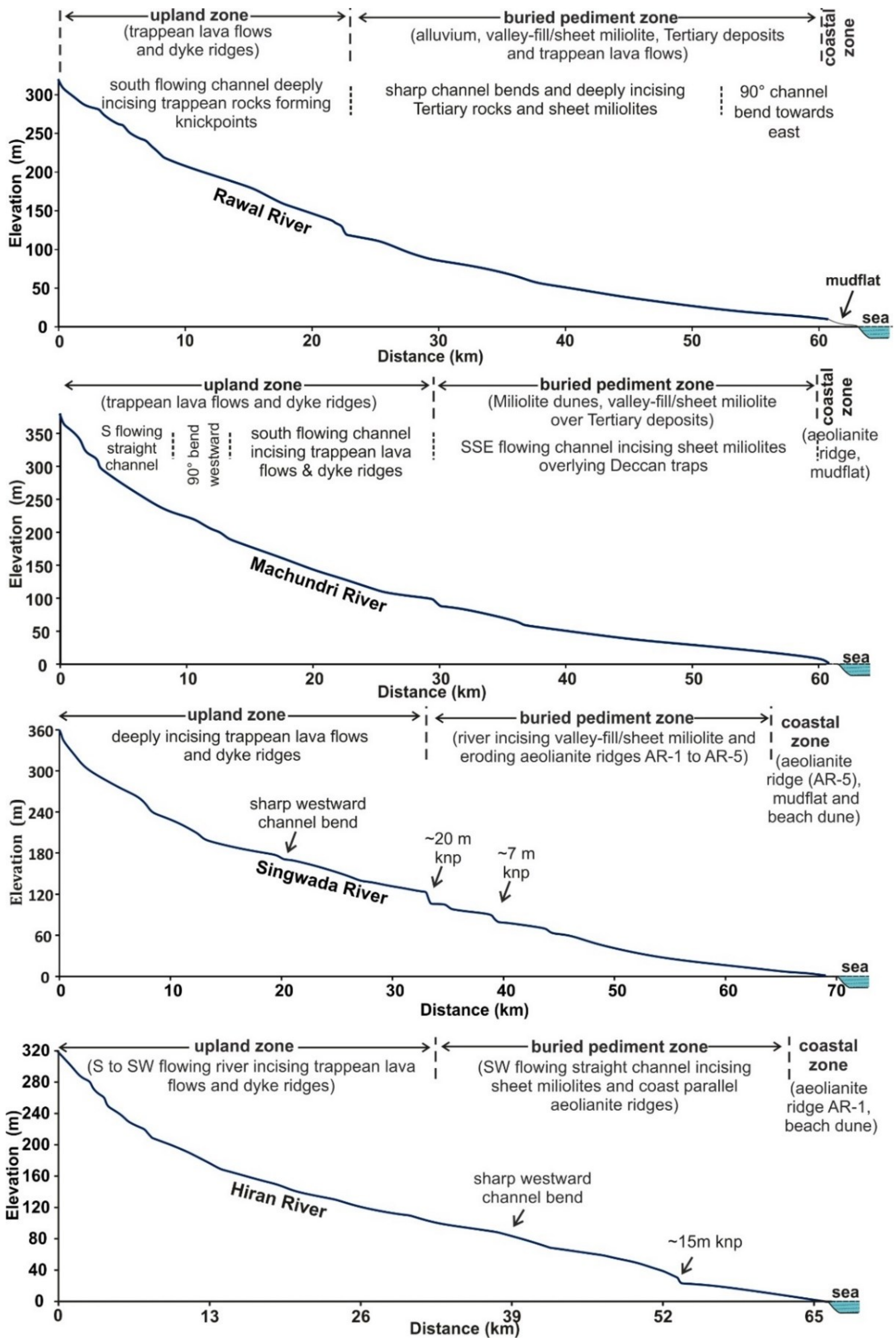


**Figure 10.5** Longitudinal profiles of rivers originating in trappean terrain in morphotectonic domain-II. Note the irregular concave upward profile with sudden slope breaks.

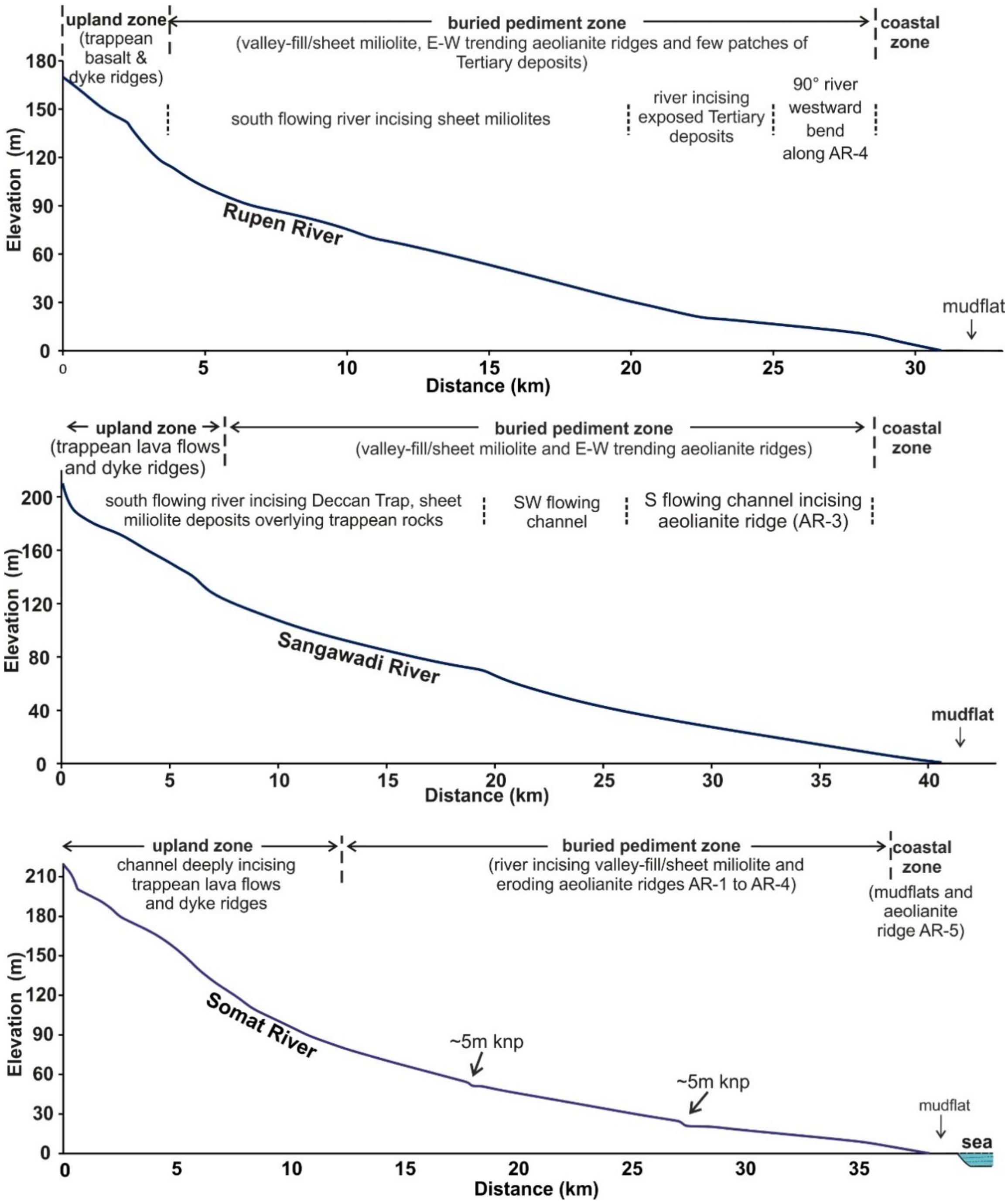


**Figure 10.6** Longitudinal profiles of river flowing mostly in miliolitic terrain in morphotectonic domain-II. Note the buried pediment zone covers the maximum area compared to other major rivers flowing in this domain.