Final Report

Water Energy Food Nexus in Urban Ecosystem:

An assessment of challenges and opportunities for adaptation in urban areas

Report on completion of Project

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For more information

Dr. Shresth Tayal
Fellow & Area Convenor
Water Resources Division
T E R I
Darbari Seth Block
IHC Complex, Lodhi Road
New Delhi – 110 003
India

Tel. 2468 2100 or 2468 2111
E-mail stayal@teri.res.in
Fax 2468 2144 or 2468 2145
Web www.teriin.org
India +91 • Delhi (0)11

Table of contents

List of Tables

List of Figures

List of Photos

1. Water Energy Food Nexus in Urban Ecosystem

Introduction

Water energy food (WEF) nexus is not a new concept but awareness about the importance of nexus and the role it plays in management of natural resources has grown in recent years. The idea of the nexus gained momentum globally only after 2007-08 economic crises, essentially through the lens of World Economic Forum and Rio+20 Conferences[1][2][3]. The idea was to raise awareness as well as to develop better understanding of WEF nexus and its relationship with economic growth, socio-ecological linkages and path of resilience. Thus, the approach has been used by many experts, researchers and organizations like Food and Agriculture Organization (FAO), International Centre for Integrated Mountain Development (ICIMOD), United Nation Environment Program, Global Water Partnership and others in order to develop synergies between water-energy-food systems, and aims to provide framework for optimal use of resources to manage trade-offs between them[4][5].

Food consumption is affected by wide range of factors, which includes, food availability, food accessibility and food choice, which in turn is influenced by geography, demography, socio-economic status, urbanization, culture, marketing and consumer attitudes. As the lifestyle of people are changing, the burgeoning middle class societies need to look to meet the growing demand for goods and services, new pressures are mounting to reduce the carbon footprints, the energy production chain and reduce greenhouse gas emissions in all sectors. Therefore understanding their inter linkages is important for better planning and management. Moreover, with the nexus approach for resource management, resource use efficiency in production and consumption can be increased substantially, thus improving the system efficiency in total.

The present study is focused on Water-Energy-Food nexus and optimization of resources, is a useful concept that describes the complex as well as interrelated nature of natural resources on which different social, environmental and economic goals are dependent. The WEF relationship is continuously evolving with changing resource conditions, development priorities and technological advancements and thus provides an interface to explore synergies for maximum positive outputs. This study will help to understand the dynamic interrelationships between water, energy and food through a case study of Gurgaon in India so that management of resources can be optimized and managed sustainably.

[1] World Economic Forum. (2009).
[2] Hoff, H. (2011). Understanding the Nexus. Background Paper for the Bonn 2011 Conference: The Water, Energy and Food Security Nexus.
[3] Middleton, C. and Allen, S. (2014). The (re)discovery of "the Nexus": Political economies and dynamic sustainability of water, energy and food security in Southeast Asia. Paper presented at the Asia Pacific Sociological Association (APSA) conference "Transforming Societies: Contestations and Convergences in Asia and the Pacific", 15-16 February 2014, Chiang Mai, Thailand.
[4] Hellegers, P., Zilberman, D., Steduto, P., and McCornik, P. (2008). Interactions between water, energy, food and environment: evolving perspectives and policy issues. *Water Policy, 10 (1)*1-10.
[5] Rasul, G. (2014). Food, Water and Energy Security in South Asia: A Nexus perspective from the Hindu Kush Himalayan Region. *Environmental Science and Policy, 39*, 35-48.

Significance of nexus approach

Water, energy and food security form the basis of self-sufficient economy, however, the three are inextricably linked, and achieving one is not possible without the other two. Water is needed for power generation, and energy is required to treat and transport water; while both energy and water are needed to grow, process and consume food. World Economic Forum (2011) describes water-energy-food security problem as "A rapidly rising global population and growing prosperity are putting unsustainable pressures on resources. Demand for water, food and energy is expected to rise by 30 to 50% in the next two decades, while economic disparities incentivize short-term responses in production and consumption that undermine long-term sustainability. Shortages could cause social and political instability, geopolitical conflict and irreparable environmental damage".

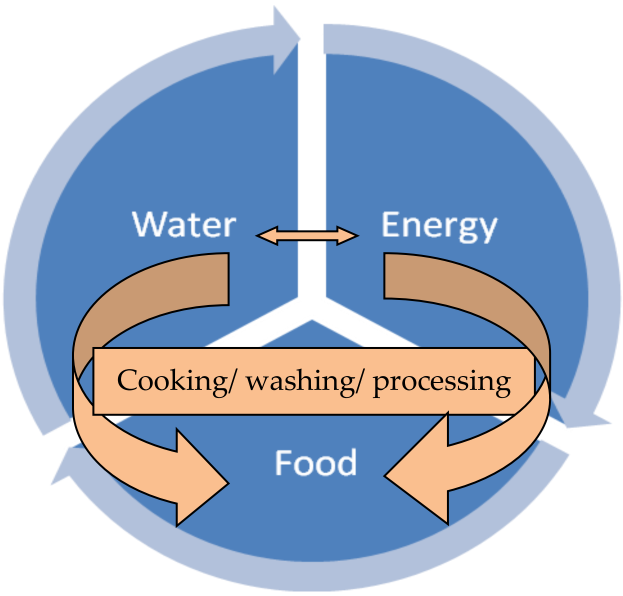


Figure 1 Diagram showing inter-linkage of Water, Energy and Food

Rise in population, rampant urbanization, growing prosperity and transition in lifestyle demands for more water and energy along with increase in the demand of food. The world population has already reached seven billion and as projected by United Nations by 2050 it will be home to nine billion people. The world is under sustained process of urbanization pulling more people under city centre. 60 years back the world urban population was 29 percent today it is 50 percent and as per the projections made, by 2050 it will grow by 72 percent[6]. The point of concern is that most of this growing population will be absorbed into rapidly growing cities, notably in Asia's fast developing economies[7] including India which is in a state of transition from traditional rural economies to modern industrial one and moving towards more urbanized world.

The growing population and speed of urbanization in India puts unprecedented challenge on its environment and natural resources. As per the 12th Five Year Plan [8] of India, 300 million Indians currently live in towns and cities, which is 31 percent of the total population

[6] UNDESA (2012). *World Urbanization Prospects: The 2011 Revision.* Department of Social and Economic Affairs, Population Division. United Nations, New York. Retrieved from http://esa.un.org/unup/pdf/wup2011_highlights.pdf

[7] Bentham, J. (2011). Water, Energy and Food Security in Urban Context. Published speech on World Water Week-Stockholm.

[8] The Planning Commission, GoI. (2012). *The challenges of Urbanization in India: Approach to 12th Five Year Plan*

of India, and are likely to increase in coming years putting stress on its resources if not managed sustainably. The report further projects that within 20 to 25 years another 300 million people will get added to the cities and towns. Urban development, growing population density and the infrastructure development like housing societies, mall and markets, highways, office premises etc., all will have an obvious impact on the efficiency of energy and water use as well as availability of food to support the growing population. As stated[9], urban living promotes more resource intensive lifestyles and concentrates consumption and waste production, and thus escalates the scarcity of natural resources base.

History is the evidence that no nation survive for long if natural resources of a state are exhausted or polluted. Meadows et al. in 1972 came up with an excellent work on "Limits to Growth" where it has been illustrated that natural resources depletion may jeopardized the economic growth of the nation. However, the work further stated that global equilibrium could be designed to alter the negative growth trend and establish a harmony between economic and ecological stability that is sustainable far in future[10]. Thus, developing synergies and interrelationship between water, energy and food security for optimization of resource use efficiency has become a necessity, and it is also the demand of the time. The nexus plays a crucial role in developing countries like India which can lead to smarter and more resilient development solutions.

Recognizing the importance and relevance of nexus approach in assuring sustainable economic growth of the country, Ministry of Water Resources, Government of India organized first "India Water Week" on the theme "Water, Energy and food Security: Call for solutions" in April 2012[11]. The event recognized the importance of inter linkages among different sectors (water, energy, food and environment) as well as emphasized on strengthening the institutional framework for the same. Steps are being taken in the direction; however, research is required to understand and harmonize the nexus.

Water, energy and food: key challenges in urban areas

Key challenges related to water, energy and food in urban areas are population growth, urbanization, increasing prosperity and changes in dietary habits. Hence, it is important to understand their influences on water-energy-food scenarios of a city.

Rising population

India stands second in the world after China in terms of population, and supports 17.5 percent of total world's population with just 2 percent of geographical land[12] per the recent projections made by United Nations, India is on the way to be most populous country by 2022, surpassing China within next seven years[13]. Population pressure on land and water resources is very high to meet its food and developmental priorities. Comparing the data of last 50 years, India's population has grown and doubled from 541 million in 1971 to 1210

[9] Hoff, H. (2011). Understanding the Nexus. Background Paper for the Bonn 2011 Conference: The Water, Energy and Food Security Nexus.
[10] Meadows, D.H., Meadows, D.L., Randers, J. & Behrens W.W.(1974). The Limits to Growth: A Report for the Club of Rome's Project on the Predicament of Mankind. New York: Universe Books.
[11] http://www.indiawaterweek.in/download/Report%20on%20IWW-2012-%20II.pdf
[12] Ministry of Agriculture, GoI. (2011). Agricultural Statistics at a Glance.
[13] UNDESA (2015). World Population Prospects: The 2015 Revision, Key Findings and Advance Tables. Working Paper No. ESA/P/WP.241.

million in 2011. To support its large and growing population, India made a significant progress in agricultural production, doubling its food grain production capacity from 108 million tons in 1970's to 218 million tons in 2011 and has reached from a stage of self sufficiency to surplus agricultural produce[14 15]. The credit for such progress goes to "Green Revolution" that started in late sixties and made India from a country of food grain importer to food grain exporter.

However, attaining a level of food sufficiency has been at the cost of high extraction of water together with higher consumption of energy in agriculture. An analysis of food consumption pattern in the table below (table 1) of three most water intensive crops rice, wheat and cane sugar shows that average urban Indian consumes approximately 653 liters of water per person per day by consuming these three food commodities.

Table 1 Water consumption on three food commodities by an average urban Indian

Food commodities	C=Consumption * (Kg/month/person)	W=Water used in Production (Kg/litre)	CxW=Water consumed (litre/month/person)
Rice	4.5	2500	11,250
Wheat	4.3	1600	6880
Cane Sugar	0.81	1800	1458

Source: *NSSO, 68th Round (2013)

According to Hanumantha Rao, 2002[16] and projections made by National Commission for Integrated Water Resources Development Plan, requirement of water for irrigation in India will grow by more than 50 percent by 2050. While, the per capita water availability has declined by 69% from 5200 m^3 in 1951 to 1588 m^3 in 2010, as per the projections made it will decrease further to 1191 m^3 by 2050 (Figure 1).

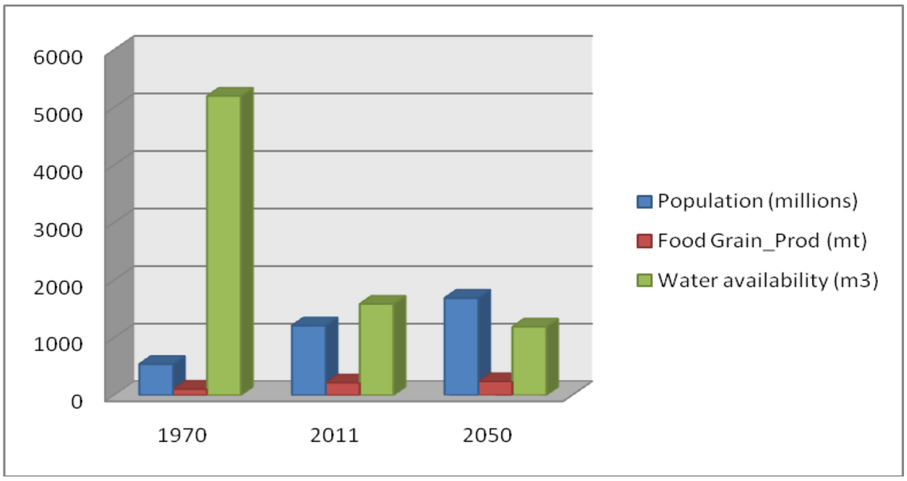


Figure 2 Graph projecting the declining trend of water resources with increasing population and food production
(Source: Computed from WRIS, 2011)

[14] Swaminathan, M.S. & Bhavni, R.V. (2013). Food Production and Availability. Essential Prerequisites for Sustainable Food Security. *Indian J Med Res, 138,* pp. 383-391
[15] Ahmad, F. & Haseen,S. (2012). The Performance of India's Food grains Production: A Pre and Post Reform Assessment. *International Journal of Scientific and Research Publications, 2(3)*,pp.1-15.
[16] Rao Hanumantha, C.H. (2002). Sustainable use of Water for Irrigation in Indian Agriculture. *Economic and Political Weekly,37(18)*,pp. 1742-1745.

Water is used in the production of almost all kind of energy and demand of electrical energy for agricultural usage is showing an increasing trend in India[17]. Mechanization of various agricultural operations from farm to supply chain like irrigation, harvesting, processing etc. account for the energy consumption in agricultural sector. Electricity consumption in the country has increased from 56 billion kWh in 1971 to 768 billion kWh at present which is more than 13 times its levels in 1951. According to United Nations, 90% of global electricity requires water either to rotate turbines or as a coolant in thermal power plants[18]. Population will continue to rise and as per the projections made by various organizations (UN 2012, Planning Commission of India), India's population will be about 1690 million by 2050, which implies that further increase in rate of production within the available land and water resources has to be achieved. Thus water, energy and food requirement is expected to increase in near future to meet the demand of the growing population of India.

Urbanization

Currently, half of the world's population is living in cities, largely seeking increased economic opportunity to sustain them. An analysis of Indian census data from 1901 to 2011 shows that number of urban agglomeration/towns and cities has grown from 1827 in 1901 to 7935 in 2011 and population residing in these urban areas has increased from 25.8 million in 1901 to 377 million in 2011, making 31.16% of the total population of the country at present.

Table 2 Trends in India's Urbanization (1901-2011)

Census Year	Urban population (in millions)	Percentage Urban	Towns/Cities
1901	25.85	10.84	1827
1911	25.94	10.29	1825
1921	28.08	11.18	1949
1931	33.45	11.99	2072
1941	44.15	13.86	2250
1951	62.44	17.29	2843
1961	78.93	17.97	2363
1971	109.11	18.24	2590
1981	159.46	23.33	3378
1991	217.17	25.72	3768
2001	285.35	27.78	5261
2011	377.10	31.16	7935

(Source: Census of India, (1901-2011)

An analysis of Indian Census data (table 2) of last 50 years shows that number of urban agglomeration/towns and cities has grown more than three times from 1970 to 2011. Population residing in these urban areas has almost doubled and is likely to increase in coming years. If the current trend continues, it has been projected by United Nations that India's urban population will increase to 50 percent by 2050, showing an increase of almost

[17] Swarnkar, K.N. & Singh, S.N. (2013). Analysis of Electrical Energy Consumption of Agricultural Sector in Uttarakhand State. *International Journal of Emerging Technology and Advanced Engineering*, *3(3)*, pp.343-347

[18] Lundy, J. and Bowdish, L. (2013). The energy-water-food nexus: Insights for the business community. US Chamber of Commerce Foundation.

100 percent with reference to present (Figure 3); intensifying the stress on its resources if not managed sustainably.

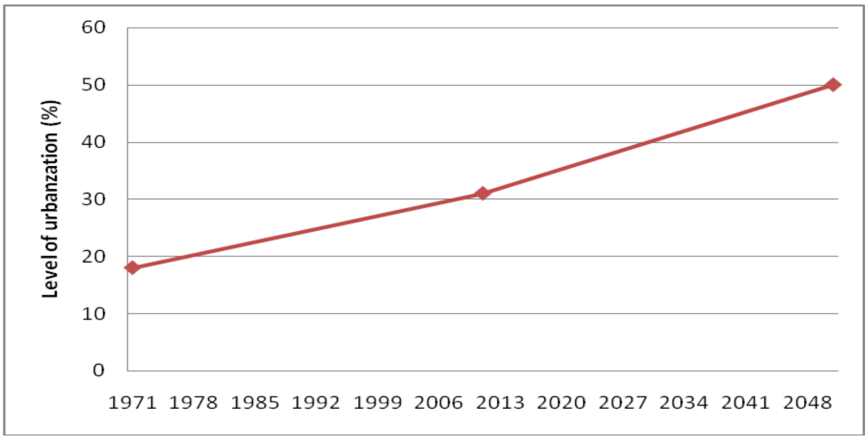


Figure 3 Line chart projecting level of urbanization in India
(Source: Census of India, 1971-2011)

As stated by Dutta (2006)[19], India's urbanization has been termed as "over-urbanization" or "pseudo-urbanization" because of inordinately large population size in big cities leading to virtual collapse in the urban services followed by basic problems in the field of housing, sanitation, slums, water, infrastructure as well as quality of life. The current pattern of urbanization is actually taking place on the fringes of cities, wherein, putting pressures on Municipal Corporation for the supply of basic amenities. In urban water supply as well as wastewater and drinking water treatment, energy is required at every step and forms the main operational cost component. In most cities, water supply is sourced from long distances and the length of pipeline determines the cost including the cost of pumping water. The very process of collecting, transporting and distributing water is energy intensive and cost of operation is very high. As per the National Sample Survey of India (2010)[20], 75 percent of urban households are covered with piped water; 40-50 percent of water is lost in the distribution system and approximately 30-50 percent electricity is spent to pump water in most Indian cities. Thus, rapid and accelerating economic growth, growing population, burgeoning middle class, expanding cities and urbanization are increasing the demand for water, energy and food.

Increasing prosperity and change in dietary habit

India's per capita income has grown ten times in the past six decades. In the last decade (2000-2010), India's gross domestic product has grown at an average rate of 7.27 percent[21] and as projected by Planning Commission this rate will touch the figure of 9-9.5 percent during the 12th Five Year Plan (2012-2017) almost near to double digit growth rate. As per the recent report of Rangrajan Committee on poverty status of India[22], there has been significant decline in the poverty ratio of India which fell down from 38.2 percent in 2001 to 29.5 percent in 2011 lifting almost 10 percent of population above poverty line. This further

[19] Dutta,P. (2006). Urbanization in India. Retrieved from http://www.infostat.sk/vdc/epc2006/papers/epc2006s60134.pdf

[20] NSSO (2010). Housing Condition and Amenities in India. Government of India.

[21] Sethia, S. (2013). India's Changing Consumption Pattern. *Gyanpratha-Accman Journal of Management, 5(2).*

[22] The Planning Commission, GoI. (2012). *The challenges of Urbanization in India: Approach to 12th Five Year Plan*. Retrieved from http://12thplan.gov.in/12fyp_docs/17.pdf

implies that more and more people have been added to cities, who have a higher purchasing power as compared to rural population. This is indeed a positive development but it is accompanied by increase in demand and supply of basic amenities intensifying the environmental stresses and putting pressures on natural resources.

Food basket has diversified significantly with the rising income levels. According to the World Bank report the per capita Gross Domestic Product of India shows all time increase today at $1610 in 2014 and as per the projections made, by 2050 will increase six times from now. The economic growth, urbanization and taste preferences have resulted in changing food consumption pattern away from traditional food commodities[23] [24] [25] [26]. Indian diet is diversifying with fruit/vegetable and animal based food share increasing and cereal and pulses declining[27]. Increase in income has also changed the dietary habit of affluent urban people where consumption of processed foods and ready to eat foods has gone up[28]. There has also been an increase in the nutritional intake in terms of calories, and it is projected to increase to 3000 calories in 2050 from 2495 calories at present. According to the NSSO report of 2013, there is around 33 percent increase in the consumption expenditure from 66th round to 68th round[29] where expenditure on beverages, refreshment and processed food is highest and forms the significant amount to drive the food sustainability issues. Energy is used in the production, processing as well as delivery of food, pumping of water for irrigation, transport of food, its distribution and storage. The full food production and supply chain is responsible for around 30 percent of total global energy demand[30]. Food processing consumes substantial amount of energy which is comparatively high in bread, animal food products and sugar processing[31]. The table below (Table 2) gives water and energy inputs for some of the processed foods most commonly used these days.

Table 3 Water and energy inputs for some processed foods

S.No.	Food stuff	Water consumed (litres)*	Energy consumed (Kcal/kg)**
1	Chocolate (Kg)	17,196	18,948
2	Meat (kg)	10,412	1,206
3	Milk (l)	1,022	354
4	Wine (l)	436	830
5	Coke (l)	600	1,425

(Source:*IME (2013), **Pimentel, et al. (1985))

[23] Meenakshi, J.V. (1996). How important are Changes in Taste? A State-Level Analysis of Demand. *Economic and Political Weekly*, December 14, 1996.

[24] Murty, K.N. (2000). Changes in Taste and Demand Patten for Cereals: Implication for Food Security in Semi-Arid Tropical India, *Agricultural Economic Research Review*, Vol 13(1):25-51.

[25] Amarsinghe, U.A., Shah, T. and Singh, O.P. (2007). Changing Consumption Patterns : implications on food and water demand in India.

[26] Pathak, H.,Jain,N.,Bhatia, A.,Patel, J., & Aggarwal, P.K. (2010). Carbon Footprints of Indian food Items. *Agriculture, Ecosystems and Environment,139*, pp.66-73.

[27] NCEAR (2014). An analysis of changing food consumption pattern in India. A research paper prepared under the project agricultural outlook and situation analysis reports Impact of globalization on food consumption pattern of urban India.

[28] Vepa, S.S. (2004). Impact of globalization on food consumption of urban India

[29] Sinha, G. (2014). Linkages between food consumption pattern, food security and sustainable food system. A synopsis submitted for Doctor of Philosophy in Economics, Dyalbagh Educational Institute, Agra.

[30] Hoff, H. (2011). Understanding the Nexus. Background Paper for the Bonn 2011 Conference: The Water, Energy and Food Security Nexus.

[31] UNIDO. (1995).Food Processing Industry. Output of a seminar on energy conservation in food processing industry.

Government policies are predominantly focused on the production side to increase the food availability in order to feed billion populations. But at present, around one-third of all food produced, is lost along the food supply chain and considerable amount of food is wasted at consumption level. It has been estimated[32] that global food loss and waste is approximately 1.3 billion tons annually, and occurs throughout the supply chain and across the socio-economic spectrum[33]. In India, the domestic food loss has been estimated to be 30-40 percent of total food supply[34]. A significant share of total energy and water inputs are embedded in these losses. Therefore, there is an urgent need to develop holistic and effective strategies for promoting sustainable consumption as well as improving the food supply chain vis-a-vis efficient production which will address the nexus issues.

Rationale for selecting Gurgaon as study area

The Gurgaon city has been chosen for the present study, which is located in the vicinity of Delhi and has grown significantly over the last two decades. Gurgaon is witnessing rapid urbanization, changing food consumption patterns, water scarcity, and energy crisis. High rise buildings, malls, shopping complex, and recreation centres are the visual landmarks of the city. The reasons for selecting Gurgaon for present study are as below:

Rapid urbanization

Gurgaon being in the vicinity of Delhi (India), has grown significantly over the last two decades. High rise buildings, malls, shopping complex, creation centers are the visual landmark of the city. The most important factor for its growth has been real estate boom after 1990s. . There has been huge influx of population largely from neighboring states like Delhi, Uttar Pradesh, Punjab and Rajasthan due to expansion of business processing outsourcing, knowledge processing outsourcing, and information technology (IT) sector. The glitzy city has emerged as a major outsourcing hub in the northwest India which has seen a rampant process of urbanization. As per the census report of 2011, the total population of Gurgaon is 1.5 million and urban population is more than one million. The urban outgrowths have pushed the municipal boundaries of the city and are known as the Urban Agglomeration (Census of India, 2011). As per the report of National Capital Region Planning Board[35], a unit of Ministry of Urban Affairs, the district has seen growth of 73.96% in population from 2001 to 2011, while the same from 1991 to 2001 was 44%. The growth in rural population from 2001 to 2011 is 15.82% while that in urban population is 293.9%. The graph below shows the growth rate of urban Gurgaon from 1971 to 2011.

[32] FAO (2011). Energy-Smart Food for People and Climate. Issue Paper. Retrieved from http://www.fao.org/docrep/014/i2454e/i2454e00.pdf

[33] Moomaw, W., T. Griffin, K. Kurczak, J. Lomax (2012). "The Critical Role of Global Food Consumption Patterns in Achieving Sustainable Food Systems and Food for All, A UNEP Discussion Paper", United Nations Environment Programme, Division of Technology, Industry and Economics, Paris, France.

[34] Emerson report (2013). The Food Wastage and Cold Storage Infrastructure Relationship in India: Developing Realistic Solutions.

[35] Ministry of urban affairs, GoI (2011). Regional Plan 2021. National capital Planning Board.

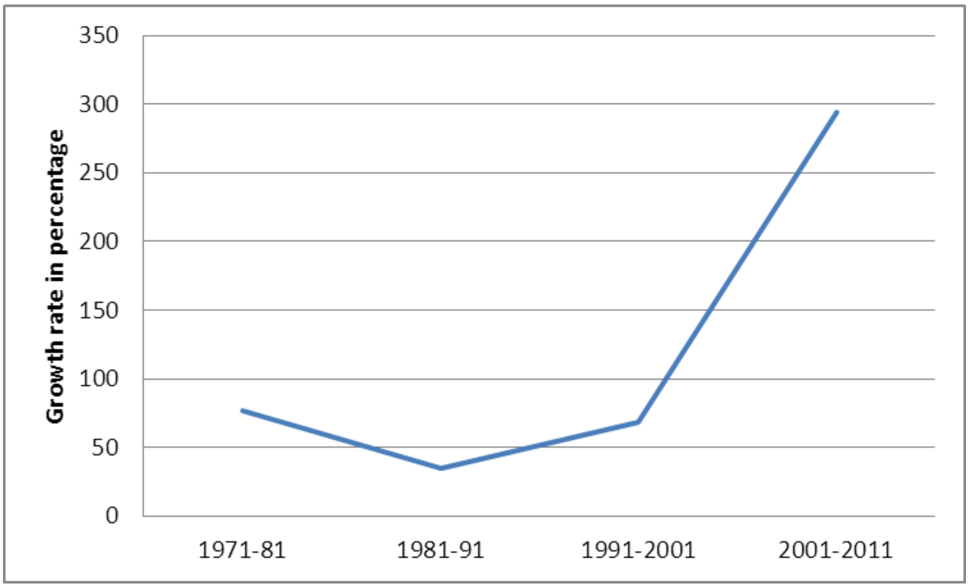


Figure 4 Line graph depicting the trend of growth rate of urban population in Gurgaon. *(Source: Department of Town and Country Planning, Haryana)*

The same report has projected the population growth of Gurgaon city till 2021 to be above four million. A major impetus to such an exponential growth of Gurgaon, as depicted in the graph above, has come from various employment opportunities in retail, information technology, real estate and different other industries.

Changing food consumption pattern

Exponential population growth, increasing middle class, changing lifestyles and dietary habits are putting pressures on natural resources and ecosystems. Change in lifestyle has caused change in the food consumption pattern of the people. There are a number of malls (more than 40 in numbers) and eating joints (almost 1000 restaurants) within the city, which offer wide variety of cuisine, and are being visited by a large number of people for meals. More and more processed foods are being preferred due to time constraint and ease of cooking. Hoff[36] further argues that urban living promotes more resource intensive lifestyles and concentrates consumption and waste production. Growing demand and non-sustainable management of resources have increased ecological footprints along with degradation of various ecosystems, and further escalating the scarcity of natural resource base.

Water resources at risk

Rapid urbanization and population growth has led to huge gap in demand and supply which has resulted into the indiscriminate use and over exploitation of ground water resources. According to a report of CGWB, the ground water estimation of the district was done in 2004 when groundwater development was 209% (CGWB report, 2008) which has exceeded the available recharge. This figure shows that the district has been categorized as overexploited zone. According to an analysis by Centre for Science and Environment,

[36] Hoff, H. (2011). Understanding the Nexus. Background Paper for the Bonn 2011 Conference: The Water, Energy and Food Security Nexus. Stockholm Environment Institute, Stockholm.

Gurgaon had 30,000 tube wells in 2009, drawing around 70-230 mld of groundwater, leading to a decline in water table by 1.12 m per year. Scientists at the Central Ground Water Authority have predicted that the city will have no ground water left by 2017 and will have serious implications for the residents.

Energy crisis

With rise in population, urbanization, and commercial activities, the demand for energy has been rising exponentially in the city. According to one of the reports of Dakshin Haryana Bijli Vitran Nigam (DHBVN), the growth of power demand in Haryana on an average has been of the order of 7 to 8% , but for certain pockets like Gurgaon and other industrial hubs the rate has touched a level of 20 to 25% because of rapid urbanization, upcoming developers, colonizers, Special Economic Zone promoters, multistoried complex etc. This gap widens in summer seasons as supply is short of demand when temperature rises.

The study area

Gurgaon, a district and growing city of Haryana, has been in existence since Mahabharata times. The city derives its name after the legendary Guru Dronacharya and was initially known as Guru-Gram. For administrative and governance purpose, presently the district has been divided into three sub-divisions, four blocks and five tehsils. The details have been given in the table below (Table 4).

Table 4 Administrative set-up of Gurgaon (2011)

S. No.	Sub-division	Tehsils	Blocks
1	Gurgaon-North	Gurgaon	Gurgaon
2	Gurgaon-South	Pataudi	Pataudi
3	Pataudi	Farukhnagar	Farukhnagar
4		Sohna	Sohna
5		Manesar	

(Source: District Statistics, Gurgaon (2010-11).)

For the present study, Gurgaon block was covered in detail because of the following reasons:

- Highly urbanized block of the city;
- It has the highest population concentration (72%) and therefore, it is assumed that food consumption will be maximum;
- Because of high population density water resources are at constraint, according to statistics given by CGWB (2008), the level of groundwater development of this block is 311%, which indicates that it is highly exploited;
- Most of the sub-watershed is located in this block (six in numbers);
- It covers the largest geographical area of the district (28%);

Geography and drainage pattern of the city

The Gurgaon district lies between 28⁰28′0′′N to 77⁰2′0′′E. The total geographical spread of the city is 1254 sq.km and the height above the mean sea level is 190 to 280 m comprising hills and depressions and forming irregular topography. The table below gives the view of geographical area block wise (Table 5).

Table 5 Total Geographical area Block wise

Blocks	Area (Sq.Km)	%
Gurgaon	356	28
Sohna	275	22
Pataudi	327	26
Farrukhnagar	296	24
Total	1254	100

(Source: District Statistics, Gurgaon (2010-11).)

Two ridges namely, Firojpur Jhirka-Delhi ridge forms the western boundary and Delhi ridge forms the eastern boundary of the district. These hills are northern continuation of Aravalli hills.The natural drainage pattern of the city comprises of large depressions and streams, tending to converge inland instead of flowing into Yamuna. The important depressions in the level of districts are Khalipur, Chandaini, Sangel-Ujina, Kotla Daher Jheels and Najafgarh lake. Sahibi (a tributary of Yamuna) and Indrani are two seasonal streams of the district.

Demographic Characteristics of Gurgaon

The population of Gurgaon district as per the 2011 census is 1.5 million. This population constitutes around 5.97% of total population of Haryana. Male population constitutes almost 54% and female constitute 46% of the total population. The city has a sex ratio of 853 females for every 1000 males which is quite low when compared to national sex ratio which is 940 females per 1000 males. The average literacy rate of the city is 84.70%. The district has the population density of 1,204 inhabitants per square kilometer and population growth rate over the decade (2001-2011) was 73.96%. Out of the total population of Gurgaon, 68.8 % lives in the urban region of the city whereas 31.18% lives in the rural villages of the district. The demographic detail of the city has been provided in the table below (Table 6) and block wise population has been provided in the table 7.

Table 6 Demographic detail of Gurgaon District

Description	2011
Total Population	1, 514 ,805
Male	816, 991
Female	697, 844
Population growth	73.96%
Area Sq.km	1, 254
Density/sq.km	1,204
Proportion to Haryana Population	5.97%
Rural Population	472, 179 (31.18%)
Urban Population	1,042, 253 (68.82%)

(Source: District Statistics, Gurgaon (2010-11).)

Table 7 Population of the district

Blocks	Population	%
Gurgaon	1,093,765	72
Sohna	165, 513	11
Pataudi	1 19 ,980	08
Farrukhnagar	134, 827	09
Total	1,514,805	100

(Source: District Statistics, Gurgaon (2010-11).)

Watershed Delineation for Gurgaon city

Rationale for Watershed Delineation

Watershed is a geo-hydrological unit comprising of all land and water within the confines of a drainage divide. Adopting a watershed approach for selecting the hot spots provide information about the availability of water, natural flow patterns and developing strategy for resource conservation and its optimized usage. Within the administrative boundaries of the city, it is important to demarcate the hydrological and sub-hydrological units. This is necessary to understand the natural drainage patterns within the city limits, and to identify the sub-hydrological units which may be at a greater stress due to preferential construction of multi-storied buildings.

Delineation of watershed boundary of the study area was done by using Digital Elevation Model (DEM) as a tool. For the purpose of research, the study area has been divided into six micro watersheds, each differentiated by different colours as shown in the figure 5.

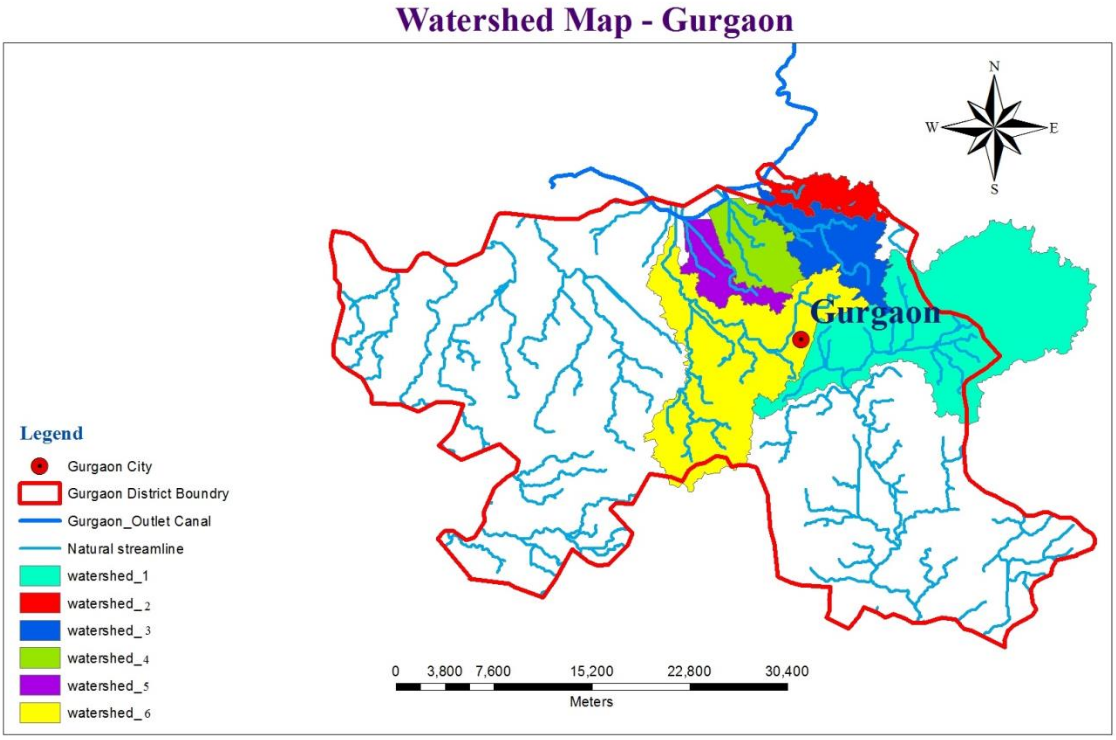


Figure 5 Hydrological map of Gurgaon
(Source: TERI)

Methodology for Watershed Delineation of Gurgaon District

DATA Requirement

SRTM DEM – 90m: The SRTM digital elevation data, produced by NASA originally, is a major breakthrough in digital mapping of the world, and provides a major advance in the accessibility of high quality elevation data for large portions of the tropics and other areas of the developing world.In February of 2000 the Space Shuttle mapped most of the land surfaces of the Earth to create a high resolution elevation dataset. Global data were released at a 3-arc-second (90 m) resolution.

Link for data download: http://srtm.csi.cgiar.org/

District Boundary – Downloaded from the website http://www.diva-gis.org/

Re-projection of the data

Before proceeding with watershed delineation or any other kind of hydrological analysis, all the data sets need to be projected in a same coordinate system.

Delineation of Gurgaon Watershed – Overview

DEM fill–the fill function fills the sinks in a grid. If cells with higher elevation surround a cell, the water is trapped in that cell and cannot flow. The Fill Sinks function modifies the elevation value to eliminate this problem. Fills sinks in a surface raster to remove small imperfections in the data.

Flow Direction -One of the keys to deriving hydrologic characteristics of a surface is the ability to determine the direction of flow from every cell in the raster. In a Digital Elevation Model (DEM), the Flow direction operation determines into which neighboring pixel any water in a central pixel will flow naturally. Flow direction is calculated for every central pixel of input blocks of 3 by 3 pixels, each time comparing the value of the central pixel with the value of its 8 neighbor's. The output map contains flow directions as N (to the North), NE (to the North East), etc.

Flow Accumulation - The accumulated flow is based on the number of cells flowing into each cell in the output raster. The Flow accumulation operation performs a cumulative count of the number of pixels that naturally drain into outlets. The operation can be used to find the drainage pattern of a terrain.

Snap pour point: The Snap Pour Point tool is used to ensure the selection of points of high accumulated flow when delineating drainage basins using the Watershed tool. Snap Pour Point will search within a snap distance around the specified pour points for the cell of highest accumulated flow and move the pour point to that location.

Watershed Delineation: In this final step, we select the flow direction grid as the input flow direction raster, and the raster version of the pour point as the input pour point data.

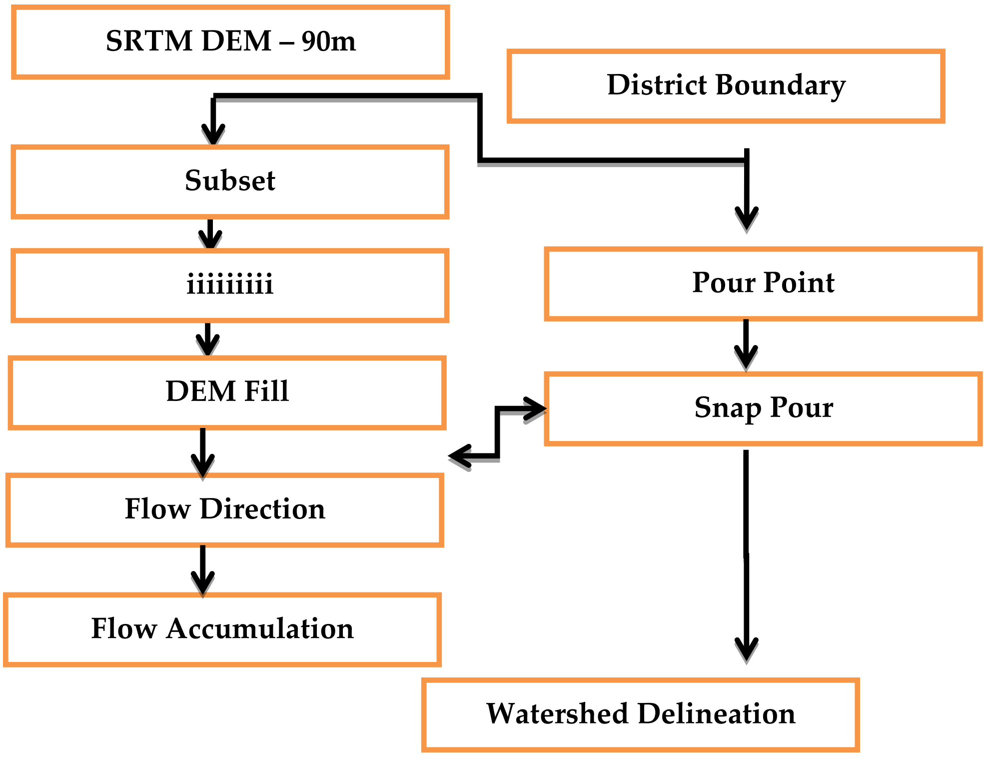


Figure 6 Flow diagram showing methodology for watershed delineation
(Source: TERI)

Criteria and indicators for selecting hot spots for WEF nexus

In the present study, identifying linkages among water energy and food consumption patters is an approach towards sustainable urban development through identifying different stakeholders and providing synergies among different sectors.

Hot spots for Water Energy Food nexus

Within the boundary of cities watershed, the vulnerable areas and regions of high risks have been identified as **hot spots** based on the following indicators:

Region of minimum water availability (Rw): This is defined on the basis of watershed map prepared where different sub-watershed and micro- watershed has been delineated. These are the areas which are at greater stress due to preferential construction of multistoried buildings and market complexes. Upstream localities in a sub-watershed are taken as hot spots.

Region of maximum food consumption (Rf): It is widely recognized that food consumption pattern significantly impacts water and energy requirements. Since the primary objective of the study was to focus on the food element from consumption point, it was important to identify the regions within the city boundary which may be likely the regions with maximum food consumption. The region of maximum food consumption within the study area were identified as areas with high population density; large number of hotels and restaurants; conglomeration of malls and food courts etc. While larger population translates into higher food consumption, presence of hotels, restaurants etc add to the overall food consumption.

Regions of minimum energy availability/ high energy intensity (Re): Region of minimum energy availability was to be defined on the basis of power stressed area within the city boundary.

The first two indicators have been integrated by selecting the regions of maximum food consumption in the regions of minimum water availability, which are basically the places of high population concentration, located in upstream regions of a watershed (R_{w-f}). The third indicator was not considered while selecting the hotspots due to non-availability of sufficient information related to power stress in R_{w-f} regions. However, selected hotspots represent places with higher intensity of energy consumption also, due to high demand and usage.

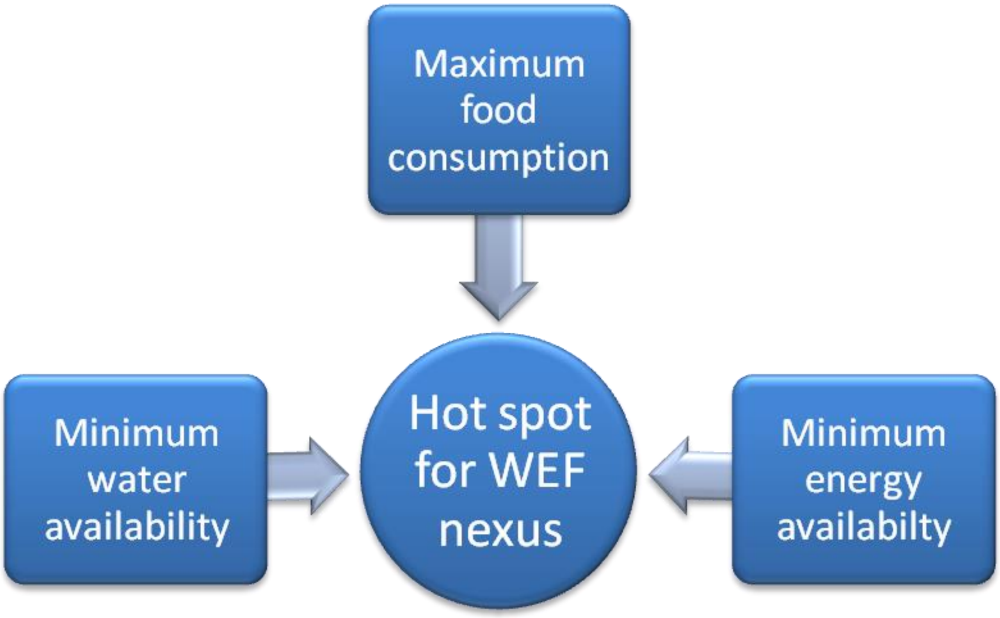


Figure 7 Indicators for identifying hot spots for WEF nexus
(Source: TERI)

Criteria for selecting survey units within the hot spots

Based on integration of above indicators, following classification was used for selecting survey units within the hot spots:

- Residential: This will cover both societies as well as unorganized colonies.
- Commercials: This will include hotel, restaurants, food court, recreational centres etc.
- Institutional: Hospitals, Schools/colleges, worship places, office complex, etc.

Based on the above criteria and indicators total 150 sites have been identified in six micro watersheds selected for the present study. The list of study area has been provided as Annexure I. The sites will be further selected based on the availability of data and accessibility to the area.

Survey Design

Random survey of total 125 sample units, distributed across various classes of survey units was conducted in the selected sites. Structured questionnaire (attached as Annexure II) will be used to elucidate the responses besides key person interviews will be done among the selected stakeholders. Qualitative and quantitative information received from the survey will be analysed to meet the objectives.

- Total sample size: 125
- Sampling method: Random sampling
- Tools: Structured questionnaire, KPIs, personal interviews, informal discussions

Pilot testing of the questionnaire developed for the survey has been conducted on 10% of the sample size. Based on the responses, questionnaire has been updated and finalized.

For the purpose of survey and research, the study area was divided into six micro watersheds. This demarcation was important to understand the natural drainage patterns within the city limits, and to identify the sub-hydrological units which may be at a greater stress due to preferential construction of multi-storied buildings. Based on the demarcation done, 150 sites lying on the upstream of the different watersheds was identified.

Survey

Primary survey was conducted at household level in all six micro watersheds of the study area as delineated for the purpose of the research. Random stratified sampling tool was used to capture different strata of the urban society. For the purpose of the research, the study area was divided into organized and unorganized sectors which were further stratified into single and multiple storied houses/buildings in each sector. The objective of such stratification was to understand the water and energy use at different level of housing societies in food consumption. Total 125 samples were taken which represents 0.01 percent of total urban population of Gurgaon as per 2011 census data. Minimum of 4 sample sizes was taken in under each category; however sample size varied as per the area of the watershed. The number of respondents in each sector and watersheds has been shown in the table below:

Table 8: Number of respondents under each category

Watershed no.	Organized sectors		Unorganized sectors		Total
	Single storied	Multiple storied	Single storied	Multiple storied	
1	10	4	12	4	30
2	6	8	4	4	22
3	4	4	5	4	17
4	4	4	4	4	16
5	4	4	4	5	17
6	10	5	4	4	23
Total	38	29	33	25	125

Surveys for commercial kitchens were also done which was selected randomly in the watersheds. Four restaurants under different categories were surveyed in the study area. One commercial kitchen of big industry was also done.

Tools used for data collection:

1. **Primary data:** was collected through structured interview scheduled in the identified micro watersheds under each category. A pilot study on 10 percent of sample was conducted to test the questionnaire and understand the respondent's behavior. Based on the responses of the pilot study, questionnaire was modified before final survey. Focused group discussion (FGD) was also conducted to understand the perceptions, ideas and suggestions of the respondents to reduce water and energy wastage.

2. **Secondary data collection:** Secondary sources of data were collected to trace the growth of Gurgaon, the drivers of urbanization and their implications for water resources of the city, drawing on government sources, media reports and published articles in books and journals. National Sample Survey (NSS) Consumer Expenditure Survey results of 68th round were used for analyzing the result of the survey and drawing conclusion. A summary of various tools used in data collection has been provided in the table below.

Table 9: Tools used for data collection

Secondary Data	Primary data
Documents like annual reports of Town and Country Planning, Economic survey of Haryana, magazines, and newspaper articles, NSSO household survey data	Survey by using detailed structured interview schedules at individual household level.
Information and records produced by different departments like Municipal Corporation of Gurgaon, Haryana Urban Development Authority and other related departments.	Personal observations along with Focused Group discussion with various stakeholders, key informants interview
Internets, library, journals etc.	Transect walk to understand the watersheds

Data analysis:

- **Data coding and data entry:** For the purpose of quantification, codes were assigned to different attributes of respective variables. After coding data were entered in the database package of MS excel.
- **Statistical analysis and tabulation:** Percentage analysis as well as descriptive statistics was used to analyze the data. Tabulations were done as per objectives of the study.
- **Data interpretation and inference:** Information was interpreted with site and objective and accordingly inferences were drawn. Report was prepared as per the objectives of the study.

Study limitations:

To get institutional and commercial data was a big challenge. Respondents were not very keen to share the data of water and electricity. In household survey, the responses of annual income may not be true representation as respondents were bit hesitant in sharing the family income for reasons unknown to the researcher.

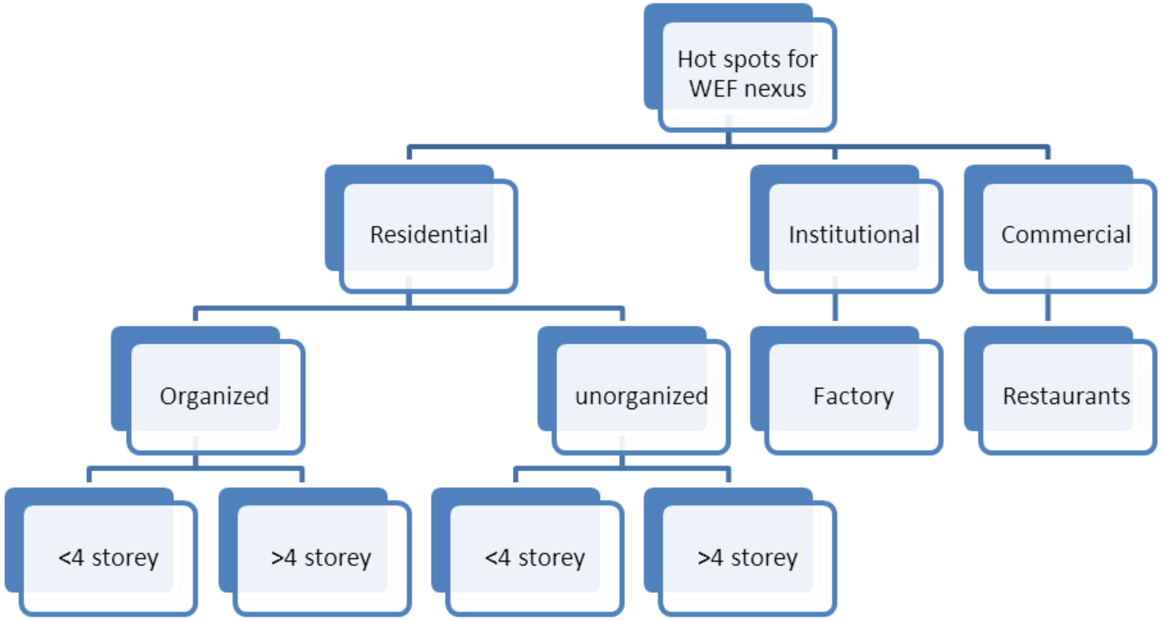


Figure 8 Flow diagram showing sampling design for assessment of water energy food nexus in Gurgaon city.
(Source: TERI)

2. Identification of Water-energy-food inter-linkages in the study area

To identify the inter-linkages between water, energy and food consumption in a region, it is necessary to understand the life style of population living in that region. The life style of people living in a region, in turn, is a function of its demographic profile and its developmental patterns. Demographic profile exhibited in terms of total population, density of population, level of urbanization and growth rate of population influences level of water, energy and food consumption of a region. Similarly, developmental patterns reflected through urbanization trends, land use changes and socio-economic status of people of a region regulate the general consumption patterns and food habits of its population.

Gurgaon is among those unique districts of the country which serve as satellite town and makes the part of a larger metropolitan region i.e., Delhi NCR. Gurgaon has developed as a town of residence for the people employed in Delhi NCR and commuting between the two cities. Also, owing to its closeness to the national capital, Guragon has developed as a hub for service industry like IT and tourism. Hence, it become important to understand the life style of population living in Gurgaon district to explore the inter-linkages between water, energy and food consumption of the region.

Developmental patterns in Gurgaon

Gurgaon is one of the largest city of Haryana, which is urbanizing and expanding very fast. With the advent of economic reforms and modernization in 1990s, the cultural and ecological landscape of the city has undergone a rapid change. The recent developmental pattern of Gurgaon is attributed to the development of real estate initially by Delhi Lease and Finance (DLF) and later by other developers including Ansals, Unitech, Supertech, Eldeco etc. Apart from real estate development, the city has emerged as one of the prominent business hub in North India because of the favorable tax policy by Haryana Government, rapid development of infrastructure as well as good connectivity with the International Airport. Many multinational companies in automobiles and software sector have found their way into the city premises due to the availability of high level of infrastructure of airways, railways, highways, medical and educational institutions in its close proximity. There has been huge influx of population largely from neighboring states like Delhi, Uttar Pradesh, Punjab and Rajasthan in the city because of various employment opportunities in retail, information technology, real estate and different other industries. With the rising job opportunities in non-agricultural set up, rate of inflow to urban set-up is increasing. As per Chaudhari and Gupta, 2009, Gurgaon has the highest average level of living amongst all the rural districts of 20 major states of India. The reported monthly per capita expenditure (MPCE) is Rs 1,559 for rural areas and 1292 for urban areas[37] .

[37] Chaudhuri, S., Gupta, N., 2009. Levels of Living and Poverty Patterns: A district wise analysis for India, Economic and Political Weekly, Vol XLIV, No. 9

Trend of Urbanization in Gurgaon

As per the census report of 2011, the total population of Gurgaon is 1.5 million and urban population is more than one million. According to the report of National Capital Region Planning Board (NCRPB), a unit of Ministry of Urban Affairs, the district has seen growth of 73.96% in population from 2001 to 2011, while the same from 1991 to 2001 was 44%. The growth in rural population from 2001 to 2011 is 15.82% while that in urban population is 293.9%. With a decadal growth rate of more than 250%, this increase in population has created a demand for better utility services which has altered the land use change in the Gurgaon city. Natural areas like water bodies, forest land and agricultural fields have been converted for township development, habitation and industrial activities.

Land use pattern in Gurgaon

Out of the total geographical area of Gurgaon, around 61 percent of land is available for cultivation, 26 percent is not available for cultivation, whereas forest occupies only 3 percent of the land as per the district statistical handbook of 2010-11. The urban pull and rural push factors have changed the land use pattern of Gurgaon significantly, which in turn have changed the socio-economic status of the city (Figure 9). There is a strong correlation between the land use pattern and developmental process.

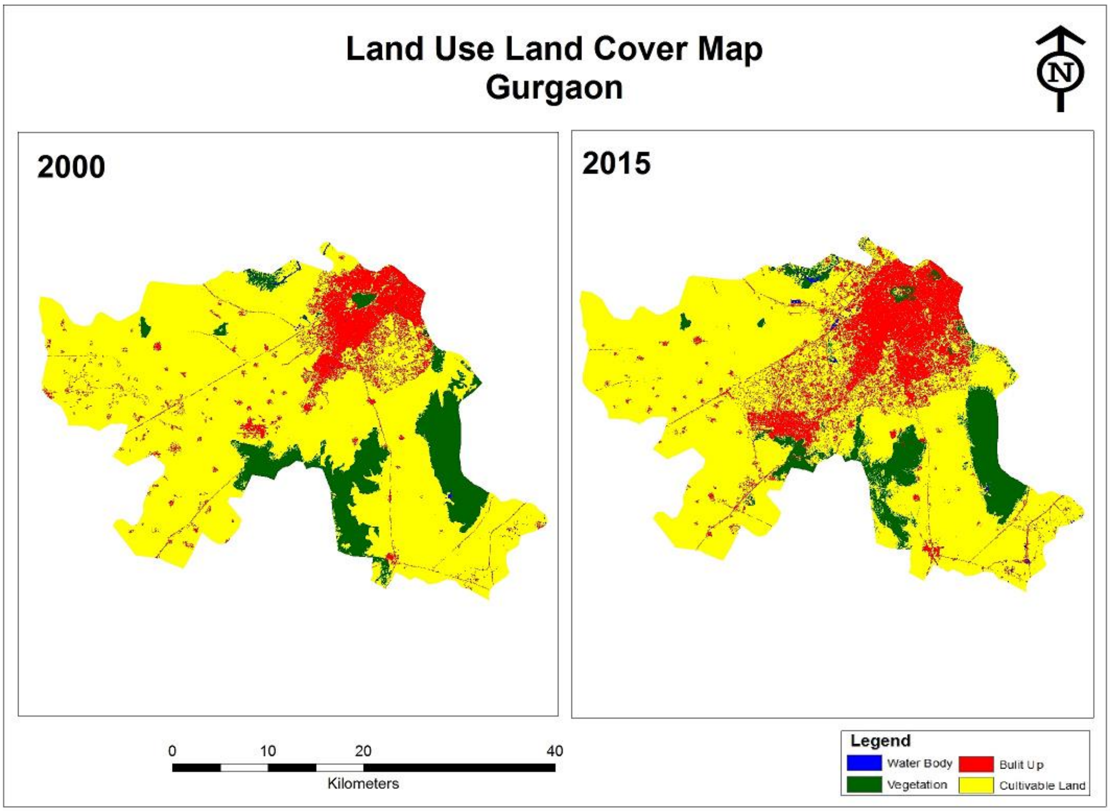


Figure 9 Changes in Land use pattern in Gurgaon District between 2000 and 2015
(Source: TERI)

Analysis of satellite images of Gurgaon was done as part of this study to understand the latest variations in developmental pattern in the district from 2000 to 2015. As evident from figure 9, red coded area shows the built up area within the city, which has sprawled significantly in the time period of 15 years from 2000-2015, indicating rampant urbanization in Gurgaon. With increase in urbanization, there has been shift from agricultural activities to non-agricultural one. The agricultural land in Gurgaon has declined significantly from 78.03 per cent in1971-81 to 61.11 per cent in 2011. With the coming of multinational companies in software and manufacturing sectors in the region, and blooming of real estate businesses; primary economic activities have been displaced by secondary and tertiary activities, showing declining trend in agricultural land. In search of better job opportunities in the urban centre, people are shifting from agriculture to non agricultural occupations and land uses.

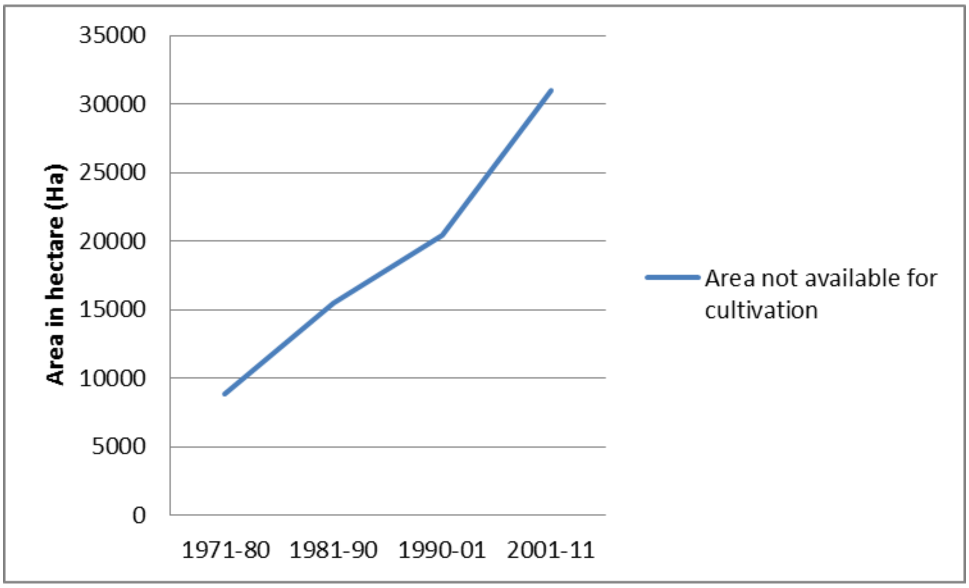


Figure 10 Line graph depicting increase in non-agricultural land in Gurgaon from 1971 to 2011

(Source: Computed from District Census hand books, 1981-2011)

The graph above shows that land not available for cultivation has increased from 8,815 hectare in 1971-80 to 31,000 hectare in 2001-11. The acquisition of agricultural land for non-agricultural purposes has brought huge economic transformations in the millennium city. The principal government stakeholders like Town and Country Planning Department, Industrial development corporations, Haryana Urban Development Authority etc. are playing pioneer role in this developmental process. Looking into the population growth and urbanization trend of Gurgaon, the city has been planned for the projected population of more than 4 million by 2031 (Town and country Planning Department, Haryana).

Table 9 Proposed land uses in Gurgaon Manesar urban complex

Land use	Master plan 2031 (Area in Ha)	%
Residential	16,020	48.56
Commercial	1,616	4.89
Industrial	4,613	13.9
Institutional	2,027	6.14
Transport and communication	4,428	13.42
Others	4,283	12.98

Total	32,988	100

(Source: NCR Regional Plan, 2031.)

According to the Master Plan of 2031, out of the total planned area 49 percent is reserved for residential purpose, 14 percent for industrial, 6 percent for institutional, 5 percent for commercial, 13 percent for transport and communication and 17 percent for other purposes including public utilities, open spaces etc. (table). With the extension of municipal limits, a number of villages have also been incorporated into the master plan.

Socio-economic status of Gurgaon

Haryana is one of the prosperous states of India where the per capita income is significantly higher than the national average. As per the financial year 2013-14, the per capita income of Haryana (INR 1,33,427) is 44 per cent more than the India's per capita income. The economy of the state has undergone major structural changes. There has been shift from primary sector to secondary and tertiary sectors. During the last decade, the service sector in the state has performed significantly better and has emerged as a major segment contributing to the economic growth of the state.

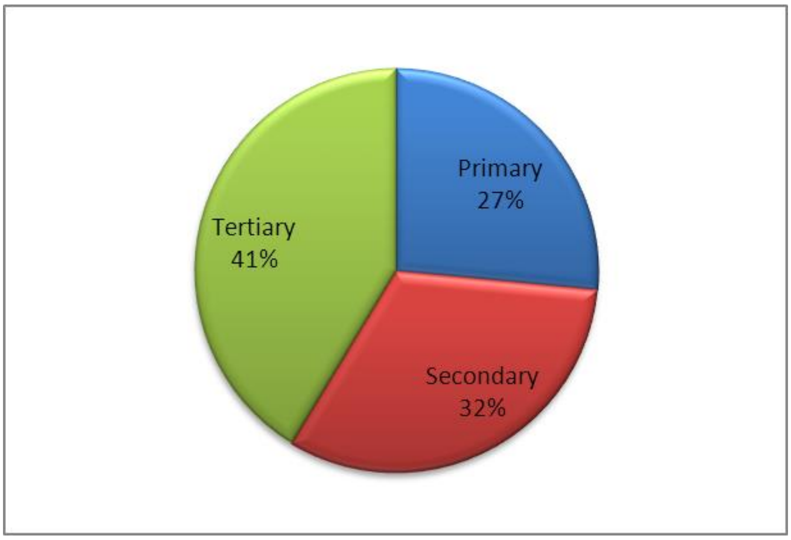


Figure 11 Contribution of different sectors in Gross State Domestic Product of Haryana
(Source: Economic Survey Report of Haryana, 2013-14)

The State has excelled in the field of information technology with the emergence of Gurgaon as the third largest hub of IT industry after Bangalore and Hyderabad. According to the Economic Survey Report (2013-14) of Haryana, out of the total Gross State Domestic Product (GSDP), the primary industry contribution is 27 per cent which is less than the secondary and tertiary industries (Figure11).

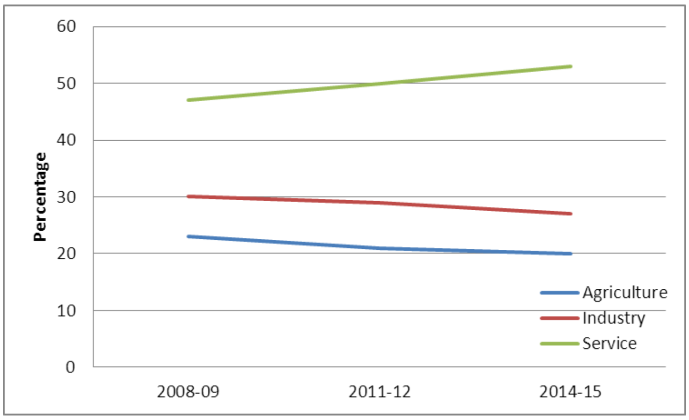


Figure 12 Line graph depicting sectoral contribution in GSDP from 2008-2015
(Source: Computed from PHD Research Bureau)

The line graph in figure 12 above shows that share of agriculture has declined from 23 percent to 20 percent from 2008 to 2015 whereas share of services have scaled up significantly from 47 per cent to 53 percent from FY 2008 to 2015 indicating a shift from agriculture to non-agricultural occupation.

On the social front, the State has done reasonably well with the small share of people living below the poverty line. There has been appreciable decline in the percentage of population below the poverty line from over 35 percent in the 1970s to 11.2 percent in 2011-12. This percentage is significantly less as compared to the national average of 21.9 percent during 2011-12. The state's literacy level also shows very impressive progress over the last four decades. The literacy rate has increased from 26 per cent in 1971 to 75.6 per cent in 2011.

General Socio-economic profile of the representative area within Gurgaon city

Watershed is a geo-hydrological unit comprising of all land and water within the confines of a drainage divide. Adopting a watershed approach provide information about the availability of water, natural flow patterns and developing strategy for resource conservation and its optimized usage. For the purpose of the research and to identify interlinkages among water, energy and food consumption, the study area was divided into six micro watersheds namely watershed no.1, 2, 3, 4, 5 and 6. In terms of area watershed no. 1 is biggest occupying 164.36 sq.km of geographical area followed by watershed no.6 which occupies 123.51 sq.km of the geographical area. The smallest watershed in terms of area is watershed no.2 which occupies only 17.51 sq.km.

The socio-economic profile of watershed 6 is high in comparison to other watersheds because maximum respondents surveyed had an annual income of more than 10 lakhs. In this watershed most of the societies have high raised buildings, are organized and well planned which are maintained by private developers like DLF and Ansals. Watershed no. 1 and 5 has more respondents having annual income less than 2 lakhs. Respondents have their own houses but built in a haphazard way, and colonies are highly unorganized. In the survey it was found that these areas also faces water scarcity particularly Dundahera and Kapashera region in watershed no.5. Family size is inversely correlated with the annual income. Respondents in watershed no.5 have higher family size in comparison to other watersheds.

Water security is a major issue in watershed no.5. Respondents depend upon water tankers to fulfil their drinking water need during summer season. Most of the respondents surveyed in unorganized colonies in the all watersheds do not pay water bill.

General characterization of watersheds have been summarised in the table below:

Table 10: General characterization of watersheds under study

Watershed no.	Area (sq.km)	% in terms of Gurgaon area	Socio-economic status	Family size	Water issues
1	164.36	13.10	Low	5	Water logging, water is misused like washing cars using piped water, overexploitation of groundwater
2	17.51	1.39	Medium-high	3	Water logging
3	37.54	2.99	Medium-low	3	Water logging, no proper drainage system
4	28.87	2.30	Medium-high	6	Problem of water logging in areas like Palam Vihar
5	20.63	1.64	Low	7	Water scarcity, alkaline water, mostly dependent on tankers supplied by Municipal Corporation of Gurgaon for drinking water.
6	123.51	9.84	High	4	Water logging

Family size

While it was not possible to estimate the population of indivdula watersheds, due to lack of any specific data, the mean size of households in the study area was found to be 4.7. It is significantly less than the family size of Haryana which is 5.37 and slightly less than the family size in India which is 4.9. The mean family size of Gurgaon district and urban region is 5 and 4 respectively, which is similar to the family size as found in the survey.

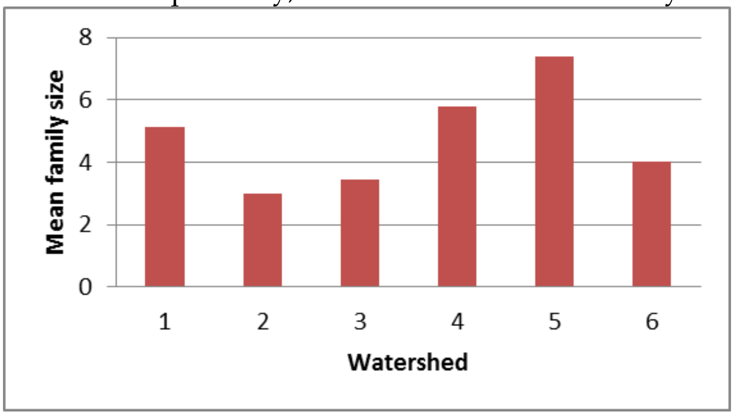


Figure 13: Graph showing mean family size in different watersheds in the study area.
(Source: TERI survey results)
Figure 13 above shows the average family size in different watersheds in the study area. The minimum family size is observed in watershed no.2 which is three whereas watershed no.5 has the maximum members in the family (7.4). Most of the respondents in watershed no.5 had joint family, hence could be attributed to high mean family size.

Family Income

Income is an important developmental indicator that shows positive correlation with level of living standard. Increase in economic status has strong influence on purchasing power which also affects the way we consume our food. In the study area, it was found that maximum respondents (31 percent) were among INR 2-5 lakh per annum, followed by 27 percent above 10 lakhs, 23 percent below two lakhs and 19 percent between 5-10 lakhs per annum. However, this figure varied for different watershed taken separately as shown in the graph below (Figure 14).

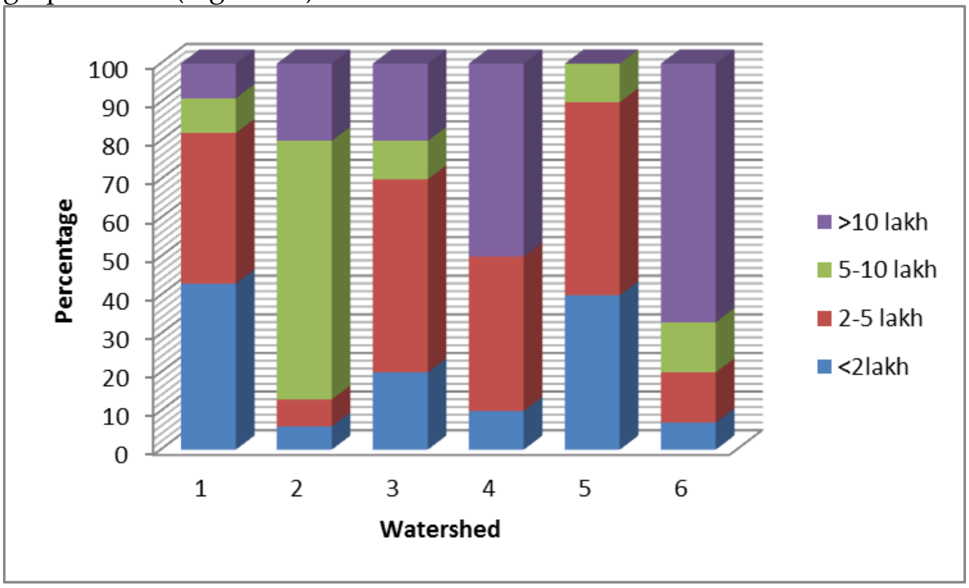
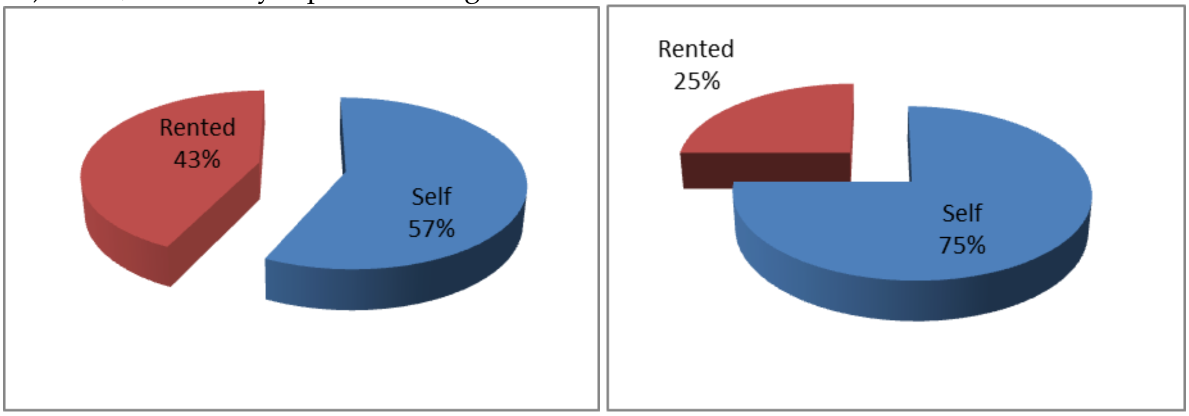


Figure 14: Income level among respondents in different watersheds
(Source: TERI survey results)
Maximum respondents in watershed no.6 (50 percent) were found to be above INR 10 lakhs annually whereas in watershed no. 1 and 5 maximum respondents were below two lakhs per annum. Based on the income group, different watersheds can be ranked from lowest to highest income groups as below:
Watershed 1 ~ Watershed 5 < Watershed 3 <watershed 2 < watershed 4< watershed 6
The areas that come under watershed no.6 are very posh, developed and organized and includes DLF phase II and IV, Sector 51, 52, Jalvayu towers, Ardee city etc. These regions are planned and consists of well off residents whose socio-economic status is quite high which is evident in the survey. Most of the region surveyed in watershed no. 1 and 5 are highly unorganized with haphazard planning.

Household type

Out of the total sample surveyed in the study area, 69 percent of respondents stay in organized colonies and 39 percent in unorganized localities. Within the group of organized colonies, 57 percent were owner of the houses and 43 percent stayed as tenant. On the other hand, within unorganized sector 75 percent were owner and 25 percent was tenants (Figure 15). Thus, the survey represented a good mix of both the owner and tenant households.



(a) Organized colonies **(b) Unorganized areas**

Figure 15: Pie chart showing household type in an organized (a) and unorganized (b) sector

(Source: TERI survey results)

Out of the total respondents, 45 percent had 2 BHK house, 30 percent had 3 BHK and 25 percent stayed in 1 BHK house. 70 percent respondents stayed in multiple storey apartments with less than four storey whereas 30 percent respondents stayed in apartment with more than four storey.

Water and Energy Consumption patterns

Gurgaon get its water supply both from surface as well as ground water. Piped water supply is the major source of drinking water supply in Gurgaon. According to the Town and Country Planning Department of Haryana, about 64 percent households were covered with piped water supply in 2011 as against 45 per cent covered in 2001. The per capita rate of water supply in the Haryana sub-region ranges from 110 lpcd to 145 lpcd. Still, water scarcity is the common problem being faced by many urban areas. According to Global Water Partnership (GWP), rapid population growth due to growing economy, pollution, poverty etc., contributes to water stress conditions and will consequently double the urban water consumption by 2025. In most cities, water supply is sourced from long distances and the length of pipeline determines the cost including the cost of pumping water. Due to the lack of local resource, water is conveyed from the nearest source to the city. As per the National Sample Survey of India (68th round), 75% of urban households are covered with piped water; 40-50% of water is lost in the distribution system and approximate 30-50% electricity is spent to pump water in most cities.

Over the years, several canals and diversion works have been constructed in Yamuna and Ganga basin to fulfill the water need of the nearby region. Gurgaon gets its surface water supply from Yamuna River's Tajewala head works near Yamunanagar. Water comes through the water canal near Sonepat and then through the 70 km Gurgaon water supply canal from Kakaroi village to Basai into Gurgaon city.

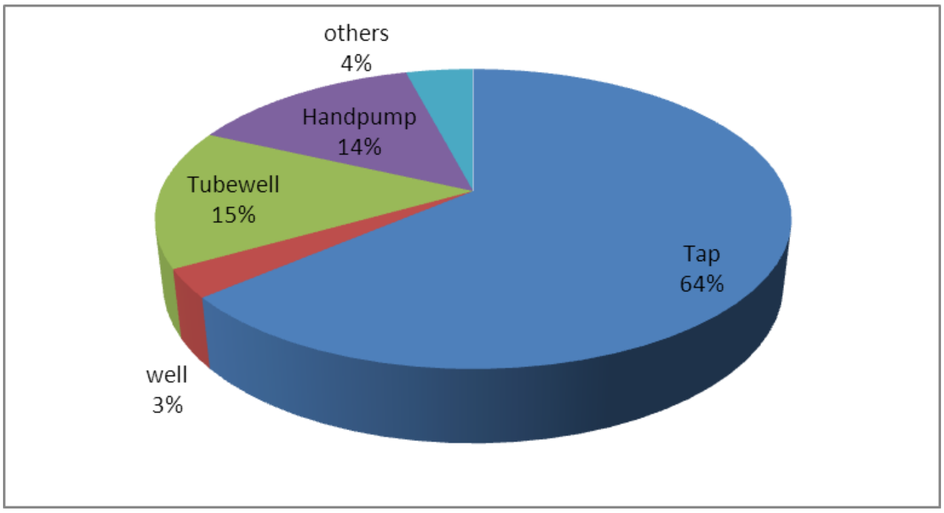


Figure 16 Household classified by source of drinking water in Haryana sub-region, 2011
(Source: Computed from Town and Country Planning Department, Haryana)

Groundwater

Ground water in Gurgaon is depleting at a very fast pace. Also, it has been reported that the quality of groundwater is deteriorating due to overexploitation and contamination. The water table in Gurgaon has reached 15.2 m which is marginally less than the Rewari district of Haryana that has deepest groundwater table (16.3 m) in the state. During the last 20 years, there has been 3-7 m decline in ground water table. In terms of temporal change in groundwater table, Gurgaon district has recorded a decline of 0.5 m per annum. Groundwater estimation of the district was done in 2009 by Central Groundwater Board

(CGWB). The estimates as calculated by CGWB reveals that overall stage of groundwater development in the district is of the order of 232 percent which has exceeded the available recharge and thus the district has been categorized as overexploited.

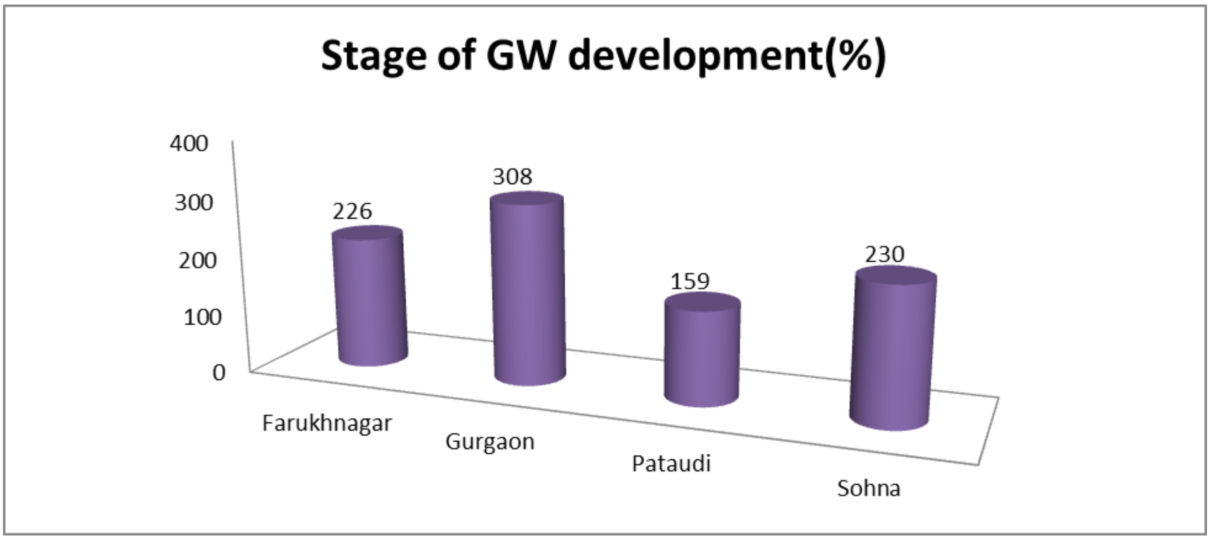


Figure 17 Line graph depicting the stage of groundwater development in different blocks of Gurgaon

(Source: Computed from CGWB, 2009)

The graph (Figure 14) above shows that of all the four blocks of Gurgaon district, Gurgaon block is most exploited. The overall stage of groundwater development in the block is of the order of 308 percent which is significantly higher than the other blocks. The reason could be that it is highly urbanized block of the city with highest population concentration. Water resources are at constraint due to high population density and preferential construction activities. As per the District Statistical Book of 2011, 72 percent of the total population of the district resides in this block.

Water supply and demand

Water is an essential component in life and must be valued and safeguarded. At present due to increase in consumption pattern water is becoming scarce posing threat to growing population. Traditional water management systems like ponds are neglected or encroached upon. The total water supply in different sectors (including domestic, agriculture and industrial) in Haryana Sub-region is 5,224 million cubic meter (MCM) annually at present. The supply does not suffice the present demand which is 42 per cent more than the water supplied at present to different sectors (Figure 15). A significant amount of water is lost on the way, mainly through leaks, before it reaches the end user, often termed as non revenue water (NRW). It has been estimated by Town and Country Planning of Haryana that NRW in urban areas of Haryana Sub-region accounts for almost 10-55 percent. Lack of metering, leakage from pipes, valves, lack of maintenance of infrastructure, corroded pipes etc. are observed to be major reasons for such high NRW.

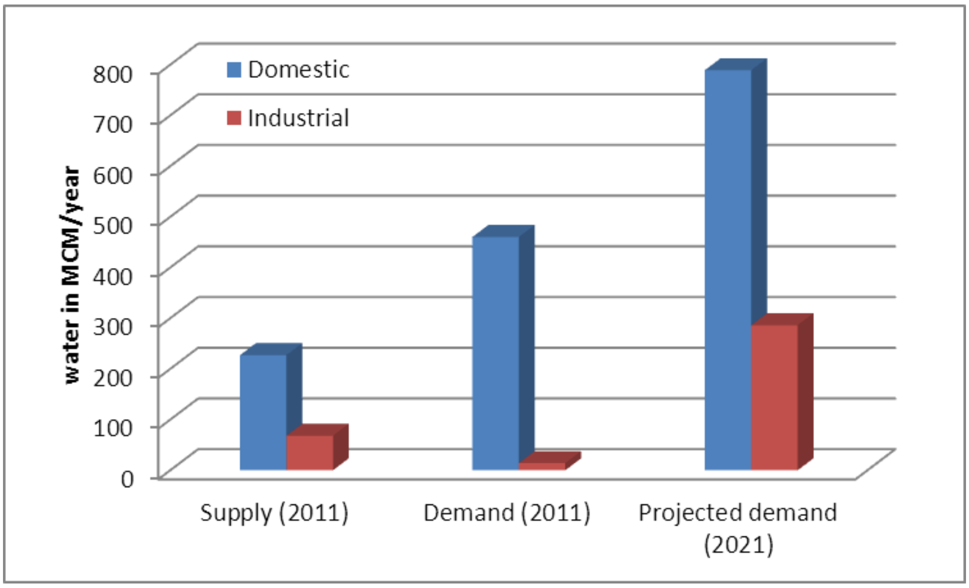


Figure 18 Graph showing water supply and demand in different sectors in Haryana sub-region

(Source: Town and Country Planning Department, Haryana)

Energy consumption pattern

The per capita energy consumption of the state of Haryana is 784 units annually. Maximum electricity is supplied to agricultural sector followed by industrial sector constituting 38% and 32% of the energy sale respectively. Domestic sector is at third place with a share of 18%, while public water works and sewerage accounts for 2% of energy sale (Source:)).

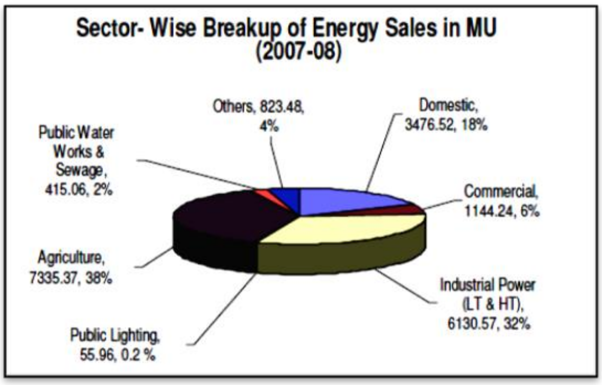


Figure 19 Sector wise break up of energy sales to various sectors

As per the sub-regional plan for Haryana sub region, the state has been witnessing a surge in power demand which doubles every ten years. Because of rise in population and urbanization, the NCR region of Haryana is expected to witness a high surge in energy requirement. As per the estimates given by Central Electricity Authority (CEA), the energy requirement will increase by almost 30% in Haryana sub-region of NCR.

Table 11: Energy Requirement of Haryana Sub-region (2021)

Energy requirement	
2016-17	2021-22
29607 MU	37864 MU

(Source: Central Electricity Authority (CEA) & Draft Revised Regional Plan NCR 2021)

Linkages between Water-Energy and Food

Water for food Consumption

Water is essential for production of food grains, fruits, vegetables and is also needed for preparation of meal using these food grains. Water is thus an essential raw material for food production and consumption. The use of water can be traced through the entire value chain of any food item, beginning from the crops to ending at processed food item, with various intermediary stages for some items. Another linkage with water is direct water requirement for drinking purpose by humans. Thus water, also known as elixir of life draws a close linkage with food and dietary needs of humans.

Food Consumption pattern in India

As reported by the analysis done by IWMI, the long term National Sample Survey (NSS) data on food consumption pattern suggests that there has been decline in per capita cereal consumption since early 1970s. It reports that average monthly per capita cereal consumption in urban areas of India have fallen from 11.24 kg in 1973-74 to 10.63 kg in 1993-94 with the highest decline for coarse cereals. The reason explained for this decline is partly due to the wide selection of food items like milk and milk products, meat, fish and eggs, fruits and vegetables etc. Besides this, change in the lifestyle of the peoples – such as less time available for food preparation (in urban areas). The table below present food demand projection for the two future time slices 2025 and 2050. The rise in the 25 years in not very steep when compared to the growth in population expected.

Table 12 Projection for Food Demand for 2025 and 2050 (Million tonnes)

Name of the States	Cereals			Pulses	Milk	Oil & Fat	Meat, fish & Eggs	Vege-tables	Fruits	Sugar & *Jaggery*
	Rice	Wheat	Total							
					2025					
Haryana	1.13	3.38	4.50	0.39	1.47	0.20	0.58	1.56	0.29	0.29
					2050					
Haryana	1.18	3.53	4.71	0.41	1.54	0.21	0.62	1.64	0.31	0.31

(Source: Assessing Agriculture and Livestock Water Demand in 2025/50: Food Habits, Income Growth and Spatial Pattern, O. P. Singh, IWMI)

The figure below presents changes in demand of general food items in the state of Haryana from 1993 to 2003.

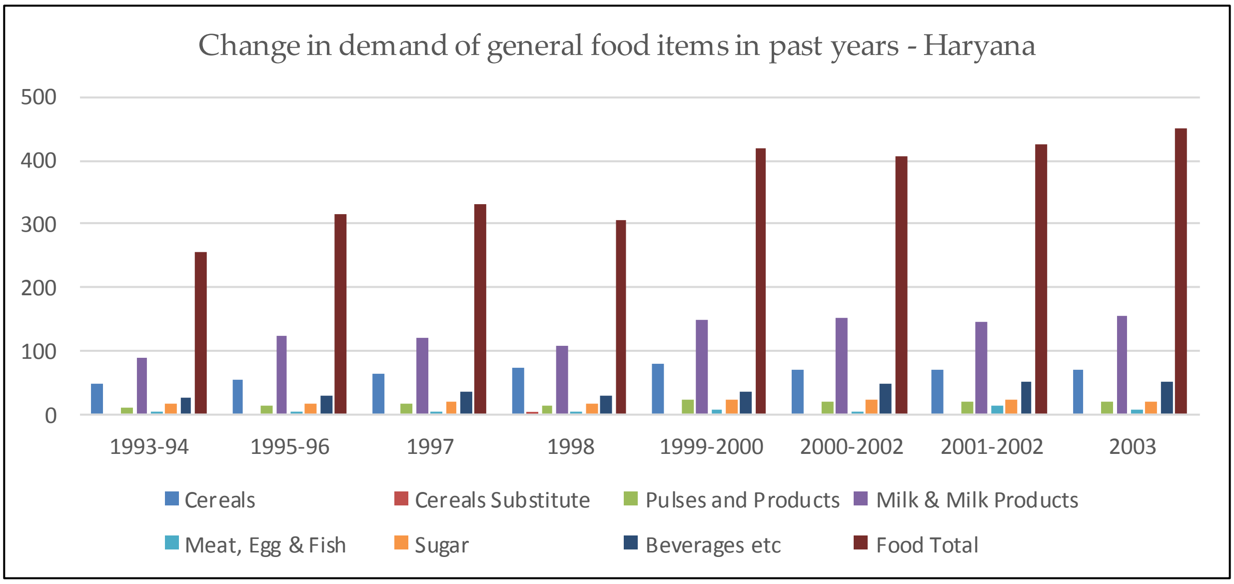


Figure 20 Change in demand of general food items in Haryana

The figure 17 shows that cereals demand increased till 1999-2000 and then after shows decrease, while meat, egg, fish starts showing presence in graph from 1999-2000 and then after keeps dwindling showing no definite trend. Year 1999-2000 shows sharp increase in total food demand when compared to previous years.

Consumption of general food items in Haryana state

Some of the most essential food commodities used in Indian households include rice, wheat, pulses, sugar, milk, eggs, chicken, etc. Depending on the dietary habits, lifestyle and socio-economic profile, consumption pattern and quantity of food items consumed varies from household to household. As an indicative averages, as per the NSSO survey of 68th round, for three basic commodities, urban Haryana has registered household consumption of 4.38 kilograms of rice, 29.66 kilograms of wheat and 5.57 kilograms of sugar monthly. (The average household size of Haryana is 4.6).

The table below provides per capita consumption in urban Haryana for some basic food items as per the report of NSSO survey 68th round.

Table 13 Per capita consumption of basic food items in Haryana

Food item	Quantity consumed per capita in a month on an average
Rice	1.061 kgs
Wheat	7.197 kgs
Arhar dal	0.076 kgs
Moong dal	00.168 kgs
Suji	0.024 kgs
Bread	0.143 kgs
Noodles	0.028 kgs
Besan	0.141 kgs
Milk	11.033 Litres

Tea leaf	137.156 grams
Coffee powder	2.4 grams
Chicken	0.064 kgs
Eggs	1.815 kgs
Mineral water	0.031 Litres
Cooked meals purchased	1.240 kgs
Papad, namkeen	0.144 kgs
Chips	15.284 gms
Pickle	21.238 gms
Sauce, jam	14.986 gms

(Source: NSSO survey, 68th Round (2013))

As seen from the table 11, wheat forms the major part of the diet as compared to rice, which is more prevalent in eastern and southern states of India. Also other processed foods like bread, noodles, and chips etc. are consumed more in urban part of the state than rural parts. The table below presents comparison of some of the general food items consumed in urban parts of Haryana vis-à-vis urban India.

Table 14 Comparison of some of the general food items consumed in urban parts of Haryana vis-à-vis urban India

Food item	Monthly per capita consumption – Urban Haryana (in kgs)	Monthly per capita consumption- urban India (in kgs)
Rice	1.061	4.487
Wheat	7.197	4.011
Arhar dal	0.076	0.301
Moong dal	0.168	0.117
Milk (Litres)	11.033	5.422
Egg	1.815	3.180
Chicken	0.064	0.239

(Source: NSSO survey, 68th Round (2013))

These values indicate that wheat consumption in urban part of the state is almost double than national average for urban India, while consumption of rice is almost 25% of the national average. Arhar dal is less consumed in urban Haryana while moong dal is consumed more when compared to national average. Consumption of milk is also higher in urban Haryana than average of urban India. The consumption quantity is close to double of national average value of 5.422 litres per month per capita. Consumption of egg and chicken is less than national average.

Besides these drinking water need of around 2-3 litres per person per day also form important part of dietary requirement.

Food preference in study area

The kind of food we prefer has direct correlation with water and energy usage. Generally, preparation of per capita vegetarian food consumes less water and energy as compared to non vegetarian food. In the survey, it was found that 63 percent of respondents were pure vegetarian, 27 percent were non-vegetarian and 10 percent respondents preferred eating only eggs.

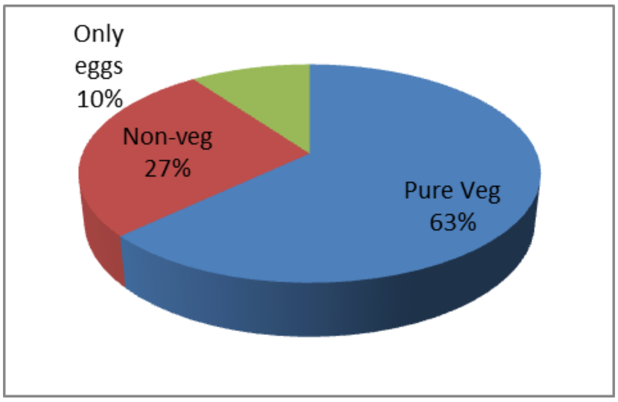


Figure 21: Pie chart showing food preference in the study area

Consumption of beverages in study area

Preparation of beverage items especially tea and coffee consume significant amount of water and energy. In the survey, it was found that 7.14 cups of tea is consumed daily by a family of four. This figure varied for different watersheds as shown in the figure below.

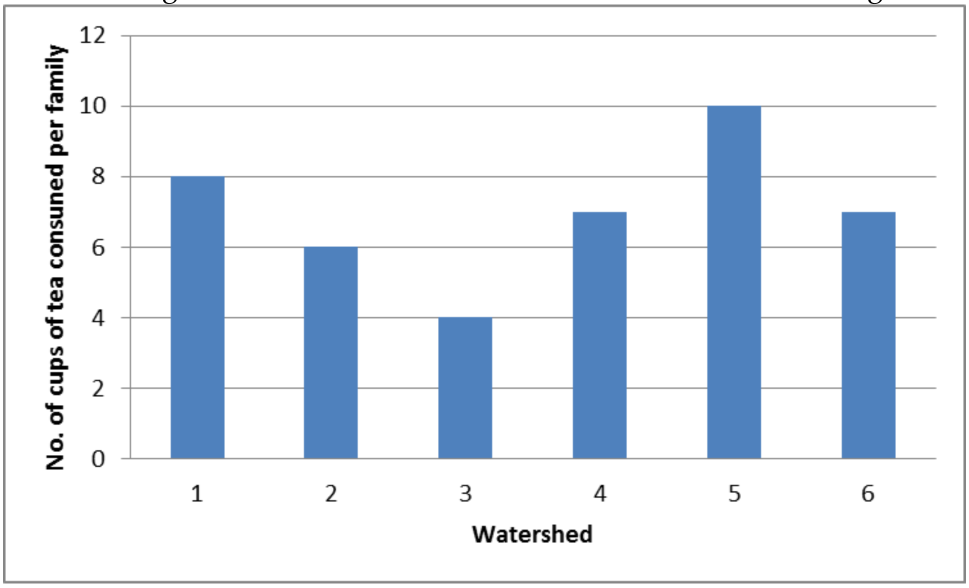


Figure 22: Graph showing no. of cups of tea consumption per family in different watershed

Maximum consumption of tea was found in watershed no.5 (10 cups) and minimum consumption was observed in watershed no.3 (4.4 cups), owing to the difference in family size in different watersheds.

Water footprint of main food items in Haryana

As defined by Water Footprint Network, 'The water footprint measures the amount of water used to produce each of the goods and services we use.' Water foot print can be assessed at production level, at consumption level or throughout the value/supply chain. Water footprint at production level is more than that at the consumption level.

Among the general food items, rice and wheat are the two most important food items which form part of daily meal in one form or the other. As reported by Chapagain and Hoekstra, 2010, national water footprint for production of rice is 255 billion m^3/year. It accounts to total of 432.8 billion m^3/year which includes 177.4 billion m^3/year from percolation and residual soil moisture. For consumption of rice, the estimated water footprint is 250,305 Mm^3/year or 239 m^3/capita/year.

For wheat the water footprint for production is 145851 Mm^3/year and for consumption it amounts to 142699 Mm3/year and 135 m^3/capita/year.

Taking these figures into consideration along with per capita consumption of rice and wheat in urban Haryana, the total consumption of rice and wheat comes out to be 13,269,965.196 kilograms and 90,013,138.092 kilograms respectively. The total water footprint of the annual consumption of rice and wheat in urban Haryana amounts to 249,098,467 m^3 and 140,704,155 m^3 respectively.

Thus, rice being more water intensive crop, has higher water footprint as compared to wheat. But, consumption patterns show that average monthly per capita consumption of wheat is more than rice in urban areas of state of Haryana. So in general, less water intensive wheat is consumed more in urban Harayna than more water intensive rice. But simultaneously, consumption of dairy and poultry products is more prevalent in Haryana. These items have higher water footprint as they depend on fodder to feed animals, and are at higher position in human food chain, thus adding more water footprint in their value chain.

Processed foods are also common part of urban households and include common items like chips, ready to eat meals. These items are more water intensive than general food items. For example potato chips need additional water during processing, like cleaning, for producing oil that is required for frying, together with their transportation and packaging.

Other common items that consume water are tea and coffee beverages, besides other aerated and non-aerated drinks which contain water. Also, as reported, Gurgaon district has the highest average level of living with MPCE of Rs 1292 for urban areas.

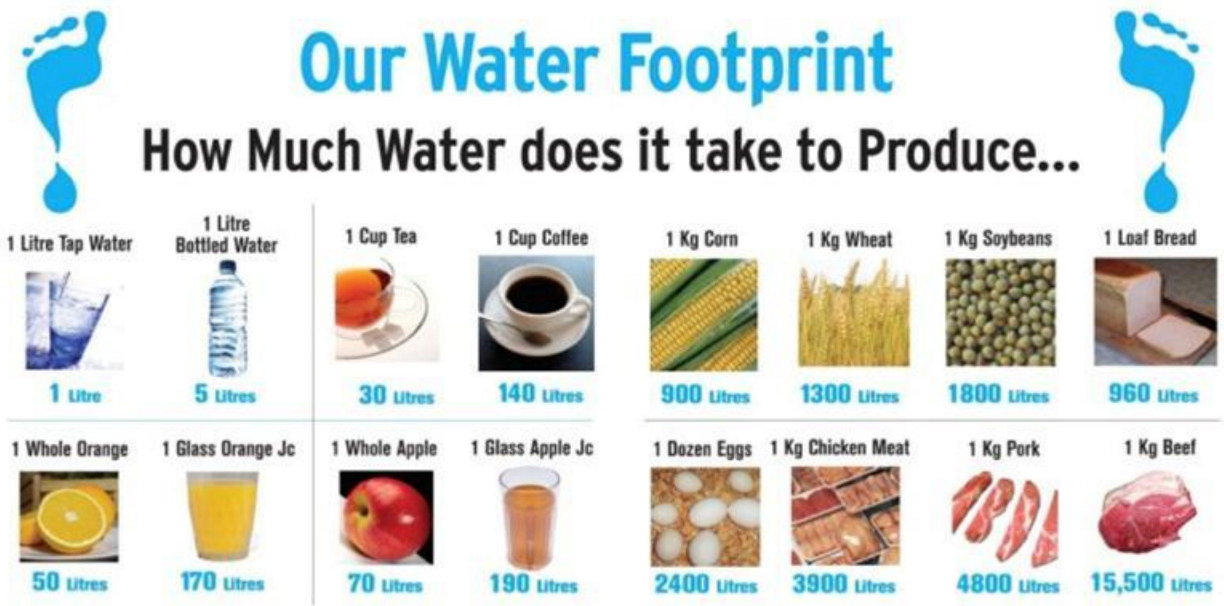


Figure 23 Water Footprint of main food items
(Source: Water Footprint Network)

Water for food consumption in study area

The concept of water footprints in food production has limited potential in explaining the water consumed at the stage of actual food consumption at the household level. Within the overall value chain of any specific food item, water consumption is significantly higher at the stage of its production as compared to food consumption stage. Water consumed at the food consumption stage may be less than 5% of the total water footprint of any specific food item. But considering the total water supply standards per family, as prescribed by Government of India for urban areas, it is important to understand the proportion of actual water consumed at the stage of food consumption.

At the stage of food consumption, water is required for cleaning the raw food items like vegetables, for cooking food like rice, wheat and beverages as well as for cleaning utensils used for cooking food. The daily domestic water use in food consumption (including cooking and washing utensils) was found to be 45L per household in the study area. This water accounts for almost 30 percent of minimum water use, as set up by the Government of India for communities residing in urban region with population of more than one lakh[38]. During the survey, it was found that in cooking three basic food items daily (rice, pulses and chapattis) six litres of water is consumed on an average whereas in washing utensils 38.31L of water is used. Thus, washing utensils is the biggest consumer of water at the stage of food consumption with 85% of total water consumption at this stage.

Photo 1: Water being wasted while washing utensils by domestic maids

[38] Indian Standard: Code of basic requirements for water supply, drainage and sanitation. Bureau of Indian Standards, fourth reprint December, 2010.

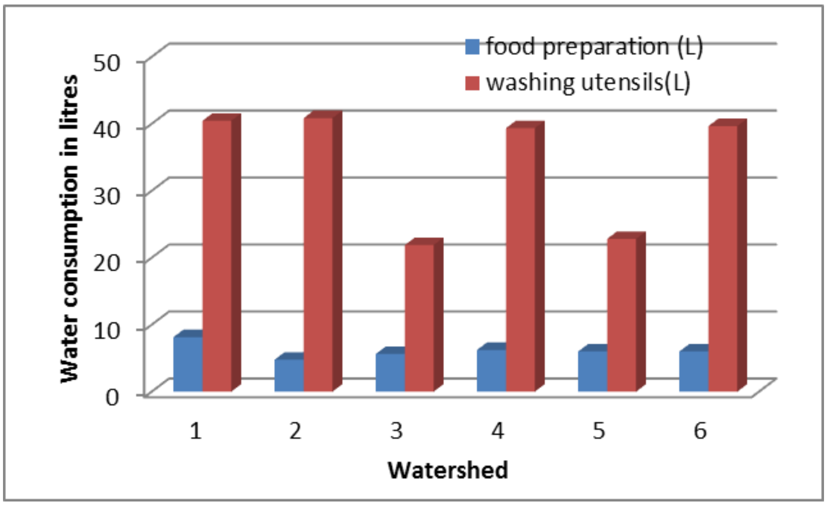


Figure 24: Graph showing water consumption in litres in different watersheds

However, variation was observed among different households located in different watersheds. The figure above shows the pattern of daily water use at food consumption level in different watersheds. Minimum water consumption is in watershed no.3 (27 L) followed by watershed no.5 (29L). The low water consumption in watershed no.3 can be due to small household size (3.4). But watershed no. 5 has highest family size yet the water consumption is low. In the survey it was found that watershed no.5 is a water stressed region and faces huge scarcity of water. Respondents store water even for washing utensils therefore, water wastage is minimal in the region. Along with quantity, water quality is also an issue in the watershed no.5.

This indicates that water consumption for food preparation, is not just the function of size of family or the amount of food cooked in a family. But it has more direct influence of ease of water availability and the general approach of human being towards water.

Based on the survey results, the daily water consumption for food was calculated for entire urban Gurgaon area and for urban population of India as shown in the table below. The present water demand for food consumption of the Gurgaon city is 11 MLD whereas that of urban India is 424 MLD per day. This water demand will increase by 2.5 times for Gurgaon city and 1.5 times for urban India by 2031 based on the population projections made by Planning Commission of India.

Table 15: Water for Food for Urban India and Gurgaon

	India		Gurgaon	
	2011	**2031**	**2011**	**2031**
Urban population	37,710,000	60,000,000	1,042,253	3,000,000
Water for food in MLD (including cooking food and washing utensils)	424.23	675	11.72	30

*Calculated on the basis of result obtained from the study

Water consumption in organized and unorganized sectors

A comparative analysis of water consumption among residents of organized colonies and unorganized localities shows that water consumption is more in organized colonies (46.8 L) than unorganized localities (41.31 L) as shown in the figure below. This accounts for 12 percent more water consumption/wastage in organized colonies in comparison to unorganized one (Figure..).

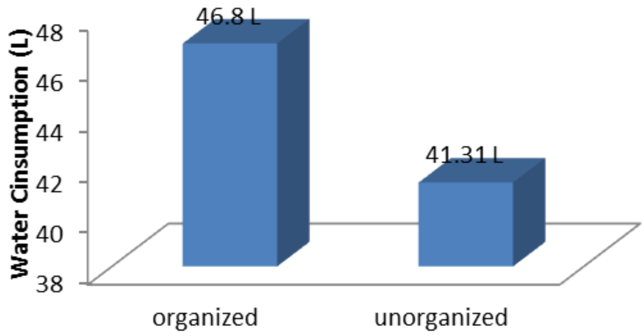


Figure 25: Water consumption in organized and unorganized sectors

In the survey, it was found that respondents residing in organized sectors were more affluent than those of unorganized one. Domestic maids are integral part of these households and they waste water by keeping the tap running even when not in use while washing utensils.

Water consumption in single and multiple storied building

When compared with single and multiple storied building, it was found that water consumption was less among residents of <4 storey buildings (41 L) than residents of > 4 storied buildings (53 L). This is approximately 23 percent more water consumption, mainly during washing utensils (Figure…). This may be attributed to higher tap outflow rates in higher buildings due to steep vertical gradient of water from overhead tanks.

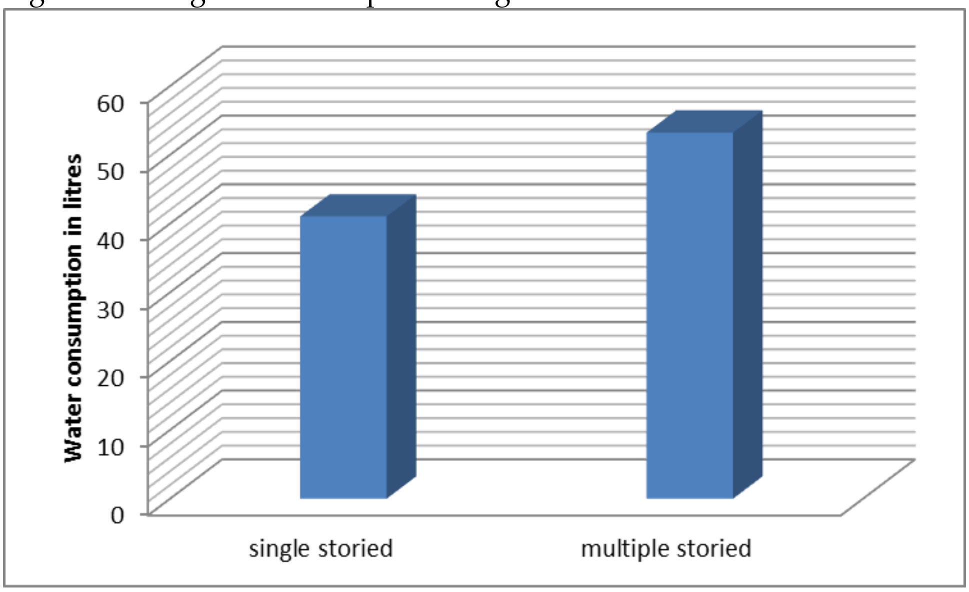


Figure 26: Water consumption in <4 and >4 storied buildings

Energy for Food Consumption

As food is a necessity for life, equally important is cooking the food, due to inability of human beings to consume raw food both due to inability to digest uncooked food as well as suitability to their taste buds. For cooking the food and making it suitable for human consumption, energy is a necessary input. Energy input is required at various stages of the journey of food from being produced at the agricultural fields to the food reaching to the human plate for its consumption. Figure 19 represents the different stages of energy consumption across food consumption chain.

At different stages of food consumption chain, energy produced from different fuel types could be used. This could be energy from petroleum products used for transport of food material from farm to market and to homes, electrical energy for storage of food material at cold storages or at homes and cooking energy from LPG, Kerosene or wookstocks for conversion of raw food material to the cooked food.

As the current study focuses on the energy used for consumption of food at the household level, energy for food consumption has been categorized into two classes:

1. Energy for cooking food
2. Energy for food other than for cooking

Energy for Cooking Food

This is the energy used at the household level mainly for cooking i.e., for converting the raw food material to an edible form. Primary sources of energy for cooking in the country are Liquefied Petroleum Gas (LPG), firewood and chips, kerosene, dung cake and coal & coal.

At all India level, firewood & chips are used by more than two-third (67.3%) of rural households, followed by LPG, which was used by 15.0% households. However, in *urban* areas, most of the households use LPG as primary source of energy for cooking. LPG is used by 68.4% of the *urban* households at all-India level, followed by firewood and chips, used by 14.0 % households and 5.7% of the households using kerosene for cooking[39].

The percentage of households using LPG as primary source of energy for cooking is highest in Haryana (86.5% households), followed by Andhra Pradesh (77.3%), Punjab (75.4%) and Maharashtra (74.5%). Moreover, compared to rural areas, use of kerosene as primary source of energy for cooking is more prevalent in urban areas, especially in Gujarat (10.5%), Maharashtra (10.1%) and Punjab (10.0%)[38].

[39] NSS Report 567 (68/1.0/4): Energy Sources of Indian Households for Cooking and Lighting, 2011-12, Government of India

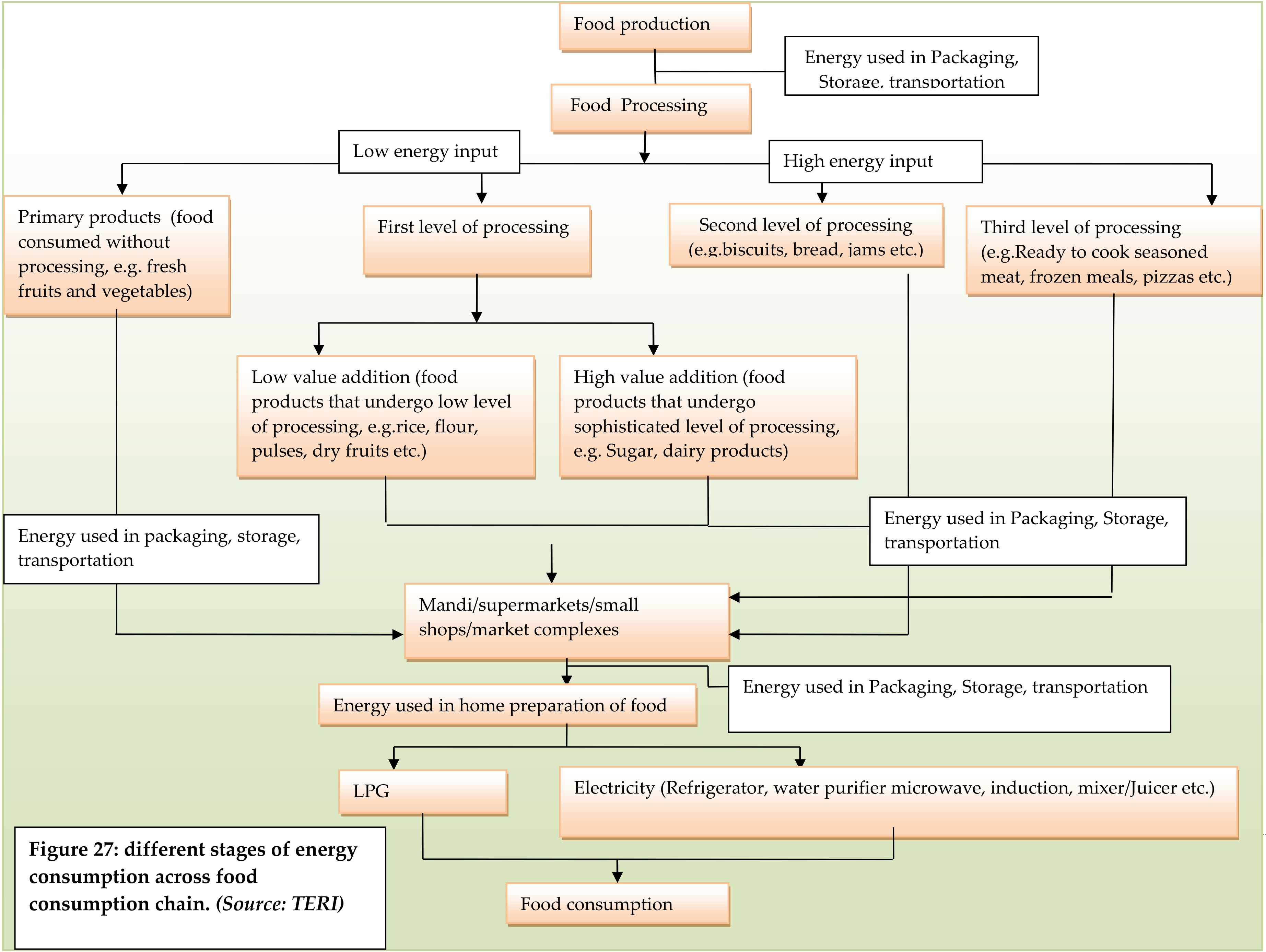


Figure 27: different stages of energy consumption across food consumption chain. ***(Source:** TERI)*

With improvement in availability of LPG in the country and intensive efforts by the government for a wider access to LPG connections, the percentage of households using LPG has risen steadily during the last decade. % of households using LPG for cooking food has increased by 83% in 2011-12 as compared to 2004-05 in rural areas. For urban areas, this increase has been limited to 20% during the same time period, but has increased the access to LPG to almost 71% of urban households. Figure 20 shows the trends of change in source of energy for cooking at household level for urban areas[38].

Simultaneous to increase in access to LPG for cooking food, there has been an increase in amount of LPG being consumed at the household level, in both rural as well urban areas. It has been reported that per capita consumption of LPG has increased by almost 75% from 0.21 kg per month to 0.38 kg per month from 2004-05 to 2011-12 in rural areas. For urban areas, per capita monthly consumption of LPG has increased from 1.6 to 1.9 kg, during the same time period[38].

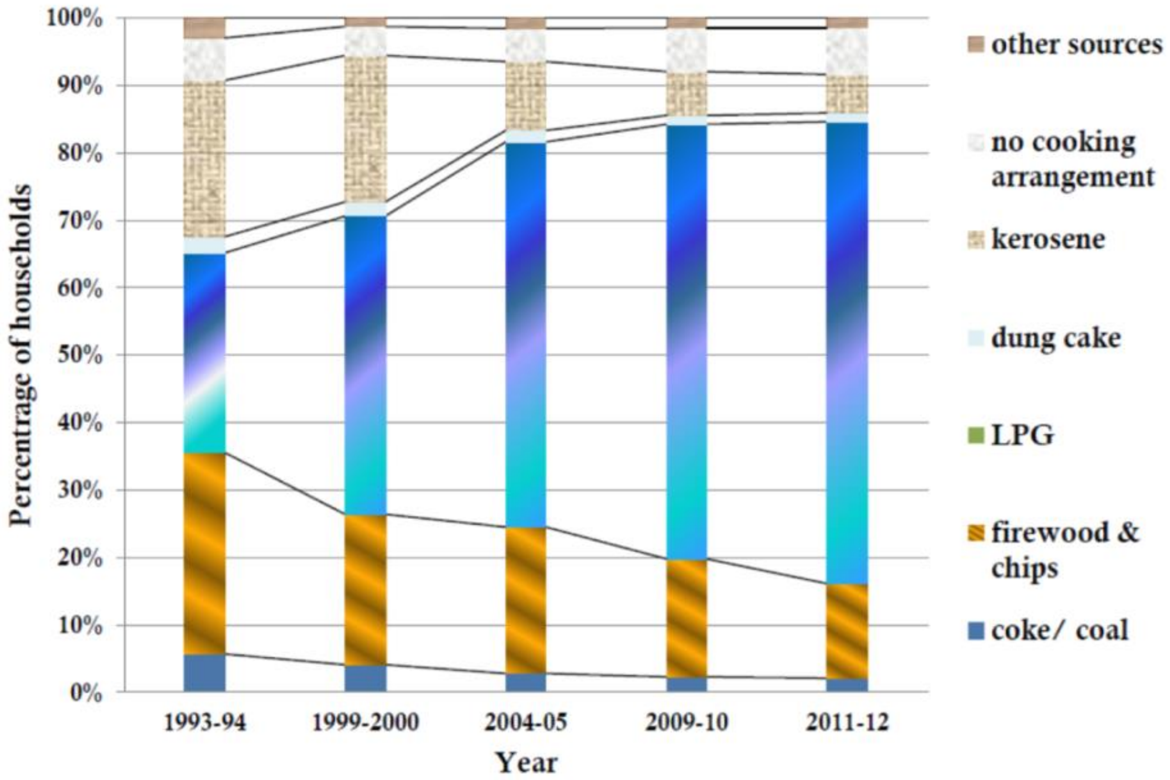


Figure 28 Distribution of households by primary source of energy used for cooking: all-India (Urban), 1993-94 to 2011-12

(Source: NSS Report 567 (68/1.0/4)

Energy for cooking food

Energy is an important input in growing, processing, preparing, serving and disposing of food. The per day energy consumption in the form of LPG by the family of four is 0.39 kg. It is marginally higher than the LPG consumption of urban India which is 0.25 kg[40].

[40] NSS 68th Round, 2011-12

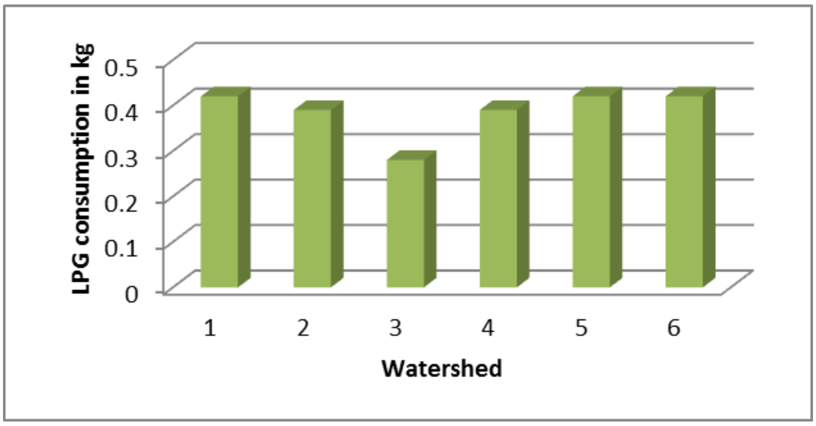


Figure 29: LPG consumption (kg) in different watersheds

The graph above shows LPG consumption pattern in different watersheds. LPG consumption is less in watershed no. 3 (0.28 kg) followed by watershed no. 2 and 4 (0.39 kg in each) respectively. The low LPG consumption can be due to small household size in these two watersheds.

Photo 3: Different types of electrical appliances used for food other than cooking at household level

Photo 3: Electrical appliances used in a kitchen at household level

Energy for cooking in organized/unorganized sector and single/multi storied building: A comparative analysis of sector wise data shows that LPG consumption is same (0.39 kg per household) in both organized and unorganized sectors as well as single and multiple storied buildings.

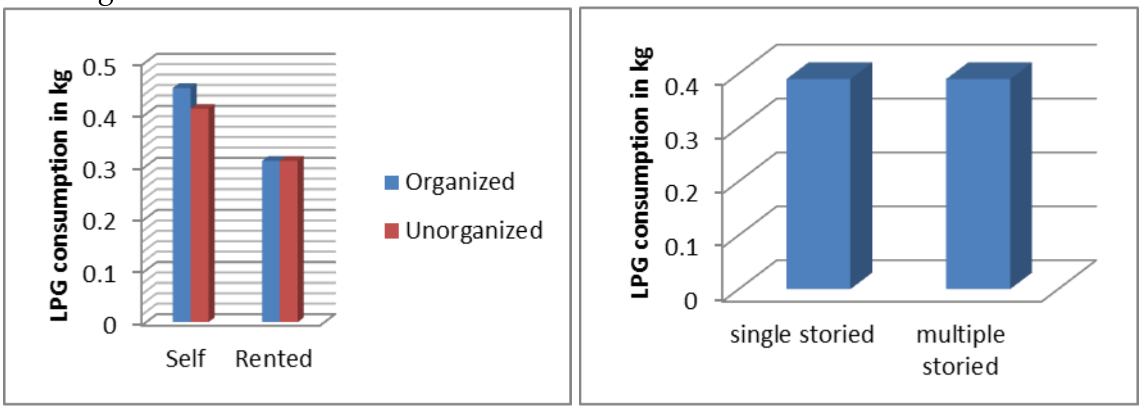


Figure 30: Energy used in cooking in different sectors

Energy for food other than for cooking

With changing lifestyles, increasing urbanization and also prosperity, additional amount of energy is being used for consumption of food other than for cooking.

This is the energy which is used for reheating food, preservation/ storage of food at cooler temperature, processing of food at the household level like grinding, mixing etc. Modern day consumer appliances like refrigerators, microwave ovens, mixer-grinders etc. are used for the purpose. These consumer appliances run on electricity, and hence are more prevalent in urban areas having better connectivity to electricity supply.

At the all-India level, 72.7% of rural households and 96.1% of urban households use electricity as primary source of energy for purposes other than for transport. On an average, the proportion of urban households dependent on electricity is more than 90% in all major States since 1999-2000. Similarly, per capita monthly consumption of electricity in rural areas is about 9 kwh, while it ranges to 26 kwh in urban areas. Recently, electricity consumption has increased by 57% in rural areas and by 29% in urban areas, indicating an increasing dependence of population on electrical appliances, apart from usual lightening purpose.

Among different states in India, monthly per capita electricity consumption is highest in more urbanized small states, ranging above 40 kwh with Himachal Pradesh having the highest consumption of 49 kwh. In Haryana, monthly per capita consumption of electricity is 16 kwh in rural areas and 37 kwh in urban areas, which is towards the higher side of urban electricity consumption as compared to other states of India.

Moreover, Electricity makes about 50% of fuel (other than transport fuel) expenditure in the average urban household and 22% in the average rural household. In Haryana, urban areas report monthly per capita expenditure of Rs. 239 for fuel (other than for vehicle) and lightening.

Energy for food other than for cooking

With increase in urbanization and economic conditions, lifestyle is also changing. One of the major changes is seen in the way we consume food. More energy in the form of electricity is being used for food consumption. This is the energy used for reheating, food preservation, food processing etc. Electricity usage per day in food consumption is 3.28 units in the study area which is slightly less than of urban India (3.44 units for a family of four).

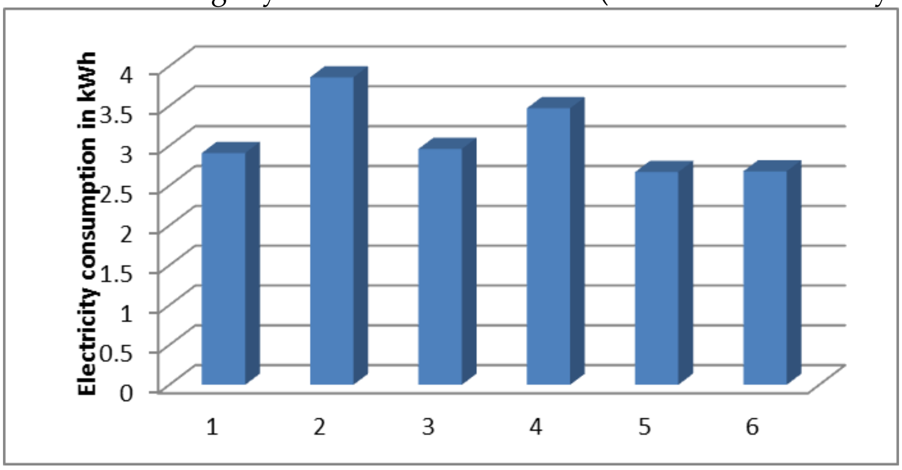


Figure 31: Energy consumption pattern in different watersheds

The graph above shows that electricity consumption is more in watershed no.2 followed by watershed no.4 which is contrary to the LPG used in these watersheds. Electricity consumption is more in these watersheds because of more electric appliances used in the kitchen. The respondents preferred to cook food using induction cooker and microwave as it saves time. These two appliances consume more electricity. Among all electrical appliances used for food consumption, refrigerator is the most common appliance across all income groups in the study area which is used continuously. The wattage consumption of refrigerator varies from 100-200 watt depending upon the capacity. A 100 watt refrigerator consumes 2.4 units of electricity, thus consuming significant units of the electricity at household level per day.

Energy consumption in organized and unorganized sectors:

A comparative analysis of organized and unorganized sector shows that electricity consumption is higher in organized sectors (3.99 kWh) as compared to unorganized sectors (2.17 kWh). In an analysis of self and rented households in these two sectors, it was found that both LPG and electricity consumption is higher in self owned houses than rented one.

Figure 32: Electricity consumption in organized and unorganized sectors

Energy consumption in single and multiple storied building:

When compared with energy consumption in single vs multiple storied building, electricity consumption was found more in multiple storied building than single storied buildings.

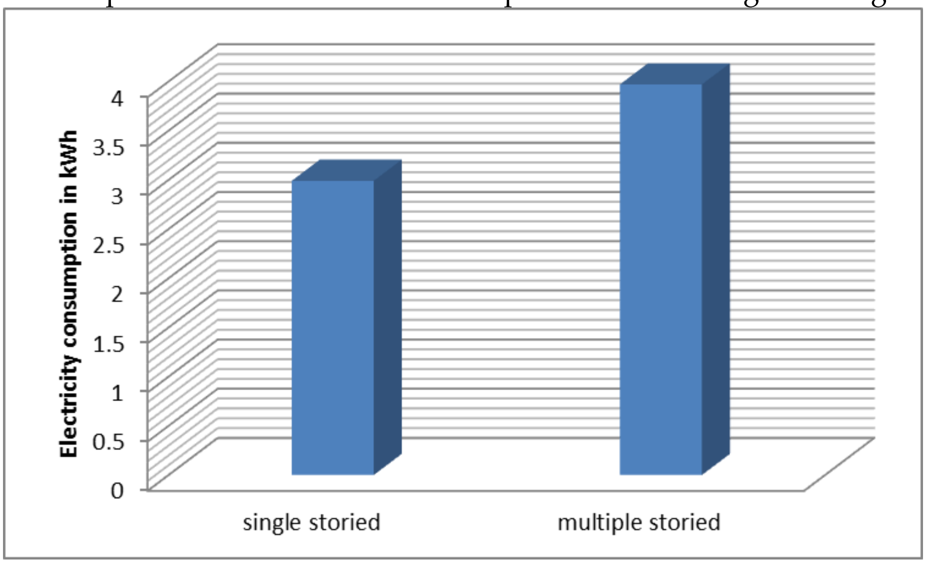


Figure 33: Energy consumption in single/multiple storied buildings

Based on the above result for energy used in cooking food and energy used for food other than cooking was calculated for India as well as Gurgaon as shown in the table below. The energy used in the form of LPG is more than 1 lakh kg for Gurgaon whereas for urban India it is 36 lakh kg per day. This figure is projected to increase by 4 times for Gurgaon and 2 times for urban India by 2031. The same projection was made for energy for food other than cooking mainly in the form of electricity. It is observed that energy in the form of electricity will also increase by 4 times for Gurgaon and 2 times for urban India by 2031. Both energy use (LPG and electricity) are following the same trend.

Table 16: Energy for food for urban India and Gurgaon

	India		Gurgaon	
	2011	2031	2011	2031
Energy for cooking food (kg)*	3676725	5850000	101619.67	390000
Energy for food other than cooking (kWh)*	30922200	49200000	854647.46	3280000

*Calculations based on the result obtained from study

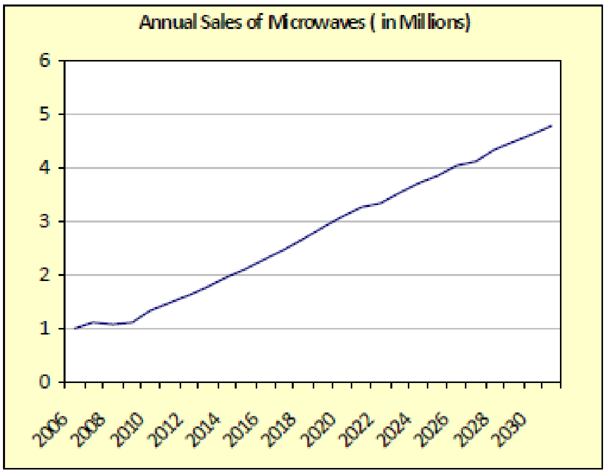
Kitchen appliances and their electricity consumption

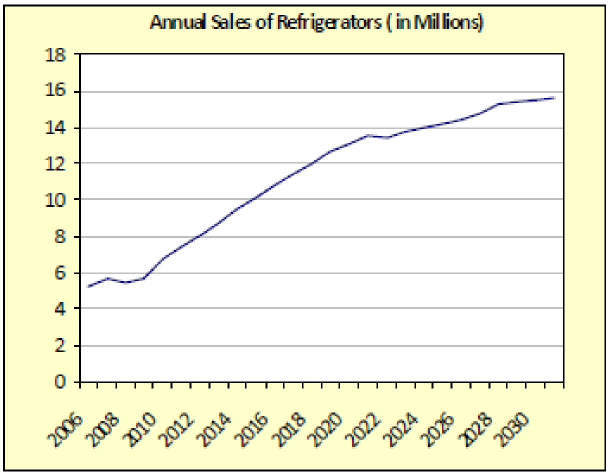
Refrigerators, electric oven, toaster and microwaves are the most popular kitchen appliances used for the purpose of food consumption. As per NSS report 558 (68/1.0/2), refrigerators were possessed by 44% urban households in 2011-12 compared to 32% in 2004-05, indicating an increase of 37.5% over 7 years.

As per a report by The World Bank in 2008, India had about 33.3 million refrigerators in 2006 which is likely to be 201 million by 2031. Similarly, number of electric ovens is likely to increase by 650% from 5.8 million in 2006 to 40 million in 2031[41].

According to CEAMA 2014, refrigerator sales stood at ~14.0 million units in 2013. Refrigerator market in the country makes up 18.0 per cent of the consumer appliances market. The market share of direct cool and frost free segment is 76.3 per cent and 23.7 per cent respectively. Fridges with a capacity range of 142-340 litres dominated fridge sales over the review period, representing 74% of total volume sales. Market share of LG is 24.50% and Samsung is 20.60% in 2013[42].

Figure 34 represents the annual sales and projected sales of key kitchen appliances in the country for the period from 2006 to 2031.





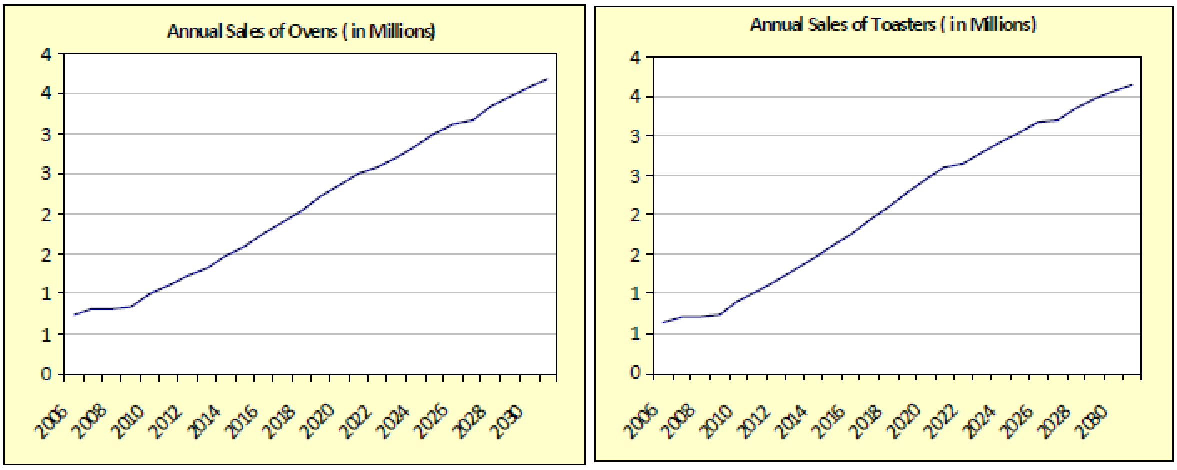


Figure 34 Annual sales and projected sales of key kitchen appliances in the country for the period from 2006 to 2031.
(Source: The World Bank, 2008[39])

As refrigerators are an appliance operating on a continuous basis without being switched off, they are the biggest electricity consumers among all the kitchen appliances. A typical 5 star rating refrigerator consumes about 350-400 kWh electricity annually. In general, it ranges from 350 to 500 kwh/ yr for any typical refrigerator available currently in the Indian markets. However, other kitchen appliances like electric toasters and microwaves are used only when required, their total electricity consumption is far less as compared to refrigerators. Assuming that electric toasters are used for 15 minutes a day and microwaves are used for 6 minutes a day, their annual electricity consumption ranges from 90-110 kwh/ yr and 60-80 kwh/ yr, respectively.

Total electricity consumed by kitchen appliances was 25000 Gwh/ yr in 2006 which is projected to increase to 50000 Gwh/yr in 2016 and 103,000 Gwh/ yr in 2031 indicating an increase of almost 400% in 25 years. Among the different kitchen appliances, refrigerators consumed 23500 Gwh/yr in 2006 which was almost 95% of the total electricity consumed by all the kitchen appliances. It has been projected that electricity consumption by refrigerators will increase by 3.6 times upto 2031. However, its share in overall consumption of electricity by kitchen appliances will reduce to 81%, owing to larger increase in usage of other electrical appliances like microwave and toasters. Total electricity consumption by electrical appliances like ovens, toasters and microwaves is projected to increase by 9, 20 and 5 times respectively, in 2031 as compared to 2006.

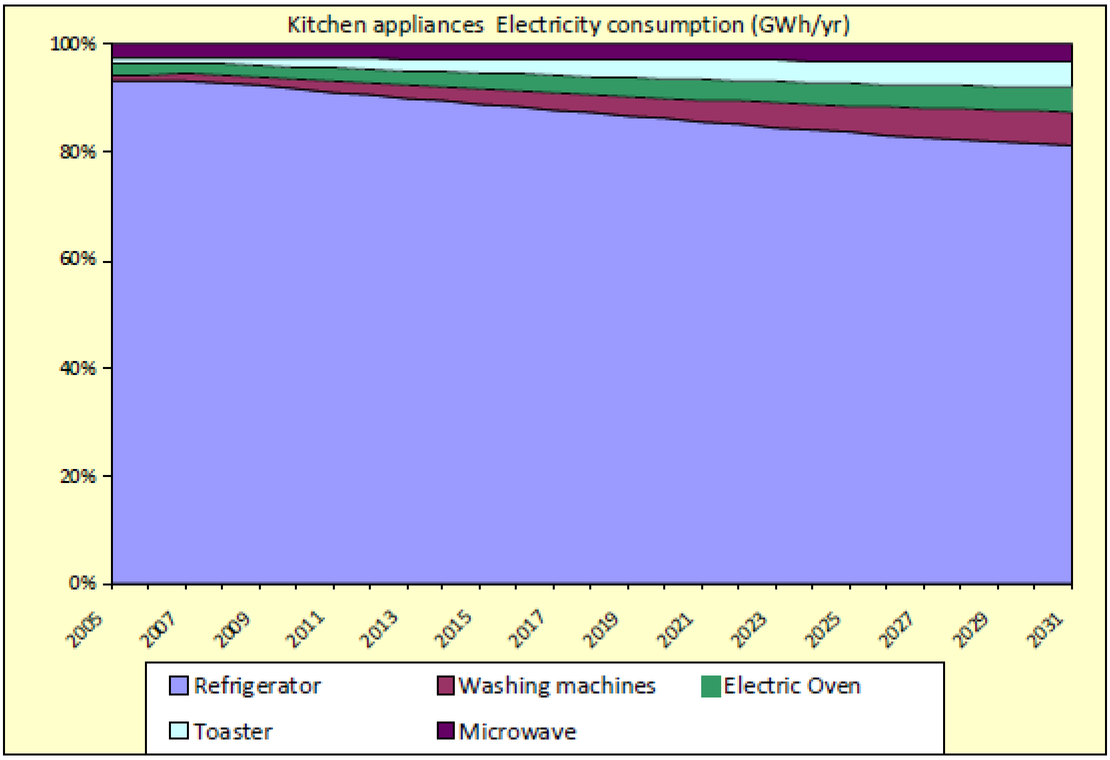


Figure 35 Distribution of electricity consumption by different kitchen appliances
(Source: The World Bank, 2008[39])

Energy for water consumption

In urban water supply and municipality, sanitation, wastewater treatment and drinking water supply, energy is required at every step and forms the main operational cost component. In most cities, water supply is sourced from long distances and the length of pipeline determines the cost including the cost of pumping water. Due to the lack of local resource, water is conveyed from the nearest source to the city. Gurgaon gets its surface water supply from Yamuna River's Tajewala head works near Yamunanagar. Water comes through the water canal near Sonepat and then through the 70 km Gurgaon water supply canal from Kakaroi village to Basai into Gurgaon city.

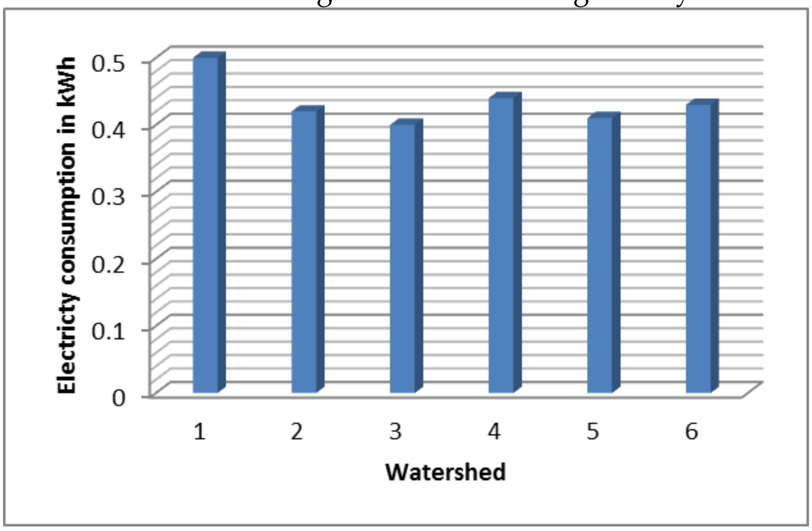


Figure 36: Electricity used (kWh) in pumping water

The graph in the figure 36 shows mean consumption of electricity at household level in different watersheds in the study area. The mean consumption of electricity in pumping water at household level is 0.44 kWh per day. This includes water use for all purposes including cooking and washing utensils. It accounts for 12.79 percent of total domestic electricity consumption in urban India and 9.16 percent in urban Haryana per day by a family of four[43]. The maximum consumption is in watershed no.1 (0.50 kWh), whereas minimum consumption is in watershed no.3 (0.40). The minimum consumption in watershed no.3 can be attributed to small family size which is 3.4.

Photo 4: Three pumps being used for pumping water

Based on the these results from survey, for energy used in the form of electricity for pumping and storing water at household level, a projection was made for urban population of the city. It indicates that Gurgaon consumes about 1.15 Lakh units of electricity for pumping water at the household level. This is further projected to increase by 300% for the future population of Gurgaon in 2031. Similar assessment for the urban population of India, shows a consumption of about 4 million units of electricity per day for pumping water at the household level. Considering the electricity used by municipal bodies in pumping water from source to the households, in pre-treatment of water for supply and in treatment of waste water being generated in the city, overall consumption of electricity for water in urban areas will be manifold.

Table 17: Energy for water for India and Gurgaon

	India		Gurgaon	
	2011	2031	2011	2031
Energy for water(kWh)*	4148100	6600000	114647.83	440000

*Calculations based on the result obtained from study

[43] NSS 68th Round, 2011-12 (Domestic electricity consumption of urban India is 3.44 kWh and urban Haryana is 4.8 kWh per day by a family of four)

Energy for Water Purification

In the survey, it was found that 47 percent of respondents use water filtered through reverse osmosis system at their home, before using it for preparing food. Reverse osmosis is a water purification technology that uses semi permeable membrane to remove larger particles from drinking water. These RO systems are used on a continuos basis without being switched off any time of the day.

Around 36 percent respondents use supply water directly for cooking food which is supplied by Haryana Urban Development Authority (HUDA) in newly developed areas and Municipal Corporation of Gurgaon in old regions of the study area. 11 percent respondents depend on bottled water for drinking as well as cooking food which is supplied by various private agencies and six percent use ground water through their own borewells.

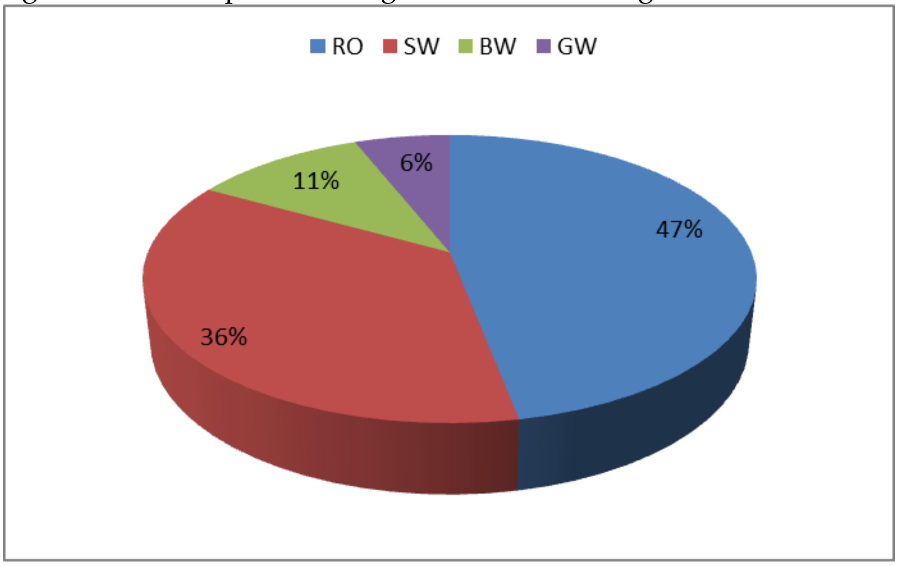


Figure 39: Source of water for cooking food

Case study: Water-Energy-Food Nexus in New Panvel

The results from survey conducted in Gurgaon to understand the linkages between water, energy and food at the household consumption level, were applied for another city in India. Panvel, Maharashtra was selected for the purpose, which like Gurgaon is basically a satellite town for the metropolitan region of Mumbai, and is a hub of residential townships for the people working in Mumbai. Considering the limited variations likely to be observed in interlinkage between water, energy and food at the consumption level, the results from survey at Gurgaon were applied for the population of Panvel city.

Panvel, a new city of Maharashtra which forms a node of Navi Mumbai, has grown extensively in the last decade; largely because it adjoins Mumbai, the glamour and business hub of India. The city is also known as the **"gateway of Konkan"** region. It presents an excellent example of township where the state's initiative of involving private players in urban development has been a great success in India. The city is being developed, maintained and administered by City and Industrial Development Corporation of Maharashtra (CIDCO). The city is gaining its popularity because it is only Indian mega city to be featured on National Geogarphic Channel's 'Super Cities of the World'.

Despite its planned and gleaming infrastructure, the government has not been able to keep the pace with growing population and increasing level of urbanization in the city. The areas that are dilapidated and poorly connected, lacks adequate water and power supply with no proper sewage handling mechanisms. Though the Panvel basin receives adequate rainfall (more than 3000 mm annually), it frequently faces water scarcity as well as water quality problems in some of the areas[44]. The city meets its water supply demand from Dehrang Dam. During summer the water in the dam dries up and the city faces acute water shortage. Groundwater is used to supplement the water need that constitutes the main source of water for construction sector as well as bottling plants. The unsustainable pattern of developmental pattern has led to some obvious consequences with wells running dry and city turning into a concrete desert.

The population of the city as per 2011 census is 1.8 lakhs, where male and female constitutes 51 and 49 percent of the population respectively. The total water demand of the city as per the city agency is 26 MLD.

An application of results of survey at Gurgaon, indicate that water required for cooking food in Panvel city would be around 2 MLD, which constitutes eight percent of its total water demand. This water requirement includes water for cooking as well as washing utensils. The city needs 17551 kg of energy in the form of LPG for cooking raw food whereas requires 147.6 Mwh of electricity in consumption of food other than cooking. This includes reheating, processing and storage of foods using electrical appliances. The city also needs 198 Mwh of energy in the form of electricity for pumping water into the storage tanks which is further used for cooking along with other purposes like washing clothes, sanitation, flushing and floor cleaning. The table below summarizes the water and energy requirement of the city.

[44] Anbazaghan.S and Nair, A.M. (2004). Geographic Information System and Groundwater mapping in Panvel basin, Maharashtra, India. *Environmental Geology,45(6)*:753-761.

Table 18: Water and energy requirement for food in the Panvel City

The city	Panvel
Municipal Area	24 sq.km
Urban Population (2011 census)	180,020
Total water demand as per the city agency	26.5 MLD
Total water demand as per CPHEEO@150 LPCD	27.003 MLD
Water Supply source	Dehrang Dam, Groundwater
Water for food **per day (Including cooking and washing utensils)***	2 MLD (8 percent of total water demand)
Energy for food **(cooking) per day (only LPG)***	17551.95 kg
Energy for food **other than cooking per day***	147.6 Mwh
Energy for water **(pumping) per day***	198.02 Mwh

*Calculated on the basis of results obtained from the study

The Panvel city is experiencing a phenomenal rate of urban growth for last two decades. The rapid rate of growth of population and increasing urbanization resulted in the fast deterioration in the quality of life for the majority of people living in the city. The prosperity and growth of a regions depends upon the availability of infrastructure and services. Water and energy is the most crucial amongst these. Advance planning for the development of such resources are necessary taking into account the projected population of the region. Hence, in such scenarios harmonizing the water energy food nexus will reduce the burden on its resources, and the city authorities must focus on promoting resource optimization to meet the future demands.

Commercial kitchens

Commercial kitchens, found in restaurants and institutional facilities are intense energy users, putting food service facilities among the biggest energy consumers per square foot of all commercial buildings. In a typical food service facility food preparation, water heating and refrigeration combined together represent 60 percent[45] of the energy use. As a result they leave large carbon footprint, often using ten times the energy of the average commercial buildings[46].

Water and energy consumption

Four restaurants under different categories were surveyed in the study area whose details have been provided in the table below. The mean per day customers in these restaurants varied from 50 to 500. Per day mean consumption of energy in the form of LPG is 9.48 kg and in the form of electricity it is 31.60 kWh. Kitchens of restaurants like Subway are fully electrified and have **"flameless kitchen"** therefore uses more energy in the form of electricity. Energy used in Haldiram was highest both in the form of LPG as well as electricity. The reason attributed could be the highest number of mean customers daily in the restaurant. The daily mean water requirement of these restaurants is 100 l showing variation from 20 l to 200 l including cooking as well as cleaning of utensils.

Table 19: Mean water and energy use in commercial kitchens in the study area

Restaurant name	Mean customer daily	Food served	Water use (l)	Energy consumed	
				LPG (kg)	Electricity (kWh)
Subway	100	Veg+non-veg	80	0	32.37
Pizza Hut	50	Veg+non -veg	20	4.73	20.8
Haldiram	500	Veg	100	19	55.94
Dawat	60	Veg+non-veg	200	14.2	17.3

Source: TERI

Electrical appliances used in commercial kitchens

Key appliances used in commercial kitchens are commercial food processor, refrigeration, blenders, ovens, commercial ice makers, toaster, Bain Marie, grills, dish washer and kitchen exhaust systems. The power consumption by these appliances has been shown in the figure below. Food preparation makes up the largest percentage of restaurant's energy bill with refrigeration occupying the maximum consumption of energy (26 percent) followed by Bain Marie (22 percent). Bain Maries are regularly employed in commercial kitchens to maintain food at the desired temperature while further food items are waiting to be served. But on

[45] http://www.hospitalitybizindia.com/detailNews.aspx?aid=20135&sid=5
[46] Mudie, S., Essah, E.A., Grandison, A., and Felgate, R. (2013). Benchmarking Energy Use in Licensed Restaurants and Pubs. Chartered Institute of Building Service Engineering (CIBSE) Technical Symposium 2013, Liverpool John Moores University, UK

the contrary literature suggests that this practice reduces the nutrient content and palatability of the food items.[47] Both of these appliances account for 48 percent of total electricity consumption in food preparation.

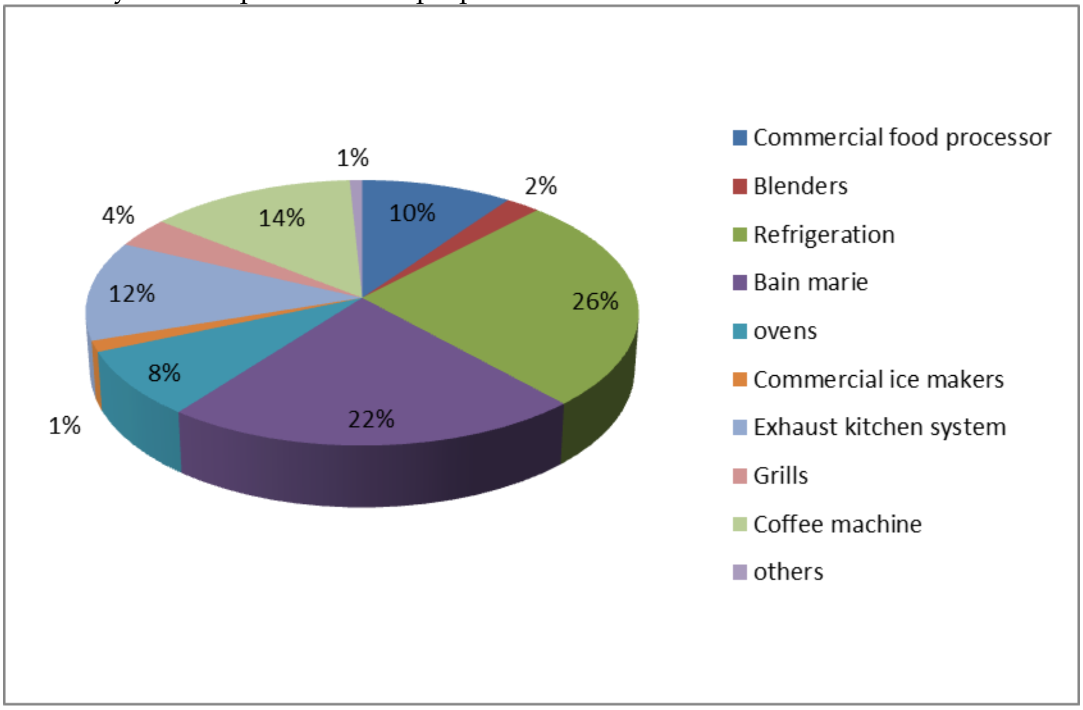


Figure 40: Pie chart showing daily consumption of electricity by commercial kitchen appliances

Coffee machine is the third largest consumer of electricity (14 percent) followed by kitchen exhaust system (12 per cent). Mixers, grinders, microwaves, ovens etc. are small electrical appliances but consume significant amount of electricity. Most of them need between 1 to 2 kWh of electricity daily.

Energy and water use in the kitchen of industry

An estimation of water and energy use in the kitchen of big industrial plant like Hero Honda was done. It was found that a plant with approximately 6500 workers having three shifts in rotation and one general shift consumes on an average 240 kL of water on daily basis. This includes water for cooking food, washing utensils and drinking water.

In term of energy use, the same plant consumes 120 kg of energy in the form of LPG and 4500 kWh of energy in the form of electricity on daily basis. To serve such a large working population in these plants , large Kitchen appliances are used such as chapatti making machines, grinders, potato mashing machines, flour machine and water coolers. Since these are big kitchens, insects like cockroach causes menace hence they are checked by using electrified insect killing machines. The type of food served in these kitchens is mainly vegetarian which also includes two time tea followed by snacks in each shifts. The table below summarizes the water and energy consumption in the kitchen of big industrial plant.

[47] Probert, S. and Newborough, M. (1985). "Designs, Thermal Performances and Other Factors Concerning Cooking Equipment and Associated Facilities." Applied Energy vol. 21: 81-222.

Table 20: Water and energy consumption in the kitchen of a big industry

Total workers	**6500**
Type of food served	Vegetarian
Water use	2400000 l/day (240 kL)
Electricity use	4500 kWh/day
Electrical appliances used in the kitchen	4 (in nos.)
• **Chappatti making machines**	2 (in nos.)
• **Grinder**	2 (in nos.)
• **Potato mashing machines**	1 (in no.)
• **Flour machine**	6 devices
• **Insect killing machines**	
LPG (6 cylinders of 20 kg each daily)	120 kg/day

Source: TERI

Recommendations

The issue of food security has to be seen in connection with water and energy security. Energy is required at all stages of food production and consumption whereas water is needed to extract energy for power generation . Thus, the interrelationship is so robust that improving the efficiency in one processes either through technological interventions or through regulatory approach will have impact on overall nexus elements. India needs to work on several areas to manage its developmental goal along with key challenges like urbanization and rising population. The key recommendations for optimizing the WEF nexus are:

1. From master plan to integrated development of cities

India is growing very fast in terms of population as per the recent projections made by United Nations and Planning Commission. Therefore, proper planning is required by taking the cognizance of projections made for the future; otherwise the country may face collapse of urban infrastructure leading to unmanageable situations in cities. Master plans have failed in our country because they are rigid and obsolete. They have been unable to cope up with the pace of growth of Indian cities. Lack of regional planning approach has led to haphazard proliferation of slums. As per the 12th Five Year Plan of India very few Indian cities have 2030 master plans that take into account basic services like water, sanitation, food, transportation, roads etc. This is the time to move a step ahead from master plans towards an integrated development of "smart cities" which aims at developing the urban ecosystem by strengthening institutional, physical, social and economic infrastructure. Ministry of Urban Development (MoUD) has already taken a step by releasing a new Urban and Regional Development Plan Formulation and Implementation Guidelines (URDPFI) in 2015. The objective of this plan is to replace the existing 1996 guidelines for formulating master plans and to promote and facilitate planned and integrated urban development in all cities of the country. Thus cities and towns need to be designed to be compact and connected, with energy efficient transport, green buildings, easy and secure access to water and food.

2. Sustainable food consumption

The food consumption pattern of India's urban and burgeoning middle class is changing with change in lifestyle and increasing prosperity. Research shows that there is increasing trend towards fast food and ready to eat food with more shares of animal products, sugar and fats. The change in food habit is not only causing health related issues like obesity and hypertension but significant amount of water and energy gets wasted at consumption level. According to FAO and UNEP, Sustainable Food System Program, which was adopted at the Rio+20 Conference in 2012, consumers exert strong influences through the ways they buy, transport, conserve, cook and consume their food. Food consumption is affected by wide range of factors, which includes, food availability, food accessibility and food choice, which in turn is influenced by geography, demography, socio-economic status, urbanization, culture, marketing and consumer attitudes. Therefore, there is an urgent need to develop holistic and effective strategies for promoting sustainable consumption as well as improving the food supply chain vis-a-vis efficient production which will address the nexus issues.

3. Governance, Institutions and integrated policy approach

Urban planning and management in India is basically a state subject. With the enactment of 74th Amendment Act of India in 1992, Urban Local Bodies (ULBs) like Municipal

Corporations and Municipal Councils have been constituted and entrusted with the task of town planning as well as social and economic development of their urban areas. Cities are growing beyond the municipal boundaries, hence, ULBs needs to be strengthened for the proper management of cities. Proper institutional mechanisms need to be relooked so that ULBs have their defined roles and responsibilities. Currently, India does not have policies that look at food, water and energy sectors in an integrated manner. Policies in the energy, water and food can only be successful if they are interlinked with each other, inclusive of climate change and environment policies.

4. *Green economy approach*

"Green economy" and "Green Growth concept" is a new policy approach being promoted in many international conferences and seminars to address the WEF nexus. The green economy promotes low carbon, efficient utilization of resources and social inclusion as drivers for sustainable development. Investing more on renewable energy, increasing efficiency in irrigation system, sustainable agriculture, reducing food wastage, checking water wastage, increasing fuel efficiency, etc. will reduce the carbon foot prints along with addressing the nexus issues. India has already taken steps towards developing a road map for transition towards green economies; however, more investment is needed on research and development towards green solutions.

5. *Ecosystem approach*

Ecosystem, to which we are an integral part, provides with many goods and services (regulating, provisioning, supporting and cultural services) that are required to sustain our livelihood. Organizations like International Centre for Integrated Mountain Development (ICIMOD) and United Nations Environment Program (UNEP) have promoted ecosystem based approaches in addressing WEF nexus policy dialogues. These ecosystems must be protected and enhanced to ensure the resilience of water, energy and food sectors.

Thus, the nexus approach recognizes the synergies between social, institutional, environmental and economic pillars of the society and mainstream the concept of "sustainable development" in planning at global, regional and national level.

6. *Watershed as a unit of micro level planning*

Traditionally, colonies and residential areas have been the unit of micro level planning within the city limits. Planning has been focussed on providing civic amenities like water supply, electricity, road connectivity and sewage facilties to the residents of an area. In cities like Gurgaon, focus of water supply schemes has been to lay down the pipelines, import water from outside the city limits and supply to the residents. While this is a convenient approach to solve water scarcity within the city, it increases its dependence on natural resources outside the city or state jurisdiction, and increases the vulnerability by limiting the scope of management only on supply and not on availability of water.

Moreover, the approach of laying sewage lines to expand the coverage only, disturbs the natural drainage patterns of a city. This is responsible for increasing incidences of water logging and urban floods, being reported across Indian cities, recently.

Adopting a watershed approach for micro-level planning, provides a leverage to incorporate greater degree of self sustainability to the city in terms of reducing its dependence on natural resources like water from outside the city limits. It increases the potential for water conservation options like rainwater harvesting and aquifer recharge. But it is more important to incorporate the watershed approach within the city development plans itself, especially in siting of residential colonies and other facilities. It is advisable that commercial and institutional establishments having less consumption intensity of water and food may be sited on the upstream locations of a watershed and residential colonies on the downstream localities. This will increase the availability of water for residential areas together with reducing the energy consumption in transporting water to upstream locations. This will also lead to reduction in financial expenditure for laying the pipelines.

7. Designing the residential buildings

Primary focus of architects and housing development agencies has been on optimizing the space utilization and reducing the cost of construction. Considerations about inter-linkages among three basic necessities of residents, i.e., water, energy and food, in planning and designing of building architecture, will ease the pressure on Residents Welfare Associations (RWAs) of maintaining their supply. For example, provisions of rooftop water harvesting, separate pipe connections of water supply for flush and cleaning systems, provision of renewable energy like solar, separate wiring for supply of off-grid electricity etc. could reduce the overall water and energy footprints of a building, while harmonizing their nexus with food consumption.

References

Ahmad, F. & Haseen,S. (2012). The Performance of India's Food grains Production: A Pre and Post Reform Assessment. International Journal of Scientific and Research Publications, 2(3),pp.1-15. Retrieved on 27.07.2015 from http://www.ijsrp.org/research_paper_mar2012/ijsrp-Mar-2012-64.pdf

Amarsinghe, U.A., Shah, T. and Singh, O.P. (2007). Changing Consumption Patterns : implications on food and water demand in India. Retrieved from http://nrlp.iwmi.org/PDocs/DReports/Phase_01/03.%20Consumption%20pattern%20changes-%20Amarasinghe%20et%20al.pdf.

Bentham, J. (2011). Water, Energy and Food Security in Urban Context. Published speech on World Water Week-Stockholm. Retrieved from http://s07.static-shell.com/content/dam/shell/static/aboutshell/downloads/our-strategy/shell-global-scenarios/speech-jeremy-benthamworldwaterwater24082011.pdf.

Dutta,P. (2006). Urbanization in India. Retrieved from http://www.infostat.sk/vdc/epc2006/papers/epc2006s60134.pdf

Emerson report (2013). The Food Wastage and Cold Storage Infrastructure Relationship in India: Developing Realistic Solutions. Retrieved on 28.07.15 from http://www.emerson.com/SiteCollectionDocuments/India%20Cold%20Storage%20Report%202013/Report_layout_Reduced.pdf

Hellegers, P., Zilberman, D., Steduto, P., and McCornik, P. (2008). Interactions between water, energy, food and environment: evolving perspectives and policy issues. Water Policy, 10 (1)1-10.

Hoff, H. (2011). Understanding the Nexus. Background Paper for the Bonn 2011 Conference: The Water, Energy and Food Security Nexus. Stockholm Environment Institute, Stockholm.

IARI (2012). Agriculture Policy: Vision 2020. Retrieved on 27.07.15 from http://www.planningcommission.nic.in/reports/genrep/bkpap2020/24_bg2020.pdf

Govt. of India (2011). Size, Growth Rate and Distribution of Population. Retrieved from http://censusindia.gov.in/2011-prov-results/data_files/india/Final_PPT_2011_chapter3.pdf

Lundy, J. and Bowdish, L. (2013). The energy-water-food nexus: Insights for the business community. US Chamber of Commerce Foundation.

Meadows, D.H., Meadows, D.L., Randers, J. & Behrens W.W.(1974). The Limits to Growth: A Report for the Club of Rome's Project on the Predicament of Mankind. New York: Universe Books.

Meenakshi, J.V. (1996). How important are Changes in Taste? A State-Level Analysis of Demand. Economic and Political Weekly, December 14, 1996.

Middleton, C. and Allen, S. (2014). The (re)discovery of "the Nexus": Political economies and dynamic sustainabilities of water, energy and food security in Southeast Asia. Paper presented at the Asia Pacific Sociological Association (APSA) conference "Transforming Societies: Contestations and Convergences in Asia and the Pacific", 15-16 February 2014, Chiang Mai, Thailand.

Ministry of Agriculture, GoI. (2011). Agricultural Statistics at a Glance. Retrieved on 27.07.2015 from http://eands.dacnet.nic.in/latest_20011.htm.

Moomaw, W., T. Griffin, K. Kurczak, J. Lomax (2012). "The Critical Role of Global Food Consumption Patterns in Achieving Sustainable Food Systems and Food for All, A UNEP Discussion Paper", United Nations Environment Programme, Division of Technology, Industry and Economics, Paris, France.

Murty, K.N. (2000). Changes in Taste and Demand Patten for Cereals: Implication for Food Security in Semi-Arid Tropical India, Agricultural Economic Research Review, Vol 13(1):25-51.

NCEAR (2014). An analysis of changing food consumption pattern in India. A research paper prepared under the project agricultural outlook and situation analysis reports Impact of globalization on food consumption pattern of urban India. Retrieved from http://www.fao.org/3/a-y5736e/y5736e02.pdf

NSS (2010). Housing Condition and Amenities in India. Government of India.

Pathak, H.,Jain,N.,Bhatia, A.,Patel, J., & Aggarwal, P.K. (2010). Carbon Footprints of Indian food Items. Agriculture, Ecosystems and Environment,139, pp.66-73.

Planning Commission, GoI. (2014). Report of the expert group to review the methodology for measurement of poverty. Retrieved from http://planningcommission.nic.in/reports/genrep/pov_rep0707.pdf

Rao Hanumantha, C.H. (2002). Sustainable use of Water for Irrigation in Indian Agriculture. Economic and Political Weekly,37(18),pp. 1742-1745.

Rasul, G. (2014). Food, Water and Energy Security in South Asia: A Nexus perspective from the Hindu Kush Himalayan Region. Environmental Science and Policy, 39, 35-48.

Sethia, S. (2013). India's Changing Consumption Pattern. Gyanpratha-Accman Journal of Management, 5(2).

Sinha, G. (2014). Linkages between food consumption pattern, food security and sustainable food system. A synopsis submitted for Doctor of Philosophy in Economics, Dyalbagh Educational Institute, Agra. Retrieved from http://shodh.inflibnet.ac.in:8080/jspui/bitstream/123456789/2060/1/synopsis.pdf.

Swaminathan, M.S. & Bhavni, R.V. (2013). Food Production and Availability. Essential Prerequisites for Sustainable Food Security. Indian J Med Res, 138, pp. 383-391

Swarnkar, K.N. & Singh, S.N. (2013). Analysis of Electrical Energy Consumption of Agricultural Sector in Uttarakhand State. International Journal of Emerging Technology and Advanced Engineering, 3(3), pp.343-347. Retrieved from http://www.ijetae.com/files/Conference%20ICERTSD-2013/IJETAE_ICERTSD_0213_53.pdf

The Planning Commission, GoI. (2012). The challenges of Urbanization in India: Approach to 12th Five Year Plan. Retrieved from http://12thplan.gov.in/12fyp_docs/17.pdf

UNDESA (2015). World Population Prospects: The 2015 Revision, Key Findings and Advance Tables. Working Paper No. ESA/P/WP.241.

UNDESA (2012).World Urbanization Prospects: The 2011 Revision. Department of Social and Economic Affairs, Population Division. United Nations, New York. Retrieved from http://esa.un.org/unup/pdf/wup2011_highlights.pdf

UNDESA (2006) "World Urbanization Prospects: The 2005 Revision". Uited Nations Department of Economics and Social Affairs- Population Division, New York http://www.un.org/esa/population/ publications/WUP2005/2005wup.htm.

UNIDO. (1995).Food Processing Industry. Output of a seminar on energy conservation in food processing industry. Retrieved from https://www.unido.org/fileadmin/import/userfiles/puffk/food.pdf

Vepa, S.S. (2004). Impact of globalization on food consumption of urban India. Retrieved from http://www.fao.org/3/a-y5736e/y5736e02.pdf.

Water Resources Information System of India, GoI. Retrieved on 27.07.2015 from http://india-wris.nrsc.gov.in/wrpinfo/?title=India%27s_Water_Wealth

World Economic Forum. (2009). Thirsty Energy: Water and Energy in the 21st Century. World Economic Forum in partnership with Cambridge Energy Research Associates.

Web linkages

http://articles.economictimes.indiatimes.com/2013-10-04/news/42718322_1_food-habits-foodpanda-in-restaurants.

http://dhbvn.org.in/staticContent/new/planning_manual.pdf

Annexure I List of study sites in different watershed

Watershed no.1

S. No.	Sites identified	S. No	Sites identified
1	Patel Nagar	18	Durga Colony
2	Adarsh Nagar	19	Janak Puri C Block
3	Sadar Bazar	20	Sector 11
4	Roshan Pura	21	Ohm Nagar
5	Housing Board Colony	22	Shivaji Nagar
6	Sector 15	23	Shanti Nagar
7	HVPNL Colony	24	Institutional Area
8	Officers colony	25	Sector 38
9	Civil lines	26	Sector 10 B
10	Sector 31	27	Sector 37 A
11	Sector 32 A	28	Sector 37 B
12	LIG colony	29	Sector 37
13	Prempuri	30	Udyog Vihar
14	Sainipura	31	Ambedkar colony
15	Sector 39	32	Khandsa Block B
16	Jharsa	33	Pace city II
17	Garoli Khurd	34	Godoli

Watershed no.2

S. No	Sites identified	S. No	Sites identified
1	Kherkimajra	11	Shakti park colony
2	Sector 102	12	Gandhi Nagar
3	Sector 101	13	Heera Nagar
4	Sector 10	14	Shivaji park nagar
5	Sector 10A	15	Khadipur village
6	Sector 37 C	16	Housing Board colony
7	Sector 37 D	17	Garauli Khurd
8	Sector 99	18	Gopalpur
9	Sector 100	19	Dhankot
10	Vikash Nagar		

Watershed no.3

S. No	Sites identified	S. No	Sites identified
1	Dharampur	21	Sector 3
2	Sector 108	22	Kheri
3	Daulatabad	23	Ashok Vihar 1&2
4	Md.Heri Village	24	Gurgaon Rural
5	Sector 106	25	Sector 3A
6	Panwala Khusropur	26	Surat Nagar 1 &2
7	Shastri Nagar	27	Laxman vihar -2
8	Vishnu Garden	28	Dahiya colony
9	Sector 105	29	Huda colony
10	Ratan vihar	30	Urban Estate
11	Sector 4	31	Sector 7
12	Sector 8	32	Shivpuri
13	Dayanand colony	33	Feroz Gandhi Colony
14	Surya vihar	34	Ambedkar Nagar
15	Krishna Colony	35	Sector 7 extension
16	Model town	36	Shakti Nagar
17	Laxmi Nagar	37	Shanti nagar
18	Ravi Nagar	38	Sector 9
19	New Jyoti park	39	Devi lal colony
20	Dhanwanpur colony	40	Kharkikhera majra

Watershed no.4

S. No	Sites identified	S. No	Sites identified
1	Shiv Vihar	15	Palam Vihar
2	Masani Vihar	16	Carterpuri village
3	Girgaon Village	17	Sukhrali village
4	Sheetla Colony	18	IFFCO colony
5	Ashok Vihar-2	19	Sarhol
6	South City	20	Inayatpur
7	DLF Phase IV	21	Sector 12 A
8	PWO apartments	22	Sector 13
9	Kanahi colony	23	Sector 17
10	Sushant Lok 1 & 2	24	Sector 22 A
11	HUDA	25	Sector 23 A
12	Sector 28	26	Sector 30
13	Sector 41	27	Sector 44
14	Sector 6		

Watershed no.5

S. No.	Sites identified	S. No	Sites identified
1	Kapashera	5	Sector 21
2	Palam farm	6	Sector 22 A
3	Salapur Khera village	7	Sector 23
4	Sector 20	8	Dundahera

Watershed no.6

S. No	Sites identified	S. No	Sites identified
1	Saraswati Vihar	9	Kendriya Vihar
2	Sector 26 A	10	Sector 56
3	Sector 26	11	Ardee city
4	DLF Phase I and IV	12	Bindapur
5	Sector 27	13	Koyal Vihar
6	Garden Vilas Block C-2	14	Orchid Island
7	Sector 52 A	15	Sector 46
8	Sector 52	16	Jalvayu Towers

Annexure II Questionnaire Component: Household survey

Data Item 1: General Information

Respondent Name	Locality	Total members in a house

1.1. Type of Flat

Owned	**HK**	**HK**	**HK or more**
Rented	**HK**	**HK**	**HK or more**

1.2. Type of building

High Rise Apartments (Specify the floor/Construction firm name)	Society (Name)

Data Item 2: Food consumption

2.1. Type of meal preferred (most)

Veg	Non-veg	Both	Eggs only

2.2. No. of days HH consume non-veg in a week

1	2	3	4	5	6	7

2.3. Most preferred non-veg

Chicken	Fish	Meat	Eggs	Others (specify)

2.4. How often do you eat outside?

No. of Meals (breakfast/lunch/dinner)	Daily	In a week (days)	In a month (days)

2.5. (a). Preference for ready to eat food

Yes	No

2.5. (b). Ready to eat food consumed

Item	Quantity	Daily/in a week/in a month
Bread		
Butter		
Cheese		
Jam		
Pickles		
Biscuits		
Chocolates		
Juice (Topicana/Real)		
Others		

2.6. Do you treat water for drinking? Yes/No (if yes please fill the table below)

Method	Quantity	Time	Quantity used for cooking
Water purification (without electricity)			
Water purification (with electricity)			
Boiling			
Bottled water		NA;	

2.7. Consumption of daily food item

Item	Quantity per week/month
Rice	
Pulses	
Wheat flour	
Vegetables	
Dalia	
Oats	
Others	

2.8. Water used in washing of utensils daily

No. of times washed	Duration (in minutes)

2.9. Consumption of beverages:

Tea (cups/day)	Coffee (cups/day)	Lemonade/tangs/glucose/others (glass/day)

2.10.(a). Total no. of cylinders used in a year
2.10.(b) Gas consumed in a year as per meter
2.12. Electrical appliances used in a kitchen

APPLIANCE	Brand/ Specification	Wattage (if mentioned)	No. of Minutes used
Microwave			
Induction			
Toaster			
Mixer			
Juicer			
Sandwich maker			
Refrigerator			
RO (water purification)			
Food Processor			
Others			

2.13. Management of left-over food daily

Type of food	Management (fed to cows/dogs/maid/dustbin/others)	Approx. quantity
Rice		
Pulses		
Chappatti		
Vegetables		
others		

Data Item 3: Water Component

3.1. Water bill per month
3.2. Water sources:

City/town water supply	HUDA	Own borewell

3.3. Pump details

Pump capacity	No. of pump(s) used	No. of hrs used in a day	Storage tank capacity (L)

3.4. Water used appliances

Appliance	Brand/ Specification	Wattage (if mentioned)	No. of Minutes used
Hot water geyser			
Water Coolers (not refrigerators)			
Washing Machine			
Others			

Data Item 4: Energy Component

4.1. Electricity Bill

4.2. Do you use inverter (Yes/ No)

4.3. Power cut (hrs/day)