INTERNATIONAL FOOD POLICY RESEARCH INSTITUTE

IFPRI

IFPRI Discussion Paper 01742

July 2018

Increasing Food System Resilience for Nutrition Sensitivity and Sustainability: A Decentralized Analysis for India

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ABSTRACT

Enhancing food security in vulnerable regions requires both short- and long-term investments. Even though targeted interventions are needed for short-term relief, building resilient food systems is crucial for providing continued food and nutrition security. Resilient food systems have the capacity to bounce back to normal or higher levels of food supply after a shock. Moreover, tracking and measuring food system resilience is critical. Because the current system lacks indicators to measure food system resilience, this paper develops a conceptual framework that can be used to measure food system resilience. We use nutrition sensitivity and sustainability of the food system as the key indicators of food system resilience outcomes. Because changes in food consumption patterns can impact both the nutrition sensitivity of a food system and its sustainability, we analyze the food consumption patterns at the national, state, and district levels in the context of India, and use the results of this analysis to provide strategies to build a resilient food system. Changes in food consumption patterns offer opportunities for introducing new foods into the farming system and can have significant implications for achieving food system resilience.

Keywords: resilience, food system, nutrition-sensitive agriculture, decentralization, sustainability, consumption and dietary patterns, South India.

ACKNOWLEDGMENTS

The authors would like to thank S. Mohammad Arif, S. Abdul Mannan, and N. Swathi for collecting requisite data from both rural and urban sample households of Kurnool district. This work was undertaken as part of the CGIAR Research Program on Policies, Institutions, and Markets, led by the International Food Policy Research Institute, and benefited from research and writing assistance by Namita Paul.

1. Introduction

Nutrition policy making and program interventions in developing countries continue to bring together several sectors that contribute to nutrition improvement. Yet the progress toward reducing malnutrition in all forms has been extremely slow (Development Initiatives 2017). Reaching the Sustainable Development Goals of eliminating hunger and eradicating poverty has become a key development objective in most developing countries. However, the approach to implementing food security and nutrition interventions continues to be through nutrition-specific programs, rather than through those that integrate nutrition goals into the existing agricultural and rural development interventions and thereby result in a nutrition-sensitive food system (FAO 2017). This shift in the paradigm is imperative to speed up the process of hunger reduction and elimination of malnutrition in all forms (HLPE 2017). In addition, the approach to integrating nutrition goals involves the food system as a whole, which has much more to offer in terms of achieving the nutrition objective if its elements are made nutrition sensitive at all stages. Operationalizing this approach to a nutrition-sensitive food system has been a challenge because there is no well-documented evidence for the design and implementation a food systems approach to nutritional outcomes in various locality-specific contexts. To keep up with the changing demands for food products, production patterns also need to change to ensure that the food system is nutrition sensitive and sustainable. The strategies to make a food system both sustainable and nutrition sensitive may work against each other and will require context-specific approaches to identify opportunities for mainstreaming nutrition goals at the local level of decision making that do not compromise the sustainability goals. Few attempts have been made to address the nutrition and sustainability goals in the food system context (Pinstrup-Andersen 2011).

In this paper, we present steps to improve food system resilience using changing consumption patterns. First, we analyze currently changing patterns at the national, state, and district levels in India. For the purpose of this paper, we use data from Andhra Pradesh for state-level analysis and from Kurnool district in Andhra Pradesh for district-level analysis. Using this analysis, we provide potential strategies that can be implemented to develop sustainable production systems that meet the food and nutrition needs of the population. Because the consumption patterns in India have changed over the past few decades, it is important to develop strategies that promote nutrition and improve the quality of inputs used for crop production to develop a resilient food system.

The rest of the paper is organized as follows. Section 2 provides an overview of the literature and the country context. Section 3 provides the conceptual framework developed in this paper, the area studied in depth, and the data and methodology used. Section 4 presents the results, explaining how the consumption pattern in India has changed at the national, state, and district levels. Section 5 presents strategies to improve resilience at the district level, and concluding remarks are presented in Section 6.

2. Context and Literature Review

Food systems are complex networks of individuals and institutions that provide food for everyone (Pinstrup-Anderson 2012, FAO and WHO 2013). They determine the availability, affordability, accessibility, and quality of the food. A food system gathers all the elements (environment, people, inputs, processes, infrastructures, institutions, and so on) and activities that relate to the production, processing, distribution, preparation, and consumption of food, and the outputs of these activities, including socioeconomic and environmental outcomes (HLPE 2017).

The current global food systems are becoming increasingly vulnerable due to climate change and extreme weather events, a rising middle class, urbanization, a changing diet, agriculture-related risks, growing land and water constraints, persistent conflicts, and increased inequality (Fan, Pandya-Lorch, and Yosef 2014). Thus, developing food systems that meet the nutrition requirements of the population and are sustainable is crucial. Further, it is important that these food systems be resilient in case of shocks such as droughts, famines, or human-made disasters, such as conflicts. Climate change and variability, as well as more severe and frequent natural disasters such as floods and droughts, will impact the health, productivity, and resilience of ecosystems, communities, and households, particularly of the most vulnerable. Food systems need to adapt to climate change and can make a significant contribution to its mitigation. The production and consumption patterns in a region are a major determinant of the nature of the components of a food system. Understanding food production and consumption patterns helps us to begin to link food supply and demand to the challenges of the food system.

In order to cope with and recover from shocks such as those mentioned, it is important to increase the resilience of current food systems. A resilient food system is one in which people, communities, countries, and global institutions can prevent, anticipate, prepare for, cope with, and recover from shocks, and not only bounce back to where they were before the shocks occurred, but become even better off (IFPRI 2014). As a framework, resilience presents a systems-oriented way of coping with shocks (Fan, Pandya-Lorch, and Yosef 2014), whereby food systems can help countries to transition from a relief stage to a development path (Babu and Blom 2014). Both food and nutrition security are important elements of individual resilience. Further, they also enhance the resilience of whole economies by improving the health and productivity of individuals. Therefore, we need to build resilient food and agriculture systems in order to preserve food availability and access in case of both small and large shocks (Fan, Pandya-Lorch, and Yosef 2014). Shocks include both natural disasters, such as floods and droughts, and human-made disasters, such as conflicts. Both of these shocks can increase food prices. Zseleczky and Yosef (2014) provide an overview of recent shocks and suggest that although some shocks have not increased, the severity of other shocks will continue to rise. Investing in early warning systems, infrastructure, education, and sustainable agriculture will enable people to prepare for and withstand these shocks because shocks have both immediate and long-term consequences, and resilience focuses on both of them (Hoddinott 2014).

As seen from the recent effort to create special programs for food security and nutrition, the government of India has also mainstreamed nutrition objectives as part of its rural development programs. The recently initiated National Nutrition Initiative is one example. India is the second-largest food producer in the world after China (Ross 2015). According to government of India estimates, for fiscal year 2015–2016, the country's total food market was valued at US $39.71[1] billion, and it is projected to double in the next 10 years (Rastogi 2017). Having successfully attained national self-sufficiency in food, India benefits from a marginal surplus in production and is among the leading global producers of pulses, fruits and vegetables, milk, and other food products. Table 1 compares India's agriculture production with that of the entire world.

[1] Currency for all money mentioned in this report is US dollar.

Table 1: India's production position in world agriculture, 2014

Item	India	World	% Share	India's rank
Total area (million hectares)	329	13,467	2.4	7th
Land area	297	13,009	2.3	7th
Arable land	156	1,417	11.0	2nd
Population (millions)				
Total population	1,295	7,266	17.8	2nd
Rural population	857	3,364	25.5	1st
Crop production (million metric tons)				
(a) Total cereals	295	2,819	10.5	3rd
(b) Total pulses	20	78	25.8	1st
(c) Vegetables & melons	127	1,169	10.8	2nd
(d) Fruits, excluding melons	88	690	12.8	2nd
Livestock (million head)				
(a) Cattle	187	1,475	12.7	2nd
(b) Buffalo	110	194	56.6	1st
Animal products (thousand metric tons)				
(a) Milk total	146,314	801,649	18.3	1st
(b) Eggs (primary) total	3,965	75,524	5.3	3rd
(c) Meat total	6,601	31,7855	2.1	6th

Source: FAO (2016).

Over the past two decades, although India showed significant growth in terms of population, gross domestic product, food grain production, and per capita consumption, along with phenomenal industrial progress, the nation has been unable to provide access to food to a large number of its people, especially women and children. India had one of the world's lowest per capita daily supplies of calories and protein in 2014–2015, according to the Organization for Economic Co-operation and Development (OECD) (cited in Jain 2015). In India, low per capita food availability at the national level (calculated as production plus imports minus exports divided by the population) is largely a reflection of high poverty, which makes it difficult for a large fraction of the population to access nutritious food (Jain 2015). However, India reduced its poverty rate to 12.4 percent in 2015–2016, from the 2011–2012 estimate of 21 percent, according to new data released by the World Bank (2017), which identified rural electrification as an important driving factor for everything from greater rural spending to schooling for girls. Against the earlier estimate of 269 million people living below the poverty line (BPL) in 2011–2012, according to government data, by 2015–2016, India had 172 million people living BPL (IndiaSpend 2015), although the World Bank has revised the poverty line upward[2]. As per the Food and Agriculture Organization of the United Nations (FAO 2015), India is the world's second-largest food producer yet is also home to the second-highest population of undernourished people in the world. India is ranked 97th among the 118 countries surveyed in 2016 for the Global Hunger Index (GHI), scoring 28.5 on the 100-point scale of the index (von Grebmer et al. 2017). The GHI report describes India's hunger situation as "serious" (von Grebmer et al. 2017). In contrast, Brazil, Russia, China, and South Africa, all of whom share the BRICS high table with India, have single-digit scores. India's neighbors, including Bangladesh, Nepal, Sri Lanka, and Myanmar, have better GHI scores as well (von Grebmer et al. 2017). This contradiction remains a puzzle and is further explored in this paper in the context of the food systems approach.

Table 2 presents the per capita availability of macronutrients, fruits, and vegetables across some selected countries, including India. In 2014–2015, the average Indian had access to 2,455 kcal per day, with protein and fat availability at 60.0 g and 52.1 g, respectively. This is far lower than the 3,000 or more kcal per day available to OECD nations.

Table 2: Per capita availability of macronutrients, fruits, and vegetables across selected countries, 2014–2015

Country	**Per capita availability**			
	Calories (kcal/day)	**Proteins (g/day)**	**Fruits (kg/year)**	**Vegetables (kg/year)**
China	12,161	407.2	347.9	666.1
Turkey	3,680	104.8	122.9	241.0
US	3,639	109.2	97.1	113.1
UK	3,414	102.7	125.7	94.1
Russia	3,358	101.3	68.4	109.7
Brazil	3,286	94.5	139.2	53.9
Mexico	3,028	85.4	100.7	51.6
South Africa	3,007	83.5	39.1	45.3
Indonesia	2,712	61.2	66.2	41.3
India	**2,455**	**60.0**	**51.5**	**80.5**

Source: FAO (2016).

As of 2014, India ranked second in world rice and wheat production, contributing slightly more than 21 percent and 13 percent, respectively, of world paddy and wheat output (2014). Food grains constitute 62.3 percent of the gross cropped area, although they account for less than 25 percent of the total value of the output of agriculture and allied activities (India, MoAFW/DES 2017). In India, there is an imbalance in the cropping pattern of food grains because a large proportion of the area under food grains is occupied by cereals. Food grains occupied an area of 97.32 million ha in 1950–1951 and have increased to 122.65 million ha in 2015–2016. Over these years, the area under pulses and under cereals such as rice and wheat has grown, but that under coarse cereals and millets has decreased (Table 3).

[2] The global poverty line represents the ability to live on $1.90 (equal to 123.5 Indian rupees, or Rs) per day, up from $1.25 (Rs 81). The World Bank made this change to reflect differences in the cost of living across countries based on 2011 prices—in other words, to adjust for inflation and other economic variables.

Table 3: Shifts in the production pattern, in million ha, from coarse cereals and millets toward paddy and wheat in India

Year	Paddy	Wheat	Coarse cereals	Total cereals	Pulses	Total food grains
1950–1951	30.81	9.75	37.67	78.23	19.09	97.32
2015–2016	43.39	30.23	23.78	97.40	25.26	122.65

Source: India, MoAFW/DES (2017).

Table 3 shows that paddy is the major cereal crop among food grains and experienced a gradual increase in area, along with wheat. But coarse grains, such as sorghum (*jowar*), pearl millet (*bajra*), and maize, showed a decline in area. If we study the area of cultivation of food grains and nonfood grains, there was a gradual shift from nonfood grains to food grains. This is because the prices of food grains have been rising quite fast, and farmers have started growing food crops in a way similar to the way they grow commercial crops such as cotton, oilseeds, sugarcane, and so on. Cultivation of food grains has become highly remunerative and productive under the influence of new technology. Traditionally, the minimum support prices for wheat and rice have been maintained reasonably high in comparison with support prices for millets such as sorghum (*jowar*) and pearl millet (*bajra*). This has helped farmers to increase their production. Thus, consumers in the country are moving away from inferior cereals, such as sorghum and pearl millet, to superior grains, such as wheat and rice.

Moreover, there is a drastic increase in production of high-value food products such as milk, eggs, meat, fruits, and vegetables (Table 4), and the consumption pattern is now moving away even from superior cereals and toward these high-value food products. This income-induced diet diversification is a natural corollary, because the income elasticity for cereals is negative in India but positive for high-quality foods. This change is occurring among both rural and urban households. Another factor contributing to the change in the consumption pattern is increasing urbanization. Since 1991, reforms under the banner of liberalization-privatization and globalization have also played an important role in the transformation of the food consumption patterns of Indian households. There has been a significant increase in imports of fresh fruits such as apples, dry fruits such as almonds, and processed food products following removal of trade restrictions (NCAER 2014).

Table 4: Trends in production of high-value food products in India

Year	Milk (metric tons)	Eggs (billions)	Meat ('000 metric tons)	Fish ('000 metric tons)	Fruits ('000 metric tons)	Vegetables ('000 metric tons)
1985–1986	44.0	16.1	5,514.0*	2,876.0	28,632.0#	58,532.0#
2015–2016	155.5	82.9	7,020.0	10,796.0	91,443.0	166,608.0

Source: India, MoAFW/DES (2017).
Note: * 2011–2012; # 1991–1992.

There is a drastic increase in production of high-value food products such as milk, egg, meat, fruits and vegetables (Table 4) and the consumption pattern is now moving away even from superior cereals towards these high value food products. This income-induced diet diversification is a natural corollary, as for cereals the income elasticity is negative in India, and the same for high-quality food is positive. This change is occurring both among rural and urban households (Table 5). Other factors contributing to the change in the consumption pattern is the increasing urbanization. Since 1991, Liberalization-Privatization and Globalization (LPG) reforms have also played an important role in the transformation of food consumption patterns of Indian households. There has been a significant increase in imports of fresh fruits such as apple, dry fruits such as almonds and processed food products following removal of trade restrictions (NCAER, 2014).

Table 5: Trends in nutrition transition due to changes in the consumption pattern of food items at national level

Food Product	1993–1994		2011–2012	
	Rural	Urban	Rural	Urban
Calories (kcal/day)	2,153	2,071	2,099	2,058
Proteins (g/day)	60.2	57.2	56.5	55.7
Fat (g/day)	31.4	42	41.6	52.5

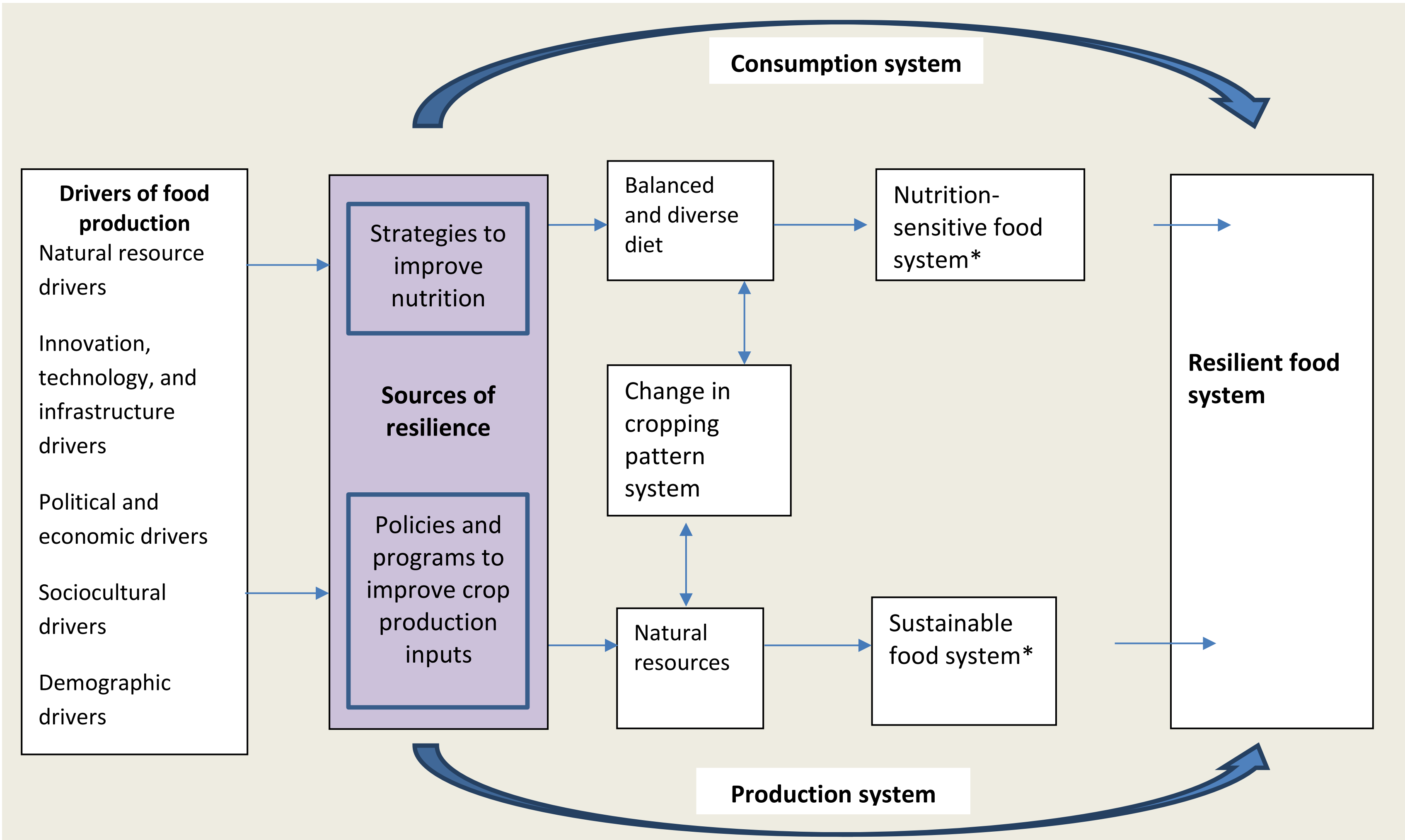
Source: NSSO (various dates).

3. Conceptual Framework

This section fills in gaps in the current literature by presenting a conceptual framework that can be used to measure indicators of system resilience. To do so, we measure whether the current food system is nutrition sensitive and sustainable. A food system is nutrition sensitive if the entire food chain (production, processing, retail, consumption, and so on) places emphasis on the consumption of micronutrient-rich foods through a variety of market and nonmarket interventions (Pingali and Sunder 2017). For the entire food system to be nutrition sensitive, its individual components need to focus on nutrition outcomes to enhance the diversity, quality, and safety of the food available to the population. Part of this approach is the need to promote dietary diversity because diverse diets are balanced in terms of calories, protein, and micronutrient intake (Arimond et al. 2010, Arsenault et al. 2013, Kant 2004). Further, for a nutrition-sensitive food system to be resilient, it is crucial that all interventions be sustainable. A sustainable food system is a system that ensures food security and nutrition for all without compromising the economic, social, and environmental bases of the system for future generations. In many cases, current practices of food production, processing, storage, distribution, and consumption are depleting natural resources and polluting the environment, even as the present food systems do not meet the changing dietary and nutritional requirements of the population. As a result, there is a need to transform the existing food system and its contribution toward providing food and nutrition security for all (HLPE 2017).

The conceptual framework presented in Figure 1 shows how we can use nutrition sensitivity and sustainability as the indicators to measure the resilience of a food system. In this paper, we start by examining district-level food consumption patterns. Understanding current consumption patterns is crucial because in the event of a shock, it allows us to develop strategies to improve the nutrition intake of the population. Similarly, on the production side, policies and programs to improve the use of crop production inputs can be implemented based on consumption patterns. This will allow us to alter our current production systems to meet the nutrition needs of the population and ensure that the agricultural production system is sustainable in the long run.

Figure 1: Conceptual framework: Measuring food system resilience



Source: Authors' compilation.
Note: * Indicators of system resilience.

Area Description, Data, and Methodology

In this paper, we study the food consumption pattern at the national, state, and district levels in India. For the purpose of this paper, we use data from Andhra Pradesh for state-level analysis and from Kurnool district in Andhra Pradesh for district-level analysis. National-level and state-level data were collected by the National Sample Survey Organization (NSSO), and district-level consumption data were collected by the authors. Figure 2 presents the map of India and highlights both the state and the district studied in this paper.

Figure 2: Map showing Andhra Pradesh state (inset) and Kurnool district (in red)

Source: Maps of India (2018).

Despite being the largest of the four districts of Rayalaseema region, Kurnool district remains the backward region of Andhra Pradesh. It is identified as being in the Scarce Rainfall Zone of Andhra Pradesh, with an annual rainfall of 500 to 750 mm (average rainfall in the state is approximately 670 mm). Kurnool district has limited water resources. The main source of irrigation in the district is project canals (112,000 ha of the total irrigated area). The total area that benefits from major irrigation under the KC (Kurnool-Cuddapah) Canal, the Tungabhadra Low-Level Channel, and the Telugu Ganga Project is 100,000 ha. Important medium-size irrigation projects are Zurreru, Sanjeevaiah Sagar, and Varadarajaswamy Gudi, which together irrigate 4,836 ha of land. Under minor irrigation projects/canals, the Guru Raghavendra Project, the Srisailam Right Bank Canal, and the Tungabhadra Project High-Level Canal irrigate 6,527 ha. The gross cropped area of the district is 1,035,000 ha, of which 289,000 ha were irrigated through canals, tanks, wells, and other sources during 2011–2012. Because 72 percent of the agricultural area in Kurnool district is under rainfed farming systems, the farmers are vulnerable to drought, and this suggests the need for building a resilient food system (Naik 2015).

Agriculture in the Kurnool district is predominantly a "fallow-chickpea" cropping system. The major crops grown in the district are chickpeas, groundnuts, sunflowers, rice, sorghum, cotton, pigeon peas, black gram, and onions. Over the last 20 years, there has been a significant shift in the production pattern. Constraints such as low rainfall, labor scarcity, increasing wage rates, and a lack of adequate irrigation sources have encouraged farmers to cultivate water-efficient rainfed crops that require minimal labor. As a result, the amount of land dedicated to chickpeas, groundnuts, and sunflowers has increased. Additionally, most of the farm households' rear livestock in the backyard, the most common being buffalo, cows, sheep, and goats.

The rural population in drought-prone Kurnool district is generally at risk for undernutrition owing to their poverty, illiteracy, dependence on primitive agricultural practices, and poor personal and environmental hygienic practices. In addition, lack of access to health care, poor communication, and traditional beliefs and customs aggravate the situation. The rural and urban populations constitute 66 and 33 percent, respectively, of the total population of Kurnool district.

At the national level, the existing dietary consumption pattern has changed rapidly, especially during the first decade of the 21st century. Today this challenge is more complex in the context of increasing urbanization, along with gross inequalities between rural and urban households. In light of these changes, we conduct an in-depth analysis of the food consumption pattern among rural and urban households in Kurnool district. This serves to help us draw a new paradigm for identifying various challenges in the existing food system and, accordingly, stressing the need for increasing food system resilience.

Survey Sampling Strategy

An exploratory study among rural and urban (sample) households of the Kurnool district in the Scarce Rainfall Zone of Andhra Pradesh, India, was conducted to analyze the trends in the food consumption pattern; trends in consumption of cereals, pulses, edible oils, milk, and sugar; percentage of total expenditure on different food items; and percentage of food in overall expenditure across different income groups and social statuses. The data collection started in December 2017 and was completed by April 2018. This survey was undertaken with the objective to ascertain about the changes in the dietary consumption pattern of households over a period of time in the context of changing income levels, urbanization, increasing sedentary activities etc. To elicit the requisite information from both rural and urban households, two large, populous *mandals* (subdistricts), Kurnool and Nandyal, were purposively selected. Information about the number of households in Kurnool and Nandyal mandals was obtained from the *Village/Town-wise Primary Census Abstract, 2011—Kurnool District* (India, NIC 2012). Because the study uses household food consumption data, a total of 2,500 households—1,500 from rural areas and 1,000 from urban areas from the two mandals—were selected randomly in accordance with the principles of probability in proportion to size. The local agricultural extension officers of the Department of Agriculture, Kurnool district, government of Andhra Pradesh, actively participated in collecting the requisite data from the sample households. These extension officers were experienced in the chosen communities and interacted freely with the local people. Respondents were encouraged to express their own feelings on and perceptions of issues. Data were obtained from families' ration cards and pass books for purchasing food items on a subsidy basis from "fair price shops" of the public distribution system (PDS), which are in turn supplied by Andhra Pradesh State Civil Supplies Corporation Ltd., for the years 2005, 2010, and 2015. For households who do not maintain these ration cards and pass books properly, the data were collected based on their memory recall. The sample households' data are analyzed using descriptive statistics.

Methodology

In this paper, we analyze trends in consumption patterns. Because changing consumption patterns will impact production systems, we use this information to analyze how current production should be altered to meet the nutrition needs of the population while ensuring that the food system is sustainable. Further, we present recommendations that could be implemented to increase food system resilience in Kurnool district.

4. Results and Discussion

This section discusses consumption patterns in India at the national, state (Andhra Pradesh), and district (Kurnool) level. Using in-depth analysis of the district-level consumption pattern, we present strategies that should be applied to develop a sustainable production system that meets the dietary requirements of the population. This is crucial because Kurnool district is in the Scarce Rainfall Zone of Andhra Pradesh, with an average rainfall of 670 mm per year. The strategies identified in this paper could be applied to other drought-prone regions in India as well.

Dietary Consumption Pattern of Households at the National Level

The most recent NSSO consumer expenditure survey, the 68th round, for 2011–2012 (NSSO 2014) showed that cereal consumption has declined gradually over the years, affecting nearly all the individual cereals. Monthly cereal consumption per person fell from 12.12 kg to 11.23 kg in rural India and from 9.94 kg to 9.32 kg in urban India between 2004–2005 and 2011–2012 (Table 6). Rice consumption per person per month has fallen in rural India from 6.38 kg in 2004–2005 to 5.98 kg in 2011–2012, a fall of 0.4 kg in 7 years. In urban India, it has fallen from 4.71 kg to 4.49 kg (a fall of 0.20 kg) per person per month. The share of PDS purchases in consumption has, however, risen substantially. Per capita consumption of PDS rice has, in fact, doubled in rural India and risen by 66 percent in urban India since 2004–2005. However, per capita consumption of wheat showed a slight rise of about 0.10 kg per person per month since 2004–2005 in rural areas and a fall of 0.35 kg in urban areas. This decline in intake of major cereals despite abundant availability has caused a decline in per capita dietary energy intake. As in the case of rice, the share of PDS wheat purchases in consumption has increased considerably, per capita consumption of PDS wheat having more than doubled since 2004–2005 in both geographic sectors. Similarly, table 7 and 8 show national level trends in pulses and oil consumption in India.

Table 6: Trends in consumption of different cereals at all-India level

Cereal	**Year**	**Per capita qty (kg) consumed in 30 days**	
		Rural	**Urban**
Rice: All sources	2004–2005	6.38	4.71
	2009–2010	6.00	4.52
	2011–2012	5.98	4.49
Wheat (*atta*): All sources	2004–2005	4.19	4.36
	2009–2010	4.25	4.08
	2011–2012	4.29	4.01

Cereal	Year	Per capita qty (kg) consumed in 30 days	
		Rural	**Urban**
Sorghum (*jowar*) & its products	2004–2005	0.43	0.22
	2009–2010	0.29	0.18
	2011–2012	0.20	0.13
Pearl millet (*bajra*) & its products	2004–2005	0.39	0.11
	2009–2010	0.26	0.09
	2011–2012	0.24	0.08
Maize & its products	2004–2005	0.310	0.025
	2009–2010	0.200	0.021
	2011–2012	0.130	0.014
All cereals	2004–2005	12.12	9.94
	2009–2010	11.35	9.37
	2011–2012	11.22	9.28

Source: NSSO (various years).

Table 7: Trends in consumption of different pulses at all-India level

Pulse	Year	Per capita qty (kg) consumed in 30 days	
		Rural	**Urban**
Pigeon peas (*arhar, tur*)	2004–2005	0.208	0.295
	2009–2010	0.163	0.264
	2011–2012	0.212	0.301
Mung beans (*moong*)	2004–2005	0.092	0.114
	2009–2010	0.073	0.104
	2011–2012	0.091	0.117
Red lentils (*red masur*)	2004–2005	0.105	0.092
	2009–2010	0.079	0.078
	2011–2012	0.112	0.093
Black gram (*urad*)	2004–2005	0.080	0.090
	2009–2010	0.072	0.090
	2011–2012	0.084	0.098
Gram split (*Chana Dal*)	2004–2005	0.058	0.073
	2009–2010	0.077	0.079
	2011–2012	0.079	0.085
Gram whole (*Kala Channa*)	2004–2005	0.026	0.033
	2009–2010	0.033	0.039
	2011–2012	0.040	0.045
Peas (*black masur*)	2004–2005	0.037	0.015
	2009–2010	0.057	0.025
	2011–2012	0.052	0.023
Gram flour (*besan*)	2004–2005	0.031	0.050
	2009–2010	0.038	0.058
	2011–2012	0.050	0.075

Pulse	Year	Per capita qty (kg) consumed in 30 days	
		Rural	**Urban**
All pulses & pulse products	2004–2005	0.705	0.824
	2009–2010	0.651	0.788
	2011–2012	0.783	0.901

Source: NSSO (various years).

Table 8: Trends in consumption of edible oils at all-India level, 2011–2012

Oil	Quantity (g)	
	Rural	**Urban**
Margarine, hydrogenated vegetable oil (*vanaspati*)	20	21
Mustard oil	304	242
Coconut oil	15	16
Groundnut oil	40	81
Refined oil	227	400
Edible oils: Others	69	94
Edible oils: Total	674	853

Source: NSSO (2014).

Urban per capita consumption levels (in quantity terms) were higher than rural levels for all the animal protein–supplying foods except fish, rural consumption of which was slightly higher (266 g per person per month) than urban (252 g). Also, consumption was markedly higher in urban India for milk, eggs, goat meat, and chicken, but lower for fish. The per capita consumption of eggs was 1.94 per month (0.45 per week) in rural India and 3.18 per month (0.74 per week) in urban India (Table 9). Between 2004–2005 and 2011–2012, estimated per capita consumption of liquid milk increased by about 470 ml per month in rural India and 315 ml per month in urban India.

Table 9: Trends in consumption of high-value food products at all-India level

Food product	1993–1994		1999–2000		2004–2005		2009–2010		2011–2012	
	Rural	**Urban**	**Rural**	**Urban**	**Rural**	**Urban**	**Rural**	**Urban**	**Rural**	**Urban**
Milk (liters)	4.00	4.96	3.84	5.17	3.92	5.18	4.17	5.43	4.33	5.42
Eggs (no.)	1.11	2.09	1.02	1.74	1.75	2.71	1.94	3.18	1.94	3.18
Chicken (kg)	0.06	0.11	0.07	0.1	0.05	0.07	0.05	0.09	0.18	0.24
Fish (kg)	0.02	0.03	0.04	0.06	0.05	0.09	0.13	0.18	0.27	0.25

Source: NSSO (various dates).

India's Planning Commission has delineated 15 agroclimatic zones (table 10), taking into account the country's wide variations in geographic area, population density, soil types, and crops grown (India Planning Commission 1989). These zones are identified for the purpose of conducting location-specific research and planning strategies for increasing agricultural production. To plan agricultural activities more accurately, each zone is subdivided into 73 subzones based on soil, climate (temperature), rainfall, and other agro-meteorological characteristics. Although the zones were created to ensure scientific management of regional resources to meet the food requirements of the mounting population in the country without adversely affecting the status of natural resources and the environment, the changing dietary consumption pattern of households (for reasons mentioned above) calls for a food systems approach to improving nutrition. There has been considerable discussion in the national literature on how to increase the productivity of the agricultural sector in these zones. Based on our review and discussions with key policy advisors, and our analysis of the consumption pattern presented above, Table 10 presents a broad set of food system interventions that can increase the sustainability of current production systems within each agroclimatic zone.

Table 10: Strategies to improve food system resilience at the national level

Region	States covered	Mean annual rainfall	Major crops grown	Strategies to improve food system resilience
Western Himalayan Region	Jammu and Kashmir, Himachal Pradesh, and the hill region of Uttarakhand	750 mm to 1500 mm	Rice, maize, barley, oats, wheat, apples, peaches, apricots, pears, cherries, almonds, lychees, walnuts, saffron, and so on; rearing of sheep, goats, cattle, and horses	• Increase rice production by scaling up climate-resilient agriculture • Increase production of horticulture sector (apples, peaches, apricots, pears, cherries, almonds)
Eastern Himalayan Region	Arunachal Pradesh, the hills of Assam, Sikkim, Meghalaya, Nagaland, Manipur, Mizoram, Tripura, and the Darjeeling district of West Bengal	2,000–4,000 mm	Rice, maize, potatoes, tea, pineapples, lychees, oranges, and limes	• Improve horticulture production • Increase crop diversification
Lower Gangetic Plains Region	West Bengal (except the hilly areas), eastern Bihar, and the Brahmaputra Valley	1,000–2,000 mm	Rice, jute, maize, potatoes, pulses, bananas, mangoes, citrus, pisciculture, poultry, livestock, forage production, and seed supply	• Improve rice farming, horticulture (bananas, mangoes, and citrus fruits), pisciculture, poultry, livestock
Middle Gangetic Plains Region	Large parts of Uttar Pradesh and Bihar	1,000–2,000 mm	Rice, maize, millets, wheat, gram, barley, peas, mustard, potatoes, pisciculture, and so on	• Increase pisciculture
Upper Gangetic Plains Region	Central and western parts of Uttar Pradesh and the Haridwar and Udham Singh Nagar districts of Uttarakhand	750–1,500 mm	Wheat, rice, sugarcane, millets, maize, gram, barley, oilseeds, pulses, and cotton	• Increase livestock production, horticulture, and promotion of mixed cropping patterns to improve nutrition

Region	States covered	Mean annual rainfall	Major crops grown	Strategies to improve food system resilience
Trans-Gangetic Plains Region	Punjab, Haryana, Chandigarh, Delhi, and the Ganganagar district of Rajasthan	650–1,250 mm	Wheat, sugarcane, cotton, rice, gram, maize, millets, pulses, oilseeds, and so on	• Increase productivity of wheat and sugarcane
Eastern Plateau and Hills	Chota Nagpur plateau, extending over Jharkhand, Orissa, Chhattisgarh, and Dandakaranya	800–1,500 mm	Rice, millets, maize, oilseeds, finger millet (*ragi*), gram, and potatoes	• Increase production of high-value pulses such as pigeon peas (*arhar*, *tur*), groundnuts, soybeans, and the like, on upland rainfed areas • Grow crops like black gram (*urad*), castor, and groundnuts in kharif season • Grow mustard and vegetables in irrigated areas • Improve indigenous breeds of cattle and buffalo • Extend fruit plantations, develop inland fisheries in permanent water bodies
Central Plateau and Hills	Bundelkhand, Baghelkhand, Bhander plateau, Malwa plateau, and Vindhyachal hills	500–1,000 mm	Millets, wheat, gram, oilseeds, cotton, and sunflowers	• Increase livestock production • Increase crop diversification and focus on pulse production for improved nutrition
Western Plateau and Hills	Southern part of Malwa plateau and Deccan plateau (Maharashtra)	250–750 mm	Wheat, gram, millets, cotton, pulses, groundnuts, sugarcane, rice, wheat, oranges, grapes, and bananas	• Increase water efficiency by popularizing water-saving devices such as sprinklers and drip systems • Increase production of high-value crops such as oilseeds instead of low-value crops such as sorghum and pearl millet

Region	States covered	Mean annual rainfall	Major crops grown	Strategies to improve food system resilience
				• Increase production of fruits such as pomegranates, mangoes, and guava • Improve milk production of cattle and buffalo through cross-breeding • Develop poultry production
Southern Plateau and Hills	Interior Deccan, including parts of southern Maharashtra, the greater parts of Karnataka and Andhra Pradesh, and the Tamil Nadu uplands from Adilabad district in the north to Madurai district in the south	500–1,000 mm	Millets, oilseeds, pulses, coffee, tea, cardamom, and spices	• Divert some of the area under coarse cereals to pulses and oilseeds • Promote horticulture, dairy development, and poultry farming
Eastern Coastal Plains and Hills	Coromandel and Northern Circar coasts of Andhra Pradesh and Orissa	750–1,500 mm	Rice, jute, tobacco, sugarcane, maize, millets, groundnuts, and oilseeds	• Improve the cultivation of spices (pepper and cardamom) and development of fisheries • Discourage growing of rice on marginal lands and bring such lands under alternative crops such as oilseeds and pulses • Develop horticulture in upland areas, social forestry, and dairy farming
Western Coastal Plains and Ghats	Malabar and Konkan coastal plains, and the Sahyadris	More than 2,000 mm	Rice, coconuts, oilseeds, sugarcane, millets, pulses, and cotton	• Increase production of high-value crops such as pulses, spices, and coconuts • Promote prawn culture in brackish water
Gujarat Plains and Hills	Hills and plains of Kathiawar, and the fertile valleys of the Mahi and Sabarmati rivers	500–1,000 mm	Groundnut, cotton, rice, millets, oilseeds, wheat, and tobacco	• Promote dryland farming • Develop marine fishing and brackish/backwater aquaculture

Region	States covered	Mean annual rainfall	Major crops grown	Strategies to improve food system resilience
Western Dry Region	Rajasthan, west of the Aravalli Range	Less than 250 mm	Pearl millet, sorghum, moth beans, wheat, and gram	• Promote cultivation of horticultural crops such as watermelon, guava, and date palm
Island Region	Andaman-Nicobar and Lakshadweep	Less than 3,000 mm	Rice, maize, millets, pulses, betel (areca) nuts, turmeric, cassava, and coconuts	• Use improved rice seeds to enable farmers to produce multiple crops • Promote brackish-water prawn culture in coastal areas

Source: Khanna (1989).

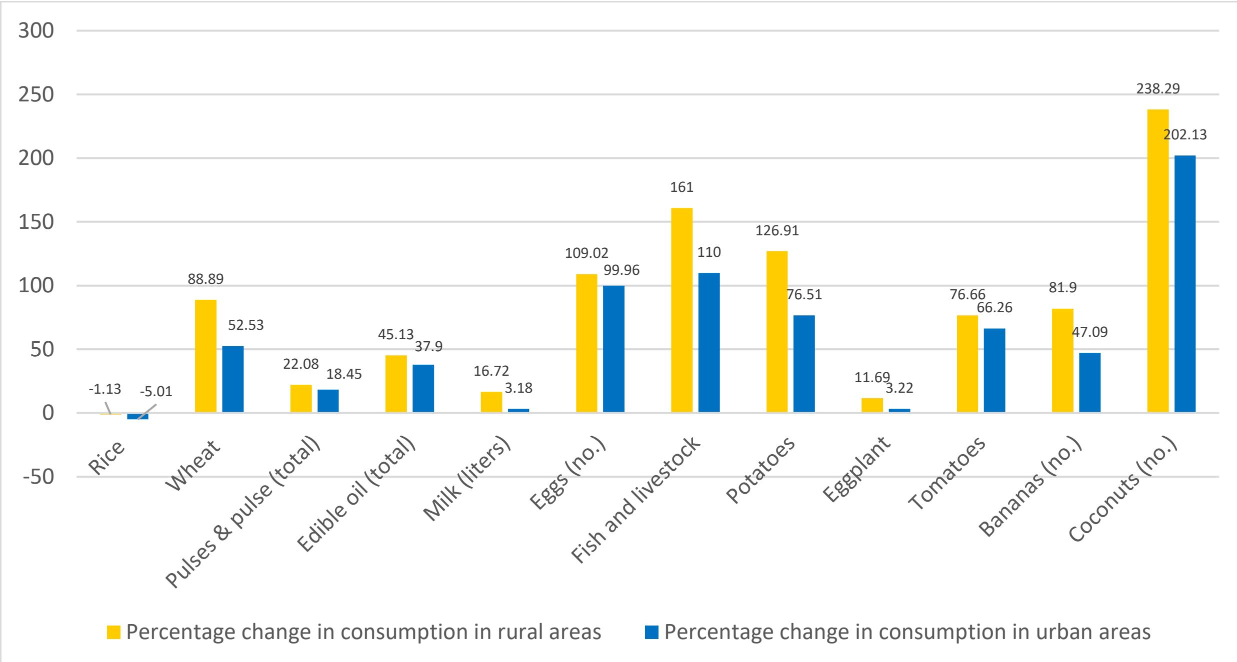
Dietary Consumption Pattern in Andhra Pradesh (State Level)
Table 11 presents the monthly per capita consumption in Andhra Pradesh of the food groups just discussed. The percentage change in consumption over time (between 2004–2005 and 2011–2012) is depicted in Figure 3.

Table 11: Monthly per capita quantity (kg) consumption in Andhra Pradesh

Commodity	**Rural**		**Percentage change**	**Urban**		**Percentage change**
	2004–2005	**2011–2012**		**2004–2005**	**2011–2012**	
Rice	10.951	10.827	-1.13	9.424	8.952	-5.01
PDS rice	2.547	3.519	38.16	1.371	1.990	45.15
Wheat	0.144	0.272	88.89	0.455	0.694	52.53
PDS wheat	0.004	0.006	50.00	0.038	0.049	28.95
Pigeon peas (*arhar, tur*)	0.424	0.463	9.20	0.448	0.459	2.46
Gram (split)	0.050	0.058	16.00	0.055	0.072	30.91
Mung beans (*moong*)	0.089	0.104	16.85	0.075	0.100	33.33
black gram (*urad*)	0.104	0.146	40.38	0.178	0.192	7.87
Red lentils (*masur*)	0.008	0.016	100.00	0.016	0.024	50.00
Pulses & pulse products (total)	0.702	0.857	22.08	0.802	0.950	18.45
Groundnut oil	0.239	0.184	-23.01	0.244	0.174	-28.69
Mustard oil	0.001	0.000	-100.00	0.002	0.001	-50.00
Refined oil		0.340			0.524	
Edible oils (total)	0.554	0.804	45.13	0.620	0.855	37.90
Milk (liters)	3.051	3.561	16.72	4.375	4.514	3.18
Eggs (no.)	2.251	4.705	109.02	2.636	5.271	99.96
Fish	0.071	0.153	115.49	0.076	0.108	42.11
Goat meat or mutton	0.086	0.121	40.70	0.101	0.149	47.52
Chicken	0.136	0.491	261.03	0.155	0.440	183.87
Potatoes	0.223	0.506	126.91	0.298	0.526	76.51
Eggplant (*brinjal*)	0.402	0.449	11.69	0.373	0.385	3.22
Tomatoes	0.634	1.120	76.66	0.658	1.094	66.26
Bananas (no.)	3.917	7.125	81.90	5.602	8.240	47.09
Coconuts (no.)	0.269	0.910	238.29	0.328	0.991	202.13

Raw Data Source: National Sample Surveys, 61st and 68th rounds (NSSO 2006, 2014).
Note: PDS = Public Distribution System.

Figure 3: Trends in quantity of monthly per capita consumption of selected food items in Andhra Pradesh



Raw Data Source: National Sample Surveys, 61st and 68th rounds (NSSO 2006, 2014).

The consumption pattern of Andhra Pradesh follows the same transition as that at the national level across different consumption goods. A comparative analysis of consumption data for the periods 2004–2005 (the 61st Round, results reported in NSSO 2006) and 2011–2012 (the 68th Round, NSSO 2014) highlights the following differences. Rice consumption per person per month in rural Andhra Pradesh was estimated at 10.827 kg in 2011–2012, compared with 10.951 kg in 2004–2005, a fall of 0.122 kg in 7 years. In urban Andhra Pradesh, the fall in rice consumption between these 2 years was 0.472 kg per person per month, from 9.424 kg to 8.952 kg. In addition, in 2011–2012, per capita consumption of PDS rice increased by 38.16 percent in rural Andhra Pradesh and by 45.15 percent in urban Andhra Pradesh over 2004–2005 amounts, implying that the share of PDS purchases in rice consumption has risen substantially.

Per capita consumption of wheat per month in 2011–2012 had almost doubled since 2004–2005 in rural areas and increased by 52.5% in urban areas. Compared with PDS rice, the share of PDS purchases in wheat consumption has increased considerably in 2011–2012: per capita consumption of PDS wheat increased by 9.5 and 8.2 times in rural and urban sectors, respectively.

For the pulses and pulse products group as a whole, monthly per capita consumption rose by 155 g between 2004–2005 and 2011–2012, from 702 g to 857 g in the rural sector, and from 802 g to 950 g in the urban sector. Of this rise, however, as much as 112 g in the rural sector and 75 g in the urban sector was contributed by five items: pigeon peas (*arhar*, *tur*), split gram, mung beans (*moong*), black gram (*urad*), and red lentils (*red masur*). In 2011–2012, these five pulses together made up about 92 percent of consumption of pulses and pulse products in rural Andhra Pradesh and 89 percent in urban Andhra Pradesh—registering a total increase in monthly per capita consumption of 155 g in the rural sector and 148 g in the urban sector over this 7-year period.

Monthly per capita consumption of edible oils (total) rose by 45 percent between 2004–2005 and 2011–2012, from 554 g to 804 g in the rural sector and by 38 percent, from 620 g to 855 g in the urban sector. In this group, however, the consumption of groundnut oil and mustard oil recorded declining trends (23 percent and 29 percent, respectively) during this period. Among the different kinds of edible oils, refined oil (which includes sunflower oil and soybean oil) had the largest share—about 42 percent in the rural sector and 61 percent in the urban sector.

Monthly per capita consumption of milk, eggs, fish, goat meat, and chicken showed an increasing trend in both rural and urban areas of Andhra Pradesh. Further, their consumption was higher in rural areas than in urban areas except for goat meat. The percentage change in monthly per capita consumption of potatoes, eggplant (*brinjal*), and tomatoes was appreciably more in rural areas than in urban Andhra Pradesh. However, the rural-urban disparity in consumption of potatoes, bananas, and coconuts is relatively low.

In terms of nutrient intake, in 2011–2012 (NSSO 2014), the daily calorie and protein intake of an average resident of Andhra Pradesh fell short of the standard intake prescribed by the National Institute of Nutrition (NIN). The per capita daily protein consumption in rural Andhra Pradesh was found to be 59.9 g. For urban Andhra Pradesh, it was found to be a little lower, at 59.3 g per day, as against the standard of 60 g of protein per day for men and 55 g for women recommended by NIN in its dietary allowances for Indians. The per capita daily calorie consumption in rural Andhra Pradesh was found to be 2,365 kcal, and for urban Andhra Pradesh it was a little lower, at 2,281 kcal. These numbers are lower than the Indian Council of Medical Research (ICMR) standard requirement of 2,400 kcal per day. However, per capita daily fat consumption, in both rural (49.9 g) and urban (55.2 g) Andhra Pradesh, was much higher than the ICMR standard requirement of 43 g per day.

From the foregoing discussion, it is evident that there have been some significant changes in the food consumption basket both at the national level and in the state of Andhra Pradesh. In addition, similar trends in the dietary consumption patterns of rice, edible oils, milk, eggs, fish, and chicken are found in both rural and urban areas, both at the national level and in Andhra Pradesh. However, in the case of wheat and pulses, at the national level, their monthly per capita consumption declined during the reference period and in Andhra Pradesh, it was found to have increased. This analysis of changes across NSSO rounds revealed that the pace of change accelerated during the first decade of 21st century.

The data also confirm the presence of a sustained shift within the food groups to noncereals, and within cereals away from traditional staples, such as sorghum (*jowar*), pearl millet (*bajra*), and maize, to rice and wheat. The increase in per capita cereal production in India and in Andhra Pradesh is not leading to an increase in the domestic intake, despite the increase in supply of grains at a highly subsidized rate. This, in turn, is not bringing about any improvement in nutrition intake. The primary reason for lower domestic intake vis-à-vis production is the declining preference of consumers for a cereal diet. Although the per capita consumption of other food items such as edible oils, eggs, fish, fruits, vegetables, sugar, meat, and milk witnessed moderate to high increases, even these increases did not help in offsetting the decline in dietary energy intake and protein intake caused by the decline in cereal consumption. The latest National Sample Survey data, for 2011–2012 (68th Round; NSSO 2014) show a further shift in consumer spending away from food to nonfood items across both rural and urban areas.

In pulses, all varieties (except gram and peas) have witnessed a drop in consumption. The consumption of edible oils showed a significant increase over the years, particularly in the "other edible oils" category (those excluding groundnut, mustard, and hydrogenated vegetable oils, mainly palm oil). The consumption of milk increased in both rural and urban areas, with a more rapid growth in rural areas lately. The intake of sugar in urban areas has fallen at double the rate in rural areas. On average, the consumption of pulses, edible oils, sugar, and milk continues to be higher in urban areas. These significant changes in dietary consumption patterns among rural and urban households can be attributed to changes in food habits due to increasing urbanization, breaking up of the traditional joint family system, desire for quality, an increasing number of working women, rise in per capita income, changing lifestyles, and an increasing level of affluence in the middle-income group.

The changes in the dietary consumption pattern among rural and urban households in Andhra Pradesh can be attributed to the increase in food production during the past decade, which has allowed food prices to decrease in real (deflated) terms, as the food supply has grown faster than the demand in spite of an increasing population. This declining price trend has contributed to the alleviation of hunger among households especially the BPL population. Cheaper calories have also contributed to easing the nutrition transition. Relative prices of food items have influenced the dietary composition by favoring food items that are unhealthy from a nutritional point of view. For example, the increase in prices of fruits and vegetables in the market reduced fiber consumption and increased body mass index; at the opposite end, the relatively stable and lower prices of junk foods increased their consumption and reduced the consumption of dietary fiber, calcium, fruits, and vegetables. Table 12 presents strategies to improve production system sustainability based on the rainfall and soil conditions of different districts in Andhra Pradesh.

Table 12: Strategies to promote sustainable production systems in Andhra Pradesh

Zone	Districts	Rainfall per year	Soils	Crops produced	Strategies to improve food system resilience
Krishna-Godavari Zone	East Godavari, West Godavari, Krishna, Guntur, and contiguous areas of Khammam, Nalgonda, and Prakasam	800–1,100 mm	Deltaic alluvium, red soils with clay, black cotton soils, red loams, coastal sands, and saline soils	Rice, groundnuts, sorghum, pearl millet, tobacco, cotton, chilies, sugarcane, and horticultural crops	• Improve rice production by scaling up climate-resilient agriculture
North Coastal Zone	Srikakulam, Vizianagaram, Visakhapatnam, and uplands of East Godavari district	1,000–1,100 mm	Red soils with clay base, pockets of acidic soils, laterite soils with pH 4–5.	Rice, groundnuts, mesta, jute, sun hemp, sesamum, sorghum, pearl millet, black gram, and horticultural crops	• Improve rice farming, horticulture (bananas, mangoes, and citrus fruits), pisciculture, poultry, and livestock
Southern Zone	Nellore, Chittoor, southern parts of Prakasam and Kadapa (formerly known as Cuddapah), and eastern parts of Anantapur	700–1,000 mm	Red loamy soils, shallow to moderately deep	Rice, groundnuts, cotton, sugarcane, millets, and horticultural crops	• Increase production of coarse cereals, pulses, and oilseeds • Promote horticulture, dairy development, and poultry farming
Scarce Rainfall Zone	Kurnool, Anantapur, Prakasam (western parts), Kadapa (northern part), and Mahabubnagar (southern border)	500–750 mm	Red earths with loamy soils (chalkas), red sandy soils, and black cotton soils in pockets	Cotton, sorghum, millets, groundnuts, pulses, and rice	• Increase livestock production • Increase crop diversification and focus on pulse production for improved nutrition • Introduce high-yielding-variety crops • Promote food fortification to

Zone	Districts	Rainfall per year	Soils	Crops produced	Strategies to improve food system resilience
					improve nutritional value of crops
High-Altitude and Tribal Areas	Northern borders of Srikakulam, Vizianagaram, Visakhapatnam, East Godavari, and Khammam	> 1,400 mm	Hill slopes, undulating transported soils	Horticultural crops, millets, pulses, chilies, turmeric, and pepper	• Improve the cultivation of spices (pepper and cardamom) • Develop fisheries

Source: Andhra Pradesh Department of Agriculture; Institute of Health Systems (2018).

Trends in Food Consumption Patterns in Kurnool District (District Level)

The consumption pattern in India has changed at the national, state, and district levels. In Kurnool district, there has been a shift from food to nonfood items (in all expenditure categories across both rural and urban areas). Further, consumption of traditional staples, such as sorghum (*jowar*), pearl millet (*bajra*), and maize has decreased over time. In pulses, all varieties (except gram and peas) have witnessed a drop in consumption. The consumption of edible oils has shown a significant increase over the years. The consumption of milk and sugar has increased in both rural and urban areas, with a more rapid growth in rural areas lately. Overall, the consumption of pulses, edible oils, sugar, and milk continues to be higher in the urban areas. It is found interesting that, with life running at a faster pace both in rural and urban areas of Kurnool district, food habits have also changed due to Western influence and the increase in availability of processed food products, especially in urban areas.

Table 13 reports the changes in monthly per capita consumption (by quantity) of selected food items among rural and urban households of Kurnool district between 2005 and 2017. There are several noteworthy trends in the actual consumption patterns of these food articles. First, consumption of cereals is higher in rural areas and is declining over time in both rural and urban areas. Second, the consumption of pulses is higher in urban India but also shows a declining trend in both rural and urban areas. Third, consumption of edible oils and liquid milk has been increasing over the years, with higher consumption in urban areas relative to rural areas. Sugar consumption has been declining consistently in both rural and urban areas but continues to be higher in urban areas.

Table 13: Monthly per capita consumption of selected food articles (kg)

	Year	**Total cereals**	**Total pulses**	**Total edible oils**	**Liquid milk (liters)**	**Sugar**
Rural	2005	14.16	0.84	0.44	3.93	0.81
	2010	13.18	0.79	0.53	4.12	0.78
	2017	12.47	0.72	0.69	4.38	0.72
Urban	2005	12.41	0.93	0.66	4.53	0.92
	2010	10.82	0.88	0.74	4.91	0.88
	2017	9.87	0.81	0.92	5.67	0.79

Raw Data Source: Author (2017). Sample survey among rural and urban households of Kurnool district

Trends in Cereal Consumption

The gap in rural-urban cereal consumption is narrowing, as the higher consumption of cereals in rural areas is waning at a slightly faster rate. Rice and wheat continue to be the core cereals consumed by households, collectively constituting about 91 percent of total cereal intake in rural areas and 93 percent in urban areas in 2017. This is a rise from a consolidated share of 87 percent in rural areas and 89 percent in urban areas in 2005. Wheat consumption is relatively stable, not showing any major changes during the period analyzed. Rice, on the other hand, has witnessed a consistent decline in both rural and urban areas.

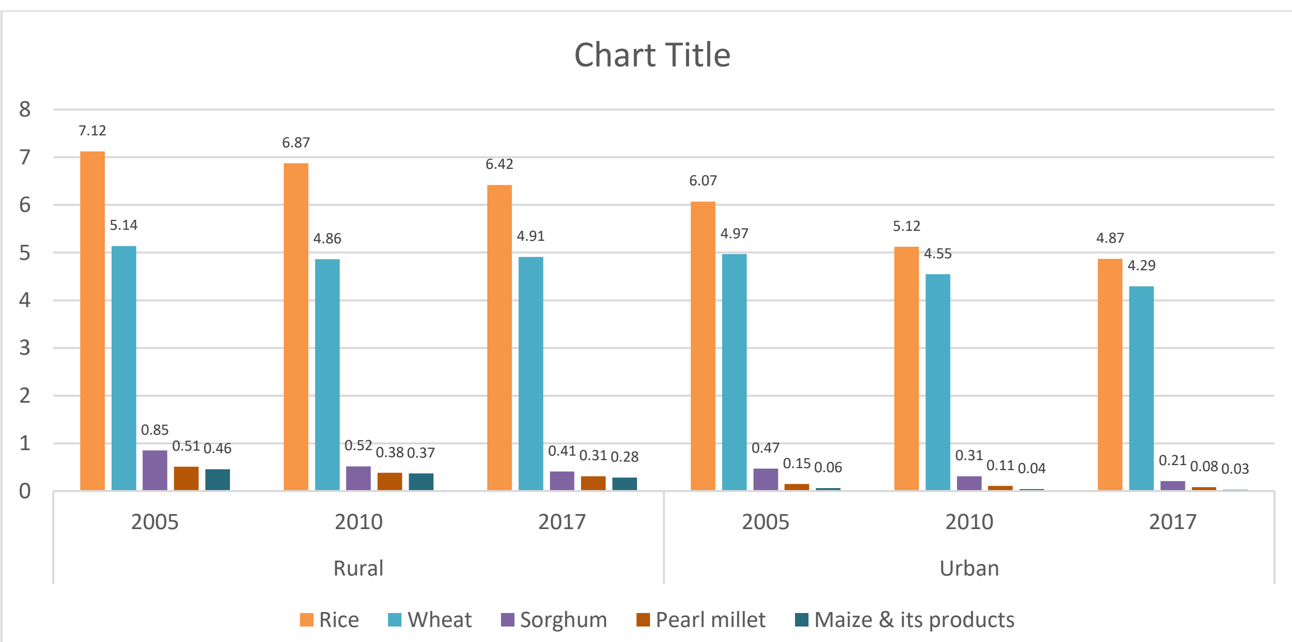
Traditional staples are valuable sources of macro- and micronutrients for households. However, from a combined share of 13.0 percent in rural and 5.5 percent in urban cereal intake in 2005, the consumption of sorghum (*jowar*), pearl millet (*bajra*), maize, and their products has declined to an 8 percent share in rural and a 3 percent share in urban areas in 2017. Relative to the "core" cereals (rice and wheat), the decline in these staples has been faster for some time now, but the rate of decline appears to be greater between 2005 and 2010. This is in tune with the consumption pattern of coarse cereals at national level. The decline in traditional staple consumption during the period has been most significant for sorghum (*jowar*), followed by pearl millet (*bajra*) and maize. Compared with urban areas, rural areas continue to dominate the consumption of these coarse cereals throughout the selected reference periods. All this clearly represents a consistent decline in consumption of cereals, with a relatively higher shift away from traditional staples. The change in monthly consumption of cereals is presented in Table 14 and Figure 4.

Table 14: Monthly per capita consumption of selected cereals (kg)

	Year	Rice	Wheat	Sorghum & its products	Pearl millet & its products	Maize & its products
Rural	2005	7.12	5.14	0.85	0.51	0.46
	2010	6.87	4.86	0.52	0.38	0.37
	2017	6.42	4.91	0.41	0.31	0.28
Urban	2005	6.07	4.97	0.47	0.15	0.06
	2010	5.12	4.55	0.31	0.11	0.04
	2017	4.87	4.29	0.21	0.08	0.03

Raw Data Source: Author (2017). Sample survey among rural and urban households of Kurnool district.
Note: Rice excludes rice products and wheat excludes wheat products.

Figure 4: Monthly per capita consumption of selected cereals (kg)



Raw Data Source: Author (2017). Sample survey among rural and urban households of Kurnool district.

Trends in Consumption of Pulses

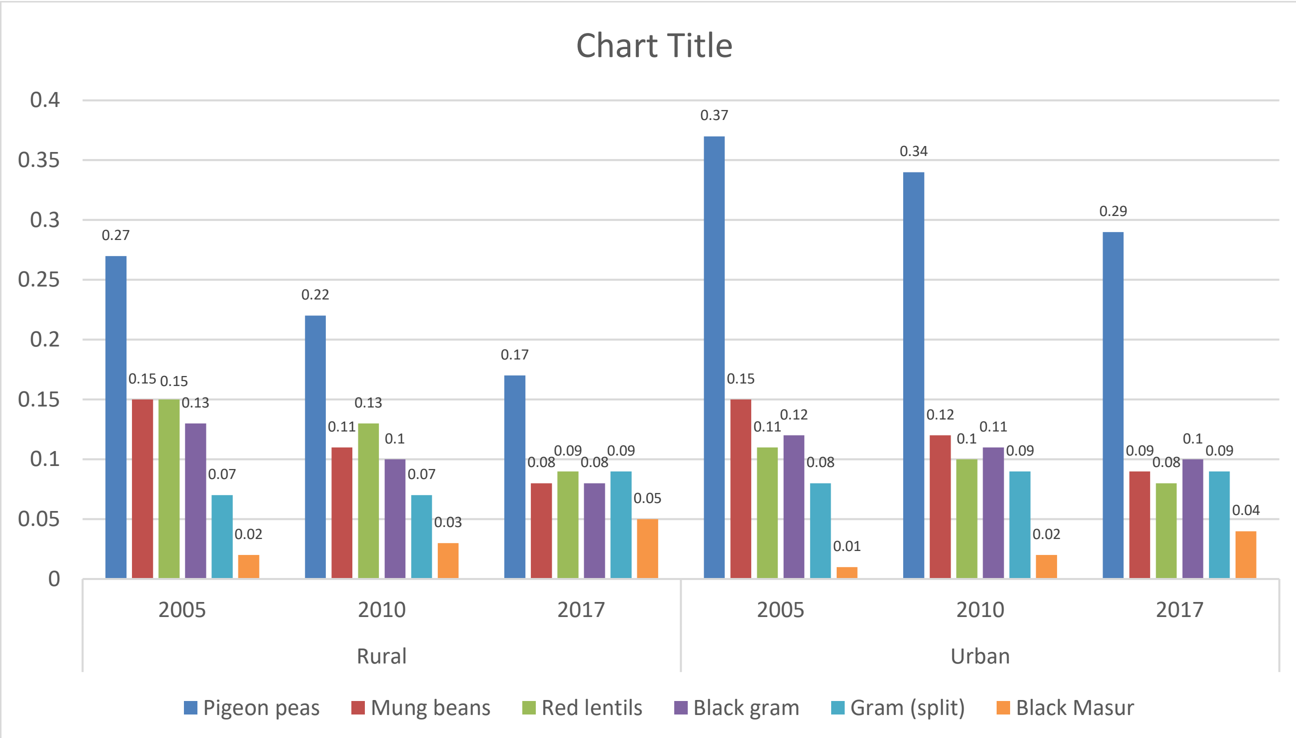
Consumption of pulses of all kinds (except split gram and peas) has been declining in both rural and urban areas. Unlike cereals, the per capita urban-rural consumption gap of pulses has been diverging over the years, due to the more rapid decline in consumption of pulses in rural areas (Table 15 and Figure 5). Pigeon peas (*arhar*), mung beans (*moong*), red lentils (*masur*), black gram (*urad*), split gram, and peas together constitute about 78 percent and 85 percent, respectively, of total pulse consumption in rural and urban areas in 2017, down from 94 percent and 90 percent, respectively, in 2005. Among these, pigeon peas continue to dominate overall pulse consumption, despite showing a very rapid reduction in consumption. Most of the decline in pulse consumption was concentrated in the period 2010 to 2017. Although split gram and peas used to constitute only 11 percent of the total pulse consumption, in both 2005 and 2010, they are the only pulses that witnessed a per capita increase in consumption over the years. In 2017, they together constituted 19 percent of pulse consumption in rural areas and 16 per cent in urban areas. This could signify a redirection of consumer expenditure to these cheaper pulses.

Table 15: Trends in pulse consumption (kg)

	Year	**Pigeon peas (*arhar*)**	**Mung beans (*moong*)**	**Red lentils (*masur*)**	**Black gram (*urad*)**	**Gram (split)**	**Peas**
Rural	2005	0.27	0.15	0.15	0.13	0.07	0.02
	2010	0.22	0.11	0.13	0.10	0.07	0.03
	2017	0.17	0.08	0.09	0.08	0.09	0.05
Urban	2005	0.37	0.15	0.11	0.12	0.08	0.01
	2010	0.34	0.12	0.10	0.11	0.09	0.02
	2017	0.29	0.09	0.08	0.10	0.09	0.04

Raw Data Source: Author (2017). Sample survey among rural and urban households of Kurnool district.

Figure 5: Trends in monthly per capita quantity (kg) consumption of pulses in Kurnool



Raw Data Source: Author (2017). Sample survey among rural and urban households of Kurnool district.

Trends in Edible Oil Consumption

The monthly per capita consumption of edible oils between 2005 and 2017 has shown an increase of about 57 percent and 39 percent in rural and urban areas, respectively, increasing more rapidly during 2010–2017 (Table 13). In 2005, mustard oil and groundnut oil together accounted for more than 70 percent of edible oil consumption among both rural and urban households of Kurnool district (Table 16). Over the years, although mustard oil continues to dominate in rural areas, constituting about 46 percent of edible oil consumption in 2017, there is a significant decrease in the consumption of groundnut oil and an even sharper increase in the consumption of other varieties of edible oils (all kinds of edible oils excluding groundnut oil, mustard oil, and butter). The share of these new varieties of edible oils witnessed a whopping 420 percent increase in consumption in rural areas between 2005 and 2017. Similar is the case in urban areas, where the high share of groundnut oil has been completely supplanted in favor of these other edible oil categories, which constituted about 49 percent of edible oil consumption in 2017.

Groundnut oil and butter together formed the only category of edible oils that has witnessed a decline over the years, despite an overall increase in consumption of edible oils during the reference periods. In 2017, their share in total edible oil consumption had been reduced to 16 percent in rural and 23 percent in urban areas, from 45 percent and 55 percent, respectively, in 2005. There has been considerable rearrangement between edible oils in household consumption over the years. Mustard oil remains the only edible oil with a relatively stable proportion of consuming households. There is a noteworthy decline in the proportion of households consuming groundnut oil and butter, and a considerable increase in those consuming other varieties of edible oil.

Table 16: Monthly per capita consumption of edible oils (kg)

	Year	Groundnut oil	Mustard oil	Butter	Other edible oils
Rural	2005	0.14	0.19	0.06	0.05
	2010	0.09	0.24	0.05	0.15
	2017	0.06	0.32	0.05	0.26
Urban	2005	0.29	0.17	0.07	0.13
	2010	0.20	0.21	0.05	0.28
	2017	0.18	0.26	0.03	0.45

Raw Data Source: Author (2017). Sample survey among rural and urban households of Kurnool district.

Trends in Milk and Sugar Consumption

The monthly per capita intake of milk and sugar has increased in both rural and urban areas (Table 17). The percentage of households consuming milk continues to be higher in urban than in rural areas; it increased from 58 to 79 percent of households surveyed in rural areas and from 83 to 91 percent of those in urban areas between 2005 and 2017.The proportion of surveyed households that consume sugar has, however, shown an increase over the years—starting from an almost similar proportion (about 90 percent) of sugar-consuming households in rural and urban areas, the proportion has increased by about 4.9 percentage points in rural areas and 3.1 percentage points in urban areas during the period analyzed.

Table 17: Monthly per capita consumption of milk and sugar

	Year	Milk (liters)	Sugar (kg)
Rural	2005	2.82	0.42
	2010	3.04	0.47
	2017	3.12	0.51
Urban	2005	4.17	0.50
	2010	4.26	0.56
	2017	4.52	0.62

Raw Data Source: Author (2017). Sample survey among rural and urban households of Kurnool district.

Percentages of Expenditure on Different Food Items

The pattern of household expenditure on different food items (Table 18) reveals that the major part of expenditure was on cereals, and this portion was higher in rural households (45 percent) than in urban households (42 percent). Edible oils, milk and milk products, meat, eggs, and fish were equally important after cereals among both rural and urban households. Pulse consumption was gaining popularity in both rural and urban areas because pulses are a cheap source of protein and prevent major health disorders. Urban households account for a major share of expenditure on processed food products compared with rural households because the former have more access to these foods. Fruits and vegetables were the least important food items in terms of expenditure. They constituted only about 2–3 percent (rural) and 3–4 percent (urban) of the total expenditure on food.

The trend analysis revealed that there is a clear indication of reallocation of consumer food expenditure away from cereals toward commodities such as eggs, fish, meat, vegetables, milk and milk products, beverages, and so on, among both rural and urban households of Kurnool district.

Cereals, meat, eggs, and fish continue to be the key food expenditure categories, while milk and milk products, processed food products, and the like emerged as other significant expenditure items among both rural and urban households of Kurnool district in 2017.

Table 18: Share of expenditure on individual food items (percentage)

Food items	Rural		Urban	
	2010	2017	2010	2017
Cereals	45.61	43.18	42.18	41.62
Pulses	6.23	7.06	6.31	6.92
Edible oils	9.58	9.16	10.03	9.73
Sugar and jaggery	2.15	1.96	3.07	2.61
Vegetables	3.04	4.16	3.94	4.31
Fruits	2.08	3.21	3.68	4.16
Milk and milk products	10.68	11.16	13.57	14.26
Meat, eggs, and fish	9.41	11.37	9.52	12.67
Processed food products	1.62	2.31	5.21	8.26

Raw Data Source: Author (2017). Sample survey among rural and urban households of Kurnool district.

Percentages of Total Expenditures on Food, Different Income and Social Groups

Table 19 shows that the highest proportion of expenditure on food among the expenditure classes was by the poor in both rural and urban areas of Kurnool district. It was observed that low-income groups spent a large part of income on food items, while higher-income groups spent the least across both rural and urban household categories. Scheduled tribes spent the largest part of their income on food items, followed by the scheduled castes and other social groups, among both rural and urban households.

Table 19: Percentage of food expenditure across different income groups and social statuses (2017)

Category	Rural	Urban
Income (Indian rupees)		
a) Poor (< 50,000/year)	67.12	65.18
b) Middle class (≥ 50,001–100,000/year)	64.28	62.17
c) Rich (≥ 100,001)	60.18	61.07
Social group		
a) Scheduled castes	70.52	68.16
b) Scheduled tribes	68.78	66.28
c) Backward classes	67.21	65.94
d) Others	63.19	61.57

Raw Data Source: Author (2017). Sample survey among rural and urban households of Kurnool district.

Challenges in the Existing Food System

The transformations in dietary habits that have occurred over recent decades draw attention to identifying the challenges of the existing food system and to designing a nutrition-sensitive, sustainable food system. The challenges of the existing food system arise from different areas of production, marketing, and trade, and from consumers' demand for food products. Each area is confronted with respective limitations, making the existing food system insensitive to the changing dietary consumption needs of the mounting population. The background analysis on dietary transformations among rural and urban households draws the attention of researchers to design a nutrition-sensitive food system, duly involving all the stakeholders of the agricultural and food sectors. Stakeholder involvement will make the nutrition-sensitive food system meet the dietary requirements of households as per prescribed nutrition standards. Further, this nutrition-sensitive food system should be sustainable, considering the dynamic dietary needs of consumers, and go beyond agricultural production to deal with processing, storage, trade, marketing, and consumption, which nowadays contribute significantly to improving the quality of the diet and eradicating malnutrition. Thus, the food system needs to be resilient in order to provide continued food and nutrition to the population.

At present, due to changing dietary requirements among rural and urban households in Kurnool district and the coexistence of problems related to under- and overnourishment, there is a need to review the existing food system by considering institutional roles and functions, the food environment, and consumers' preferences. It is important that the enabling environment in the state of Andhra Pradesh and at the national level be encouraging to bring desirable changes to the design of a nutrition-sensitive food system in Kurnool district to increase dietary diversity, intake of protein through pulses and livestock, and consumption of micronutrients. To meet all of these nutrition needs of the population, the production system needs to be improved. Table 20 shows production system challenges and opportunities to increase food system resilience in Kurnool district.

Table 20: Production system challenges and strategies to improve food system resilience in Kurnool district

Drivers of food production	**Production system challenges**	**Strategies to improve food system resilience**
Crop production inputs	• Declining soil quality and high risk of soil degradation	• Increase access to soil testing for improved soil quality
	• Limited access to water (from both rain and irrigation): Decline in per capita area under irrigation in upland cultivation, increasing demand for water due to urbanization and industrialization, waterlogging-induced soil salinity in lowland areas, and poor quality of the water that is available for irrigation	• Improve water efficiency through development and adaptation of efficient methods of water harvesting, recycling, and planning
Technology and innovation	• Lack of knowledge, experience, and resources among majority of farmers to bring innovations in crop and livestock systems	• Produce high-yielding varieties of crops, fruits, vegetables, spices, and medicinal plants that offer the farmer higher-value products
Political and economic drivers	• Lack of institutional support and enabling environment for growth in agriculture sector	• Government support for initiatives to fortify crops and increase awareness regarding using fortified crops. • Government support for cooperatives and marketing groups to encourage trade of nutritious food commodities. • Provide financing and agri-insurance for farmers
Agriculture trade	• Domination of agriculture trade by small-scale subsistence farmers • Inadequate infrastructure and facilities for storage and agri-processing	• Increase access to markets and information regarding market prices to increase competitiveness • Invest in storage facilities and promote agri-processing

Source: Authors' compilation.

To build a resilient food system, we need to develop a sustainable food system that meets the dietary needs of the population. In this paper, we use the trends in consumption patterns to identify strategies to build sustainable production systems. The substantial nutrition transition at the national, state, and district levels implies that the diversification of food systems—and hence food production programs—across different agroclimatic zones of India and Andhra Pradesh should be reoriented to design resilient food systems. The advances in crop production made during the Green Revolution were dependent mostly on improvements in cereal cropping systems (rice, wheat, and maize) to prevent massive starvation. However, this technology led farmers to go for monoculture systems of cereals and thus affected the balanced diet pattern among consumers. This is so because although cereals form the major portion of consumers' diet, they supply only carbohydrates and a small amount of protein, but few other nutrients in required amounts. Cereals thus appear to be contributing to micronutrient malnutrition by limiting food crop diversity (Welch, Combs Jr., and Duxbury 1997). Further, with increased migration of population from rural areas contributes to urbanization, lifestyle change, and dietary changes. So, this reduced the available micronutrient supplies to the poor households formerly dependent on more diverse cropping systems, which provided more traditional micronutrient-rich food crops (such as pulses, fruits, and certain vegetables) that are now in low supply (Tontisirin, Nantel, and Bhattacharjee 2002). Thus, the farming community should recognize these changes in economics. This shift will drive the future of agriculture in India. Further, the forward linkages, such as transportation, storage, processing, grading, communication, and so on, are essential to move food products from farm to plate.

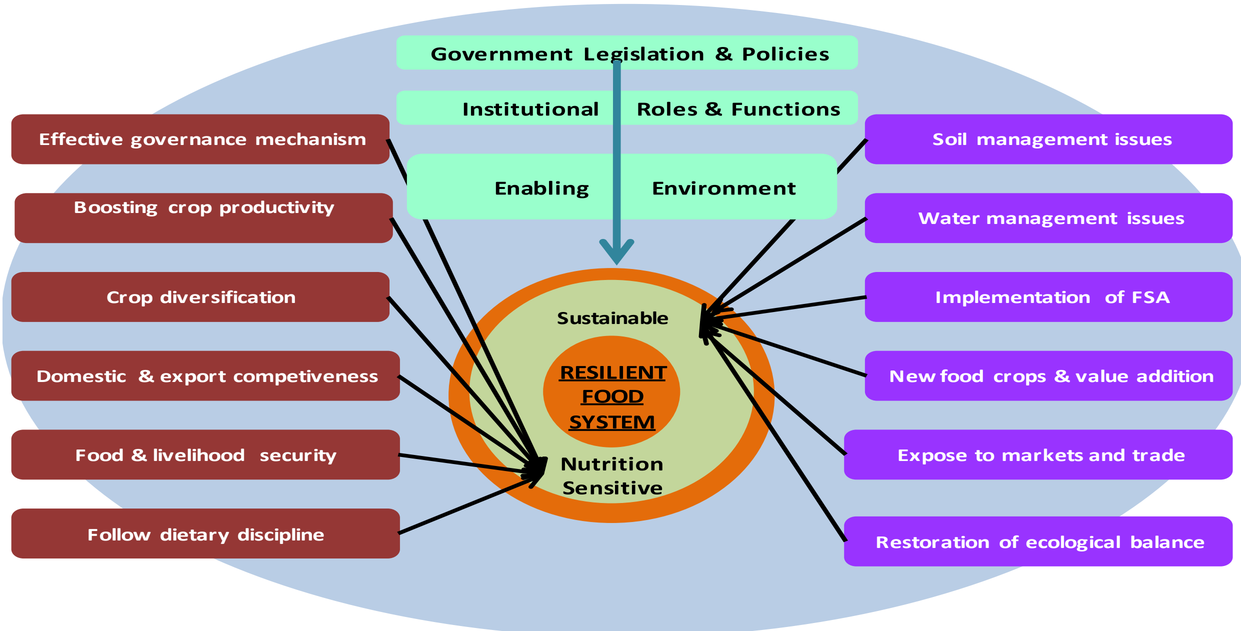
There is ample scope for refining the existing food system considering the ease of the nutrition transition among households and the production potential of different agroclimatic zones suited to a wide variety of crops and allied enterprises.

All these paradigm shifts and economic forces will reflect the importance of consumer issues in determining successful farming operations, resulting in a resilient food system. Das, Sharma, and Babu (2017), using data from two states in India (Uttar Pradesh and Madhya Pradesh), explain the disconnect between agricultural production and nutrition security. Even though growth in the agriculture sector is measured in terms of performance, the purpose of agriculture is to grow healthy, well-nourished people (Fan, Pandya-Lorch, and Fritschel 2012). Thus, steps need to be taken to improve food system resilience.

5. Recommendations

Based on the consumption data presented in this paper, there are several opportunities to increase food system resilience in Kurnool. Because we use a nutrition-sensitive food system as an indicator for measuring system resilience, consumption of a balanced diet should be encouraged through increasing dietary diversity. Further, strategies should be developed to increase access to information regarding the consumption of nutrition food. Such a food system demands a holistic approach to addressing nutritional issues right from food production to final consumption. We need to address different interventions at all stages of the food chain, such as the demand-driven production of a variety of affordable, nutritious, culturally appropriate, and safe foods in adequate quantity and quality to meet the dietary requirements of the population in a sustainable manner. This reflects the broader focus of the entire food system. Based on the analysis, Figure 6 presents recommendations that can improve food system resilience.

Figure 6: Strategies to increase food system resilience



Source: Author's illustrations
Note: FSA = Farming Systems Approach.

First, agriculture productivity can be improved through improvement in soil and water management techniques. Soil management challenges for Kurnool district include achieving food security with minimal risks to the environment, high risks of soil degradation by a wide range of degradative processes, resource-poor farmers, and weak institutional support. Most of the soils in this district are black soils (61 percent) and red soils (33 percent), and through their scientific management, productivity loss can be minimized for major food crops. Soil-specific technologies for agricultural intensification will have to be developed, fine-tuned, and adopted. These technologies will enhance soil structure, improve the nutrient efficiency of soil through integrated nutrient management, strengthen nutrient recycling mechanisms, conserve soil and water through residue management and conservation tillage, restore degraded soils, and replenish nutrients to maintain soil quality.

Because Kurnool district is in the Scarce Rainfall Zone of Andhra Pradesh, with an average rainfall of approximately 670 mm, it is crucial to prioritize issues of water management. The decline in per capita area under irrigation in upland cultivation, increasing demand for water due to urbanization and industrialization, waterlogging-induced soil salinity in lowland areas, and poor quality of the water available for irrigation are challenges faced by farmers during agriculture production. Due to water scarcity, farmers face limitations on cultivating crops year-round, resulting in declining yields of crops such as rice, groundnuts, chilies, and others. Farmers in Kurnool district should adopt efficient methods of water harvesting, recycling, and irrigation, and plan for improvements in rainfed agriculture through water conservation. Further, using drought-resilient crop varieties could be a possible solution.

State agricultural universities and Indian Council of Agricultural Research institutes should focus on bridging research gaps in improving yields of the food crops in different agroecological regions of Kurnool district. Climate change, population growth, growing urbanization, and changes in consumption patterns increase pressure on the agriculture sector. Recent changes in climate show adverse impacts on food production in Kurnool district, in view of the high population depending on agriculture and excessive pressure on natural resources. Research programs in the farmers' fields must be given priority because they will lead to substantial improvement in crop and soil management.

Second, there is a need to promote innovations in the existing cropping pattern. Because the majority of the farmers in Kurnool district are resource poor, there is a need to increase access to timely and reliable information regarding new crops and better cropping techniques. There is an urgent need for the development of participatory innovation approaches, ranging from farmer-led approaches, in which farmers define the research agenda, to approaches that build the capacity of farmers to participate in formal research. Further, because Kurnool district is blessed with a good natural resource base, there is ample scope to introduce new food crops of high-yielding varieties (HYVs) in the existing food system. Using HYVs can contribute to improved food security and income generation for resource-poor farmers. Apart from using HYVs, farmers could also use drought-resistant varieties due to limited access to water.

Third, improving access to markets and trade can result in improved competitiveness and increased access to food. Agriculture in Kurnool district is dominated by small-scale subsistence farming and is transitioning toward a market-based production system. Despite the overall economic growth, the majority of the population lives in poverty and has limited access to food. Enhancing the competitiveness of farmers in both domestic and international markets deserves special attention through generating cost-effective production programs and producing quality output. Policy options include harmonizing legislation and regulations to enhance fair and free marketing of food crops; establishing an institutional framework that will improve performance of the agricultural marketing systems based on needs assessments; creating awareness of quality, standards, grades, and governing regulations among agricultural marketing stakeholders; supporting training in entrepreneurial and marketing skills for agricultural marketing stakeholders; promoting primary agri-processing and value-addition chains; strengthening links between local and foreign firms; mobilizing adequate resources for investment in agriculture; developing agricultural marketing infrastructure in rural areas; and strengthening agricultural marketing information services to enhance timely, demand-driven collection, analysis, storage, and dissemination of marketing information.

Fourth, improved governance and political structure can increase food system resilience in Kurnool district. Government ministries (for agriculture, health, water, finance, and social development), research institutions, and other stakeholders must play a crucial role in promoting and adopting nutrition-sensitive agriculture practices and policies. The government can plan and implement nutrition-sensitive strategies that promote agriculture productivity, for example, promoting food fortification, establishing cooperatives and marketing groups to encourage trade of more nutritious food commodities, promoting awareness among farmers of better farming practices, promoting protein-based crops through better extension services, and improving coordination among all stakeholders (farmers, researchers, extension providers, and the public sector). The government must also strengthen the food supply chain to reduce waste and losses that occur during storage, transportation, and other food system activities.

Fifth, to ensure sustainability of production systems, it is important to promote good agricultural practices among the farming community without affecting the soil health environment. The Department of Agriculture, Krishi Vigyan Kendras (at Yagantipalli and Banavasi), nongovernmental organizations, and others play a key role in training farmers and promoting ecosystem-based adaptation (EbA) strategies, such as use of agroforestry systems to buffer the impacts of high temperatures, heavy rains, or other climate impacts on crops or livestock; establishment of windbreaks to reduce impacts of extremely strong winds; use of soil conservation practices (cover crops, terracing) to prevent soil erosion and maintain soil fertility under heavy rainfall; establishment of live fences to prevent soil erosion and provide fodder to cattle during the dry season; and diversification of crops and animal breeds to minimize the risk of production losses due to changing climatic conditions, climate-driven pest or disease outbreaks, and so on (Harvey et al. 2017). These EbA strategies are useful for smallholder farmers in Kurnool, who have limited access to new technologies and require external inputs (such as improved seed varieties, irrigation systems, or increased fertilizer and pesticide use).

Last, it is crucial to increase awareness regarding the importance of a balanced diet and agriculture-nutrition linkages among consumers and producers. Household income has the greatest potential effect on nutrition, especially among the most vulnerable. Interventions increasing household incomes can result in improved access to food. The seasonality of agricultural income and irregular cash flow also increase risk for these households, decreasing their ability to spend on quality food and animal-source protein for consumption. Increasing incomes of the households in agriculture (through training them in farm management) and in alternative ways (by strengthening other livelihood streams such as wage labor and other value chain functions) can increase the consumption of a nutritious diet. Informal discussions held with the sample households in Kurnool district revealed that households, especially from urban areas, are spending more than half of their food budget on junk foods, despite a healthier diet's being more affordable. There is an increase in consumption of sugar, fat, salt, and alcohol, especially in urban Kurnool. Therefore, there is a need to increase awareness regarding the importance of nutritious food and a balanced diet to increase food system resilience.

6. Summary and Conclusions

A balanced diet and nutritious food are essential for human development. In order for a food system to be resilient, a production system should be sustainable and meet the dietary needs of the population. In this paper, we present a conceptual framework that provides steps to improve food system resilience using changing consumption patterns. First, we analyze currently changing patterns at the national, state, and district levels in India. We use data collected by NSSO for the national and state-level analysis. Primary data from 2,500 households in Kurnool district in Andhra Pradesh were collected for the district-level analysis. Using this analysis, we provide potential strategies that can be implemented.

Overall, there has been a shift in consumption pattern over time as food baskets have diversified. The national and state-level assessment of consumption patterns reveals gradual diversification in the food basket, resulting largely from the growing inclination of consumers toward high-value commodities such as edible oils, fruits, vegetables, milk and its products, and non-vegetarian food items, from the traditionally narrow dietary mix dominated by food grains and pulses. At the district level, the important factor contributing to the change in the consumption pattern is the increasing urbanization in Kurnool district of Andhra Pradesh. The advent of globalization and removal of trade restrictions have also played an important role, and urban households especially prefer high-value and processed food products.

Informal discussions with the sample households revealed that about 30–40 percent of the population in both rural and urban areas is undernourished. The present food system in India in general, and in the Kurnool district of Andhra Pradesh in particular, is unable to meet the food and nutrition security needs of the population. These conditions are worsened in the case of a natural disaster. There is an urgent need to increase resilience in Kurnool's food system in order to provide continued food and nutrition security to consumers. Based on the analysis presented in this paper, we provide recommendations that can be implemented in Kurnool district to improve its food system's resilience. Further, these recommendations can also be implemented in other regions with similar characteristics.

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