IV. SUB-REGIONALISATION INTO BLOCK LEVEL ECOLOGICAL TYPOLOGIES

4.1 Approaches To Sub-Regionalisation

In this chapter, we introduce different approaches to sub-regionalisation and then undertake a mammoth multi-variable exercise to classify Chhattisgarh into different ecological typologies. Analytically, the sub-regionalisation of an area into units can be done in many different ways, depending on the purpose. In the present study, our aim is to classify blocks (an administrative unit) into agro-ecological types that are amenable to a similar drought proofing treatment. Therefore, commonality of a number of features from this point of view is far more important than the sub-division on the basis of landform or rainfall alone. Furthermore, there is little reason to either expect or indeed desire that blocks in the same typology be close to each other.

A region is a contiguous area of any size, which is homogeneous in terms of specified criteria and is distinguished from surrounding regions by a particular grouping of such criteria (Garnier 1976). Whittlesey has defined a region as an intellectual concept, which facilitates the study of groupings of complex phenomena within an area unit. It is a spatial or horizontal concept.

An ***agro-ecological zone*** or region is a land resources mapping unit, defined in terms of climate, landform and soils, and/or land cover with a specific range of potentials and constraints with respect to land use. ***Agro-ecological zoning*** (AEZ) refers to the division of an area of land into smaller units within a geographical continuum, which have similar characteristics related to land suitability, potential production and environmental impact.

Agro-ecological typologies, on the other hand, are distinct from regions or zones in that although they are homogeneous in terms of certain key ecological and production-related factors, and are amenable to a common matrix of solutions, they need not be adjacent or lie within the same spatial continuum, as a single continuous land unit. Thus homogeneity in agro-ecological attributes becomes possible if a sufficient level of dis-aggregation is used in evolving the typology. Thus, regionalization through typologies is a taxonomic or vertical classification while zoning is a spatial or territorial concept. *Sub-regionalisation that is based on the principle of typology need not result in a classification of adjacent units or those contiguous in the same typology*. A parallel can be drawn from biology, where the classification of species according to distinguishing characteristics is an exercise in classification of ‘typology’ whereas division of human beings into nationalities is an exercise in ‘regionalisation’.

Regionalisation has been used for planning at the state level. Several methodologies have been used for regionalisation depending on the purpose and ends. An important objective of most of these efforts was to evolve agro-ecological regional maps for the country in order to delineate comparable resource regions, for generating and transferring agro-technology to meet the country’s needs of food, fodder and fibre.

Most early attempts at regionalisation were on the basis of broad natural regions, existing cropping patterns, as well as a broad framework of climatic variations at a macro scale. Mitra [42] divided the country into 7 natural regions, 31 sub regions and 89 divisions. In 1964 the Planning Commission based its regionalisation on physical conditions, topography, geomorphology, rainfall, cropping pattern, development of irrigation and land resources at the district level. In 1988 under the Planning Commission another attempt at regionalisation was made and the country was divided into 15 agro-climatic regions with 73 sub-regions. In all the attempts at agro-climatic zoning, although importance was given to other indicators, greatest emphasis was given to the inherent commonality of the agro-meteorological indicators and water resources development. An important outcome of these exercises was that a need was felt by several scholars and organizations to include parameters like soils, temperature, topography, vegetation, geo-hydrology, water and farm technologies in order to have more comprehensive agro-ecological zoning. Some of the notable attempts were as follows.

Murthy and Pandey [43] demarcated the country into 8 regions on the basis of physiography, soils, rainfall and water balance, and agricultural practices. This regionalisation suffered from too much generalization and over-emphasis on agro-climatic indicators. Bhattacharya *et al*[44] prepared bio-climatic maps on the basis of rainfall and potential evapo-transpiration (PET) values, which influence the biotic environment. Krishna [45] prepared 40 soil climatic zones (areas falling in the same climate and water balance class and having similar soil types) on the basis of soil types and moisture index. The moisture index was based on Thornthwaite-Mather[46] moisture index (MI) approach (where P is Precipitation):

$$MI = \frac{P - PET}{PET}$$

Thus 9 climatic classes were superimposed on 13 zone soil maps to evolve 40 soil climatic zones. The basic criticism of this approach was that, although soil types were included in the zonation, however, soils were not classified on the basis of their water retention capacity.

In 1988 the Planning Commission came up with a growth strategy based on a holistic approach of area planning for long-term resource efficiency and sustainability. The motivation behind this was that resource based planning became feasible once homogeneous regions with respect to natural resource endowments (agro-climatic factors) were delineated and their utilization of available natural resource endowments was related to requirements of output and employment.

During the late nineteen eighties, a consensus seemed to have been achieved on the primacy of topography for a regional division of India. Based on this notion the Planning Commission[47]

[42] Mitra Ashok (1961): Levels of Regional Development in India, Economic Regionalisation of India: Problems and Approaches, Supplement I, *Census of India*, *Monograph 8*.
[43] Murthy, R.S. and S. Pandey (1978): Delineation of Agro-Ecological Regions of India, Paper presented in Commission V 11th Congress of ISSS, Edmonton, Canada, June 19-27.
[44] Bhattacharya, J. C., C. Roychowdhury, R.J. Landey, and S. Pandey, (1982): Bio-climatic Analysis of India, *NBSS and LUP Bulletin* 7, Nagpur, 21 pp and maps.
[45] Krishna, A. (1988): Delineation of Soil Climatic Zones of India and its practical Application in Agriculture, *Fertiliser News*, 33(4), pp. 11-19.
[46] Thornthwaite, C W and J R Mather (1955): The Water Balance, *Climatology*, VIII, Johns Hopkins University.
[47] Planning Commission (1989): Agro-climatic Regional Planning: An Overview, New Delhi, Government of India.

delineated 15 agro-climatic zones; there still existed wide variation in geographical area, population density, soil types and crops grown. To increase the degree of homogeneity in agro-climatic factors, these 15 zones were further sub-divided into 73 sub-zones based on more specific soil types, topography, climate and cropping pattern characteristics. A planning team was set up for each zone (ZPTs) and each zone was sub-regionalised on the basis of factors intrinsically related with the character of the agricultural economy. These included soil type, climate (temperature, and rainfall and its variation), relevant meteorological characteristics, water demand and supply, including quality of water and aquifer conditions. It was also decided that, at this stage, it was better to concentrate on agro-climatic characteristics, and to not bring in other social and administrative criteria for regionalisation (Government of India, 1988a, p.2). Though other features like land holding, workforce, population, employment, living standards were considered for the process of building up of systematic computer compatible data sets, the major emphasis was on agricultural development levels and trends.

These regionalisation methods over-emphasize the importance of physiographic divisions and administrative boundaries. Water balance analysis, soil water retention capacity for crop potential, and land capability mapping/carrying capacity estimation were not incorporated in this regionalisation.

The launching of the National Agricultural Research Project in 1979 by the Indian Council of Agricultural Research (ICAR) initiated experimental programmes on agricultural research. Agro-climatic zonation or ecological land classification was undertaken on the basis of parameters like soils, climate, topography, vegetation, crops etc. for delineation of 126 zones. The National Bureau of Soil Survey and Land Use Planning (NBSS-LUP) made a comprehensive attempt at agro-ecological regionalisation and the country was divided into twenty regions following the FAO methodology of sequential layering of information on maps (NBSS Publication, 1992). The regions were aggregated on the basis of uniform climatic factors, physiography, natural vegetation, soils and length of growing period[48] (LGP). The major emphasis of this regionalisation was on the bio-climatic factors and length of growing period. Ghosh,[49] in his review of the Indian experience of zoning has commented, and rightly so, that growing period was considered as a better index of climatic types and soil groups have been given precedence over physiography[50]. It is now recognised that information about soils and crop-growing period is more pertinent than rainfall and landform in delineating agro-ecological regions.

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[48] *Length of Growing Period* is defined as the period during the year when prevailing temperatures are conducive to crop growth (T mean ≥ 5°C) and precipitation and moisture stored in the soil profile exceed half the potential evapo-transpiration (PET) (on a daily basis sufficient soil moisture should be accumulated in the soil profile to permit seed germination (model variable set to 50 mm)). The estimation of the growing period is based on a water balance model, which compares rainfall (P) with potential evapo-transpiration (PET). If the growing period is not limited by temperature, the ratio of P/PET determines the start, end and type of growing period. The growing period starts when rainfall exceeds 50 per cent of PET and ends with the utilization of the stored soil moisture after rainfall falls below PET.

[49] Ghosh S.P. (1996): Regionalisation Experiences in Indian Agriculture, in Agro-climatic Regional Planning in India Concepts and Applications, (ed.) by D. N. Basu and G.S. Guha, Concept Publishing Company, New Delhi pp 62-83.

[50] The thermal regime is the other basic climatic parameter used to define the agro-ecological zones. The thermal regime refers to the amount of heat available for plant growth and development during the growing period. It is usually defined by the mean daily temperature during the growing period. In the regional and national AEZ assessments, thermal zones may be defined based on temperature intervals of 5°C or 2.5°C.

In the NBSSLUP methodology the major physiographic units of the country were further subdivided into 19 landform units, which was superimposed by the 61 broad soil units to generate 24 soil-scape units. Nine moisture availability regions were identified from analysis of the LGP and bio-climatic units. Finally, twenty generalised agro-ecological regions (AERs) were identified after overlaying the bio-climatic units and the moisture availability regions. Thus, though a major step forward, this regionalisation method has a definite bias towards soil resources, and factors like irrigation and other production conditions were ignored.

Shah *et al* [51] identified dry lands of India by a modification in the NBSSLUP approach. Moisture deficit regions were those where the length of growing period was less than or equal to 180 days. 282 moisture deficit districts in India were identified, namely those with LGP less than 180 days. Following the recommendation of the Irrigation Commission and the method adopted by the DPAP programme, since irrigation is a major input, which modifies the soil moisture regime leading to changes in LGP, irrigation criteria were used to further redefine these regions. This criterion was used since the ultimate effect of dryness in an area is due to reduction in water availability for crop growth. Therefore, districts with a high proportion of irrigated area were eliminated from the category of dry districts. Districts with GIA/GSA[52] less than 50 per cent in 1-8 AERs and districts with less than 40 per cent in 9-12 AERs were incorporated within this zonation. Thus, the new definition of dry lands that was proposed was as follows: those districts which are located in the AERs 1-12 (NBSSLUP Regions), having LGP of less than 180 days and GIA/GSA less than 40 to 50 per cent. Using this definition it was found that 42 per cent of the districts in India, covering a geographical area of 56 per cent, fell under the category of dry lands. Using this technique, in all, 177 dry districts were identified in the country.

To sum up, then, there are broadly two types of approaches to classification into typologies for drought management. In one, rainfall and irrigation or soil moisture and irrigation are used in order to identify dry or drought prone areas, and interventions are designed independently. In the other, the aim is to plan interventions and development strategies for the different typologies, as was attempted by the Agro Climatic Zones (ACZs) of the Planning Commission. Though important, in the next chapter we present a GIS based methodology of ecological regionalisation into typologies, which in our view is far more advanced and holistic. Given the current state of data availability and computational proficiency in this country, we are convinced that not only is this desirable, it is also feasible for the entire country.

4.2 Block Level Ecological Typologies

Drought proofing and conservation measures would vary from block to block depending upon their characteristics, such as geographical locations, climatic conditions, soil types, other socio economic indicators, etc. Hence, to suggest policy guidelines for areas which are amenable to similar kind of treatment, the identification and classification of blocks into broad groups becomes inevitable. Generally speaking, ecological, production system and socio-economic parameters are considered to be the three most important components in typology formulation.

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[51] Shah M, D Banerjee, P S Vijayshankar, P Ambasta (1998): India's Drylands: Tribal Societies and Development through Environmental Regeneration, Oxford University Press, New Delhi, pp-118-121.
[52] GIA: Gross Irrigated Area, GSA: Gross Sown Area. GIA/GSA= Irrigation Intensity

For building ecological typologies, the first step is to identify the key or primary characteristics that would be the basis for classification. The problem is fundamentally the same as that encountered in sub-regionalisation for vulnerability. Namely, identifying the variables that would best characterise a block from the point of view of determining the type of intervention required. It also involves identifying features that can act as an indicator, that can represent others in clusters or groups of variables.

However there is a crucial dimension, specific to the issue of typology. The addition of the values assigned to each feature across all variables, an exercise requiring extreme caution even for ranking, becomes an exercise in futility when taxonomical classification is required. A simple example will suffice: whales are mammals, although they look like fish, because they share the attribute of warm bloodedness with human beings and other mammals.

For this reason typologies involve moving towards the essence or to the fundamentals. On the other hand, these fundamentals should have sufficient detail and applicability to guide policy interventions in a meaningful way. For example, drainage density is a very good indicator of the rate of runoff of rainwater. In fact, it is a major tool in hydro-geo-morphological analysis and planning. We too were tempted to use this as a representative of areas prone to flash floods or high run off. After all, it is an outcome of a complex interplay of natural phenomena and human interventions, depending on rainfall intensity, soil depth and texture, vegetation, landform, slope, geology, settlements, roads, etc. However, precisely for these very reasons it is not a very good guide for interventions, since the value of the variable does not clearly indicate why it is high or low. Drainage density is a good and reliable variable to use for assessing proclivity to rapid runoff, etc, and alerts us to the important problem of high runoff rates in some blocks, However, it neither sheds light on the underlying causes nor gives a more precise direction to policy, since it derives from a complex interplay between form, structure, precipitation, vegetation and human interventions.

This implies that variables or attributes that are paramount for one purpose say for prioritisation, are inappropriate for others, namely taxonomical classification. We therefore started with the building blocks, namely soil, rainfall, landform, vegetation. Before proceeding with the categorisation, we had to ascertain whether the ecological variables related with each other in the way we expected them to, and as have discussed in previous sections, or whether the data held any surprises for us.

Table 4.1: Correlation Matrix of Ecological Variables

	Por_ For	Deg Slope	Forest _Topo	Drng_ Density	GW Depth	Land Form	Per Slope	Soil Depth	Soil Drng	Soil Taxon	Bifur 1\2	LGD	UIPD	SRFI	ARFI	Parent Material	Particle Size	SRF	ARF	CSR	Inter spell
Por_ For	1.00	0.44	0.74	0.24	-0.21	-0.43	0.44	-0.52	0.20	-0.61	0.04	-0.38	0.31	-0.04	-0.05	-0.45	-0.50	0.31	0.34	0.09	-0.05
Deg Slope	0.44	1.00	0.59	0.35	-0.23	-0.59	1.00	-0.60	0.09	-0.60	-0.09	-0.42	0.26	-0.13	-0.14	-0.54	-0.52	0.28	0.24	0.13	-0.04
Forest_ Topo	0.74	0.59	1.00	0.29	-0.15	-0.55	0.59	-0.73	0.04	-0.67	-0.01	-0.48	0.36	-0.12	-0.11	-0.56	-0.43	0.22	0.26	0.18	0.03
Drng_ Density	0.24	0.35	0.29	1.00	-0.20	-0.29	0.35	-0.35	-0.08	-0.45	-0.05	-0.23	0.04	-0.20	-0.21	-0.16	-0.18	-0.03	-0.03	0.09	0.02
GW_ Depth	-0.21	-0.23	-0.15	-0.20	1.00	0.09	-0.23	0.25	-0.06	0.12	-0.16	0.01	-0.03	-0.02	-0.03	0.24	0.20	0.03	0.04	-0.03	0.05
Land Form	-0.43	-0.59	-0.55	-0.29	0.09	1.00	-0.59	0.65	-0.33	0.65	0.21	0.39	-0.09	0.07	0.09	0.67	0.68	-0.32	-0.31	-0.19	0.21
Per Slope	0.44	1.00	0.59	0.35	-0.23	-0.59	1.00	-0.60	0.09	-0.60	-0.09	-0.42	0.26	-0.13	-0.14	-0.54	-0.52	0.27	0.24	0.13	-0.04
Soil Depth	-0.52	-0.60	-0.73	-0.35	0.25	0.65	-0.60	1.00	0.08	0.65	0.06	0.43	-0.28	-0.06	-0.05	0.60	0.39	-0.24	-0.25	-0.20	0.12
Soil Drng	0.20	0.09	0.04	-0.08	-0.06	-0.33	0.09	0.08	1.00	-0.06	-0.18	-0.10	0.05	-0.12	-0.13	-0.40	-0.78	0.38	0.40	0.11	-0.20
Soil Taxon	-0.61	-0.60	-0.67	-0.45	0.12	0.65	-0.60	0.65	-0.06	1.00	0.11	0.45	-0.21	0.12	0.14	0.54	0.53	-0.23	-0.22	-0.18	0.05
Bifur1\2	0.04	-0.09	-0.01	-0.05	-0.16	0.21	-0.09	0.06	-0.18	0.11	1.00	0.08	0.01	-0.11	-0.09	0.11	0.21	-0.18	-0.16	-0.01	0.05
LGD	-0.38	-0.42	-0.48	-0.23	0.01	0.39	-0.42	0.43	-0.10	0.45	0.08	1.00	-0.30	0.07	0.05	0.46	0.36	-0.22	-0.26	-0.15	-0.04
UIPD	0.31	0.26	0.36	0.04	-0.03	-0.09	0.26	-0.28	0.05	-0.21	0.01	-0.30	1.00	-0.05	-0.04	-0.16	-0.14	0.12	0.16	0.13	0.20
SRFI	-0.04	-0.13	-0.12	-0.20	-0.02	0.07	-0.13	-0.06	-0.12	0.12	-0.11	0.07	-0.05	1.00	0.92	0.14	0.12	0.20	0.10	0.08	-0.16
ARFI	-0.05	-0.14	-0.11	-0.21	-0.03	0.09	-0.14	-0.05	-0.13	0.14	-0.09	0.05	-0.04	0.92	1.00	0.14	0.15	0.17	0.15	0.08	-0.09
Parent Material	-0.45	-0.54	-0.56	-0.16	0.24	0.67	-0.54	0.60	-0.40	0.54	0.11	0.46	-0.16	0.14	0.14	1.00	0.67	-0.32	-0.34	-0.09	0.19
Particle Size	-0.50	-0.52	-0.43	-0.18	0.20	0.68	-0.52	0.39	-0.78	0.53	0.21	0.36	-0.14	0.12	0.15	0.67	1.00	-0.48	-0.48	-0.16	0.24
SRF	0.31	0.28	0.22	-0.03	0.03	-0.32	0.27	-0.24	0.38	-0.23	-0.18	-0.22	0.12	0.20	0.17	-0.32	-0.48	1.00	0.92	0.05	-0.18
ARF.	0.34	0.24	0.26	-0.03	0.04	-0.31	0.24	-0.25	0.40	-0.22	-0.16	-0.26	0.16	0.10	0.15	-0.34	-0.48	0.92	1.00	0.05	-0.16
CSR	0.09	0.13	0.18	0.09	-0.03	-0.19	0.13	-0.20	0.11	-0.18	-0.01	-0.15	0.13	0.08	0.08	-0.09	-0.16	0.05	0.05	1.00	0.04
Inter spell	-0.05	-0.04	0.03	0.02	0.05	0.21	-0.04	0.12	-0.20	0.05	0.05	-0.04	0.20	-0.16	-0.09	0.19	0.24	-0.18	-0.16	0.04	1.00

***Note*: Abbreviations**

Por For: Proportion of geographical area under forests; Deg Slope: Average Degree Slope; Forest Topo: Percentage area under forests from toposheets; Drng_Density: Drainage Density; GW_depth: Groundwater depth; Per Slope: Percentage Slope; Soil Drng: - Soil Drainage; Soil Taxon: Soil Taxonomy; Bifur1/2: - Bifurcation ratio of first and second order streams; LGD: Level of groundwater development our estimate; UIPD: Utilisable irrigation potential for development our estimate; SRFI: Seasonal rainfall intensity; ARFI: Annual rainfall intensity; SRF Avg (1951-2001): Seasonal rainfall average (1951-2001); ARF. Avg. (1951-2001): Annual rainfall average (1951-2001); CSR 15-28 June: Frequency distribution of commencement of sowing rains between June 15 and June 28; Inter spell > 8 days: Inter spell more than 8 days

As far as the two indicators of terrain are concerned, average slope and landform move in the same direction *vis a vis* all the variables, with landform having a more significant relationship in each case. We must remember that the values for landform and slopes move in opposite direction in our treatment—while average slope for the block rises as we move to areas with higher slopes, the value of the average landform variable falls as we move to locales that are the worst from the viewpoint of stable and productive agriculture. Further, soil depth, type, parent material and particle size show high correspondence to landform. This implies that as we move to more suitable landforms we also move to more advantageous soil situations. As we move to better landforms, all the rainfall parameters worsen and drainage density declines. Therefore, while precipitation reduces, so does run off. However, the commencement of sowing rains is earlier in the better landforms. Soil drainage is significantly worse in the plains and valleys with heavier soils and lower drainage density. The main determinants of soil drainage are the low slopes and heavier soils in the alluvium and colluvium clayey tracts, with little relation to soil depth and soil parent material. Soil particle size is one of the most important determinants of soil moisture retention, and is positively correlated to landforms. Not surprising, what is considered to be a very important attribute from the point of view of soil moisture retention becomes a source of great trouble in areas which are poorly drained on account of the terrain, giving rise to water logging.

Frequency of years with an interspell gap of more than eight days is a very important sign of proclivity to soil stress for crops, especially for paddy in unirrigated, upland situations. Besides these variables that capture the specificities of rainfall, forest cover is an important determinant of runoff and soil moisture retention as well as vegetation. Forests, are by and large, confined to the hills of the rimlands and the undulating plateau area. Therefore, it is no surprise that forest cover is correlated to higher sloping worst landforms, where groundwater and soil depth are lower and hard rock is the predominant geological characteristic.

After generating all the relevant data layers, by coding and classifying the indicators, the model for typology was created. Based on the ecological parameters the state was broadly divided into five types of landform categories and a matrix was created to differentiate between various sub-classes on the basis of differences in the soil drainage parameter. Overlay analysis of landform types and soil drainage characteristics was carried out to generate the following matrix table and the number of blocks falling under the different combinations of landform and soil drainage criteria were listed (TY-1). Out of the sixteen possible combinations, the blocks were clubbed together to form five broad categories of landform and soil drainage types.

Table 4.2: Typology 1 (TY-1)

Soil Drainage		Categories			
Landform		1 and 2	3 and 4	5	6
Categories	1	1* (1)**	5 (1)	9 (0)	13 (6)
	2 and 3	2 (9)	6 (23)	10 (19)	14 (14)
	4 and 5	3 (6)	7 (22)	11 (11)	15 (8)
	6	4 (3)	8 (19)	12 (5)	16 (0)

Note: * Typology categories
** Number of blocks within the respective category.

The features of the various typologies categories are as follows:

Typology 1A: Rugged and dissected to undulating terrain with poor to moderately drained soils. Typology categories included in this class are **1, 2, 5 and 6**. It can be seen in the map- these are the rim land areas in the eastern part of the state where the terrain is very rugged and inaccessible. The blocks are mainly located in the districts of Korea, Dantewara, Kawardha, Korba, Bastar and Raipur.

Typology 1B: Valleys to plains and level areas with poorly drained soils. Typology categories included in this class are **3 and 4**. This category comprises of very few blocks within the central plains area, in the districts of Durg, Rajnandgaon and Raipur.

Typology 1C: Valleys and river plains and level land with well-drained soils. Typology categories included in this class are **7 and 8**. This typology encompasses a large area, with almost the whole of the Chhattisgarh basin falling within this category. Small pockets in Surguja and Raigarh districts also come under this category. The main areas are across the Durg, Rajnandgaon, Raipur, Dhamtari, Bilaspur and Mahasamund districts.

Typology 1D: Ridges, dissected, undulating and rugged topography with somewhat excessively drained soils. Typology categories included in this class are **10, 13 and 14**. These are the worst effected areas, as the topography is rugged and the runoff is also fairly high, with high percolation rate due to sandy soils. These are the areas bordering the high ridge areas, where the forest cover is low due to human intervention. Areas in the districts of Jashpur, Bilaspur, Dantewara, Bastar, Surguja and Raipur fall in this category.

Typology 1E: Rolling plains to valleys with poorly drained soils. Typology categories included in this class are **11, 12 and 15.** This area forms the transition zone between flat plains and the dissected topography. It encompasses parts of the districts of Korba, Bilaspur, Dantewara, Bastar, Kanker and Janjgir Champa.

Another overlay analysis was carried out between the soil particle size and the percentage distribution of inter-spell gap of greater than eight days in the blocks. It must be remembered that inter-spell duration subsumes the required rainfall to support paddy in *kharif* and therefore average annual/seasonal rainfall is already a part of this variable. In the prevailing climatic condition of Chhattisgarh region the soil moisture requirements for the plants to sustain are retained for eight days, beyond which the situation becomes critical. A matrix of 16 combinations of soil particle size and inter spell gap were generated with the number of blocks falling within each category. These categories were further grouped together to evolve four distinct typologies. The matrix created from the overlay analysis of soil particle size and the inter spell gap in rainfall of greater than eight days is as follows (TY-2):

Table 4.3: Typology 2 (TY-2)

Inter spell gap		Categories			
Soil Particle size		1	2	3	4, 5 and 6
Categories	1	1* (7)**	2 (16)	3 (8)	4 (8)
	2 and 3	5 (2)	6 (17)	7 (18)	8 (8)
	4 and 5	9 (1)	10 (5)	11 (9)	12 (8)
	6	13 (2)	14 (3)	15 (9)	16 (13)

Note: * Typology categories
** Number of blocks within the respective category.

The features of various typologies are as follows:

Typology 2A: Skeletal loamy soils with low inter- spell gaps. Typology categories included in this class are **1, 2, 5 and 6**. These are the areas with poor soil quality, lacking in nutrients but the rainfall is fairly good with smaller inter spell gap duration. Areas in the districts of Dhamtari, Surguja, Rajnandgaon, Raipur and Kanker fall in this typology.

Typology 2B: Skeletal loamy soils with high inter- spell gaps. Typology categories included in this class are **3, 4, 7 and 8**. These are the areas with poor soil quality and very high inter spell duration gaps. These are some of the least productive areas in terms of agriculture, spread over the districts of Kawardha, Rajnandgaon, Jashpur, Dantewara, Kanker and Bastar.

Typology 2C: Clayey loamy to clayey soils with low inter- spell gaps. Typology categories included in this class are **9, 10, 13, and 14**. There are very few blocks with low interspell duration gaps and fairly good soils. This category spreads over the districts of Surguja, Korea and parts of Janjgir Champa and Bilaspur.

Typology 2D: Clayey loamy to loamy soils with large inter- spell gaps. Typology categories included in this class are **11, 12, 15 and 16**. The whole of the central belt, along the river valleys of the Mahanadi and the Godavari sub- basin areas, comes under this typology. This encompasses the districts of Raipur, Durg, Rajnandgaon, Bilaspur, Surguja and small patches in Bastar and Dantewara.

Another overlay was carried out with the landform types and the percentage of forest cover within the blocks. Then a matrix was generated with twelve possible combinations of the landform features and the percentage of forest cover. These categories were further clubbed together to evolve five broad typologies of landform and forest cover interface.
The matrix of overlay analysis of landform categories and the forest cover is as follows (TY-3):

Table 4.4: Typology 3 (TY-3)

Forest Cover		Categories		
Landform		1	2 and 3	4, 5 and 6
Categories	1	1* (1)**	2 (6)	3 (1)
	2 and 3	4 (17)	5 (24)	6 (24)
	4 and 5	7 (25)	8 (12)	9 (10)
	6	10 (26)	11 (1)	12 (0)

Note: * Typology categories
** Number of blocks within the respective category.

The features of the various typology categories are:

Typology 3A: Undulating to gently rolling plains with fairly high forest cover. The typology categories included in this class are **9**. These areas are concentrated in the districts of Kanker, Bastar, Korba, Dantewara and Bilaspur.

Typology 3B: Valleys and river plains and level land with low to no forest cover. Typology categories included in this class are **10 and 11**. This is the ‘rice bowl’ region of the state where agriculture is predominantly practiced and the forest cover is very low. The districts are Durg, Raipur, Dhamtari, Bilaspur and Janjgir Champa.

Typology 3C: Undulating to rolling valleys with low to moderate forest cover. Typology categories included in this class are **7 and 8**. This area immediately borders the preceding region (in typology 3B), and comprises gently undulating to rolling plains with grassland type of vegetation. The districts falling in this typology are Surguja, Bastar, Dantewara, Rajnandgaon, Durg, Janjgir Champa, Korba, Bilaspur and Dhamtari.

Typology 3D: Ridges, undulating, dissected and rugged topography with low to moderate forest cover. Typology categories included in this class are **1, 2, 4 and 5**. These are the rugged areas, which have low forest cover due to higher human intervention and greater accessibility. The region falls within the districts of Surguja, Jashpur, Korea, Kawardha, Dantewara, Bastar, Kanker, Raipur and Mahasamund.

Typology 3E: High ridges with high forest cover. Typology categories included in this class are **3 and 6**. These are the inaccessible regions of the state where development is fairly low and the forest cover is still retained. This category comprises districts of Surguja, Korea, Korba, Bilaspur, Raipur Dhamtari, Kanker, Rajnandgaon and Bastar.

Once these three independent typologies were formed, they were further overlayed with each other to evolve the final broad categories of typology. First the landform feature, forest cover and soil drainage characteristisc were overlayed to evolve a 5x5 matrix of 25 possible combinations (Table 4.5). Thus typology category 1 was combined with typology category 3. Then a matrix of typology 1 and typology 3 were further overlayed with inter spell gap and the soil particle size to generate a 4x14 matrix (Table 4.6). *This final matrix was interpreted to evolve seven broad typologies of blocks on the basis of terrain, soil, rainfall and forest cover features*.

Table 4.5: Final Typology Matrix (i)

Ty3		Categories				
Ty1		1	2	3	4	5
Categories	1	1* (0)**	2 (0)	3 (0)	4 (12)	5 (15)
	2	6 (0)	7 (3)	8 (6)	9 (4)	10 (3)
	3	11 (2)	12 (19)	13 (20)	14 (0)	15 (0)
	4	16 (0)	17 (0)	18 (0)	19 (32)	20 (7)
	5	21 (8)	22 (5)	23 (11)	24 (0)	25 (0)

Note: * Typology categories
** Number of blocks within the respective category.

Table 4.6: Final Typology Matrix (ii)

	Ty 1-Ty 3													
Ty2	4	5	7	8	9	10	11	12	13	19	20	21	22	23
1	1*(2)**	2(6)	3(0)	4(0)	5(2)	6(1)	7(0)	10(1)	11(3)	12(17)	13(3)	14(2)	15(4)	16(1)
2	17(5)	18(7)	19(0)	20(0)	21(2)	22(0)	23(1)	24(0)	25(0)	26(14)	27(3)	28(4)	29(0)	30(9)
3	31(2)	32(0)	33(2)	34(1)	35(0)	36(1)	37(1)	38(3)	39(10)	40(0)	41(0)	42(0)	43(0)	44(0)
4	45(3)	46(2)	47(1)	48(5)	49(0)	50(1)	51(0)	52(15)	53(7)	54(1)	55(1)	56(2)	57(1)	58(1)

Note: * Typology categories
** Number of blocks within the respective category.

In the final typology matrix (i) table overlay was done between the TableTY-1 and TableTY-3, and in the final matrix table (ii) overlay was done between the TY-2 and the final matrix table (i). From the above table blocks with similar feature were clubbed together in a similar group. Along the vertical axis of the table (ii) the categories of the typology 2 table are represented and along the horizontal axis of the table the categories of the overlay of table (i) typology1 and 3 are represented.

The final typologies formed are as follows (Table 4.6):

Typology 1 (categories 1, 2, 4, 5, 6, 11, 12, 13 and 31) has a total of 36 blocks.
The landform of the area is ridges, dissected, undulating and rugged topography to undulating valleys with somewhat excessive to excessively drained soils. The soils are mainly skeletal loamy soils to loamy soils with low inter spell duration gaps in rainfall. The area has low to moderate forest cover.
Typology 2 (categories 52, 53, 47 and 57) 24 blocks.
Valleys, river plains and level land to undulating to rolling valleys with well-drained soils characterise the landform of this typology. Soil particle size varies form clayey loamy to loamy soils with large inter spell duration gaps. The forest type is moderate to low to sparse cover.
Typology 3 (categories 26 and 17) has 19 blocks
Ridges, dissected, undulating and rugged topography with somewhat excessive to excessively drained to poor to moderately drained soils. Soil type is skeletal loamy soils with high inter spell duration gaps. Forest cover is low to moderate forest type.
Typology 4 (categories 36, 45, 46, 50, 54, and 55) has 9 blocks
The landform is characterised by ridges, undulating, dissected and rugged topography with somewhat excessive to excessively drained to poor to moderately drained soils. Soil particle size varies from clayey loamy to loamy soils with large inter spell gaps. Forest cover type is low to moderate.
Typology 5 (categories 10, 14, 15, 16, 43, 34, 37, 39, 33, 35, 44, 32, 38, 40 and 41) 25 blocks
The landform is characterised by undulating to rolling valleys to river plains and level land with fairly well drained to poorly drained soils. The soil particle size varies from clayey loamy to clayey soils with low inter spell gaps. The forest cover varies from moderate to low to sparse cover.
Typology 6 (categories 28, 30, 48, 51, 56 and 58) 21 blocks
The topography of this area is undulating to rolling valleys to plains with poorly drained to excessively drained soils. The soil particle size varies from clayey loamy to loamy soils to skeletal soils with large inter spell duration gaps. The forest cover is low to moderate
Typology 7 (categories 18, 21, 23, 25 and 27) 13 blocks
The landform is characterised by dissected, undulating to rolling valleys with somewhat excessive to excessively drained to poorly drained soils. The soil particle size can be classified as skeletal loamy soils. The inter spell duration gaps is high. The nature of forest cover is low to moderate type.

Table 4.7: Blocks and Districts Falling in Different Ecological Typologies

Dist Name	Block ID	Block Name	Features
Typology 1 Final			
Bastar	110	Keshkal	The landform of the area is ridges, dissected, undulating and rugged topography to undulating valleys with somewhat excessive to excessively drained soils. The soils are mainly skeletal loamy soils to loamy soils with low inter spell duration gaps in rainfall. The area has low to moderate forest cover.
	112	Narayanpur	
	113	Orchha	
Bilaspur	206	Lormi	
Dantewara	301	Dantewada	
	303	Kuwakonda	
Jashpur	701	Jashpur	
	705	Kunkuri	
	706	Kasavel	
	707	Pathalgaon	
	708	Farsabahar	
Kanker	801	Kanker	
	802	Charama	
	803	Sarana	
	804	Bhanupratpur	
	807	Koyalibada	
Korba	1003	Pondi	
Korea	1102	Baikunthpur	
	1103	Manendragarh	
	1105	Bharatpur	
Mahasamund	1205	Basna	
Raigarh	1304	Gharghoda	
	1307	Sarangarh	
Raipur	1413	Chhura	
Surguja	1601	Rajpur	
	1605	Lundra	
	1606	Sitapur	
	1607	Batauli	
	1608	Mainpat	
	1612	Ramanujnagar	
	1614	Pratappur	
	1615	Ramchandrapur	
	1616	Balrampur	
	1617	Wadraf nagar	
	1618	Kusmi	
	1619	Shankargarh	

Typology 2 Final			
Bilaspur	205	Patharia	Valleys and river plains and level land to undulating to rolling valleys with well-drained soils characterize the landform of this typology. Soil particle size varies form clayey loamy to loamy soils with large inter spell duration gaps. The forest type is moderate to low to sparse cover.
Dhamtari	402	Kurud	
Durg	501	Durg	
	502	Dhamdha	
	503	Gunderdeh	
	504	Patan	
	508	Dondilohara	
	509	Bemetara	
	510	Saja	
	511	Berla	
	512	Navagarh	
Janjgir Champa	601	Akaltara	
Kawardha	902	Kawardha	
	903	Sahaspur	
Raipur	1401	Dharsiwa	
	1402	Arang	
	1403	Tilda	
	1404	Abhanpur	
	1407	Balodabazar	
	1408	Palari	
	1410	Bilaigarh	
Rajnandgaon	1501	Rajnandgaon	
	1504	Khairagarh	
	1508	Amba Chauki	
Typology 3 Final			
Bastar	102	Londigura	Ridges, dissected, undulating and rugged topography with somewhat excessive to excessively drained to poor to moderately drained soils. Soil type is skeletal loamy soils with high inter spell duration gaps. Forest cover is low to moderate forest type.
	103	Darbha	
	105	Bastanar	
Dantewara	304	Katekaley	
	309	Sukma	
	311	Gedam	
Dhamtari	404	Sihawa	
Jashpur	702	Manora	
	703	Bagicha	
	704	Duldula	
Mahasamund	1202	Bagbahara	
	1203	Pithora	
Raigarh	1305	Lailunga	
	1306	Tamnar	
	1309	Dharmjaigarh	
Raipur	1409	Kasdol	
Rajnandgaon	1507	Mohla	
Surguja	1609	Surajpur	
	1611	Bhaiyathan	

Typology 4 Final			
Bastar	104	Tokapal	The landform is characterized by ridges, undulating, dissected and rugged topography with somewhat excessive to excessively drained to poor to moderately drained soils. Soil particle size varies from clayey loamy to loamy soils with large inter spell gaps. Forest cover type is low to moderate.
Bilaspur	208	Gourela(2)	
	209	Gaurela (1)	
Durg	506	Doundi	
Kawardha	901	Pandariya	
	904	Bodla	
Korea	1101	Sonhat	
Surguja	1603	Lakhanpur	
	1610	Odgi	
Typology 5 Final			
Bastar	111	Baderajpu	The landform is characterized by undulating to rolling valleys to river plains and level land with fairly well drained to poorly drained soils. The soil particle size varies from clayey loamy to clayey soils with low inter spell gaps. The forest cover varies from moderate to low to sparse cover.
	114	Makdi	
Bilaspur	201	Bilha	
	202	Masturi	
	203	Takhatpur	
	207	Kota	
Dhamtari	401	Dhamtari	
	403	Magarlod	
Durg	505	Sanjari Balod	
	507	Gurur	
Janjgir Champa	603	Nawagarh	
	604	Pamgarh	
	605	Bamhnidih	
	606	Shakti	
	607	Jaijaipur	
	609	Dabhra	
Korba	1002	Katghora	
Mahasamund	1201	Mahasamund	
Raigarh	1301	Raigarh	
	1303	Kharsia	
Raipur	1405	Simga	
	1406	Bhatapara	
Rajnandgaon	1502	Dongargaon	
	1503	Chhuriya	
	1506	Dongargarh	

Typology 6 Final			
Bastar	101	Jagdalpur	The topography of this area is undulating to rolling valleys to plains with poorly drained to excessively drained soils. The soil particle size varies from clayey loamy to loamy soils to skeletal soils with large inter spell duration gaps. The forest cover is low to moderate
	106	Bastar	
	107	Bakaband	
	108	Kondagaon	
	109	Pharasgaon	
	204	Mungeli	
	210	Marwahi	
Dantewara	308	Konta	
	310	Chhindgarh	
Bastar	312	Jagdalpur	
Janjgir Champa	602	Baloda	
	608	Malkharoda	
Kanker	805	Durg Kodal	
Korba	1004	Pali	
	1005	Kartala	
	1104	Khadgawan	
Mahasamund	1204	Saraipali	
Raigarh	1302	Pusaur	
	1308	Sarai Lengha	
Raipur	1411	Rajim	
	1415	Deobhog	
Typology 7 Final			
Dantewara	302	Bijapur	The landform is characterized by dissected, undulating to rolling valleys with somewhat excessive to excessively drained to poorly drained soils. The soil particle size can be classified as skeletal loamy soils. The inter spell duration gaps is high. The nature of forest cover is low to moderate type.
	305	Bheramgar	
	306	Bhopal Patnam	
	307	Asur	
Kanker	806	Antagarh	
Korba	1001	Korba	
Raipur	1412	Gariyaband	
	1414	Mainpur	
Rajnandgaon	1505	Chhuikhadan	
	1509	Manpur	
Surguja	1602	Ambikapur	
	1604	Udeypur	
	1613	Premnagar	