Typology of Agriculture for India for Technology Targeting and Development Planning[1]

P. Parthasarathy Rao[2], M. Lagesh[3], UK Deb[4] and E. Jagadeesh[3]

Abstract

A **crop-livestock typology** for India has been constructed using *Agricultural activity - based approach (AAA).* The classification identifies systems / zones having similar features (agro-climatic and socioeconomic) for agricultural development and are homogeneous in terms of the expected outcomes in response to an external change. The systems / zones thus generated are characterized for their relative importance in terms of area and population, economic significance, crop and livestock activities, input use, infrastructure development and key socioeconomic and agro-climatic indicators. The crop-livestock typology is a useful tool for targeting development planning initiatives and transfer of technology.

Keywords: Typology, Crop-Livestock, Agro-climatic, Socio-economic, Technology targeting

[1] Paper presented at the pre- workshop symposia session on "Rapid Transformation of Rural Economies in South Asia: Insights from Village Dynamics Studies" at the 8th ASAE International Conference, 14 October 2014, Dhaka.

2 Assistant Research Program Director, RP-MIP, ICRISAT, Patancheru-502324, Telangana, India.
3 Scientific Officer, RP-MIP, ICRISAT, Patancheru-502324, Telangana, India.
4 Principal Scientist RP-MIP, ICRISAT, Patancheru-502324, Telangana, India.

Background and Introduction

Agricultural growth can be the most appropriate instrument for achieving sustainable poverty reduction in developing countries by increasing farmers' incomes, providing employment for agricultural labor, increasing the wages of agricultural labor, and lowering food prices for both the urban and rural poor (Chaudhuri, 2003). However, its role can vary across countries, and even in regions within countries, based upon the overall economic structure and potential for agriculture. A country as large and diverse as India is a prime example for such challenges to development initiatives owing to the diverse agro-ecological and socio-economic conditions underlying currently observed agricultural practices. This study addresses the crucial question of how to create a useful number of spatial sub-divisions-- a typology, to aid development-planning bodies and policy makers. ***Agro-ecological typologies*** are homogeneous zones or regions defined 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 a single continuous land unit.

Demarcating homogenous zones or regionalization has been used for planning at the state level in India for many years. 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 fiber. By focusing attention on a limited number of agricultural scenarios that offer similar opportunities for response to development initiatives, a set of well-defined regions is a useful aid in developing research programs, policy initiatives, and infrastructure development projects. Delineation of homogenous regions also provides a clear focus for measuring achievement and

impact that facilitates resource allocation decisions across alternative uses. In research, the identification of similar geographical units to which successful development initiatives can be extended helps utilize economies of scale (Bidinger et al. 1994). Analysis of the spatial units thus created will provide information about the predominant causes of differences in agriculture, and the rate of adoption of development initiatives across rural areas.

Spatial variations in agricultural activities are a result of many decisions made by individual farmers and not merely a reflection of agro-climatic factors alone. Farmers' response to development initiatives now assumes greater importance. What is needed is a typology of agriculture that incorporates not only agro-ecological factors but also the socioeconomic factors. Socioeconomic factors determine the nature of constraints that limit the ability of farmers to produce more efficiently, sustainably and make more efficient use of scarce resources.

Objective of the study

This study addresses the question of how to create a useful tool based on spatial subdivisions i.e. a typology of agriculture to aid researchers and development bodies whose geographic mandate spans the full range of diversity within a country to better target their technologies and development initiatives to specific systems so as to have the maximum impact. For example, a crop technology that may fit a region based on agro-climatic situation may be misplaced when introduced due to lack of markets or related infrastructure. Similarly a development initiative providing subsidized fodder seeds may be misplaced if farmers are not able to fit the crop in their cropping pattern or dairy is not an important activity in that system. These are simple examples,

but the typology can aid in bigger issues related to resource allocation, priority setting, impact assessment, up-scaling specific initiatives etc.

Delineation of homogenous zones and need for improved typology of agriculture

Globally, FAO (Dixon 2003) delineates 72 farming systems with an average agricultural population of about 40m inhabitants in the developing world by grouping farm households with similar characteristics and constraints. The classification of the farming systems is based on a number of key factors such as the available natural resource base; dominant pattern of farm activities and household livelihoods, including relationship to markets; and the intensity of production activities.

In India, most early attempts at regionalization were on the basis of broad natural regions, existing cropping patterns, as well as a broad framework of climatic variations at a macro scale In view of the complexity and diversity of agricultural activities pursued within a given country, several approaches were used to delineate homogeneous regions that would be amenable to policy prescriptions and technology targeting. Since the primary goal of agriculture is increasing agricultural production, agro-ecological characteristics --physiography, climate and soils -- were assigned primary importance in the classification of agricultural systems (Sehgal et al. 1992; ARPU 1993; GOI 1989 and Scholz 1987). For a detailed literature review on delineation of agro-ecological zones in India.

However, given the broad vision of agricultural development, i.e., increasing returns to farmers, delineation of regions based only on agro-ecological characteristics is too narrow to be

considered homogeneous for agricultural development planning. It does not incorporate socio-economic factors that determine the nature of constraints limiting the ability of farmers to produce more efficiently and sustainably. Further, the importance of livestock is not captured. Livestock especially in India has seen an enormous development, and has come to be regarded as a main driver out of poverty.

It is thus important to construct a typology that identifies regions having similar constraints to agricultural development, in which development initiatives can be directed to identifiable economic activities, and are homogeneous in terms of the expected outcomes in response to an external change .

Database and Methodology for Constructing the Crop-Livestock Typology

For the typology construction the methodology developed under the Rainfed Agriculture Project (in collaboration with ICAR, funded by World Bank) was adapted (ICRISAT 1999). Further this methodology was also used to construct a crop-livestock typology under the System wide Livestock project Parthasarathy Rao et al (2004). The methodology followed in this report will be the same as the earlier studies carried out by ICRISAT as indicated above.

Agricultural activities followed by millions of farmers are an articulation of the multiple objectives of the farm within the underlying agro-ecological and socio-economic constraints of the environment (Collinson 1996). Thus, agricultural activities are likely to fulfill the required role as an integrator of key structural variables i.e., agro climatic (rainfall, LGP, soils etc) and socioeconomic factors (wages, markets, credit etc). Regions identified on the basis of

agricultural activities can then be expected to exhibit similar patterns in both the underlying socio-economic and bio-physical characteristics that have been identified (and perhaps some that were not identified). A structural model was eschewed as it was felt that the success of the structural approach hinged on a comprehensive list of agro climatic and socio economic factors that is often not feasible due to data constraints. Also, it is not possible to perfectly model the interaction between underlying variables with difficulties in assigning weights, threshold levels etc. Furthermore, there is no guarantee that one would be able to relate each zone to a dominant determinant variable or set of variables, or be able to link zones to specific production systems.

A robust typology should be such that each system /zone in the typology can be identified on the basis of similar specific agricultural activities and their relative importance rather than being simply a nondescript agglomeration of areas formed on the basis of a combination of weighted 'key' variables. As basic descriptors of agricultural activities, agricultural enterprises and their combinations (in area or value terms) can be used to construct a typology with disaggregated data at district level. These districts are clustered into groups (agricultural systems/ zones) based on similar shares of the Total Value of Production (TVP) contributed by specific crop and livestock activities.

Identifying key crop –livestock activities and their integration

To capture the economic importance of various agricultural activities and integrate them to capture their relative importance, the values of production data for the crop- and livestock-based activities and their share in total value were used as the integrator variables in clustering districts into systems. Specifically, these values were:

- Gross value of production for the major crop / crop group activities, expressed relative to the TVP for all crop and livestock activities in a particular district

- Gross value of production for three major livestock activities: dairy and meat and eggs, expressed relative to the TVP for all crop and livestock activities in a particular district

Data base and data transformation

The database used for this study included data for key agricultural variables – crops, livestock, inputs, rainfall, infrastructure demography and socioeconomic, covering state and district level data for 19 states in India. A total of 520 districts were thus included for the study. Only Jammu and Kashmir and the north eastern states of India (except Assam) were not included due to non-availability of data for all key variables. For maintaining continuity in the dataset over time the data for newly formed districts after 1970 were given back to their parent districts and removed from the file. The typology was thus based on 310 districts i.e., 1966 district boundaries. This will enable to study the dynamics of the zones in the typology over time for key variables.

District level data for the years 2005-07 was used to construct crop –livestock typology. As a first step State level value of production data for 2005-07 for all crops and livestock activities was assembled and deflated to 2004-05 constant prices. District level crop values were calculated by apportioning the state level VOP according to district production shares for each state. Additionally, since crop residues are an important component of total value of crop production for cereals, legumes, and sugarcane the value of crop residue for these group of crops was included in the grain value to get total crop value (grain + crop residue).

Estimating fruits and vegetables value, value of crops other than those included in the clustering to get total value of all crops, and estimating value of livestock output was a challenging task as these are not readily available and the best method for their estimation was selected after several

iterations with different methods. The value of fruits and vegetables were estimated separately. Another variable called 'Other crops' was created to account for plantation crops, fibers (excluding cotton), spices, etc., that are not included in the district level data base for this study but are available at the state level. For livestock value of milk production, meat (ruminant + poultry) and eggs was estimated and included in the clustering process as a single variable under livestock value (for details of the methodology to generate the fruits and vegetables and milk, meat and eggs value).

Having generated the crop and livestock values (at constant prices) at district level, given the relative importance of each crop and livestock value share in total value of agricultural production the following crop activities or crop groups (coarse cereals, pulses etc) and livestock activities were chosen as the base activities for construction of the typology:

- Rice
- Wheat
- Coarse cereals (sorghum, millets, maize, barley)
- Pulses (*Kharif and Rabi* like: chickpea, pigeon pea, minor pulses etc.)
- Oilseeds *((Kharif and Rabi* like: sunflower, soybean, groundnut, safflower, linseed, rapeseed and mustard sesamun etc).
- Sugarcane
- Cotton
- Fruit
- Vegetables
- Other crops (tea, coffee, coconut, fibers (excluding cotton), spices)

- Livestock i.e., milk, meat and eggs

Clustering

Cluster analysis is the grouping and characterizing of disparate variables with little fore knowledge of the data and with no assigned model specification. There are two clustering methods hierarchical and non-hierarchical. When the variables are in the same scale and range, a standard metric such as the Euclidean distance measure can be used (for details of cluster analysis see Kaufman and Rousseeuw 1990. For this study the statistical software Stata version 8 was used was for clustering the districts based on the key integrator variables.

The final clustering algorithm that was chosen was a non-hierarchical algorithm based upon square of the Euclidean distance measure of dissimilarity. The numbers of base clusters are pre-determined with several runs made specifying various numbers of clusters within a range of 10 to 24. The following is a list of several important issues for cluster validation.

- Determining the clustering tendency of a set of data, i.e., distinguishing whether non-random structure actually exists in the data.
- Determining the correct number of clusters.
- Evaluating how well the results of a cluster analysis fit the data without reference to external information.
- Comparing the results of a cluster analysis to externally known results, such as externally provided class labels, such as the agro-ecological zones and subzones.
- Comparing two sets of clusters to determine which is better.

Following the clustering of districts into zones many tests were carried out to examine the consistency and homogeneity of the zones in the typology. Coefficient of variation (CV) of Agricultural Activities across districts within a zone were calculated to get a measure of the zones with respect to the dominant activities. Duncan's Multiple Range Test (DMRT) (Duncan (1955) and Tukey's honestly significant difference test, proposed by Tukey (1953), were carried out to evaluate the significant differences for each agricultural activity across zones. To further confirm the significance of the clusters formed, we execute a bunch of variance based tests of significance viz., F-test, Bartlett Test, Levene Test and Brown-Forsythe Test.

Construction of crop-livestock typology and testing its robustness

First the clustering algorithm was run only using crop variables. A typology with 10 zones / systems was considered the best fit (identifying variables had the lowest CVs among cluster). Since livestock activities, particularly milk was important in all districts, at first a map was generated that divided the districts into high, medium and low categories of milk production. Another map was generated using the relative shares of cattle milk, buffalo milk, meat and eggs to observe the regional dispersion. These maps were overlaid on the crop typology map. Since the objective of this study is to construct a crop–livestock typology; a typology using all variables crop and all livestock activities (combined livestock) was constructed. After several iterations a 14 zones / systems typology was selected. Clustering was also tried separating the livestock activity by milk (cattle, buffalo) and meat but the number of zones had to be greater than 25 for any meaningful results. Hence only the combined livestock activity was considered. The typology thus generated was subjected to some fine tuning like for instance: In 3-4 cases,

certain outlier districts were merged with appropriate neighboring zones to ensure a more cohesive geographical distribution. For example, in West Bengal, the districts of Malda, Murshirabad, and Nadia were shifted into zone / systems 11 as all three districts had high proportion of rice and livestock the dominant activities of Zone 11. Similarly in Kerala, Palakkad district was merged with the other districts in zone / system 1.

Additionally, some zones / systems that were geographically not contiguous were treated as 2 or 3 separate sub-zones for the purposes of characterization of the zones. Specifically, zone / system 6 was split into two sub-clusters 6a and 6b, with 6a covering districts in the northern part of India (Uttar Pradesh and Uttaranchal), and 6b covering the southern and western parts of India (Karnataka, Gujarat, Maharashtra, and Tamil Nadu). Zone / system 8 was split into two with 8a covering Andhra Pradesh and Madhya Pradesh and 8b covering Rajasthan. Similarly zone /system 9 was divided into two sub clusters with 9a covering north India and 9b covering south India. Zone / system 14 covered a large number districts all over India, however they can be divided into three separate sub-zones with 14a covering the northern hilly states of Himachal Pradesh and Uttarakhand, 14b covering Bihar and Uttar Pradesh, and 14c covering the south central states of Maharashtra and Madhya Pradesh.

The geographical location of zones / systems in the typology and dominant activities are shown in Table 1 and Figure 1). As can be seen crop activities are dominant as number 1 activity in 10 zones the combined livestock activity emerged as the dominant activity in 9 zones. Among the crops, rice, wheat, cotton, sugarcane, oilseeds, fruits and vegetables appear as dominant activities

(no.1) across zones. Plantation crops came out as the dominant activity in one zone covering districts in Assam, Kerala and Karnataka.

Tests for robustness of systems/ zones in the typology

The tests for robustness of the zones in the typology was carried out for the 14 original zones generated from the clustering methodology. The subsequent division of a few zones into sub-zones mainly to account for geographical continuity are not included in the tests.

Table 2 provides details of zone wise contribution of crop and livestock activities to the total value of product (TVOP). The first, second and third dominant activities within the zone are highlighted with the superscript a, b and c respectively. For instance in Zone 1 plantation crops (45%), livestock (24%) and fruits (15%) activities have the major share in the TVOP. Similarly, in zone 5 the Livestock (32%), Wheat (26%) and Rice (20%) are the major contributors to the total crop-livestock activity and hence these are considered as the dominant activities in that zone.

Several tests of consistency and homogeneity of the zones in the typology were carried out. In order to examine the robustness of the cluster analysis the Coefficient of Variation (CV) of the agricultural activities across districts with in each zone was calculated. Table 3 shows by and large the CV for the top 3-4 dominant activities across districts within a zone is low thus implying robustness of the clustering analysis (Table 3). Only for non-dominant activities within a zone the CV's are high. For example in the Zone 1, when compared to the non-dominant agricultural activities, the coefficient of variation (CV) is less for the dominant activities like

plantation crops, livestock, fruit and vegetable. Likewise the CV is less for the dominant activities like livestock, wheat, rice and vegetables in Zone 5.

To evaluate the significant differences for each agricultural activity across zones, different statistical tests which look at the group's mean differences namely, Duncan's Multiple Range Test (DMRT) and Turkey's multiple range tests were carried out. The tests indicate that by and large the zones in the typology were homogenous but significantly different from each other (Table 4). For example, the DMRT test revealed that zone 1 is different from all other zones with respect to the importance of other crops (plantation crops) in terms of its contribution to the total value of production.

To further establish the above findings the tests on differences in variances across zones viz. F-test, Bartlett, Levene and Brown-Forsythe were also carried out. The tests confirm that there exists a significant difference in the variance of the dominant activity compared to the similar activity across zones (Table 5). For example in Zone 1 the variance of other crops activity is significantly different, at 5% level, from the rest of the zones. It is for this reason that the cluster analysis grouped the districts in zone 1 together. Similarly in zone 11 the variance of the rice and vegetable activities are significantly different from other zones and hence the districts in the zone 11 grouped together.

In some cases, it is not the dominant activity which alone distinguishes a zone from the others. For example the combined livestock activity is dominant in almost every zone yet it represents distinctly different clusters. This is mainly because of their significant differences with respect to the second, third or fourth most important activities.

Agro-ecological classification of zones and characterization

Prior to characterization of the zones in the typology the zones are rearranged by Agro-Ecological Regions delineated by National Bureau of Soil Survey and Land Use Planning, 1992 (Table 6). Although the Crop-livestock zones in the typology do not follow the NBBS classification there is considerable over lapping between the two and there are also a few cases where some zones fall in two agro ecological regions. Of the 19 zones 1 zone (Zone 1) falls in the humid region while 8 zones fall in the sub-humid agro-ecological region (that includes 2 zones falling in the Hill and Mountain region as per NATP classification), 3 zones fall in the sub-humid/semi-arid regions, 6 fall in the semi-arid/ arid ecological region and one zone falls in the arid region. This classification will be maintained in all the remaining tables on characterization of the typology.

From Table 6 we find that rainfall is higher in hot humid and sub-humid zones, a little lower in the sub-humid (dry) zones, and decreases progressively as we move from semi-arid to arid regions. Rainfall and LPG are largely correlated, i.e., higher rainfall is associated with higher LPG. Zones 6a, 14b and 5 have high irrigation levels (70-90%) and also fall under irrigated zones as per NATP classification of agro-ecological zones.

Relative importance of zones and crop vs. livestock activities

The zones in the crop-livestock typology have been characterized for relative importance of zones in the typology, importance of crop vs. livestock activities, key crop and livestock activities, socioeconomic features, input use and infrastructure.

Zones 13 and 11 are the largest in terms of area and population while Zones 9a, 14a, 6a and 8a

and 8b are the smallest (Table 7). Share of urban population also follows similar order with zones 13 and 11 with highest urban population respectively across all zones.

The value of agriculture VOP (crop and livestock) per hectare is highest in zones 9a followed by 14a both falling under hill and mountain agro-ecology. This is followed by zones with high irrigation levels (6a, 14b and 5) and zone 9b (mainly coastal agro-ecology) that have values ranging from Rs. 65,000 to 50,000/ha which is higher than the average value of Rs.44000/ha across all zones (Table 8). The productivity levels are by and large lower in zones falling under semi-arid regions (Rs. 35000 to 25000/ha) and lowest in the arid zone (Rs 9500/ha). The exception is Zone 13 falling in the semi-arid ecology where the average value of production is more than Rs. 50000/ha since about 30% of the districts in this zone fall under coastal agro ecology where rice and fruits are important.

Across all zones out of the total value of production crop value accounts for 72% and livestock 28%. However there is considerable variation across zones. Zones 12, 10, 14a have a high share of livestock in total value of production 40% to 50%. Generally, several of the zones falling in the humid / sub-humid agro-ecology have low share of livestock compared to zones falling in the semi-arid and arid ecologies with exception of Zone 4 that has somewhat higher level of irrigation compared to other zones in semi-arid ecologies.

Crop activities

Rice is an important activity in the humid and sub-humid zones as also zones with higher levels of irrigation (with exception of Zone 4). It is the dominant activity in 3 zones (zones 11, 12, 13).

Wheat is the in dominant activity in zone 5 and has a high share in the irrigated zones (Table 9). Coarse cereals, pulses and oilseeds have a higher share in zones falling under semi- arid, arid and hot sub-humid dry regions. Sugarcane is the dominant activity in Zone 6a (high irrigation) and 6b (semi-arid). A few more important zones (14c and 13) also fall under semi-arid regions.

Cotton is less spread out and is the dominant activity in Zone 7 (semi-arid). Fruits are dominant activity in 2 zones while vegetables are dominant activities in 4 zones. These include the Zones falling under hill and mountain agro ecology. Fruits have a big share in zone 9b with coastal agroecology. Other crops that includes plantations, fiber crops other than cotton, spices, fodder crops etc is the dominant activity in Zone 1 that includes Assam and Kerala, Zone 2 (Assam and West Bengal), and Zone 8a (Madhya Pradesh).

Livestock activities

Among the livestock outputs milk is by far the most important with an average share of 78% in total value of livestock production, followed by meat 19% (Table 10). The share of meat in livestock value is relatively higher in Zones 11, 1, 2, all falling in humid to sub-humid ecologies. The share of meat is lowest in the zones falling under hill and mountain and in zones with high levels of irrigation.

Socioeconomic features, input use and infrastructure

The average population density across all zones in 378 no/sq.km GA. The density is generally low in zones falling in semi-arid ecologies and lowest (39.9) in the zone falling under arid ecology (Table 11). It is relatively higher in the zones with high irrigation levels (Zones 14b, 6a

and 5). Per capita land availability is on an average 0.18 ha of cropped area per person (rural). Land availability is low in all zones falling in the humid and sub-humid ecologies and zones with higher irrigation levels. Land availability is higher in semi-arid and very high in arid ecologies (0.91). Per capita availability of livestock expressed in livestock units is 0.36 across all zones and is low in the zones with higher irrigation levels and is above average in zones falling under semi-arid regions and is highest in Zone 8a falling in arid ecology. Zone 1 is an exception with low livestock unit per person (0.15).

Urban literacy is higher compared to rural literacy across all zones. The average rural literacy levels is 53% compared to 68% for urban population. About 5 zones have rural literacy levels higher than 60%. The lowest rural literacy level is in zone 8a (arid ecology).

Density of tractors and pumpsets is higher in the irrigated zones and lowest in Zone 8a (arid ecology). The density of pumpsets is high in Zones 1, 12, 4 and 13 that fall under the humid and semi-arid ecologies (Table 12). Fertilizer consumption is high in the zones with high levels of irrigation (150-210). But contrary to expectation its use is also high (>150 kg/ha) in Zone 13 and 4 (semi-arid) and Zones 1, 9b and 12 (humid and sub-humid).

Market and bank density is high in zones with high irrigation. Infrastructure density including roads is the lowest in the arid zones. Bank density is low in Zones 8b, 3, 4. Road density is low in Zones 4, 12, 3, 14b.

Like for share of crops and livestock activities across districts with a zone, CVs are also calculated for a few selected variables across districts within each zone. Generally the CVs for total value of production, crop value, irrigated area, livestock units / ha, markets and roads are low indicating low variation across districts with in a zone. There are a few exceptions in a few cases that are indicated in Table 13. Thus the zones in the typology are homogenous not only in terms of the crops grown (3-4 dominant ones) but are also homogenous in terms of selected indicators.

Conclusion

Previous approaches to the classification of agricultural areas have exhibited a preoccupation with potential without paying adequate attention to the existing scenario, and hence ignored key socio-economic factors limiting the ability of farmers to produce more efficiently and sustainably

The agricultural activity based approach is based on the premise that agricultural activities are an articulation of a farm's multiple objectives within the underlying agro-ecological and socioeconomic constraints of the environment. Information on the dominant agricultural activities must be an integral part of any attempt to classify districts in India to help in designing agricultural research programs or in making infrastructure investments or in designing poverty alleviation programs for rural India. The need for and usefulness of a agriculture typology, the methods used in constructing the typology, the empirical results including validation and the characterization of the typology itself, are all addressed in this study .

The 19-zone agricultural activity based typology has been characterized in terms of geographic spread, dominant agricultural activities and spatial variability with respect to crop and livestock performance. Although the activity-based typology is not a permanent system of classification, and may undergo moderate change over time, because it integrates both socioeconomic and agro-ecological factors, it is a highly appropriate research and development policy planning tool. Since it integrates both agro-ecological and socioeconomic factors, there is no question of seeking a compromise between socio-economic and agro-ecological based typologies. This approach incorporates both. It is hoped that this typology will be given consideration for use in agricultural research and development planning in India.

References

ARPU (Agro-climatic Regional Planning Unit).1993. Agro-climatic Regional Planning District Level. ARPU Working Paper NO.7Ahemadabad India: ARPU.283pp.

Bhattacharjee JC, Roychaudhury C, Landey J and Pandey S.1982. Bioclimatic analysis of India. NBBSS LUP Bulletin. 7. National Bureau of Soil Survey and Land Use Planning, Nagpur, India, 21 pp.+map.

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

Bidinger, F.R., Weltzien, R.E., Mahalakshmi, V., Singh, S.D., Rao,K.P., 1994. Evaluation of landrace topcross hybrids of pearl millet for arid zone environments. Euphytica 76, 215-226.

Chaudhuri, S. 2003. Assessing Vulnerability to Poverty: Concepts, Empirical Methods and Illustrative Examples. Mimeo. Department of Economics, Columbia University.

Collinson 1996. Social and Economic Considerations in Resource Management Domains. Paper presented at the International Workshop on Resource Management Domains, 26 Aug 1996, Kula Lumpur, Malysia.

Dixon, J. and A. Gulliver with D. Gibbon. 2001. Farming Systems and Poverty: Improving Farmers' Livelihoods in a Changing World. FAO & World Bank, Rome, Italy & Washington, DC, USA.

Duncan, D B. 1955. Multiple range and multiple F tests. Biometrics 11:1–42,

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.

GOI(Government of India. 1989. Agro-climatic regional planning (an overview), New Delhi, India: Planning commission, Government of India.

Kaufman, L., and Rousseeuw, P. J. 1990. Finding groups in data: an introduction to cluster analysis. Wiley Series in Probability and Mathematical Statistics. Applied Probability and Statistics. New York, USA: John Wiley & Sons. 356 pp.

Krishna, A. 1988. Delineation of Soil Climatic Zones of India and its practical Application in Agriculture, Fertiliser News, 33(4), pp. 11-19.

Mitra Ashok 1961: Levels of Regional Development in India, Economic Regionalization of India: Problems and Approaches, Supplement I, Census of India, Monograph 8.

Murthy, R.S. and S. Pandey 1978. Delineation of Agro-Ecological Regions of India, Paper

presented in Commission V11th Congress of ISSS, Edmonton, Canada, June 19-27.

Parthasarathy Rao P, Birthal PS, Dharmendra SHG and Shrestha HR. 2004. Increasing livestock productivity in mixed crop-livestock systems in South Asia. Project report. National Centre for Agricultural Economics and Policy Research and ICRISAT, Patancheru.

Sehgal, J.L., Mandal, D.K., Mandal, C. and Vadivelu, S. 1992. Agro-ecological Region of India. NBSS & LUP (ICAR) Publication 24, Nagpur

Scholz U. 1987. Crop geography for agro-ecological characterization in Sumatra and Costa Rica. Pages 247-259 in Agricultural environments: characterization classification and mapping: proceedings of the workshop on Agro-ecological Characterization, Classification and Mapping, 14-18 April1986, Rome, Italy. Wallingford UK:CAB International.

Tukey, John W. 1953. The Problem of Multiple Comparisons. Unpublished Manuscript, Princeton University

Figure 1. Crop-Livestock Typology, India, 2008

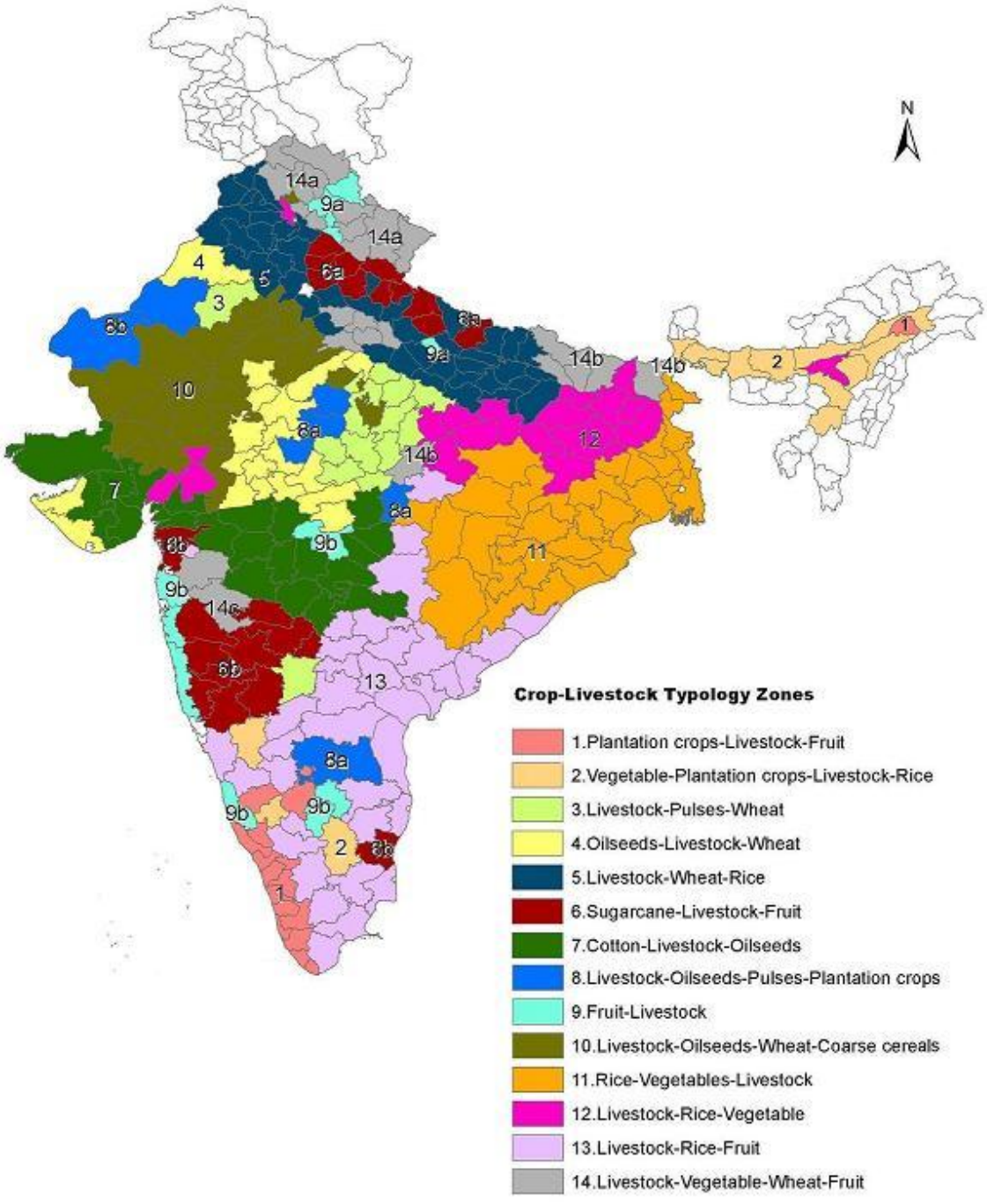

Table 1. Crop livestock Typology of India: Location and Dominant Activities

System/ Zones	Dominant Activities	Location	Number of districts	Dominant Activities (% to crop VOP)
1	Plantation crops[1]--- Livestock[2]---Fruit	Assam, Kerala, Karnataka, TN	16	Plantation crops (45%); Livestock (24%); Fruit (15%); Vegetables (9%); Rice (6%)
2	Vegetable--- Plantation crops --- Livestock—Rice	Assam, Karnataka, W. Bengal, TN	14	Vegetables (27%); Plantation crops (20%); Livestock (19%); Rice (14%); Fruit (10%);
3	Livestock---Pulses--- Wheat	Karnataka, MP, UP, Rajasthan	14	Livestock (31%); Pulses (29%); Wheat (14%);
4	Oilseeds---Livestock--- Wheat	Gujarat, MP, Rajasthan	19	Oilseeds (38%); Livestock (21%); Wheat (16%); Pulses (5%)
5	Livestock---Wheat---Rice	Bihar, Haryana, Punjab, UP	42	Livestock (32%); Wheat (26%); Rice (20%); Vegetables (6%)
6a	Sugarcane---Livestock--- Wheat	UP, Uttarakhand	11	Sugarcane (37%); Livestock (23%); Wheat (13%); Rice (8%); Fruit (8%);
6b	Sugarcane---Livestock--- Fruit	Gujarat, Karnataka, Maharashtra, Tamil Nadu	13	Sugarcane (26%); Livestock (25%); Fruit (11%); Coarse cereals (8%); Rice (5%);
7	Cotton--- Livestock--- Oilseeds	AP, MP, Gujarat, Maharashtra	22	Cotton (25%); Livestock (18%); Oilseeds (15%); Coarse cereals (7%); Vegetables (7%): Pulses (6%);
8a	Livestock--- Plantation crops---Oilseeds--- Pulses	AP, MP	6	Livestock (33%); Plantation crops (23%); Oilseeds (20%); Pulses (14%); Wheat (7%)
8b	Livestock--- Oilseeds--- Pulses --Plantation crops	Rajasthan	2	Livestock (29%); Oilseeds (26%); Pulses (11%); Plantation crops (9%); Wheat (5%);
9a	Fruit--- Vegetables --- Livestock	HP, UP, Uttarakhand	4	Fruit (44%); Vegetables (20%); Livestock (17%)
9b	Fruit---Livestock	Maharashtra, Karnataka	7	Fruit (56%); Livestock (15%); Rice (9%); Plantation crops (7%);
10	Livestock--- Oilseeds -- Wheat-- Coarse cereals	Gujarat, HP, MP, Rajasthan	25	Livestock (43%); Oilseeds (17%); Wheat (13%); Coarse cereals (11%); Pulses (4%)
11	Rice--- Vegetables ---- Livestock	Chhattisgarh, MP, Jharkhand, Orissa, W.Bengal	33	Rice (31%); Vegetables (29%); Livestock (21%); Fruit (7%)
12	Livestock ---Rice	Gujarat, Jharkhand, MP,Rajasthan, UP, Assam	20	Livestock (49%); Rice (16%); Vegetable (10%); Wheat (8%); Pulses (5%)
13	Livestock--- Rice--- Fruit	AP, Gujarat, TN, MP, Karnataka, Maharashtra	36	Livestock (31%); Rice (21%); Fruit (13%); Plantation crops (10%); Oilseeds (5%); Coarse cereals (4%)

System/ Zones	Dominant Activities	Location	Number of districts	Dominant Activities (% to crop VOP)
14a	Livestock---Vegetable	Uttarakhand, HP	13	Livestock (39%); Vegetable (24%); Wheat (10%); Coarse cereals (9%); Fruit (8%); Rice (5%);
14b	Livestock---Vegetable	Bihar, UP	10	Livestock (34%); Vegetable (20%); Wheat (15%); Fruit (10%); Rice (7%); Coarse cereals (5%);
14c	Livestock---Vegetable	Maharashtra, MP	3	Livestock (30%); Vegetable (20%); Fruit (15%); Sugarcane (10%); Coarse cereals (7%); Wheat (5%); Pulses (5%);

1. *Plantation crops include tea, coconut and spices & condiments.*
2. *Livestock includes milk, meat and eggs value*

Table 2. Contribution (%) of Crop and Live-Stock Activities to Total Value of Product (TVOP)

Systems/ Zone	Livestock	Rice	Wheat	Core-Cereals	Pulses	Oil seeds	Sugarcane	Cotton	Fruit	Veg	Plantation crops
1	24[b]	5	0	1	0	1	0	0	15[c]	9	45[a]
2	19[c]	14	1	3	1	2	2	1	10	27[a]	20[b]
3	31[a]	3	14[c]	4	29[b]	9	1	1	1	4	3
4	21[b]	1	16[c]	3	5	37[a]	1	6	3	4	3
5	32[a]	20[c]	26[b]	2	2	2	4	2	4	6	1
6	24[b]	7	7	5	2	4	32[a]	1	10[c]	5	4
7	20[b]	1	4	7	6	15[c]	3	25[a]	13	4	2
8	29[a]	5	5	3	12[c]	25[b]	0	0	6	4	11
9	15[b]	8[c]	1	3	2	3	1	2	54[a]	6	6
10	43[a]	1	13[c]	11	4	17[b]	0	2	2	4	4
11	21[c]	31[a]	1	0	2	2	0	0	7	29[b]	5
12	49[a]	16[b]	8	4	5	1	0	0	4	10[c]	3
13	31[a]	21[b]	0	4	3	5	5	3	13[c]	4	10
14	34[a]	6	12[c]	6	2	2	3	0	11	21[b]	2

Note: 1. Superscript a, b and c indicates first, second and third dominant activities respectively.

2. Plantation and other crops include tumeric, chillies, tobacco, arecanut, garlic, ginger tea, other condiments, jute, other drugs, nigerseed, garlic, other condiments, coconut, coffee, black pepper, cardamom, coriander, tea.

Table 3. Coefficient of Variation (CV) for Crop-livestock Activities across the districts within the zone

Systems/ Zone	Livestock	Rice	Wheat	Coarse cereals	Pulses	Oilseeds	Sugarcane	Cotton	Fruit	Vegetable	Plantation crops
1	58[b]	94	105	290	267	326	296	216	62[c]	53	52[a]
2	108[c]	49	138	211	140	155	324	312	85	60[a]	36[b]
3	48[a]	221	62[c]	180	48[b]	94	195	373	257	65	154
4	53[b]	200	82[c]	66	75	57[a]	296	206	164	104	102
5	59[a]	87[c]	72[b]	125	100	191	128	430	103	55	126
6	48[b]	91	95	130	130	116	55[a]	343	76[c]	93	101
7	36[b]	198	63[b]	111	83	82[c]	148	70[a]	90	91	135
8	65[a]	151	95	87	80[c]	67[b]	135	160	186	156	121
9	50[b]	116[c]	197	139	215	260	273	332	103[a]	127	132
10	55[a]	166	78[c]	58	82	85[b]	198	234	191	162	133
11	79[c]	65[a]	202	158	136	100	153	297	107	70[b]	127
12	54[a]	82[b]	87	95	70	63	321	342	144	88[c]	148
13	50[a]	67[b]	301	99	117	109	109	168	82[c]	93	101
14	84[a]	123	99[c]	95	143	159	325	319	123	80[b]	143

Note: 1. Superscript a, b and c indicates first, second and third dominant activities respectively

2. Plantation and other crops include tumeric, chillies, tobacco, arecanut, garlic, ginger tea, other condiments, jute, other drugs, nigerseed, garlic, other condiments, coconut, coffee, black pepper, cardamom, coriander, tea.

Table 4. Duncan's multiple range tests for significance difference in agricultural activity across zone

Systems/ Zone	Livestock	Rice	Wheat	Coarse cereals	Pulses	Oilseeds	Sugarcane	Cotton	Fruit	Vegetable	Plantation crops
1	CD	C	C	A	B	D	B	B	B	BC	A
2	CD	BC	C	A	B	CD	B	B	B	A	B
3	BCD	C	ABC	A	A	CD	B	B	B	C	C
4	CD	C	AB	A	B	A	B	B	B	C	C
5	BCD	AB	A	A	B	D	B	B	B	BC	C
6	CD	BC	BC	A	B	CD	A	B	B	C	C
7	CD	C	BC	A	B	BCD	B	A	B	C	C
8	BCD	C	BC	A	B	AB	B	B	B	C	BC
9	D	BC	C	A	B	CD	B	B	A	BC	BC
10	AB	C	ABC	A	B	BC	B	B	B	C	C
11	CD	A	C	A	B	D	B	B	B	A	C
12	A	BC	BC	A	B	D	B	B	B	BC	C
13	BCD	AB	C	A	B	CD	B	B	B	C	BC
14	BC	C	BC	A	B	CD	B	B	B	AB	C

Note: 1. In each column any two zones with common letter are not significantly different @5% level.
2. 'A' stands for most dominant activity across cluster.
3. The Turkey's tests also provided similar result.

Table 5. Test for Differences in Variances across Clusters

Systems/ Zone	Livestock	Rice	Wheat	Coarse cereals	Pulses	Oilseeds	Sugarcane	Cotton	Fruit	Vegetable	Plantation crops
1	SD	SD	SD	SD	SD	SD	SD	SD	SD	SDA1,A2	DA
2	NS	SD	SD	NS	SD	SD	SD	SD	SD	DA1,NSA2	SD
3	SD	SD	SD	NS	DA	SD	SD	SD	SD	SDA1,A2	SD
4	SD	SD	SD	SD	SD	SD	SD	SD	SD	SDA1,A2	SD
5	NS	NS	DA	SD	SD	SD	SD	SD	SD	SDA1,A2	SD
6	NS	SD	SD	SD	NS	SD	DA	SD	SD	SDA1,A2	SD
7	SD	SD	SD	SD	NS	NS	SD	DA	SD	SDA1,A2	SD
8	NS	SD	SD	SD	NS	NS	SD	SD	SD	SDA1,A2	NS
9	SD	SD	SD	NS	NS	SD	SD	SD	DA	SDA1,A2	SD
10	NS	SD	SD	DA	SD	SD	SD	SD	SD	SDA1,A2	SD
11	NS	DA	SD	SD	SD	SD	SD	SD	SD	DA2,NSA1	SD
12	DA	SD	SD	SD	SD	SD	SD	SD	SD	SDA1,A2	SD
13	NS	NS	SD	NS	SD	SD	SD	SD	SD	SDA1,A2	NS
14	NS	SD	SD	NS	SD	SD	SD	SD	SD	NSA1,SDA2	SD

*we carried-out tests viz. F-test, Bartlett, Levene and Brown-Forsythe to see whether the variance of the dominant activity is significantly different across clusters (@5% level of significance)

DA= Dominant activity: DA1 and DA2=Dominant Activity 1 and 2

NS=Not Significant

SD= significantly Different

Table 6. Typology Zone classified by Agro-Ecological Region (AER), India

Crop-Livestock System/ Zones	Agro-Ecological Region[1]	Normal Rainfall (mm)	LGP (days)	Annual moisture availability Index	Irrigated Area (NIA to NCA (%))	Agro-Ecological Zone (NATP)[2]
	Humid					
1	Hot Humid-Perhumid	2572	225	1.5	18	Rainfed
	Sub-Humid					
2	Hot Subhumid to Humid	2353	232	1.4	15	Rainfed
9b	Hot Humid-Perhumid	2057	187	0.8	15	Coastal (70%)-Rainfed (30%)
11	Hot Subhumid/Hot Subhumid to Humid	1512	225	0.8	34	Rainfed
14a	Warm Subhumid	1485	272	1.3	17	Hill & mountain
9a	Warm Subhumid	1282	262	1.3	60	Hill & mountain
8b	Hot Subhumid (Dry)	1033	193	0.5	30	Rainfed
12	Hot Subhumid	1165	211	0.7	38	Rainfed (65%)-Irigated (30%)
6a	Hot Subhumid (Dry)	1080	213	0.6	84	Irrigated
	Sub-Humid/Semi-Arid					
3	Hot Subhumid/Hot Semi-Arid	1113	201	0.6	36	Rainfed
14b	Hot Subhumid/Hot Semi-Arid	1031	217	0.6	67	Irrigated
5	Semi-Arid/Hot Subhumid	939	189	0.5	88	Irrigated
	Semi-Arid					
7	Semi-Arid/Hot Semi-Arid	867	178	0.4	22	Rainfed
6b	Semi-Arid	972	170	0.5	32	Rainfed
14c	Hot Semi-Arid	905	212	0.0	26	Rainfed
13	Hot Semi-Arid	931	169	0.5	46	Rainfed (70%)-Coastal (30%)
4	Semi-Arid	941	183	0.5	54	Rainfed
	Semi-Arid/Arid					
10	Hot Semi-Arid/Hot Arid	702	133	0.4	39	Rainfed (44%)-Arid (36%)
	Arid					
8a	Arid	263	36	0.1	20	Arid

Note: 1. Agro-Ecological Region, National Bureau of Soil Survey and Land Use Planning, 1992.
2. National Agricultural Technological Project, ICAR

Table 7. Relative importance of systems/zones in crop-livestock typology

Crop Livestock System/Zones	Total Geographical Area (million ha)	Net Cropped Area (million ha)	Total Population (million nos)	Urban Population (million nos)
	Zone share in total (%)			
1	2.5	2.6	3.9	6.2
2	4.1	3.7	4.3	3.3
9b	2.3	1.8	3.2	6.6
11	13.7	11.3	13.4	11.3
14a	2.7	0.6	0.9	0.3
9a	0.6	0.2	0.6	1.3
8b	2.5	2.3	1.3	1.0
12	6.3	4.9	8.3	5.4
6a	2.2	3.0	4.5	4.6
3	4.1	5.2	2.3	2.0
14b	2.4	3.3	6.7	3.2
5	7.7	11.8	14.9	11.7
7	9.7	10.4	6.2	8.5
6b	5.0	6.6	5.0	6.4
14c	1.5	1.8	1.3	1.6
13	15.6	12.4	13.4	17.0
4	5.8	6.9	3.7	4.5
10	9.0	10.1	6.0	5.0
8a	2.4	1.3	0.3	0.3
All Zones total	**284.7**	**137.9**	**1076.9**	**302.64**

Table 8. Value of production and share of crop and livestock-activities

Crop-Livestock System/Zones	Crop Livestock VOP (in billion)	Average Value (Rs/ha NCA)	Share of crops (%)	Share of livestock (%)
1	206	58312	76	24
2	286	56245	81	19
9b	157	64271	85	15
11	739	47591	79	21
14a	59	70923	61	39
9a	31	118540	83	17
8b	96	29771	71	29
12	267	39739	51	49
6a	318	75841	75	25
3	130	19692	69	31
14b	243	53620	66	34
5	1063	65253	68	32
7	455	31685	80	20
6b	335	36857	76	24
14c	88	36341	70	30
13	886	53068	69	31
4	305	31951	79	21
10	338	24288	57	43
8a	17	9578	67	33
All Zones	**6,018**	**43,933**	**72**	**28**

Table 9: Share of crop Activities in Total Crop Value (%)

Crop-Livestock System/Zones	Rice	Wheat	Core-Cereals	Pulses	Oilseeds	Sugarcane	Cotton	Fruit	Veg	Others
1	7.2	0.0	1.5	0.5	1.1	0.3	0.0	19.4	11.1	58.9
2	17.6	0.6	3.3	1.4	3.1	2.6	1.2	12.1	33.4	24.7
9b	10.3	0.4	3.3	2.8	4.3	0.1	2.2	65.6	3.1	7.9
11	39.5	1.1	0.5	2.7	2.3	0.6	0.2	9.2	37.3	6.7
14a	8.5	16.8	15.5	2.1	0.7	0.5	0.0	13.3	40.0	2.7
9a	4.4	7.9	1.9	1.2	0.4	4.0	0.0	52.6	24.3	3.3
8b	8.4	6.3	4.0	15.5	36.6	0.5	0.5	9.3	6.3	12.5
12	30.7	14.9	8.0	10.0	2.2	0.3	0.6	6.9	20.3	6.1
6a	10.6	17.1	0.6	1.1	1.3	48.3	0.0	10.7	5.2	5.2
3	4.0	20.4	5.7	41.8	13.5	2.1	1.0	1.5	5.8	4.3
14b	11.0	22.9	8.0	2.0	3.9	1.1	0.1	15.8	30.9	4.4
5	30.0	38.2	2.4	2.3	2.4	5.6	3.1	5.3	9.0	1.8
7	1.2	5.1	8.1	8.0	18.5	3.9	31.1	16.5	5.0	2.5
6b	7.0	2.5	11.1	5.4	8.9	35.0	1.4	15.2	8.9	4.5
14c	2.8	7.6	10.6	6.7	4.4	14.3	1.8	21.6	28.2	1.9
13	30.3	0.1	6.2	4.2	7.6	7.7	4.1	19.4	6.3	14.0
4	1.1	20.7	3.6	6.7	47.2	1.1	7.6	3.5	5.2	3.3
10	1.0	22.4	19.2	7.7	29.6	0.2	3.7	2.9	6.5	6.9
8a	0.0	8.1	4.7	21.3	29.9	0.0	1.1	0.4	0.3	34.1

Table 10. Share of livestock output in livestock VOP

Crop-Livestock System/Zones	Livestock VOP (billion Rs.)	Milk (%)	Meat (%)	Eggs (%)
1	48.5	63.0	31.9	5.1
2	54.6	59.1	32.1	8.8
9b	23.6	69.8	23.8	6.5
11	157.2	54.7	40.2	5.2
14a	23.1	95.2	4.2	0.5
9a	5.3	92.4	6.2	1.4
8b	27.8	76.9	20.8	2.3
12	130.5	80.0	17.6	2.4
6a	73.3	89.2	10.3	0.5
3	39.6	88.1	11.5	0.5
14b	82.2	85.8	12.8	1.3
5	338.2	85.6	11.9	2.5
7	89.0	77.7	20.4	1.9
6b	82.9	82.9	14.2	2.9
14c	26.5	80.3	15.5	4.1
13	275.6	62.6	28.6	8.9
4	62.6	94.0	5.4	0.6
10	144.8	93.4	5.8	0.8
8a	5.5	87.7	12.2	0.1
All Zones	**1690.9**	**77.4**	**18.9**	**3.7**

Table 11. Selected Socio Economic Indicators

Crop-Livestock System/Zones	Population Density (No./Sq. Km GA)	Per capita Land (NCA(ha) / rural population)	Per capita Livestock (LU / rural population)	Rural Literacy (%)	Urban Literacy (%)
1	584.1	0.13	0.15	77.6	68.1
2	391.2	0.14	0.37	55.3	71.1
9b	520.1	0.17	0.29	64.6	73.1
11	369.4	0.14	0.38	56.3	71.3
14a	119.6	0.10	0.56	71.7	82.9
9a	381.4	0.09	0.31	59.8	70.9
8b	196.4	0.30	0.56	50.6	64.7
12	495.9	0.09	0.38	47.6	71.0
6a	795.4	0.12	0.30	46.3	57.1
3	215.2	0.37	0.51	50.0	65.4
14b	1063.6	0.07	0.17	41.9	56.0
5	735.5	0.13	0.26	51.0	65.4
7	242.6	0.35	0.43	56.1	71.4
6b	374.7	0.27	0.36	60.6	71.5
14c	318.5	0.28	0.44	61.3	73.3
13	326.1	0.18	0.44	55.4	69.5
4	239.8	0.37	0.52	51.8	67.8
10	251.9	0.28	0.48	48.6	66.2
8a	39.9	0.91	0.70	39.7	63.5
All Zones	**378.3**	**0.18**	**0.36**	**53.2**	**68.5**

Table 12. Input use and Market and road density

Crop-Livestock System/Zones	Density of Tractors (per 000 ha NCA)	Density of Pump set (per 000 ha NCA)	Cropping Intensity (GCA/NCA)	Fertilizer Consumption (Kg/ha NCA)	Markets (per 10,000 Sq. Km GA)	Road Density (Km/10 Sq. Km GA)	Banks (per 10,000 Sq. Km GA)
1	2.4	165.3	126.7	209.3	NA	8.8	282.7
2	3.9	57.9	141.5	170	9.9	7	178.3
9b	7.5	95.5	116.7	201.1	8.3	9.5	436.6
11	3.7	57.2	152.7	119.1	3.9	6.9	100.4
14a	NA	NA	NA	NA	7.6	4.1	135.9
9a	NA	NA	NA	NA	10.9	5.1	328.5
8b	11.3	138	121.5	71.7	18.8	4	60.1
12	15.6	143.5	128.1	158.6	7.5	3.2	201.4
6a	37.1	140.9	153	138.7	15.4	4.8	345.5
3	17.2	87.4	125.6	100.1	8.6	3	64.4
14b	24	126.1	148.6	170.9	11.7	3	389.9
5	51.6	191.7	169.9	210.3	16.3	7.1	409.7
7	7.3	67.6	121.2	133	9.6	4.5	136.1
6b	7.3	86.6	123.4	87	9.9	7.8	229
14c	14.6	104.2	122.3	87.8	7.7	5.5	121.7
13	7.9	134.6	125.4	217.1	21.7	8.9	185.9
4	19.5	144	143.1	165.6	12.1	2	87
10	21.2	109.2	129.9	128.4	12.7	3.3	126.5
8a	7.1	4.1	112.3	110.7	1.5	1.2	25.5
All Zones	**15.2**	**109.0**	**133.1**	**145.8**	**10.8**	**5.7**	**181.5**

Table 13. Coefficient of Variation (CV) of Selected Indicators within Zones

Systems/ Zone	VOP (Rs/ha)	Crop VOP (Rs/ha)	Irrigated area (NIA/NCA)	LU/NCA (No./ha)	Banks per 10,000 Sq. Km GA	Markets per 10,000 Sq. Km GA	Road Density (Km/Sq. Km GA)
1	24	19	97	64	52	133[e]	66
2	119[a]	137[b]	108[d]	38	53	72	73
3	26	32	43	39	65	40	52
4	29	33	33	23	71	38	35
5	32	29	13	28	72	69	56
6a	30	29	11	30	61	65	21
6b	42	45	54	31	52	55	55
7	23	27	59	35	102	39	83
8a	5	6	14	26	94	95	33
8b	42	42	35	24	66	46	72
9a	39	45	73	29	97	63	64
9b	38	46	86	32	100	42	52
10	46	49	48	56	65	42	54
11	67	68	50	26	77	53	89
12	61	59	79	61	84	79	90
13	37	37	44	36	70	66	47
14a	83[c]	117[c]	113[c]	251[c]	114[f]	119[g]	103[h]
14b	23	30	32	20	33	29	71
14c	44	38	49	32	35	41	62

a. due to high Agricultural VOP of N.C Hills district
b. due to high crop VOP of N.C Hills district
c. due to very less NCA in Lahul & Spiti district
d. due to zero or very less NIA of Dibrugarh and The Nilgiris districts
e. due to high market density in Alappuzha and Trivandrum districts
f. due to high bank density in Kullu district
g. due to high market density in Garwal and Kullu districts
h. due to high road density in Kullu district