

Document Control Sheet

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Abstract	This manual highlights the use of satellite remote sensing techniques for geomorphological and lineament mapping. A three level classification system based on the origin of landforms was used in creating geomorphology and lineament database on 1:50,000 scale. A total of 417 landforms under 11 genetic classes were mapped in this project. This manual (web version) also addresses uniform geodatabase standard to be followed during the mapping stage. A detailed description of the landforms is also provided in the project manual.
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**National geomorphological and lineament mapping on 1:50,000 scale
using Resourcesat-1 LISS-III data
(ISRO - GSI collaboration under *Standing Committee on Geology*)**

INTRODUCTION

Geomorphology is defined as scientific study of landforms. **Geo means 'earth', Morpho means 'form' and Logy means 'discourse' or 'science'**. It is a branch of Earth Science, which has grown after the advent of Aerial photographs and satellite data. Geomorphology, along with information on soil, water and vegetation has become one of the essential inputs in planning for various developmental activities. The scope of geomorphology has further expanded with the landform maps widely used in various fields of resource surveys, environmental analysis, hydrological studies, engineering applications and geo-technical studies. As a result, experts in various fields such as geoscience, pedology, hydrology, civil engineering, urban planning etc. have started intuitively using landform maps for various applications in their respective fields. But classification schemes of landforms used for resource surveys and other research applications are derived based on the requirement of the specific activity for which it would be used without giving much emphasis on the genesis of the landforms. Though, Geological Survey of India (GSI) has prepared the geomorphological map on 1:2,000,000 scale, it is desirable to map the landform of the country on 1:50,000 scale due to demands from various user communities.

Similarly, the significance of structural lineaments, which reveal the hidden architecture of rock basement has been recognised only recently with the advancement in geologic remote sensing. Lineament studies have found applications in various fields of earth science such as global tectonic studies, delineation of litho-contacts and tectonic units, analysis of deformation pattern, ground water and oil exploration, geo-technical and geo-engineering applications and seismo-tectonic studies. Though, small-scale lineament maps are available, their utility is limited to regional scale tectonic studies. Also, with the advancement in digital image processing techniques, the satellite data in

conjunction with Digital Elevation Model (DEM) have great potential in lineament detection and mapping. Therefore, there is a need for detailed lineament maps of the entire country, which along with landform maps could form the basis for applications in various fields of earth science.

This project is an outcome of the need projected in Standing Committee on Geology Chaired by Secretary, Ministry of Mines and attended by the various geological organizations like GSI, ONGC, NMDC, AMD, MECL etc. A pilot study was carried out jointly by GSI and ISRO in some of the important geological provinces of India to develop a National schema on landform classification. A National committee on the schema deliberated on the results from the pilot study and finalised the geomorphological classification system for national geomorphological mapping on 1:50,000 scale using satellite data. The accepted schema was used to carry out the mapping, and after 6 months of the project initiation, the schema was revisited based on suggestions received from various partner institutes as well as from GSI and ISRO teams. The revised schema is listed in table-1.

Geomorphology classification schema

The new genesis-based classification system is conceived with three levels (Table 1). Level-1 of the classification system consists of 11 genetic classes such as structural, denudational, fluvial, coastal, aeolian, glacial, karst, volcanic, impact, lacustrine and anthropogenic. Level-2 consists of 42 landforms (unique combination of levels 1 and 2), identified based on morphostructure. For example, structurally originated landforms were classified in level-2 as highly, moderately and less dissected hills and valleys, if it is a hill or highly, moderately and less dissected plateaus, if it is flat land. Level-3 of the geomorphic schema consists of 417 landforms (unique combination of levels 1, 2 and 3) identified based on morphography. For example, under highly dissected hills and valleys of structural origin, 21 landforms (e.g. hogback, cuesta, antiformal hill, ridge etc.) were identified. The landforms such as cuesta, strike ridge and antiformal hill, where geological structures played a crucial role in the landform development and the imprints of primary structures (e.g. bedding) are still preserved, were classified into structural

category. Similarly, landforms such as channel bar, meander scar and oxbow lake developed essentially due to the action of river, were classified into fluvial category.

Detailed description of the classification system with definition and illustration of the landforms is available in the project manual.

The display is restricted to Level-2 (i.e. total 42 landforms) classification for un-authenticated access through the portal. However, the original data with 417 landforms is available with NRSC and the same shall be provided to the users who have undergone authorization process through Bhuvan.

Table 1. Genesis-based three level geomorphological classification system.

S.N	Level-1	Level-2	Level-3
1	Structural origin	Highly Dissected Hills and Valleys	Same as Level2
2	Structural origin	Highly Dissected Hills and Valleys	Hogback
3	Structural origin	Highly Dissected Hills and Valleys	Cuesta
4	Structural origin	Highly Dissected Hills and Valleys	Strike Ridge
5	Structural origin	Highly Dissected Hills and Valleys	Strike Valley
6	Structural origin	Highly Dissected Hills and Valleys	Homocline
7	Structural origin	Highly Dissected Hills and Valleys	Monocline
8	Structural origin	Highly Dissected Hills and Valleys	Antiformal Hill
9	Structural origin	Highly Dissected Hills and Valleys	Antiformal Valley
10	Structural origin	Highly Dissected Hills and Valleys	Synformal Hill
11	Structural origin	Highly Dissected Hills and Valleys	Synformal Valley
12	Structural origin	Highly Dissected Hills and Valleys	Intermontane Valley
13	Structural origin	Highly Dissected Hills and Valleys	Rift Valley
14	Structural origin	Highly Dissected Hills and Valleys	Strath Terrace
15	Structural origin	Highly Dissected Hills and Valleys	Ridge
16	Structural origin	Highly Dissected Hills and Valleys	Hill
17	Structural origin	Highly Dissected Hills and Valleys	Valley
18	Structural origin	Highly Dissected Hills and Valleys	Dyke / Sill Ridge
19	Structural origin	Highly Dissected Hills and Valleys	Dome
20	Structural origin	Highly Dissected Hills and Valleys	Basin
21	Structural origin	Highly Dissected Hills and Valleys	Scarp
22	Structural origin	Highly Dissected Hills and Valleys	Gorge
23	Structural origin	Moderately Dissected Hills and Valleys	Same as Level2
24	Structural origin	Moderately Dissected Hills and Valleys	Hogback
25	Structural origin	Moderately Dissected Hills and Valleys	Cuesta
26	Structural origin	Moderately Dissected Hills and Valleys	Strike Ridge
27	Structural origin	Moderately Dissected Hills and Valleys	Strike Valley

28	Structural origin	Moderately Dissected Hills and Valleys	Homocline
29	Structural origin	Moderately Dissected Hills and Valleys	Monocline
30	Structural origin	Moderately Dissected Hills and Valleys	Antiformal Hill
31	Structural origin	Moderately Dissected Hills and Valleys	Antiformal Valley
32	Structural origin	Moderately Dissected Hills and Valleys	Synformal Hill
33	Structural origin	Moderately Dissected Hills and Valleys	Synformal Valley
34	Structural origin	Moderately Dissected Hills and Valleys	Intermontane Valley
35	Structural origin	Moderately Dissected Hills and Valleys	Rift Valley
36	Structural origin	Moderately Dissected Hills and Valleys	Strath Terrace
37	Structural origin	Moderately Dissected Hills and Valleys	Ridge
38	Structural origin	Moderately Dissected Hills and Valleys	Hill
39	Structural origin	Moderately Dissected Hills and Valleys	Valley
40	Structural origin	Moderately Dissected Hills and Valleys	Dyke / Sill Ridge
41	Structural origin	Moderately Dissected Hills and Valleys	Dome
42	Structural origin	Moderately Dissected Hills and Valleys	Basin
43	Structural origin	Moderately Dissected Hills and Valleys	Scarp
44	Structural origin	Moderately Dissected Hills and Valleys	Gorge
45	Structural origin	Low Dissected Hills and Valleys	Same as Level2
46	Structural origin	Low Dissected Hills and Valleys	Hogback
47	Structural origin	Low Dissected Hills and Valleys	Cuesta
48	Structural origin	Low Dissected Hills and Valleys	Strike Ridge
49	Structural origin	Low Dissected Hills and Valleys	Strike Valley
50	Structural origin	Low Dissected Hills and Valleys	Homocline
51	Structural origin	Low Dissected Hills and Valleys	Monocline
52	Structural origin	Low Dissected Hills and Valleys	Antiformal Hill
53	Structural origin	Low Dissected Hills and Valleys	Antiformal Valley
54	Structural origin	Low Dissected Hills and Valleys	Synformal Hill
55	Structural origin	Low Dissected Hills and Valleys	Synformal Valley
56	Structural origin	Low Dissected Hills and Valleys	Intermontane Valley
57	Structural origin	Low Dissected Hills and Valleys	Rift Valley
58	Structural origin	Low Dissected Hills and Valleys	Strath Terrace
59	Structural origin	Low Dissected Hills and Valleys	Ridge
60	Structural origin	Low Dissected Hills and Valleys	Hill
61	Structural origin	Low Dissected Hills and Valleys	Valley
62	Structural origin	Low Dissected Hills and Valleys	Dyke / Sill Ridge
63	Structural origin	Low Dissected Hills and Valleys	Dome
64	Structural origin	Low Dissected Hills and Valleys	Basin
65	Structural origin	Low Dissected Hills and Valleys	Scarp
66	Structural origin	Low Dissected Hills and Valleys	Gorge
67	Structural origin	Highly Dissected Upper Plateau	Same as Level2
68	Structural origin	Highly Dissected Upper Plateau	Plateau Top
69	Structural origin	Highly Dissected Upper Plateau	Plateau Remnant
70	Structural origin	Highly Dissected Upper Plateau	Mesa

71	Structural origin	Highly Dissected Upper Plateau	Butte
72	Structural origin	Highly Dissected Upper Plateau	Scarp
73	Structural origin	Highly Dissected Upper Plateau	Valley
74	Structural origin	Highly Dissected Upper Plateau	Bench
75	Structural origin	Highly Dissected Lower Plateau	Same as Level2
76	Structural origin	Highly Dissected Lower Plateau	Plateau Top
77	Structural origin	Highly Dissected Lower Plateau	Plateau Remnant
78	Structural origin	Highly Dissected Lower Plateau	Mesa
79	Structural origin	Highly Dissected Lower Plateau	Butte
80	Structural origin	Highly Dissected Lower Plateau	Scarp
81	Structural origin	Highly Dissected Lower Plateau	Valley
82	Structural origin	Highly Dissected Lower Plateau	Bench
83	Structural origin	Moderately Dissected Upper Plateau	Same as Level2
84	Structural origin	Moderately Dissected Upper Plateau	Plateau Top
85	Structural origin	Moderately Dissected Upper Plateau	Plateau Remnant
86	Structural origin	Moderately Dissected Upper Plateau	Mesa
87	Structural origin	Moderately Dissected Upper Plateau	Butte
88	Structural origin	Moderately Dissected Upper Plateau	Scarp
89	Structural origin	Moderately Dissected Upper Plateau	Valley
90	Structural origin	Moderately Dissected Upper Plateau	Bench
91	Structural origin	Moderately Dissected Lower Plateau	Same as Level2
92	Structural origin	Moderately Dissected Lower Plateau	Plateau Top
93	Structural origin	Moderately Dissected Lower Plateau	Plateau Remnant
94	Structural origin	Moderately Dissected Lower Plateau	Mesa
95	Structural origin	Moderately Dissected Lower Plateau	Butte
96	Structural origin	Moderately Dissected Lower Plateau	Scarp
97	Structural origin	Moderately Dissected Lower Plateau	Valley
98	Structural origin	Moderately Dissected Lower Plateau	Bench
99	Structural origin	Low Dissected Upper Plateau	Same as Level2
100	Structural origin	Low Dissected Upper Plateau	Plateau Top
101	Structural origin	Low Dissected Upper Plateau	Plateau Remnant
102	Structural origin	Low Dissected Upper Plateau	Mesa
103	Structural origin	Low Dissected Upper Plateau	Butte
104	Structural origin	Low Dissected Upper Plateau	Scarp
105	Structural origin	Low Dissected Upper Plateau	Valley
106	Structural origin	Low Dissected Upper Plateau	Bench
107	Structural origin	Low Dissected Lower Plateau	Same as Level2
108	Structural origin	Low Dissected Lower Plateau	Plateau Top
109	Structural origin	Low Dissected Lower Plateau	Plateau Remnant
110	Structural origin	Low Dissected Lower Plateau	Mesa
111	Structural origin	Low Dissected Lower Plateau	Butte
112	Structural origin	Low Dissected Lower Plateau	Scarp
113	Structural origin	Low Dissected Lower Plateau	Valley

114	Structural origin	Low Dissected Lower Plateau	Bench
115	Denudational origin	Highly Dissected Hills and Valleys	Same as Level2
116	Denudational origin	Highly Dissected Hills and Valleys	Residual Hill
117	Denudational origin	Highly Dissected Hills and Valleys	Hill
118	Denudational origin	Highly Dissected Hills and Valleys	Dome
119	Denudational origin	Highly Dissected Hills and Valleys	Scarp
120	Denudational origin	Highly Dissected Hills and Valleys	Valley
121	Denudational origin	Moderately Dissected Hills and Valleys	Same as Level2
122	Denudational origin	Moderately Dissected Hills and Valleys	Residual Hill
123	Denudational origin	Moderately Dissected Hills and Valleys	Hill
124	Denudational origin	Moderately Dissected Hills and Valleys	Dome
125	Denudational origin	Moderately Dissected Hills and Valleys	Scarp
126	Denudational origin	Moderately Dissected Hills and Valleys	Valley
127	Denudational origin	Low Dissected Hills and Valleys	Same as Level2
128	Denudational origin	Low Dissected Hills and Valleys	Residual Hill
129	Denudational origin	Low Dissected Hills and Valleys	Hill
130	Denudational origin	Low Dissected Hills and Valleys	Dome
131	Denudational origin	Low Dissected Hills and Valleys	Scarp
132	Denudational origin	Low Dissected Hills and Valleys	Valley
133	Denudational origin	Highly Dissected Upper Plateau	Same as Level2
134	Denudational origin	Highly Dissected Upper Plateau	Plateau Top
135	Denudational origin	Highly Dissected Upper Plateau	Plateau Remnant
136	Denudational origin	Highly Dissected Upper Plateau	Mesa
137	Denudational origin	Highly Dissected Upper Plateau	Butte
138	Denudational origin	Highly Dissected Upper Plateau	Scarp
139	Denudational origin	Highly Dissected Upper Plateau	Valley
140	Denudational origin	Highly Dissected Upper Plateau	Bench
141	Denudational origin	Highly Dissected Upper Plateau	Residual Capping
142	Denudational origin	Highly Dissected Lower Plateau	Same as Level2
143	Denudational origin	Highly Dissected Lower Plateau	Plateau Top
144	Denudational origin	Highly Dissected Lower Plateau	Plateau Remnant
145	Denudational origin	Highly Dissected Lower Plateau	Mesa
146	Denudational origin	Highly Dissected Lower Plateau	Butte
147	Denudational origin	Highly Dissected Lower Plateau	Scarp
148	Denudational origin	Highly Dissected Lower Plateau	Valley
149	Denudational origin	Highly Dissected Lower Plateau	Bench
150	Denudational origin	Highly Dissected Lower Plateau	Residual Capping
151	Denudational origin	Moderately Dissected Upper Plateau	Same as Level2
152	Denudational origin	Moderately Dissected Upper Plateau	Plateau Top
153	Denudational origin	Moderately Dissected Upper Plateau	Plateau Remnant
154	Denudational origin	Moderately Dissected Upper Plateau	Mesa
155	Denudational origin	Moderately Dissected Upper Plateau	Butte
156	Denudational origin	Moderately Dissected Upper Plateau	Scarp

157	Denudational origin	Moderately Dissected Upper Plateau	Valley
158	Denudational origin	Moderately Dissected Upper Plateau	Bench
159	Denudational origin	Moderately Dissected Upper Plateau	Residual Capping
160	Denudational origin	Moderately Dissected Lower Plateau	Same as Level2
161	Denudational origin	Moderately Dissected Lower Plateau	Plateau Top
162	Denudational origin	Moderately Dissected Lower Plateau	Plateau Remnant
163	Denudational origin	Moderately Dissected Lower Plateau	Mesa
164	Denudational origin	Moderately Dissected Lower Plateau	Butte
165	Denudational origin	Moderately Dissected Lower Plateau	Scarp
166	Denudational origin	Moderately Dissected Lower Plateau	Valley
167	Denudational origin	Moderately Dissected Lower Plateau	Bench
168	Denudational origin	Moderately Dissected Lower Plateau	Residual Capping
169	Denudational origin	Low Dissected Upper Plateau	Same as Level2
170	Denudational origin	Low Dissected Upper Plateau	Plateau Top
171	Denudational origin	Low Dissected Upper Plateau	Plateau Remnant
172	Denudational origin	Low Dissected Upper Plateau	Mesa
173	Denudational origin	Low Dissected Upper Plateau	Butte
174	Denudational origin	Low Dissected Upper Plateau	Scarp
175	Denudational origin	Low Dissected Upper Plateau	Valley
176	Denudational origin	Low Dissected Upper Plateau	Bench
177	Denudational origin	Low Dissected Upper Plateau	Residual Capping
178	Denudational origin	Low Dissected Lower Plateau	Same as Level2
179	Denudational origin	Low Dissected Lower Plateau	Plateau Top
180	Denudational origin	Low Dissected Lower Plateau	Plateau Remnant
181	Denudational origin	Low Dissected Lower Plateau	Mesa
182	Denudational origin	Low Dissected Lower Plateau	Butte
183	Denudational origin	Low Dissected Lower Plateau	Scarp
184	Denudational origin	Low Dissected Lower Plateau	Valley
185	Denudational origin	Low Dissected Lower Plateau	Bench
186	Denudational origin	Low Dissected Lower Plateau	Residual Capping
187	Denudational origin	Piedmont Slope	Same as Level2
188	Denudational origin	Piedmont Slope	Colluvial Fan
189	Denudational origin	Piedmont Slope	Talus / Scree
190	Denudational origin	Mass Wasting Products	Same as Level2
191	Denudational origin	Mass Wasting Products	Landslide
192	Denudational origin	Mass Wasting Products	Talus / Scree
193	Denudational origin	Pediment-Pediplain Complex	Same as Level2
194	Denudational origin	Pediment-Pediplain Complex	Residual Mound
195	Denudational origin	Pediment-Pediplain Complex	Inselberg
196	Denudational origin	Pediment-Pediplain Complex	Monadnock
197	Denudational origin	Pediment-Pediplain Complex	Bornhardt
198	Denudational origin	Pediment-Pediplain Complex	Tor
199	Denudational origin	Pediment-Pediplain Complex	Pediment

200	Denudational origin	Pediment-Pediplain Complex	Pediment-Corestone-Tor Composite
201	Denudational origin	Pediment-Pediplain Complex	Pediplain
202	Denudational origin	Pediment-Pediplain Complex	Rolling Plain
203	Denudational origin	Pediment-Pediplain Complex	Wash Plain
204	Denudational origin	Pediment-Pediplain Complex	Valley Fill
205	Denudational origin	Pediment-Pediplain Complex	Gullied Land
206	Denudational origin	Pediment-Pediplain Complex	Badland
207	Denudational origin	Pediment-Pediplain Complex	Plain (Lateritic)
208	Denudational origin	Pediment-Pediplain Complex	Upland (Lateritic)
209	Fluvial origin	Older Alluvial Plain	Same as Level2
210	Fluvial origin	Older Alluvial Plain	Palaeochannel
211	Fluvial origin	Older Alluvial Plain	Abandoned Channel
212	Fluvial origin	Older Alluvial Plain	Palaeolevee
213	Fluvial origin	Older Alluvial Plain	Oxbow Lake
214	Fluvial origin	Older Alluvial Plain	Cut-off Meander
215	Fluvial origin	Older Alluvial Plain	Meander Scar
216	Fluvial origin	Older Alluvial Plain	Terrace
217	Fluvial origin	Older Alluvial Plain	Gullied Tract
218	Fluvial origin	Older Alluvial Plain	Valley Fill
219	Fluvial origin	Older Alluvial Plain	Ridge
220	Fluvial origin	Older Alluvial Plain	Marsh
221	Fluvial origin	Younger Alluvial plain	Same as Level2
222	Fluvial origin	Younger Alluvial plain	Palaeochannel
223	Fluvial origin	Younger Alluvial plain	Abandoned Channel
224	Fluvial origin	Younger Alluvial plain	Natural Levee
225	Fluvial origin	Younger Alluvial plain	Oxbow Lake
226	Fluvial origin	Younger Alluvial plain	Cut-off Meander
227	Fluvial origin	Younger Alluvial plain	Meander Scar
228	Fluvial origin	Younger Alluvial plain	Terrace
229	Fluvial origin	Younger Alluvial plain	Gullied Tract
230	Fluvial origin	Younger Alluvial plain	Valley Fill
231	Fluvial origin	Younger Alluvial plain	Ridge
232	Fluvial origin	Younger Alluvial plain	Marsh
233	Fluvial origin	Older Flood plain	Same as Level2
234	Fluvial origin	Older Flood plain	Palaeochannel
235	Fluvial origin	Older Flood plain	Abandoned Channel
236	Fluvial origin	Older Flood plain	Palaeolevee
237	Fluvial origin	Older Flood plain	Oxbow Lake
238	Fluvial origin	Older Flood plain	Cut-off Meander
239	Fluvial origin	Older Flood plain	Meander scar
240	Fluvial origin	Older Flood plain	Terrace
241	Fluvial origin	Older Flood plain	Point Bar
242	Fluvial origin	Older Flood plain	Gullied Tract

243	Fluvial origin	Older Flood plain	Valley Fill
244	Fluvial origin	Older Flood plain	Ridge
245	Fluvial origin	Older Flood plain	Marsh
246	Fluvial origin	Older Flood plain	Back Swamp
247	Fluvial origin	Active Flood plain	Same as Level2
248	Fluvial origin	Active Flood plain	Palaeochannel
249	Fluvial origin	Active Flood plain	Abandoned Channel
250	Fluvial origin	Active Flood plain	Natural Levee
251	Fluvial origin	Active Flood plain	Oxbow Lake
252	Fluvial origin	Active Flood plain	Cut-off Meander
253	Fluvial origin	Active Flood plain	Meander scar
254	Fluvial origin	Active Flood plain	Crevasse Splay
255	Fluvial origin	Active Flood plain	Point Bar
256	Fluvial origin	Active Flood plain	Braid Bar
257	Fluvial origin	Active Flood plain	Lateral Bar
258	Fluvial origin	Active Flood plain	Channel Bar
259	Fluvial origin	Active Flood plain	Channel Island
260	Fluvial origin	Active Flood plain	Valley Fill
261	Fluvial origin	Active Flood plain	Back Swamp
262	Fluvial origin	Active Flood plain	Flood Basin
263	Fluvial origin	Piedmont Alluvial Plain	Same as Level2
264	Fluvial origin	Piedmont Alluvial Plain	Alluvial Fan
265	Fluvial origin	Piedmont Alluvial Plain	Dissected Alluvial Fan
266	Fluvial origin	Piedmont Alluvial Plain	Palaeochannel
267	Fluvial origin	Piedmont Alluvial Plain	Abandoned Channel
268	Fluvial origin	Piedmont Alluvial Plain	Oxbow Lake
269	Fluvial origin	Piedmont Alluvial Plain	Cut-off Meander
270	Fluvial origin	Piedmont Alluvial Plain	Meander scar
271	Fluvial origin	Piedmont Alluvial Plain	Marsh
272	Fluvial origin	Piedmont Alluvial Plain	Gullied Tract
273	Fluvial origin	Bajada	Same as Level2
274	Fluvial origin	Bajada	Alluvial Fan
275	Fluvial origin	Bajada	Gullied Tract
276	Coastal origin	Older Deltaic Plain	Same as Level2
277	Coastal origin	Older Deltaic Plain	Palaeo Distributary
278	Coastal origin	Older Deltaic Plain	Intra-Meander belt shallow depression
279	Coastal origin	Older Deltaic Plain	Aggraded palaeo channel
280	Coastal origin	Older Deltaic Plain	Swamp
281	Coastal origin	Older Deltaic Plain	Marsh
282	Coastal origin	Younger Deltaic Plain	Same as Level2
283	Coastal origin	Younger Deltaic Plain	Inter-distributary Marsh
284	Coastal origin	Younger Deltaic Plain	Aggraded palaeo channel
285	Coastal origin	Younger Deltaic Plain	Active Distributary

286	Coastal origin	Younger Deltaic Plain	Swamp
287	Coastal origin	Younger Deltaic Plain	Marsh
288	Coastal origin	Older Coastal Plain	Same as Level2
289	Coastal origin	Older Coastal Plain	Beach Ridge
290	Coastal origin	Older Coastal Plain	Swale
291	Coastal origin	Older Coastal Plain	Beach Ridge-Swale Complex
292	Coastal origin	Older Coastal Plain	Aggraded palaeochannel
293	Coastal origin	Older Coastal Plain	Tidal Flat
294	Coastal origin	Older Coastal Plain	Mud Flat
295	Coastal origin	Older Coastal Plain	Tidal Lake
296	Coastal origin	Older Coastal Plain	Creek Network
297	Coastal origin	Older Coastal Plain	Rann
298	Coastal origin	Older Coastal Plain	Swamp
299	Coastal origin	Older Coastal Plain	Marsh
300	Coastal origin	Younger Coastal Plain	Same as Level2
301	Coastal origin	Younger Coastal Plain	Beach
302	Coastal origin	Younger Coastal Plain	Beach Ridge
303	Coastal origin	Younger Coastal Plain	Swale
304	Coastal origin	Younger Coastal Plain	Beach Ridge-Swale Complex
305	Coastal origin	Younger Coastal Plain	Tidal Flat
306	Coastal origin	Younger Coastal Plain	Inter Tidal Flat
307	Coastal origin	Younger Coastal Plain	Mud Flat
308	Coastal origin	Younger Coastal Plain	Tidal Inlet
309	Coastal origin	Younger Coastal Plain	Marine Terrace
310	Coastal origin	Younger Coastal Plain	Wave cut Terrace
311	Coastal origin	Younger Coastal Plain	Sea Cliff
312	Coastal origin	Younger Coastal Plain	Spit
313	Coastal origin	Younger Coastal Plain	Longitudinal Bar
314	Coastal origin	Younger Coastal Plain	Barrier Bar
315	Coastal origin	Younger Coastal Plain	Offshore Bar
316	Coastal origin	Younger Coastal Plain	Lagoon
317	Coastal origin	Younger Coastal Plain	Mangrove swamp
318	Coastal origin	Younger Coastal Plain	Tidal Lake
319	Coastal origin	Younger Coastal Plain	Creek Network
320	Coastal origin	Younger Coastal Plain	Back Water
321	Coastal origin	Younger Coastal Plain	Estuarine Island
322	Coastal origin	Younger Coastal Plain	Swamp
323	Coastal origin	Younger Coastal Plain	Marsh
324	Coastal origin	Offshore Island	Same as Level2
325	Coastal origin	Offshore Island	Beach
326	Coastal origin	Offshore Island	Beach Ridge
327	Coastal origin	Offshore Island	Swale
328	Coastal origin	Offshore Island	Beach Ridge-Swale Complex

329	Coastal origin	Offshore Island	Tidal Flat
330	Coastal origin	Offshore Island	Inter Tidal Flat
331	Coastal origin	Offshore Island	Mud Flat
332	Coastal origin	Offshore Island	Tidal Inlet
333	Coastal origin	Offshore Island	Spit
334	Coastal origin	Offshore Island	Longitudinal Bar
335	Coastal origin	Offshore Island	Barrier Bar
336	Coastal origin	Offshore Island	Offshore Bar
337	Coastal origin	Offshore Island	Lagoon
338	Coastal origin	Offshore Island	Mangrove Swamp
339	Coastal origin	Offshore Island	Tidal Lake
340	Coastal origin	Offshore Island	Back Water
341	Coastal origin	Offshore Island	Swamp
342	Coastal origin	Offshore Island	Marsh
343	Coastal origin	Coral Reef	Same as Level2
344	Coastal origin	Coral Reef	Fringing Reef
345	Coastal origin	Coral Reef	Barrier Reef
346	Coastal origin	Coral Reef	Atoll
347	Coastal origin	Sea-stacks	Same as Level2
348	Aeolian origin	Aeolian Plain	Same as Level2
349	Aeolian origin	Aeolian Plain	Wadi
350	Aeolian origin	Aeolian Plain	Sand Dune
351	Aeolian origin	Aeolian Plain	Sand Sheet
352	Aeolian origin	Aeolian Plain	Parabolic Dune
353	Aeolian origin	Aeolian Plain	Linear Dune
354	Aeolian origin	Aeolian Plain	Longitudinal Dune
355	Aeolian origin	Aeolian Plain	Transverse Dune
356	Aeolian origin	Aeolian Plain	Barchan
357	Aeolian origin	Aeolian Plain	Seif Dune
358	Aeolian origin	Aeolian Plain	Star Dune
359	Aeolian origin	Aeolian Plain	Dune Complex
360	Aeolian origin	Aeolian Plain	Interdunal Depression
361	Aeolian origin	Aeolian Plain	Playa
362	Aeolian origin	Aeolian Plain	Dissected Dune Complex
363	Aeolian origin	Aeolian Plain	Desert Pavement
364	Aeolian origin	Aeolian Plain	Deflation Plain
365	Aeolian origin	Aeolian Plain	Hamada
366	Aeolian origin	Aeolian Plain	Loess
367	Aeolian origin	Aeolian Plain	Stabilised Dune
368	Aeolian origin	Aeolian Plain	Ridge
369	Glacial origin	Glacial Terrain	Same as Level2
370	Glacial origin	Glacial Terrain	Outwash Plain
371	Glacial origin	Glacial Terrain	Terminal Moraine

372	Glacial origin	Glacial Terrain	Lateral Moraine
373	Glacial origin	Glacial Terrain	Medial Moraine
374	Glacial origin	Glacial Terrain	Kame Terrace
375	Glacial origin	Glacial Terrain	Esker
376	Glacial origin	Glacial Terrain	Lake
377	Glacial origin	Glacial Terrain	Ice Pavement
378	Glacial origin	Glacial Terrain	Cirque
379	Glacial origin	Glacial Terrain	Arete
380	Glacial origin	Glacial Terrain	Hanging Valley
381	Glacial origin	Glacial Terrain	Valley
382	Glacial origin	Glacial Terrain	Valley Glacier
383	Glacial origin	Glacial Terrain	Horn
384	Glacial origin	Glacial Terrain	Nunatak
385	Glacial origin	Glacial Terrain	Avalanche Chute
386	Glacial origin	Glacial Terrain	Crevasse
387	Glacial origin	Snow Cover	Same as Level2
388	Karst Origin	Karst Terrain	Same as Level2
389	Karst Origin	Karst Terrain	Sink Hole
390	Karst Origin	Karst Terrain	Doline
391	Karst Origin	Karst Terrain	Uvala
392	Karst Origin	Karst Terrain	Lapies
393	Volcanic Origin	Volcanic Terrain	Same as Level2
394	Volcanic Origin	Volcanic Terrain	Crater
395	Volcanic Origin	Volcanic Terrain	Volcanic cone
396	Volcanic Origin	Volcanic Terrain	Shield Volcano
397	Volcanic Origin	Volcanic Terrain	Strato Volcano
398	Volcanic Origin	Volcanic Terrain	Lava flow
399	Volcanic Origin	Volcanic Terrain	Lava Channel
400	Impact Origin	Impact Crater	Same as Level2
401	Impact Origin	Impact Crater	Crater Basin
402	Lacustrine Origin	Lacustrine Terrain	Same as Level2
403	Lacustrine Origin	Lacustrine Terrain	Plain
404	Lacustrine Origin	Lacustrine Terrain	Lake Island
405	Lacustrine Origin	Lacustrine Terrain	Swamp
406	Lacustrine Origin	Lacustrine Terrain	Marsh
407	Lacustrine Origin	Lacustrine Terrain	Delta
408	Anthropogenic Origin	Anthropogenic Terrain	Same as Level2
409	Anthropogenic Origin	Anthropogenic Terrain	Mine Dump
410	Anthropogenic Origin	Anthropogenic Terrain	Active Quarry
411	Anthropogenic Origin	Anthropogenic Terrain	Abandoned Quarry
412	Anthropogenic Origin	Anthropogenic Terrain	Road cutting
413	Anthropogenic Origin	Anthropogenic Terrain	Embankment
414	Anthropogenic Origin	Anthropogenic Terrain	Dam and Reservoir

415	Anthropogenic Origin	Anthropogenic Terrain	Archaeological Excavation
416	Anthropogenic Origin	Anthropogenic Terrain	Dike
417	Anthropogenic Origin	Anthropogenic Terrain	Salt Pan

Lineament classification system

Lineaments from remote sensing data can be identified mainly based on their linear nature, presence of moisture, alignment of vegetation, alignment of ponds, straight stream segments, etc. All linear features are interpreted from the image. The cultural features like road, railway line, high tension lines etc. are excluded during the interpretation. However, interpretation of lineaments is done in conjunction with other characteristic geomorphic criteria such as channel offset, bank erosion and down-cutting of channel along lineament, warping and displacement of sediment layer, and branching of river course, abrupt change of river course, presence of dry channel in an active river course, channel rejuvenation and land subsidence, linear ridges, scarp surface, linear alignment of water bodies and straight channel segments. The lineaments were classified into two broad categories as listed below with the subcategories. The geomorphic lineaments are essentially satellite based whereas the structural lineaments are satellite based with conformity evidence from ground / ancillary published data sets.

Classification of lineaments

A. Geomorphic lineaments

- i.* Scarp parallel
- ii.* Drainage parallel
- iii.* Ridge parallel
- iv.* Parallel to shoreline
- v.* Gorge / trench parallel
- vi.* Break-in slope

B. Structural lineaments

- i.* Fault,
- ii.* Joint/Fracture

- iii. Shear Zone,
- iv. Axial trace of fold,
- v. Dyke

Magnitude of lineaments

All lineaments are also classified based on their length into the following two types.

A. Minor lineaments – Very small (magnitude) linear features frequently observed in the image. They correspond to minor faults, fractures, joints and bedding traces in the rock. Geomorphologically they are expressed as linear alignments of local depressions/ ponds and tonal changes in soil and vegetation. For quantification purpose, lineament with length < 3 km is classified as a minor lineament. The length-based classification is adopted from the RGNDWM project.

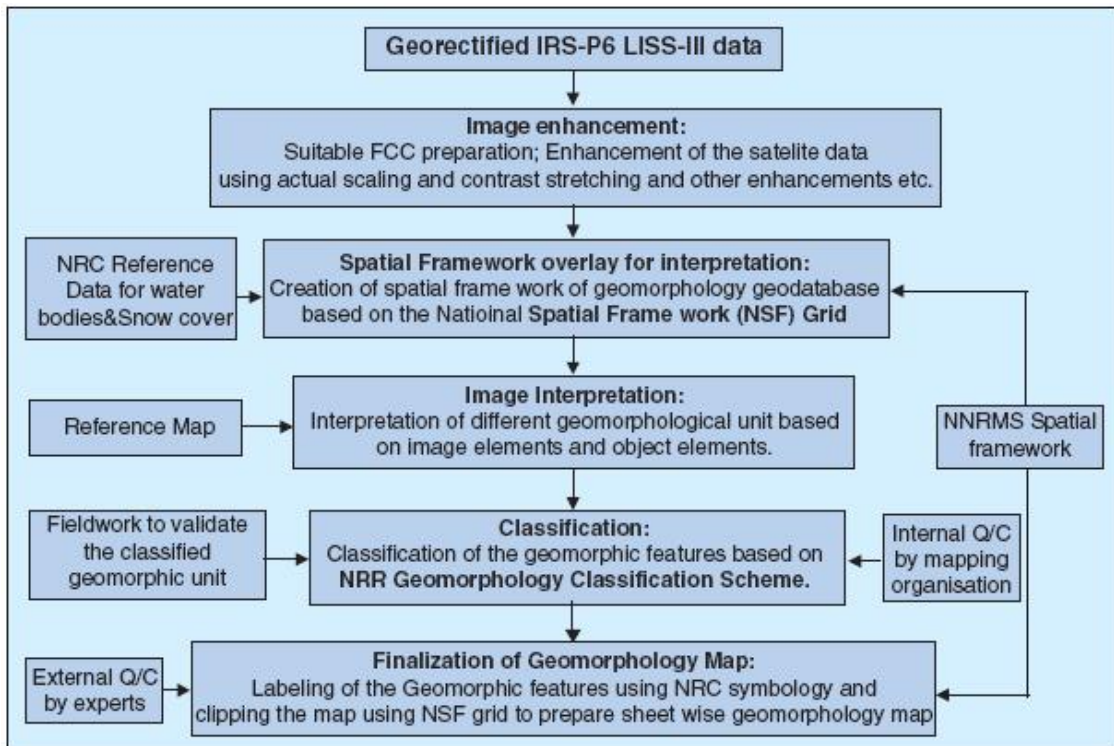
B. Major lineaments – Large linear features. Adjacent/coincides with regional trends/structural features. It cuts across various geomorphic units both in time and space. Lineament with length > 3 km is classified as a major lineament.

METHODOLOGY

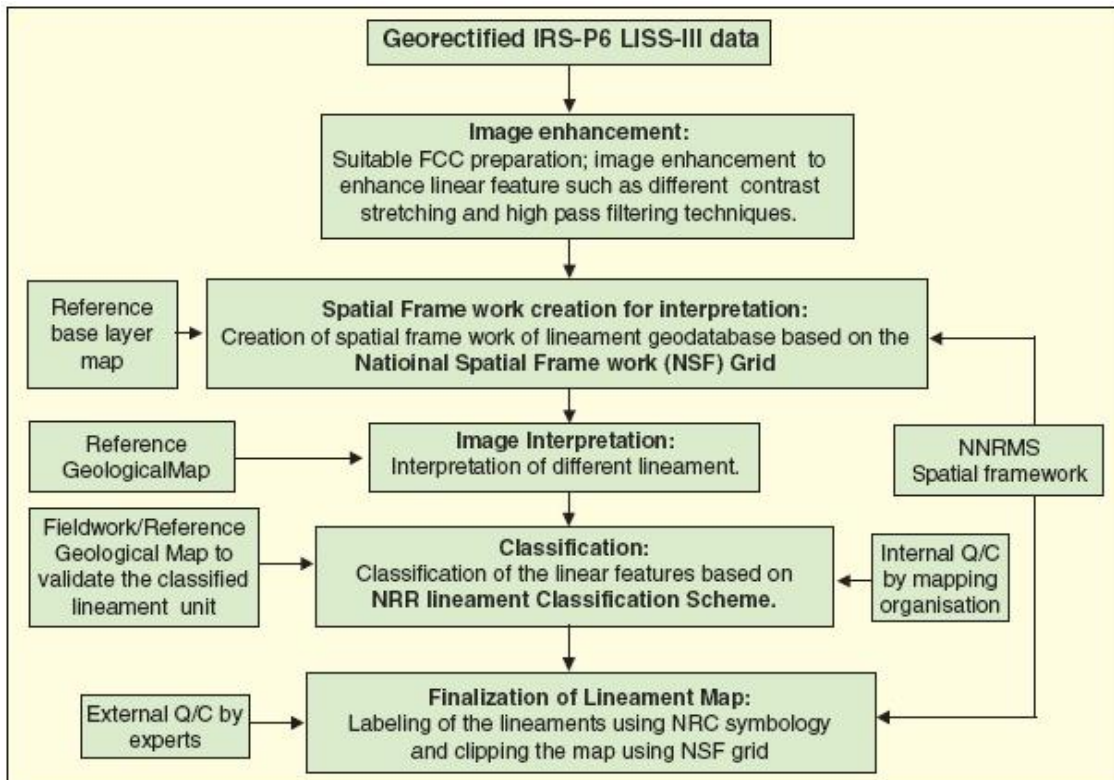
The following input data have been used for carrying out the study.

- Resourcesat-1 LISS-III imagery for year 2005-06 belonging to all three major cropping seasons of India (*kharif, rabi and zaid*).
- Survey of India topomaps on 1:50000 scale for reference.
- Ancillary data such as DEM, 1:50K geological maps, 1:250 K geological maps, geospatial web portals (Bhuvan or GoogleEarth).
- Legacy data like NRIS & RGNDWM.
- Land use / land cover vector layer created using multi-temporal satellite data of 2005-06 for extracting only water bodies.
- Limited ground truth.

The following two figures explain the procedure that was followed to generate geomorphology and lineament database.



(Methodology for generating geomorphology database)



(Methodology for generating lineament database)

Geodatabase creation

Geodatabase consists of vector data on various geomorphology categories. The geomorphic units were captured in polygon feature, geomorphic / structural lineament in line and field surveyed locations were noted as points with description of observed inputs and two field captured photographs which describes the data content. These databases were first checked for edge-matching across inter-district and inter-state borders so that data gaps and overlaps are eliminated amongst the datasets of different states. The feature classes are also matched across these borders to maintain the data continuity and to facilitate generation of a seamless dataset for the entire country. NNRMS spatial framework has been used to create the seamless data.

Quality Assurance Mechanism

A two-fold quality assurance mechanism involving in-process quality control by the Internal Quality Checking (IQC) team members at Partner Institutions and external quality audit by External Quality Checking (EQC) was adopted. Every sheet on 1:50,000 scale is checked. Each polygon is verified systematically with respect to imagery and incase of ambiguity, ancillary databases were referred.

Database Organisation

All the databases are stored in state-wise. Each database consists of two feature datasets (Project and FieldPro) and two tables (FieldPhoto1 and FieldPhoto2). The "Project" feature dataset consist of two feature classes (Geom and Geological_Stru) and FieldPro feature dataset consist of FieldData in the form of point information. The Project Feature dataset is connected to topology layer facility to correct topological anomaly like must not have gaps and overlaps for geomorphology layer and must not have dangle for lineament layer.

SUGGESTED USE

The geomorphology and lineament maps should be used at broad level for the following purposes:

- Mineral exploration studies

- Geo Hazards
- Geo-environmental studies
- Geo-engineering studies
- Ground water studies
- Seismotectonic studies

LIMITATIONS

Geomorphic boundaries are gradational in nature and hence may not be accurately fixed on the ground.

DISCLAIMER

- Different geomorphology and lineament class accuracies are subjected to availability of appropriate ancillary data during image interpretation, skill and experience of the interpreter. Hence some of the boundaries may not be accurate.
- The boundary of landforms may not match at a scale higher than 1:50,000.
- The spatial disposition of landform is as on the date of satellite data acquisition (2005-2006).
- Data cannot be used for any legal purpose.
- The minimum mappable unit depicted in the maps are scale dependent and any unit smaller than this mappable units are not mapped
- Maps should not be used for commercial purpose.
- User shall exercise reasonable skill, care and diligence while using the information and will keep indemnified NRSC/ISRO in respect of any loss, damage or claim howsoever arising out of use of this information.

User of this data/information will consult NRSC to commercially exploit / use the intellectual property generated in the Projects.

ISRO - GSI External quality checking team and Partner institutions

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B. Geodatabase schema design and software customisation

A software is designed and developed with components containing features such as Geodatabase creation, Field data template, Help and Uninstall facility. The geodatabase creation is a map template with customized toolsets to form a GIS data model. The Field data template is a predefined excel template to ease the efforts of database generation pertaining to field collected information. The Help component consists of design part, implementation procedure of GIS data model and thematic data interpretation with well explained examples. The uninstall facility to ease the removal of software from the system. All these components are embedded to form a package.

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