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Changes in Land Use Pattern, Crop Diversification and Resource Use Efficiency of Major Crops in Humid South-Eastern Plains of Rajasthan, India

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Abstract

The present study was undertaken to examine the changes in land use, crop diversification and resource use efficiency of major crops in Humid South-Eastern Plain of Rajasthan, India. The study was based on secondary data to examine the changes in land use pattern and changes in cropping pattern from TE 1994 to TE 2014 from various published sources of Government of Rajasthan. The primary unit level data collected from Cost of Cultivation Scheme, MPUAT, Udaipur, Rajasthan was used for collecting information on of major crops for the block period TE 2013-14. Results of the study revealed that there has been considerable increase in concentration of land under miscellaneous tree crops and groves (location coefficient 2.14 to 3.19) due to the decline in concentration in current fallow and fallow lands other than current fallow and net sown area. The percentage share of gross cropped area under total foodgrains has shown drastic decrease from 54.79 per cent to 35.80 per cent. The total oilseed crops has shown remarkable increase in share of gross cropped area from 34.23 per cent to 50.97 per cent which could be mainly due to Technology Mission on Oil and Oil Palm Scheme (TMOP) for enhancing the oilseeds production in the country initiated by the government. Cropping intensity had increased during the study period from 133 per cent to 180 per cent. This zone showed lower crop diversification index during the study period from 0.11 to 0.22 Among all the crops, technical, allocative and cost efficiency in paddy cultivation was found highest and significantly efficient i.e. 95 per cent, 96 per cent and 91 per cent, respectively followed by sorghum and fenugreek.

Keywords: *Land use pattern, Cropping pattern, Crop diversification, Technical, Allocative, Cost efficiency*

JEL Classification: *D6, Q18, L25, D24*

Introduction

Rajasthan state with its large geographical area coverage of 342.7 lakh hectares is the largest state of India. The state is predominantly an agriculture state with 75 per cent population living in rural areas. Agriculture and allied activities contributed 21.71 per cent of Net State Domestic Product at constant price 2004-05 while its share in Gross State Domestic Product is 20.27 per cent during 2013-14 (Statistical Abstract, 2014). Agriculture is the single largest sector of the

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state economy employing 70 per cent labour force directly and indirectly. Agriculture and animal husbandry forms the mainstay of the state's economy. Irrigation is an essential input for agriculture production in the state.

The agro-climatic zone IX (Humid South-Eastern Plain) covers the four districts of Rajasthan state namely Baran, Bundi, Jhalawar and Kota. This zone receives the highest rainfall in the state 700-1000 mm. The landscape is characterized by hills pediments and vast alluvial plain formed by the rivers Chambal, Parbati, Parwan, Kalisindh and their tributaries. Because of these rivers, deep gullies and ravines have been formed. Because of the presence of fine textured alluvium deposited by the rivers in this zone, the land is very productive. Black of alluvial origin, clay loam, groundwater salinity are found in this zone. Paddy and sorghum are the chief food crops grown in the *Kharif* season. This area is suitable for soybean crop also in *kharif* season. Wheat, barley and rapeseed & mustard are grown in winter. In the zone of the state, the cropping pattern is inefficient in terms of available resource use and unsustainable from natural resource use point of view. This leads to serious misallocation of available resources, efficiency loss, indiscriminate use of land and water resources, and it adversely affecting long term crop production prospects. Keeping in view the above considerations, a research study entitled "Changes in Land Use, Crop Diversification and Resource Use Efficiency in of Major Crops in Humid South-Eastern Plain in Rajasthan, India" was carried out.

Data Sources and Methodology

The study was conducted based on primary and secondary data. The primary data were collected from the 600 representative households of 60 cluster villages during each year of the block period (2011-12 to 2013-14) from the Cost of Cultivation Scheme, Rajasthan. The secondary data were collected from various published records and reports of Government of Rajasthan and Government of India. Data of existing land use pattern and cropping pattern were collected from the year 1990-91 to 2013-14.

Changes in Land Use Pattern

Location coefficient (L) was useful to identify the pattern of distribution of the given category of lands across different zones of state (Sofios, S. and Arabatzis, G. 2006). This was explained as follows:

$$L = \frac{L_{ij} / L_i}{L_j / L_s}$$

Where,

L_{ij}= area of jth category of land in ith zone

L_i = area of all categories of land in the zone

L_j = area of jth category of land in the state

L_s = area of all categories of land in the state

A higher value for location coefficient for a state or zone was indicated the higher concentration of that particular category of land in that state or region.

Changes in Cropping Pattern

Diversification refers to changes in crop choices or changes in land allocated to various crops. The extent of crop diversification at a given point in time may be examined by using several indices namely: Herfindahl Index (HI), Transformed Herfindahl Index (THI), Ogive Index (OI), Entropy Index (EI), Modified Entropy Index (MEI), Composite Entropy Index (CEI), Gini's Coefficient (Gi) and Simpson Index (SI). Among these indices, the THI, SI and EI are widely used in the literature of agricultural diversification. All these indices are computed on the basis of proportion of gross cropped area under different crops cultivated in a particular geographical area (Pal and Kar, 2012)

In the present study, to capture the extent of diversification in the state, Simpson's Index (SI) of Diversification has been employed to measure degree of crop diversification and was explained as follows:

$$SI = 1 - \Sigma (pi / \Sigma pi)^2$$

Where,

pi is the area proportion of the i^{th} crop in total cropped area and

i = 1,2,3,….n. is the number of crops

The value of index increases with the increase in diversification and assumes 0 (zero) value in case of perfect concentration.

Resource Use Efficiency for Major Crops

In this study, the DEA approach, **Version 2.1** has been used to analyze the data for optimizing the performance measure of each production unit and determined the most preferable ones. Farm household data from CCS for the year 2012, 2013 and 2014 from various zones of Rajasthan have been used. The information obtained included the amount of inputs costs which were used in crops production (such as family labour, causal labour, NPK, insecticides, herbicides, seeds, machine upkeep) and the yield as an output.

In order to specify the mathematical formulation of model, let us assume that we have K farmers (DMU) using N inputs to produce M outputs. Inputs are denoted by x_{jk} (j=1,2,…….,n) and the outputs are represented by Y_{ik} (i=1,2,……..,m) for each farmer k (k=1,2,………,K). The technical efficiency (TE) of the farmers can be measured as (Coelli, 1998; Worthington, 1999):

$$TE_k = \sum_{i=1}^{m} u_i y_{ik} / \sum_{i=1}^{n} v_j x_{jk}$$

Where,

Y_{ik} is the quantity of the i^{th} output produced by the k^{th} farmer,

x_{jk} is the quantity of j^{th} input used by the k^{th} farmer, and

u_i and v_j are the output and input weights respectively.

The farmer maximizes the technical efficiency, TE_k, subject to

$$TE_k = \sum_{i=1}^{m} u_i y_{ik} / \sum_{i=1}^{n} v_j x_{jk} \leq 1$$

Where,

u_i and $v_j \geq 0$

The above equation indicated that the technical efficiency measure of a farmer cannot exceed one and the input and output weights were positive. The weights were selected in such a way that the farmer maximizes its own technical efficiency which was executed separately. To select optimal weights the following linear programming model was specified:

Min TE_k

Subject to

$$\sum_{i=1}^{m} u_i y_{ik} - y_{jk} + w \geq 0$$

Where,

k=1,2,……………,K

$$x_{jk} - \sum_{i=1}^{m} u_j x_{jk} \geq 0$$

and u_i and $v_j \geq 0$

The above model showed technical efficiency (TE) under constant returns to scale (CRS) with an assumption if w = 0 and it changes into variable returns to scale (VRS) if w is used unconstrained. In the first case it leads to technical efficiency (TE) and in the second case pure technical efficiency (PTE) is estimated.

Technical efficiency (TE) has been expressed generally as the ratio of sum of the weighted outputs to sum of weighted inputs. The value of technical efficiency varies between zero and one; where a value of one implied that the DMU was the best performer located on the production frontier and has no reduction potential. Any value of TE lower than one indicated that the DMU used inputs inefficiently (Mousavi–Avval *et al*., 2011)

Cost Efficiency (CE): One was measured both technical and allocative efficiencies to verify the behavioral objectives such as cost minimization or revenue maximization.

Cost minimization DEA was expressed as

$$\text{Min } YX_{k*}w_k'\, X_k^*,$$
$$\text{Subject to} - y_k + YY > 0,$$
$$X_k^* - XY > 0,$$
$$Y > 0,$$

Where,

w_k' is a vector of input prices for the k[th] farmer and X_k^* (which is calculated by LP) was the cost minimizing vector of input quantities for the k[th] farmer, given the input prices w_k and the output level y_k.

Total Cost Efficiency (CE) of the k[th] farmer was calculated as CE = $w_k'X_k^* / w_k'\, X_k$ *i.e.* the ratio of minimum cost to the observed cost.

While the **Allocative efficiency (AE)** was calculated as the ratio of cost efficiency to technical efficiency

AE = CE / TE

Results and Discussion

Changes in land use pattern

Over time changes in land use pattern of Zone IX (Humid South-Eastern Plain) were analyzed and presented in Table 1 and Figure 1. During the TE 1994, the location coefficient was highest in forest (3.41) and it was lowest in culturable waste land (0.41). Under the two categories of land *i.e.* forest (3.41) and land under miscellaneous tree crops and groves

Table 1. Changes in Land Use Pattern fromTE 1994 to TE 2014 in the Zone -IX (Humid South-Eastern Plain)

Particulars	Location Coefficient				
	TE	TE 1999	TE 2004	TE	TE 2014
Forest	3.41	3.28	3.19	3.15	3.14
Area under Non-Agricultural Uses	0.94	0.93	0.93	0.94	0.96
Barren and Unculturable Land	0.93	0.93	0.93	0.93	0.88
Permanent Pastures & Other Grazing Lands Grazing Land	1.00	1.03	1.05	1.02	1.00
Land under Misc. Tree Crops and Groves	2.23	2.86	2.69	2.85	3.28
Culturable Waste Land	0.41	0.41	0.40	0.36	0.36
Fallow Lands Other than Current Fallow	0.56	0.52	0.54	0.49	0.47
Current Fallows	0.42	0.35	0.60	0.35	0.28
Net Area Sown	0.98	0.98	0.98	0.97	0.96
Geographical Area as per Village Papers	1.00	1.00	1.00	1.00	1.00

Source: *Various Issues of Statistical Abstract of Rajasthan, Agricultural Statistics of Rajasthan, Government of Rajasthan*

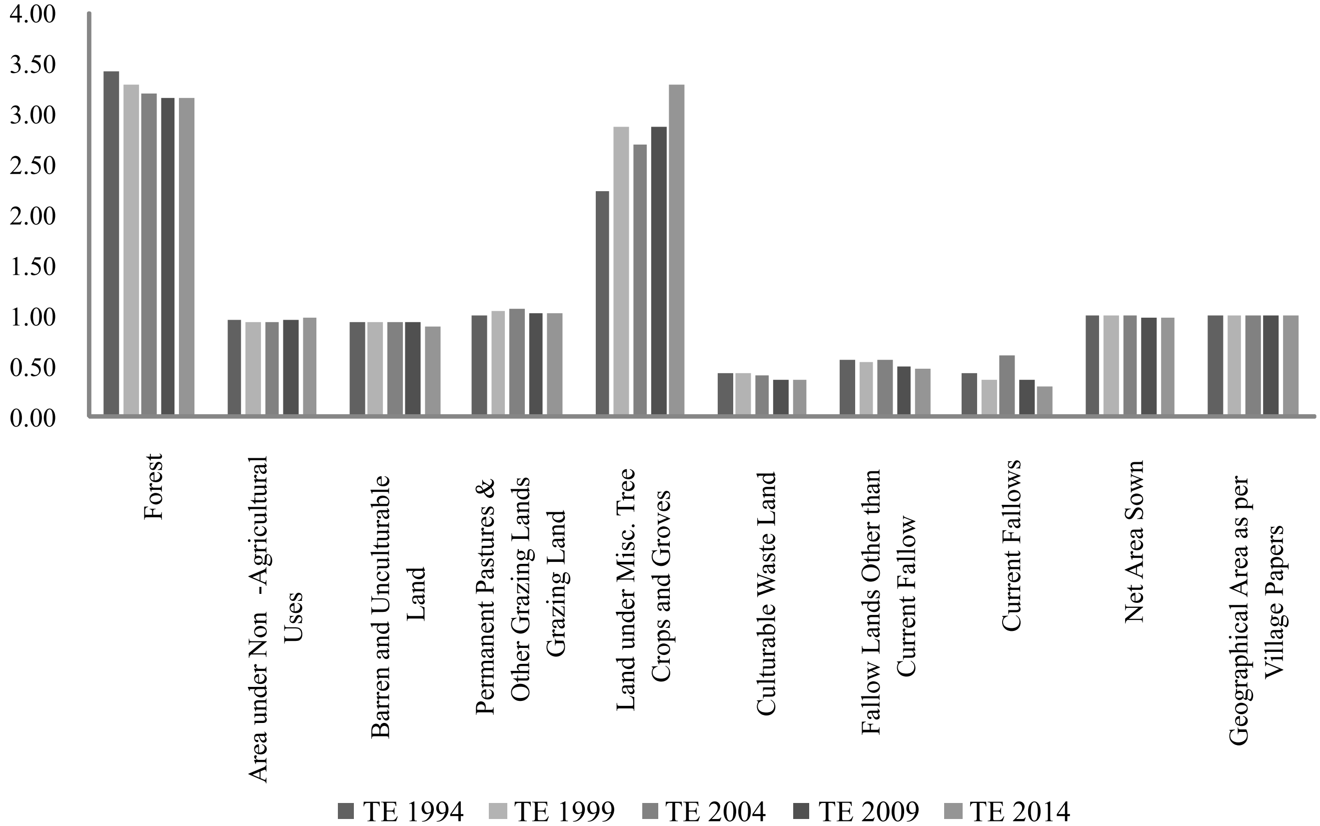

Figure 1. Changes in Land Use Pattern from TE 1994 to TE 2014 in the Zone-IX (Humid South-Eastern Plain) Changes in Cropping Pattern

(2.23), the location coefficient was observed more than one which indicated higher the concentration of land in these categories of land while it was observed less than one in remaining six categories of land namely area under non-agricultural uses (0.94), barren and unculturable land (0.93), culturable waste land (0.41), fallow lands other than current fallow (0.56), current fallow (0.42) and net sown area (0.98) indicated lower the concentration of land in these categories of land. At par location coefficient was observed in permanent pastures and other grazing land.

Over a period of more than 20 years from TE 1994 to TE 2014, the location coefficient was the highest in land under miscellaneous tree crops and groves (3.28) and it was found lowest in current fallow (0.28) instead of forest and culturable waste land, respectively. However, over this period, the location coefficient has remarkably increased in land under miscellaneous tree crops and groves (2.23 to 3.28) while there were remarkably decrease in forest, culturable waste land and current fallow.There was no change in location coefficient over the study period in permanent pastures and other grazing land.

Thus, the decreasing location coefficient has shown that the area has been diverted into land under miscellaneous tree crops and groves and area under non-agricultural uses. The similar results were also observed in the studies conducted by Ramasamy *et al.* (2005), Sinha *et al.* (2017), Burark *et al.* (2017) and Deka *et al.* (2018).

Table 2, Figure 2, Figure 3 and Figure 4 indicated the changes in cropping pattern of

Table 2. Changes in Cropping Pattern from TE 1994 to TE 2014 in Zone IX (Humid South Eastern Plain) (per cent of GCA)

Crops	TE 1994	TE 1999	TE 2004	TE 2009	TE 2014
Rice	1.44	2.15	2.03	1.68	1.84
Sorghum	10.05	3.44	3.37	0.93	0.20
Bajra	0.26	0.17	0.52	0.33	0.18
Maize	8.56	6.09	8.68	5.32	3.64
Wheat	17.96	20.88	17.20	12.83	24.29
Barley	0.38	0.22	0.20	0.07	0.11
Total Cereals	**38.65**	**32.94**	**32.00**	**21.15**	**30.26**
Pegionpea	0.29	0.13	0.10	0.04	0.01
Greengram	0.53	0.18	0.09	0.05	0.03
Blackgram	2.49	1.62	3.73	1.56	3.05
Pea	0.18	0.12	0.14	0.02	0.05
Gram	8.42	5.44	2.89	1.33	1.61
Lentil	0.49	0.53	0.34	0.17	0.76
Total Pulses	**16.14**	**11.01**	**7.90**	**3.17**	**5.54**
Total Foodgrains	**54.79**	**43.95**	**39.90**	**24.32**	**35.80**
Sesamum	1.38	0.20	0.80	1.76	1.25
Groundnut	0.85	0.54	0.34	0.15	0.11
Soybean	13.05	25.33	28.17	31.42	36.98
Castorseed	0.00	0.00	0.00	0.00	0.00
Rapeseed & Mustard	17.04	16.39	12.19	14.46	12.51
Taramira	0.32	0.13	0.07	0.06	0.10
Linseed	1.31	0.56	0.19	0.02	0.02
Total Oilseeds	**34.23**	**43.23**	**41.77**	**47.87**	**50.97**
Coriander	8.74	11.02	10.94	6.67	9.08
Fenugreek	0.19	0.31	0.80	0.53	0.36
Ajwain	0.20	0.18	0.02	0.01	0.02
Total Spices	**9.28**	**11.51**	**11.78**	**7.22**	**9.46**
Sugarcane	0.62	0.58	0.26	0.11	0.06
Clusterbean	0.02	0.06	0.35	0.03	0.13
Chillies	0.20	0.09	0.06	0.01	0.02
Potato	0.05	0.04	0.03	0.02	0.02
Garlic	0.05	0.12	0.54	0.33	1.50
Onion	0.02	0.02	0.02	0.01	0.07
Sweet Potato	0.03	0.02	0.03	0.01	0.01
Other Crops	0.64	0.37	5.27	20.05	1.96
Gross Cropped Area	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**
Cropping Intensity (%)	**132.38**	**149.58**	**141.92**	**155.74**	**180.02**
SID	**0.11**	**0.16**	**0.15**	**0.18**	**0.22**

Source: *Various Issues of Statistical Abstract of Rajasthan, Agricultural Statistics of Rajasthan, Government of Rajasthan*

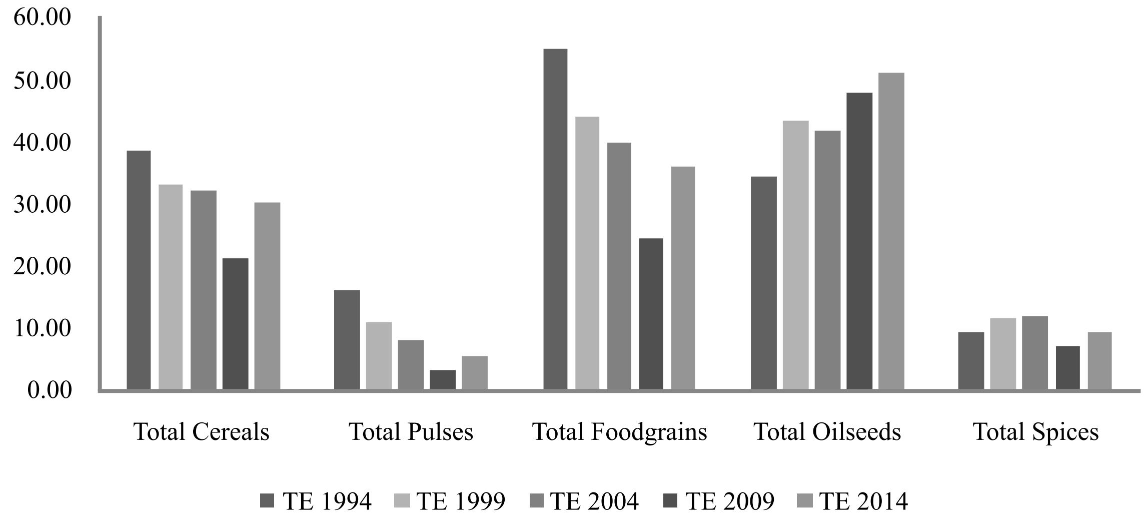

Figure 2. Changes in Cropping Pattern from TE 1994 to TE 2014 in Zone-IX (Humid South-Eastern Plain)

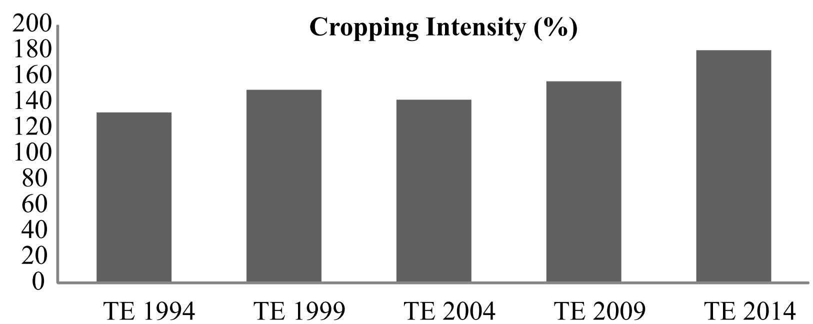

Figure 3. Cropping Intensity in Zone-IX (Humid South-Eastern Plain) of Rajasthan from TE 1994 to TE 2014

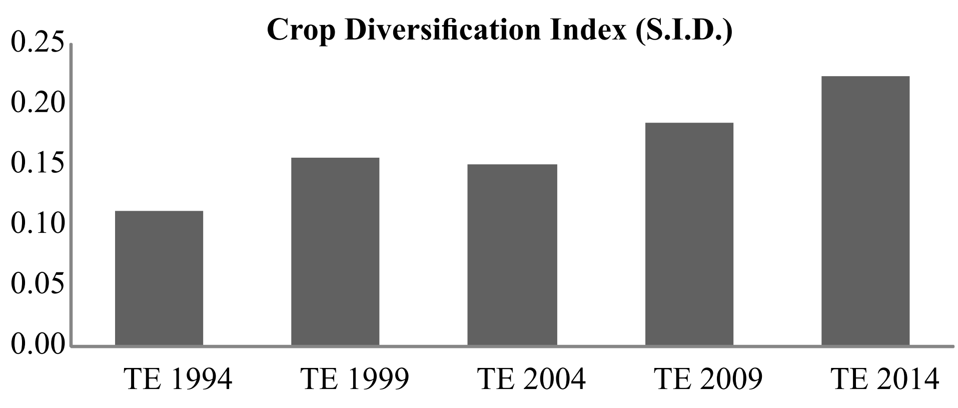

Figure 4. Crop Diversification Index in Zone-IX (Humid South-Eastern Plain) of Rajasthan from TE 1994 to TE 2014

Table 3. Resource Use Efficiency of Major Crops Cultivated in Zone IX (Humid South-Eastern Plain) during TE 2013-14

S. No.	Crops	Sample Size (Numbers)	Resource Use Efficiency		
			Technical Efficiency	Allocative Efficiency	Cost Efficiency
A	**Cereals**				
1	Paddy	5	0.95	0.96	0.91
2	Maize	54	0.54	0.65	0.29
3	Sorghum	6	0.67	0.77	0.52
4	Wheat	270	0.17	0.56	0.09
B	**Pulses**				
5	Gram	51	0.65	0.65	0.41
6	Blackgram	47	0.65	0.62	0.40
7	Greengram	3	0.90	0.96	0.86
8	Lentil	9	0.82	0.88	0.73
C	**Oilseeds**				
9	Soybean	338	0.18	0.76	0.13
10	Groundnut	6	0.93	0.92	0.86
11	Sesamum	3	1.00	0.54	0.54
12	Rapeseed & Mustard	108	0.58	0.58	0.34
D	**Spices**				
13	Coriander	89	0.51	0.72	0.37
14	Fenugreek	6	0.84	0.87	0.74
15	Garlic	50	0.37	0.71	0.27

Source: *Plot Level Cost of Cultivation Data of Rajasthan (TE 2013-14)*
Note: *Working hours of human labour/ha, machine labour/ha, quantity of seed (kg/ha) and quantity of fertilizers (kg/ha) with their unit prices and output produces per hectare*

Zone IX (Humid South-Eastern Plain) during the study period. Data presented table indicated that area under total cereals has been declined remarkably about more than 8.0 per cent over the study period from 38.65 per cent in TE 1994 to 30.26 per cent in TE 2014 because of decrease in area under maize and sorghum. Area under total pulses occupied 16.14 per cent of gross cropped area in TE 1994 fell to 5.54 per cent in TE 2014 due to drastic decline in gram and significantly decrease in pegionpea, greengram and pea. The share of total foodgrains was 54.79 per cent in TE 1994 which has continuously decreased in different periods and fell to 35.80 per cent in TE 2014, it was due to remarkable decrease in the area under total cereals (about 8.0%) and total pulses (about 10.0%).The total oilseed crops are most important crops like soybean in this zone which were contributing more than 50 per cent share of area in gross cropped area during TE 2014. Among the total oilseed crops, soybean individually contributes about 37 per cent in TE 2014.Thus, it can be assumed that there is shift in area from foodgrain crops to oilseed crops. Area under total spices has shown steadily increased from 9.28 per cent in TE 1994 to 9.46 per cent in TE 2014, it was due the major share contribution of coriander. Area under other crops has shown significant increase in share from 0.64 per cent to 1.96 per cent during the study period. The cropping intensity has increased by 47 per cent (133% to 180%). It seems that because of increase in irrigation facilities and technological development efforts, the intensity of crop cultivation has been increased. The crop diversification index (Simpson's Index of Diversification) has been decreased by 0.11 (0.11 to 0.22) over the study period but does not closer to one indicated that there was no more diversification of crops from sowing of traditional crops. Similar findings were also found in their respective studies conducted by Saraswat and Sharma (2014), Singh (2014), Yadav *et al.* (2017), Burark *et al.* (2017) and Deka *et al.* (2018).

Resource Use Efficiency on Selected Farms in Zone IX (Humid South-Eastern Plain) during TE 2013-14

Data depicted in Table 3 showed that among the cereals, technical, allocative and cost efficiency of paddy was highest and found to be significantly efficient *i.e.* 95 per cent, 96 per cent and 91 per cent, respectively followed by sorghum during TE 2013-14 in the zone. This implied that on an average, farmer is efficient in allocation of available resources as well as conversion of inputs into output. Technical efficiency scores among oilseed crops were observed highest in sesamum (100%) followed by groundnut (93%) and rapeseed & mustard (58%) indicated that sample farmers were efficiently utilize the available resources. This zone is well known for high production of soybean but still showed technical inefficiency for soybean by 82 per cent. The result of spices crops indicated that technical, allocative and cost efficiency of fenugreek was observed highly efficient *i.e.* 84 per cent, 87 per cent and 74 per cent, respectively. This implied that on an average, farmer is efficient in allocation of available resources as well as conversion of inputs into output. Similar results were also observed in the studies conducted by Coelli *et al.* (2002), Rohit (2015), Khan *et al.* (2016), Ahmad *et al.* (2017), Burark *et al.* (2017) and Yadav *et al.* (2017).

Conclusion and Policy Implications

The empirical results revealed that urbanization, road infrastructure expansion and industrial development were the most important factors affecting agricultural land. Therefore, proper planning and management of land resources and appropriate policy framework are required to check conversion of agricultural land. Managing urbanization process and industrial as well as infrastructure expansion in a desired way that protects productive agricultural land and uses barren and unculturable wastelands is very critical to country's prosperity and sustainability. Hence, restriction on conversion of agricultural land for non-agricultural uses (mainly for industrial estates) and proper planning and implementation of land use policies are needed.

There has been a gradual shift from cultivation of foodgrain crops to other crops like cultivation of fruits, vegetables, oil-seeds and industrial crops. This has led to the reduction in net sown area under cereals and pulses. With the growing population of the country, the declining foodgrain production puts a big question mark over the country's future food security. The competition for land between non-agricultural uses such as housing, roads, etc. and agriculture has resulted in reduction in the net sown area. The productivity of land has started showing a declining trend. Fertilizers, pesticides and insecticides, which once showed dramatic results, are now being held responsible for degrading the soils. Periodic scarcity of water has led to reduction in area under irrigation. Inefficient water management has led to water logging and salinity.

Farmers were inefficient in the application of productive resources, the relatively low technical know-how, low output prices and imperfect condition of input markets in the study area may have hampered efficient utilization of production inputs. Therefore, in order to achieve optimality in resource allocation, there is need to increase the quantity of such inputs employed in crop production, as this will raise the productivity of resources, increase output, and consequently improve revenue and net return. For improve efficiency in resource allocation in crop production, access to current technical and price information is needed by farmers, and the government should facilitate this as a matter of policy.

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