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Agro-Ecological Zones of North-western Hot Arid Region of India

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Abstract: The north-western hot arid region of India has been classified into four agro-ecological sub-regions, eleven agro-ecological zones and thirty four agro-ecological sub-zones. The sub-regions are based on physiography, rainfall and water resources (surface water through streams, canal and ground water). Within the sub-region, agro-ecological zones have been identified on the basis of land form- soil association, land use and cropping pattern. For recognition of agro-ecological sub-zones, an integrated approach involving land features; soil texture, depth and salinity; surface and ground water potential has been adopted. The sub-zones are homogeneous with respect to potentials/constraints for rainfed/irrigated agriculture and silvipasture and will require specific technology for sustainable development.

Key words: North-western hot arid region, agro-ecological zones.

Identification of homogeneous agro-ecological zones is necessary for proper utilisation of land, water and other resources for development through transfer of suitable technology. The strategy is more relevant in the arid region of India, which is characterised by hostile climate, scarce resources and increasing human and animal population.

In the past few decades, several attempts have been made, at national and regional levels, to recognise agro-climatic and agro-ecological zones in the country. Based on Thornthwaite's moisture index, Krishnan (1968) delineated the boundaries of arid and semi-arid zone of the country. The Planning Commission of India recognised 15 agro-climatic regions for the entire country, which were uniform with respect to land and water endowment. Three of these occur in the north-western arid zone (Basu and Guha, 1996). In 1974, National Commission on Agriculture subdivided the arid zone of Rajasthan into three zones, which are based on the quantum of rainfall received during the rainy season. The Indian Council of Agricultural Research (ICAR), under the auspices of National Agricultural Research Projects (NARP), identified 126 agro-climatic zones in the country, out of which, 10 occur in north-western arid region (Ghosh, 1991). Based on physiography, soil and length of growing season, the National Bureau of Soil Survey and Landuse Planning (NBSS&LUP) identified 54 agro-ecological zones (Sehgal *et al.*, 1989). Subsequently, the Bureau published another map with 21 agro-ecological regions (Sehgal *et al.*, 1990).

The north-western arid region of India has large spatial variability of climate and land resources. The agro-climatic/agro-ecological zones recognised by different agencies/organisations are broad-based. Each zone has large variations in rainfall, terrain,

soil characteristics, surface and ground water potential and have different technological requirement. Therefore it is necessary to classify the entire region into homogeneous agro-ecological zones and sub-zones so that a uniform package for development can be adopted. The present paper attempts to meet this requirement.

Environmental Setting

The north-western arid region lies between 22°30′ and 32°05′ N and between 68°05′ and 75°45′ E, covering the western part of Rajasthan (19.6 m ha, 69%), Gujarat (6.22 m ha, 21%) and south western parts of Haryana and Punjab (2.75 m ha, 10%). The region is bordered by the irrigated Indus plain in the north, Aravalli hill ranges in the east, international border with Pakistan in the west and black soil region and alluvial plain of the Sabarmati in the south.

The region receives low rainfall (<100 mm to >400 mm), has high evapo-transpiration and high temperature regime. Ground water is deep and often brackish. The ephemeral rivers flow along the northern, eastern and southern fringe. Western and central parts are devoid of integrated drainage system and surface water resources are scanty. Soils are coarse textured and the surface is covered with sand dunes. Low available water capacity, vulnerability to wind erosion and low fertility are major soil constraints. High salinity, calcareous and gypsiferous nature are the other problems associated with the soils. Rainfed agriculture with animal husbandry is the main basis of livelihood. Frequent droughts result in failure of crops and migration of human and animal population. In spite of such hostile environment, the region is endowed with best breeds of animals, nutritious and drought tolerant grasses and tree species and culturally rich, hospitable dwellers.

Methodology

During integrated natural resources survey of arid region over the last four decades, CAZRI has collected valuable information on the distribution and characteristics of land forms, soils, surface and ground water potential, natural vegetation and land use. This information has been used for the delineation of agro-ecological sub-regions, agro-ecological zones and sub-zones. The criteria adopted for this classification has been given below:

- *agro-ecological sub-regions*: physiography, rainfall and water resources (surface water through streams, canals and ground water);
- *agro-ecological zones*: landform-soil association, and land use; and
- *agro-ecological sub-zones*: integrated approach involving terrain characteristics, parent material; soil texture, depth and salinity; surface and ground water potential and cropping pattern.

The sub-zones are homogeneous with respect to potentials/constraints for rainfed/irrigated cropping and silvipasture and will require specific technology for sustainable development.

The agro-ecological sub-regions, zones and sub-zones, have been mapped at 1:2 million scale.

Results and Discussion

North-western hot arid region has been subdivided into four agro-ecological sub-regions, eleven zones and thirty four sub-

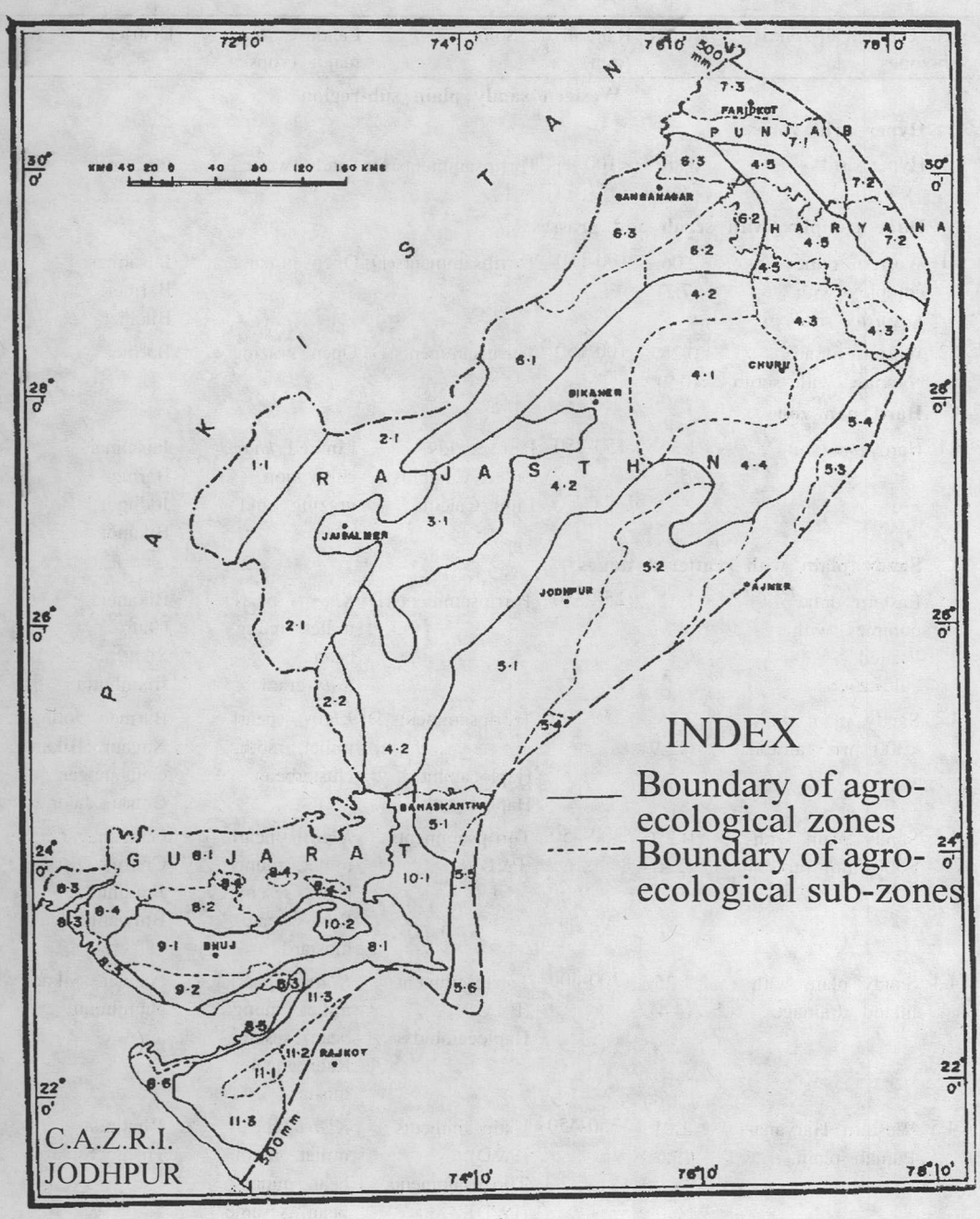

Fig. 1. North-west arid zone of India agro-ecological zones and sub-zones.

Table 1. Agro-ecological sub-regions, zones and sub-zones in the north western hot arid region of India

Agro-ecological zones/ sub-zones	Area*	Rainfall (mm)	Soils	Landuse/ major crops	District
			Western sandy plain sub-region		
1. Hyper arid zone					
1.1 Hyper arid	0.86 (3.0)	<100	Torripsamments(D)	Sandy waste	Jaisalmer
2. Dune complex with scrub and grasses					
2.1 Western dune complex with *Lasiurus sindicus*	2.06 (7.2)	100-150	Torripsamments(D)	Open grazing	Jaisalmer, Barmer, Bikaner
2.2 Western dune complex with scrub	0.26 (0.9)	100-150	Torripsamments(D)	Open grazing	Barmer
3. Hard pan zone					
3.1 Hard pan soil	1.57 (5.5)	150-250	Petrocalcids Lithic Cambids Lithi Calcids	Limited *kharif* cultivation, grazing land	Jaisalmer Barmer Jodhpur Bikaner
4. Sandy plain with scattered dunes					
4.1 Eastern dune complex with limited cultivation	1.32 (4.6)	250-350	Torripsamments(D)	*Kharif*- pearl millet, mung bean *Rabi*-gram	Bikaner, Churu, Sikar, Jhunjhunu
4.2 Sandy plain with <300 mm rainfall	3.68 (12.9)	250-300	Torripsamments(D) Haplocambids Haplocalcids	*Kharif*- pearl millet, moth, clusterbean	Barmer, Jodhpur, Nagaur, Bikaner, Ganganagar, Churu, Jalor
4.3 Sandy plain with >300 mm rainfall	0.270 (2.4)	300-450	Torripsamments (P&D)	*Kharif*- pearl millet, mung bean, sesame Rabi-wheat, mustard	Ganganagar, Churu, Jhunjhunu, Bhiwani
4.4 Sandy plain with inland drainage	1.25 (4.4)	300-400	Torripsamments (P) Haplocambids	*Kharif*- pearl millet, mung bean, sesame Rabi-wheat, mustard	Nagaur, Sikar, Jhunjhunu
4.5 Western Haryana-Punjab plain	1.01 (3.6)	350-450	Ustipsamments (P&D), Torripsamments (P&D), Haplocambids	*Kharif*- pearl millet, moth bean, mung bean, sesame Rabi-wheat, mustard	Bhatinda, Hisar, Sirsa

Contd...

Table 1 (contd.)

Agro-ecological zones/ sub-zones	Area*	Rainfall (mm)	Soils	Landuse/major crops	District
Central alluvial plain sub-region					
5. Luni-Banas basin					
5.1 Luni basin with coarse loamy soils	2.67 (9.4)	300-450	Haplocalcids Haplocambids	*Kharif*- pearl millet, clusterbean, mung bean, sesame *Rabi*- cumin, mustard, wheat, isabgol with brackish water irrigation	Nagaur, Pali, Jodhpur, Jalor, Barmer, Banaskantha
5.2 Luni basin with fine loamy soils	1.44 (5.0)	300-450	Haplocambids Haplocalcids Haplosalids	*Kharif*- pearl millet, sorghum, sesame, maize *Rabi*- wheat, mustard, cotton	Pali, Jalor, Nagaur, Jodhpur
5.3 Mendha basin	0.17 (0.6)	400-450	Torripsamments(P) Torrifluvents Haplocambids Haplosalids	*Kharif*- cotton *Rabi*- wheat mustard spices	Sikar, Nagaur
5.4 Aravalli foot hill	0.76 (2.6)	450-500	Lithic cambids Haplocambids	*Kharif*- maize, sorghum, sesame, cowpea	Jhunjhunu, Sikar, Pali, Jalor, Nagaur
5.5 Aeo-alluvial plain of Banas	0.07 (0.2)	450-500	Ustipsamments	*Kharif*- pearl millet, pulses, castor *Rabi*- *wheat cumin, isabgol*	Banaskantha
5.6 Sabarmati plain	0.34 (1.2)	400-500	Haplocambids Ustipsamments(P)	*Kharif*- maize, sorghum, ground nut, castor *Rabi*- wheat, mustard, spices	Banaskantha, Mehsana
Northern canal irrigated sub-region					
6. Canal irrigated sandy plain					
6.1 Dune complex with canal irrigation	1.18 (4.1)	150-250	Torripsamments(D) Petrogypsids Petrocalcids	Sand dunes- silvipasture, inter dunes irrigated wheat, mustard, ground nut	Jaisalmer, Bikaner

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Table 1 (contd.)

Agro-ecological zones/ sub-zones	Area*	Rainfall (mm)	Soils	Landuse/ major crops	District
6.2 Aeolian plain of north-east	0.55 (1.9)	250-300	Torripsamments(P) Haplogypsids	*Kharif*- pearl millet, sorghum, cotton *Rabi*- wheat, mustard	Ganganagar, Sirsa, Faridkot
6.3 Gaggar flood plain	1.06 (3.7)	250-300	Torrifluvents Torripsamments(P), Haplosalids	Cotton, wheat, paddy, sugarcane	Ganganagar, Firozpur, Faridkot
7. Canal irrigated alluvial plain					
7.1 Sutlej plain with coarse loamy soils	0.54 (1.9)	400-450	Ustipsamments(P)	Rainfed- pearl millet, gram *Rabi*- wheat paddy	Firozpur, Faridkot, Bhatinda, Hisar
7.2 Yamuna plain with loamy soils	0.51 (1.8)	450-500	Haplocambids Ustorthents Ustochrepts	*Kharif*- maize, blackgram, sorghum *Rabi*- wheat, paddy, sugarcane, gram	Sangrur, Hisar, Jind, Bhiwani
Southern coastal and basalt sub-region					
8. Coastal saline/rocky uplands					
8.1 Rann and mudflats	2.07 (7.3)	200-300	Salids	Saline waste salt pan	Kachchh, Jamnagar
8.2 Banni ecosystem	0.28 (1.0)	250-300	Torrifluvents	Open grazing salt waste	Kachchh,
8.3 Mangrove ecosystem	0.24 (0.8)	150-250	Udifluvents Salids	Mangroves	Kachchh, Jamnagar
8.4 Rocky upland with limited agriculture	0.28 (1.0)	200-250	Lithic orthents	*Kharif* - pearl millet, pulses, limited cropping	Kachchh
8.5 Coastal saline plain	0.20 (0.7)	200-300	Salids	Open grazing, saline waste	Kachchh, Jamnagar
8.6 Dwarka coastal plain	0.25 (0.9)	150-200	Lithic Haplocalcids Haplosalids Petrocalcids	Rainfed ground nut, castor, cowpea, sorghum	Jamnagar, Junagarh

Contd....

Table 1 (contd.)

Agro-ecological zones/ sub-zones		Area*	Rainfall (mm)	Soils	Landuse/ major crops	District
9.	**Kachchh alluvial plain**					
9.1	Central plain with valley fill and rocky upland	0.81 (2.8)	250-300	Haplocambids Ustipsamments Ustertic Haplocambids Lithic, Calcids	Limited irrigation ground nut, cotton, blackgram, pulses horticulture	Kachchh
9.2	Coastal alluvial plain with intensive agriculture	0.25 (0.9)	350-450	Haplocambids Haplocalcids	Extensively irrigated ground nut, cotton, pulses	Kachchh
10.	**Santhalpur plain with saline soils**					
10.1	Santhalpur plain with coarse loamy soils	0.55 (1.9)	250-350	Torripsamments (P), Haplocambids	Rainfed - ground nut, sesame, castor saline waste	Banaskantha, Mehsana, Jalor
10.2	Rapar plain with fine loamy soils	0.16 (0.6)	250-300	Paleargids	Rainfed sorghum, sesame, pearl millet, castor *Rabi* - wheat	Kachchh
11.	**Basaltic piedmont plain**					
11.1	Basaltic gravely/rocky upland	0.12 (0.4)	250-350	Lithic Orthents	Limited rainfed ground nut, open grazing	Jamnagar
11.2	Basaltic piedmont plain with shallow soils	0.18 (0.6)	400-500	Lithic Ustorthents	Limited irrigation ground nut, spices	Jamnagar, Rajkot
11.3	Basaltic piedmont plain with moderately deep soils	0.81 (2.8)	250-400	Vertic Ustochrepts Typic Haplustarts	Ground nut, cotton, sugarcane, spices	Jamnagar, Junagarh, Rajkot

* Area in million ha, percentage is given in parenthesis.

zones (Fig. 1). Salient characteristics of these units have been summarised in Table 1 and are discussed below.

The western sandy plain sub-region (44.5% of total area) is characterised by intensive occurrence of dune complex associated with sandy plain, low rainfall (<100-200 mm) and poor surface/ground water resources. The sub-region, according to landform-soil relationship and land use, has been classified in four zones, viz., hyper-arid, dune complex, hard pan soil and sandy plain with scattered sand dunes. Based on terrain and soil characteristics and cropping pattern,the zones have been further classified into nine sub-zones.

The central alluvial plain sub-region is a vast alluvial plain created by the rivers Luni and Banas, and covers 19% area. The sub-region occurs in a better rainfall

zone (300-450 mm) and has rich surface and ground water resources. The sub-region has been classified into one zone, i.e., Luni-Banas basin. Six sub-zones have been identified on the basis of sub-catchments of the basin, uniform with respect to terrain and soil characteristics, ground and surface water resources and cropping pattern.

Northern canal irrigated sub-region covers 14.7% area and is an alluvial plain created by the rivers Ghaggar, Sutlej and Yamuna. This sub-region has net works of canals for irrigation. The rainfall varies from 250 to 450 mm. Based on landform-soil relationship this sub-region has been subdivided into two zones, viz., canal irrigated sandy plain and canal irrigated alluvial plain. Sources of alluvium, terrain characteristics, soil texture, land use and cropping pattern. These two zones have been further classified into six sub-zones.

The northern coastal and basaltic sub-region occurs in 21.7% area. It is characterised by rocky/gravely upland, coastal saline mud and shallow to moderately deep undulating basaltic plain. The sub-region falls in 150 to 450 mm rainfall zone with poor surface and ground resources. According to landform-soil relationship it has been classified into four zones, viz., coastal saline/rocky upland, Kachchh alluvial plain, Santhalpur plain with saline soils and basaltic alluvial plain. The zones have been further subdivided into 13 sub-zones on the basis of terrain characteristics, parent material, soil texture, depth and salinity, land use and cropping pattern.

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