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Case Study

Vulnerability to Food and Nutritional Insecurity in Different Reaches of Tungabhadra Command Area of Karnataka: A Case Study

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ABSTRACT

This study assessed the vulnerability to food and nutritional insecurity of farm households across multiple water regimes in the Tungabhadra command area of Karnataka by collecting data from 120 households comprising 40 respondents from head, middle and tail-end reaches. The Gini coefficients used to measure the inequality, which showed a high degree of income inequality among tail-end reach households. In head-reach regime, households experienced low vulnerability to food insecurity as they spent lesser proportion of their total expenditure on food, whereas, middle and tail-end reach farm households were more vulnerable. As land use decision is hard to change, there is a need for a comprehensive strategy and plan for irrigation water management and administration.

HIGHLIGHTS

- High degree of income inequality prevails among harm households at tail-end reaches of Tungabhadra command areas of Karnataka and high extent of vulnerability faced by both tail-end and middle reaches farmers.
- Farmers at tail-end and middle reaches experienced severe to high level and those at head reaches are prone to moderate to mild level of nutritional insecurity.

Keywords: Food insecurity, Gini coefficient, Irrigation water, Tungabhadra command area, Water regimes

Irrigation improves food security in India by reducing reliance on the monsoon, increasing agricultural production, and creating rural job opportunities. Due to a poor water resource management system and climate change, India experiences repeated irrigation water shortages. India will face catastrophic water shortages by 2050, according to the OECD's environmental estimate. Because of its link to malnutrition, which leads to poor physical and mental health, food insecurity has piqued the world's interest. According to Collins (2005), food insecurity is linked to both acute and chronic physical and mental health issues. Food insecurity can have a detrimental impact on human capital development since it can lead to lower labour productivity. Food insecurity has numerous negative consequences for livelihood security and the overall economy. As a result, food security was always given first importance.

Irrigation is the technique of artificially supplying water to crops to compensate for a lack of rainfall (Cantor, 1967). Irrigation is a critical determinant of agriculture since its inadequacy is the most powerful constraint on agricultural production development. In traditional agriculture, irrigation was originally thought to be a safeguard against the whims of

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rainfall and drought. Irrigated agriculture, on the other hand, has been shown to have a significant potential for increasing income and improving quality of life. Irrigation is frequently cited as a way to improve rural life, food security, and poverty alleviation (Lipton *et al*. 2003; Bennin and Mugarura, 2006; Polak and Yoder, 2006). According to Rosegrant and Cai (2001), irrigated farming has the ability to reduce food insecurity and lift millions of people out of poverty. On the other front, agriculture is the major culprit in times of local absolute scarcity because it is responsible for the highest amount of water extraction (FAO, 2007a). Water is necessary for all types of socioeconomic development as well as the maintenance of healthy ecosystems. As the world's population expands, need for groundwater and surface water also increases proportionately for domestic, industrial, and agricultural uses, resulting in tensions, disputes, and extreme environmental stress (UN, 2006).

Water scarcity has the potential to reduce productivity and have a negative influence on global food security. The United Nations has concluded that water scarcity in arable land will be the most significant constraint to enhanced food production in the next decades (UNDP, 2007b). In desert and semi-arid regions, irrigation has enhanced agricultural yields and outputs while also stabilizing food production (Hanjra and Hussain, 2009; Hanjra and Qureshi, 2010). All arable land should be put to agriculture for increasing agricultural production to alleviate poverty in rural areas and enhance economic growth (Hanjra and Gichuki, 2008). The majority of developing countries face a shortage of long-term fresh water supply (Kamal, 2009). Water scarcity can be relieved through better water management of irrigation infrastructure and new investments (Hanjra and Qureshi, 2010). Throughout history, large-scale water development projects have played an important role in poverty alleviation, providing food security, flood and drought protection, and expanded employment opportunities. In many regions, irrigated agriculture has played a critical role in the development of rural economies, poverty reduction, and economic prosperity of the society. As a result, rising scarcity and competition for water, particularly in rural regions, pose severe threats to future poverty reduction initiatives. So, there is a pressing need to focus on issues like fairness in distribution of water and the social implications of water allocation policies (UN, 2006).

Inequity in the distribution of irrigation water is a common problem faced in almost all the command areas/ tank irrigated areas (Ravi and Umesh, 2018) as it is treated as common property resources and Tungabhadra Command Area is no exception for this. Farmers on the front end of the distribution chain and those on the back end of the distribution chain are in quite different locations. Farmers with a narrowly selfish head reach would ignore the shortages they cause for those at the bottom (Ostrom and Gardner, 1993).

During periods of water scarcity, the situation of tail-end users deteriorates even more, and they are forced to bear the brunt of the consequences more than head and middle-reach farmers. There are few instances where farmers incur more transaction cost in obtaining the water for irrigation purpose (Ravi *et al.* 2018). Water scarcity limits farming options, lowers crop yields, reduces income and job opportunities and also increases food insecurity in the tail-end reach compared to the head and middle reach. In the irrigated basin, a designed cropping pattern was established to embrace semi-arid crops, although water intensive crops such as paddy dominated.

In the Tungabhadra command area, rule violations (regarding irrigation water consumption and prescribed cropping pattern) are common and difficult to monitor (Umesh and Puttaiah, 2013). Also, the agricultural sector competes for water with other sectors such as drinking, industry, and the environment. Economic output by the agriculture sector is lesser than the other sectors but livelihood dependency is higher in agriculture. With this backdrop, this study was conducted to identify the inequality in food consumption across different water regimes, and to assess vulnerability to food and nutritional insecurity as influenced by the water availability.

METHODOLOGY

Sampling procedure

Gangavathi taluk of Koppal district, which falls under the Tungabhadra command region of

Karnataka, which is known as "Rice Bowl of Karnataka" was purposefully chosen for the study, since substantial portion of the *taluk* comes under the Tungabhadra command area. The region of Gangavathi is nicknamed as rice bowl of Karnataka. There are many rice mills in Gangavathi taluk, and it is believed that the mills hull and process a million tonnes of rice each year. Villages in *Gangavathi taluk's* irrigation system were chosen with the presumption that people' vulnerability would increase as access to reliable irrigation water decreased. To illustrate different water availability regimes, forty farmers were chosen from the head, middle, and tail reaches of the Tungabhadra left bank canal comprising a total of 120 sample farmers as respondent.

Nature and sources of data

Both primary as well as secondary data were used for the study. Primary data pertains to the agricultural year 2019-20 comprising information on socioeconomic status, land holdings, monthly income and expenditure, food consumption patterns, etc. were collected from the sample respondents using a structured interview schedule through survey. The information gathered was solely based on the respondents' recollections, hence, to reduce personal bias, the sample respondents were categorically convinced about the reason for which the data was collected during the time of survey.

The district and *taluk* wise data pertaining to the area occupied by different crops were collected from Directorate of Economics and Statistics (DES), Government of Karnataka, Bengaluru. The details about the command area, water inflows, outflows and utilization of water from different canal systems of Tungabhadra command area were collected from Command Area Development Authority, Tungabhadra Project, Munirabad. The National Institute of Nutrition (NIN), Hyderabad, under the Indian Council of Medical Research (ICMR), provided statistics on the nutritional value of Indian foods and the derivative of consumptive units (CU) (Gopalan *et al.* 2007). The figures for the Recommended Dietary Allowances (RDA) for calories, protein, fat, calcium, and other nutrients for Indians were obtained from the expert group's paper "Nutritive requirements and recommended dietary allowances for Indians" (Anon., 2010).

MATERIALS AND METHODS

Assessment of food insecurity

Vulnerability to food insecurity: If the food budget share is high, the household is likely to expose more to food insecurity. Based on the share of total expenditure for food items, the following categories were made to describe a household's vulnerability to food insecurity (Asghar, 2011).

More than 75 per cent	:	very high vulnerable to food insecurity
65 to 75 per cent	:	high vulnerable to food insecurity
50 to 65 per cent	:	medium vulnerable to food insecurity
Less than 50 per cent	:	low vulnerable to food insecurity

Inequality analysis: In any distribution, the Gini coefficient is a measure of inequality. It is mathematically defined by the Lorenz curve. It's the area under the uniform distribution line divided by the area between the distribution's Lorenz curve and the uniform distribution line. The uniform distribution line is a diagonal line that divides the graph into two equal halves at a 45-degree angle. The Gini coefficient ranges from 0 to 1, in which perfect inequality in the distribution is represented by the number one, whereas perfect equality is represented by the number zero. The Gini coefficient was used to examine food consumption expenditures and income inequality by household and cross the three water regimes. The coefficient was calculated using the formula,

$$G = 1 + \frac{1}{n} - \frac{1}{n^2 Y}\left[Y_1 + 2Y_2 + 3Y_3 + \ldots + nY_n\right]$$

Where,

G = Gini coefficient

Y = Mean income

$Y_1 \ldots\ldots\ldots Y_n$ = Monthly household consumption expenditures / net income per household in the descending order.

n = Population size

Assessment of nutritional security

To analyse the nutritional security of households, Kiresur and Chourad (2015) used the security ratio, which is defined as the ratio of actual to recommended energy consumption, according to the ICMR. The recommended dietary allowances (RDA) are the amounts of essential nutrient consumption that are regarded appropriate or sufficient to meet the nutrient needs of virtually all (97 to 98 percent) healthy individuals in a given life stage and gender group. The actual energy intake of farm households was gathered for this study, and the security ratio was determined using the ICMR's RDA. The following categories were formed based on the ratios:

Nutritionally secured households	:	> 1
Moderately nutritionally insecure households	:	0.8 - 0.99
Mildly nutritionally insecure households	:	0.5 - 0.79
Severely nutritionally insecure households	:	< 0.5

Food consumption pattern of farm households

In their study, Gopalan *et al*. (2007) used (Annexure 1) to indicate the nutritive value of Indian food products per 100 g of consumption. The same table was used to compute the food consumption patterns of farm households in this study and conclusions were drawn on nutritive value of food items consumed by the households per month.

Concepts and definitions

1. ***Household:*** A household is made up of people who live in the same house and eat from the same kitchen. Temporary visits are usually not allowed.
2. ***Household consumption expenditure:*** The consumption expenditure of a household is the amount spent on domestic consumption during the reference period. Household consumption expenditure is the sum of the monetary values of consumption for two types of products: (a) food, and (b) non-food items such as gas bills, fees, travel and entertainment expenses, clothing, and other durable goods.
3. ***Consumptive Unit (CU):*** One Consumptive Unit (CU) is equal to the energy intake of an average male doing moderate work, and the other coefficients are based on calorie requirements compared to an adult moderate man. A daily energy requirement of 2320 kcal is equal to one CU unit.
4. ***Group of food consumption items:*** Different items of consumption considered were (a) cereals (b) pulses (c) vegetables (d) fruits (e) oils and fats (f) sugar and jaggery (g) milk and milk products and (h) egg and meat.
5. ***Household consumption method:*** Based on monthly household intake, this approach calculates energy and nutrient consumption. As a result, daily calorie and nutrient availability per person was calculated.
6. ***Head, mid and tail reach:*** The total length of the canal in Gangavathi *taluk* was divided into three parts based on the length along the canal from the dam. Fig. 1 and 2 of Annexure depicts the location of the project area and three water regimes of TCA project respectively.
   - Head reach : 0-15 km length along the canal from the dam
   - Mid reach : 15-30 km length along the canal from the dam
   - Tail reach : Beyond 30 km length along the canal from the dam

Due to the guaranteed availability of canal water, the crops produced in the study region's head reach was primarily paddy and a small portion of sugarcane. Paddy, cotton, and chickpea were the main crops in the middle reach, whereas, tail-end farmers' grow paddy, chickpea, sorghum, and cotton.

RESULTS AND DISCUSSION

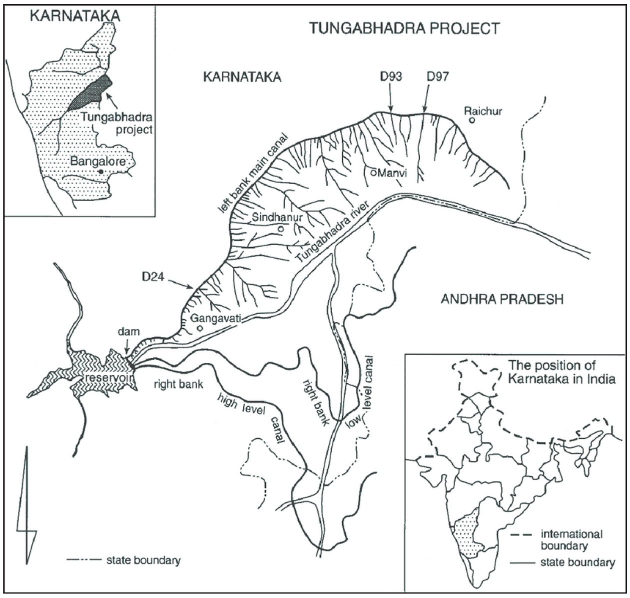
The results and discussion part of this study has been divided into four parts for better understanding of the results viz., (i) inequality in food consumption expenditures and incomes, (ii) Assessment of vulnerability to food insecurity, (iii) Nutritional security status of households and (iv) Food consumption pattern.

Inequality in food consumption expenditures and incomes

Inequality in the food consumption expenditure and monthly income per household is presented in Table 1. It is evident that inequality in food consumption expenditure per household was slightly higher for head-reach households (0.62) in comparison to middle reach households (0.59) and tail-end reach households (0.58). There is a high degree of income inequality among tail-end reach household because they were more vulnerable to the irrigation water deficits than that of the head and middle-reach households.

Table 1: Inequality in food consumption expenditures and incomes

Particulars	Food consumption expenditure per household per month (Gini-coefficient)	Monthly income per household (Gini-coefficient)
Head-reach (n=40)	0.62	0.83
Middle reach (n=40)	0.59	0.84
Tail-end reach (n=40)	0.58	0.85

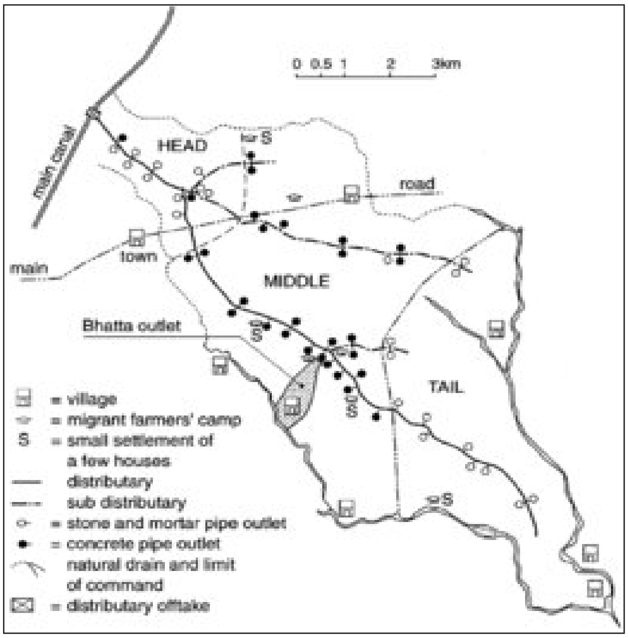


Source: *Mollinga, 2003*

Fig. 1: Location of Tungabhadra Left Bank Canal irrigation project

Assessment of vulnerability to food insecurity

The assessment of vulnerability to food insecurity is presented in Table 2. In head-reach regime, households experienced "low" vulnerability to food insecurity as they spent about 48.47 per cent of their total expenditure on food. Middle and tail-end reach farm households were more vulnerable to food insecurity because they are more likely to face irrigation water shortage compared to the head reach farm households due to which, they could not cultivate second/summer crop leading to low level of income than that of head-reach farm households.



Source: *Mollinga, 2003*

Fig. 2: Head-middle-tail zones of the Tungabhadra command area

The households of the head-reach regime were able to take up the summer/second crop during water deficit years also, hence they were able to maintain their household income from crop production, which making them less vulnerable to food insecurity.

Table 2: Assessment of vulnerability to food insecurity

Particulars	Proportion of food consumption expenditure (%)	Vulnerability to food security
Head-reach (n=40)	48.47	Low
Mid-reach (n=40)	65.15	High
Tail-end reach (n=40)	66.01	High
Total (n=120)	61.13	Medium

The findings show that, while both middle and tail end reach farm households were classified under high vulnerable to food insecurity category, there was a little difference in food consumption expenditure between them, indicating that tail end water users were more vulnerable than middle reach water users. The findings clearly illustrate that as irrigation water scarcity increases, households become more vulnerable to food insecurity, demonstrating a clear negative link between irrigation water scarcity and food security in the command area water regimes.

Nutritional security status of households

According to the FAO (2009), nutrition security implies "physical, economic and social access to balanced diet, clean drinking water, safe environment, and health care (preventive and curative) for every individual. There is a strong link between poverty, food security, nutritional security and agriculture especially in developing countries like India, and this has long been recognized and hence included in the Sustainable Development Goals (SDGs) of the United Nations. The details of the household nutritional security status of three different water access regimes were shown in Table 3.

Table 3: Nutritional security status of households

Nutritional security status	Head-reach	Mid-reach	Tail-end reach
Number of households			
Secured (> 1.00)	13	05	06
Moderately insecured (0.80-0.99)	06	09	04
Mildly insecured (0.50-0.79)	19	25	24
Severely insecured (< 0.50)	02	01	06
Total no. of households	40	40	40
Proportion of households (per cent)			
Secured (> 1.00)	32.50	12.50	15.00
Moderately insecured (0.80-0.99)	15.00	22.50	10.00
Mildly insecured (0.50-0.79)	47.50	62.50	60.00
Severely insecured (< 0.50)	05.00	2.50	15.00
Total	100	100	100

The nutritional security ratio was determined for each household in this study, and the number of

Table 4: Food consumption pattern of farm households in TCA based on household monthly consumption (n=120)

Sl. No.	Food items	Daily intake of food per CU (g)	Nutrient contribution									
			Energy (kcal)	Proteins (g)	Fats (g)	Calcium (mg)	Iron (mg)	Thiamine (mg)	Riboflavin (mg)	Niacin (mg)	Vitamin C (mg)	Carotene (µg)
1	Rice	205.68	709.60	13.99	1.03	20.57	1.44	0.12	0.12	3.91	0.00	0.00
2	Jowar	128.99	450.17	7.17	1.31	17.25	2.83	0.18	0.10	2.01	0.00	0.00
3	Wheat	96.03	327.47	7.26	1.02	28.81	2.94	0.29	0.10	2.58	0.00	17.41
4	Ragi	24.05	78.88	1.76	0.31	82.73	0.94	0.10	0.05	0.26	0.00	10.10
5	Gram	8.99	33.44	1.87	0.50	5.03	0.48	0.04	0.02	0.22	0.09	11.60
6	Tur dal	23.20	77.72	5.17	0.39	16.94	0.63	0.10	0.04	0.67	0.00	30.62
7	Tomato	49.92	9.98	0.45	0.10	23.96	0.32	0.06	0.03	0.20	13.48	175.22
8	Onion	68.99	40.70	1.24	0.07	27.60	0.83	0.06	0.01	0.34	1.38	10.35
9	Potato	45.86	44.48	0.73	0.05	4.59	0.22	0.05	0.00	0.09	7.80	11.01
10	Other vegetables	70.25	16.86	0.98	0.21	12.65	0.27	0.03	0.08	0.63	8.43	51.99
11	Fruits	14.20	16.47	0.17	0.04	2.41	0.05	0.01	0.01	0.01	0.99	11.08
12	Oil	36.85	331.65	0.00	36.8	0.00	0.00	0.00	0.00	0.00	0.00	276.38
13	Milk	190.30	127.50	6.09	7.80	228.36	0.38	0.10	0.36	0.19	3.81	100.86
14	Sugar	9.04	35.98	0.01	0.00	1.08	0.01	0.00	0.00	0.00	0.00	0.00
15	Meat	17.99	19.61	4.66	0.11	4.50	0.00	0.00	0.03	0.00	0.00	0.00
16	Egg	1.72	2.98	0.23	0.23	1.03	0.04	0.00	0.01	0.00	0.00	7.22
Total		**992.06**	**2323.49**	**51.78**	**49.97**	**477.51**	**11.38**	**1.14**	**0.96**	**11.11**	**35.98**	**713.84**

households falling into different nutritional security categories were counted individually for different regimes. This counting allows us to determine the number of households in each of the three regimes that are extremely food insecure, allowing us to better understand the relationship between irrigation water limitations and nutritional security. Households with mild and severe nutritional insecurity were more prevalent in the mid and tail-end reach regimes than in the head reach regime. Another noteworthy take away from the table was that, even under the head reach regime, only 32.50% of households were fully nutritionally secure, which is less than half of the respondents, indicating that the severity of the nutritional security crisis in the region. The majority of households in all three regimes were mildly food insecure, and the problem was more severe in the tail-end, followed by the middle and head reach. The findings are consistent with the findings of Nagesh (2016).

Food consumption pattern

The food consumption pattern of the farm households on monthly basis is presented in Table 4. The consumption of an adult moderate man (equivalent to one CU) was highest from rice (205.68 g), followed by milk (190.30 g), jowar (128.99 g), wheat (96.03 g) and vegetables (70.25 g). Highest quantum of energy was derived from rice (709.60 kcal), followed by jowar (450.17 kcal) and oil (331.65 kcal), which indicates that major staple food of the households in that region was rice followed by jowar, which are extensively grown in the area. The highest amounts of protein were obtained from rice (13.99 g), followed by wheat (7.26 g), jowar (7.17 g), and milk (6.09 g). The food consumption pattern of the region helps to explain high overall dietary diversity of the region. Since rice and jowar are the main source of energy in this area, efforts should be made to increase the nutritional benefits of these items through schemes like food fortification and ensuring availability of such fortified foods through public distribution system (PDS).

CONCLUSION AND POLICY RECOMMENDATIONS

This study tried to link irrigation water shortage and food and nutritional security across different water access regimes in the study area. From the empirical evidences, it was observed that there is a negative relation between food security and the irrigation water shortage in the Tungabhadra command area. The monthly income and monthly expenditure data of the farm household indicated that the degree of inequality of monthly income was higher in case of tail-end households followed by middle and then head reach households showing a high degree of income inequality among tail-end reach household. Both in middle-reach and tail-end reach, the households were highly vulnerable to food insecurity as they spent higher proportion (65 to 75 per cent) of their total expenditure on food alone.

It would also be a misjudgment to believe that just irrigated agriculture plans are affected. We need to understand that a land-use decision is also a water-use decision. This problem of water use among the head reach and tail end reach farmers cannot be solved completely unless a focused and integrated plan for irrigation water is implemented and monitored regularly. We can also say that irrigation water shortage problem among the end users of the stream is a geographical problem and much can't be done in this case. Use of a plan which is centered on increasing rain-fed agriculture through adoption of techniques to make better use of rainfall can be implemented and land-use as well as water-resource issues must be analyzed together in order to plan for future food security. On the other hand, direct benefit schemes from the concerned authorities is critical to close the gaps in existing food and nutritional programmes with better targeting and monitoring, as well as to address the multifaceted drivers of food and nutritional insecurity as soon as possible.

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ANNEXURE

Annexure 1: Nutritive value of Indian food items per 100 g of consumption

Food items	Energy (kcal)	Protein (g)	Fat (g)	Calcium (mg)	Iron (mg)	Thiamine (mg)	Riboflavin (mg)	Niacin (mg)	Vitamin C (mg)	Carotene (µg)
Rice	345.00	6.80	0.50	10.00	0.70	0.06	0.06	1.90	0.00	0.00
Ragi	328.00	7.30	1.30	344.00	3.90	0.42	0.19	1.10	0.00	42.00
Wheat	341.00	12.10	1.70	48.00	4.90	0.49	0.17	4.30	0.00	29.00
Tur dal	335.00	22.30	1.70	73.00	2.70	0.45	0.19	2.90	0.00	132.00
Grams	372.00	20.80	5.60	56.00	5.30	0.48	0.18	2.40	1.00	129.00
Onion	59.00	1.80	0.10	40.00	1.20	0.08	0.02	0.50	2.00	15.00
Tomato	20.00	0.90	0.20	48.00	0.64	0.12	0.06	0.40	27.00	351.00
Potato	97.00	1.60	0.10	10.00	0.48	0.10	0.01	0.20	17.00	24.00
Beans	158.00	7.40	1.00	5.00	2.60	0.34	0.19	0.00	27.00	34.00
Green leafy vegetables	45.00	4.00	0.05	397.00	3.49	0.03	0.30	1.20	99.00	5520.00
Other vegetables	24.00	1.40	0.30	18.00	0.38	0.04	0.11	0.90	12.00	74.00
Fruits	116.00	1.20	0.30	17.00	0.36	0.05	0.08	0.05	7.00	78.00
Oil	900.00	0.00	100.00	0.00	0.00	0.00	0.00	0.00	0.00	750.00
Groundnut	561.00	25.30	40.10	90.00	2.50	0.90	0.13	19.90	0.00	37.00
Coconut	444.00	4.50	41.60	10.00	1.70	0.05	0.10	0.80	0.10	0.00
Sugar	398.00	0.10	0.00	12.00	0.16	0.00	0.00	0.00	0.00	0.00
Milk	67.00	3.20	4.10	120.00	0.20	0.05	0.19	0.10	2.00	53.00
Egg	173.00	13.30	13.30	60.00	2.10	0.10	0.40	0.10	0.00	420.00
Meat	109.00	25.90	0.60	25.00	0.00	0.00	0.14	0.00	0.00	0.00

Source: *Gopalan et al. (2007).*