Pedological Development of Soils in Eastern Agroclimatic Zone of Haryana through Field Morphology Rating System

ABSTRACT

A study was carried out to evaluate the pedological development of soils in eastern agroclimatic zone of Haryana using field morphologyrating system. For this, nine pedons were excavated to study the morphological properties in field and rating scale was used to compare adjacent horizons with each other to give a comparison of the relative distinctness of horizons or to compare horizons in the solum with the C-horizon to give a relative profile development in soils occurring in different physiographic positions i.e. Shiwalik hills, recent and old alluvial plains with different precipitationsthroughout the study area. Some chemical properties were also used to evaluate the pedogenic factors as a result of being affected by process and factors of soil formation due to the distinct effect of climate. The Relative Horizons Distinctness (RHD) ratings were made by a comparison of adjacent horizons. The soils of Shiwalik hills, recent and old alluvial plains have RHD ratings varied from 6 to 14, 3 to 11 & 3 to 12, respectively. The RPD ratings were made by a comparison of the C horizon to the horizons above it in the profile. The soils of Shiwalik hills, recent and old alluvial plains have RPD ratings varied from 7 to 15, 3 to 14 & 5 to 16. The RPD values of all the profiles were maximum in A horizon due to maximum pedological development influenced by weathering. So, studies of these soils indicated the pedological development in the order of Shiwalik hills >old alluvial plains >recent alluvial plains.

Keywords: Relative Horizons Distinctness; Relative Profile Development; morphology and pedon.

1. INTRODUCTION

Soil morphology and the relative development of profile have been used significantly in the determinations of degree of development of soils and surficial depositions [1,6]. The soil formation under different landforms and occurrence of parent material discontinuities or other disturbance is sometimes difficult to determine. The morphology of soil reflects in a cumulative way the alteration of the parent material by soil forming processes. These can then be more quantitatively characterized and distinguished from those due to pedogenesis. [2] described a system for rating soil morphology and profile development using field morphological data. According to [8], Relative Horizon Distinctness (RHD), a comparison of the morphological features of two adjacent horizons, was tested as a means of identifying depositional or parent material discontinuities whereas, Relative Profile Development (RPD) compares morphological features of discrete horizons with the C horizon within a pedon (P).The lack of information on pedogenesis of soils using soil morphology rating scale for Eastern agroclimatic zone of Haryana having different physiographic units such as Shiwalik hills, recent and old alluvial plains with scattered rainfall (1100 to 300 mm). The presentstudy attempts to evaluate pedological variation in terms of developments of soils of Eastern agroclimatic zone using field morphology rating system.

2. MATERIALS AND METHODS

The Eastern Agroclimatic zone of Haryana extends from Panchkula (30^0 41’ 42"N-latitude, 76^0 51’ 15"E- longitude) to Palwal (28^0 08’ 55"N-latitude, 77^0 19’ 55"E- longitude) in N-S

direction and from Jind (29^0 19’ 00"N-latitude, 76^0 18’ 59"E- longitude) to Yamunanagar (30^0 07’ 44"N-latitude, 77^0 16’ 03"E- longitude) in E-W direction (Figure 1).

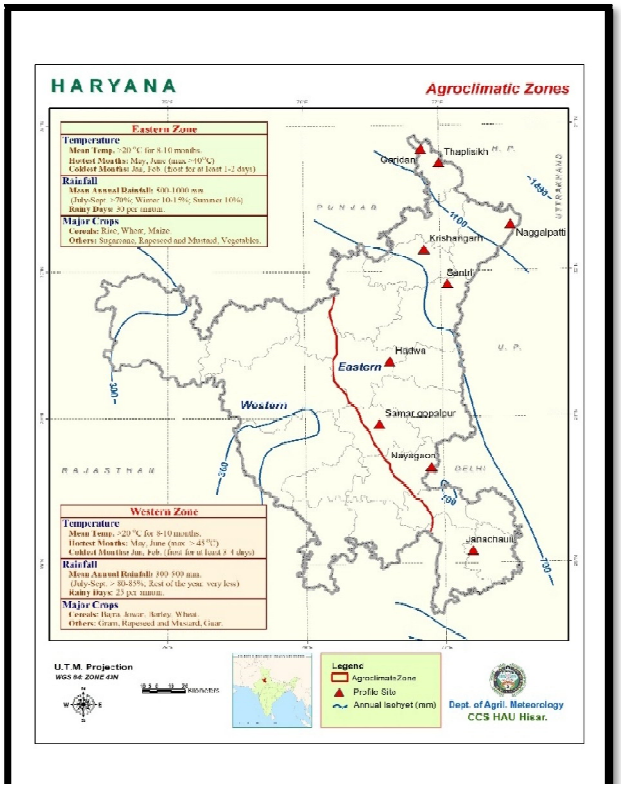

Figure 1: Location of the studied area

The different landforms of the study area are Shiwalik hills, recent and old alluvial plains. Nine representative pedons were studied for present investigation. P1 &P2 with mean annual rainfall (>1100 mm) occurring on Shiwalik hills; P3 with mean annual rainfall (1100-700 mm) and P4 with mean annual rainfall (700-300 mm) occurring on recent alluvial plains and P5, P6,P7, P8&P9 with mean annual rainfall (700-300 mm) on old alluvial plains. The area has hyperthermic temperature regime with mean annual temperature >20°C [13].

Two indices of soil development viz. RHD and RPD were calculated from the soil morphological data as defined by [2]. RHD was determined by comparing the morphological features of two adjacent horizons and RPD by comparing of the morphological feature of each horizon with the C horizon within each pedon. Soil pedons were studied in the field and classified in accordancewith Key to Soil Taxonomy[14]. The soils were evaluated and points assigned as described below:

1. Boundaries: Points are assigned according to the distinctness of the lower or shared horizon as follows: diffuse-0, gradual-1, clear-2, abrupt-3 and very abrupt-4.

2. Colour (dry and moist): One point is assigned for any class change in hue and for any unit change in value or chroma. For example, a change from 10 YR 4/6 to 5 YR 3/8 would have a value of 5 for the twofold class change, the one – unit change in value, and two – unit

change in chroma. Where two colours are observed (other than mottles), each one is compared, and the average difference is used.

3. Texture: One point is assigned for each class change on the textural triangle. In addition, a change from non-gravelly to gravelly or very gravelly is assigned one or two points, respectively.

4. Structure: One point is assigned for any change in type of aggregated structure, for each unit change in grade (1, 2, 3), and for each class change in size (vf, f, m, c, vc), irrespective of the aggregate type. For example, a change from weak, very fine subangular blocky (Ivfsbk) to moderate, medium angular blocky (2m abk) is assigned a value 4. When the change is from no aggregated-to-aggregated structure (or vice versa), however, only the grade of the aggregate type is evaluated, in addition to the one point assigned for the type change. For example, a change from massive to weak, fine subangular blocky (1f sbk) is assigned a value of 2.

5. Consistence: One point is assigned for any class change in wet (so, ss, s, vs, po, ps, p, vp) consistence.

6.Cutans: One point is assigned for each class change in frequency or thickness at any single location.

7. Coarse Fragments/Stoniness (>7.5 cm diameter): Points are assigned according to the volume of coarse fragments (>7.5 cm diameter) present in the matrix of the soil (1 for 80%).

8. The chemical rating system [10] was evaluated and points assigned as follow:

8.1 Soluble salts (dS/m): One point is assigned for each class change in quantity (non, very slightly, moderately, highly, extremely saline).

8.2 The pH value of soil paste: One point is assigned for each class change in quantity (ultra-acid, extremely acid, very strongly acid, strongly acid, moderately acid, slightly acid, neutral, slightly alkaline, moderately alkaline, strongly alkaline and very strongly alkaline).

3. RESULTS AND DISCUSSION

Data in Table 1 shows the morphological, physical and chemical properties of two pedons each covering soils of Shiwalik hills and recent alluvial plains and five pedons representing soils of old alluvial plains. The data were evaluated and prospective points were assigned as described by [2,8,10] and the soil rating scale are applied.

3.1 Morphological Characteristics

The morphology of the soils is presented in Table 1. The soils of the Shiwalik hills (P1&P2) were dark yellow brown to dark brown in colour. The soil of P1 was deep, sandy loam to silty clay loam in texture with well developed A, B and C horizons and classified as Coarse loamy, Mixed, Hyperthermic, Typic Udorthents due to high rainfall and nearly levelled

topography[9]whereas,P2 was shallow,silty clay loam to silt loam in texture with A and C horizons and classified as Loamy skeletal, Mixed, Hyperthermic, Typic Udorthents due to variation in parent material and coarse fragments.[12,15] also find the similar results.

The soils of recent alluvial plains (P3&P4) were dark greyish brown to yellowish brown in colour. The soils of P3 were deep, sand to silt loam in texture with well-developed A, B and C horizons and classified as Coarse loamy, Mixed, Hyperthermic, Typic Udorthentsdue to high rainfall and levelled topography, also supported by [9] whereas,P4 was deep,sand to loamy sand in texture with A and C horizons and classified as Coarse loamy, Calcareous, Mixed, Hyperthermic, Typic Ustorthents due to periodic deposition of new sediments much faster than the soil development. Similar findings were also reported by[3,9].

The soils of old alluvial plains (P5, P6, P7, P8 &P9)were dark greyish brown to light yellowish brown in colour. The soils of old alluvial plains were deep, loamy sand to clay loam in texture with well-developed A,B/A,B,C horizons which might be due to their fine texture and sufficient exposure to pedogenic processes and classified as Fine loamy, Calcareous, Mixed, Hyperthermic, Typic Ustochrepts. Similar results were ascertained by [5,12].

3.2 Relative horizon distinctness

The values of RHD rating are listed in Table 2 and plotted at the boundary between horizons to give graphical representation of the relative horizon distinctness of the soils in Figure2.

The soils of P1&P2 of Shiwalik hills, have RHD value ranging from6to 14, revealingmoderate distinctness within the soil profiles. The distinctness of the horizon boundary, variations in moist colour, texture, structure and consistency contributed most of the ratings. Soils of P1 have RHD ratings (6to 11), whereas of P2have RHD ratings (6 to 14) consider the oldest one thanP1 due to coarse fragmentation. [11]also reported thatthe distinctness of the horizon boundaries and coarse fragments has contributed mostly to the ratings in hills.According to [8], the RHD ratings greater than 10 were obtained for observed and suspected parent material or soil formation discontinuities is detected.

The soils of P3 &P4 of recent alluvial plains have RHD value ranging from 3 to 11, contributed by horizon boundary, variations in moist colour, texture and pH. Soils of P3 have RHD ratings (3to11), whereas of P4 have RHD ratings (3to8) consider the oldest one than P4 due to weathering as influenced by more precipitation. Similar findings were also reported by [4].

The soils of P5, P6, P7, P8 &P9 of old alluvial plains have RHD value ranging from 3 to 12, contributed by horizon boundary, variations in moist colour, texture, structure and pH. Soils of P5, P6, P7, P8 & P9 have RHD ratings 4 to 12, 4 to 9, 5 to 11, 6 to 8&3 to 8, respectively.Based on the RHD values the profiles of old alluvial plains can be arranged in a sequence i.e.P5 >P7 >P8 >P9 >P6 mainly due to change in structure differences, influenced by pedological rather than geological processes[9].

3.3 Relative profile development

The values of RPD rating are listed in Table 3 and plotted in Figure 3 to give graphical representation of RPD of the soils of study area.The RPD values of all the profiles were maximum in A horizon due to maximum pedological development influenced by weathering [4,5,8].

The soils of P1 &P2 of Shiwalik hills, have RPD value ranging from 7 to 15. The development of the horizon boundary, variations in moist colour, texture, structure and consistency contributed most of the ratings. Soils of P1 have RPD ratings 11to 13, whereas of P2 have RPD ratings 7to 17. The RPD value of P2 is more as compare to P1 due to more stratification,as reported by [9,11].

The soils of P3 &P4 of recent alluvial plains have RPD value ranging from 3 to 14 and maximum value 14 was found in P3 which may be due to slight stratification resulting from flooding. Similar results were ascertained by [4,15]. Soils of P3 have RPD ratings 8 to 14, whereas of P4 have RPD ratings 3 to 5.

In old alluvial plains with levelled and stable landforms, soils of P5, P6, P7, P8 & P9 have RPD ratings 11 to 13, 7 to 15, 9 to 16, 7 to 15 & 5 to 7, respectively. The RPD values of different pedons in old alluvial plains varied from 5 to 16, contributed by horizon boundary, variations in moist colour, texture, structure, consistency, pH and EC;as also reported by [15].[7] also reported that the larger the rating scale values for particular horizon, the greater was its pedological development. Under the stable landform condition, soil profile development results in the changes of different soil morphological parameters thereby leading to more RPD values [8].

4. CONCLUSION

The study reveals a close relationship between landforms units and profile development in all the three physiographic units i.e.Shiwalik hills, recent alluvial plains and old alluvial plains. Generally, soils of old alluvial plains and Shiwalik hills appears more pedological development than soils of recent alluvial plains. The poorly developed recent alluvial soils lacked distinct diagnostic horizons then moderately well developed alluvial plains.The pedogenic development of the soils assessed through field morphological rating system revealed that the RHD and RPD values of the pedons help in judging the development of the soils.

Table 1. Morphological and physico-chemical properties of the studied pedons.

Profile No.	Horizon	Depth (cm)	Horizon Boundary	Colour (moist)	Texture	Structure	Consistence	Cutans	Coarse fragment	pH	EC (dSm^{-1})
Shiwalik hills											
1 (Thaplisikh)	Ap	0-20	a-s	10YR 4/4	sl	2 m sbk	NSNP	-	2%	8.03	0.29
	AB	20-30	a-s	10YR 4/3	sil	3 m sbk	NSSP	-	2%	8.03	0.36
	B1	30-68	d-w	7.5YR 4/2	sil	3 m sbk	NSSP	-	2%	8.01	0.40
	B2	68-138	d-w	7.5YR 4/4	sicl	3 m sbk	SSSP	-	-	7.91	0.80
	C1	138-158	a-s	7.5YR 5/4	si	1 m sbk	NSNP	-	10%	7.98	0.75
	C2	158-180+		7.5YR 4/4	sil	2 m sbk	SSSP	-	-	8.15	0.99
2 (Garidan)	Ap	0-20	a-s	7.5YR ¾	sicl	1 f sbk	SSNP	-	25-30 % Pebbles	6.99	0.22
	AC	20-95	a-w	7.5YR 4/2	sil	2 m sbk	SSNP	-	25-35 % Pebbles	7.76	0.28
	C1	95-150	d-w	7.5YR 4/2	sil	2 c sbk	NSNP	-	>50 % Boulders	7.52	0.09
	C2	150+		7.5YR ¾	sil	2 c sbk	NSNP	-	>50 % Boulders	8.35	0.10
Recent alluvial plains											
3 (Naggalpatti)	Ap	0-23	a-s	10YR 4/2	ls	1m sbk	NSSP	-	-	7.15	0.07
	AB	23-80	a-s	10YR 5/3	sl	1 m sbk	SSSP	-	-	7.50	0.06
	B1	80-112	a-s	10YR 5/4	ls	1m sbk	SSSP	-	-	8.04	0.03
	B2	112-158	a-w	10YR 5/4	ls	1 m sbk	SSSP	-	-	8.14	0.05
	C1	158-194	a-w	10YR 5/4	s	2 c sbk	SSSP	-	fn 10-15%	8.50	0.04
	C2	194+		10YR 5/4	sil	2 m sbk	SSSP	tn p (fe coating)	fn (>15%)	8.48	0.09
4 (Janachauli)	Ap	0-24	a-s	10YR 5/6	ls	1 m sbk	NSNP	-	-	8.20	0.20
	AC	24-94	a-s	10YR 5/4	ls	1 m sbk	NSNP	-	vffn	7.97	0.24
	C1	94-170	a-s	10YR 5/4	ls	1 m sbk	NSNP	-	-	8.48	0.38
	C2	170+		10YR 5/6	s	1 c sbk	NSNP	-	-	8.76	0.41
Old alluvial plains											
5 (Kishangarh)	Ap	0-42	a-s	10YR 4/2	l	2 m sbk	SSSP	Flood coatings	-	7.79	0.32
	AB	42-70	a-w	10YR 5/4	sl	1 m sbk	SSSP	-	-	8.10	0.21
	B1	70-98	a-w	10YR 5/4	sl	2 m sbk	SSSP	-	-	8.10	0.22
	B2	98-152	a-w	10YR 5/4	ls	1 m sbk	SSSP	-	-	8.70	0.39
	C1	152+		10YR 4/3	cl	2 m sbk	SP	-	-	8.90	0.55
6 (Santri)	Ap	0-20	a-s	10YR 4/2	l	2 f sbk	SP	-	-	7.66	0.12
	AB	20-65	a-s	10YR 5/4	l	2 f sbk	SP	-	<1%	7.63	0.09
	B1	65-105	a-s	10YR 5/3	l	2 f sbk	SP	-	8-10% $CaCO_3$	7.80	0.07
	B2	105-146	a-w	10YR 5/2	sl	2 m sbk	SSSP	-	1-2% $CaCO_3$	8.01	0.09
	B3	146-172	a-s	10YR 5/2	ls	1 m sbk	SSSP	-	-	8.23	0.07
	C1	172+		10YR 5/2	s	0 c sbk	NSNP	-	-	8.27	0.08
7 (Samar gopalpur)	Ap	0-20	a-s	10YR 3/3	sl	1 m sbk	SSSP	-	-	8.03	0.29
	AB	20-38	a-s	10YR 5/3	sl	1 m sbk	SSSP	-	-	8.03	0.36
	B1	38-74	d-s	10YR 5/3	scl	2 f sbk	SSSP	-	-	7.85	0.48
	B2	74-140	d-s	10YR 5/3	l	2 m sbk	SP	-	-	7.91	0.80
	B3	140-172	a-s	10YR 5/4	cl	2 m sbk	SP	-	-	7.98	0.84
	BC	172-210	a-s	10YR 5/4	cl	3 f sbk	SP	-	-	8.15	0.99
	C1	210+		10YR 6/4	l	3 f sbk	VSVP	-	-	8.56	0.70
8 (Hadwa)	Ap	0-17	g-w	10YR 4/4	sl	2 m sbk	SSNP	-	-	8.38	0.22
	AB	17-55	a-s	10YR 4/3	l	2 m sbk	SSSP	-	-	8.21	0.24
	B1	55-90	a-s	10YR 5/3	l	2 m sbk	SSSP	tn p (fe, mn coatings)	-	8.48	0.18
	B2	90-137	a-s	10YR 5/3	cl	2 f sbk	SP	tn p (fe, mn coatings)	-	8.80	0.21
	B3	137-194	a-s	10YR 5/3	cl	2 f sbk	VSSP	th (fe coating)	-	8.14	0.78
	C1	194+		10YR 5/2	cl	2 f sbk	VSSP	-	m fn	7.60	1.18
9 (Nayagaon)	Ap	0-15	a-w	10YR 3/3	sl	2 m sbk	SSSP	-	-	7.33	0.30
	AB	15-53	a-s	10YR 4/3	sl	2 m sbk	SP	-	-	7.24	0.51
	B1	53-102	a-s	10YR 4/3	sl	2 m sbk	SP	-	-	7.07	0.66
	B2	102-154	a-s	10YR 5/4	ls	2 m sbk	SSSP	-	-	7.56	0.58
	B3	154-180	a-s	10YR 4/3	ls	2 m sbk	SSSP	-	-	8.06	0.21
	C1	180+		10YR 5/3	sl	2 m sbk	SSSP	-	1-2%	7.78	0.56

Table 2. Relative Horizon Distinctness Ratings of the studied pedons.

Profile No.	Horizon	Horizon Boundary	Colour (moist)	Texture	Structure	Consistence	Cutans	Coarse fragment	pH	EC	RHD
Shiwalik hills											
1 (Thaplisikh)	Ap/AB	3	1	1	1	1	0	0	0	0	7
	AB/ B1	3	2	0	0	0	0	0	0	1	6
	B1/ B2	3	2	4	0	2	0	0	0	0	11
	B2/ C1	0	1	3	2	2	0	0	0	0	8
	C1/ C2	3	1	2	1	2	0	0	0	1	10
2 (Garidan)	Ap/AC	3	3	4	2	0	0	1	1	0	14
	AC/ C1	3	0	0	1	1	0	2	0	0	7
	C1/ C2	0	3	0	0	0	0	2	1	0	6
Recent alluvial plains											
3 (Naggalpatti)	Ap/AB	3	2	1	0	1	0	0	1	0	8
	AB/ B1	3	1	1	0	0	0	0	1	0	6
	B1/ B2	3	0	0	0	0	0	0	0	0	3
	B2/ C1	3	0	1	2	0	1	0	1	0	8
	C1/ C2	3	0	4	1	0	1	1	1	0	11
4 (Janachauli)	Ap/AC	3	2	0	0	0	0	0	0	0	5
	AC/ C1	3	0	0	0	0	0	0	0	0	3
	C1/ C2	3	2	1	1	0	0	0	1	0	8
Old alluvial plains											
5 (Kishangarh)	Ap/AB	3	3	1	1	0	1	0	1	0	10
	AB/ B1	3	0	0	1	0	0	0	0	0	4
	B1/ B2	3	0	1	1	0	0	0	1	0	6
	B2/ C1	3	2	4	1	1	0	0	0	1	12
6 (Santri)	Ap/AB	3	3	0	0	0	0	0	0	0	6
	AB/ B1	3	1	0	0	0	0	0	0	0	4
	B1/ B2	3	1	2	1	1	0	0	1	0	9
	B2/ B3	3	0	1	1	0	0	0	0	0	5
	B3/C1	3	0	1	2	1	0	0	0	0	7
7 (Samar gopalpur)	Ap/AB	3	2	0	0	0	0	0	0	0	5
	AB/ B1	3	0	4	2	0	0	0	1	1	11
	B1/ B2	0	0	4	1	1	0	0	1	0	7
	B2/ B3	3	1	2	0	0	0	0	0	1	7
	B3/BC	3	0	0	2	0	0	0	0	0	5
	BC/C1	3	1	2	0	1	0	0	1	1	9
8 (Hadwa)	Ap/AB	3	1	1	0	1	0	0	0	0	6
	AB/ B1	3	2	0	0	0	1	0	0	0	6
	B1/ B2	3	0	2	1	1	0	0	1	0	8
	B2/ B3	3	0	0	0	1	0	0	1	1	6
	B3/C1	3	1	0	0	0	1	0	1	1	7
9 (Nayagaon)	Ap/AB	3	1	0	0	1	0	0	0	1	6
	AB/ B1	3	0	0	0	0	0	0	0	0	3
	B1/ B2	3	2	1	0	1	0	0	1	0	8
	B2/ B3	3	2	0	0	0	0	0	1	1	7
	B3/C1	3	1	1	0	0	0	0	1	1	7

Table 3. Relative Profile Development Ratings of the studied pedons.

Profile No.	Horizon	Horizon Boundary	Colour (moist)	Texture	Structure	Consistence	Cutans	Coarse fragment	pH	EC	RPD
Shiwalik hills											
1 (Thaplisikh)	Ap/ C1	3	2	4	1	0	0	0	0	1	11
	AB/ C1	3	3	3	2	1	0	0	0	1	13
	B1/ C1	3	3	3	2	1	0	0	0	0	12
	B2/ C1	3	1	3	2	2	0	0	0	0	11
2 (Garidan)	Ap/ C1	3	3	4	3	1	0	2	1	0	17
	AC/ C1	3	0	0	1	1	0	2	0	0	7
Recent alluvial plains											
3 (Naggalpatti)	Ap/ C1	3	3	1	2	1	1	0	3	0	14
	AB/ C1	3	1	1	2	0	1	0	2	0	10
	B1/ C1	3	0	1	2	0	1	0	1	0	8
	B2/ C1	3	0	1	2	0	1	0	1	0	8
4 (Janachauli)	Ap/ C1	3	2	0	0	0	0	0	0	0	5
	AC/ C1	3	0	0	0	0	0	0	0	0	3
Old alluvial plains											
5 (Kishangarh)	Ap/ C1	3	1	2	0	1	1	0	2	1	11
	AB/ C1	3	2	4	1	1	0	0	1	1	13
	B1/ C1	3	2	4	0	1	0	0	1	1	12
	B2/ C1	3	1	2	4	1	0	0	0	1	12
6 (Santri)	Ap/ C1	3	1	3	4	2	0	0	1	0	14
	AB/ C1	3	2	3	4	2	0	0	1	0	15
	B1/ C1	3	1	3	4	2	0	0	1	0	14
	B2/ C1	3	0	1	2	1	0	0	0	0	7
	B3/C1	3	0	1	2	1	0	0	0	0	7
7 (Samar gopalpur)	Ap/ C1	3	4	1	4	2	0	0	1	1	16
	AB/ C1	3	2	1	4	2	0	0	1	1	14
	B1/ C1	3	2	4	1	2	0	0	2	0	14
	B2/ C1	3	2	0	2	1	0	0	1	0	9
	B3/C1	3	1	2	2	1	0	0	1	1	11
	BC/C1	3	1	2	0	1	0	0	1	1	9
8 (Hadwa)	Ap/ C1	3	3	3	1	2	0	0	1	2	15
	AB/ C1	3	3	2	1	2	0	0	1	2	14
	B1/ C1	3	1	2	1	2	1	0	1	2	13
	B2/ C1	3	1	0	0	1	1	0	2	2	10
	B3/C1	3	1	0	0	0	1	0	1	1	7
9 (Nayagaon)	Ap/ C1	3	2	0	0	0	0	0	1	1	7
	AB/ C1	3	1	0	0	1	0	0	1	0	6
	B1/ C1	3	1	0	0	1	0	0	1	0	6
	B2/ C1	3	1	1	0	0	0	0	0	0	5
	B3/C1	3	1	1	0	0	0	0	1	1	7

Figure 2: Relative Horizon Distinctness

Figure 3: Relative Profile Development

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