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Examining Linkage between Dietary Pattern and Crop Diversification: An Evidence from Tamil Nadu§

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Abstract

This paper has studied the impact of crop diversification on dietary diversity of households in different regions of Tamil Nadu. Two different types of data set were used: (1) National Sample Survey Organization's (NSSO) consumer expenditure survey data for the years TE 2004-05 and TE 2012-13, and (2) Cropping pattern data from Season and Crop report for the years TE 2004 and TE 2012-13. Multiple linear regression model was used to study the linkages between crop and dietary diversification. The study has revealed that dietary diversification of Cauvery delta zone, Northern zone and North-eastern zone was parallel with crop diversification. The crop diversification influenced positively the dietary diversification, whereas vegetable diversification was negatively related with diet diversification, irrespective of income groups in the state. Also, larger household size, presence of own land, older age and higher education level of household-head have been found positively related with dietary diversity of households in Tamil Nadu. The current nutrients intake pattern has been found about 50 per cent of the RDA, particularly of crude fibre and iron and about two-thirds in case of energy and vitamin A. The nutrient intake gap is further widened in low-income non-farm groups. Appropriate nutritional security programmes maybe initiated particularly covering children, pregnant women and aged people.

Keywords: Dietary diversity, crop diversification, food security, nutritional security

JEL Classification: Q18, I32, P46

Introduction

A diverse diet is more likely to meet nutrient requirements, and therefore diversified farm production is regarded as a means to increase dietary diversity. However, the access and the buying and selling of food stamps[1] and eliminate the production diversity–consumption diversity relationship. The majority of farmers in developing regions of India are subsistence farmers and their diets depend largely on the crops they harvest and the livestock they breed. In the presence of such semi-autarkic environments, non-separable household models predict a link between foods produced and consumed, but the existing empirical evidence on these relation remains weak.

In most developing countries, the trend towards reduced crop diversity began after the 1960s with the spread of green revolution technologies (Jacques and Jacques, 2012). A series of new advances in agricultural research and crop genetics boosted agricultural

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[1] Selling of subsidized food items through public distribution system

production worldwide, mostly in rice, wheat and maize. The reduced crop diversity increases the risks due to pests and disease, and climate change. Recently, the developing countries have experienced strong income growth leading to the emergence of a new middle-income class in the developing countries, and increased demand for high-value food products, such as meat, eggs and dairy products. Besides, rapid urbanization and multi-national food industries have encouraged greater consumption of processed, imported and fast food (Hawkesworth *et al.,* 2010).

The literature on dietary diversity places emphasis on the consumption of diversified and well-balanced diets as the most sustainable strategy to address malnutrition (Meenakshi *et al.,* 2010; Ruel, 2003a). Interventions tailored at diversifying and increasing food production therefore have a high potential of directly influencing nutritional outcomes in farm households that primarily consume from own production (Ecker *et al.,* 2011). The empirical evidence on the linkage between household farm diversity and diet quality is limited in both Tamil Nadu and India. Examining this relationship within the context of Tamil Nadu is particularly important given the widespread food insecurity and under-nutrition observed in the region.

Given the enormous global burden of micronutrient deficiencies borne by vulnerable populations (Micronutrient Initiative, 2009), the seemingly intractable problem of child growth stunting that is in part due to poor quality diets (Bhutta *et al.,* 2008), and emerging trends in overweight and obesity even in rural areas of low-income countries where over-nutrition was not previously a concern (Popkin *et al.,* 2011), understanding the capacity of farming systems to meet human nutritional needs is of paramount importance.

The usual household diets in low-income countries are often limited to one or two starchy staple foods and may be lacking in micronutrient-rich fruits, vegetables and animal-source foods. For farming households that consume primarily what they themselves produce, it seems reasonable that diversified agricultural production would lead to more diverse diets. However, most farming households throughout the globe in fact practise some mix of subsistence and market-oriented production, thus adding complexity to the relationship between farm production diversity and dietary diversity (Jones *et al.,* 2014).

Implications of crop diversity on food and nutritional security can largely be addressed through crop diversification. However, the decreasing crop diversity and increasing market depended food consumption have caused increasing nutritional and micro nutrients deficiencies. Nutritional security is largely contributed by pulses consumption due to its contribution of high quality protein and other essential amino acids and vitamins. The aforesaid discussion raised the following research questions to be explored: (1) Is the current crop diversification positively related to dietary diversification? and (2) what are the other determinants of farm and non-farm characters to achieve nutritional security?

Agricultural farm diversification can influence the households' dietary diversity by (i) production of crop for own consumption and (ii) marketing crop produce that affects household income and household food purchase decisions. In Ethiopia, self-sufficiency in milk has a positive impact on milk consumption and children's growth, but not in villages that have an access to markets (Hoddinott *et al.,* 2015). The diversity of farms probably plays an important role in influencing the diversity of diets in low-income, semi-subsistence, smallholder settings (Jones *et al.,* 2014).

Many other studies (Immink and Alarcon, 1991) have also reported that crop diversification is associated with higher household income but no significant nutritional change to individual or household level. However, Jones *et al.* (2014) have found that in Malawi, farm production diversity is consistently positively associated with farm household dietary diversity [HDD]. They have observed that the household whose diets relied less on subsistence production had more diverse diet even controlling for household wealth. In Mali, Torheim *et al.*(2004) have found that the number of crops cultivated by a household was positively associated with adult nutrient adequacy. A study by Remans *et al.* (2011) has revealed that the diversity of plant species on farms to be positively associated with the diversity of nutrients provided by farms based on the nutritional composition of their plant species in rural areas of Malawi, Mali, and Uganda. In the success of Asian Green Revolution, crop diversification is strongly regarded as a vital element in raising incomes, improving food security and reducing poverty (Ibrahim *et al.,* 2009). Ruel (2003b) concludes that a relationship between household dietary diversity score and nutrient

deficiencies varies across countries and contexts. There is an increasing support in literature for agricultural intervention playing an important role in improving nutrition (Masset *et al.,* 2012). Similar result have also been reported by McIntyre *et al.* (2001). In the rural highlands of Ecuador, on-farm species diversity and family-level dietary diversity were also found positively correlated (Oyarzun *et al.,* 2013). At the household level crop diversification is a potential vital pathway for household food security and nutrition through incomes realized from the sale of agricultural produce. Joshi *et al.* (2006) have found that a crop diversification portfolio that includes cultivation of high-yielding and high-value crops, has the strongest impact on incomes at the household level. Hence, the present study has attempted to identify the level of crop diversification and nutritional security linkages in different zones of Tamil Nadu.

Data and Methodology

A positive relationship between farm production diversity and dietary diversity has some limitations as most of the households consume what they produce in the local farms. Since many of the food commodities are consumed through market purchasing, directly linking the production diversity and dietary diversity is challenging. Though food commodities are not produced at home, households can buy diverse set of food items in the local market when they generate sufficient income. Many of the food commodities are not locally available and they are consumed by importing or purchasing from other regions where these commodities are produced. A diversified cropping pattern in the local region may provide access to more number of food commodities from small millets to high-value commodities like meat, milk products, fruits, etc. and can be incorporated in the dietary pattern of the households. Therefore, dietary diversification in a household is directly proportional to the increased farm diversity in local region and can be written as:

Dietary diversification = f (Crop diversification, household characteristics, infrastructure, etc.) ...(1)

For the studies, district level data on area under major crops (45 crops) from cereals, pulses, oilseeds, vegetables, fruits and spices from Tamil Nadu state were used to derive the triennium averages for triennium ending 2004-05 and 2012-13 were used to estimate Herfindhal crop index (HI) for each district and the state. The NSSO consumption survey data for the years TE 2004-05 and TE 2012-13 were used to estimate the nutritional security indicators.

Analytical Framework

Dietary Diversification Index

Dietary diversification maybe captured through Household Dietary Diversification Index (HDDI) and Individual Dietary Diversity score (IDDS). The dietary diversity scores are calculated by summing the number of food groups consumed in the household or by the individual respondent. Currently, there is no international consensus on the food groups to be included in the scores to capture the Household Dietary Diversity score (HDDS) and Individual Dietary Diversity score (IDDS). The proposed food groupings for HDDS and IDDS are based on the synthesis of currently available research and literature to achieve harmonization with other guidelines (FAO, 2007). The values of dietary diversity variable can be computed by summing all food groups included in the dietary diversity score (approximately 16 food groups). The score for these combined food groups is either 1 (if one or more of the original food groups used to create the combined group, were consumed) or 0 (if none of the original food groups used to create the combined group was consumed). More than 100 food commodities are grouped into different food groups based on nutritional importance.

Crop Diversification Index

Herfindahl index (HI) was used to measure the level of crop diversification in a particular region and the state. It is estimated by using the Equation (2) (Ghosh *et al*., 2015):

$$H.I. = \sum_{i=1}^{N} P_i^{\,2} \qquad \ldots(2)$$

where, N is the total number of crops; and Pi is the acreage proportion of the i^{th} crop in total cropped area/ crop group. The value ranges between zero and one. Since the index is a measure of concentration, it was transformed by subtracting it from one that is, 1-HI. The transformed value of H.I will avoid confusion to compare it with other indices. It takes zero value in

case of complete diversification and value one indicates perfect mono cropping.

Besides crop diversification, some household characteristics such as age and education level of household-head, asset position, social category, income, etc. and infrastructure developments such as road, number of markets etc. may determine the level of dietary diversity at household level.

Linkage between Crop Diversity and Nutritional Security - Econometric Model

To analyse the major determinants of individual dietary diversity and impact of crop diversification on dietary diversity, the regression models of the following form (3) (FAO, 2007) was used:

$$IDDS = \alpha+\beta_1 Gender+\beta_2 Age+\beta_3 HHS+\beta_4 WL+ \beta_5 EDUC+\beta_6 UR+\beta_7 TIME+\sum\beta_i CDI_i+\mu \quad \ldots(3)$$

where, IDDS is the Individual Dietary Diversity score; HHS is the household size; WL is the presence of own land; EDUC is the education level; UR is location of households in urban; TIME is the time period; CDIs are the crop diversification indices for all crops, cereals, pulses, fruits, vegetables, oilseeds and spices. A positive sign of coefficients of CDIs indicates that crop diversification causes more dietary diversity at the household level.

Results and Discussion

Production Diversification in Tamil Nadu

Table 1 presents the zone-wise cropping pattern in Tamil Nadu for the years TE 2004-05 and TE 2012-13. It is observed that Central Zone has the highest share of cereal crops cultivation, followed by north-eastern zone, western zone, Cauvery delta zone and southern zone. The area under cereal crops was 4.38 lakh ha in TE 2004-05 and 4.92 lakh ha in TE 2012-13 in Cauvery delta zone. Cauvery delta zone is the largest pulse grower of the state with the area of 1.27 lakh ha in TE 2004-05 and 1.66 lakh ha in TE 2012-13, followed by western zone and north-eastern zones with all three constituting 71 per cent state pulses area in TE 2012-13. The Central Zone has the highest area under fruits and vegetables cultivation (1.58 lakh ha) in TE 2012-13. It is noted that north-eastern zone is one of the oilseed dominated areas showing a declining trend from 2.95 lakh ha to 1.82 lakh ha between TE 2004-05 and TE 2012. This combined with the declining trend in vegetable cultivation needs to be checked for the linkage of crop diversity and dietary diversity. Other zones cultivated less than fifty thousand ha of oilseeds (Table 1).

It reveals that there was an improvement in the area under cultivation of all food crops in the Cauvery delta zone. Specifically, pulses and vegetables were grown on more than 20 per cent area in TE 2012-13 over TE 2004-05 in this region. Western zone shows a significant growth in the area under fruits, vegetables and pulses. Almost in all the regions, area under oilseeds and cereal crops cultivation has fallen during TE 2012-13 (Figure 1), as compared to TE 2004-05.

Dietary Changes in Tamil Nadu

Zone-wise changes in per capita food consumption pattern are presented in Table 2. In TE 2004-05, the average monthly per capita consumption of coarse grain was observed highest in Cauvery delta zone (12.0 kg), followed by central zone (11.05 kg), north-eastern zone (10.06 kg), high rainfall zone (10.3 kg), southern zone (9.88 kg) and northern zone (9.44 kg) clearly indicating cereal dominated crop production system and its consumption pattern showed a declining trend in consumption reflecting shifting from cereals to high nutritive value based non-crop foods like meat, egg, milk and milk product.

About 10-13 per cent increase in the consumption of cereals, fruits and vegetables was observed in all the zones, probably due to increase in per capita income, educational status, etc. Specifically, northern zone consumed these food commodities more than the other zones. Also, northern zone was the major consumer of vegetables, pulses, edible oils and spices. Western zone consumed a higher amount of millets. Highest consumption of roots and tubers was observed in high rainfall and hill stations, maybe due to being the production centres. Cauvery delta zone consumed higher amounts of fruits, nuts and beverages. The per capita consumption of fish was found highest in high rainfall zone. In TE 2012-13, the consumption of all food commodities, except coarse grain and millets, has increased in most of the zones. Millet consumption has

Table 1. Zone-wise cropping pattern in Tamil Nadu in TE 2004-05 and TE 2012-13

(in lakh ha)

Food crop group	Northern zone		North-eastern zone		Cauvery delta zone		Central zone		Southern zone		Western zone		Hills and high rainfall zone		Tamil Nadu	
	TE 2004-05	TE 2012-13	TE 2004-05	TE 2012-13	TE 2004-05	TE 2012-13	TE 2004-05	TE 2012-13	TE 2004-05	TE 2012-13	TE 2004-05	TE 2012-13	TE 2004-05	TE 2012-13	TE 2004-05	TE 2012-13
Cereals	1.87	1.69	4.99	4.57	4.38	4.90	5.89	4.92	4.08	4.07	4.71	3.73	0.22	0.16	25.93	24.04
Pulses	0.18	0.11	1.02	1.08	1.27	1.66	0.60	0.55	0.92	1.00	1.13	1.37	0.02	0.01	5.15	5.79
Fruits	0.14	0.16	0.62	0.69	0.11	0.12	1.20	1.24	0.43	0.51	0.71	0.91	0.10	0.10	3.31	3.74
Vegetables	0.01	0.01	0.05	0.05	0.01	0.01	0.29	0.34	0.08	0.09	0.27	0.32	0.02	0.02	0.74	0.82
Oilseeds	0.58	0.32	2.95	1.82	0.56	0.62	1.93	1.61	0.89	0.68	3.44	3.16	0.24	0.25	10.59	8.45
Others	0.20	0.24	1.75	2.48	0.28	0.28	1.31	1.73	1.11	0.90	2.39	2.91	0.80	0.69	7.82	9.25
GCA	2.91	2.58	9.21	10.83	6.12	7.65	11.07	10.97	7.84	7.66	14.42	14.65	1.70	1.62	53.17	55.94

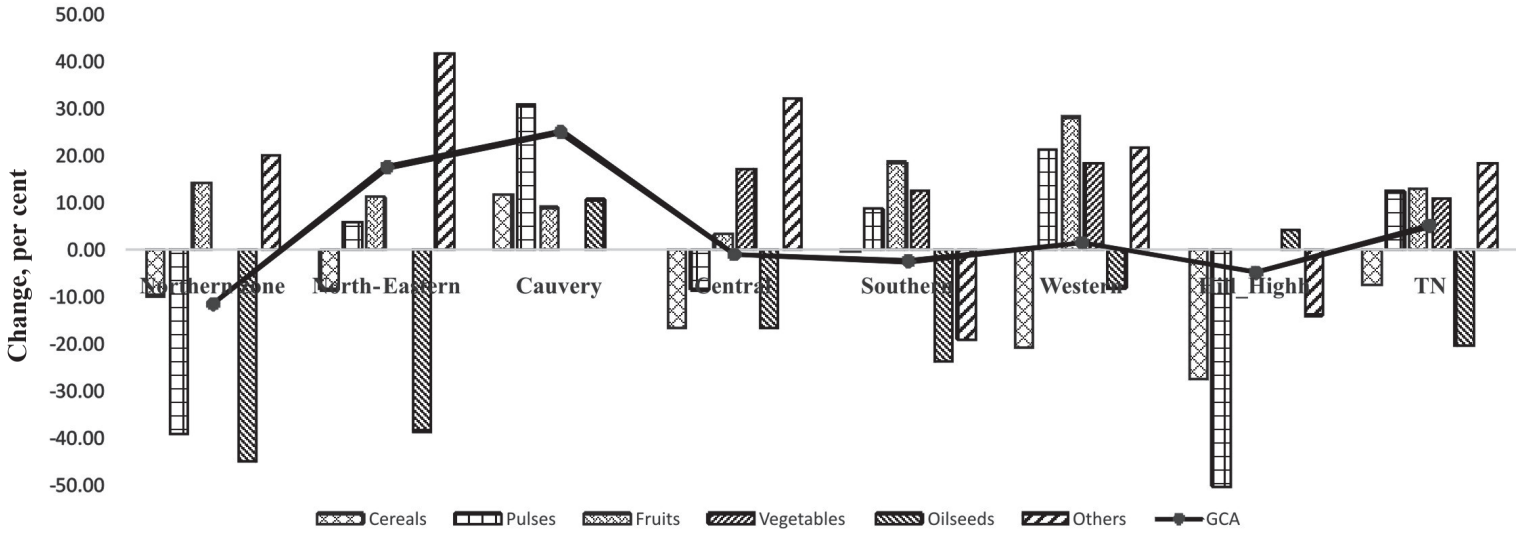

Figure 1. Zone-wise change in cropping pattern between TE 2004-05 and TE 2012-13 in Tamil Nadu (in %)

Table 2. Zone-wise changes in food consumption pattern in Tamil Nadu

(kg/capita/month)

Food commodities	Northern zone		North-eastern zone		Cauvery delta zone		Central zone		Southern zone		Western zone		Hills and high rainfall zone	
	TE 2004-05	TE 2012-13	TE 2004-05	TE 2012-13	TE 2004-05	TE 2012-13	TE 2004-05	TE 2012-13	TE 2004-05	TE 2012-13	TE 2004-05	TE 2012-13	TE 2004-05	TE 2012-13
Coarse grains	9.44	7.87	10.06	8.07	12.36	9.62	11.05	10.64	9.88	8.94	9.10	8.95	10.30	8.52
Millets	0.07	0.08	0.51	0.13	0.02	0.05	0.06	0.02	0.05	0.04	0.60	0.25	0.26	0.05
Roots and tubers	0.38	0.55	0.23	0.35	0.36	0.49	0.38	0.57	0.29	0.43	0.25	0.45	0.61	0.72
Vegetables	3.32	4.91	2.78	3.00	3.25	3.79	3.23	4.82	2.57	3.06	2.49	4.34	2.52	2.93
Fruits	0.77	1.81	0.44	0.93	0.96	1.22	0.60	1.35	0.45	1.08	0.59	1.54	0.67	1.48
Meats	0.21	0.52	0.17	0.51	0.20	0.32	0.24	0.52	0.20	0.41	0.27	0.53	0.22	0.60
Eggs	3.45	6.11	1.24	3.80	2.14	2.79	1.83	4.97	2.29	4.23	1.39	3.15	2.65	5.04
Fish	0.16	0.34	0.06	0.14	0.41	0.79	0.06	0.16	0.18	0.32	0.03	0.07	0.47	1.19
Pulses	1.00	1.10	0.82	0.85	0.84	0.88	0.78	1.15	0.80	0.95	0.83	1.11	0.72	0.86
Milk & milk products	4.81	5.08	2.80	3.55	3.41	4.80	3.22	4.65	2.92	3.98	3.61	4.60	4.06	4.70
Oil & fat foods	0.64	0.78	0.49	0.53	0.49	0.67	0.45	0.68	0.42	0.59	0.46	0.70	0.42	0.50
Nuts	0.02	0.07	0.02	0.07	0.03	0.02	0.01	0.06	0.01	0.03	0.01	0.06	0.01	0.04
Sugar	0.58	0.61	0.40	0.55	0.51	0.71	0.51	0.65	0.61	0.66	0.58	0.68	0.79	0.78
Spices	0.47	0.55	0.39	0.41	0.44	0.53	0.36	0.65	0.33	0.45	0.28	0.50	0.33	0.49
Beverages	0.12	0.13	0.12	0.10	0.29	0.17	0.19	0.22	0.14	0.19	0.18	0.22	0.19	0.23
Packaged foods	0.01	0.06	0.00	0.01	0.00	0.01	0.01	0.06	0.00	0.02	0.00	0.03	0.00	0.04

increased over the period in northern and Cauvery delta zones. Western zone has increased their vegetable consumption by 18.5 per cent more over TE 2004-05. In all the zones, meat consumption has increased more than 20 per cent over the period. It is important to note that egg consumption has increased more than 200 per cent in all the zones. However, increment in pulse consumption was just three per cent in north eastern zone and four per cent in Cauvery delta zone. The consumption of milk and milk products has increased more than 40 per cent in Cauvery delta, central and southern zones.

Incidence of Production and Dietary Diversity

The zone-wise production and dietary diversification linkage for the years TE 2004-05 and TE 2012-13 are presented in Figure 2. The crop diversification was found inversely related to dietary diversification in all the zones in TE 2004-05, whereas dietary diversification was positively correlated with crop diversification in north, north-eastern and Cauvery delta zones in TE 2012-13 (Figure 2).

The North-eastern and Western zones had more diversified cropping which had high dietary diversity compared to Cauvery delta and central zones with low crop diversity in TE 2004-05. However, in TE 2012-13, the direction was changed with less crop diversification which favoured few crops. However, over the decades all the production zones have been exhibiting improvement in the dietary diversity through the market purchase.

Dietary Diversification and Nutritional Security in Tamil Nadu

The changes in consumption pattern between 2004-05 and 2010-11 were estimated using the NSSO data set along with their nutritional security and the results are presented in Table 3 and Figure 3. It could be inferred from Table 3 that on average, the per day intake of a normal person in Tamil Nadu was 48 g of protein,

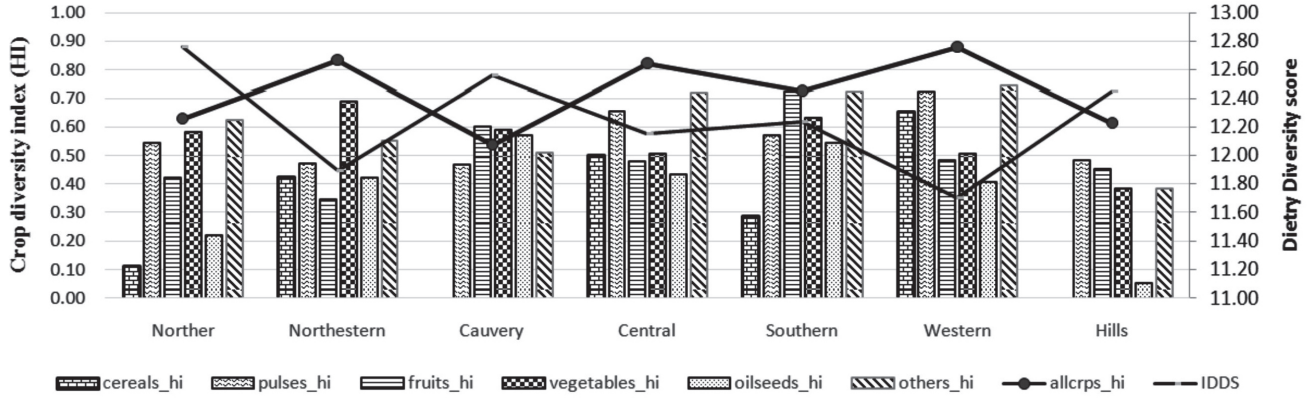

Figure 2a. Zone-wise incidence of dietary and production diversity in Tamil Nadu in TE 2004-05

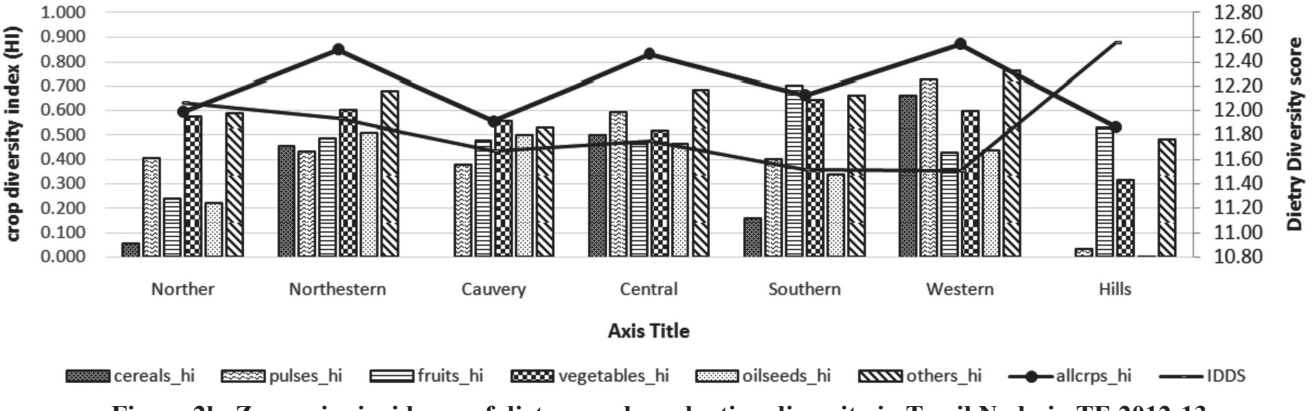

Figure 2b. Zone-wise incidence of dietary and production diversity in Tamil Nadu in TE 2012-13

Table 3. Zone-wise incidence of nutritional security in Tamil Nadu

Zone	Year	Protein (g)	Fat (g)	Crude fibre (g)	Energy (kcal)	Calcium (mg)	Iron (mg)	Vitamin A (µg)	Vitamin B1 (Thiamine) (mg)	Vitamin B2 (Riboflavin) (mg)	Vitamin B12 (folic acid) (mg)	Vitamin C (mg)
Northern	TE 2004-05	49	39	6	1804	481	11	1432	1.20	0.85	165	38
	TE 2012-13	58	51	8	1821	589	13	1791	1.24	1.07	205	54
North-eastern	TE 2004-05	46	24	5	1773	420	10	1304	1.30	0.69	141	31
	TE 2012-13	56	41	8	1813	512	12	1562	1.42	0.95	180	43
Cauvery delta	TE 2004-05	52	33	6	2064	426	11	1327	1.33	0.78	153	43
	TE 2012-13	56	45	7	1999	585	11	1858	1.23	0.91	171	49
Central	TE 2004-05	48	29	6	1912	428	10	1533	1.25	0.75	157	42
	TE 2012-13	64	48	10	2202	613	15	2234	1.49	1.11	222	67
Southern	TE 2004-05	47	29	5	1804	408	10	1222	1.17	0.75	147	38
	TE 2012-13	56	42	7	1896	509	12	1437	1.23	0.93	178	42
Western	TE 2004-05	45	25	6	1682	446	9	1139	1.22	0.71	131	32
	TE 2012-13	58	46	9	1975	599	14	1836	1.45	0.99	190	55
Hills and high	TE 2004-05	54	33	6	1890	519	11	1188	1.24	0.89	158	38
rainfall (HHR)	TE 2012-13	64	44	9	1951	603	13	1704	1.26	1.05	190	49
Tamil Nadu	TE 2004-05	48	29	6	1816	440	10	1317	1.24	0.75	148	37
	TE 2012-13	59	45	8	1962	573	13	1803	1.36	1.01	194	53
Recomd. Dietary Allowance (RDA)		60	20	20	2875	400	28	2400	1.40	1.66	100	40

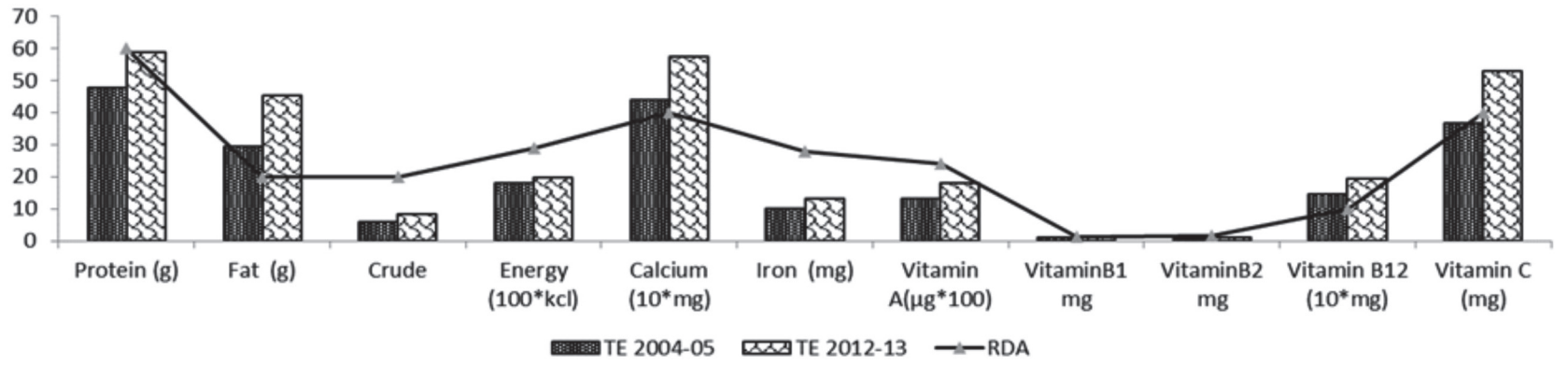

Figure 3. Change in nutritional security between TE2004-05 and TE 2012-13 in Tamil Nadu

29 g of fat, 6 g of crude fibre, 1816 kcal of energy, 440 mg of calcium, 10 mg of iron, 1317 mg of vitamin A, 1.24 mg of vitamin B1, 0.75 g of vitamin B2, 148 mg of vitamin B12 and 37 g of vitamin C in TE 20012-13 which was increased over TE 2004-05. However, except fat, calcium, vitamin B2 and vitamin C, the intake of all other nutrients was still below the Recommended Dietary Allowance (RDA). The same pattern of nutrient intake was observed in all the agro-climatic zones of Tamil Nadu. The protein intake of Central zone (64.48 g) and High Rainfall zone (64.45 g) was more than the RDA in TE 2012-13.

Determinants of Dietary Diversification

To estimate the major determinants of dietary diversification at the household level, multiple regressions was employed for different income groups, separately. The estimated regression results of low, middle and high income groups are presented in Table 4. There was a positive relationship between crop

Table 4. Determinants of dietary diversity across different income groups in Tamil Nadu
(Dep. variable : IDDS)

Variables	Low income	Middle income	High income	All income
Gender of household-head (Dummy: 0= Female, 1 = male)	-0.192* (0.100)	-0.237*** (0.069)	0.561*** (0.140)	-0.013 (0.059)
Age of household-head (yrs)	-0.005* (0.003)	-0.006*** (0.002)	0.032*** (0.004)	0.008*** (0.002)
Household size	0.705*** (0.021)	0.551*** (0.015)	0.866*** (0.030)	0.667*** (0.012)
Presence of own land (Dummy: 1 = own land)	0.914*** (0.091)	0.559*** (0.061)	1.200*** (0.111)	0.903*** (0.050)
Education level of household-head (years)	-0.013 (0.030)	-0.004 (0.018)	0.132*** (0.033)	0.073*** (0.015)
Urban location of resident (Dummy: urban = 1)	-0.330*** (0.087)	-0.030 (0.053)	0.069 (0.106)	0.187*** (0.045)
Time period (Dummy 2012-13=1)	-5.070*** (0.206)	-2.016*** (0.088)	-0.378*** (0.127)	-0.795*** (0.050)
HI-cereals-pulses-oilseed-fruits veg	1.133 (0.948)	0.189 (0.519)	1.984* (1.118)	1.017** (0.464)
Share of surface water area to GCA (%)	4.169*** (1.264)	2.333*** (0.791)	1.790 (1.743)	1.689** (0.694)
Share of ground water area to GCA (%)	4.522*** (1.189)	2.495*** (0.738)	0.744 (1.622)	1.216* (0.645)
Irrigation intensity (%)	-0.399 (0.562)	0.203 (0.310)	0.989* (0.598)	0.195 (0.268)
Irrigation (%)	-0.463 (0.311)	-0.167 (0.192)	-1.173*** (0.412)	-0.424** (0.167)
Crop diversification	-1.631 (1.216)	-0.985* (0.573)	-2.689** (1.213)	-1.310** (0.518)
Cereals diversification	-1.388** (0.639)	-0.447 (0.334)	0.742 (0.623)	-0.136 (0.283)
Pulses diversification	0.139 (0.330)	-0.180 (0.184)	-0.085 (0.401)	0.111 (0.162)

Contd.

Table 4...

Variables	Low income	Middle income	High income	All income
Fruits diversification	0.107	0.332**	0.310	0.116
	(0.260)	(0.151)	(0.313)	(0.131)
Vegetables diversification	0.577*	1.074***	1.427***	1.094***
	(0.348)	(0.190)	(0.383)	(0.165)
Oilseeds diversification	0.210	-0.131	0.534*	-0.061
	(0.308)	(0.169)	(0.311)	(0.143)
Other crops diversification	1.049**	0.415	-0.334	0.238
	(0.426)	(0.253)	(0.492)	(0.216)
Middle-income households				1.341***
				(0.055)
High-income households				1.858***
				(0.068)
Monthly per capita income (₹)	0.010***	0.001***	-0.000	
	(0.000)	(0.000)	(0.000)	
Constant	0.142	6.485***	4.250**	5.006***
	(1.739)	(1.055)	(2.164)	(0.915)
Observations (No.)	2,729	7,018	3,949	13,696
R-squared	0.460	0.255	0.292	0.259

diversification and dietary diversification in all income groups. The impact of cereal diversification affected the dietary diversity positively at high Income household level. There was a positive relationship between dietary diversification and fruit crop diversity in the middle-Income households, while middle income group households' diatery diversity score was positively influenced by oilseeds diversification. The vegetable diversification positively influenced the dietery diversification, in all income groups. Besides, larger household- size, presence of own land, older age and higher education levels of household-head have shown positive impact on the dietary diversity in overall analysis. It is found that there was a negative diet diversity in both the periods TE 2004-05 and TE 2012-13. As compared to the low - income households, there was a higher possibility of more dietery diversity in middle and high income households.

Conclusions

The study has found that, cropping pattern in different zones of Tamil Nadu has changed significantly over the period. Cereal crops occupied a predominant area in all the period, but the percentage change over the period was negative in most of the zones, indicating crop shift towards non-cereal based cropping system. In the Cauvery delta zone, area under cultivation of all food crops has increased in 2012 over TE 2004. Particularly, pulses and vegetables have been cultivated on more than 20 per cent area in 2012 in this region. It was also found from the consumption data that the Cauvery delta zone consumed more amounts of fruits, nuts and beverages. Millet consumption has increased over the period in the northern and Cauvery delta zones. It is noted that per capita daily intake of fat, calcium, vitamin B2 and vitamin C was less than the Recommended Dietary Allowance (RDA) in Tamil Nadu.

The dietary diversification of Cauvery delta zone, Northern zone, North-eastern zone has been positively correlated with crop diversification. The crop diversification influenced positively the dietary diversification in all the levels of income groups. But, vegetable diversification was negatively related with diet diversity, irrespective of income groups. Further, larger household-size, presence of own land, older age and higher education levels of household-head have shown a positive impact on the dietary diversity.

The study has confirmed that linkage between cereal based cropping and dietary diversity is fairly strong in zones like Cauvery delta and Central zone, whereas this linkage is weak among more diversified cropping pattern in other zones.

There was about 10 -15 per cent increase in nutritional security from the current consumption pattern over TE 2004-05. However, there is a large gap between the nutrient intake and RDA recommendations as per the current consumption pattern in Tamil Nadu, particularly in energy, crude fibre, iron and vitamin A. The nutrient intake gap is further widened in low-income non-farm groups. Appropriate nutritional security programmes maybe initiated particularly covering children, pregnant women and aged people.

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