Indian Agriculturist, Vol. 64, No. 3 & 4, pp. 75-81, 2020

Characterizing the Farming System Components of Small and Marginal Land Holder Farming Systems of Patan District, Gujarat

Desai, L.J. Patel[1], R.R[2]. Patel, K.M. Patel[3], P.K[4]. Patel, K.N[5]. Patel, AND V.K[6] Patel

Centre for Research on IFS, S.D. Agricultural University, Sardarkrushinagar, Sardarkrushinagar, Gujarat-385506, India

Received : 06.09.2022 **Accepted : 05.01.2022** **Published : 28.10.2022**

Abstract

Small and marginal farmers play an important role in Indian Agriculture. However, shortage of capital become the main challenge for small and marginal farmers. To foster the economically sustainable farming, the diversity and the characteristic of household should be understood. This study identified farmers' types by using typology approach based on the capital as active variables. Typologies may be used as tools for dealing with farming system heterogeneity. This is achieved by classifying farms into groups that have common characteristics, *i.e.* farming components, which can support the implementation of a more tailored approach to agricultural development. A characterization survey of 120 farmers was conducted during 2016-17 in Patan district of North eastern part of Gujarat. Crop-dairy farming systems was adopted by most of the farmers. Among different enterprises, crop production contributed major portion of total income and livestock farming system. Study revealed that income from and crop and cash crop intensity have strong correlation. Similarly income from and livestock and fodder intensity have positive correlation.

Key words: Crop-dairy, North West Gujarat Agro-climatic Zone**,** Typology

Introduction

India is predominantly rural, with 70 to 80 % of the population engaged in agriculture. A farming system is defined as the complex of resources that are arranged and managed according to the totality of production and consumption decisions taken by a farm household, including the choice of crops, livestock, on-farm and off-farm enterprises. Food security is one of the largest concerns globally, particularly considering increasing global food demand related to projected population growth (Balzer, 2011). Crop production can be increased by expanding crop land area (intensification) and/or by increasing crop yield (intensification, production/crop land area). Farming systems in the any areas across the world has wide variety of cultures and landscapes. The biophysical, institutional, social and economic drivers differ between contexts, resulting in different responses of farmers and communities between and within areas due to different development stages of farms and different skills and ambitions of farmers. Therefore over a long period, these lead to temporal and spatial variability between and within farming systems. One of the great challenges in agricultural development and sustainable intensiûcation is the assurance of social equity in food security oriented interventions. Identification and characterization of farming systems simplify huge diversity of farm types in complex agro-ecosystems, which is of critical importance for precise technological intervention and informed policy support. The diversity

[1] Research Scientist, Centre for Research on IFS, SDAU, Sardarkrushinagar

[2] Assistant Research Scientist, On Farm Research, SDAU, Adiya

[3] Corresponding author Assistant Research Scientist, Centre for Research on IFS, SDAU, Sardarkrushinagar

[4] Assistant Research Scientist, Centre for Research on IFS, SDAU, Sardarkrushinagar

[5] Senior Research Fellow, Centre for Research on IFS, SDAU, Sardarkrushinagar

[6] Senior Research Fellow, Centre for Research on IFS, SDAU, Sardarkrushinagar

of smallholder farms in space, resource endowment, production and consumption decisions are often a hindrance to the design, targeting, implementation and scaling out of agricultural development.

Smallholders farming system complexity and diversity can be artificially stratify into sub groups that are homogenous according to specific criteria i.e. similar resource bases, enterprise, livelihoods and difficulties, problem faced, and constraints. Farm typologies attempt to perform such groupings; the term ‘typology’ designating both the science of type delineation and the system of types resulting from this procedure. Based on objectives of the typology and data availability we can differentiating criteria of choice. After that results can be used for the selection of farms, targeting and scaling-out of innovations and scaling up of impact assessments. Typologies might also inform the academic study of farming system heterogeneity. For example, they can be applied to assist in farming system analyses or inform further exploratory studies through the selection of representative farms for detailed characterization. Farm typology study recognizes that farmers are not a monolithic group and face differential constraints in their farming decisions depending on the resources available to them and their lifestyle (Soule 2001).Typologies may also be used in modeling and simulation studies to evaluate potential effects of specific interventions on farming systems (Köbrich *et al.* 2003).

The present study was undertaken to identify the predominant farm components in semi arid agro-ecosystem of Gujarat and to characterize them by some important socio-economic indicators. The article demonstrates the methodology of farm typology study when farming systems are heterogeneous and in need of appropriate technology for agricultural sustainability.

The district is characterized by complex, diverse and risk-prone ecosystem in which extreme climatic events, high temperature in summer, low rainfall and soil salinity. Patan district falls under North West Gujarat Agro-climatic Zone V (AZ86) & it is lies between 23 0 55’ to 24 0 41’ N latitude & 71 0 31’ to 72 0 20’ E longitude under semi arid agroecosystem. The climate of the district is sub-tropical monsoon type and falls in an arid and semi-arid climate. The average rainfall in the range of 536 mm. The district has a population density of 234 inhabitants per square kilometer (610/sq mi). Its population growth rate over the decade 2001-2011 was 13.53%. The soil of Patan district, in general, possesses neutral to alkaline properties (Soil pH - 7.25 to 8.50). Average size of land holding in the district is 2.51 ha. The 58.04% cultivators belong to small and marginal farmers. The main *Kharif* crops in the district are bajra, jowar, cotton, castor, pulses and during *rabi* season mustard, wheat, cumin crops were grown. Yields are generally poor due to low and erratic rainfall, low and declining soil fertility, lack of quality seed and land preparation equipment, high cost of inputs and labour constraints. Dairy farming is the very important and predominant

Fig. 1 Map of the Patan district showing the location of blocks under study (Harij and Radhanpur)

economic activity bringing a sea change in the economy of Patan district. The milk and milk products meet the nutritional requirement of rural. It serves as a rural family livelihood which can provide supplementary but sustainable income thereby increasing the ability to face crop failures during droughts and floods. Productivity of animals is average due to appropriate feeding and animal husbandry practices and improved livestock breeds.

Materials and Methods

Two blocks (namely Harij-high productive block and Radhanpur- low productive block) were selected from 9 blocks of Patan district. After that, three villages from each of the block (Adiya, Aritha and Bortwada of Harij block, Kamalpur, Dev and Bhilot of Radhanpur block) and 20 farmers from each village (total 120 farmers) were selected, out of them 60 farmers were beneficiaries of On Farm Research project of ICAR- IIFSR, Modipurum and remaining sixty farmers are small and marginal farmers of same villages(total ten farmers from each village). A survey of these 120 households was conducted with a focus on socio-economic information and income of the farms from different farm enterprises. In 2016-17, farm households were surveyed across these two block as part of a baseline characterization study. Basic information on household composition and education of household members, land holdings, livestock ownership, labour use, assets, housing, production orientation, major crops and sources of income were collected. This data was used for identification of predominant farming types for the area.

Typology construction

Total different 34 variables were selected for typology analysis and two multivariate statistical techniques were employed sequentially for generating a typology of the surveyed farm households: PCA to reduce the dataset into non-correlated components and CA for partitioning the PCA output into clusters. The approach has been used in many studies to categorize farming systems (Bidogeza, *et al.* 2009). All analyses were executed in R (version 3.1.0) with the ade4 package (version 1.6-2, available online at: http://pbil.univ-lyon1.fr/ADE-4/) and the cluster package (version 1.15.2). Out of 34 variable total six variables were selected as per their good distribution in histogram and they have good correlation with other variable found correlation

Principal component analysis

To avoid distortions in the statistical analysis, the dataset based on the six variables were carefully examined. Box plots were used to detect outliers which were deleted at the risk of improving the multivariate analysis while limiting its general inability to the entire population (Hair *et al.*, 2010). Of the 120 farm households sampled by the survey, the decision of how many principal components (PC's) to keep was made based on three criteria: (i) according to Kaiser's criterion, all PC's exceeding an Eigen value of 1.00 were initially retained (Köbrich, *et al.* 2003). This decision was cross-checked by looking at (ii) the minimum cumulative percentage of variance chosen, here 70% (Table 1). The final criteria, that of (iii) interpretability, was used to assess the conceptual meaning of the PC's in terms of the apparent constructs under investigation. This was done by examining the correlations between the variables and the PC's, higher correlation coefficients signified a closer relationship to the PC (Lebart *et al.*,1955). In this study, loadings greater or equal to 0.70 were considered for interpretation purposes.

Following six variables are selected which have good correlation and distribution,

1. Income from the crop
2. Income from livestock
3. Total cost of cultivation
4. Cash intensity
5. Fodder intensity
6. Family nutrition

Of the 34 variables measured in surveys, scree plots of the Eigen values resulting from the PCA indicated that the diversity in farm household characteristics was associated with two principal components (PC), together explaining 70% of the variability (Fig.1).

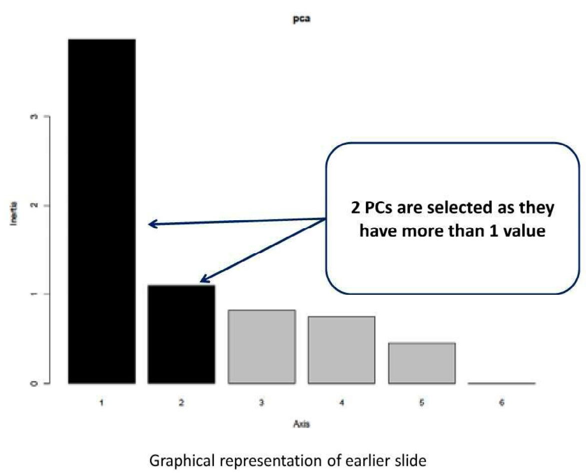

Figure : 1 Scree plots of the Eigen values

Results and Discussion

Characterization of farm types: The PCA resulted in the extraction of the first two PC's explaining about 70% of the variability in the dataset (Table 1). The first PC explained the greatest part of the variation, about 55.21% of variability in the data. The first component (PC 1) was closely related to the variables describing income from the crops and cash crop intensity and also income from the livestock and fodder crop intensity. Thus, it seemed to explain the cash crops has major role for increasing farm income from the field crops and fodder crop intensity for increasing income from livestock of farm households (Fig. 2).

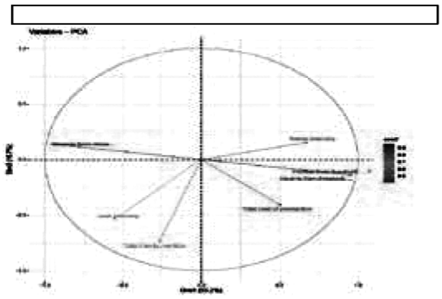

Fig. 2. PCA and CA output: circles of correlation and in the planes PC1-PC2. The directions and lengths of arrows within the circles show the strength of the correlations between variables and and PC's. The arrows highlighted in red represent those variables that correlate strongly (>0.70) with PC 1, whereas the arrows highlighted in green represent those variables that correlate strongly with each subsequent PC

Table 1. Eigen values and percentage variance explained by six principal components (PC's) using PCA.

Variables	Eigen value	Variance (%)	Cumulative variance (%)
Ax1	3.8646928	55.21	55.21
Ax2	1.0984826	15.69	70.90
Ax3	0.8278585	11.83	82.73
Ax4	0.7524324	10.75	93.48
Ax5	0.4564272	6.52	100.00
Ax6	0.0001064	0.00	100.00

Cluster analysis

The PCA output in the form of a reduced dataset based on the retained PC's was subjected to CA. A two-step approach was followed: first, a hierarchical, agglomerative clustering algorithm using Ward's method was employed to define the number of groups Cluster analysis is a collective term covering a wide variety of techniques for defining natural groups or clusters in data sets (Anderberg 1973). These groups are relatively homogeneous within themselves and heterogeneous between each other based on a defined set of variables. In a word, it is the art of finding groups in data (Kaufman and Rousseeuw 1990).

The typology results can be visualized using box plots. Box plots can support the farm type interpretation but also the identification of variables with distinctive power.

As per the circle color dark circle has more positive value and they positively correlated, white color circle has 0 value (Non significant) and dark blue color has more positive value and they positively correlated.

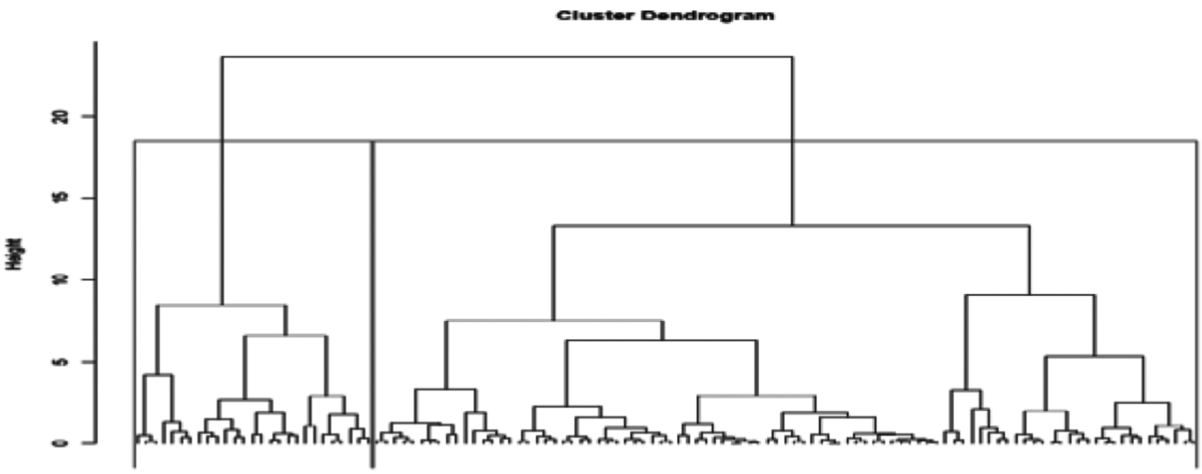

Fig. 3. Dendrogram displaying a range of cluster solutions resulting from Ward's method of CA

From the correlation it is clearly indicated that cereal intensity is negatively correlated with fodder intensity and Livestock income is highly positively correlated with income from livestock and income from crops is positively correlated with cash crop intensity.

TABLE 2. Contributions of variables to accounting for variability in PCs (%)

Variables	Dim.1 (PC1)	Dim.2 (PC2)
Total cost of production	6.76	15.19
Income from crops & livestock	**23.76**	1.77
Income from livestock	**23.80**	1.76
Income from livestock (%)	**23.80**	1.76
Fodder intensity	11.88	2.14
Cash intensity	8.12	26.74
Total Family nutrition	1.88	**50.65**

Conslusion

The typology revealed the general underlying structure of farming system heterogeneity, the complex and dynamic coexistence of diverse farm households in space and time was only partially captured, as neither unrepresented groups nor system trajectories were specifically accounted for. We demonstrated the use of quantitative systems analysis tools to characterize the diversity of farming systems and assess the impact of different farming components which is the indicator of household food security. The results showed that the impact of cash and fodder crop intensiûcation and livestock product production can have considerable negative or positive impact on economic status and family nutrition.

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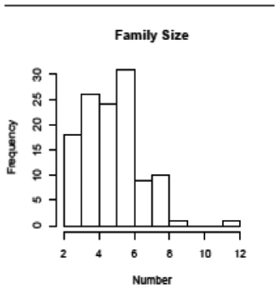
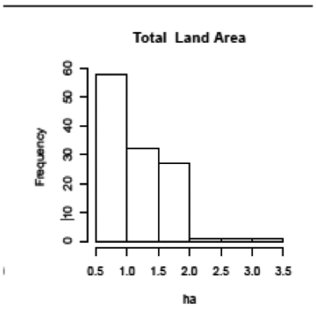
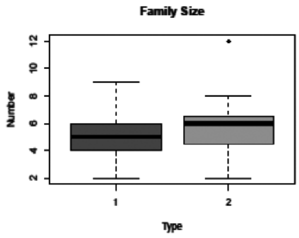
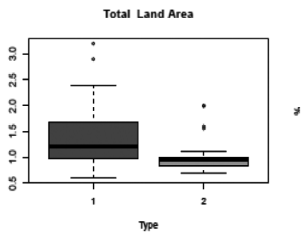




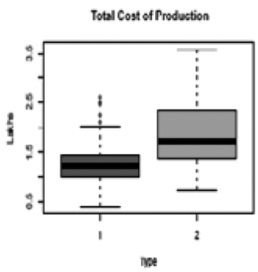
3(a) 3(b)

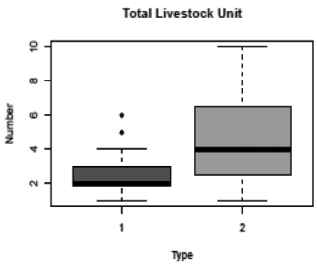




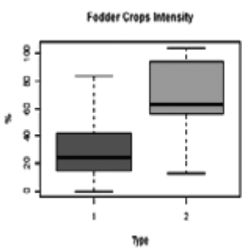
3(c) 3(d)

Figure : 3 The range of family size of household is 2 to 12 members in which majority farmers family falls under cluster 1 with the average size of 5-6 family members (3c). In case of house hold landholding, the average land holding is 1.0 to 1.5 ha in which majority landholders falls under cluster 1 with average landholding of 1.2 ha(3d)

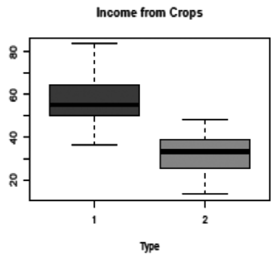


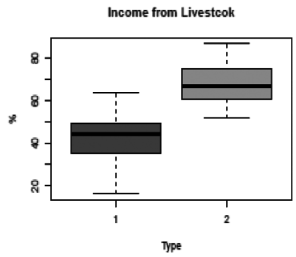


4(a) 4(b)



4(c) 4(d)

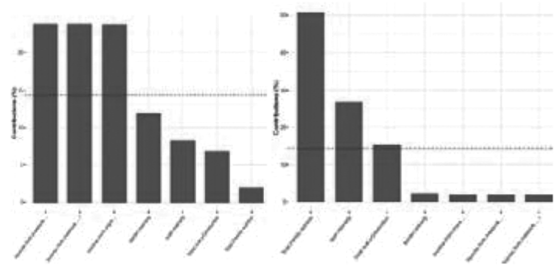




4(e) 4(f)

Figure 4 From the figure 4, it can be seen that in type 1, majority farmer cost of production was about 1.25 lacs, while in case of type 2 farmer cost of production was more than 1.5 lacs (4a). Similarly, type 2 has higher number of total livestock unit with an average of 4 cattle (4b). The type 1 has higher cash crop intensity (4c) and low fodder crops intensity(4d). Ultimately, the income from crops was higher under type 1 cluster(4e). In case of total livestock unit(4b) and fodder intensity (4d) were higher in type 2 cluster as compared to type 1 cluster, so that total income from livestock is higher under cluster 2(4f)

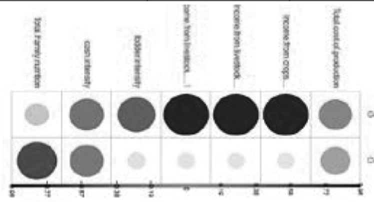
Figure 3 : Quality of Representation



- The red dashed line on the graph above indicates the expected average contribution.

Most determinant variables on the PCs (Coordinates of variable)

	Comp1	Comp2
Total cost of production	0.51122	-0.40844
Income from crops & livestock	-0.95826	0.139251
Income from livestock	0.958971	-0.13897
Income from livestock (%)	0.958971	-0.13897
Fodder intensity	0.677625	0.153384
Cash intensity	-0.56029	-0.542
Total Family nutrition	-0.2697	-0.74589



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