ASSESSMENT OF AFFORDABILITY AND SUSTAINABILITY OF SELECTED INDIAN DIETS USING SECONDARY SOURCE DATA

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ASSESSMENT OF AFFORDABILITY AND SUSTAINABILITY OF SELECTED INDIAN DIETS USING SECONDARY SOURCE DATA

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CERTIFICATE

This is to certify that the research work presented in this thesis has been carried out independently by Ms. Purva Bahadkar under the guidance of Dr. Suneeta Chandorkar in pursuit of Degree of Master of Science (Family and Community Science) with major in Foods and Nutrition (Public Health Nutrition) and this is her original work.

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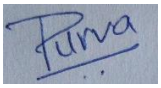

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ABSTRACT

The availability of affordable and sustainable diets is the key to achieve SDG-2 targets. Our country is facing the dual burden of malnutrition and incidence of NCDs is increasing among rural and socio-economically disadvantaged groups. The usually consumed diets by our population are either lacking in nutrients as the nutritious diets are not affordable while certain population groups are consuming nutritious diets that are not sustainable.

Present study aimed at assessing the affordability of usually consumed and 4 hypothetical diets (vegan, vegetarian, ovo-vegetarian and mixed) from various states of India. Minimum dietary diversity for women in rural and urban areas of various states of India was also studied. Accessible, affordable and sustainable healthy diet for all is pre-requisite to achieve SDG's related to economic growth, health, well-being, life expectancy, climate change and environmental sustainability. Therefore, the study also investigated mean GHG emissions from usually consumed diets and nutritious diets from various states of India.

The exploratory study was carried out using appropriate secondary source data. Cost of Diet software was used to arrive at the 4 hypothetical diets.

The cost of usually consumed diet for men was reported to be higher in rural areas than in urban areas in most of the states of India while the vice versa was true for women. The average cost of usually consumed diet for men and women was ₹45.2 and ₹36.4, respectively in rural areas, and mean average cost of usually consumed diet of men and women was ₹40.2 and ₹49.9 respectively in urban areas.

Women from rural areas were less food and nutrition secure than those from the urban areas from various states of India as measured using dietary diversity score. Rural women from 7 out of 27 states were reported to have good dietary diversity while urban women from 11 out of 27 states had satisfactory dietary diversity score. Women from Kerala, Goa, Arunachal Pradesh, and Jammu & Kashmir states had satisfactory dietary diversity score while those from Manipur, Nagaland, and Jharkhand states had lowest dietary diversity score.

The energy only diet and macronutrients diet were found to be affordable for populations across all the regions while the nutritious diet was affordable for some population from various states of India.

Mean GHG emissions from usually consumed diets was higher from those states with higher consumption of animal source foods and rice. Mean GHG emissions of Vegan diets were comparatively lower than vegetarian diet, ovo-vegetarian, and mixed diets in various states of India. However, it is important to understand that vegan products are highly processed, high in fats, and transported from long distances, and have high water footprint.

The shift from production of staple diets with rice and wheat towards coarse cereals, pulses, and fruits and vegetables is necessary to make food system healthier, affordable, and environmentally more sustainable in India which will eventually improve dietary diversity and food security in India.

INTRODUCTION

1. INTRODUCTION

The availability of affordable and sustainable diets is the key to achieve SDG-2 targets **(Fanzo, 2019)**.Every country is affected by malnutrition either as under nutrition, micronutrient deficiencies, or overweight and obesity with some countries struggling with multiple forms. These forms of malnutrition present a major impediment to achieving sustainable development, with adverse consequences for human health, the environment, and human capabilities. While there are multiple underlying determinants of malnutrition, sub-optimal diets is a common factor for poor nutrition outcomes**(Mozaffarian & Forouhi, 2018)**.

Overview of current situation of malnutrition and food insecurity

Food insecurity exists when all people, at all times, do not have physical, social, and economic access to sufficient, safe, and nutritious food that meets their food preferences and dietary needs for an active and healthy life. The world is neither making progress towards SDG target 2.1 i.e. ensuring access to safe, nutritious and sufficient food for all people all year round, nor towards target 2.2 i.e. eradicating all forms of malnutrition. Before COVID-19 pandemic, nearly 690 million people in the world were undernourished. In 2019, 2 billion people, experienced hunger or did not have regular access to nutritious and sufficient food. Food insecurity affects diet quality of vulnerable population (young children and women) and health of population in different ways. In 2019, 144 million of children under 5 years ago were stunted, 47 million were wasted, 38.8 million were overweight and at least 340 million children suffered from micronutrient deficiencies. Majority of world's undernourished people i.e. 381 million people lives in Asia. After a prolonged decline, world hunger appears to be on the rise again. Conflict, drought, and disasters linked to climate change are among the key factors causing reversal in progress **(FAO, 2020)**.

The prevalence of underweight children under 5 years is 35.8% according to NFHS-4. The prevalence of stunting and wasting among children under 5 years is 38.4% and 21.0% respectively according to NFHS-4**(International Institute for Population Sciences,**

2017). In Gujarat, 39% and 25.1% of children under 5 years were stunted and wasted respectively. Around 3.9% of children under 5 years were overweight**(Indian Institute of Population Sciences, 2020)**. Ahmadabad, Surat, Sabar Kantha, Anand, Banas Kantha, and Vadodara has highest food security status and Porbandar, Amreli, Tapi, Navsari, Patan, Narmada, and Jamnagar has lowest food security status**(Surendra Singh & Singh, 2019).**

Stunting has lifelong effects on young child like impaired mental health, and physical development, and reducing the earning potential in future. Overweight and obesity are major causes of diabetes, strokes, and cardiovascular disease. Overall, poor diet is the major risk factor of morbidity and mortality than the risk factors such as alcohol, drug, tobacco, and unsafe sex. Accessible, affordable and sustainable healthy diet for all is pre-requisite to achieve SDG's related to economic growth, health, well-being, life expectancy, climate change and environmental sustainability**(Global Panel, 2017)**.

Minimum Dietary diversity for women

MDD-W is a dichotomous indicator which measures whether or not women 15–49 years of age have consumed at least five out of ten defined food groups the previous day or night. The MDD-W was developed as a proxy indicator to reflect the micronutrient adequacy of women's diets.(**FAO & 360, 2016)**

Dietary diversity is the number of food groups consumed in a given period. Food diversity adds several dimensions to human health as it encourages biodiversity and sustainability. It also, provide nutritional adequacy, minimizes adverse consequences of food on health, provides interest in food, and finally reduces the prevalence of chronic diseases**(Mukherjee et al., 2018)**.

Dietary diversity in the urban and rural India is slightly improving from over 2 decades. The rural diets are more diverse than the urban diets on an average. The relationship between dietary diversity and income is not linear. Diet should become more diverse as income increases but the richest quintile has low dietary diversity than poor quintile households. As the income increases the expenditure also increases on processed foods and animal-sourced foods. This results in

consumption of empty calories and increases the risk of obesity**(Sukhwinder Singh, 2020)**.

Affordability and sustainability of healthy diet

A healthy diet includes adequate calories, nutrients, and food diversity. The EAT-Lancet reference diet consists of fruit and vegetables, with a plant-based source of proteins and fats, unsaturated oils from fish, and carbohydrates from whole grains. The average calorie consumption in India is below the recommended 2503/kcal/capita/day in the population. The diets in India consist of a significantly higher amount of cereals than the EAT-Lancet recommendations and consumption of fruits, vegetables, legumes, egg, and meat is significantly less(Sharma et al., 2020a). Consumption of processed foods such as biscuits, chocolates, chips, sweets, juices, etc. among adults in urban areas is higher (13.4%) than that of vegetables (10.6%)**(*What_india_eats.Pdf*, n.d.)**. Healthy diets are unaffordable to many people, especially the poor **(FAO, 2020)**.Affordability means that people have the capacity to buy all the healthy foods they want in the income they have available (Sharma et al., 2020a).

The most conservative estimate shows healthy diets are unaffordable for more than 3 billion people in the world. Healthy diets are estimated to be, on average, five times more expensive than diets that meet only dietary energy needs through a starchy staple **(FAO, 2020)**. The cost of the EAT-Lancet reference diet in 2011 was estimated at $2.84. Fruits and vegetables account for a large (31.2%) share of quantity and price of the total diet, followed by legumes and nuts (18.7%), meat, egg, and fish (15.2), and dairy (13.2%)**(Hirvonen et al., 2020)**. The cost of a healthy diet is beyond the reach of people living in poverty or just above the poverty line as it is much higher than the international poverty line, established at USD 1.90 purchasing power parity (PPP). Growing trends of overweight and obesity are maybe due to higher prices of healthy diets and easy access to cheaper, less nutritious food options. The inexpensive energy-dense foods that are high in sugars and fats are found to be positively related to excess body weight in adults**(FAO, 2020)**. To change the consumption pattern of India, a change in production pattern is

required. India produces too much rice and too little of coarse cereals, pulses, fruits, and vegetables. The shift from producing rice towards coarse cereals and pulses will make India's food system healthier, affordable, and environmentally more sustainable **(Sharma et al., 2020a)**.

Sustainable diets are: 1) protective and respectful of biodiversity and ecosystems; 2) culturally acceptable; 3) accessible, economically fair and affordable; 4) nutritionally adequate, safe and healthy; 5) optimize natural and human resources; 6) Resilient to shocks and change.

Diets in India are changing and in recent decades there has been a decline in the consumption of some cereals like millets, while the consumption of salt, oils, and animal products has increased**(Joshi et al., 2019)** . The diet can be diversified by including meat. But in India the predominant diet is vegetarian diet because of the cultural principles and also may be due to unaffordability of animal foods. Meat is more nutrient dense and bioavailable than plant source protein. However, the animal source protein is much more expensive than plant source protein. An Indian household already spends about 40% of the income on the food expenses. As the urbanization is increasing the consumption of meat is also increasing**(Rao et al., 2018)**. These changes are associated with an increase in NCDs and impact on environmental parameters. A Rice-based low dietary diversity diet was found to be associated with the lowest Greenhouse Gas emission while those comprising wheat, sugar, oil, and animal-source protein were found to have the highest Green House Gas emission. In India, widespread adoption of healthy diets may lead to small increases in the environmental footprints of the food system although, much larger increases would occur if there was the widespread adoption of diets comprising of ultra-processed foods which is currently consumed by the wealthiest quartile of the population**(Alae-Carew et al., 2019)**.

The agriculture sector accounts for 17.6% of India's greenhouse gas (GHG) emissions in 2007 and due to its large population, India is already the 4th largest emitter of GHGs in the world. Per capita, GHG emissions associated with current dietary patterns in India are relatively low compared with that of other countries largely due to low consumption of animal products but future dietary changes in conjunction with continuing population growth could make it hard for India to meet its targets of reducing GHG emissions intensity

by 33–35% below 2005 levels by 2030**(Green et al., 2018)**. The agriculture sector is also a major user of ground and surface water and recent changes in dietary patterns in India are linked to increased demand for irrigation water. This lead to an additional issue for environmental sustainability as irrigation water for agricultural use is increasingly being drawn from rapidly depleting groundwater resources(**Rodell et al., 2009)**.Current and future trends in Indian diets, therefore, have potential implications for GHG emissions, health, ground and surface water availability, and potentially several other environmental factors**(Aleksandrowicz et al., 2019)**.

To reduce GHG emissions, dietary changes as well as mitigation options in farm management are needed**(Vetter et al., 2017)**. Making shifts in the intake of cereals from rice to wheat and other coarse grains and reducing cereal consumption and increasing vegetables and fruit intake will be a helpful route for reducing GHG emissions and also achieving health benefits**(Aleksandrowicz et al., 2019)**. To change the consumption pattern of India, a change in production pattern is required. India produces too much rice and too little of coarse cereals, pulses, fruits, and vegetables. The shift from producing rice towards coarse cereals and pulses will make India's food system healthier, affordable, and environmentally more sustainable**(Sharma et al., 2020b)**.

RATIONALE

To achieve the SDG 2 target, End hunger, food insecurity, and malnutrition, affordability, and sustainability are important components. The current food system is not sustainable and dietary changes can help achieve sustainability. Therefore, assessment of the affordability and sustainability of healthy diets for all states of India will provide an understating of the gaps in the food system, help to achieve food security.

Objectives

Broad objective

To assess the affordability and sustainability of selected Indian diets using secondary data.

Specific objectives

- To estimate the cost of usually consumed diets for various states of India.
- To estimate minimum dietary diversity for women of usually consumed diets for various states of India.
- To estimate the cost of 3 hypothetical diets (Energy only diet, macronutrients diets, and nutritious diets) for various states of India.
- To assess the affordability of usually consumed diets and nutritious diets for various states of India.
- To assess the sustainability of usually consumed diets and 3 hypothetical diets for various states of India.

REVIEW
OF
LITERATURE

2. REVIEW OF LITERATURE

The relevant literature has been reviewed in this chapter under the following heads:

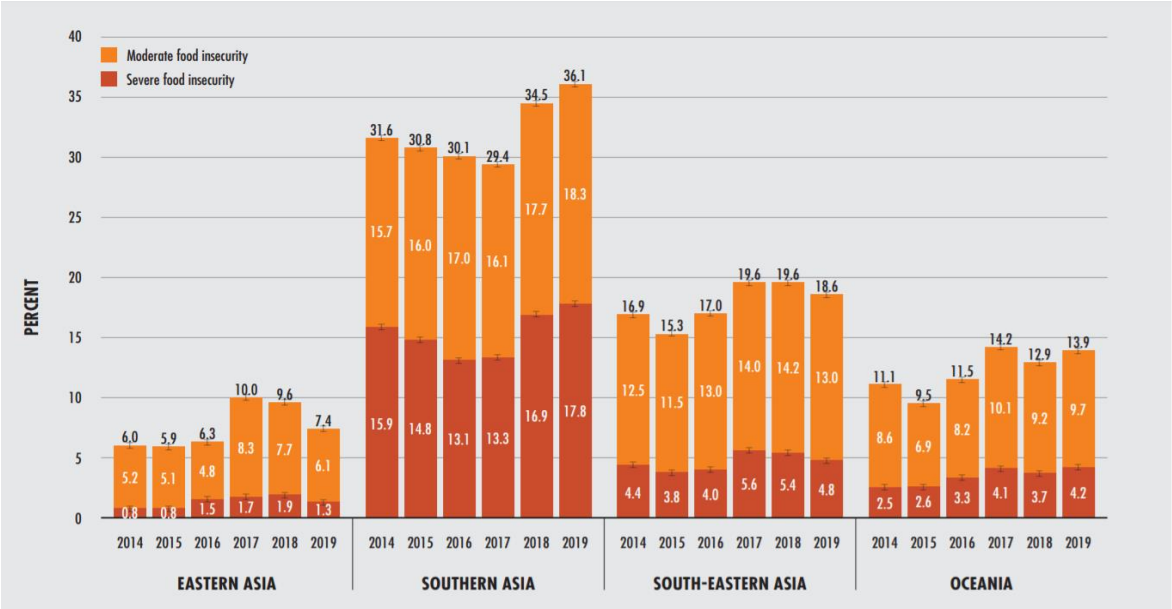
- ✓ Food security
- ✓ Minimum Dietary Diversity for Women
- ✓ Affordability of healthy diets
- ✓ Sustainability of healthy diet

Food security exists when all people, at all-time, have physical and economic access to sufficient, safe, and nutritious food to meet their dietary needs and food preference for an active and healthy life. Food security is dependent on its all components food availability, accessibility, and stability. It shows that all the 3 components of food security are important to maintain sustainable food security. Worldwide, the production of food is enough to feed everyone but the technology to produce it and the food itself does not always reach the person in need. Food insecurity can increase the risk of various forms of malnutrition as it can worsen diet quality. In 2019 globally, 21.3 percent of children under 5 years of age were stunted, 6.9 percent wasted and 5.6 percent were overweight. The world is progressing to achieve targets but is not on track to achieve it by 2025 **(Boliko, 2019) (Jain, 2016) (FAO et al., 2020).**

Food is a basic need of a human. Article 11 of the International Covenant on Economic, Social, and Cultural Rights states that 'it is the fundamental right of a human to get freedom from hunger and under-nutrition **(Swaminathan, 2020.**). Hunger can be used to measure food insecurity. Global Hunger Index (GHI) indicates the level of hunger in the population. The GHI 2019 shows that the world is making gradual progress in reducing hunger since 2000, but this progress is uneven. GHI score of 2019 was 20.0 which comes under the category of serious to moderate. South Asia's high GHI is driven by its high rates of child under-nutrition. The child stunting rate for this region is 37.6% and the child wasting rate is 17.5% **(Global Hunger Index, 2019)**. India ranks 102nd out of 117 qualifying countries. GHI score of India is 30.3 which indicates a serious hunger level. This score reflects calorie deficiency as well as poor nutrition in the population **(Global Hunger Index,**

2019).Around 945 million people in Asia and the Pacific region are experiencing moderate or severe food insecurity. Southern Asia has the highest percentage of severe and moderate or severe food insecurity. These estimates were collated by FAO before COVID-19, so the figures could be higher as a result of the pandemic. Figure 2.1, shows the prevalence of food insecurity in Asia and the Pacific, by sub region levels from 2014-2019. **(FAO et al., 2020)**

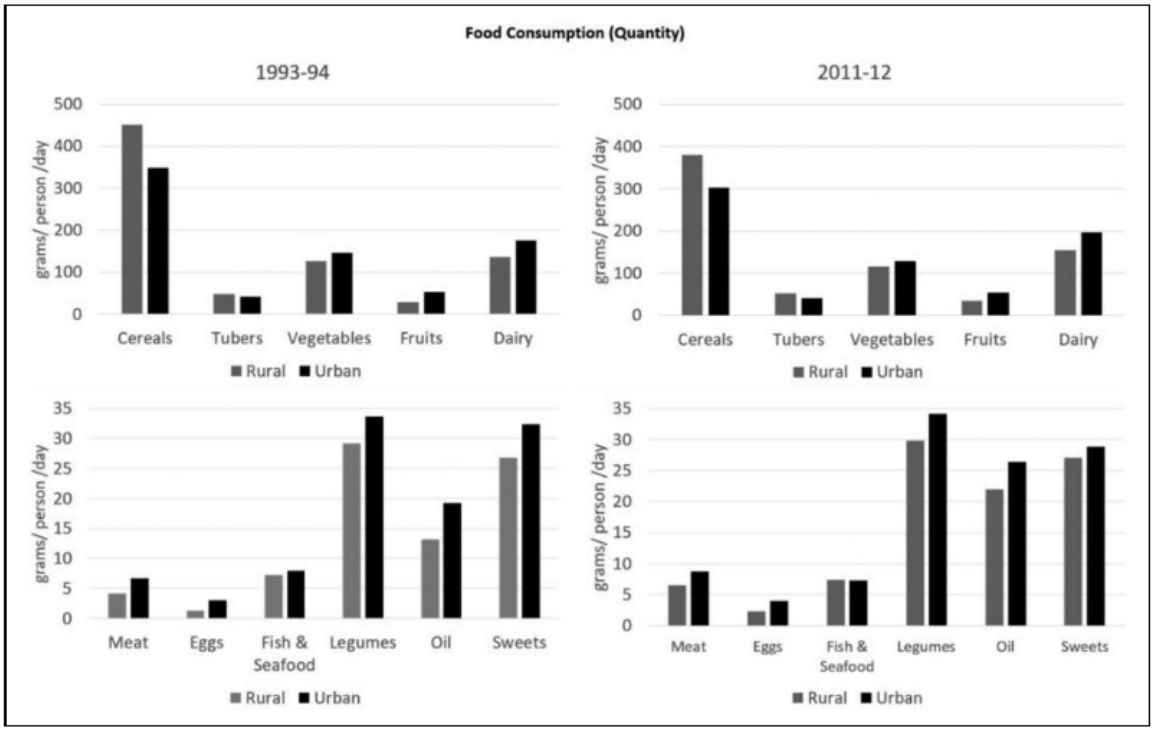
Figure 2.1: Prevalence of food insecurity in Asia and the Pacific, by sub region, 2014-2019



Source: FAO

According to FAO, if a person's per day calorie consumption is less than 1800kcal, then the person is considered as undernourished. The calories, protein, and fat consumption show an increase during 2004-05 and 20011-12. Also, the Global Hunger Index (GHI) 2014 shows a decline in malnutrition and the intensity of hunger in India. However, India's hunger index is under a serious category**(S. P. Singh, 2016).**

Figure 2.2: Consumption of individual food groups from 1993-94 to 2011-12



Source: (Tak et al., 2019)

The above figure shows changes in per capita quantity of food consumed between 1993-94 and 2011-12. From 1993-94 to 2011-12, consumption of cereals is declined by 70g/day and 50g/day in rural and urban respectively. Consumption of vegetables (approx. 13g less), fruits (approx. 20g less), and dairy (approx. 42g less) are less in rural households as compared to urban households. There is a slight increase in the consumption of animal-source foods in both rural as well as urban households. In rural areas consumption of dairy has increased approximately by 19g/person/day and in urban areas, it is increased approximately by 21g/person/day. There is also an increase in consumption of meat and egg by 2.29g/person/day and 1.08/person/day respectively in rural areas. Similarly, in urban areas consumption of meat and egg is increased by 2.04g/person/day and 0.99g/person/day respectively. Consumption of pulses, nuts, and seeds, legumes, and fish has changed little in the past 2 decade's period. The above figure shows that consumption of oil is increased substantially over 2 decades from 8.8g/capita/day in rural areas and

7.13g/capita/day in urban areas. Consumption of sweets shows a slight decline in urban and a slight rise in rural households. **(Tak et al., 2019)**

One-sixth of the global population lives in India. Fall in death rates and unaltered birth rates give rise to rapid population growth. This growing population imposes a great strain on the country to reduce hunger and food insecurity **(Ramachandran, 2014)**Removal of hunger is necessary for improving the overall development of the country. The higher the healthy people in the country higher the level of productivity and efficiency (S. P. Singh, 2016). Ensuring food security in India is a challenge due to its high level of poverty and malnutrition. There are many challenges which India faces in attaining food security like excessive rainfall, accessibility of water for irrigation purpose, droughts, soil erosion, degraded soil, infertile soil, acidic and alkaline soil, growth in population, lack of education, and lack of job opportunities and non-improvement in agriculture facilities **(Jain, 2016).** Causes of food insecurity are as follows:-

I. **Climate extremes:** Climate change is a major cause of food insecurity. Climate changes and extremes are a rising trend in frequency as well as in multiple types of climate extremes **(Boliko, 2019)**Climate change adversely affects agricultural growth. Climate change gives rise to a rise in temperature which affects the availability of water, agricultural production, land use, and other factors **(Jain, 2016)**In India, the highest temperature occurs between May or the beginning of June. In the arid areas in the northwest area of India, afternoon temperature rises as high as 40degree C. In May 216, the temperature in the India-Pakistan border exceeded 50 degrees C. In Phalodi temperature reached 51.6 degrees C, which was India's record from 2015. The previous record was 50.6 degrees C from 1956. Extreme heat can have devastating impacts on human health like heat cramps, exhaustion, and life-threatening heat strokes. On 19 May 2016, 17 heat-related deaths occurred in the Gujarat state, 7 in Madhya Pradesh, and Rajasthan 16 deaths, and hundreds of people were admitted to the hospitals in western India due to heat-related illness. **(Van Oldenborgh et al., 2018).** Climate change adversely affects agricultural growth **(Jain, 2016)**. Climate changes affect the consumption of calories and crop yields in Asia. In India, the production loss of wheat is

approximately -0.7% and rice is approximately -2.1%. Consumption of calories was reduced by approximately 1.2% due to climate change. Climate change has increased the risk of food insecurity in many food-insecure countries as it reduces calorie consumption and also yields **(Ray et al., 2019)**.

II. **Crop diversification:** After the Green Revolution objective of food security was achieved by the nation in successive years. Farmers were encouraged to produce wheat and rice. Low crop diversity affects food security. Agricultural scientists encouraged farmers to cultivate oilseeds and pulses that would yield less quantity of irrigation, high profits as compared to field crops**(Jain, 2016)(Chadha, 2016)**.

III. **The mismatch between Water Demand and Availability:** Major problem India faces in achieving food security is a dependency on monsoon for the cultivation **(Jain, 2016)**The negative relationship between the demand and supply of water constrains agricultural growth and food security. About 20% of global land is irrigated, it utilizes an estimated 70% of the global water to get high yields but due to the squat quality of seeds, it causes lesser yields. The global water demand is about 2.4% higher as compared to the supply of water**(Chadha, 2016)**.

IV. **Globalization:** Globalization also affects food security. Though globalization bought many positive changes in technology development, communication, transport, and high growth in the service sector at the same time it has also resulted in widening the gap between rich and poor sections. **(Jain, 2016)**

V. **Land Fragmentation and Agricultural Marketing:** Increased population has led to an increase in the land for developmental activities leading to land fragmentation and low productivity. Poor marketing of agriculture in India is also the reason for poor food security. Poor roads, poor market infrastructure, and excessive regulations hamper farmer's access to the market**(Jain, 2016)**

VI. **Conflicts:** Countries in conflicts show the highest level of food insecurity and undernutrition. Conflicts lead to insufficient access to food and other services. As people have limited access to food, the price of food sharply increases **(Boliko, 2019)**. In the conflicts or situations like pandemics diets of households get disrupted. In 4 states of India during the COVID Pandemic, 62% of farmer households reported disruption to their diets. The majority of the household was

able to access the staple foods and the largest of the population failed to access fruits and animal source foods other than dairy. Around 30% of households reported that they failed to consume vegetables on the contrary 15% of households reported increased consumption of vegetables. This suggests the highest vulnerability of female farmers and young children in terms of both livelihoods and diet. **(Harris et al., 2020)**

To achieve food security in India, an adequate and consistent food supply is needed, as per nutritional requirements and food preferences. In the world, India ranks among the top 3 in the production of many crops, fruits, and animal products. Although India is the top producer of many crops in the world, the country is still facing extreme hunger and food insecurity among children and women **(Ministry of Statistics and, 2019)**.

The Government of India has adopted various policies to address food insecurity. One of the key responses is the distribution of food grains through the government-controlled Public Distribution System (PDS). However, the studies which examined the effectiveness of the PDS, suggested that the PDS was not working effectively, a large amount of food is not reaching the intended recipients, and high wastage results in the high cost for limited benefits. For example, a study conducted by Dhanaraj and Gade estimated that in Tamil Nadu, for every 5.43 kg of PDS rice distributed by the government, only 1kg reaches the recipient. Conversely, in Bihar, wherein 1993, 90% of the food grains were not reached to the recipient; by 2001 this number came down to just 12.5% of diverted food grains. This attributed to better transparency and infrastructure. **(George & McKay, 2019)**The nutrition quality of the foods (i.e. are these foods contributing to meet age-specific nutritional needs?) delivered by the Government programs like PDS, MDM, take-home ration, etc. can help to reduce household food insecurity. The effective coverage of these Government programs to the population groups that are most vulnerable from a point of view of nutritional needs can be essential to achieve food security. **(Chandrasekhar et al., 2017)**

To overcome food insecurity each of its components i.e. food availability, food affordability, food accessibility, and stability needs to be addressed. Food availability is total food production and buffer stocks maintained in government granaries. It is also referred to as the ‘supply side’ of food security. Availability can be achieved by increasing

production, import, and better distribution systems **(Jain, 2016)**.). According to a study conducted in Urban Vadodara, out of 23 slums about 52% of the slums were secure in terms of availability dimension, 26% of the slums were secure in terms of accessibility, 17% of the slums were secure in terms of utilization and 30 % of the slums were secure in terms of stability **(Chandorkar and John, 2017).**

Figure 2.3: District wise food security index for Gujarat

District	FAVI	FACI	FSTI	FSI	Rank	Degree of Food Security Status
Ahmadabad	0.06	0.04	0.01	0.03	1	Very High
Vadodara	0.06	0.00	0.05	0.04	2	Very High
Banas Kantha	0.05	0.04	0.00	0.00	3	Very High
Anand	0.03	0.02	0.00	0.00	4	Very High
Sabar Kantha	0.04	0.06	0.00	0.02	5	Very High
Surat	0.08	0.03	0.04	0.08	6	Very High
Rajkot	0.05	0.06	0.00	0.01	7	High
The Dangs	0.07	0.07	0.02	0.05	8	High
Junagadh	0.05	0.01	0.00	0.04	9	High
Kachchh	0.04	0.04	0.00	0.01	10	High
Mahesana	0.04	0.05	0.00	0.01	11	High
Kheda	0.08	0.03	0.01	0.02	12	High
Gandhinagar	0.04	0.05	0.00	0.00	13	Medium
Bhavnagar	0.08	0.05	0.01	0.02	14	Medium
Surendranagar	0.08	0.05	0.01	0.02	15	Medium
Valsad	0.04	0.06	0.02	0.03	16	Medium
Bharuch	0.05	0.07	0.01	0.03	17	Medium
Dohad	0.05	0.06	0.01	0.04	18	Medium
Panch Mahals	0.08	0.04	0.02	0.04	19	Medium
Jamnagar	0.00	0.04	0.00	0.00	20	Low
Narmada	0.05	0.08	0.01	0.03	21	Low
Patan	0.07	0.01	0.01	0.03	22	Low
Navsari	0.02	0.08	0.00	0.01	23	Low
Tapi	0.08	0.03	0.02	0.02	24	Low
Amreli	0.05	0.05	0.00	0.02	25	Low
Porbandar	0.08	0.05	0.10	0.08	26	Low

Source:(Surendra Singh & Singh, 2019)

The above figure shows the status of food security in the state of Gujarat. The food security was calculated by combining the food availability index, food accessibility index, and food stability index. Ahmadabad had the highest food security whereas Porbandhar has the lowest. The low literacy rate, cash reserve ratio, urbanization, safe drinking water, and secured household condition are the major influencing indicators for low food accessibility. Low yield of food grains, oilseeds, condiments and spices, fertilizer consumption, and

forest area are major influencing factors for lower stability. Low per capita availability of oilseeds, vegetables & fruits, and livestock are major influencing factors for lower food availability**(Surendra Singh & Singh, 2019)**

Minimum Dietary Diversity for women:

MDD-W is a proxy indicator that reflects the micronutrient adequacy of women's diet. If the proportion of food groups consumed are at least five or more than five out of ten food groups then the group is more likely to have higher micronutrient adequacy than other groups consuming less than five food groups**(FAO & 360, 2016)**. Dietary diversity is important to ensure food security since nutrient requirements are multifaceted. Poor quantity and diversity of food are an immediate cause of poor nutritional status **(Gupta & Sunder, 2020)**.

In rural household women consumes less diverse diets and the diet lacks in non-staple food groups like Vitamin A rich fruits and vegetables, dairy, eggs, and GLV. The factors influencing consumption are inter-household allocation of food, income, social status, literacy, and interpersonal relationships between household **(Gupta et al., 2020a)**.

Young children and women are the most vulnerable population. The child is vulnerable as their nutritional needs are higher as compared to other populations. Optimal diets and feeding practices are essential for a young child to prevent malnutrition. Half of the children in Southern Asia and one in five children in Eastern Asia and the Pacific are malnourished as either they are stunted, wasted, overweight or some of them have a combination of all three. These children who are malnourished fails to reach their developmental potential. These children are at high risk of developing diet-related non-communicable diseases later in life**(FAO et al., 2020)**

Household food insecurity is the underlying cause of maternal and child undernutrition and inadequate dietary intake and diseases are immediate causes of maternal and child undernutrition. Children which are moderately food-insecure and severely food-insecure

households are more likely to have lower diet diversity scores. **(Chandrasekhar et al., 2017)**

High crop diversity is associated with high dietary diversity in the household. The male and female farmers had higher crop diversity also has higher dietary diversity in Gujarat and Haryana. Annual income is also associated with male dietary diversity but with a low significance of $p<0.10$. The significance of the association of annual income and education with dietary diversity was stronger in Haryana **(Sukhwinder Singh, 2020)**). The female-headed family tends to have higher dietary diversity as compared to men. The result from a study conducted in Mozambique reveals that a female-headed family consumes a slightly greater share of cereals and vegetables and slightly lower shares of sugar, syrups, and sweets as well as oils and fats. Educated female household head has a significant correlation with increased dietary diversity of household. For each additional year of education of female head, the number of food groups consumed in the household diet increases by 0.06 to 0.08 percent of 13 food groups. **(Smart et al., 2020)**

To improve the individual and household dietary diversity, on-field production diversity i.e. cultivation of pulses, on-farm livestock management, and kitchen garden shows a significant association. Other significant determinants of dietary diversity include women's literacy and market purchases of non-staples like dairy products and pulses**(Gupta & Sunder, 2020)**). Food insecurity increases among women when the dietary diversity is low among women. To improve the dietary diversity of women in rural areas, the field level cultivation of pulses and on-farm livestock management, kitchen gardens show high significance. Improving women's literacy and awareness of nutrition can be helpful to increase dietary diversity**(Gupta et al., 2020b)**. From 2000 to 2017, the availability of foods like fruits and vegetables and dairy products is increased and the availability of staple foods remained stable. The proportion of availability of food groups across the country significantly differs. Food availability is strongly associated with food prices. **(FAO, 2020)**

Food Affordability:

Food affordability means that people should have enough money to have safe, healthy, nutritious food to meet daily requirements. India is the largest producer of food grains in the world. But the fact is that there are millions of people below the poverty line who are unable to get square meals per day and approximately 320 million people in India go to bed without food. **(Jain, 2016)**

A healthy diet is an important factor for optimal nutrition and health outcomes through all stages of the lifecycle. Unhealthy diets are linked with all forms of malnutrition and other health risks. A healthy diet consists of calories from different food groups. Indians consume more cereals, starchy vegetables, dairy foods, and palm oils as compared to reference diet. In the poorest households, the share of cereals in calories is 70%. Calorie intake from protein sources is low as compared to reference diet. The fruits and vegetable consumption in both rural and urban households are significantly lower. The calorie consumption from fruits and vegetables is less than 40% of what EAT- lancet recommends. Palm oil is widely consumed in India. Between 1993-94 and 2011-12 consumption of vanaspati oil is increased by 51%. Processed food like bread, refined wheat flour, bakery products, suji, cold and hot beverages, outside cooked meals including snacks, sweets, chips, pickles, sauce, jams, jelly, ice-creams, biscuits, and chocolates generally has a high amount of sugar, salt, saturated fats which are associated with obesity and NCDs. Nearly 10% of total calorie consumption accounts for processed foods in rural as well as in urban India. A diet that is consumed in India is way more different than the EAT-Lancet diet recommendation and even diets recommended by the ICMR. Also, the dietary diversity in Indian diets is below the recommendations. (Sharma et al., 2020a)

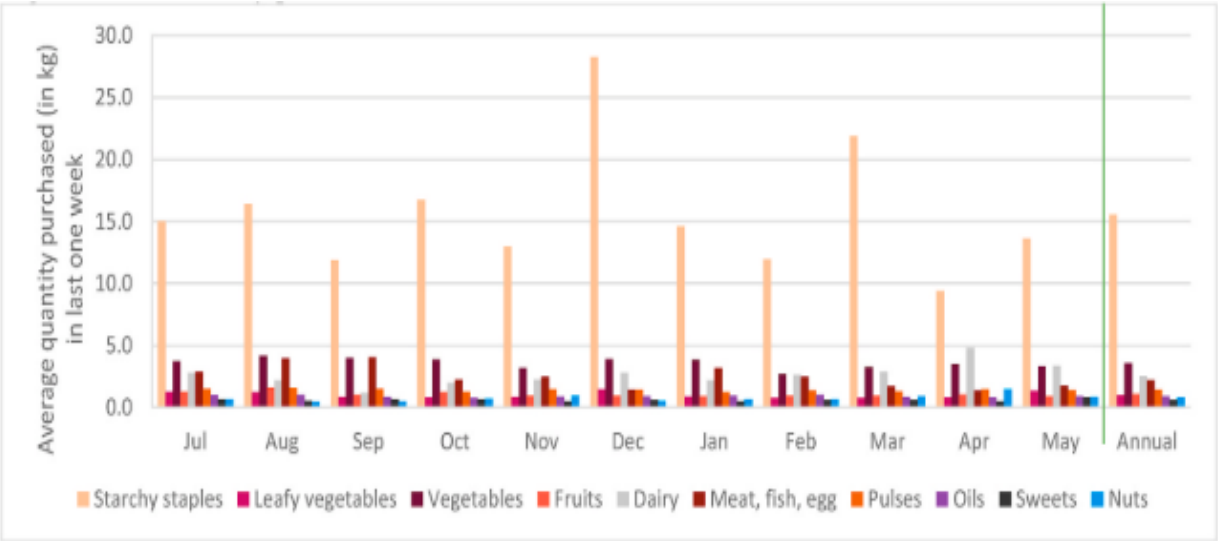
To shift the current diet to healthy diets, the availability and affordability of healthy diets need to improve in low-income countries like India. In 2011, the EAT-Lancet reference diet was estimated to be $2.84. Globally, a healthy diet referred to by EAT-Lancet is unaffordable. Fruits and vegetables in the reference diets account for large quantities and prices as compared to other food groups. In lower-middle-income countries, this share was on average 295, in high-income countries 35.1%, in lower income countries 26.7%. And in upper-middle-income countries 30.3%. And globally the next largest cost is from

legumes and nuts 18.7%, meat, fish, and egg 15.2% and dairy products 13.2%. This shows that EAT-Lancet reference diets are not affordable for many of the low-income countries **(Hirvonen et al., 2020)**. The diet which consists of energy-dense foods made of refined grains added sugars, and added fats are more affordable than the recommended diets based on fruits and vegetables, fish, and lean meats. The Indian diet majorly consists of cereals and tubers and fewer fruits and vegetables **(Barosh et al., 2014)**.

The Cost of Recommended Diet (CoRD) - based nutritious diet in Sri Lanka was SL Rs 187, 87 PRs in Pakistan, and 45Af in Afghanistan. The cost of CoRD- based nutritious diet in India was not calculated due to a lack of price data. This cost was higher than of official poverty line. In Sri Lanka the cost of CoRD- based diet was 38 percent higher than the poverty line and in Afghanistan, it is 15 percent high **(Dizon & Herforth, 2018)**.

The study conducted in four districts of India- Munger, Maharajganj, Kandhamal, Kalahandi, states that the cost of the Eat-Lancet recommended diet on the minimum and average prices are $3.33 and $5.32 per person per day. This is the cost when the foods are purchased from the cheapest source i.e. weekly market. If the food items are purchased from the retail shop the cost of the recommended diet exceeds $5.00 per day per person. The food groups which have the highest share are meat/ fish/ egg (nearly 30%) and dairy (20%). The vegetables account for around 5-8% of the cost even though their share in the recommended diet is 15% **(Gupta et al., 2021)**.

Figure 2.4: Quantity purchased by household



Source: **(Gupta et al., 2021)**.

The above figure explains that a food group that is purchased by a higher proportion of expense doesn't need to also be purchased in greater quantity. Vegetables, oils, and protein-rich foods were reported to be purchased in low quantities than other food groups. Green leafy vegetables and fruits which are micronutrient-rich food groups are purchased in the least quantity. This figure also indicates the dietary diversity of the household **(Gupta et al., 2021).** The consumption of fruits and vegetables is low across the world. In low-income countries like India, the consumption of fruits and vegetables is particularly associated with its affordability **(Miller et al., 2016).** In India, fruits and vegetables show strong seasonal variation. Fruit prices fall by 10% in January, April, and March but then increases rapidly by 20% in June and July, and in monsoon prices again fall. Green leafy vegetables and other vegetable prices also follow a pattern. Prices increase from July to October and then fall sharply down again from November to February. These increases in fruits and vegetable prices affect the CoRD. In rural India, nutritious diets are much more expensive than the population cannot afford. As the income is low as compared to the CoRD. The rural Indian population in 2011 was unable to afford the CoRD even with 100% of the

income. The income of the population is on average 20% below the CoRD (Raghunathan et al., 2020a).

The food prices vary significantly across the states in India, also between the urban and rural areas, and even within the particular locality. Markets that serve higher-income people have the highest prices. In India, cereal consumption comprises around 50% of total calories. Access to the PDS has a significant bearing on food budgets and household choice of staples. Bajra is more nutritious than rice and wheat but it is more expensive than PDS rice and wheat. But in open markets, rice is more expensive than wheat and bajra. The zinc content and protein content are high in the meat and milk than that of pulses. But meat and milk are more expensive than pulses per gram of nutrients. The people living above the poverty line can meet their nutritional requirements with the current food budgets but people living below the poverty line would have to exceed their food budget to attain nutritional adequacy. About 5% of the increase in the current food budget would be required. Reduction in foods from animal sources and consumption more of other nutrient-dense foods can be helpful to achieve nutritional adequacy using the current food budget. But it is not clear that this diet shift would be acceptable or not. **(Rao et al., 2018)**

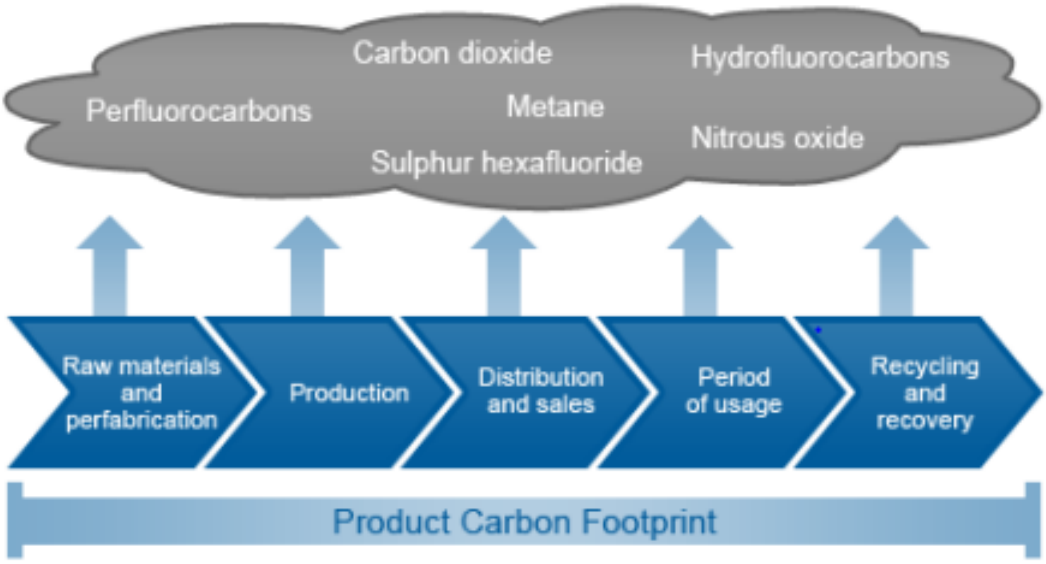
Sustainability of healthy diets:

The food system and diets are closely related to each other. A rapid growth in population and unprecedented dietary changes are placing the current Indian food system under pressure. A sustainable food system is a food system that ensures healthy food and food security for all in such a way that the economic, social, and environmental bases to generate food security and nutrition of future generations are not compromised. Around 90% of freshwater is being used for agricultural purposes. Environmental events such as ‘droughts led to food insecurity, migration, and other major social disruptions. The current food system is producing enough food but is unable to ensure food security and good nutrition. There is a major difference between countries both changes in food dietary patterns and food consumption. In the countries which show increased consumption, food patterns are generally changing towards more livestock, processed foods, vegetable oils, and sugar. Food consumption has environmental impacts. The increased consumption of processed

food leads to an increased carbon footprint of an individual. **(Meybeck & Gitz, 2017)(Dangour et al., 2018)**

"A Carbon footprint is the total greenhouse gas (GHG) emissions caused by an individual, organization, event or product directly or indirectly". It is calculated by summing all emissions by the product in each and every step of the product or service's lifetime i.e., production, transport, processing, and preparation. In a product's lifetime or lifecycle, different GHGs are produced, such as methane, carbon dioxide, and nitrous oxide. Each of these gases has a greater or lesser ability to trap heat in the environment, hence increases global warming **(Center for Sustainable Systems, 2019).**

Figure 2.5: Product carbon footprint

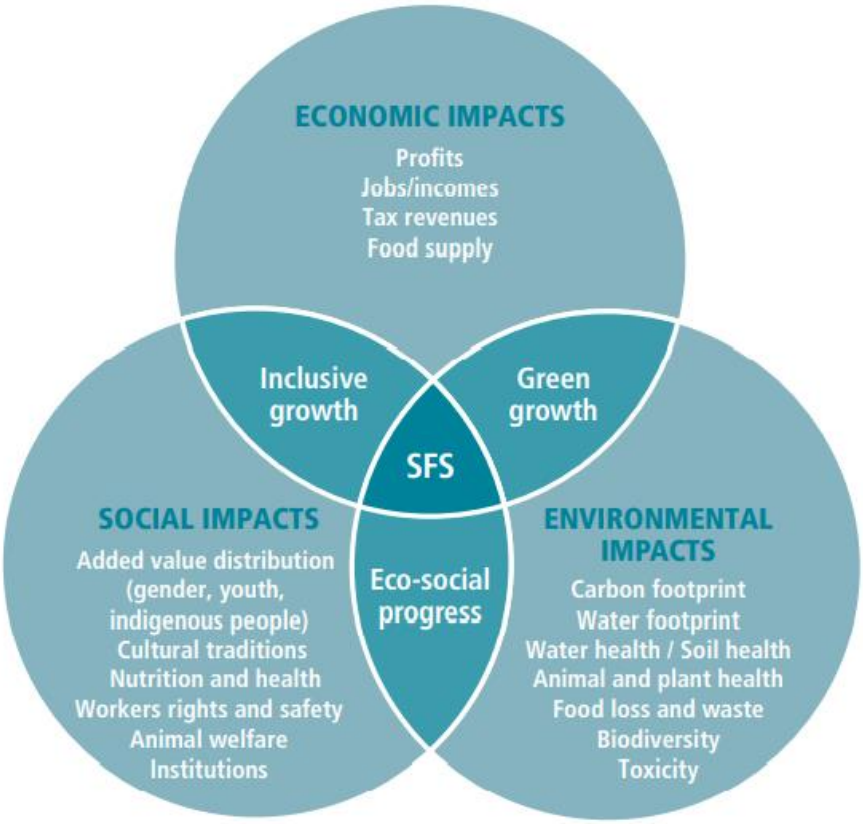


Source:(**FAO, 2011)**

To develop a sustainable food system, it needs to generate positive value along three dimensions simultaneously: economic, social, and environmental. 1) On the economic dimension, the food system should generate benefits, or economic value-added, for all categories of stakeholders like wages for workers, taxes for governments, profits for enterprises, and food supply improvements for consumers.2) On the social dimension, there should be equity in distribution and need to contribute to the advancement of

important socio-cultural outcomes, such as nutrition and health, animal welfare, tradition, and labor conditions. 3) On the environmental dimension, the food system should have a positive or neutral impact on the surrounding natural environment, by taking into consideration biodiversity, water, soil, animal and plant health, the carbon footprint, the water footprint, food loss, and waste, and toxicity. **(FAO, 2015b)**

Figure 2.6: Sustainable food system

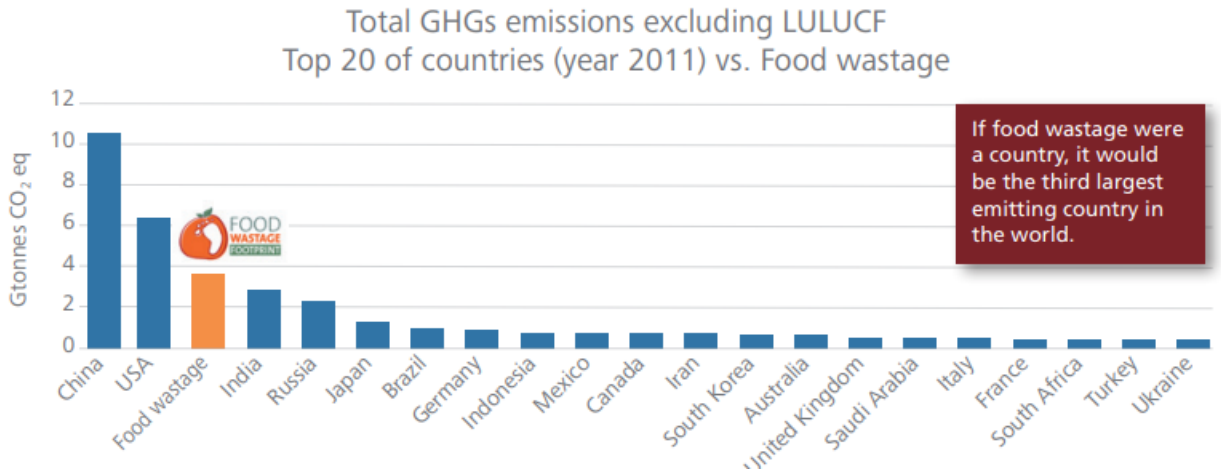


Source: **(FAO, 2015b)**

The current food system faces many challenges like biodiversity loss, all forms of malnutrition, unsustainable food consumption, diet-related no communicable diseases, food loss and waste, environmental degradation, population growth, and climate change. By just reducing food wastage and making healthier food choices, global GHG emissions can be cut by up to 50% **(Yogurt in nutrition, 2020).** One–third of all food produced in

the world never reached the consumer's table. This is not just food insecurity but also a waste of all the natural resources used for growing, processing, packing, transporting, and marketing. This leads to an increased carbon footprint.

Figure 2.7: GHG emission of food wastage



Source: **(FAO, 2015a).**

Based on an assessment of food wastage by FAO, global food loss and waste emits 4.4 GtCO2 eq. When compared with the top 20 counties emissions, if food wastage were a country it would be in 3rd position in the world. Agriculture contributes to around 30 % of food wastage**(FAO, 2015a).**

Agriculture is an important sector for the economy as well as food security. About 20% of national gross production comes from the agriculture sector. Agriculture provides a livelihood for nearly one-third of the total population in India. After Green Revolution, India achieved self-sufficiency in food production, but due to the increasing scarcity of resources, including labor, water, energy, and the rising cost of production retaining this self-sufficiency is been challenging. Increased used of mineral fertilizers to increase production, lead to an increase in greenhouse gas intensively. Agriculture accounts for around 18% of total GHG emissions in India in 2007. Agriculture is also the major source

of greenhouse gas emissions globally. Agriculture primarily emits carbon dioxide (CO2), nitrous oxide (NO2), and methane (CH4). The emissions from agriculture are primarily because of methane emission from enteric fermentation in ruminant 63% and rice fields 21%, nitrous oxide from the application of manure and fertilizer to agricultural soil 13%, and manure management and burning of crop residue 2.7%. India is already the 4th largest emitter of GHGs in the world **(Vetter et al., 2017)(Pathak et al., 2010).**

Food products show variation in GHG emissions. The consumption of rice and wheat in India is high. Rice production emits a high amount of GHGs. The higher emission of rice is due to CH4 emission under anaerobic soil conditions. Wheat and vegetables don't emit CH4 as soil condition is aerobic. The production of fruits and vegetables is associated with fairly low emissions **(Pathak et al., 2010).** About 90% of the global rice is produced and consumed in Asia. In Asia, the rice area has increased rapidly during 1964-1973 due to the promotion of the Green Revolution. China and India are the major exporters of rice. India exported 3.7 million tons of basmati rice worth Rs. 27,597 crores and 8.27 million tons of non-basmati rice worth Rs. 20.428 crores during 2014-2015. The figure represents the contribution of major rice-growing countries of Asia to Global food security **(Bandumula, 2018).**

Switching from anaerobic to aerobic cultivation of rice may increase the production of rice also it will reduce the GHG emission. This switch is also important in states such as Tamil Nadu, Odisha, and Bihar where rice is grown under submerged conditions. A study conducted in Tamil Nadu reveals that aerobic cultivation with drip irrigation increases total production by 29% and increases water saving by 50%, compared to conventional aerobic rice cultivation with surface irrigation. Also, the water footprint of aerobic cultivation of rice will be less than the traditional cultivation **(Tata-Cornell Institute, 2020)**.

As the country achieves greater stability in the economy, people tents to choose a Western diet, containing a greater quantity of meat and dairy products. Meat is a calorie-dense high protein source. It also provides micronutrients such as thiamine, niacin, vitamin B12, calcium, iron, zinc, phosphorus, and potassium. Malnutrition status and economy of the country can be improved by maintaining a certain level of livestock production and consumption of animal products. But, excessive consumption can lead to the

unsustainability of the environment by increasing GHG emissions and increasing susceptibility to a range of chronic diseases, like obesity, diabetes, CVD, and cancers **(Salter, 2017).**A study conducted in Spain and Sweden showed that vegetarian meals emit less GHG emissions and cause less impact on the environment. But in India milk is an integral part of vegetarian diets. Milk and milk products increase GHG emissions by 1.3 times that of vegetarian diets (without milk). Therefore, to reduce the GHG emission of the Indian diet, substitution of food products is needed. However, these should be made by paying attention to the nutritive value of foods**(Pathak et al., 2010).**

According to the type of livestock, the GHG emissions per kg vary considerably. The highest GHG emissions are produced by mutton meat followed by poultry and dairy products. GHG emissions per kcal show a different ranking but ruminant animals have the highest emissions using all the metrics. Rice and livestock are the highest contributors to Indian diets. Ruminant meats are 3rd contributor. It accounts for only 0.4% of total calories consumed but it emits 12.5% of GHG emission. Feed inputs to the livestock are largely associated with the GHG emission of livestock. Studies show the emission ranges between:

Milk: 0.8-2.4 kg CO_2eq kg^{-1}

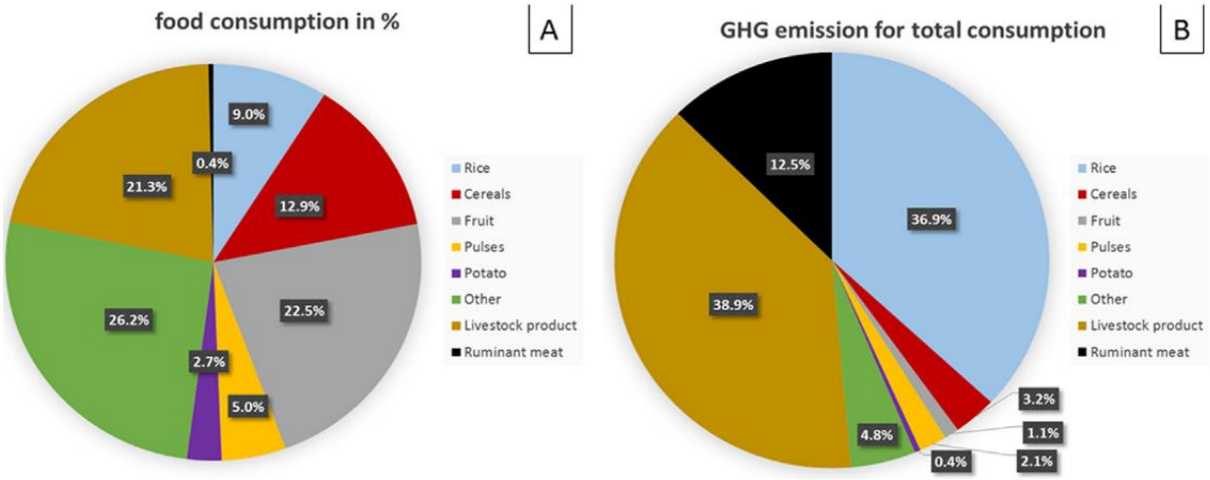
Eggs: 1.7-6.6 kg CO_2eq kg^{-1}

Poultry meat: 2.5-6.9 kg CO_2eq kg^{-1}

Mutton and lamb: 10-20 kg CO_2eq kg^{-1}

GHG emission of livestock results from the production of CH_4 through enteric fermentation, manure management, and changed feed ratios. Emissions can be reduced by following options: 1. by decreasing storage time, 2. manure storage cover with straw, 3. mechanical intermittent aeration during manure storage, 4. manure acidification, 5. feeding of livestock with nitrate supplements, and 6. stacking of poultry litter **(Vetter et al., 2017)**. Certain dietary shifts and production practices will help in the mitigation of GHG emissions**(Pathak et al., 2010).**

Figure 2.8: Proportion of consumption of food groups in India diets and its contribution to GHG emissions



Source: **(Vetter et al., 2017)**

The GHG emission of diet depended primarily on the total calorie consumption, which in turn scales with income. The food emission footprint increases with an increase in income. In most of the parts, footprints tend to be slightly higher in the urban regions than rural regions. But at the lower-income level, many rural households have a higher footprint due to higher rice consumption. If the diets are more nutritionally dense food and less meat and rice the footprint of diet would below. These diets can lead to a 19% reduction in food-related GHG emissions or 122 million tonnes out of 632m tonnes. These results will even increase if all the households purchase foods from PDS**(Rao et al., 2018).**

METHODOLOGY

3. METHODOLOGY

Overview of the chapter

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3.1 General Information

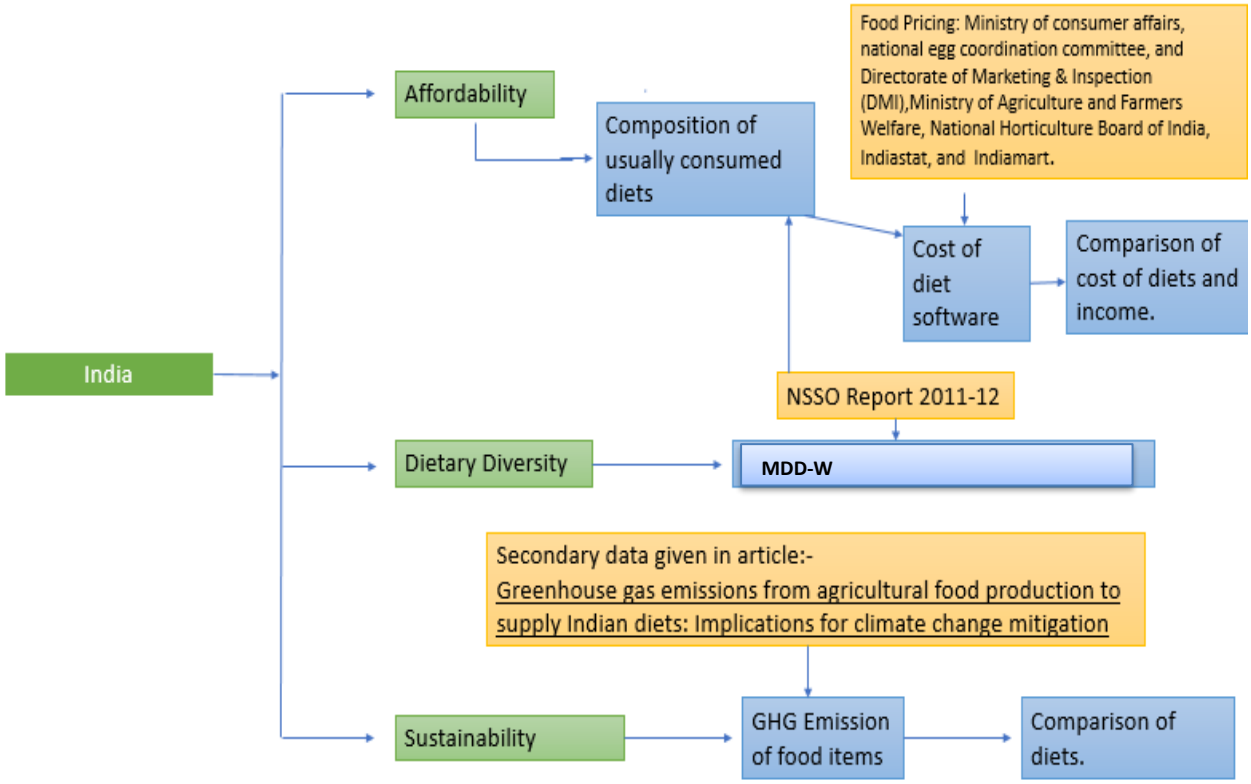
An exploratory study using secondary data sources was conducted to assess the affordability and sustainability of usually consumed diets and healthy diets using Cost of The Diet Software for all the states of India.

3.2 Ethical Approval

The study was approved by the institutional review board of the department of Foods and Nutrition, Faculty of Family and Community Sciences, The Maharaja Sayajirao University of Baroda. The ethical approval number of the study is **IECHR/FCSc/2020/54**.

3.3 Study Design

An exploratory study was carried out using secondary source of data.



3.4 Secondary Data Source

3.4.1 Consumption data

- We used the most recent round of Household Consumption Expenditure Survey (CES) conducted by the National Sample Survey Organization (NSSO) of India in 2011-12 (Round 68$^{th)}$. This survey is conducted every 5 years from 1972 to 73 onwards. This survey aims at generating estimates of average household monthly per capita consumer expenditure (MPCE), for States and Union Territories.
- The survey report provides the consumption data of 14 food groups also has break-ups of per capita consumer expenditure of 14 food groups and 18 non-food groups. All the estimates are provided separately for each State and Union territory for rural and urban sectors. **(NSSO, 2014)**

Table 3.1: Break-up of food groups according to food and non-food items

32 Broad Groups	
Food group	Non-food Group
1. Cereals	1. Pan
2. Gram	2. Tobacco
3. Cereal substitutes	3. Intoxicants
4. Pulses & Pulses products	4. Fuel and light
5. Milk & milk products	5. Clothing
6. Edible oil	6. Footwear
7. Egg, fish, and meat	7. Education
8. Vegetables	8. Medical (institutional)
9. Fruits (fresh)	9. Medical (non-institutional)
10. Fruits (dry)	10. Entertainment
11. Sugar	11. Minor durable-type goods
12. Salt	12. Toilet articles

13. Spices	13. Other household consumables
14. Beverages & processed food	14. Conveyance
	15. Other consumer services
	16. Rent
	17. Taxes and cesses
	18. Durable goods

- Out of 147 food items, 108 foods were selected based on the need of the study. Data on consumption of rice, wheat, and sugar from PDS and other sources were pooled for analysis.
- In NSSO round 68, Jammu & Kashmir & Delhi are categorized as the States of India, but from 31 October 2019, Jammu and Kashmir are administered by India as a Union Territory (U.T.) and Delhi is Capital Territory from 1 February 1992, so these two cities were considered as U.T. in this study.
- Telangana State is not included separately as it was part of Andhra Pradesh during the period of the survey.

3.4.2 Food Pricing:

To assess the affordability of diets City-level monthly retail and wholesale prices of different commodities were collected for all the states of India, from January 2020 to December 2020. Retail prices for some commodities were not available, and therefore, we used wholesale prices. It is important to note that retailers add their margins before making a sale to a consumer. Therefore, the wholesale prices do not adequately capture the prices paid by the consumer. Wholesale prices were used, as we are constrained by the availability of price data. Data was collected from following sources:

- Ministry of consumer affairs,
- National egg coordination committee, and Directorate of Marketing & Inspection (DMI),
- Ministry of Agriculture and Farmers Welfare, Government of India
- Indiastat

- Indiamart
- National Horticulture Board of India

Table 3.2: List of data source for different commodities

Data Source	Commodities
1. National Horticulture Board of India	Apples, Banana, Bitter Gourd, Urinal, Cabbage, Cauliflower, Grapes Seedless, Guava, Mango, Okra, Orange, Papaya, Peas, Pineapple, Pomegranate, Sapota, Lemon, Sweet Lime, Gooseberry, And Green Chilly.
2. Ministry of consumer affairs	Rice, Wheat, Atta, Gram Dal, Tur Dal, Urad Dal, Moong Dal, Masoor Dal, Groundnut Oil, Mustard Oil, Vanaspati Oil, Soya Oil, Sunflower Oil, Palm Oil, Potato, Onion, Tomato, Sugar, Gur, Milk, Salt, Suji, Gingerlly Oil, Maida, And Ghee.
3. Indiastat	Butter, Bread, Bajra, Jowar, Maize, Barley, Rice Flakes, Moong Whole, Dry Peas, Rajma, Coconut Fresh And Dry, Pear, Cashewnut, Raisins, Soyabeans, Gaur Beans, Cucumber, Drumstick, Pointed Gourd, Ragi, And Chicken.
4. National egg coordination committee, and Directorate of Marketing & Inspection (DMI)	Eggs
5. Indiamart	Catla, Tuna, Mackerel, Pomfret, Anchovy Fish, Fresh Water Hilsa, Silver Surmai, Fresh Ribbon Fish, Fresh Cuttlefish, Reef Cod Fish, Pangasius, Rani, Lobster, Milk Fish, Rohu, Goat, Prawns, Beef, Pork, Meat, Sheep, Seasame Oil, Cottonseed Oil, Honey, Misri, Condensed Milk, Powdered Milk, Curd, Roasted Chana, Roasted

	Chana Split, Apricot Dry, Alobukhara Dry, Pistachio, Dates Dry, Khesari Dal, Strawberry, Sugarcane, Curry Powder, Sunflower Seeds, Safflower Seeds, And Niger Seeds
6. Ministry of Agriculture and Farmers Welfare, Government of India	Amaranth Seeds, Beetroot, Betel Leaves, Black Gram Whole, Bottle Gourd, Capsicum, Carrot, Cluster Beans, Colocasia, Cowpea White, Dry Coconut, Fenugreek Leaves, Fig, Foxtail Millet, French Beans, Gram Whole, Grapes, Groundnut, Horse Gram, Jackfruit, Knol-Khol, Kuddo Millet, Litchi, Little Gourd, Raw Mango, Masoor Whole, Mataki, Muskmelon, Other Leafy Vegetables, Rajgira, Raw Banana, Sabu Dana, Snake Gourd, Spinach, Sweet Potato, Tender Coconut, Tinda, Tur Whole, Yam, Ginger, Garlic, Jeera, Dhania, Turmeric, Black Paper, Dry Chillies, Tamarind, Seaseme Seeds, Mustard Seeds, Nutmeg, Clove, And Saonf.

We analyzed price data for the cities which are capital for all states of India, as they are ideal representative of each of the states. For each of these commodities, we constructed the average price for the year from January 2020- December 2020.

3.4.3 Income data

Income data were collected from the news articles, for quintile 1 to 5 in rural and urban areas of India. The approximate estimate of food and non-food expense was calculated for both urban and rural areas for all the quintiles **(Bhattacharya, n.d.)(Krishnan, n.d.)**.

3.4.4 GHG emission data

For the sustainability of usually consumed diets and healthy diets, secondary data on Green House Gas emission of commonly consumed foods in India is used from "Environmental impacts of dietary shifts in India: A modelling study using nationally-representative data" research article **(Aleksandrowicz et al., 2019)**.

3.4.5 Food frequency

Data was given in NSSO as average monthly per capita consumption in kilogram/30 days, which was further converted according to average monthly intake per consumer unit for men and women (1 and 0.8 respectively) in kg/30 days. The value in kg was converted to grams for 30 days. The average daily intake per consumer unit was further calculated. The frequency of food consumed was calculated as below:

Food Frequency= Grams of food consumed / Portion size of the food group **(Sauvageot et al., 2013)**

Table 3.3: Portion size of each food group according to ICMR Dietary Guideline for Indians

Food Group	**Portion size**
Cereals	30 g
Pulses	30 g
Eggs	50 g
Meat/ chicken/ fish	50 g
Milk and milk products	100 ml
Roots and tubers	100 g
Green leafy vegetables	100 g
Other vegetables	100 g
Fruits	100 g
Sugar	5 g
Fats & oils (visible)	5 g
Nuts (My plate)	20 g

Source: ICMR Dietary Guideline for Indians- A Manual **(Kamala K, Bhaskaram P, Bhat RV, 2011)**

The frequency of food consumed was classified into a range with the help of method of Sauvageot et al. **(Sauvageot et al., 2013)** . The range for each frequency option were the following:-

Table 3.4 Range for each food frequency

Frequency	**Range**
Never	0
Rarely (1 to 3 times a month)	0.0001-0.066
Often (1 to 4 times a week)	0.067-0.571
Usually (1 or 2 times a day)	≥0.572

3.5 Cost of Usually Consumed Diets

Data from NSSO report round-68 was used to calculate the cost of usually consumed diets for all the states of India. NSSO report has average monthly per capita consumption in kilogram/30 days, which was further converted to average monthly intake per consumer unit for men and women (1 and 0.8 respectively) in kg/30 days. The value in kg was converted to grams for 30 days. The average daily intake per consumer unit was further calculated. The cost of each commodity was calculated according to the food pricing data described in 3.4.2. The total cost of the daily consumed diet was calculated by summing all the commodities consumed in a day. The cost of the usually consumed diet for men and women was calculated separately for rural as well as for urban areas.

3.6 Minimum Dietary Diversity - Women

MDD-W is a dichotomous indicator which measures whether or not women 15–49 years of age have consumed at least five out of ten defined food groups the previous day or night. The MDD-W was developed as a proxy indicator to reflect the micronutrient adequacy of women's diets.(**FAO & 360, 2016)**

Food group for the MDD-W are as follows

1. Grains, white roots and tubers, and plantains

2. Pulses (beans, peas and lentils)
3. Nuts and seeds
4. Dairy
5. Meat, fish, and poultry
6. Eggs
7. Dark green leafy vegetables
8. Other vitamin A rich fruits and vegetables
9. Other vegetables
10. Other fruits

Consumption data were analyzed from the Household Consumption & Expenditure Survey conducted by National Sample Survey Organization (NSSO), India in 2011-12. The food frequency of Women was analyzed by the method described in 3.4.5. The food which is consumed usually foods with score 3 were considered for MDD-W score. MDD-W was calculated for both urban and rural areas of all the states of India. A score more than or equal to five out of ten reflects good micronutrient adequacy in their diet.

3.7 Cost of 4 Hypothetical Diets

Cost of Diet software is used to assess the cost of 4 hypothetical diets (Energy only diet, macronutrients diet, nutritious diet, food habit nutritious diet) for all states of India.
URL: https://www.heacod.org/en-gb/Pages/SWCotD.aspx

Energy only diet: In this diet, software calculates a diet at the lowest cost that meets only the average energy requirements of the individual or family.

Macronutrients diet: The software calculates a diet at the lowest cost that meets the recommended intakes for energy, protein, and fats of the individual or family.

Nutritious diet: The software calculates a diet at the lowest cost that meets the recommended intakes for energy, protein, fat, and all micronutrients specified for the individual or family.

Food habits nutritious diets: The software calculated a diet at the lowest cost that meets the recommended intakes for energy, protein, fat, and all micronutrients specified for the

individual or family whilst applying a minimum and a maximum number of times a week that foods can be included in the diet **(Altilio, 2003).**

Diets in Cost of the Diet software was calculated using the method given in the "Practitioner's guide version-2". The market survey and food habits survey was entered in the assessment using the data described in 3.4.2 and 3.4.5 respectively. All the reports were downloaded and entered in excel for analysis.

3.8 Affordability of Usually Consumed diets and 3 hypothetical diets

Affordability of diets for men and women in urban and rural areas of various states of India was calculated by considering the international poverty line ($1.90) as the cutoff for per capita daily income. The Rangrajan Committee estimated the daily per capita expenditure to 47 for urban and 32 for rural areas in 2014**(Gaur & Rao, 2020)**. There is lack of recent daily per capita expenditure, so international poverty line which is estimated by World Bank was considered. This will be helpful to make comparisons with other studies.

3.9 Sustainability of Usually Consumed Diets and Nutritious Diets

To calculate the GHG emission from usually consumed diets and nutritious diets, GHG emissions from each commodity were added. The secondary data source used for the GHG emission is described in 3.4.4.

Limitation of the study:

- Due to some technical issues the sustainability of energy only and macronutrients diet was not calculated. Also, data for some states was not analyzed.

RESULTS
AND
DISCUSSION

4. RESULTS AND DISCUSSION

Available evidence shows that the current food systems are not sustainable and affordable for large populations from developing countries including India. Therefore, assessment of the affordability and sustainability of usually consumed diets was carried out to identify the gaps in food and nutrition security. Further, affordability and sustainability of healthy diets for various states of India was carried out to explore the feasibility of attaining food and nutrition security in the various states of India. The study was formulated with the following objectives:

Broad objective

To assess the affordability and sustainability of selected Indian diets using secondary data.

Specific objectives

- To estimate the cost of usually consumed diets for various states of India.
- To estimate minimum dietary diversity among women from various states of India.
- To estimate the cost of 3 hypothetical diets from various states of India.
- To assess the affordability of usually consumed diets and 3 hypothetical diets from various states of India.
- To assess the sustainability of usually consumed diets and 3 hypothetical diets from various states of India.

Results of the study are discussed in this chapter.

Cost of usually consumed diets for urban and rural areas of various states of India:

Cost of usually consumed diets was calculated using NSSO report round-68 data. The cost of usually consumed diet for men and women was calculated for rural as well as urban areas. The results of cost of usually consumed diets for men and women in rural areas are presented in figure 4.1 and 4.2. In most of the states the cost of usually consumed diet of women is higher in urban areas than in rural areas and cost of usually consumed diet of men is higher in rural areas than urban areas. In various states, the cost of usually consumed diet of men is higher than those consumed by women. In rural areas, highest cost of the usually consumed diet is in the state of Kerala and lowest in Madhya Pradesh. The mean

cost of usually consumed diet of men and women was ₹45.20 and ₹36.40, respectively in rural areas. In Kerala, inclusion of foods of animal origin namely, meat, chicken, and fish contributed to higher cost of diet. The calculated difference in cost of diet of men and women from rural areas of various states of India reveals that the difference is highest in the diet from Manipur (21.2%) followed by Haryana (20.6%), Chandigarh (20.2%), West Bengal (20.2%), Assam (15.8%), Kerala (17%), and Karnataka (19.2%) and lowest in diets from Punjab (9.3%) The results of usually consumed diets of men and women in urban areas from various states of India is represented in figure 4.3 and 4.4. The results follow a similar trend as observed for rural diets. The mean cost of usually consumed diet by men and women was ₹49.9 and ₹40.2 respectively in urban areas. The cost of diet was highest in urban Goa as foods as the diets comprised of foods from animal origin that are relatively expensive. Diets of people from urban Manipur cost the least. The calculated difference in cost of diet of men and women reveals that the same was highest in Jharkhand (20.3%) followed by Punjab (20.2%), Odisha (20.1%) Maharashtra (20.1%), Himachal Pradesh (16.8%), and Bihar (17.1%) and lowest in Uttar Pradesh (6.8%). The difference in cost of diet of men and women across the country could be due to higher nutritional requirements of men or men consuming a higher proportion of expensive foods like those from animal origin, nuts and seeds etc. However, the secondary data available is inadequate to substantiate the same. A study conducted by **(Mekoth & Thomson, 2018)** reported that foods of animal origin namely, seafood, chicken, beef, and pork are an integral part of the Goan cuisine besides Rice, coconut, vegetables, and local spices.

In a study conducted by **(Rao et al.,2018)** in urban and rural areas of India reported that prices of food commodities vary significantly across the country and between rural and urban areas Urban population tends to consume more calories, highly processed foods, fruits and vegetables, animal-sourced foods and cheap street foods as compared to rural areas. This is maybe due to higher average income of urban consumers, availability of refrigeration, and supermarkets. Urban consumers have more purchasing power than rural consumers and they are willing to spend more money on diversity of food **(Global Panel, 2017)**. Most of the Indian population depend on weekly food markets for food supply. In rural India physical access to market is good, but agricultural production system and markets fails to provide affordable and nutritious foods. (Raghunathan et al., 2020a)

Figure 4.1: Cost of usually consumed diets in rural areas of various states of India in INR/day

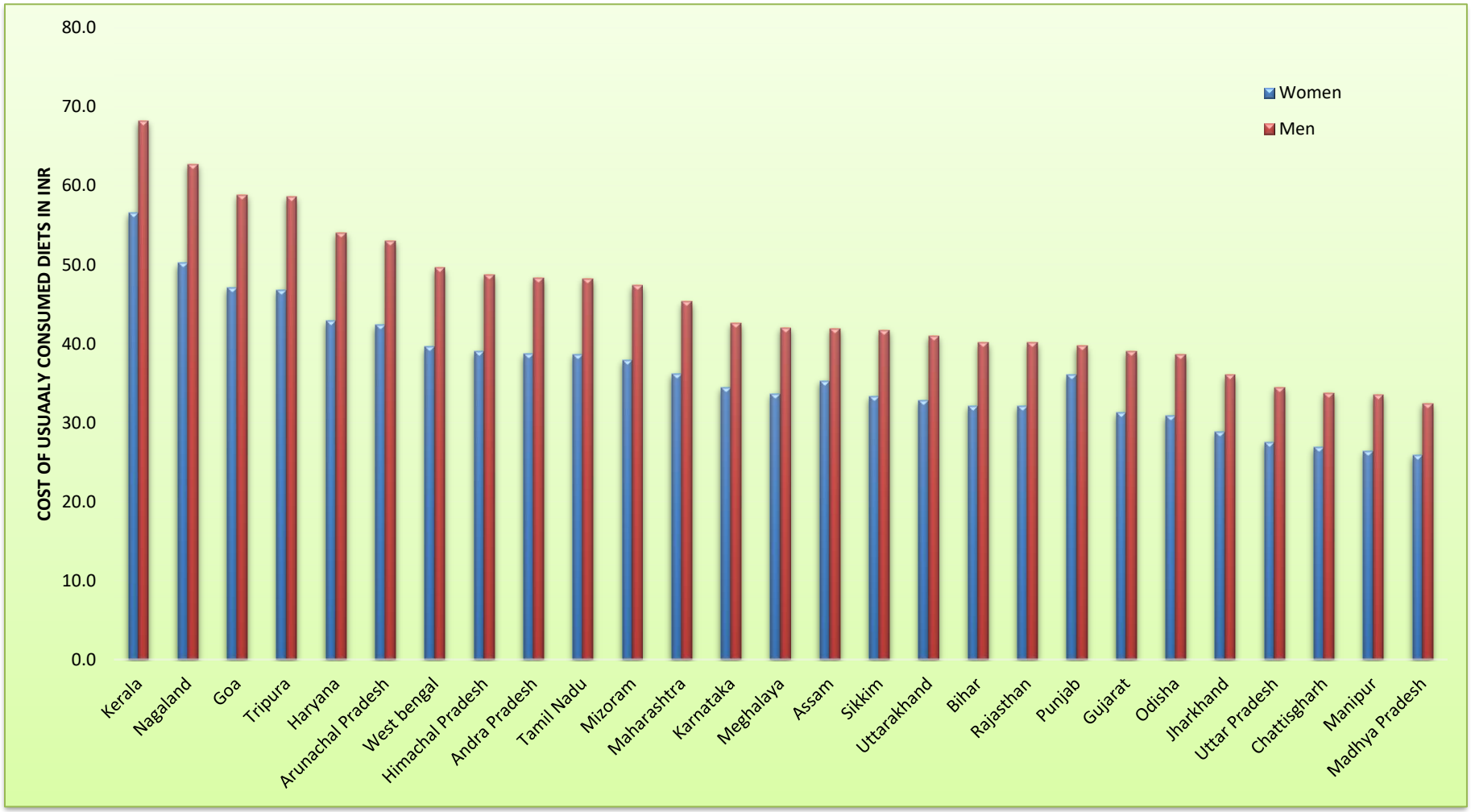


Figure 4.2: Percent difference between Men and Women in cost of usually consumed diet in rural areas of various states of India

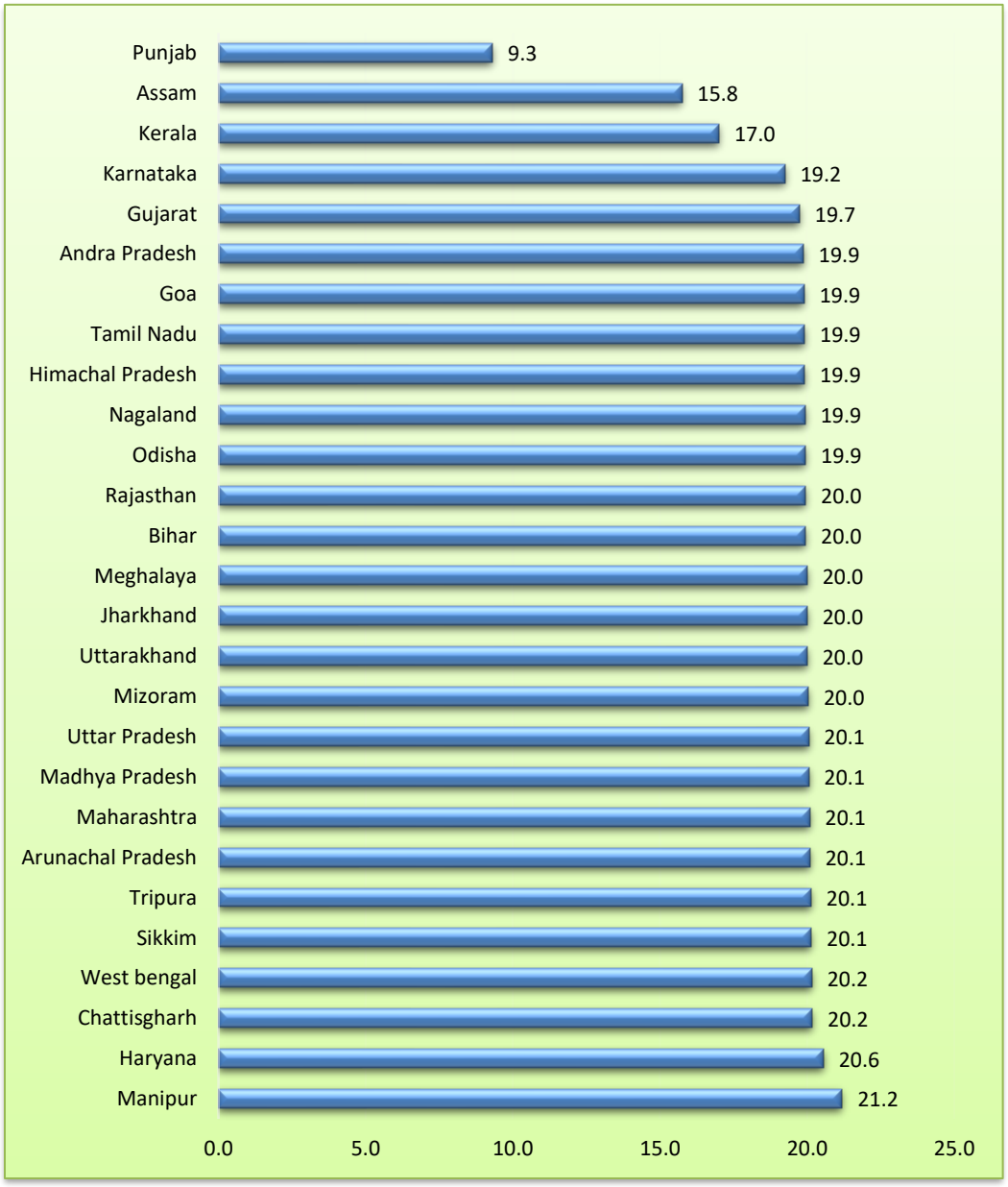


Figure 4.3 Cost of usually consumed diets in urban areas of various states of India in INR/day

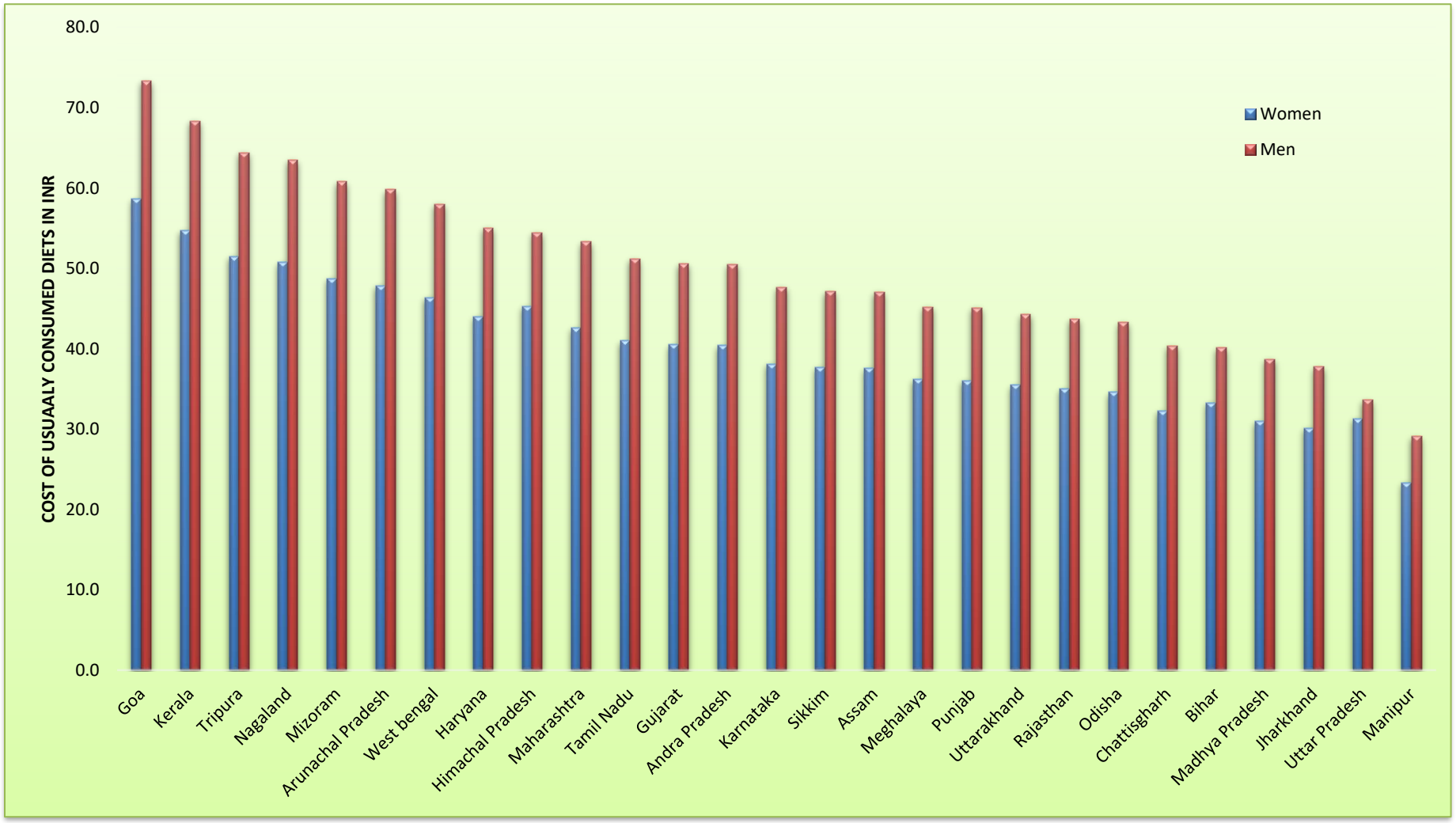
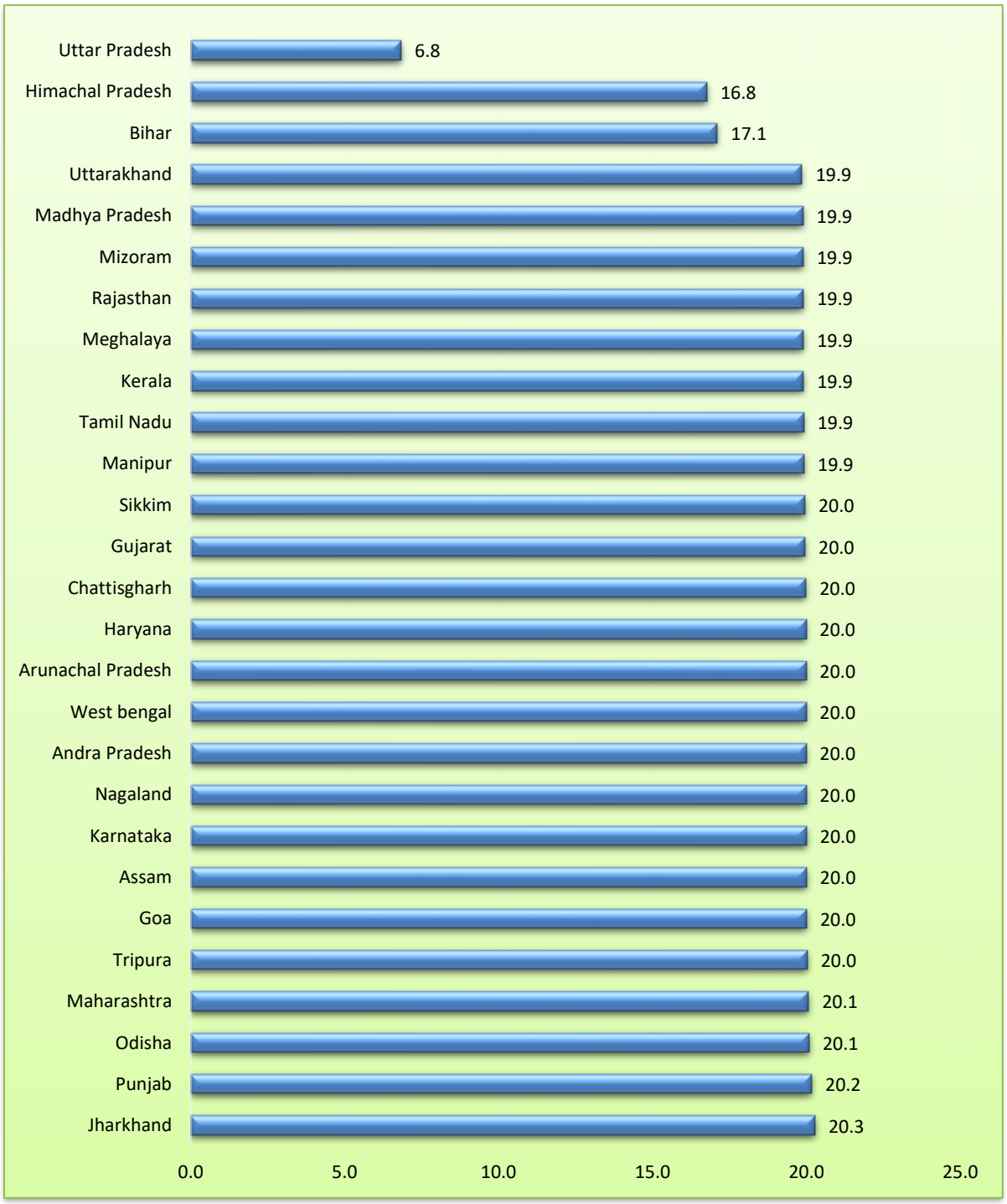


Figure 4.4 Percent difference between Men and Women in cost of usually consumed diet in urban areas of various states of India



The composition of diet in terms of food groups influences the cost and food and nutrition security. The percent contribution of individual food groups to the total cost of diet of women and men from rural and urban areas of various states was calculated to assess the same. The results are presented in Tables 4.1, 4.2, (rural region for women and men respectively) 4.3 and 4.4 (urban region for women and men respectively). Table 4.1 presents the data for women. from In 37% of the states, 25% to 37% of the of total cost of the diets is contributed by cereals.; in 33.3% of the states 27%-37% of the money is spent on meat, chicken and fish;; in 27.6% of the states 24%-43% of the money is spent on milk and milk products; eggs and nuts contributes least to the cost of total diet.

Table 4.3 and 4.4 present the percent contribution to cost of total diet of women and men by individual food groups in urban areas of various states of India. In 37% of the states the cereals contribute highest to the cost of diet; in 33.3% of the states meat, chicken and fish contribute highest to the total cost of diet and in 29.6% of states milk and milk products are the major contributors. Eggs and nuts contribute the least to the total diet cost of diet in 48.1% of the states. In 3.7% of states salt and sugar contribute least to cost of diet.

The cost of usually consumed diets is lower in rural areas than the urban areas (Figure 4.1 and 4.3) and hence the mean contribution of each food group to the cost of total diet is lower in rural regions than the urban region. The rural urban differences observed are likely due to the difference in consumer price index. However, in absence of adequate data the same cannot be substantiated.

Table 4.1: Percent contribution to cost of total diet of women by individual food groups in rural areas of various states of India

States	Cereal	Milk and milk products	Meats, chicken and fish	Vegetables	Fruits	fat and oils	Spices	Pulses	Roots and tubers	Sugar and salt	Nuts	Eggs (no.)
Andhra Pradesh	27.1	13.6	13.1	12.6	11.9	6.5	5.1	4.9	1.4	0.6	1.8	1.4
Arunachal Pradesh	23.8	4.9	29.1	19.7	6.0	3.4	2.4	2.8	3.2	1.6	2.1	1.0
Assam	26.6	6.5	27.2	17.1	4.9	4.1	2.4	3.9	4.0	1.9	0.2	1.3
Bihar	28.0	14.3	12.3	17.5	4.5	5.4	3.5	4.3	7.5	2.1	0.2	0.4
Chhattisgarh	34.5	3.0	10.5	24.2	4.3	6.3	3.0	6.1	4.4	3.2	0.3	0.3
Goa	19.2	12.3	39.1	8.9	3.5	5.6	3.4	3.2	1.4	2.3	0.1	1.1
Gujarat	19.4	24.4	4.7	15.9	5.2	12.6	4.0	5.6	3.6	3.6	0.8	0.2
Haryana	12.6	43.2	2.2	13.5	6.9	7.1	2.6	3.3	3.5	4.3	0.7	0.2
Himachal Pradesh	22.8	24.3	6.5	12.1	7.4	8.0	3.2	6.4	3.4	3.6	1.9	0.3
Jharkhand	36.6	8.5	12.0	17.4	2.6	4.9	4.3	3.9	7.2	2.1	0.1	0.5
Karnataka	29.1	10.4	14.7	10.8	10.9	7.2	4.9	5.7	1.2	2.9	1.3	0.8
Kerala	11.3	7.1	44.7	7.5	11.1	5.3	4.6	3.1	1.0	1.8	1.5	0.9
Madhya Pradesh	30.0	20.0	4.3	12.9	3.9	8.0	4.2	7.7	4.3	3.9	0.5	0.3
Maharashtra	26.9	10.8	8.4	17.5	7.3	8.4	4.6	6.7	2.4	3.8	2.6	0.6
Manipur	22.1	2.9	32.2	21.2	4.2	1.6	6.4	4.2	1.8	1.7	0.9	0.7
Meghalaya	21.3	5.5	38.4	16.8	3.8	3.2	2.4	2.0	3.4	2.4	0.2	0.6
Mizoram	15.7	4.2	37.1	22.2	3.6	4.8	2.8	3.4	1.6	3.1	0.4	1.0
Nagaland	19.6	5.1	47.5	16.4	2.6	1.4	2.3	1.5	1.9	1.0	0.1	0.7
Odisha	35.7	4.9	16.3	17.7	4.8	4.8	2.8	4.7	5.8	2.0	0.1	0.5
Punjab	11.7	40.4	1.1	15.6	5.7	7.2	3.6	4.4	4.0	5.6	0.6	0.2
Rajasthan	22.3	34.1	2.7	11.2	4.2	10.1	4.9	3.2	2.2	4.1	0.8	0.1
Sikkim	12.7	28.9	15.7	23.6	3.5	4.0	3.6	2.9	3.4	1.8	0.0	0.0
Tamil Nadu	33.8	11.2	15.1	10.9	8.5	5.1	5.2	4.9	1.5	2.3	0.3	1.1
Tripura	24.9	3.6	28.9	23.5	5.7	3.4	1.9	2.1	3.5	1.7	0.2	0.7
Uttar Pradesh	23.2	27.1	6.2	13.4	4.3	1.8	3.6	9.0	7.0	3.3	0.7	0.3
Uttarakhand	18.5	26.4	5.1	17.9	6.0	7.2	3.2	6.1	4.5	3.9	0.5	0.6
West Bengal	25.2	3.8	24.7	22.0	3.7	5.1	3.0	2.6	7.0	1.5	0.2	1.4

Table no.4.2 Percent contribution to cost of total diet of men by individual food groups in rural areas of various states of India

States	Cereal	Meats, chicken and fish	Vegetables	Milk and milk products	Fruits	fat and oils	Spices	Pulses	Sugar and salt	Eggs (no.)	Roots and tubers	Nuts
Jharkhand	36.6	12.0	17.4	8.5	2.6	4.9	4.3	3.9	2.1	0.5	7.2	0.1
Odisha	35.7	16.3	17.7	4.9	4.8	4.8	2.8	4.7	2.0	0.5	5.8	0.1
Chhattisgarh	34.5	10.5	24.2	3.0	4.3	6.3	3.0	6.1	3.2	0.3	4.4	0.2
Tamil Nadu	33.8	15.1	10.9	11.2	8.5	5.1	5.2	4.9	2.3	1.1	1.5	0.3
Andhra Pradesh	32.5	13.9	13.3	11.1	7.0	6.5	5.3	4.8	2.0	1.3	1.3	0.9
Madhya Pradesh	30.0	4.3	12.9	20.0	3.9	8.0	4.2	7.7	3.9	0.3	4.3	0.5
Karnataka	28.3	14.9	10.9	10.5	11.1	7.3	5.0	5.8	2.9	0.8	1.2	1.4
Assam	28.1	28.7	16.4	6.8	2.7	4.3	2.5	4.1	2.0	0.0	4.2	0.2
Bihar	28.0	12.3	17.5	14.3	4.5	5.4	3.5	4.3	2.1	0.4	7.5	0.2
Maharashtra	26.9	8.4	17.5	10.8	7.4	8.4	4.6	6.7	3.7	0.6	2.4	2.6
West Bengal	25.1	24.6	21.9	3.8	3.6	5.4	2.9	2.6	1.5	1.4	7.0	0.2
Tripura	24.9	28.9	23.5	3.6	5.7	3.4	1.9	2.1	1.7	0.7	3.5	0.2
Arunachal Pradesh	23.8	29.1	19.6	4.9	6.1	3.4	2.4	2.8	1.6	1.0	3.2	2.1
Uttar Pradesh	23.2	6.2	13.4	27.1	4.3	1.8	3.6	9.0	3.3	0.3	7.0	0.7
Himachal Pradesh	22.8	6.5	12.1	24.3	7.4	8.0	3.2	6.4	3.6	0.3	3.4	1.9
Rajasthan	22.3	2.7	11.2	34.1	4.2	10.1	4.9	3.2	4.1	0.1	2.2	0.8
Manipur	21.8	31.8	20.9	2.9	4.2	1.6	6.3	4.2	2.9	0.7	1.8	0.9
Meghalaya	21.3	38.4	16.8	5.5	3.8	3.2	2.4	2.0	2.4	0.6	3.4	0.2
Gujarat	19.5	4.7	15.9	24.5	4.8	12.6	4.0	5.6	3.6	0.2	3.6	0.8
Goa	19.2	39.1	8.9	12.3	3.5	5.6	3.4	3.2	2.3	1.1	1.4	0.1
Uttarakhand	18.5	5.1	17.9	26.4	6.0	7.2	3.2	6.1	3.9	0.6	4.5	0.5
Mizoram	15.7	37.1	22.2	4.2	3.6	4.8	2.8	3.4	3.1	1.0	1.6	0.4
Punjab	13.4	1.1	15.3	39.6	5.6	7.0	3.5	4.3	5.5	0.2	3.9	0.6
Haryana	13.3	2.1	13.4	42.9	6.9	7.1	2.6	3.3	4.3	0.2	3.5	0.7
Sikkim	12.7	15.7	23.6	28.9	3.5	4.0	3.6	2.9	1.8	0.0	3.4	0.0
Kerala	11.3	44.7	7.5	7.1	11.1	5.3	4.6	3.1	1.8	0.9	1.0	1.5
Nagaland	7.7	12.4	35.9	2.5	6.1	1.5	2.1	2.3	3.1	18.2	8.2	0.0

Table no.4.3 Percent contribution to cost of total diet of women by individual food groups in urban areas of various states of India

States	Cereal	Milk and milk products	Meats, chicken and fish	Vegetables	Fruits	fat and oils	Spices	Pulses	Roots and tubers	Sugar and salt	Nuts	Eggs (no.)
Andhra Pradesh	27.1	13.6	13.1	12.6	11.9	6.5	5.1	4.9	1.4	0.6	1.8	1.4
Arunachal Pradesh	20.6	6.4	28.4	19	5.6	4.3	2.8	3.1	4.4	2	1.9	1.5
Assam	21.6	8.5	26.0	16	6.3	6	2.9	4.4	4	2.1	0.8	1.6
Bihar	24.9	14.1	10.8	17.4	9.3	6.4	3.5	4.4	7.2	0.9	0.6	0.4
Chhattisgarh	27.2	9.1	8.5	24.3	6.1	6.9	3.1	6.4	3.9	3.2	0.8	0.5
Goa	14.9	13.3	33.3	8.1	2.1	12.4	7.7	3.2	1.2	1.7	0.7	1.2
Gujarat	13.9	23.3	3.6	15.2	7.4	13.5	3.6	4.9	3.4	8.5	2.3	0.3
Haryana	12	31.8	1.3	14.5	11.4	12.5	2.9	3.8	3.8	3.5	2.1	0.4
Himachal Pradesh	20.1	19.6	7.2	12.5	11	10.4	3.4	6.2	3.3	2.9	2.7	0.6
Jharkhand	13.3	16	15.7	19.4	7.6	7.3	3.7	5.3	7.2	2.6	1	0.8
Karnataka	23.8	13.7	14.1	10.7	12.7	7.6	4.8	6	1.5	2.5	1.7	1
Kerala	11.1	8.5	42.3	7.8	12	5.8	4.7	3.5	1.2	1.8	0.4	1
Madhya Pradesh	22.6	21.3	6.3	12.7	5.7	11	4.1	7.1	3.7	3.7	1.3	0.6
Maharashtra	19.2	14	12.1	17	10	9.1	3.6	5.9	2.3	2.9	2.9	0.9
Manipur	23.7	4.6	33.5	18.9	3.5	2	4.6	4.2	1.6	1.6	1.1	0.7
Meghalaya	19.1	9.8	34.5	14.1	4.9	4.2	2.5	3.2	3.6	2.1	0.6	1.2
Mizoram	13.6	9	38.5	18.9	2.9	5	2.1	3.7	1.9	2.8	0.2	1.5
Nagaland	18.7	5.7	47.1	15.8	3.1	1.6	2.3	1.6	2.3	0.8	0.3	0.8
Odisha	27.7	9.8	17.9	17.1	5.6	5.6	3	5.2	4.7	2.1	0.7	0.6
Punjab	12.6	36.7	1.6	14.8	7.5	8.9	3.6	4.7	3.9	4.4	1	0.4
Rajasthan	17.1	29.6	4.5	12.3	7.6	13.3	4.4	3.1	2.6	3.5	1.6	0.3
Sikkim	16.8	21.6	17.9	20.8	6	6	3.3	2.5	2.4	2	0	0.6
Tamil Nadu	28.1	14.3	15	10.7	10.5	5.5	4.9	4.9	1.7	2.3	0.5	1.4
Tripura	21	5	31.4	22.1	4.7	4.6	1.8	2.7	3.7	1.7	0.4	0.9
Uttar Pradesh	17.3	28.2	8.1	14.2	5.3	4.9	3.8	6.6	6.1	3.3	1.5	0.7
Uttarakhand	15.3	22.7	9.1	16.6	9	9.2	3.2	5.4	4.1	3.3	1.3	0.7
West Bengal	16.7	6.3	28.5	17.6	5.7	6.5	6.5	2.7	5.9	1.6	0.4	1.6

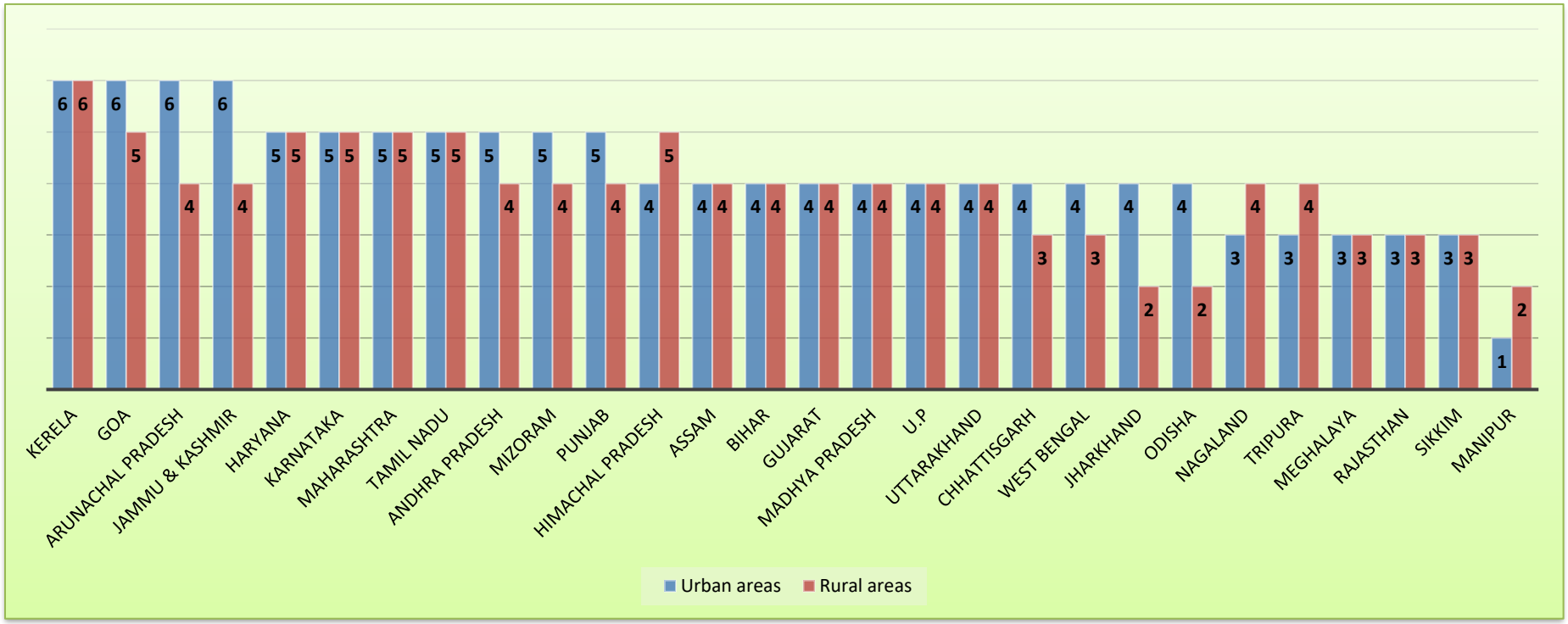
Table no.4.4 Percent contribution to cost of total diet of men by individual food groups in urban areas of various states of India

States	Cereal	Milk and milk products	Meats, chicken and fish	Vegetables	Fruits	fat and oils	Spices	Pulses	Roots and tubers	Sugar and salt	Nuts	Eggs (no.)
Andhra Pradesh	27.1	13.6	13.1	12.6	11.9	6.5	5.1	4.9	1.4	0.6	1.8	1.4
Arunachal Pradesh	20.6	6.4	28.4	19	5.6	4.3	2.8	3.1	4.4	2	1.9	1.5
Assam	21.5	8.5	26.0	16	6.3	6	2.9	4.4	4	2.1	0.8	1.6
Bihar	25.8	14.6	11.2	18	6	6.7	3.6	4.6	7.4	1	0.6	0.4
Chhattisgarh	27.2	9.1	8.5	24.3	6.1	6.9	3.1	6.4	3.9	3.2	0.8	0.5
Goa	14.9	13.3	33.3	8.1	2.1	12.4	7.7	3.2	1.2	1.7	0.7	1.2
Gujarat	13.9	23.3	3.6	15.2	7.4	13.5	3.6	4.9	3.4	8.5	2.3	0.3
Haryana	12	31.8	1.3	14.5	11.4	12.5	2.9	3.8	3.8	3.5	2.1	0.4
Himachal Pradesh	16.8	20.4	7.5	13	11.5	10.8	3.6	6.5	3.4	3.1	2.8	0.6
Jharkhand	13.2	15.9	15.7	19.3	7.6	7.3	4.1	5.3	7.2	2.6	1	0.8
Karnataka	23.8	13.7	14.1	10.7	12.7	7.6	4.8	6	1.5	2.5	1.7	1
Kerala	11.1	8.5	42.3	7.8	12	5.8	4.7	3.5	1.2	1.8	0.4	1
Madhya Pradesh	22.6	21.3	6.3	12.7	5.7	11	4.1	7.1	3.7	3.7	1.3	0.6
Maharashtra	19.2	14	12.1	17	10	9.1	3.6	5.9	2.3	2.9	2.9	0.9
Manipur	23.7	4.6	33.5	18.9	3.5	2	4.6	4.2	1.6	1.6	1.1	0.7
Meghalaya	19.1	9.9	34.5	14.1	4.9	4.2	2.5	3.2	3.6	2.1	0.6	1.2
Mizoram	13.6	9	38.5	18.9	2.9	5	2.1	3.7	1.9	2.8	0.2	1.5
Nagaland	18.7	5.7	47.1	15.8	3.1	1.6	2.3	1.6	2.3	0.8	0.3	0.8
Odisha	27.7	9.8	17.9	17.1	5.6	5.6	3	5.2	4.7	2.1	0.7	0.6
Punjab	12.6	36.7	1.6	14.8	7.5	8.9	3.6	4.7	3.9	4.4	1	0.4
Rajasthan	17.1	29.6	4.5	12.3	7.6	13.4	4.4	3.1	2.6	3.5	1.6	0.3
Sikkim	16.8	21.6	17.9	20.8	6	6	3.3	2.5	2.4	2	0	0.6
Tamil Nadu	28.1	14.3	15	10.7	10.5	5.5	4.9	4.9	1.7	2.3	0.5	1.4
Tripura	21	5	31.4	22.1	4.7	4.6	1.8	2.7	3.7	1.7	0.4	0.9
Uttar Pradesh	17.2	28.1	8	14.6	5.3	4.9	3.8	6.6	6.1	3.3	1.5	0.7
Uttarakhand	15.3	22.7	9.1	16.6	9	9.2	3.2	5.4	4.1	3.3	1.3	0.7
West Bengal	16.7	6.3	28.5	17.6	5.7	6.5	6.5	2.7	5.9	1.6	0.4	1.6

Minimum Dietary Diversity of Women in various states of India.

MDD-W is a proxy indicator that reflects the micronutrient adequacy of women's diet. If the proportion of food groups consumed are at least five or more than five out of ten food groups then the group is more likely to have higher micronutrient adequacy than other groups consuming less than five food groups **(FAO & 360, 2016)**.. The minimum dietary diversity of women in both rural and urban areas of India is represented in Figure 4.5.

Figure 4.5: Minimum Dietary Diversity of Women from rural and urban area of various states of India



Data presented in Figure 4.5, shows the score for minimum dietary diversity of women in both urban and rural India. As is evident from the data, women from 21% of the states (rural urban) had adequate MDD-W score. In 39% of the states women from urban area had adequate MDD-W while the rural women did not meet the same. In 57% of the states women from both, the rural as well as urban areas had low MDD-W. Women from rural and urban areas of Kerala, Goa, Haryana, Karnataka, Maharashtra and Tamil Nadu had desirable MDD-W. Women from the state of Odisha, Manipur, and Jharkhand had lowest MDD-W scores.

There is lack in literature review which compare MDD-W between rural and urban areas. And the only food group consumed in adequate amounts is cereals. A study conducted in Manipur showed a high prevalence of micronutrient inadequacy and macronutrient imbalance in the population. **(Loukrakpam et al., 2020)**The population from states with low minimum dietary diversity score were essentially consuming 2 food groups namely cereals and vegetables, while population from better minimum dietary diversity score also consuming pulses, meat, chicken and fish, and milk and milk products also. So, therefore it can be assumed that population with low minimum dietary diversity score states were not consuming foods rich in biologically available protein. This indicates the micronutrient adequacy in the diets. Also, fruits and vitamin- A rich foods were not included in the population with low dietary diversity score.

A study conducted in Southern and Eastern states of India along with Jammu and Kashmir shows good dietary diversity among women. The Northern, Western and Central regions show low dietary diversity score. Kerala, Tamil Nadu, and Assam showed consistently high diversity score **(Tak et al., 2019)**.

Non-diverse, low dietary diversity diets are often responsible for high burden of morbidity and mortality especially in Low- and Middle-Income Countries. These diets are often monotonous and predominantly consist of starchy foods and devoid of fruits, vegetables, sources of high biological value proteins **(Hanley-cook et al., 2020)**

A study conducted in Kayes, Mali concluded that women with a score of 5 or more than 5 consumed foods from animal sources, and /or pulses and/ or vitamin- A-rich vegetables and fruits more frequently than other women with a lower score.**(Adubra et al., 2019)**

Diets of women from rural India are less diverse lack in non-staple food groups like Vitamin A rich fruits and vegetables, dairy, eggs, and GLV. The factors influencing consumption are inter-household allocation of food, income, social status, literacy, and interpersonal relationships between household **(Gupta et al., 2020a)**. Food insecurity increases among women when the dietary diversity is low among women. To improve the dietary diversity of women in rural areas, the field level cultivation of pulses and on-farm livestock management, kitchen gardens show high significance. Improving women's literacy and awareness of nutrition can be helpful to increase dietary diversity**(Gupta et al., 2020b)**. The study by Loukrakpam et al in Manipur reported that in order to improve MDDW in Manipur, improvement in the role of women through education, economic, social, and political empowerment is needed. Awareness needs to be given about a healthy and balanced diet with high-quality locally available foods in the population **(Loukrakpam et al., 2020)**.

Affordability of 3 Hypothetical Diets from various states of India

The 3 hypothetical diets (energy only diet, macronutrients diets, and nutritious diets) for various states were calculated using the Cost of the Diet Software. In energy only diet the software calculates a diet at the lowest cost that meets only the average energy requirements of the individual or family. In macronutrients diet software calculates a diet at the lowest cost that meets the recommended intakes for energy, protein, and fats of the individual or family. In nutritious diet, the software calculates a diet at the lowest cost that meets the recommended intakes for energy, protein, fat, and all micronutrients specified for the individual or family. Software also calculates food habits nutritious diets but for majority of states food habits nutritious diet was not calculated by software.

There are several reasons why the software was not able to calculate food habits nutritious diets:

1. Specific nutrient specifications are not met by 100%either because there are not enough foods containing the nutrients in the food list or because typical dietary habits restrict the amount of foods containing these nutrients,

2. Specifications for nutrients have not been met by 100% because the upper limit for a nutrient (such as energy) has been reached.

3. Specifications for nutrients have not been met because the maximum number of times a week that a food group can be included has been reached.

4. The software has been unable to calculate a diet because there has been a conflict between the maximum food group constraints and the minimum food frequency constraints.

Therefore, in this analysis food habits diets were not included.

Due to technical issues, analysis of Kerala, Haryana, Himachal Pradesh and West Bengal states is missing exclusion of locally grown and consumed foods in the NSSO data that may have affected the cost of diets and can be cited as one of the limitations of the study.

Poverty line as described by World Bank i.e. $1.90 was used for deciding per capita income of the household. Mean fraction daily per capita income spent for 3 hypothetical diets are presented in table 4.5. The results of mean daily per capita income spent on mixed diet of men and women are represented in subsequent Tables.

Table 4.5, represents mean daily per capita income spent on mixed diet of men in urban areas of various states of India. Mixed diet includes plant based foods as well as animal-sourced foods. As shown in the table, energy only diet and macronutrient diet which provides only macronutrients from cheapest source were affordable to the population. In Gujarat the population spent the least (3.4%) on energy only diet and macronutrients diet whereas Uttar Pradesh spent highest (10.1% and 10.2%). The energy only diet and macronutrients diets were affordable to the population of all the states. The nutritious diet that provides all the essential nutrients was affordable to most of the states except Tamil Nadu and Madhya Pradesh.

Table 4.5: Mean daily per capita income spent on mixed diet by men from urban areas of various states of India

States	Energy only diet	Macronutrients Diets	Nutritious diets
Tamil Nadu	9.1	9.1	159.2
Madhya Pradesh	8.0	8.1	110.4
Bihar	9.1	9.1	50.9
Jharkhand	9.1	9.2	50.7
Himachal Pradesh	9.1	9.3	50.5
Arunachal Pradesh	8.1	8.5	50.1
Nagaland	9.1	9.3	50.0
Andhra Pradesh	8.6	8.7	49.8
Kerala	5.7	5.9	49.6
Meghalaya	8.2	8.4	49.5
Assam	9.1	9.1	49.4
Karnataka	8.1	8.4	48.3
Chhattisgarh	7.9	9.4	47.9
Haryana	8.9	9.1	47.7
Manipur	8.0	8.1	47.6
Mizoram	8.2	8.5	47.6
Goa	9.1	9.1	40.2
Gujarat	3.4	3.4	30.2
Uttar Pradesh	10.1	10.2	25.0
Sikkim	9.0	9.2	24.3
Tripura	6.0	6.0	23.4
Rajasthan	8.2	8.3	22.9
Uttarakhand	6.8	7.1	22.2
Punjab	3.4	6.0	21.4
Odisha	3.5	3.5	18.9
Maharashtra	9.1	9.1	11.6

Table 4.6: Mean daily per capita income spent on mixed diet by women from urban areas of states of India.

States	Energy only diet	Macronutrients Diets	Nutritious diets
Tamil Nadu	7.9	8.3	143.1
Madhya Pradesh	6.1	6.1	116.0
Gujarat	2.6	2.6	52.9
Bihar	7.9	8.0	45.7
Jharkhand	7.9	8.1	44.9
Himachal Pradesh	7.9	8.1	44.6
Arunachal Pradesh	6.9	7.3	44.4
Assam	7.9	8.0	44.1
Nagaland	7.2	7.6	43.0
Andhra Pradesh	6.9	6.9	42.9
Chhattisgarh	7.0	8.1	42.8
Kerala	4.6	4.6	42.8
Meghalaya	6.5	6.8	42.6
Haryana	7.7	7.9	42.1
Mizoram	6.5	6.8	42.0
Karnataka	6.5	6.7	41.2
Manipur	6.3	6.4	40.6
Goa	7.9	8.0	34.0
Uttar Pradesh	8.7	8.8	23.8
Sikkim	7.8	8.1	23.2
Tripura	5.4	5.4	22.2
Uttarakhand	6.0	6.3	21.6
Rajasthan	7.2	7.3	21.6
Punjab	3.5	5.3	19.9
Odisha	3.5	3.5	19.1
Maharashtra	7.2	7.2	9.7

Table 4.6, represents mean daily per capita income spent on mixed diet of women in urban areas of various states of India. Mixed diet includes plant based foods as well as animal-sourced foods. As shown in the table 4.6, energy only diet and macronutrient diet that provides only macronutrients from cheapest source were affordable to the population from all the states studied. In Gujarat the population spent the least (2.6%) on energy only diet and macronutrients diet whereas Uttar Pradesh spent highest (8.7% and 8.8%). The energy only diet and macronutrients diets were affordable to the population of all the states. The nutritious diet which provides all the essential nutrients was affordable to most of the states except Tamil Nadu and Madhya Pradesh.

Table 4.7, represents mean daily per capita income spent on mixed diet of men in rural areas of various states of India. Mixed diet includes plant based foods as well as animal-sourced foods. As shown in the table, energy only diet and macronutrient diet which provides only macronutrients from cheapest source were affordable to the population. In Manipur the population spent the least (8%) on energy only diet and macronutrients diet. The population of Uttar Pradesh spent highest 10.1% on energy only diet and 10.2% on macronutrients diets. The energy only diet and macronutrients diets were affordable to the population of all the states. The nutritious diet which provides all the essential nutrients was affordable to all the states except Tamil Nadu.

Table 4.7: Mean daily per capita income spent on mixed diet by men from rural areas of various states of India

States	Energy only diet	Macronutrients Diets	Nutritious diets
Tamil Nadu	9.1	9.1	159.2
Maharashtra	9.1	9.1	51.3
Jharkhand	9.1	9.1	50.7
Bihar	9.1	9.2	50.3
Goa	9.1	9.3	50.2
Arunachal Pradesh	8.1	8.5	50.1
Nagaland	9.1	9.3	50.0
Gujarat	8.9	9.0	49.6
Meghalaya	8.2	8.4	49.5
Assam	9.1	9.1	49.4
Karnataka	8.1	8.4	48.3
Madhya Pradesh	8.0	8.1	48.3
Chhattisgarh	9.7	9.8	47.9
Manipur	8.0	8.0	47.6
Mizoram	8.2	8.5	47.6
Andhra Pradesh	8.6	8.7	33.0
Uttar Pradesh	10.1	10.2	24.8
Sikkim	9.0	9.2	24.4
Tripura	6.0	6.0	23.4
Odisha	8.2	8.2	23.4
Rajasthan	8.2	8.3	22.9
Punjab	9.1	9.2	22.3
Uttarakhand	6.8	7.1	22.2

Table 4.8: Mean daily per capita income spent on mixed diet by women from rural areas of various states of India

States	Energy only diet	Macronutrients Diets	Nutritious diets
Uttarakhand	6.0	6.3	143.1
Bihar	7.2	7.4	44.6
Goa	7.9	8.1	44.3
Mizoram	6.5	6.8	43.7
Madhya Pradesh	6.4	6.4	43.6
Gujarat	7.0	7.2	43.2
Arunachal Pradesh	6.4	6.8	43.2
Rajasthan	7.2	7.3	43.0
Chhattisgarh	8.4	8.5	42.8
Odisha	7.1	7.2	42.6
Maharashtra	6.9	6.9	42.4
Punjab	7.9	8.0	42.0
Nagaland	7.2	7.6	42.0
Meghalaya	6.5	6.9	41.7
Andhra Pradesh	6.9	6.9	41.3
Assam	7.2	7.3	38.3
Uttar Pradesh	8.7	8.8	23.2
Sikkim	7.8	8.1	22.5
Tripura	5.4	5.4	21.6
Tamil Nadu	7.9	8.3	20.9
Jharkhand	7.2	7.3	NC
Karnataka	7.1	7.4	NC
Manipur	6.3	6.3	NC

*NC= Not Calculated by software.

Table 4.8, represents mean daily per capita income spent on mixed diet of women in rural areas of various states of India. Mixed diet includes plant based foods as well as animal-sourced foods. As shown in the table, energy only diet and macronutrient diet which provides only macronutrients from cheapest source were affordable to the population from all the states. In Tripura the population spent the least (5.4%) on energy only diet and macronutrients diet. The women population of Uttar Pradesh spent highest on energy only diet and on macronutrients diets 8.7% and 8.8% respectively The nutritious diet that provide all the essential nutrients was affordable to women population from all the states except Uttarakhand. Women from Uttarakhand need to spend 143.1% of the mean daily per capita income for the nutritious diet.

Table 4.9, presents mean daily per capita income spent on vegetarian diet by women from urban areas of various states of India. Vegetarian diet includes all the foods from plants source including milk and milk products. The share of energy only diet ranged from 2.6% to 8.7 %, that of macronutrient diet from 3.5% to 8.8% and that of nutritious diet from 44.7% to 150.3% of the daily per capita income for the women from rural areas of various states. Energy only diet of Gujarat state costs least (2.6%) and the macronutrients diet of Odisha contributes least (3.5%) to per capita income. Though the energy only diet is affordable it fails to meet the requirements for micronutrients. Nutritious diet aims to fulfill all the requirements for macronutrients and micronutrients. The nutritious diet forms 78%, 76.6% and 44.7% of share of per capita income respectively in Arunachal Pradesh, Assam and Andhra Pradesh and therefore affordable for rural women of these three states. The nutritious diets for women are not affordable for rural women from rest of the states.

Table 4.9: Mean daily per capita income spent on vegetarian diet by women from urban areas of various states of India

States	Energy only diet	Macronutrients Diets	Nutritious diets
Sikkim	7.8	8.1	150.3
Tripura	5.4	5.4	141.7
Maharashtra	7.2	7.2	141.0
Tamil Nadu	7.9	8.3	139.4
Uttarakhand	6.0	6.3	137.6
Odisha	3.5	3.5	134.6
Himachal Pradesh	7.9	8.1	134.0
Manipur	6.3	6.4	132.1
Haryana	7.7	7.9	131.0
Mizoram	6.5	6.8	130.1
Rajasthan	7.2	7.3	128.9
Nagaland	7.2	7.6	128.9
Punjab	3.5	5.3	128.5
Jharkhand	7.9	8.1	128.5
Kerala	4.6	4.6	128.4
Meghalaya	6.5	6.8	125.4
Uttar Pradesh	8.7	8.8	123.4
Karnataka	6.5	6.7	122.1
Goa	7.9	8.1	119.8
Chhattisgarh	7.0	8.1	119.7
Madhya Pradesh	6.1	6.1	116.0
Bihar	7.9	8.0	111.5
Arunachal Pradesh	6.9	7.3	78.0
Assam	7.9	8.0	76.6
Andhra Pradesh	6.9	6.9	44.7
Gujarat	2.6	NC	NC

*NC= Not Calculated by software.

Table 4.10: Mean daily per capita income spent on vegetarian diet by men from urban areas of various states of India

States	Energy only diet	Macronutrients Diets	Nutritious diets
Sikkim	9.0	9.2	157.9
Tripura	6.0	6.0	146.4
Maharashtra	9.1	9.1	145.8
Tamil Nadu	9.1	9.1	143.1
Goa	9.1	9.3	137.4
Uttarakhand	6.8	7.1	135.4
Bihar	9.1	9.1	134.5
Odisha	3.5	3.5	131.8
Punjab	3.4	6.0	131.1
Chhattisgarh	7.9	9.4	130.9
Rajasthan	8.2	8.3	125.4
Mizoram	8.2	8.5	120.4
Manipur	8.0	8.1	119.1
Himachal Pradesh	9.1	9.3	118.6
Jharkhand	9.1	9.2	118.5
Uttar Pradesh	10.1	10.2	118.4
Meghalaya	8.2	8.4	117.9
Nagaland	9.1	9.3	117.7
Kerala	5.7	5.9	114.6
Haryana	8.9	9.1	110.1
Karnataka	8.1	8.4	105.4
Madhya Pradesh	8.0	8.1	98.0
Arunachal Pradesh	8.1	8.4	87.4
Assam	9.1	9.1	84.4
Andhra Pradesh	8.6	8.7	49.3
Gujarat	3.4	NC	42.3

*NC= Not Calculated by software.

Table 4.10, represents mean daily per capita income spent on vegetarian diet by men from urban areas of various states of India. Energy only diets and macronutrients diets contribute to less than 10% of the daily per capita income, but it fails to meet the nutrient requirements of micronutrients. The share of energy only diet ranged from 3.4% to 10.1 %, that of macronutrient diet from 3.5% to 10.2% and that of nutritious diet from 42.3% to 157.9% of the daily per capita income for the vegetarian diet by men from urban areas of various states of India. Energy only diet of Gujarat state contributes least (3.4%) to per capita income. And macronutrients diet of Odisha contributes least (3.5%) to per capita income. Nutritious diet aims to fulfill all the requirements of macronutrients and micronutrients. Except in Madhya Pradesh (98%), Arunachal Pradesh (87.4%), Assam (84.4%), Andhra Pradesh (49.3%), and Gujarat (42.3%) other all states needs more than $1.90/day. This indicates that nutritious diets for men are not affordable to most of the population. The study on similar lines shows that 63 to 76% of the population in rural India cannot afford the nutritious diet for both men and women **(Raghunathan et al., 2020b).**

Table 4.11, represents mean daily per capita income spent on vegetarian diet by women from urban areas of various states of India. Energy only diets and macronutrients diets contribute to less than 10% of the daily per capita income, but it fails to meet the nutrient requirements of micronutrients. The share of energy only diet ranged from 5.4% to 8.7 %, that of macronutrient diet from 5.4% to 8.8% and that of nutritious diet from 66.1% to 185.4% of the daily per capita income for the vegetarian diet by women from urban areas of various states of India. Energy only diet and macronutrients diets of Tripura state contributes least (5.4%) to per capita income. Nutritious diet aims to fulfill all the requirements of macronutrients and micronutrients. Except in Arunachal Pradesh (78%), Bihar (77.3%), and Assam (66.1%) other all states need more than $1.90/day. This indicates that nutritious diets for men are not affordable to most of the population.

Table 4.12, represents mean daily per capita income spent on vegetarian diet by men from rural areas of various states of India. . The share of energy only diet ranged from 5.4% to 8.7 %, that of macronutrient diet from 5.4% to 8.8% and that of nutritious diet from 66.1% to 185.4% of the daily per capita income for the vegetarian diet by men from rural areas of various states of India. Energy only and macronutrients diets requires only 6.8% and 7.1%

respectively in Uttarakhand. Whereas nutritious diet requires more than 100% in various states of India. Except Arunachal Pradesh (87.4%), Bihar (87.9%), and Assam (84.4%). This represents that nutritious diet is not affordable to most of the population.

Table 4.11: Mean daily per capita income spent on vegetarian diet by women from rural areas of various states of India

States	Energy only diet	Macronutrients Diets	Nutritious diets
Maharashtra	6.9	6.9	185.4
Sikkim	7.8	8.1	147.3
Tamil Nadu	7.9	8.3	143.1
Tripura	5.4	5.4	141.7
Odisha	7.1	7.2	138.1
Uttarakhand	6.0	6.3	137.6
Goa	7.9	8.1	137.4
Gujarat	7.0	7.2	136.2
Manipur	6.3	6.3	134.4
Mizoram	6.5	6.8	129.8
Rajasthan	7.2	7.3	129.0
Nagaland	7.2	7.6	128.9
Punjab	7.9	8.0	128.5
Karnataka	7.1	7.4	127.4
Meghalaya	6.5	6.9	125.4
Uttar Pradesh	8.7	8.8	123.4
Madhya Pradesh	6.4	6.4	120.2
Chhattisgarh	8.4	8.5	119.3
Andhra Pradesh	6.9	6.9	119.2
Jharkhand	7.2	7.3	116.6
Arunachal Pradesh	6.9	7.3	78.0
Bihar	7.2	7.4	77.3
Assam	7.2	7.3	66.1

Table 4.12: Mean daily per capita income spent on vegetarian diet by men from rural areas of various states of India

States	Energy only diet	Macronutrients Diets	Nutritious diets
Maharashtra	9.1	9.1	190.6
Sikkim	9.0	9.2	155.9
Tamil Nadu	9.1	9.1	139.4
Tripura	6.0	6.0	146.4
Odisha	8.2	8.2	131.8
Uttarakhand	6.8	7.1	135.4
Goa	9.1	9.3	118.5
Gujarat	8.9	9.0	85.0
Manipur	8.0	8.0	114.5
Mizoram	8.2	8.5	120.9
Rajasthan	8.2	8.3	125.4
Nagaland	9.1	9.3	117.7
Punjab	9.1	9.2	131.1
Karnataka	8.1	8.4	105.4
Meghalaya	8.2	8.4	117.9
Uttar Pradesh	10.1	10.2	118.4
Madhya Pradesh	8.0	8.1	98.0
Chhattisgarh	9.7	9.8	130.6
Andhra Pradesh	8.6	8.7	158.9
Jharkhand	9.1	9.1	113.1
Arunachal Pradesh	8.1	8.4	87.4
Bihar	9.1	9.2	87.9
Assam	9.1	9.1	84.4

Table 4.13: Mean daily per capita income spent on Ovo-vegetarian diet by women from urban areas of various states of India.

States	Energy only diet	Macronutrients Diets	Nutritious diets
Sikkim	7.8	8.1	150.3
Tripura	5.4	5.4	141.7
Maharashtra	7.2	7.2	141.0
Tamil Nadu	7.9	8.3	139.4
Uttarakhand	6.0	6.3	137.6
Odisha	3.5	3.5	134.6
Himachal Pradesh	7.9	8.1	134.0
Manipur	6.3	6.4	132.1
Haryana	7.7	7.9	131.0
Mizoram	6.5	6.8	130.1
Rajasthan	7.2	7.3	128.9
Nagaland	7.2	7.6	128.9
Punjab	3.5	5.3	128.5
Jharkhand	7.9	8.1	128.5
Kerala	4.6	4.6	128.4
Meghalaya	6.5	6.8	125.4
Uttar Pradesh	8.7	8.8	123.4
Karnataka	6.5	6.7	122.1
Goa	7.9	8.1	119.8
Chhattisgarh	7.0	8.1	119.7
Madhya Pradesh	6.1	6.1	116.0
Bihar	7.9	8.0	111.5
Arunachal Pradesh	6.9	7.3	78.0
Assam	7.9	8.0	76.6
Gujarat	2.6	2.6	52.9
Andhra Pradesh	6.9	6.9	NC

*NC= Not Calculated by software.

Table 4.14: Mean daily per capita income spent on Ovo-vegetarian diet by men from urban areas of various states of India

States	Energy only diet	Macronutrients Diets	Nutritious diets
Sikkim	9.0	9.2	157.9
Tripura	6.0	6.0	146.4
Maharashtra	9.1	9.1	145.8
Tamil Nadu	9.1	9.1	143.1
Goa	9.1	9.3	137.4
Uttarakhand	6.8	7.1	135.4
Bihar	9.1	9.1	134.5
Odisha	3.5	3.5	131.8
Punjab	3.4	6.0	131.1
Chhattisgarh	7.9	9.4	130.9
Rajasthan	8.2	8.3	125.4
Mizoram	8.2	8.5	120.4
Manipur	8.0	8.1	119.1
Himachal Pradesh	9.1	9.3	118.6
Jharkhand	9.1	9.2	118.5
Uttar Pradesh	10.1	10.2	118.4
Meghalaya	8.2	8.4	117.9
Nagaland	9.1	9.3	117.7
Kerala	5.7	5.9	114.6
Haryana	8.9	9.1	110.1
Karnataka	8.1	8.4	105.4
Madhya Pradesh	8.0	8.1	98.0
Arunachal Pradesh	8.1	8.4	87.4
Assam	9.1	9.1	84.4
Gujarat	3.4	3.4	30.2
Andhra Pradesh	8.6	8.7	NC

*NC= Not Calculated by software.

Table 4.13, represents mean daily per capita income spent on ovo-vegetarian diet by women in urban areas of various states of India. Ovo-vegetarian diet includes all the foods from plants source including eggs. Energy only diets and macronutrients diets contribute to less than 10% of the per capita income, as it provides macronutrients from cheapest source available. But it fails to meet the nutrient requirements of micronutrients in both men and women. The share of energy only diet ranged from 5.4% to 8.7 %, that of macronutrient diet from 5.4% to 8.8% and that of nutritious diet from 52.9% to 150.3% of the daily per capita income for the ovo-vegetarian diet of women and men in urban areas of various states of India. Nutritious diet aims to fulfill all the requirements of macronutrients and micronutrients. Except in Arunachal Pradesh (78%), Assam (76.6%) and Gujarat (52.9%) other all states needs more than $1.90/day in women. This indicates that nutritious diets for women are beyond the means of population.

Table 4.14, represents mean daily per capita income spent on ovo-vegetarian diet by men in urban areas of various states of India. Energy only diets and macronutrients diets contribute to less than 10% of the per capita income, as it provides macronutrients from cheapest source available. But it fails to meet the nutrient requirements of micronutrients in both men and women. The share of energy only diet ranged from 3.4% to 10.1 %, that of macronutrient diet from 3.4% to 10.2% and that of nutritious diet from 30.2% to 157.9% of the daily per capita income for the ovo-vegetarian diet of women and men in urban areas of various states of India. Nutritious diet aims to fulfill all the requirements of macronutrients and micronutrients. Except in Gujarat (30.2%), Assam (84.4%) Arunachal Pradesh (87.4%), and Madhya Pradesh (98%) other all states need more than $1.90/day in men. This indicates that nutritious diets for women and men are beyond the means of population.

Table 4.15, represents the mean daily per capita income spent on ovo-vegetarian diet by women in rural areas of various states of India. Ovo-vegetarian diet includes all the foods from plants source including eggs. Energy only diets and macronutrients diets contributes to less than 10% of the per capita income but it fails to meet the nutrient requirements of micronutrients in women. The share of energy only diet ranged from 6.3% to 8.4 %, that of macronutrient diet from 6.3% to 8.5% and that of nutritious diet from 66.1% to 185.4%

of the daily per capita income for the ovo- vegetarian diet by women in rural areas of various states of India. Energy only and nutritious diets of Uttarakhand requires least per capita fraction of income i.e., 6.8% and 7.1% respectively. Nutritious diet aims to fulfill all the requirements of macronutrients and micronutrients. Except in Assam (66.1%), Bihar (77.3%), and Arunachal Pradesh (78%) other all states need more than $1.90/day in women. This indicates that nutritious diets for women are not affordable to the population.

Table 4.16, represents the mean daily per capita income spent on ovo-vegetarian diet by men in rural areas of various states of India. Ovo-vegetarian diet includes all the foods from plants source including eggs. Energy only diets and macronutrients diets contribute to less than 10% of the per capita income but it fails to meet the nutrient requirements of micronutrients in men. The share of energy only diet ranged from 6.0% to 10.1 %, that of macronutrient diet from 6.0% to 10.2% and that of nutritious diet from 84.4% to 190.6% of the daily per capita income for the ovo-vegetarian diet by men in rural areas of various states of India. Nutritious diet aims to fulfill all the requirements of macronutrients and micronutrients. Except in Assam (84.4%), Gujarat (85%), Arunachal Pradesh 987.4%), Bihar (87.9%) and Madhya Pradesh 998%) other all states needs more than $1.90/day in men. This indicates that nutritious diets for women and men are not affordable to the population.

Table 4.15: Mean daily per capita income spent on Ovo-vegetarian diet by women from rural areas of various states of India

States	Energy only diet	Macronutrients Diets	Nutritious diets
Maharashtra	6.9	6.9	185.4
Sikkim	7.8	8.1	147.3
Tamil Nadu	7.9	8.3	143.1
Tripura	5.4	5.4	141.7
Odisha	7.1	7.2	138.1
Uttarakhand	6.0	6.3	137.6
Goa	7.9	8.1	137.4
Gujarat	7.0	7.2	136.2
Manipur	6.3	6.3	134.4
Mizoram	6.5	6.8	129.8
Rajasthan	7.2	7.3	129.0
Nagaland	7.2	7.6	128.9
Punjab	7.9	8.0	128.5
Karnataka	7.1	7.4	127.4
Meghalaya	6.5	6.9	125.4
Uttar Pradesh	8.7	8.8	123.4
Madhya Pradesh	6.4	6.4	120.2
Chhattisgarh	8.4	8.5	119.3
Andhra Pradesh	6.9	6.9	119.2
Jharkhand	7.2	7.3	116.6
Arunachal Pradesh	6.9	7.3	78.0
Bihar	7.2	7.4	77.3
Assam	7.2	7.3	66.1

Table 4.16: Mean daily per capita income spent on Ovo-vegetarian diet by men from rural areas of various states of India

States	Energy only diet	Macronutrients Diets	Nutritious diets
Maharashtra	9.1	9.1	190.6
Andhra Pradesh	8.6	8.7	158.9
Sikkim	9.0	9.2	155.9
Tripura	6.0	6.0	146.4
Tamil Nadu	9.1	9.1	139.4
Uttarakhand	6.8	7.1	135.4
Odisha	8.2	8.2	131.8
Punjab	9.1	9.2	131.1
Chhattisgarh	9.7	9.8	130.6
Rajasthan	8.2	8.3	125.4
Mizoram	8.2	8.5	120.9
Goa	9.1	9.3	118.5
Uttar Pradesh	10.1	10.2	118.4
Meghalaya	8.2	8.4	117.9
Nagaland	9.1	9.3	117.7
Manipur	8.0	8.0	114.5
Jharkhand	9.1	9.1	113.1
Karnataka	8.1	8.4	105.4
Madhya Pradesh	8.0	8.1	98.0
Bihar	9.1	9.2	87.9
Arunachal Pradesh	8.1	8.4	87.4
Gujarat	8.9	9.0	85.0
Assam	9.1	9.1	84.4

Table 4.17: Mean daily per capita income spent on Vegan diet by women from urban areas of various states of India

States	Energy only diet	Macronutrients Diets	Nutritious diets
Maharashtra	7.2	7.2	79.7
Sikkim	7.8	8.1	71.9
Tripura	5.4	5.4	70.1
Uttarakhand	6.0	6.3	67.1
Himachal Pradesh	7.9	8.1	66.6
Mizoram	6.5	6.8	66.1
Goa	7.9	8.1	65.8
Odisha	3.5	3.5	65.3
Meghalaya	6.5	6.8	64.3
Nagaland	7.2	7.6	64.1
Tamil Nadu	7.9	8.3	63.9
Kerala	4.6	4.6	63.8
Manipur	6.3	6.4	63.5
Karnataka	6.5	6.7	63.1
Rajasthan	7.2	7.3	62.2
Jharkhand	7.9	8.1	61.7
Punjab	3.5	5.3	60.7
Haryana	7.7	7.9	60.1
Uttar Pradesh	8.7	8.8	55.7
Madhya Pradesh	6.1	6.1	55.3
Assam	7.9	8.1	47.8
Andhra Pradesh	6.9	6.9	43.8
Arunachal Pradesh	6.9	7.3	21.4
Chhattisgarh	7.0	8.1	16.1
Bihar	7.9	8.0	15.3
Gujarat	2.6	NC	NC

*NC= Not Calculated by software.

Table 4.18: Mean daily per capita income spent on Vegan diet by men from urban areas of various states of India

States	Energy only diet	Macronutrients Diets	Nutritious diets
Mizoram	8.2	8.5	134.5
Maharashtra	9.1	9.1	98.6
Sikkim	9.0	9.2	82.1
Manipur	8.0	8.1	81.6
Meghalaya	8.2	8.4	81.5
Uttarakhand	6.8	7.1	81.4
Nagaland	9.1	9.3	81.1
Karnataka	8.1	8.4	80.3
Kerala	5.7	5.9	79.5
Tripura	6.0	6.0	76.1
Goa	9.1	9.3	75.2
Rajasthan	8.2	8.3	72.4
Himachal Pradesh	9.1	9.3	72.3
Tamil Nadu	9.1	9.1	69.6
Odisha	3.5	3.5	65.9
Assam	9.1	9.2	65.6
Punjab	3.4	6.0	64.4
Jharkhand	9.1	9.2	64.2
Haryana	8.9	9.1	64.0
Madhya Pradesh	8.0	8.1	62.5
Andhra Pradesh	8.6	8.7	58.7
Uttar Pradesh	10.1	10.2	56.1
Arunachal Pradesh	8.1	8.4	23.8
Chhattisgarh	7.9	9.4	16.7
Bihar	9.1	9.2	15.3
Gujarat	3.4	NC	NC

Table 4.17, represents the mean daily per capita income spent on vegan diet by women in urban areas of various states of India. Vegan diet includes all the foods from plants. Energy only diets and macronutrients diets contributes to less than 10% of mean daily per capita income but it fails to meet the nutrient requirements of micronutrients women. . The share of energy only diet ranged from 2.6% to 8.7 %, that of macronutrient diet from 3.5% to 8.8% and that of nutritious diet from 15.3% to 79.7% of the daily per capita income for the vegan diets by women in urban areas of various states of India. Nutritious diet aims to fulfill all the requirements of macronutrients and micronutrients. Except in Maharashtra other all states needs less than $1.90/day in women. This indicates that nutritious vegan diets for women are affordable to the population. But this diet fails to fulfill all the nutritional requirements of women. Also it is not acceptable to most of the population.

Table 4.18, represents the mean daily per capita income spent on vegan diet by men in urban areas of various states of India. Vegan diet includes all the foods from plants. Energy only diets and macronutrients diets contributes to less than 10% of mean daily per capita income but it fails to meet the nutrient requirements of micronutrients men. . The share of energy only diet ranged from 3.4% to 10.1 %, that of macronutrient diet from 3.5% to 10.2% and that of nutritious diet from 15.3% to 134.5% of the daily per capita income for the vegan diets by men in urban areas of various states of India. Nutritious diet aims to fulfill all the requirements of macronutrients and micronutrients. Except in Mizoram other all states needs less than $1.90/day in men. This indicates that nutritious vegan diets for men are affordable to the population. But this diet fails to fulfill all the nutritional requirements of men. Also it is not acceptable to most of the population.

Table 4.19: Mean daily per capita income spent on Vegan diet by women from rural areas of various states of India

States	Energy only diet	Macronutrients Diets	Nutritious diets
Maharashtra	6.9	6.9	123.0
Tripura	5.4	5.4	70.1
Sikkim	7.8	8.1	68.9
Uttarakhand	6.0	6.3	67.1
Assam	7.2	7.4	66.1
Mizoram	6.5	6.8	66.1
Goa	7.9	8.1	65.7
Odisha	7.1	7.2	65.6
Meghalaya	6.5	6.9	64.4
Karnataka	7.1	7.4	64.2
Manipur	6.3	6.3	64.1
Nagaland	7.2	7.6	64.1
Tamil Nadu	7.9	8.3	63.5
Rajasthan	7.2	7.3	62.3
Punjab	7.9	8.0	60.7
Jharkhand	7.2	7.4	60.3
Uttar Pradesh	8.7	8.8	56.4
Madhya Pradesh	6.4	6.4	55.7
Bihar	7.2	7.4	48.6
Andhra Pradesh	6.9	6.9	43.6
Arunachal Pradesh	6.9	7.3	21.4
Chhattisgarh	8.4	8.5	16.7
Gujarat	7.0	7.2	NC

Table 4.19, represents the mean daily per capita income spent on vegan diet by women in rural areas of various states of India. Vegan diet includes all the foods from plants. Energy only diets and macronutrients diets contributes to less than 10% of the daily per capita

income but it fails to meet the nutrient requirements of micronutrients in women. . The share of energy only diet ranged from 5.4% to 8.7 %, that of macronutrient diet from 5.4% to 8.8% and that of nutritious diet from 16.7% to 123% of the daily per capita income for the vegan diets by women in rural areas of various states of India. In Gujarat the energy only diets contributes least (5.4%) to the per capita income in women. Nutritious diet aims to fulfill all the requirements of macronutrients and micronutrients. Except in Maharashtra 123% in women than other all states needs less than $1.90/day. This indicates that nutritious vegan diets for women are affordable to the population. But this diet fails to fulfill all the nutritional requirements of women. Also it is not acceptable to most of the population.

Table 4.120, represents the mean daily per capita income spent on vegan diet by men in rural areas of various states of India. Vegan diet includes all the foods from plants. Energy only diets and macronutrients diets contributes to less than 10% of the daily per capita income but it fails to meet the nutrient requirements of micronutrients in men. . The share of energy only diet ranged from 6.0% to 10.1 %, that of macronutrient diet from 6.0% to 10.2% and that of nutritious diet from 17% to 164.3% of the daily per capita income for the vegan diets by men in rural areas of various states of India. In Gujarat the energy only diets contributes least (6.0%) to the per capita income in men. Nutritious diet aims to fulfill all the requirements of macronutrients and micronutrients. Except in Maharashtra 164.3% in women than other all states needs less than $1.90/day. This indicates that nutritious vegan diets for men are affordable to the population. But this diet fails to fulfill all the nutritional requirements of men. Also it is not acceptable to most of the population.

Table 4.20: Mean daily per capita income spent on Vegan diet by men from rural areas of various states of India

States	Energy only diet	Macronutrients Diets	Nutritious diets
Maharashtra	9.1	9.1	164.3
Mizoram	8.2	8.5	84.6
Meghalaya	8.2	8.4	81.6
Manipur	8.0	8.0	81.6
Uttarakhand	6.8	7.1	81.4
Nagaland	9.1	9.3	81.1
Karnataka	8.1	8.4	80.3
Tripura	6.0	6.0	76.1
Sikkim	9.0	9.2	75.4
Goa	9.1	9.3	75.0
Bihar	9.1	9.2	72.6
Rajasthan	8.2	8.3	72.4
Andhra Pradesh	8.6	8.7	70.1
Tamil Nadu	9.1	9.1	69.3
Odisha	8.2	8.2	65.9
Punjab	9.1	9.2	64.4
Jharkhand	9.1	9.2	64.2
Madhya Pradesh	8.0	8.1	62.5
Uttar Pradesh	10.1	10.2	54.9
Assam	9.1	9.2	24.8
Arunachal Pradesh	8.1	8.4	23.7
Chhattisgarh	9.7	9.8	17.0
Gujarat	8.9	9.0	NC

A study conducted by **(Hirvonen et al.,2020)** reported that Eat Lancet Recommended diets are not affordable to most of population in the world. The estimated cost of an EAT–Lancet reference diet exceeded the mean daily per capita household income in Burkina Faso, Burundi, Democratic Republic of the Congo, Guinea-Bissau, Lesotho, Madagascar, Malawi, Nigeria, Sierra Leone, and Yemen. They also estimated that at least 1·58 billion individuals, mostly located in sub-Saharan Africa and south Asia, exceeds daily per capita income on EAT- Lancet reference diet. Healthy diets are unaffordable for population due to high cost of nutritious foods. This is the major obstacle towards achieving food and nutrition security and SDG targets. Unaffordability of nutritious diets is seen in South Asian countries and these are the hot spots for malnutrition. Diet quality becomes even more paramount, as the double burden of malnutrition is intensifying. This lead to food insecurity. Food system should focus on proving all elements of a healthy diet. Nutrition education alone cannot solve the problem in poor population. Systematic change in food system is also needed. Healthy diets are not affordable to low income population. In order to make it affordable it requires higher income and expansion of safety nets and also lowering the prices of nutritious foods. Diversity in agriculture is needed to provide low cost nutritious foods. Home grown vegetables, pulses, fruits and also production of dairy, small fish, and poultry can be helpful to provide nutritious foods in some settings. The farm production and food prices in market are closely related. In order to diversify the agriculture, the shift from starchy staple to pulses, vegetables and fruits, nuts and oilseeds as well as dairy, eggs, fish , an livestock is needed. The cost of diet and affordability of diet varies significantly by regions within countries. Therefore, identifying geographic hotspots that fails to afford healthy diet will be helpful. Nutrient adequacy and healthy diets can be achieved with small quantities of animal-source foods, which includes dairy, eggs, and small fish that complement nutrient-rich sources of plant- source foods. It is also important to focus on including lowest environmental impact animal- source foods and plant source foods **(Herforth et al., 2020)**.

Sustainability of usually consumed diets and nutritious diets

"A Carbon footprint is the total greenhouse gas (GHG) emissions caused by an individual, organization, event or product directly or indirectly". It is calculated by summing all

emissions by the product at each and every step of product or service's lifetime i.e., production, transport, processing, and preparation. In product's lifetime, or lifecycle, different GHGs are produced, such as methane, carbon dioxide, and nitrous oxide. Each of these gases has the greater or lesser ability to trap heat in environment, hence increases global warming **(Center for Sustainable Systems, 2019).** The mean GHG emission data was calculated for diet consumed by populations from rural and urban areas for various states of India and are presented in subsequent figures. The limitation of the study is the data available for GHG emissions includes GHG emissions at production stage only. Emissions during Transportation, processing, packaging, and food wastage could not be calculated due to lack of data. The results of mean GHG emissions from usually consumed diets and nutritious diets for various states of India are represented in Figure 4.6, 4.7, 4.8, 4.9, 4.10, 4.11.

Figure 4.6 and 4.7, represents the GHG emissions in g/g of diet consumed by women and men from urban and rural areas of various states of India. The mean GHG emission in g/g of diets was 1.4 and 1.3 in urban and rural areas respectively. The mean GHG emissions in g/g OD diets was 1.7 in both urban and rural areas of various states of India. GHG emission / g of diet consumed was highest in Nagaland, Mizoram and Meghalaya in rural as well as in the urban areas. Lowest GHG emission / g of diet consumed was from diets from Chhattisgarh. Highest contributor to GHG emission are animal source foods namely, meat, chicken and fish, milk and milk products and rice among cereals. States with highest GHG emission diets comprised primarily of rice and meat namely, pork, beef and yak. In Arunachal Pradesh the consumption of meat, chicken pork, beef and yak is high. Many traditional dishes like Momos, Zan, Gyapa-khazi, are prepared using Yak fat, Yak meat, and Thukpa includes beef, pork, yak, mutton, chicken and fish**(D.S. Chhonkar & Sonam Tsering Khumu, 2017)**.

Figure 4.6. Mean GHG emission from usually consumed diets by women from various states of India

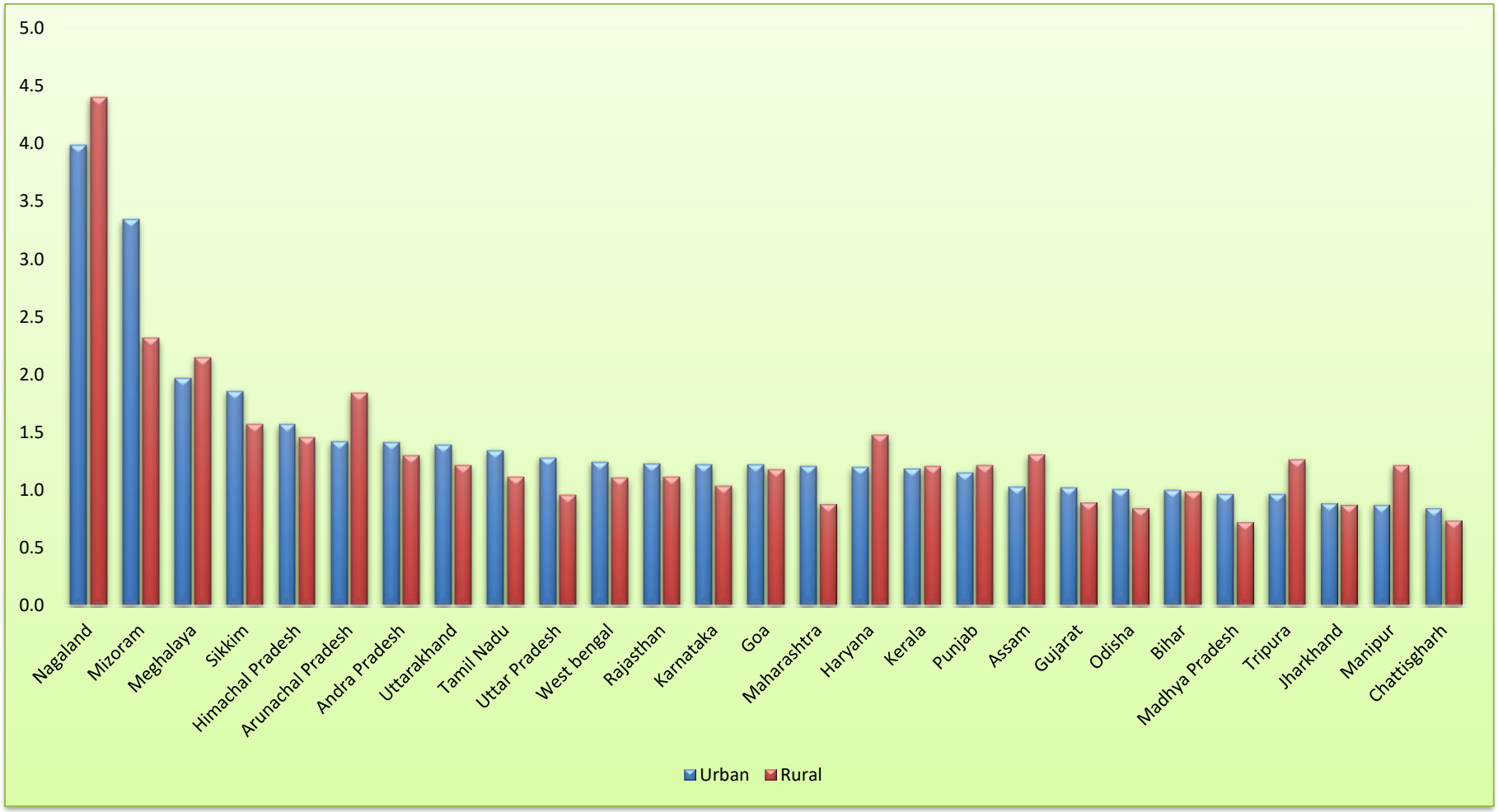
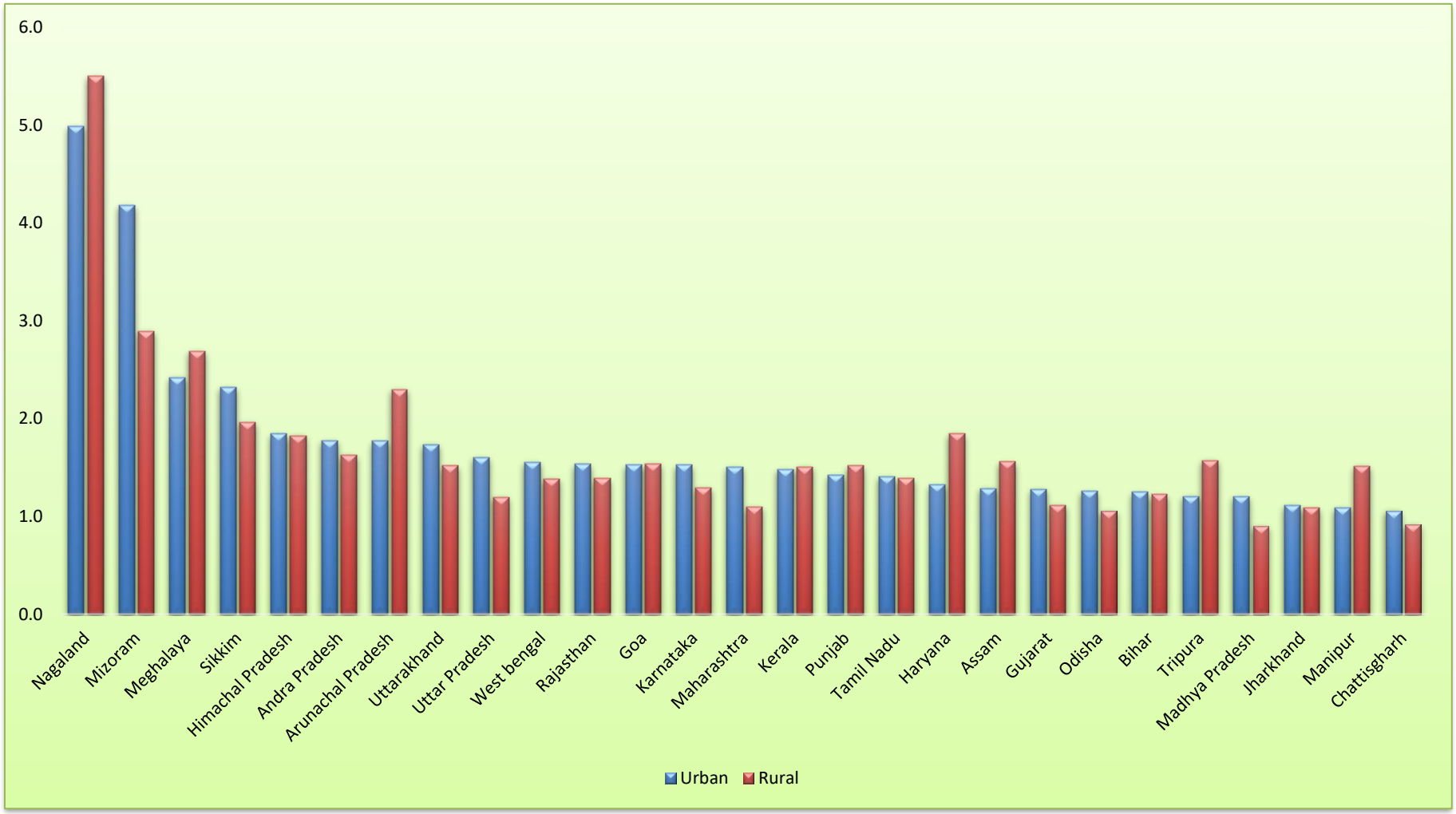


Figure 4.7. Mean GHG emission from usually consumed diets by men from various states of India



Data on mean GHG emissions from 4 hypothetical diets (Mixed diets, Vegetarian diets, Ovo-vegetarian diets, and Vegan diets) of population from various states of India is presented in figures 4.8, 4.9, 4.10 and 4.11. .

Figure 4.8: Mean GHG emissions from 4 hypothetical diets of women from urban areas of various states of India

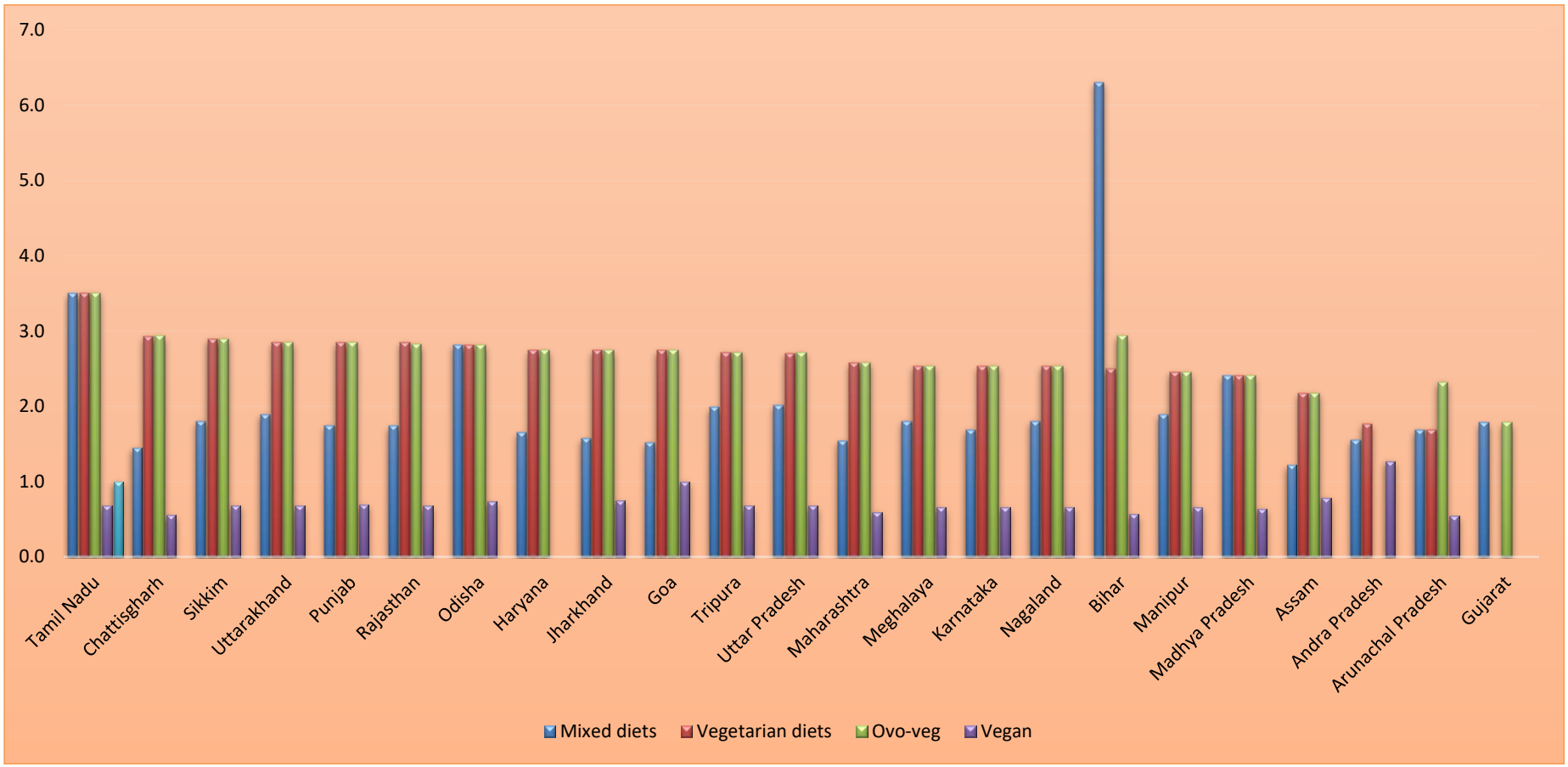
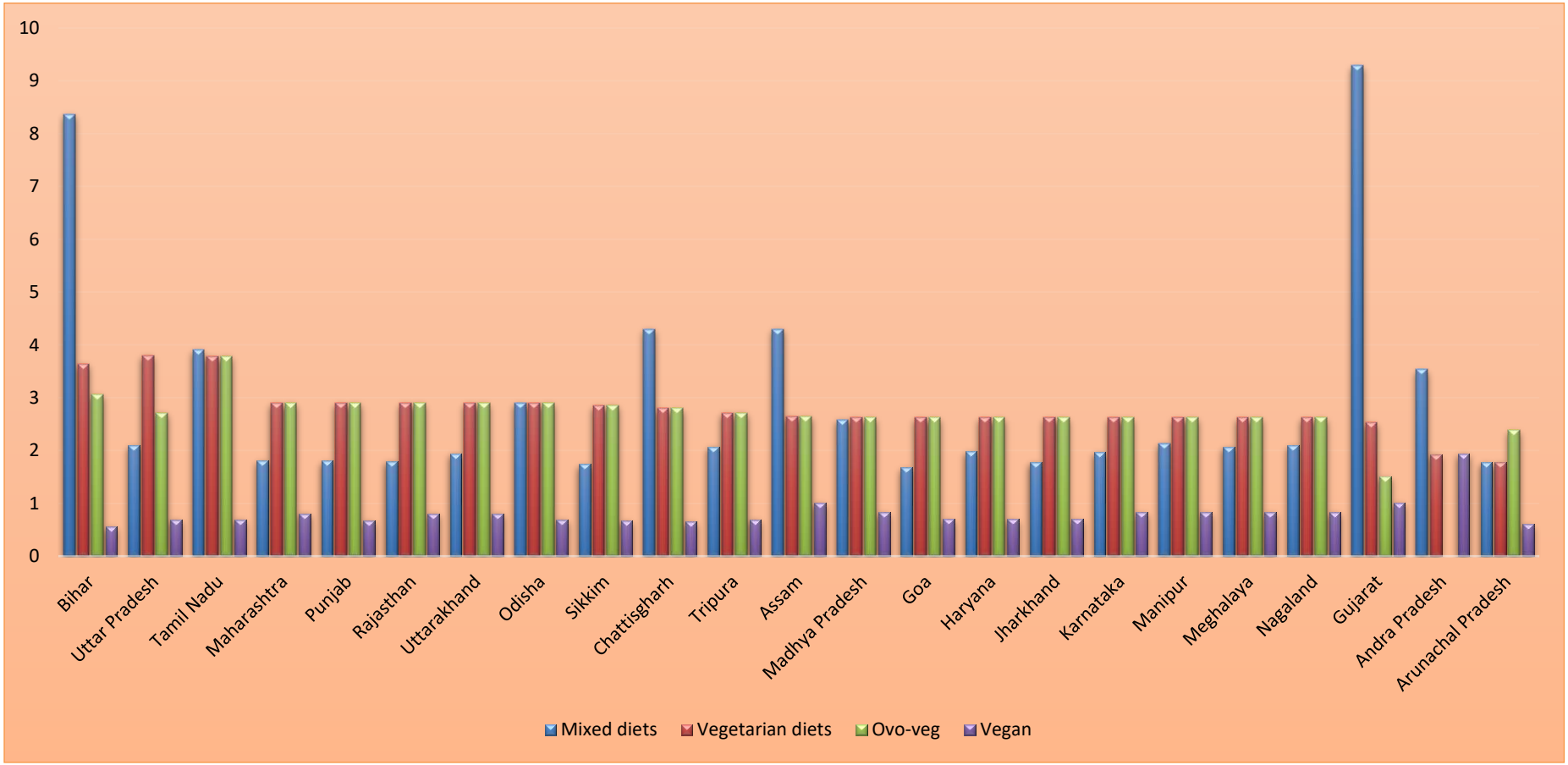


Figure 4.9: Mean GHG emissions from 4 hypothetical diets of men from urban areas of various states of India



As can be seen from Figure 4.8 and 4.9 the mean GHG emission was lowest from the vegan diet followed by vegetarian and ovo-vegetarian diet while the mixed diet did not follow a trend. The mean GHG emission from vegan, ovo-vegetarian, vegetarian and mixed diet was 0.70, 2.66, 2.59, and 2.059 respectively of women in urban areas of various states of India. And mean GHG emission from vegan, ovo-vegetarian, vegetarian and mixed diet was 0.80, 2.72, 1.33, and 2.95 respectively of men in urban areas of various states of India. Since the GHG emission values are for food production only, no rural urban differences were observed due to travelling emissions were not included in diet.

Figure 4.10: shows the mean GHG emissions from 4 hypothetical diets of women from rural areas of various states of India. The mean GHG emission from vegan, ovo-vegetarian, vegetarian and mixed diet was 0.75, 2.59, 2.62, and 1.88 respectively of women in rural areas of various states of India. The highest GHG emissions are seen in Sikkim and Tamil Nadu in vegetarian and ovo-vegetarian diets. The vegan diet of Odisha contributes to least in GHG emissions.

Figure 4.11: shows the mean GHG emissions from 4 hypothetical diets of men from rural areas of various states of India. . The mean GHG emission from vegan, ovo-vegetarian, vegetarian and mixed diet was 0.94, 2.66, 2.59 and 2.38 respectively of men in rural areas of various states of India. The highest GHG emissions are seen from mixed diets from Gujarat. The vegan diet of Chhattisgarh contributes least to the GHG emissions.

Figure 4.10: Mean GHG emissions from 4 hypothetical diets of women from rural areas of various states of India

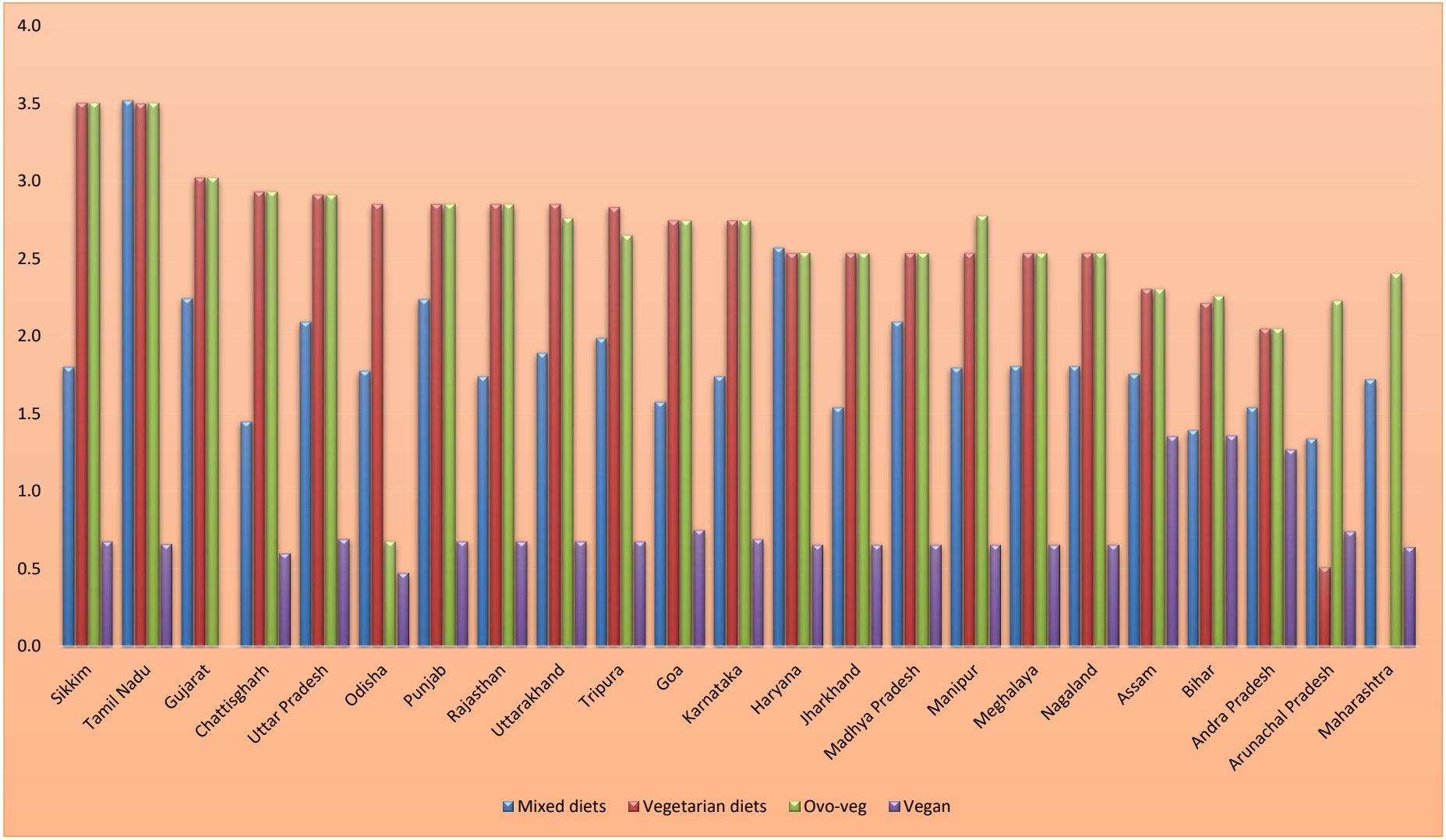
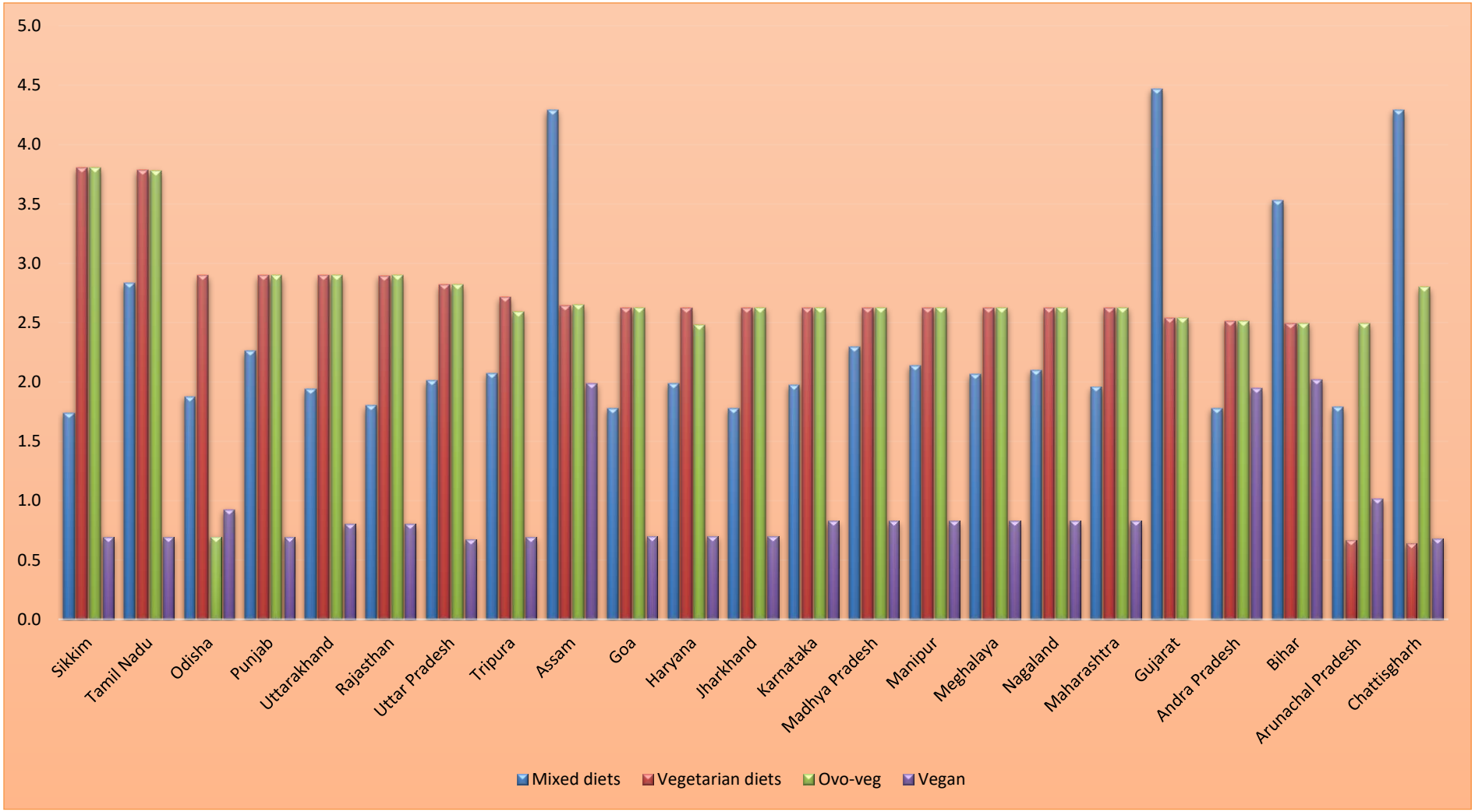


Figure 4.11: Mean GHG emissions from 4 hypothetical diets of men from rural areas of various states of India.



Studies by other investigators show that the vegan diets have least environmental impacts. However, it is very important to understand that vegan products are less healthy as they are highly processed, high in fats, and have to be transported across long distances thereby adding to GHG emission due to transportation. The water footprint of vegan foods is also high. There are chances of insufficiency of vitamin B12, calcium, iron, and other nutrients if a vegan diet is not balanced. Plant- based vegan diets are best for environment but such changes are hard to achieve at the population level **(Chai et al., 2019)**.

The foods that produce highest GHG emission in the form of methane, during production are beef, lamb and rice. The emissions from rice production are reported to be about 10.2 and 43.3 times higher respectively as compared to those from production of wheat and vegetables. Also, animal source food products such as mutton, chicken, meat, beef, dairy products, and fish contribute to higher GHG emissions. In order to mitigate GHG emissions of diets, either the consumption of rice needs to be reduced or other high GHG emission foods need to be replaced with low GHG emission foods. Alternately, newer varieties of crops and methods of cultivation need to be adopted to reduce GHG emission and lower water foot print in order to make the diets sustainable. Pathak et al., (2010) in unpublished research stated that, aerobic rice or direct-seeded rice is a good example to reduce the GHG emission. Meats can be substituted with vegetables and pulses, however, substitution of meat with milk and milk product won't be of much use. As compared to meat and poultry, fish emits less GHG emission, so substituting meat with fish can be useful to mitigate GHG emissions.

SUMMARY
AND
CONCLUSION

5. SUMMARY AND CONCLUSION

The present study was conducted to assess the affordability and sustainability of usually consumed diets and hypothetical diets for various states of India. The availability of an affordable and sustainable diet is essential to achieve SDG-2 target.

A higher proportion of daily per capita income was spent on food by people from rural Kerala, Nagaland, and Goa while the lowest percent per capita income was spent by people from rural Madhya Pradesh, Manipur, and Chhattisgarh. In Urban areas, the highest portion of daily per capita income was spent on food by people from Goa, Kerala, and Tripura and lowest daily per capita income was spent by people from Manipur, Uttar Pradesh, and Jharkhand.

Dietary diversity score is a proxy measure of food and nutrition security. Women from 21% of the states from rural area had adequate MDD-W score. In 39% of the states women from urban area had adequate MDD-W while the rural women did not meet the same. In 57% of the states women from both, the rural as well as urban areas had low MDD-W. Women from rural and urban areas of Kerala, Goa, Haryana, Karnataka, Maharashtra and Tamil Nadu had desirable MDD-W. Women from the state of Odisha, Manipur, and Jharkhand had lowest MDD-W scores.

Data also indicate that the states with higher dietary diversity have a higher cost of usually consumed diets.

Out of 3 hypothetical diets, energy-only diets and macronutrient diets were affordable for all the population from various states of India. These diets are affordable to the population but fail to fulfill nutritional requirements. Although Nutritious diets fulfill nutritional requirements, they are not affordable for most of the population from various states of India. Of the four hypothetical diets namely, mixed diets, ovo-vegetarian diets, vegetarian diets, and vegan diets, mixed diets and vegan diets were affordable to most of the population.

States in which the animal source products are consumed in large quantity show higher GHG emission from diets of both men and women. Usually consumed diets from the

state of Nagaland, Mizoram, Meghalaya, and Sikkim show higher mean GHG emissions as they comprise of animal source products. Usually consumed diets from the state of Jharkhand, Manipur, and Chhattisgarh show the lowest GHG emissions. The diets from these states also have low dietary diversity and lowest cost as compared with other states of India.

Of the 4 hypothetical diets, vegan diets had the lowest mean GHG emissions while mixed diets and ovo-vegetarian diets had the highest GHG emissions. Vegan diets are sustainable but these diets are not accessible and affordable to most of the population.

Conclusions that emerge from this study are as follows:

- Regional and gender-based differences exist in the cost of usually consumed diets. Usually consumed diets though affordable are also characterized by low dietary diversity indicating poor food and nutrition security.
- To achieve food and nutrition security in India production, productivity and marketing of nutritious foods must be raised. Limiting the advertising of and access to unhealthy processed foods, while simultaneously promoting healthy traditional foods and diets also be helpful.
- Women's empowerment and participation in the decision making process is required to promote food and nutrition security among them.
- Energy only and macronutrients diets are affordable for population from urban and rural areas of various states of India. Nutritious diets were not affordable for most of the population.
- Diets lower in animal sourced foods showed lesser GHG emission. Of the 4 hypothetical diets, vegan diets had lowest GHG emissions.
- In order to make the diets more sustainable a three pronged approach needs to be adopted –
    1. Promote consumption of locally produced foods
    2. Substitute foods with high GHG emissions like meat with low GHG emission foods like egg and fish
    3. Introduce newer varieties of rice with low water foot print and promote the consumption of millets and coarse grains that have low water foot print

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ANNEXURE-I

Annexure I- Ethical Approval Certificate

सत्यं शिवं सुन्दरम्
Estd. 1949

Institutional Ethics
Committee for Human
Research
(IECHR)

FACULTY OF FAMILY AND COMMUNITY SCIENCES
THE MAHARAJA SAYAJIRAO UNIVERSITY OF BARODA

Ethical Compliance Certificate 2020 – 2021

This is to certify that **Ms. Purva Vilas Bahadkar**'s study titled, "**Assessment of Affordability and Sustainability of Selected Indian Diets using Secondary Source Data**" has been approved by the Institutional Ethics Committee for Human Research (IECHR), Faculty of Family and Community Science, The Maharaja Sayajirao University of Baroda. The study has been allotted the ethical approval number **IECHR/FCSc/2020/54.**

Prof Mini Sheth
Member Secretary
IECHR

Prof Shagufa Kapadia
Chairperson
IECHR