PAKISTAN'S FOOD WASTE AND ITS MANAGEMENT UNDER CIRCULAR ECONOMY MODEL

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CERTIFICATE

This is to certify that this thesis entitled: **"Pakistan's Food Waste and Its Management Under Circular Economy Model"** submitted by **Ms. Aqsa Noor Shaikh** is accepted in its present form by the School of Economics, Pakistan Institute of Development Economics (PIDE), Islamabad as satisfying the requirements for partial fulfillment of the degree in Master of Philosophy in Environmental Economics.

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Dedication

I dedicate this thesis to my beloved parents who always have been my support system. I dedicate this work of mine to my father Mr. Dad Muhammad Shaikh and my Late mother Mrs. Roshan Ara. I dedicate this thesis to the hard work and sacrifices they have made for me to reach thisstage of my life.

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Abstract

Global increment of population and economic growth has increased not only the demand for food but unfortunately, it has also increased both food loss and waste Pakistan is a developing nation, though in developing nations food loss at earlier stages of the supply is chain is happening to be more, it doesn't mean that at consumption stage there is no such problem. This study has tried to shed light on the consumption stage's household-level of waste in Pakistan. The study has focused on both the quantitative and qualitative sides of food waste. On the quantitative side, the objectives of quantification of household food waste have been estimated of a total of 386 households using a random stratified sampling technique coupled with carbon, land, and Bluewater footprints and economic and nutritional loss along with impacts of main food waste drivers are estimated through mathematical and econometric models. On the qualitative side, a descriptive systematic review has been done to present efficient, effective, and adaptative policy options to manage food waste under the light of the circular economy model. Findings showed that on average 0.25, 0.05, 0.03,0.03, and 0.01 million tons/year are wasted in the food categories meat and products, cereals and pulses, toot tubers, fruits and vegetables, and fish products respectively. Although 16% of the population is food insecure according to the Pakistan Bureau of Statistics' latest FIES report, each year on average 272.8 billion tons kcal is wasted from animals and meat products category. Cereals and pulses, fruits and vegetables, and root tubers categories 7.6, 22.2, and 27 billion tons/kcal are wasted every year respectively. Due to the fish and products category 56 billion tons/kcal/year are wasted. The study calculated that each year 243, 101, 38, 66, and 228 billion are wasted due to the reported loss of meat and animal products, cereals and pulses, fish products, root tubers, and fruits and vegetable categories respectively. The econometric model shows that higher education level, income, total family members, and meals prepared in a day impact positively on the generation of food waste. The study has suggested prevention of food waste is economic, social, and administratively feasible to adapt and implement.

Key words: Household Food Waste, Circular Economy, Carbon, Land Footprint.

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Chapter One

Introduction

Food loss and waste are one of the major global challenges. It is generated at every stage of the supply chain through various problems like unawareness about production, lack of awareness, insufficient storage and transportation facilities, and lavish food consumption behavior. Food loss is occurred mostly in developing countries due to thepresence of a variety of factors i-e; lagging policies and their implementation regarding stated problems such as unnecessarily raising food prices and thereby affordability issues for poor sections of societies as well as it creates harmful impacts on the environment at every stage of the food supply chain, whereas food waste is developed nation' problem. The effects of uprising FLW affect socio-economic conditions such as unnecessarily raising food prices and thereby affordability issues for poor sections of societies as well as it creates harmful impacts on the environment (Gustavsson et al.,2011).

According to the world food and agriculture organization, food wastage not only affects already scarce resources like water, land, and energy during production, processing and transporting, and consumption stages of the supply chain but also affects world food security which alone is already a huge challenge globally. There are multiple strategies to decrease these adverse effects of food loss and waste among them the most preferable strategy is wastage reduction to meet the ever-growing food demand. Around 180 kg per person of food is wasted annually in the EU in which the wasted food at the consumption stage is around 101 kg per person yearly among which 76 kg per person waste is generated yearly from

households of the EU. This shows a significant amountof food waste comes from the household level (de Laurentiis et al., 2018). According to FAO's latest statistics, the number of undernourished people was recorded at 821.6

million in 2018 and 704.3 million people were severely food insecure. Pakistan was number 3rd in consisting of undernourished people accounting for nearly 50 million (Food and Agriculture Organization of the United Nations, 2018).

Food waste is categorized into three different; avoidable, potentially avoidable, and unavoidable wastes. Around 53% of food waste comes from households in EU countries and around 90 million tons are wasted only in the EU. About two-thirds of this waste could be reduced through different strategies. A study conducted in Croatia shows that a household unit generates about 0.21 kg per day, making 75 kg per food waste capita annually. The study shows a relationship between sociodemographic variables and food waste generation. Several children and an increase in income lead to more waste whereas; older people tend to create less waste. Households with more adults tend to waste a higher amount of meat and potatoes and households with more children waste a larger number of dairy products, rice, and pasta (Ilakovac et al., 2020).

Food waste creates several other problems that affect adversely not only economies and societies but also harm the environment. It affects natural resources like wastage of water, energy consumption, and emissions due to transportation and production of the food as well as affects land by disposal of wasted food in landfills (Nahman et al., 2012)

Under England's Waste and Resources Action Program, the water and carbon footprint of the UK's household waste an estimation of economic and environmental losses showed that about 8.3 million metric tons of food and drinks are wasted yearly in the country among which 5.3 million metric tons was identified as avoidable waste. The total waste generated by the UK's households costs around 18.6 billion dollars and about 20 million tons of Co2 is emitted yearly due to avoidable food waste which accounts for 3% of GHG domestic emissions of the country. The water footprint showed that 6% of the total water requirement accounting for 6,200 cubic metric tons is wasted due to avoidable food waste in the country (Dr. Chapagain & Keith, 2010).

The wastage of food is a global issue that contributes significantly to solid waste creation all around the globe. A report by Morisaki 2011 estimated the total edible food waste generated by households and the food industry of Japan was approximately 17 million metric tons which also accounts the 30% of the produced food in Japan. The study carried out on 134 food commodities of the US showed about 29% of produced food commodities are wasted annually which releases nearly 112 million metric tons of Co2, 2% of total carbon emissions of the country. The estimated total waste causes theloss of about 198 billion US dollars yearly (Venkat, 2011)

A circular economy in the context of sustainable consumption as well as production is considered one of the best alternatives to a linear economic model of producing, consuming, and disposing of the environment (Parajuly & Wenzel, 2017). Food waste management through a circular economy can not only be beneficial for the environmentand human health but also can be

very economical. Anaerobic digestion of food waste in the context of a circular economy is one of the best possible final destinations of wasted food (Slorach et al., 2020).

1.1. Problem Statement:

FLW is the hidden determinant of national food security and sustainable development. About one-third of the produced food is wasted annually around the globe according to a released report on FLW footprint by The Food and Agriculture Organization. This wastage creates huge direct economic costs to the tune of 1 trillion USD. Add into is the estimated 700 billion USD as environmental costs and up to 900 billion USD yearly social costs (Agyepong, 2015).

Despite the growing attention on identifying the reasons for food wastage and accounting for its impacts along with its management sustainably globally, there is not much work done in this area in Pakistan. There is a rising trend in food loss and waste at all levels of the food supply chain. Pakistan has quite limited research on food loss and waste in general and specifically at the household level. There is not much work done on quantification and monetizing food waste at the household level and its management under the latest and most sustainable way to adapt and mitigate the hazardous impacts of waste under a circular economy. Literature reveals that in Pakistan there is a grave lagging in research and development of the management processes of household waste through globally acclaimed and adopted ways like re-use (redistribution, animal feed), material recycling, nutrient recovery (composting, anaerobic digestion), energy recovery (biofuel production, incineration) under circular economy or sustainable management of food waste. There is a

severe research gap in identifying the impacts and reasons for disposing of food waste without a sustainable management process. This study aims to serve to throw light on these severe issues in Pakistan.

1.2. Objectives of the Study:

The study contains a total of six major objectives, among them 5 of them covering the quantitative side of the research, and one objective is of qualitative side of the study thefollowing objectives.

Quantitative Research Objectives:

- To quantify the household food waste in Pakistan.
- To estimate environmental losses due to the generation of household foodwaste.
- To estimate nutrition loss caused by household food waste.
- To estimate the economic loss caused by household food waste.
- To determine the main drivers of household food waste.

Qualitative Research Objective:

- To analyze the available options for managing household food waste using acircular economy.

1.3. Research Questions:

- How much food is purchased at the household level?
- What type of food (cooked and uncooked) and quantities are wasted at thehousehold level?
- How much household food waste is generating Carbon Footprint, Land Footprint, and Bluewater Footprint in Pakistan?
- What are the possible final destinations of that wasted food by households underthe circular economy model?

- How much monetary loss is happening due to household food waste?
- How many nutrients (kcal) are being wasted because of the food wasted byhouseholds in Pakistan?

1.4. Significance of the Study:

Contextual Perspective:

This is hardly any in-depth study in Pakistan that offers in-depth insights on food loss and waste in different categories of food along the supply chain. Resulting in very little effort invested in food preservation, safety, and management at all levels of society. There is an immediate need for sustainable ways to meet the ends of humans by reducing and mitigating the hazardous impacts of human activities on the environment and our economies all around the world. The adaptation of a circular economy is one of them. Despite, the given ample amount of attention to its adaptation globally, in Pakistan its thriving population, and growing food insecurity there isn't much work done in this field. The lack of awareness, inadequate facilities, and policies created an increase in the rate of food loss and waste throughout the entire food supply chain. This study aims to identify the reasons for food waste and its implication on socio-economicconditions and environmental impacts. Urban cities like Karachi being the hub of distribution and retailing and consumption of food is also generating most of the food wastage. Around 12000 tons of daily vegetable waste is generated per day FLW is creating health and societal issues along with environmental degradation through polluting land, air, and water in and around the financial hub of Pakistan.

Practical Perspective:

The significance of food loss and waste can be seen in sustainable development goals' goal number 12 of responsible production and consumption and goal 2 to reduce hunger. This study aims to estimate the waste at the food household level in Pakistan coupled with the shading light on the social drivers of food waste in the country. Otherthan that, this study has tried to enlighten its audience about the nutritional and economic losses and environmental losses by estimating the carbon footprint, land footprint, and blue water footprint.

The food hierarchy says the first and foremost step is to reduce or cut down the food loss and waste. But, in a country like Pakistan in the presence of many hurdles, it is difficult to cut down the wastage immediately and effectively. The agenda of the circular economy of reducing, reusing, and recycling is an essential and innovative tool to convert food wastage into feedstock or other resources like converting them into bioenergy. So, this dissertation has analyzed available options for food waste management at the household level with the broader conceptual lens of the circular economy to reduce the socio-economic and environmental negative impacts.

1.5. Organization of the Study:

This research study contains a total of six chapters. The first introductory chapter is followed by a thematic literature review. This chapter has a brief thematic based on all6 objectives nature. After that, the third chapter is on the methodology which explainshow we have achieved the said objectives of the study. The fourth chapter narrates the results, discussions, and descriptive statistics. And the second last chapter consists of a systematic

review. Lastly, the final chapter of this study is the conclusion and policy recommendations.

Chapter Two Thematic

Literature Review

2.1. Environmental Impact of Household Food Waste:

Every year one-third of the produced food is wasted (Agyepong, 2015). Which is nearly 1.3 billion tons. Food waste burdens the environment in many ways. In Europe, one ofthe major concerns about food waste's impact on the environment is its share in global warming. Emissions are released throughout the supply chain. Approximately three- quarters of all food waste impacts regarding global warming come from emissions of Greenhouse Gas only in the production process. Furthermore, the processing stage releases 6% of GHG, and retailing and distribution stage contributes 7%, and at food consumption and disposal stages 8% and 6% of GHG releases respectively. It releasesnitrogen oxide, and ammonia into the soil and atmosphere through the usage of fertilizers and livestock emissions respectively (Scherhaufer et al., 2018).

A study shows that the environmental impressions implanted in the daily food waste of a normal person are 124 g CO2 equivalent, 58 liters of freshwater consumption, 0.36 m2 arable land consumption, 2.90 g nitrogen, and using 0.48 g of phosphorus. Oatmeal, meat, and sugar are important nutritional categories that contribute to environmental impacts. Our results show that different countries have generally placed different ecological endorsements and imprints on their food waste that include explicit pleas for the country's waste reduction (Chen et al., 2020).

Food waste affects land, water, air, and biodiversity. It involves an additional externality in society due to the ways it is monitored (Bajzeli et

al., n.d.). Bluewater impressions are created around the world (e.g., use of surface and underground water resources). The food wastage is about 250 km3, which is equivalent to the annual supply of water from the Volga. However, food delivered unused leads to the misuse of 1.4 billion hectares of land, which also accounts for about 30% of the world's agricultural land. Not in the water and in the land, but in the wastage of food from the inappropriate use of the land for agricultural purposes, which is why there is also a loss of biodiversity. Harm to warm-blooded animals, terrestrial and aquatic creatures, and birds (Food and Agriculture Organization of the United Nations. & Food Wastage Footprint (Project), 2013).

Food waste has a direct impact on land, water, the atmosphere, and biodiversity. It can add in an additional externality due to the ways it is managed such as transportation and disposal of the waste (von Massow et al., 2019).

Around the world, the blue water impression (for example the utilization of surface and groundwater resources) of food wastage is around 250 km3, which is comparable to the yearly water release of the Volga River. Produced but uneaten food results in waste of 1.3 billion hectares of land usage which also accounts for approximately 30% of the world's agricultural land. Not on water and land but food waste due to excessive use of land for agricultural activities purpose it creates a loss of biodiversity as well. Harmingmammals amphibians and birds(Agyepong, 2015).

Food waste is a major element of food system challenges globally. With the inclining world population and urbanization, there is the rise of trends in food waste as well as pressure on using the world’s natural resources like

land, energy, and water. It is utterly important to produce, consume and manage the waste sustainably to meet the demand of the ever-growing population as well as the demand of lowering environmental degradation. Food waste also contributes to the generation of landfill gas at the dumping sites. It releases methane during the process of decomposition which is considered to have a 20 to 25% stronger warming effect than carbon dioxide on a molecular basis. Methane has a share of 18% in creating global warming one of the major elements of climate change. About 500 million tons of methane are released every year among them 40-75 million tons are generated at the organic waste landfill accounting for 8-15% of the total (Nahman et al., 2012)

The level of food loss and waste varies between nations and is influenced by financial stability, and urbanization. In less developed countries, FLW occurs mainly in the post- harvest and preparatory stages, accounting for about 44% of global food wastage. This is caused by impotent practices, specialized and mechanical limitations, labor and money constraints, and the lack of a legitimate basis for transportation and capacity. Created nations, including the European, North American, and Oceanic as well as the developed countries of Japan, South Korea, and China, produce 56% of the world's food wastage. Of these, 40% of the food loss and waste in the created countries are attributable to the use phase, which is typically determined by consumer behavior, qualities, and mindset. Much of food waste occurs after it's been prepared, cooked, or served, as well as not being eaten before its sell-by date due to over-purchasing, which can be related to a lack of common sense and bulk buying. At around 222 million tons, the Food Waste (FW) measured in the industrialized nations roughly

corresponds to thetotal net generation in Sub-Saharan Africa (SSA) regions (230 million tons). It is also a fundamental problem in health instability because it reduces the accessibility of food for human consumption. FLW also has real ecological, need, financial, and environmental impacts. When waste is disposed of in landfills, a large portion of that is converted into ozone-depleting substances (GHG) and methane, which has a multipleglobal warming potential than carbon dioxide. Food waste degrades faster than other landfill materials with a higher methane yield and almost no impact on biogenic sequestration in this space. According to Rutten, food waste appeals to scattered interest in agriculture and produces large gaps in information perspectives such as land, labor, water, compost, and energy. Some research also showed that the waste reduction campaigns in developed countries could reduce food costs in emerging economies, increase the effectiveness of their manufacturing network, and ration resources that can be used to help those who are starving. Such changes could lead to more developed approval of nutritious food varieties for vulnerable families (Ishangulyyev et al., 2019).

2.2. Economic Impact of Household Food Waste:

Economies bear a huge amount of economic cost due to the generation of food wastage around the globe. Food loss and waste at all stages create approximately USD 680 Billion for the developed countries and USD310 Billion for the developing countries. Food wastage has both direct adverse impacts in terms of loss of uneaten food as well as malnutrition and its outcomes. According to the FAO Pakistan bears USD 7.6 Billionyearly due to malnutrition (Karim Khan, 2021). An average household in Pakistan uses around 50.8% of its income monthly (Shaikh, 2020).

According to the food wastage footprint, the salient environmental and societal cost includes a carbon footprint of 3.5 Gt CO2 causes damages of USD 394 billion. Water scarcity due to food wastage costs USD 164 billion annually. Around USD 35 billion annually is lost because of nutrition loss, lower yields, and biological damages caused by soil erosion through food wastage. The estimated cost of biodiversity loss through the exploitation of marine and freshwater lives, pesticide use in production, and nitrate and phosphorus eutrophication is USD 32 billion per year. The estimated social cost due to conflicts on soil erosion is USD 396 billion. An estimated cost of the loss of livelihood due to soil erosion annually is USD 333 billion. In the production stage, exposure to pesticide generate a health cost of USD 153 billion per year (Food and Agriculture Organization of the United Nations. & Food Wastage Footprint (Project), 2013).

According to a study carried out in South Africa accounting for economic cost at the household food consumption level is estimated at around R21.7 billion (approximatelyUS$2.7 billion) annually, or 0.82% of South Africa's annual GDP(Nahman et al., 2012). Literature reveals that Australian households have a greater influence on generating food wastage in the country. Food discarded by households in Australia annually is worth around AU$3,800 (Rahman & Kim, 2020).

Literature shows a reduction in food wastage in developed countries affects positively developing countries by reducing the food prices and increasing the food accessibility for the poor. Reduction in food loss and waste also creates a win-win situation for bothretailers and consumers as retailers will be able to sell more at lessen prices and consumers will be able to save their

money. As per food waste kg per capita developing Arab countries waste 31% of cereals, 33% of roots and tubers, 29% of oilseeds and pulses, 56% of fruits and vegetables, 23% of meat and poultry, 30% of fish, and seafood, and 20% of milk and dairy accounting 210 kg per capita which is higher than European and North American countries around 95-115 kg per capital (Abiad & Meho, 2018).

The amount of food wastage tends to vary from developing to developed countries. About 40% of food is lost at the upper stream of supply in developing countries. However, in a developed nation, about 222 million tons per year is wasted. In Iran literature explains there is an ample amount of food that is wasted at every stage of the supply chain. From 18.5% to 35% of produced food is wasted according to various studies in Iran. According to the report of Iran's Food Producers Cooperatives, the total estimated amount of food products produced in 2016 was 130 million tons among them about 25 million tons were lost or wasted. Economically in 2017 30% of food produced was wasted accounting for around $5 billion annually according to the Financial Tribune (Fami et al., 2019).

The seven most wasted items in Iranian households account for 72& of total food waste. The total disposal of household food waste per week was estimated on an average at 1596.13 g. The estimated per capita food waste of Iranian households was 512.67 g and 26.7 kg per week and year respectively (Fami et al., 2019).

2.3. Nutrition Losses due to Household Food Waste:

Meanwhile, 33% of the food delivered for human consumption is lost or wasted, one billion people in the world suffer from appetite and hunger,

making food waste a majormaintenance problem. Food that is not eaten or thrown away at the end of the day is called food waste. Reducing food waste can lower food costs, benefit the climate, and further improve food security and human well-being, as food contains different nutritional supplements that are vital in preventing disease. Assessing food and livelihood waste is essential to raise awareness among the general population of the importance of disposing of food as waste and to promote regional and global strategiesto reduce food waste or redirect excess food to those in need before they are wasted. A study was conducted to quantify food waste and analyze the causes of food waste at the household level in Tehsil Kahror Pakka, Pakistan. Examine the destinations, the food waste generated during the 24 hours was collected from 51 families, sorted, and weighed into various types such as B. Organic produce, vegetables, ready meals, processed foods, meats including fish and poultry, and dairy products. The highest food waste was in ready meals (35.02g) and the lowest was in dairy (1.98g) per capita per day. The nutritional benefits of food waste were assessed by examining the benefits of each food using the Pakistan Food Synthesis Table. The family food waste total was based on an expected value of energy (54.42 kcal), protein (2.61 g), lipids (2.21 g), carbohydrates (10.58 g), dietary fiber (0.75 g), β-carotene (275.2 mcg) and nutrient A (96.83 RE), calcium (Ca) (22.49 mg) and phosphorus (P) (37.11 mg) per capita and day. Energy losses were higher for cereals (79%), while moisture losses were higher for organic produce (53%) and vegetables (69%). Approximately 2.6% of all out-kcal (2100 kcal) essentials for Pakistani food containers were wasted through food waste. In summary, the majority of respondents said prepared food is wasted because

it looks awful (50%), the feast is poorly planned (40%) and it is improperly cooked (36%). Prepared foods are mostly wasted because respondents are unaware of how dates are reported (50) (Khalid et al., 2019).

Reducing food waste can make a strong contribution to several Sustainable Development Goals (SDGs), but the differences in food waste across countries in terms of added nutritional supplements and environmental impacts are not significant. This study estimated daily food abuse per capita for 151 countries using two late markers ofimplanted food failure (wasted supplement days and wasted daily food) and five ecological impact indicators. After all, a person wastes 65 kg of food every year, of which 25% goes to vegetables, 24% to grains, and 12% to natural products. The wasteddaily amounts of the nutrients C, K, zinc, copper, manganese, and selenium are particularly high, accounting for half of your daily Recommended Dietary Intake (DRI)value. Grains and produce are the top three nutritional categories that contribute the most to supplement waste, followed by meat, dairy, and eggs, which are majorcontributors to calcium, choline, riboflavin, zinc, and nutrient B12 waste. The global standard measure of food waste per capita includes 18 robust weight management planseach year, meaning you can meet the DRIs of 25 supplements for one person for 18 days (Chen et al., 2020)

The occurrence of food loss and waste hit society by affecting livelihood and nutrition loss and increasing food insecurity. About 36 million tons are wasted in Pakistan during the supply chain. Being a developing the occurrence of food loss is likely to be more happen but the literature reveals at the consumption stage in the food service industry about 30 to 40% of food is wasted only in the catering business in weddings. About 870kg of food is wasted per day in a hotel in the capital of the country. According to the World Food Program, approximately 43% of the population in Pakistan remains food insecure (Shaikh, 2020).

According to the national nutrition, survey shows 15 % of children in Pakistan suffer from acute malnutrition which also happens to be the second-highest in the region (Shaikh, 2020). According to the Global hunger index 2019, Pakistan stands at 88th out of 132 countries (Karim Khan, 2021).

According to the Waste and Resources and Action Program report, statistics showed that 61% out of total household food waste was an avoidable waste that could have been eaten through proper management. Along with 20% of possibly avoided waste and the total inedible or unavoidable food was only 19% out of the total waste. This amount of waste can be used to feed 1 billion people around the globe. The severity of the situation shows that this huge amount of waste inclines the food insecurity and hunger challenges in less developed or developing countries. By the reduction of such an amount of food waste can improve the low nutrition and hunger problems globally (Nahman et al., 2012).

In developed countries like the U.S.A food waste is a major contributor to

the waste stream affecting nutritional losses. The study reveals around 10,205 tons of food wasted only in one the year 1998-1999. In which household food waste was accounted for 60% of total wastage followed by 20% waste production stage, 1% 19% waste was estimatedat processing and distribution level respectively. About 8.8 billion kilocalories were wasted during the same year. Such an amount was enough to feed the country's people for up to 1.5 months. Up to 28% of total food waste was recovered through composting and donations. And up to 7000 tons were dumped at landfills (Griffin et al., 2009).

2.4. Household Food Management through Circular Economy:

This old production process lacks the recycling aspect. The released residual of such process in the atmosphere destroys the ecosystem, eventually impacting negatively onhuman life in every aspect. With the rise in food demand globally, linear economical activities are stimulated. Because of this occurrence, an increment in environmental stress has been taking place. Consequently, declining food and health quality has been taking place simultaneously (Toop et al., 2017). The strong adaptation and use of the linear economic system has created more problems than solving the existing ones for the purpose of completing the products demanded. What this world has been doing since the earliest times is producing, consuming, and finally discharging. This treatmentof nature as a dump from the beginning has now created the cause of misfortune not only for humans but for the entire environment (Posthumus, n.d.).

Waste management in developing countries is affected by various issues such as weak economical-social factors, staggering or low economic

growth, lack of efficient administrative capacities, lack of awareness about environmental impact and legislation. With the lack of management facilities and infrastructure, developing countries mostly use dumping and disposal of waste in landfills. It creates a whole new set of challenges regarding health, pollution, and scarcity of resources (Ilić & Nikolić, 2016). There is an utmost need to manage such severe and complex waste through an effective and efficient method that can be useful and adaptable for developing countries as well. A circular economy with the agenda of sustainability, and socio-economic stability is the latest method getting attention all around the globe (Ferronato et al., 2019).

Food waste can be managed sustainably through a circular economy. Food waste contains organic waste which is a great source of converting waste into energy or organic nutrients or animal feed through Anaerobic Digestion, Compositing, and Valorization respectively. The study shows conversion of the linear economy into the circular economy by using life cycle assessment to treat food waste through the Anaerobic Digestion process (Ingrao et al., 2018).

With the rising in population, the increase in demand for food has put extra pressure on the usage of natural resources and the degradation of the environment. The need for more has increased the usage of freshwater making agriculture the largest consuming sector of it. Almost one-third of the energy is used to produce and supply food around the globe. The inclining demand is affecting the land as well as about double the present agricultural land would be needed to produce food to meet the demand. This overexploitation will not only cost the environment but will decline the

socio-economic conditions as well globally. To tackle down these impacts there is an immediate need to adopt a circular economy to lessen the impacts and to meet the future demand for food in a sustainable way (del Borghi et al., 2020).

The development of biogas programs in rural China has brought great economic, social, ecological, and environmental benefits. A study done to identify the benefit relationship for the different stakeholders through the evaluation of relevant policies, an analysis of the costs and benefits and an estimate of the environmental benefits of the use of animal manure in a company biogas power generation plant (BPGC) in Zhejiang province. The results of the study showed that the net present value (NPV) of the project was $ 8.85 million and the internal rate of return (IRR) of the was 36%. Compared to current projects, the BPGC had more investment potential. The annual environmental benefits of chemical oxygen demand and reduction of NH3-N are $ 2.61 million and $ 0.21 million, respectively. The environmental benefit of reducing greenhouse gas emissions is $ 1.54 million / year. When the environmental benefits were factored into the cost- benefit analysis, the NPV of the project was $ 42.01 million and the IRR of was 123.98%, and the BPGC showed social benefits. important. partnership model to achieve a common balance of benefits between government, business, pig farms, and residents (Hu, et al., 2017).

The trend of urbanization and industrialization has drastically depleted the resources. The world is now moving toward sustainability. The circular economy is an emerging way to achieve sustainability. The core of circular agriculture is to reutilize the waste as products through 3Rs; reuse, recycle and reduce. Through these 3Rs we can achieve sustainable economic

development, less resource consumption, and reduced environmental degradation (Jun & Xiang, 2011).

It can close the loopholes of residuals released by cropping patterns, animal waste, and human waste particularly from urban areas by using them and producing organic fertilizer. Discarded waste can be utilized in many ways to attain agricultural development. All three types of urban waste; i) whole fraction, ii) Solid fraction, and Liquid fraction can be reused to produce energy resources like biogas, bio- fertilizers/organic fertilizers after completion of certain processes on the waste at an anaerobic digestion plant. It is said that about 13-18% of electricity consumption can be achieved through biogas generated from urban waste (Peng & Pivato, 2019). A study was done to estimate the environmental impacts of organic waste management through circular economy tools: incineration, decentralized composting, and centralized anaerobic digestion. The authors did the comparison based on a large-scale case study in the southern Kingdom of Sweden and used input data related to similar aspects of source separation behavior, transport distances, etc. that are site-specific. Theresults reflected that both anaerobic and aerobic biological treatments lead to a reduction of greenhouse gas emissions but make a greater contribution to both nutrient enrichment and natural effect compared to incineration. The study showed that both ways can be a good energy substitution and emissions during biological processes. It was also found that using biogas as a Danish electricity replacement makes more sensethan burning organic waste. This can be mainly due to the use of plastic bags in the different incineration (compared to paper bags in the associated aerobic grade) and to the use of bio-fertilizer (digestate) from anaerobic treatment to replace

the chemical fertilizers used as an incineration alternative. The impact of the internet on the GWP ofthe management chain varies from a contribution of 2.6 kg CO2eq per household per year when incineration is used to a rejection of 5.6 kg CO2e per household per year, if anaerobic is chosen Digestion and abuse turned biogas into car fuel impacts are often enthusiastic about assigned processes from management to indigenous decision- makers, pointing to the importance of a holistic approach and expanded collaboration between stakeholders within the waste management chain (Bernstad & la Cour Jansen, 2011).

Chapter Three

Methodology and Data Collection Techniques

This chapter includes the conceptual and empirical framework of this research. This chapter explains quantitative perspective methodology. It is divided into four different parts. The first part is all about the conceptual framework. Through the conceptual framework, all the concepts and their relations are detailed and defined. Following that, the chapter contains the research design and area of the study. The second part of this chapter includes sampling methods and sampling techniques. That is how the sample size was designed through which technique data was collected. The third part of this chapter contains information about data collection. It explains the types of data sets used in the research, data collection tools, and questionnaire design. The final part of this chapter contains the empirical methods of the study. This part has a detailed explanation of all the 8 mathematical and 1 econometric model regarding their variables and their relations, how they were executed.

3.1. Conceptual Framework:

This research has been carried out purely on conceptualized based. From a broader perspective, there are two major parts of this study. The first part which is quantitative in nature has focused on the quantification and three-dimensional economic-nutritional- environmental impacts of food waste, and the second part which is qualitative in natureis all about the food system and its waste's connection with circular economy and howbasically can this waste be managed eco-friendly.

3.1.1. Household Food Waste and its Impacts:

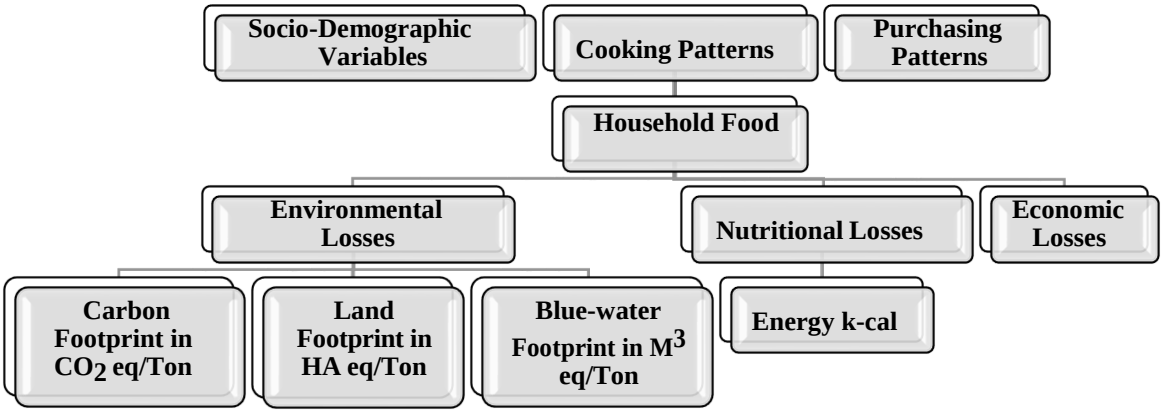

Fig No 3. 1 *Social Drivers of Household Food waste and its Impacts of Household Food Waste* The above-mentioned figure describes the concepts and their relations of this study.The conceptual framework is consisting of multiple aspects of household food waste.Each aspect is further analyzed in different dimensions. The study has firstly quantified

food waste at the household consumption level in volume. After the quantification, environmental losses in terms of how much carbon is emitted from the created waste and how much of land and blue water is affected by the waste, how many calories(kcal) are lost, and how many monetary recourses are being wasted. Furthermore, this study has analyzed the impacts of major social drivers of waste in its creation and how should this waste be managed through a circular economy to tackle all the impacts mentionedabove.

3.1.2. Food Waste Management under Circular Economy Model:

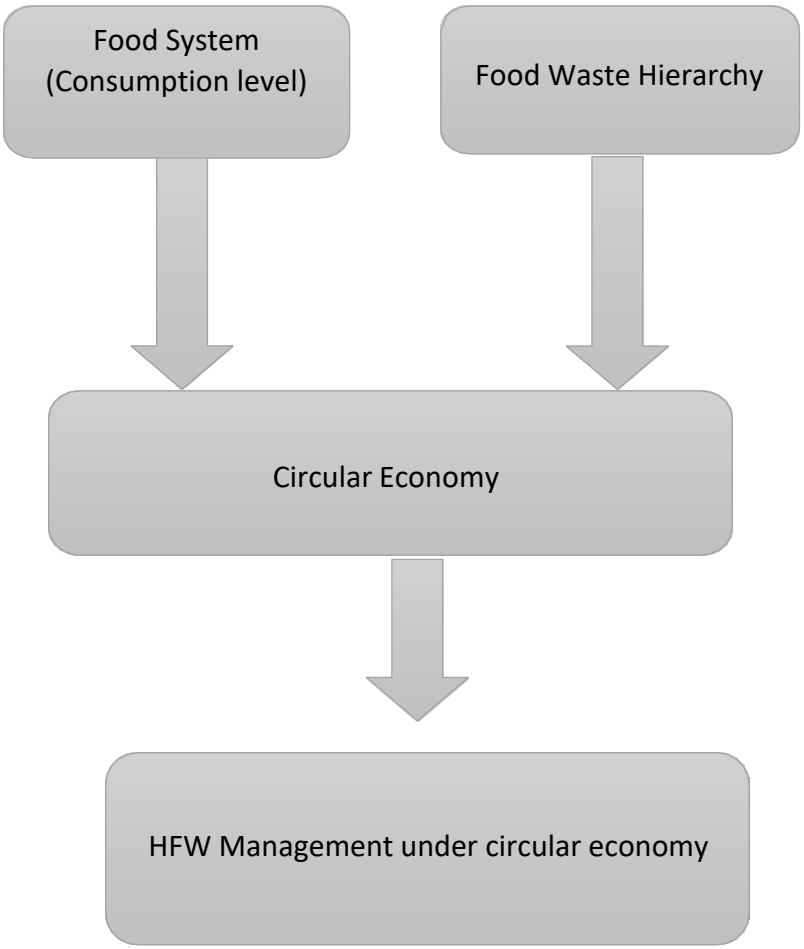

Fig No 3. 2: Food Waste and Its Management through Circular Economy Model

The above-mentioned figure explains the other part of this research. The figure is describing which stage of the food system has been focused on and analyzed and through which remedies that waste can be managed.

Food System:

The current world food system is consisting of major four steps production, processing,distribution, and consumption is not indulged in sustainable production and consumption. Food loss and waste are some of the major hurdles in the path of sustainably producing and consuming food. It generates a whole complex set of other challenges such as; hunger, environmental degradation, and depletion of natural resources (Nguyen, 2015)The study has analyzed the amount and impacts of food waste

at the lower stream of the food system i-e; Consumption at the household level in Pakistan.

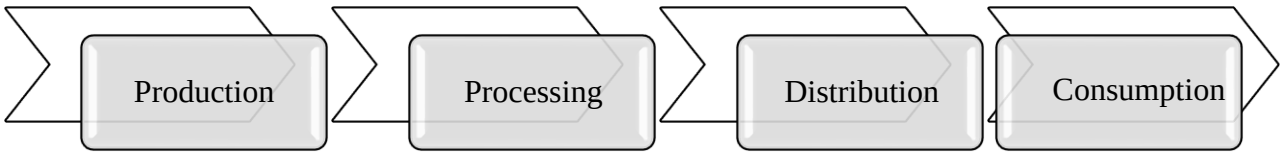

Fig No 3. 3: Food System

Food Waste Hierarchy:

Food waste at the household level contains all categorized forms. Households tend to waste both edible and inedible food. The study has analyzed the types of food wasted in households of Pakistan under the standardized food hierarchy in the context of a sustainable food system. Food hierarchy revolves around managing sustainably the food surplus and food waste. The hierarchy is based on prevention, reusing, and recycling the edible and non-edible parts of foods.

Circular Economy:

A circular economy ensures all three main objectives of a sustainable food system. A sustainable food system ensures economic uplifting, societal sustainability, and environmental sustainability (Take & Systems, 2015). The three R's of circular economy (Reduce, Re-use and Recycle) explain the best possible final destinations of food waste hierarchy instead of the traditional linear economy of producing consuming and disposing of. The study has analyzed food-management ways through the circular economy from the literature and has proposed the best destination of household food waste in the context of Pakistan.

Source: (Teigiserova et al., 2020)

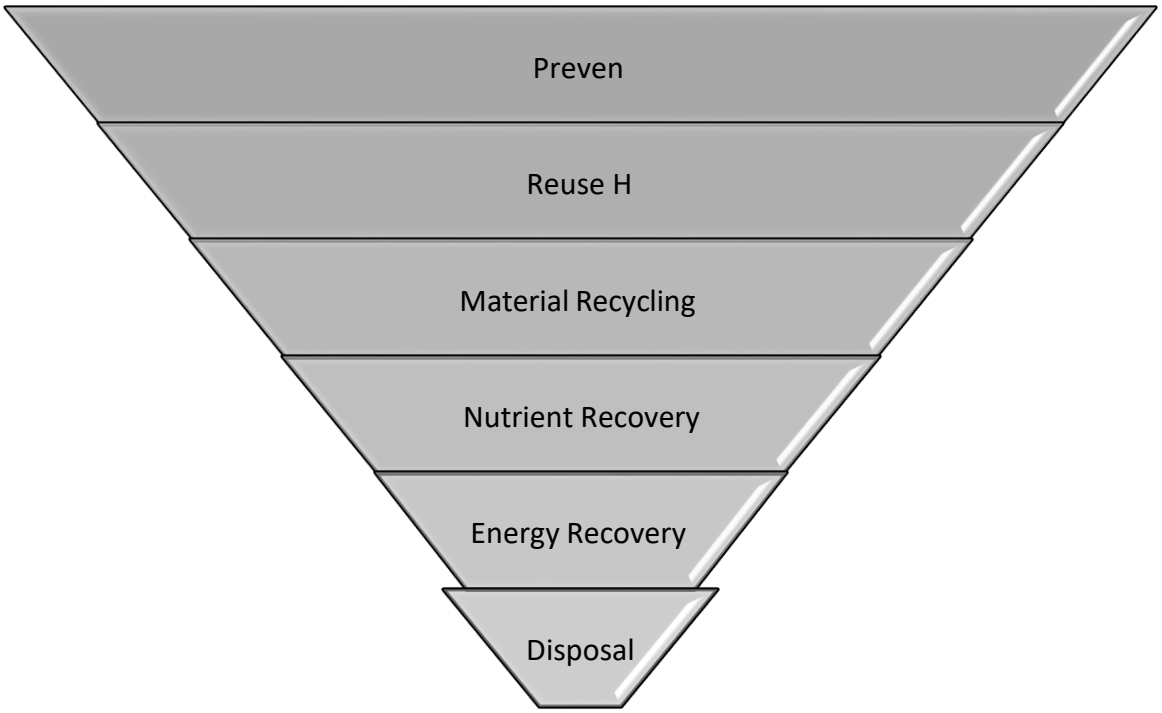

Fig No 3. 4: Food Waste Hierarchy

3.2. Research Design:

The research design of this study is based on both quantitative and qualitativeperspectives.

Quantitative Perspective:

There has been the usage of both econometrical and mathematical models in this study. For quantification of the detailed questionnaire- based survey was carried out. For the estimations of Carbon emissions, Land and Bluewater degradation through FAO's Standard South Asian coefficients (Impact Factors) simple mathematical models are used, for the objective of impacts of social drivers of the waste econometric model is used. For the estimations of nutritional and economic losses mathematical models are used.

Qualitative Perspective:

The qualitative part of this study is based on systematic review. To find out best possible waste management ways already existed literature on household food waste management using circular economy techniques was descriptively reviewed.

3.3. Study Area:

The study area of this research is Pakistan. The south-Asian located country is the fifth largest populous country with 207.77 million populations of which 132.9 million are residing in rural areas and around 75 million are from urban areas. The total number ofhouseholds in Pakistan is 32,205,111. This research is carried out at the national level. The study has analyzed household waste patterns, impacts, and management across thecountry.

3.4. Sampling Methods and Techniques:

3.4.1. Sample Size:

Due to the research limitations, household food waste survey data is not collected nationally. Since it is the national level study, total 400 sample size was selected initially to represent all four provinces of the country. But, the total sample size from which a questionnaire-based telephonic survey was conducted was selected 386. This sample size was generated from a larger sample of national representative survey. Contact numbers were taken from that survey and based on percentage share of all strata total 386 households were selected. Among them from Punjab total 180 interviews were done, from Sindh 106, from KPK total 73, and from Baluchistan 27 interviews were collected. Data from this household-scale survey was used to estimate the household food waste coefficient which was applied on PSLM data (total number of households in Pakistan) to estimate national-level food waste at the household level.

3.4.2. Sampling Method:

The sampling method of this research study is stratified-random sampling. The reason to opt stratified-random sampling method was to cover all households of Pakistan based on region, province, and income expenditure. The total number of strata selected in this study is 17. These strata were made to justify the authentication of sample size. Strata were made based on region, province, and income quantiles.

Province: The four provinces of Pakistan namely, Sindh, Punjab, KKP, Baluchistan were taken

separately as different strata.

Region: Both regions, rural and urban were taken as two individual strata.

Income Group: There were a total of 11 income groups selected based on their monthly consumption from the sample of the national representative survey.

3.4.3. Sampling Technique:

For the allocation of the selected sample size, Stata and MS Excel were used. Through Stata, firstly the percentage and then frequency of all the above-mentioned strata were estimated. Based on that percentage and frequency, 386 households were allocated in each stratum by using MS Excel. After that, through a random number generator, random households were selected from each stratum.

3.5. Data Collection:

3.5.1. Primary Data:

To achieve the first objective and quantification of household waste primary data was used in this study. Primary data was conducted through a

questionnaire-based survey. The questionnaire was filled from the household to attain the data of

quantification of food waste and to identify the main drivers of food waste in households.

3.5.2. Secondary Data:

To achieve the objectives 2nd, 3rd, 4th, and 5th the study has used secondary data.

To estimate and analyze 2nd, 3rd, and 4th objectives of estimating the economic loss, nutrition loss, and environmental losses in terms of carbon emissions, land, and blue water footprints, the data was collected from Pakistan Social and Living Standards Measurement (PSLM) and Food and Agriculture Organization of The United Nations (FAO).

3.5.3. Data Collection Tools:

For attaining qualitative and quantitative primary data, the data collection process was done through using 2 data collecting tools. To understand the major drivers which influence the generation of household food waste and to quantify the total volume of waste CATI (Computer Assisted Telephonic Interviews) was done through a detailed questionnaire. Through telephonic calls, each respondent belonging to each stated stratum was interviewed. The source of contact numbers was the sample size of the national representative done already. Furthermore, there was a huge part of secondary sourced data in the research. To estimate the carbon footprint, land footprint, and blue water footprint, the Impact Factors standard South-Asian coefficients were taken from the World Food Organization's 2019 report entitled: "State of Food and Agriculture". To estimate the nutritional loss, the nutritional table of the World Food and Agricultural Organization's

Book named: “Food composition Table for Pakistan 2001” was used. To estimate the monetary losses, recent prices were taken from different sources like the Economic Survey of Pakistan, PSLM.

For Systematic Review to suggest the best possible destination of food waste desktop data were adopted in the study.

3.5.4. Questionnaire Design:

The questionnaire consists of 4 major parts based on the various variables of the study.Part one of the questionnaire is about the respondent profile. In the 2nd part of the questionnaire, questions are made related to the socio-demographic variables. Part 3rd is designed to attain data regarding cooking, purchasing, and discarding waste in the household. The final part of the questionnaire is about 16 major and essential food items’ availability, waste, and its reasons.

Part One: Respondent’s Profile:

The first part is designed to know about the respondent and who holds the kitchen responsibilities. This part is divided into two sections further, the first section is all about the personal information of the respondent including name, age, gender, and the other section is to know from where we are getting information like which type of kitchen are we inquiring, basically to know the area and from where the kitchen is belonging since every region/area has different circumstances and cultures. Here we have asked questions about the province, area, and region.

Part Two: socio-demographic variables:

The second part of the questionnaire is again divided into several sections, about four sections with 18 questions are there in this part.

First, we had to know who is responsible (kitchen head) for kitchen chores is it a familymember or any other helper for better estimation and then there is a personal question about the kitchen head like his/her age education, and gender.

Then come to the second section in which we have asked questions about the total number of household members and then several questions to categorize the age group of household members. After that, we have asked the respondents about the age of household members' education.

The third section contains questions about the income, expenses, and shares that are included in the kitchen. In the last question in this part, we have asked about the source of storage of food if in case. Like whether the kitchen head is keeping leftovers in the refrigerator, deep freezer, plastic container, plastic bags, metallic containers, or others.

Part Three: Purchasing Patterns of Food Items:

In the third part of the questionnaire, the first question is to know how many meals arecooked in a day and then the second question is to gather the information about what isthe purchase pattern like how often they go to buy things if they are buying things annually, semiannually, quarterly, monthly, bi-weekly, weekly, daily and then items are also categorized to be more specific about which item is coming on which pattern. The third question asked in this part is about the wastage, how they are discarding the wasted food/kitchen waste again we have four categories/options for the respondents and items are being differentiated to be more specific.

Part Four: Food Items:

This is the last part of the questionnaire, which explains the selection of food baskets. About which questions related to the selected food items are being asked to know the usage, availability, wastage, and its reasons for food items per week. The selection of food basket was based on World Food and Agriculture Organization's report entitled: The State of Food and Agriculture 2019. As per the said report, there are six major commodities groups, but it has also allowed countries to choose the food items based on that country's food diet, perception, and consumption patterns. Since for the time and resources limitation, all the food items cannot be taken. So, based on the value of production of all groups 3 food items were selected in the food basket except the root tubers and oil-bearing category, and others category making an overall total of 17 fooditems. The value of production was taken from World Food Organization's latest FoodBalance Sheet.

For instance, the following mentioned food items were selected.

Table No 3. 1: Commodities Description

Commodity Group	**Food Items**
Animal products	Milk, Beef, Chicken
Root Tubers and Oil Bearing	Potatoes, Oil
Cereals and Pulses	Wheat, Rice, Maize
Fruits and Vegetables	Mangoes, Apples, Onions
Fish and Products	Fresh Water Fish, Demersal Fish, Pelagic Fish
Others	Sugar, Spices, Groundnuts.

3.6. Empirical Framework:

3.6.1. Quantification of Household Food Waste:

To quantify the food waste generated by households, one of the proposed and widely used methods "Survey Method" of the Commission for Environmental Cooperation is used in this research. The mode of carrying out the survey was a questionnaire-based interview survey. In which respondents from the selected sample of households were interviewed. This study has firstly quantified the average of tons per year of each commodity as well as of each commodity group. Then to make it on the national level, that average is multiplied by the total number of households of Pakistan. After that, the percentage is calculated of total waste from the total production of each commodity.

3.6.2. Environmental Losses:

Model Specification:

To estimate the environmental impacts of food waste the study has focused on impacts on land, water, and carbon emissions due to food waste. The coefficients of carbon, blue-water, and land are the impact factors Co2 eq./ton, M3 eq./ton and HA/ton has been used respectively. This study has calculated footprints of individual commodities as well as of four major commodity groups. These coefficients have been taken from The World Food and Agriculture Organization's report of 2019 "The State of Food and Agriculture Moving Forward on Food Loss and Waste Reduction". These coefficients are multiplied by the cumulative average quantity of food wasted of all four major commodity groups to acquire food carbon, blue-water, and land footprint. There are two general equations used to estimate all three footprints of both commodities and commodity groups as well. Equation 1is for estimating three footprints respectively of individual commodities. Whereas equation 2 is for the calculation of footprints of commodity groups.

3.6.2.1. Carbon Footprint:Equation 1:

$$\boldsymbol{CF_i = QW_i * IF_i}$$

Where:

CF_i=Carbon Footprint of Individual Commodities QW_i= Wasted Quantity of individual commodities IF_i= Carbon Impact Factor of individual commodities

Table No 3. 2:Variable Description of Carbon Footprint of Sub-Commodities

Variable	Unit	Theoretical Description
CF= Carbon Footprint	Numeric	According to The World Food and Agriculture Organization, the carbon footprint of food is the total amount of greenhouse gases emissions emitted at every stage of the food system as well as after the disposal of food. It is expressed in terms of 1 ton of Carbon dioxide (CO_2) emitted per ton of wasted food.
QWA	Numeric	Average quantity wasted of Sub-Commodity: Milk
IFA	Numeric	Carbon Impact Factor (ton C02/ton food wasted) of Sub-Commodity: Milk
QWB	Numeric	Average quantity wasted of Sub-Commodity: Beef
IFA	Numeric	Carbon Impact Factor (ton C02/ton food wasted) of Sub-Commodity: Beef
QWc	Numeric	Average quantity wasted of Sub-Commodity: Chicken
IFc	Numeric	Carbon Impact Factor (ton C02/ton food wasted) of Sub-Commodity: Chicken
QWD	Numeric	Average quantity wasted of Sub-Commodity: Fresh Water Fish
IFD	Numeric	Carbon Impact Factor (ton C02/ton food wasted) of Sub-Commodity: Fresh Water Fish
QWE	Numeric	Average quantity wasted of Sub-Commodity: Demersal Fish
IFE	Numeric	Carbon Impact Factor (ton C02/ton food wasted) of Sub-Commodity: Demersal Fish
QWF	Numeric	Average quantity wasted of Sub-Commodity: Pelagic Fish
IFF	Numeric	Carbon Impact Factor (ton C02/ton food wasted) of Sub-Commodity: Pelagic Fish
QWG	Numeric	Average quantity wasted of Sub-Commodity: Wheat
IFG	Numeric	Carbon Impact Factor (ton C02/ton food wasted) of Sub-Commodity: Wheat
QWH	Numeric	Average quantity wasted of Sub-Commodity: Rice
IFH	Numeric	Carbon Impact Factor (ton C02/ton food wasted) of Sub-Commodity: Rice
QWI	Numeric	Average quantity wasted of Sub-Commodity: Maize
IFI	Numeric	Carbon Impact Factor (ton C02/ton food wasted) of Sub-Commodity: Maize
QWJ	Numeric	Average quantity wasted of Sub-Commodity: Potato
IFJ	Numeric	Carbon Impact Factor (ton C02/ton food wasted) of Sub-Commodity: Potato
QWK	Numeric	Average quantity wasted of Sub-Commodity: Oil
IFK	Numeric	Carbon Impact Factor (ton C02/ton food wasted) of Sub-Commodity: Oil
QWL	Numeric	Average quantity wasted of Sub-Commodity: Mango
IFL	Numeric	Carbon Impact Factor (ton C02/ton food wasted) of Sub-Commodity: Mango
QWM	Numeric	Average quantity wasted of Sub-Commodity: Apple
IFM	Numeric	Carbon Impact Factor (ton C02/ton food wasted) of Sub-Commodity: Apple
QWN	Numeric	Average quantity wasted of Sub-Commodity: Onion
IFN	Numeric	Carbon Impact Factor (ton C02/ton food wasted) of Sub-Commodity: Onion

Equation 2:

$$CF_{CGi} = QW_{CGi} * IF_{CGi}$$

Where:

CF_{CGi}=Carbon Footprint of Commodity Group

QW_{CGi}= Wasted Quantity of individual commodity Group IF_{CGi}= Carbon Impact Factor of individual commodity Group

Table No 3. 3:Variable Description of Carbon Footprint of Commodity Group

Variable	Unit	Theoretical Description
CF=Carbon Footprint	Numeric	According to The World Food and Agriculture Organization, the carbon footprint of food is the total amount of greenhouse gases emissions emitted at every stage of the food system as well as after the disposal of food. It is expressed in terms of 1 ton of Carbon dioxide (CO_2) emitted per ton of wasted food.
QWCGA	Numeric	The total cumulative average quantity wasted of commodity group A (Meat and Animal Products) which contains total 3 **Sub-Commodities**: Milk, Beef and Chicken
IFCGA	Numeric	Average Carbon Impact Factor (ton $C0_2$/ton food wasted) of commodity group A (Meat and Animal Products) which contains total 3 three **Sub-Commodities**: Milk, Beef, and Chicken.
QWCGB	Numeric	The total cumulative average quantity wasted of commodity group B (Cereals and Pulses) contains a total of 3 **Sub-Commodities**: Wheat, Rice, and Maize.
IFCGB	Numeric	Average Carbon impact factor (ton $C0_2$/ton food wasted) of commodity group B (Cereals and Pulses) which contains total 3 **Sub-Commodities**: Wheat, Rice, and Maize.
QWCGC	Numeric	The total cumulative average quantity wasted of commodity group C (Root, tubers, and oil-bearing crops) contains a total of 2 **Sub-Commodities**: Potatoes and Oil.
IFCGC	Numeric	The average Carbon impact factor (ton $C0_2$/ton food wasted) of commodity group C (Root, tubers, and oil-bearing crops) contains a total of 2 **Sub-Commodities**: Potatoes and Oil.
QWCGD	Numeric	The total cumulative average quantity wasted of commodity group D (Fruits and Vegetables) contains a total of 3 **Sub-Commodity**: Mangoes, Onions, and Apples.
IFCGD	Numeric	Average Carbon impact factor (ton $C0_2$/ton food wasted) of commodity group D (Fruits and Vegetables) which contains a total 3 **Sub-Commodity**: Mangoes, Onions, and Apples.

3.6.2.2. Land Footprint:Equation 1:

$$LF_i = QW_i * IF_i$$

Where:

LF_i=Land Footprint of Individual Commodities QW_i= Wasted Quantity of individual commodities IF_i= Land Impact Factor of individual commodities

Table No 3. 4:Variable Description of Land Footprint of Sub-Commodities

Variable	Unit	Theoretical Description
LF= Land Footprint	Numeric	According to The World Food and Agriculture Organization, the land footprint is the amount of surface land which is used to produce food products. It is expressed in 1 hectare per ton of wasted food.
QWA	Numeric	Average quantity wasted of Sub-Commodity: Milk
IFA	Numeric	Land Impact Factor (HA/ton food wasted) of Sub-Commodity: Milk
QWB	Numeric	Average quantity wasted of Sub-Commodity: Beef
IFB	Numeric	Land Impact Factor (HA/ton food wasted) of Sub-Commodity: Beef
QWc	Numeric	Average quantity wasted of Sub-Commodity: Chicken
IFc	Numeric	Land Impact Factor (HA/ton food wasted) of Sub-Commodity: Chicken
QWD	Numeric	Average quantity wasted of Sub-Commodity: Fresh Water Fish
IFD	Numeric	Land Impact Factor (HA/ton food wasted) of Sub-Commodity: Fresh Water Fish
QWE	Numeric	Average quantity wasted of Sub-Commodity: Demersal Fish
IFE	Numeric	Land Impact Factor (HA/ton food wasted) of Sub-Commodity: Demersal Fish
QWF	Numeric	Average quantity wasted of Sub-Commodity: Pelagic Fish
IFF	Numeric	Land Impact Factor (HA/ton food wasted) of Sub-Commodity: Pelagic Fish
QWG	Numeric	Average quantity wasted of Sub-Commodity: Wheat
IFG	Numeric	Land Impact Factor (HA/ton food wasted) of Sub-Commodity: Wheat
QWH	Numeric	Average quantity wasted of Sub-Commodity: Rice
IFH	Numeric	Land Impact Factor (HA/ton food wasted) of Sub-Commodity: Rice
QWI	Numeric	Average quantity wasted of Sub-Commodity: Maize
IFI	Numeric	Land Impact Factor (HA/ton food wasted) of Sub-Commodity: Maize
QWJ	Numeric	Average quantity wasted of Sub-Commodity: Potato
IFJ	Numeric	Land Impact Factor (HA/ton food wasted) of Sub-Commodity: Potato
QWK	Numeric	Average quantity wasted of Sub-Commodity: Oil
IFK	Numeric	Land Impact Factor (HA/ton food wasted) of Sub-Commodity: Oil
QWL	Numeric	Average quantity wasted of Sub-Commodity: Mango
IFL	Numeric	Land Impact Factor (HA/ton food wasted) of Sub-Commodity: Mango
QWM	Numeric	Average quantity wasted of Sub-Commodity: Apple
IFM	Numeric	Land Impact Factor (HA/ton food wasted) of Sub-Commodity: Apple
QWN	Numeric	Average quantity wasted of Sub-Commodity: Onion
IFN	Numeric	Land Impact Factor (HA/ton food wasted) of Sub-Commodity: Onion

Equation 2:

$$LF_{CGi} = QW_{CGi} * IF_i$$

Where:

LF_{CGi}= Land Footprint of Commodity Groups

QW_{CGi}= Wasted Quantity of individual commodity Group IF_{CGi}= Land Impact Factor of individual commodity Group

Table No 3. 5:Variable Description of Land Footprint of Commodity Group

Variable	Unit	Theoretical Description
LF= Land Footprint	Numeric	According to The World Food and Agriculture Organization, the land footprint is the amount of surface land which is used to produce food products. It is expressed in 1 hectare per ton of wasted food.
QWCGA	Numeric	The total cumulative average quantity wasted of commodity group A (Meat and Animal Products) which contains total 3 **Sub-Commodities**: Milk, Beef and Chicken
IFCGA	Numeric	Average Land Impact Factor (HA/ton food wasted) of commodity group A (Meat and Animal Products) which contains total 3 three **Sub-Commodities**: Milk, Beef, and Chicken.
QWCGB	Numeric	The total cumulative average quantity wasted of commodity group B (Cereals and Pulses) which contains a total of 3 **Sub-Commodities**: Wheat, Rice, and Maize.
IFCGB	Numeric	Average Land impact factor (HA/ton food wasted) of commodity group B (Cereals and Pulses) which contains total 3 **Sub-Commodities**: Wheat, Rice, and Maize.
QWCGC	Numeric	The total cumulative average quantity wasted of commodity group C (Root, tubers, and oil-bearing crops) contains a total of 2 **Sub-Commodities**: Potatoes and Oil.
IFCGC	Numeric	The average Land impact factor (HA/ton food wasted) of commodity group C (Root, tubers, and oil-bearing crops) contains a total of 2 **Sub-Commodities**: Potatoes and Oil.
QWCGD	Numeric	The total cumulative average quantity wasted of commodity group D (Fruits and Vegetables) contains a total of 3 **Sub-Commodity**: Mangoes, Onions, and Apples.
IFCGD	Numeric	Average Land impact factor (HA/ton food wasted) of commodity group D (Fruits and Vegetables) which contains a total 3 **Sub-Commodity**: Mangoes, Onions, and Apples.

3.6.2.3. Water Footprint:Equation 1:

$$WF_i = QW_i * IF_i$$

Where:

LF_i=Water Footprint of Individual Commodities

QW_i= Wasted Quantity of individual commodities IF_i= Water Impact Factor of individual commodities

Table No 3. 6:Variable Description of Water Footprint of Sub-Commodities

Variable	Unit	Theoretical Description
WF= Blue Water Footprint	Numeric	According to The World Food and Agriculture Organization, water footprint is of three types: blue, green, and grey. This study focuses on the Bluewater Footprint which is the total amount of surface or groundwater used during the production of food items. It is expressed in Cubic Meter (M^3) per 1 ton of wasted food.
QWA	Numeric	Average quantity wasted of Sub-Commodity: Milk
IFA	Numeric	Blue water Impact Factor (M^3/ton food wasted) of Sub-Commodity: Milk
QWB	Numeric	Average quantity wasted of Sub-Commodity: Beef
IFB	Numeric	Blue water Impact Factor (M^3/ton food wasted) of Sub-Commodity: Beef
QWc	Numeric	Average quantity wasted of Sub-Commodity: Chicken
IFc	Numeric	Blue water Impact Factor (M^3/ton food wasted) of Sub-Commodity: Chicken
QWD	Numeric	Average quantity wasted of Sub-Commodity: Fresh Water Fish
IFD	Numeric	Blue water Impact Factor (M^3/ton food wasted) of Sub-Commodity: Fresh Water Fish
QWE	Numeric	Average quantity wasted of Sub-Commodity: Demersal Fish
IFE	Numeric	Blue water Impact Factor (M^3/ton food wasted) of Sub-Commodity: Demersal Fish
QWF	Numeric	Average quantity wasted of Sub-Commodity: Pelagic Fish
IFF	Numeric	Blue water Impact Factor (M^3/ton food wasted) of Sub-Commodity: Pelagic Fish
QWG	Numeric	Average quantity wasted of Sub-Commodity: Wheat
IFG	Numeric	Blue water Impact Factor (M^3/ton food wasted) of Sub-Commodity: Wheat
QWH	Numeric	Average quantity wasted of Sub-Commodity: Rice
IFH	Numeric	Blue water Impact Factor (M^3/ton food wasted) of Sub-Commodity: Rice
QWI	Numeric	Average quantity wasted of Sub-Commodity: Maize
IFI	Numeric	Blue water Impact Factor (M^3/ton food wasted) of Sub-Commodity: Maize
QWJ	Numeric	Average quantity wasted of Sub-Commodity: Potato
IFJ	Numeric	Blue water Impact Factor (M^3/ton food wasted) of Sub-Commodity: Potato
QWK	Numeric	Average quantity wasted of Sub-Commodity: Oil
IFK	Numeric	Blue water Impact Factor (M^3/ton food wasted) of Sub-Commodity: Oil
QWL	Numeric	Average quantity wasted of Sub-Commodity: Mango
IFL	Numeric	Blue water Impact Factor (M^3/ton food wasted) of Sub-Commodity: Mango
QWM	Numeric	Average quantity wasted of Sub-Commodity: Apple
IFM	Numeric	Blue water Impact Factor (M^3/ton food wasted) of Sub-Commodity: Apple
QWN	Numeric	Average quantity wasted of Sub-Commodity: Onion
IFN	Numeric	Blue water Impact Factor (M^3/ton food wasted) of Sub-Commodity: Onion

Equation 2:

$$WF_{CGi} = QW_{CGi} * IF_{CGi}$$

Where:

WF_{CGi}= Water Footprint of Commodity Groups

QW_{CGi}= Wasted Quantity of individual commodity Group IF_{CGi}= Water Impact Factor of individual commodity Group

Table No 3. 7:Variable Description of Blue-water Footprint of Commodity Groups

Variable	Unit	Theoretical Description
WF= Land Footprint	Numeric	According to The World Food and Agriculture Organization, water footprint is of three types: blue, green, and grey. This study focuses on the Bluewater Footprint which is the total amount of surface or groundwater used during the production of food items. It is expressed in Cubic Meter (M^3) per 1 ton of wasted food.
QWCGA	Numeric	The total cumulative average quantity wasted of commodity group A (Meat and Animal Products) which contains total 3 **Sub-Commodities**: Milk, Beef and Chicken
IFCGA	Numeric	Average Blue water Impact Factor (M^3/ton food wasted) of commodity group A (Meat and Animal Products) which contains total 3 three **Sub-Commodities**: Milk, Beef, and Chicken.
QWCGB	Numeric	The total cumulative average quantity wasted of commodity group B (Cereals and Pulses) which contains a total of 3 **Sub-Commodities**: Wheat, Rice, and Maize.
IFCGB	Numeric	Average Blue water impact factor (M^3/ton food wasted) of commodity group B (Cereals and Pulses) which contains total 3 **Sub-Commodities**: Wheat, Rice, and Maize.
QWCGC	Numeric	The total cumulative average quantity wasted of commodity group C (Root, tubers, and oil-bearing crops) contains a total of 2 **Sub-Commodities**: Potatoes and Oil.
IFLCGC	Numeric	The average Blue water impact factor (M^3/ton food wasted) of commodity group C (Root, tubers, and oil-bearing crops) contains a total of 2 **Sub-Commodities**: Potatoes and Oil.
QWCGD	Numeric	The total cumulative average quantity wasted of commodity group D (Fruits and Vegetables) contains a total of 3 **Sub-Commodity**: Mangoes, Onions, and Apples.
IFLCGD	Numeric	Average Blue water impact factor (/ton food wasted) of commodity group D (Fruits and Vegetables) which contains a total 3 **Sub-Commodity**: Mangoes, Onions, and Apples.

3.6.3. Nutritional Losses:Model Specification:

To achieve the fourth objective of estimating nutrition loss due to household food wastemathematical model has been used in the study. This study has estimated nutritional losses in terms of energy kcal. The nutritional loss has been calculated by multiplication of quantity of wasted food in ton and Nutrition Concentration (energy kcal) per ton, then it (Nutritional Losses) is converted in energy (kcal) Billion Tons from the formedbasket based on the World Food and Agriculture Organization's report entitled: The State of Food and Agriculture 2019.

Equation 1:

$$\boldsymbol{NL_{ci} = QW_{Ci} * NC_{Ci}}$$

Where:

NL_{Ci}= Nutritional Loss of Commodity (i) in Billion TonsQW_{Ci}= Wasted Quantity in Tons of Commodity (i)

NC_{Ci}= Nutritional Concentration in terms of Energy (kcal) in Tons of Commodity (i)

Table No 3. 8:Variable Specification for Nutritional Loss

Variable	Unit	Theoretical Description
NL_{Ci}	Numeric	Nutritional loss due to the wasted quantity of food at the household level of Pakistan
QWCA	Numeric	Average quantity wasted in million tons of Milk
NCCA	Numeric	Nutritional Concentration in terms of calories per ton of Milk
QWCB	Numeric	Average quantity wasted in tons of Beef
NCCB	Numeric	Nutritional Concentration in terms of calories per ton of Beef
QWCC	Numeric	Average quantity wasted in million tons of Chicken
NCCC	Numeric	Nutritional Concentration in terms of calories per ton of Chicken
QWCD	Numeric	Average quantity wasted in million tons of Fresh Water Fish
NCCD	Numeric	Nutritional Concentration in terms of calories per ton of Fresh Water Fish
QWCE	Numeric	Average quantity wasted in million tons of Demersal Fish
NCCE	Numeric	Nutritional Concentration in terms of calories per ton of Demersal Fish
QWCF	Numeric	Average quantity wasted in tons of Pelagic Fish
NCCF	Numeric	Nutritional Concentration in terms of calories per ton of Pelagic Fish
QWCG	Numeric	Average quantity wasted in million tons of Wheat
NCCG	Numeric	Nutritional Concentration in terms of calories per ton of Wheat
QWCH	Numeric	Average quantity wasted in million tons of Rice
NCCH	Numeric	Nutritional Concentration in terms of calories per ton of Rice
QWCI	Numeric	Average quantity wasted in million tons of Maize
NCCI	Numeric	Nutritional Concentration in terms of calories per ton of Maize
QWCJ	Numeric	Average quantity wasted in million tons of Potatoes
NCCJ	Numeric	Nutritional Concentration in terms of calories per ton of Potatoes
QWCK	Numeric	Average quantity wasted in million tons of Oil
NCCK	Numeric	Nutritional Concentration in terms of calories per ton of Oil
QWCL	Numeric	Average quantity wasted in million tons of Mango
NCCL	Numeric	Nutritional Concentration in terms of calories per ton of Mango
QWM	Numeric	Average quantity wasted in million tons of Apple
NCM	Numeric	Nutritional Concentration in terms of calories per ton of Apple
QWCN	Numeric	Average quantity wasted in million tons of Onion
NCCN	Numeric	Nutritional Concentration in terms of calories per ton of Onion

3.6.4. Economic Losses:

Model Specification:

One of the major negative impacts of potential household food waste is creating economical or monetary loss through wasting food that could have been eaten. The study has also focused on calculating the economic losses of only edible parts of food waste as there is no such active market of inedible parts of food waste. To achieve the second objective there has been the usage of a mathematical model in the study. The formed food basket is based on the World Food and Agriculture Organization's report entitled: The State of Food and Agriculture 2019. There are a total of 5

major commodities groups among them based on the highest value of production 3 food items are selected in the food basket except for the root tubers and oil-bearing category making an overall total of 14 food items. To estimate the economic losses, recent prices per million tons of each commodity were multiplied by the averagewasted quantity in million tons.

Equation:

$$\boldsymbol{EL_{Ci} = QW_{Ci} * P_{Ci}}$$

Where:

EL_{Ci}= Economic Loss of Commodity (i)

QW_{Ci}= Wasted Quantity (Million Tons) of Commodity (i)P_{Ci}= Price (Million Tons) of Commodity (i)

Table No 3. 9:Variable Specification for Economic Loss

Variable	Unit	Theoretical Description
EL	Numeric	Economic loss due to the wasted quantity of food at the household level of Pakistan
QWCA	Numeric	Average quantity wasted in million tons of Milk
PCA	Numeric	Price per million ton of Milk
QWCB	Numeric	Average quantity wasted in tons of Beef
PCB	Numeric	Price per million ton of Beef
QWCC	Numeric	Average quantity wasted in million tons of Chicken
PCC	Numeric	Price per million ton of Chicken
QWCD	Numeric	Average quantity wasted in million tons of Fresh Water Fish
PCD	Numeric	Price per million ton of Fresh Water Fish
QWCE	Numeric	Average quantity wasted in million tons of Demersal Fish
PCE	Numeric	Price per million tons of Demersal Fish
QWCF	Numeric	Average quantity wasted in tons of Pelagic Fish
PCF	Numeric	Price per million tons of Pelagic Fish
QWCG	Numeric	Average quantity wasted in million tons of Wheat
PCG	Numeric	Price per million ton of Wheat
QWCH	Numeric	Average quantity wasted in million tons of Rice
PCCH	Numeric	Price per million ton of Rice
QWCI	Numeric	Average quantity wasted in million tons of Maize
PCI	Numeric	Price per million tons of Maize
QWCJ	Numeric	Average quantity wasted in million tons of Potatoes
PCJ	Numeric	Price per million tons of Potatoes
QWCK	Numeric	Average quantity wasted in million tons of Oil
PCK	Numeric	Price per million ton of Oil
QWCL	Numeric	Average quantity wasted in million tons of Mango
PCL	Numeric	Price per million tons of Mango
QWM	Numeric	Average quantity wasted in million tons of Apple
PM	Numeric	Price per million ton of Apple
QWCN	Numeric	Average quantity wasted in million tons of Onion
PCN	Numeric	Price per million ton of Onion

3.6.5. Social Drivers of Household Food Waste:

Model Specification:

There are several impactful reasons for food waste. This study has also shed the lighton the identification and estimation of those impacts on the generation of waste at the household level or the lower stream of the food supply chain in Pakistan. To achieve the fifth objective to identify the main social drivers and their impacts on household food waste generation the econometric model of the "Ordinary Least Square Model" (OLS) has been used to find out the results. In this, the study has household food wasteas the dependent variable and multiple independent variables based on three broad categories: Socio-demographic variables, Storage Patterns, and the Cooking Patterns ofthe household of Pakistan. Metallic refrigerator.

Model Equation:

$$\boldsymbol{HFW} = \mathrm{Q}_0 + \mathrm{Q}_1\boldsymbol{AgeKH}_i + \mathrm{Q}_2\boldsymbol{EduHH}_i + \mathrm{Q}_3\boldsymbol{Meals}_i + \mathrm{Q}_4\boldsymbol{HS}_i + \mathrm{Q}_5\boldsymbol{MInc}_i + \mathrm{Q}\boldsymbol{SRDumi}$$

$$+ \mathrm{Q}\boldsymbol{SDFDumi} + \mathrm{Q}\boldsymbol{SPCDumi} + \mathrm{Q}\boldsymbol{SMCDumi} + \mathrm{Q}\boldsymbol{SWSDumi} + \mathrm{s}_i$$

Variable Specification

Table No 3. 10:Variable Specification for Econometric Model

Category	Variable	Type	Unit	Variable Description
	HFW	Dependent	Numeric	Household Food Waste
Socio-Demographic	Age KH	Independent	Numeric	Age of the Household Kitchen Head
	Edu HH	Independent	Numeric	Highest Education in Household in years
	M. Inc	Independent	Continuous	Average Monthly Income of the Household
	HS	Independent	Numeric	Total Family Members in the household
Cooking Patterns	Meals	Independent	Numeric	Number of Meals cooked on an everyday basis
Dummies				
Storage Patterns	Refrigerator	Independent	Categorical	Refrigerator for the storage purpose of food If the household has Refrigerator=1, if no=0
	Deep Freezer	Independent	Categorical	Deep Freezer for the storage purpose of food If the household has Deep Freezer=1, if no=0
	Plastic Con	Independent	Categorical	Plastic Containers for the storage purpose of food If the household has Plastic Containers =1, if no=0
	Metallic Con	Independent	Categorical	Metallic Containers for the storage purpose of food If the household has Metallic Containers =1, if no=0
	Wooden Shelves	Independent	Categorical	Wooden Shelves for the storage purpose of food If the household has wooden shelves=1, if no=0

Chapter Four

Results and Discussions

This chapter contains a graphical representation of the results and their interpretation of quantification of food waste, estimation of Environmental Losses, Nutritional Losses, Economic Losses due to food waste at the household level of Pakistan.Furthermore, the result and its interpretation of the econometric model for the main social drivers of household food waste in Pakistan are mentioned in this chapter.

4.1. Quantification of Food Waste:

There is a total of 14 food items named as Sub-Commodity included in the food basket. These sub-commodities are further categorized into 5 Commodity groups. So, this study has done 4 types of quantification, first estimation of food waste of individual aswell as commodity groups. Then, the total percentage wasted from the total production of sub-commodities and commodity groups as well.

4.1.1. Household Food Waste of Sub-Commodities:

The first figure (Figure No: 4.1) mentioned below describes the food waste average quantity in Million Tons/Year of a total of 14 Sub-Commodities: Milk, Beef, Chicken,Fresh Water Fish, Demersal Fish Pelagic Fish, Wheat, Rice, Maize, Potato, Oil, Mango,Apple, and Onion at the household level. On the X-Axis, Sub-Commodities is placed and on the Y-Axis quantity of percentage of food waste is placed. The results show thatthe largest amount of waste is Milk which is 0.7 million tons. The smallest amount of waste has been recorded as 0.000005 of each demersal fish and Pelagic Fish which commonly is known as Khaga/Sonaf, Palla/Mohr respectively. The

total waste of Beef, Chicken, and Wheat is recorded at 0.03 for each category. Freshwater fish which is commonly known as Rohu/Morakha along with Oil and Apple are being wasted 0.02 million tons per year in Pakistan. Furthermore, the total waste of Potato, Rice, Mango,

Maize, and Onion generated by Pakistan's HHs is 0.04, 0.06, 0.07, 0.08, and 0.003 million tons per year respectively.

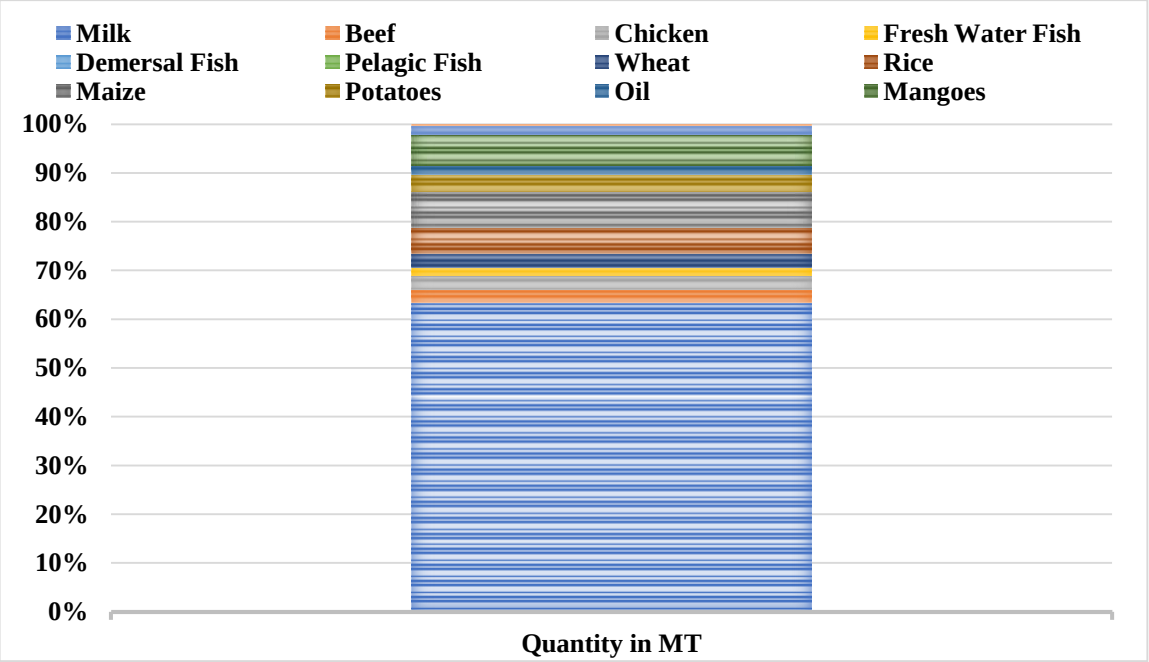

Figure No 4. 1:Food Waste of Sub-Commodities

4.1.2. Household Food Waste of Commodity Groups:

The second figure (Figure No: 4.2) shows the Cumulative average waste in million tons/year of a total of 5 major commodity groups of the food basket. On the X-axis commodity groups are placed and, on the Y- axis, the percentage of food waste is placed. The highest waste is happening in the Meat and Animal Products group which is consisted of Milk, Beef, and Chicken. Total 0.25 million tons/year is recorded. The lowest amount of waste is of Fish and Products 0.01 million tons/per. The Fish and Products group has a total of 3 sub-commodities: Freshwater Fish, Demersal Fish,

and Pelagic Fish. The second highest group in waste is Cereals and Pulses containing three sub-commodities: Wheat, Rice, and Maize. Both Roots, Tubers, and Oil-Bearing Crops and Fruits and Vegetable groups' total waste is 0.03 million tons/year each. Where, the former group consists of the Oil and Potato sub-commodity and the latter one contains a total of three commodities Mango, Apple, and Onion.

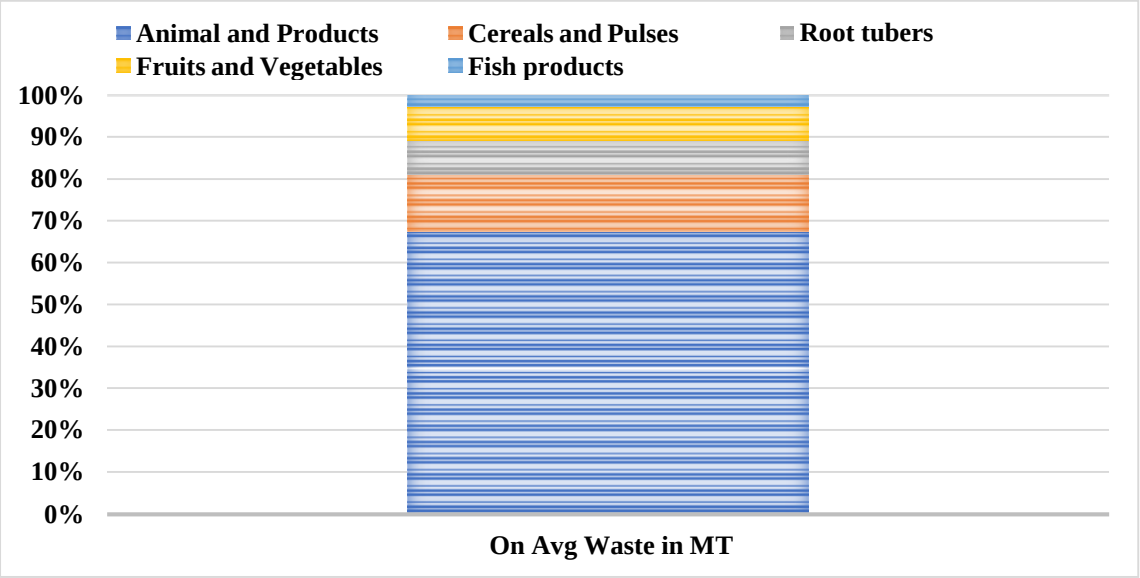

Figure No 4. 2:Food Waste of Commodity Group

4.1.3. Percentage of Food Waste of Sub-Commodities from Total Production:

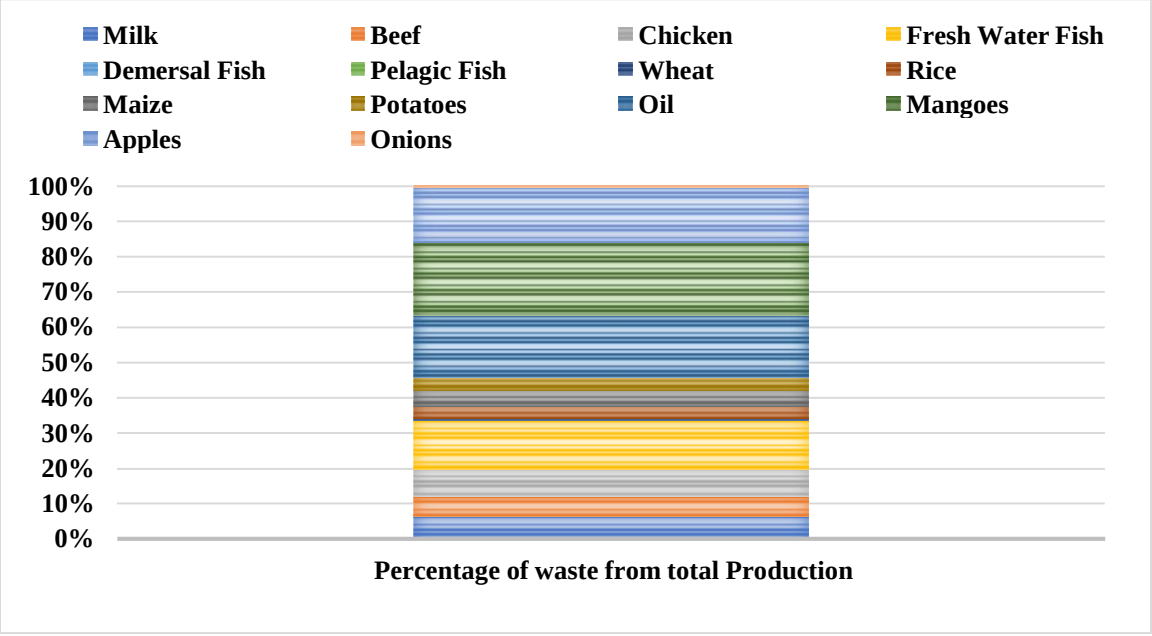

Figure No 4. 3:Food Waste Percentage of Sub-Commodities

The above-mentioned figure 4.3 shows the percentage of total waste of sub- commodities from the total produced quantity. The X-axis represents the sub- commodities, and the Y-axis represents the percentage. The results show that about 4.5percent of the total produced Mango is wasted per year by the household of Pakistan. After Mangoes, Oil stands at second number with 3.8% waste from total produced quantity domestically. Apple and Freshwater Fish's 3.4% and 3% respectively are wasted from the total production. Moreover, about 1.7% of Chicken, 1.4% of Milk, and 1.2% of Beef's total produced quantity are wasted per year. Maize's 1, along with Wheat and Potato's 0.8% of production is being wasted per year. The results revealed that Demersal Fish and Pelagic Fish's 0.0006% of their produced quantity is wasted/peryear.

4.1.4. Percentage of Food Waste of Commodity Groups from Total Production:

The following mentioned figure no: 4.4 illustrates the waste in total percentage from the total production. This figure contains 5 major commodity groups namely: Meat and Animal Products (Milk Chicken, and Beef), Cereals and Pulses (Wheat, Rice, and Maize), Roots, Tubers, and Oil-Bearing Crops (Oil and Potato), Fruits and Vegetable (Mango, Apple, and Onion) and Fish Products (Freshwater Fish, Demersal Fish, and Pelagic Fish). The define the total waste per group this study has used cumulative average of both totals produced quantity as well as the percentage of each product regarding their groups. On the X-axis commodity groups are placed and Y-axis represents the cumulative percentage waste of each group. The results show that the highest percentage of the waste is of fruits and Vegetable group which is

2.7%/year. Roots, Tubers, Oil-Bearing Crops, and Meat and Animal Products' cumulative percentage of waste/year are 2.3 and 1.4 respectively. Fish and Products account for the cumulative percentage of waste per year generated by the HHS of Pakistan is a total of 1% of production. Lastly, the study reveals Cereals and Pulses groups account for the lowest cumulative percentage of 0.6%/year.

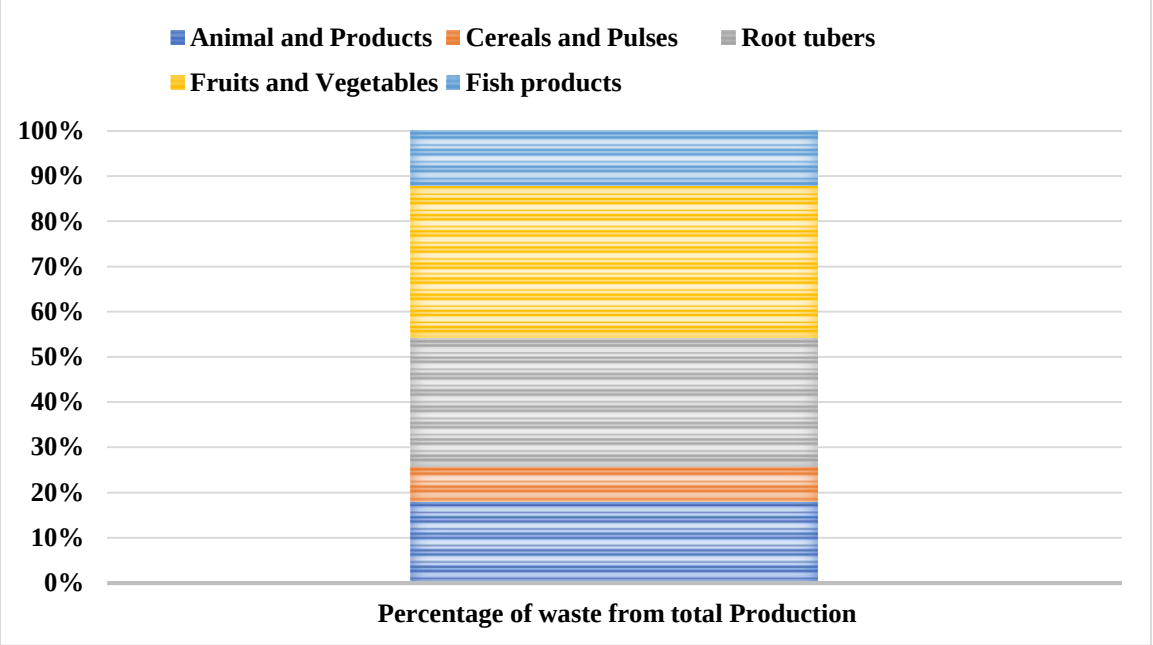

Figure No 4. 4:Food Waste Percentage of Commodity Group

4.2. Environmental Losses:

This study has shed the light on adverse effects on the environment due to food waste at the household level. There are three footprints estimated in this study namely: CarbonFootprint, Land Footprint, and Blue-water Footprint. Using the South Asian Coefficients of The World Food and Agriculture Organization this study has estimated the said footprints of 4 major Commodity Groups: Meat and Animal Products (Milk Chicken, and Beef), Cereals and Pulses (Wheat, Rice, and Maize), Roots, Tubers, and Oil-Bearing Crops (Oil and Potato), Fruits and Vegetable (Mango, Apple, and Onion) and 14 individual Sub-Commodities including (Freshwater Fish, Demersal Fish, and Pelagic Fish) in the above-mentioned sub-commodities as well.

4.2.1. Carbon, Land, and Blue-water Footprints of Sub-Commodities:

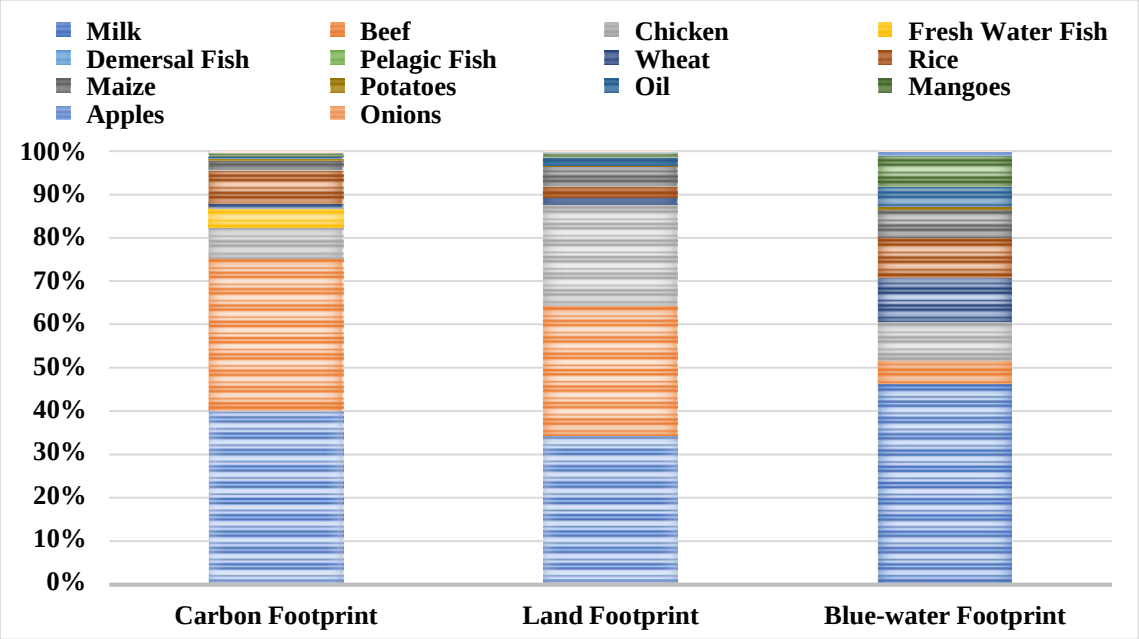

Figure No 4. 5:Carbon, Land and Blue-water Footprints of Sub-Commodities

The carbon, land, and blue-water footprints of individual sub-commodities are estimated in CO2 eq/Ton/year, HA eq/Ton/Year, and M3eq/Ton/Year can be seen in the above-mentioned figure no 4.5. Sub- commodities are placed on the X-axis and thepercentage of footprints are represented by the Y-axis. The estimations show the largest amount of CO2 is emitted due to the waste of Milk 717601 per year. Beef and Rice emits 628685.68 and 137678.82 ton/year respectively. 125753.6, 79002.88, 43524.25, 17296.14, 17033.34 C02-ton/year are emitted by Chicken, Freshwater Fish, Maize, Wheat, and Mango respectively. Furthermore, the study reveals that 7756.56, 5615.84, 3055.35, and 2634.72 C02-ton/year are emitted by the waste generated of Oil, Potato, Apple, and Onion respectively. Pelagic Fish and Demersal Fish's waste releases 15.686 C02-ton/year each. The estimations also reveal that a total of 222944 hectares of land is wasted due to the waste of milk by households. Beef, Chicken, Maize, Rice, Oil, and Wheat waste generate 194128.32, 150455.2, 30071.3, 16230.43, 11022.48,

and 10879.83 hundred thousand hectares are wasted per year respectively. Moreover, Mango, Potato, Apple, and Onion's waste generates 8146.38, 2105.94, 1425.83, and 209.58 thousand hectares waste per year respectively. However, results show that thereis no land footprint generated by all three types of fish: Freshwater Fish, Demersal Fish,and Pelagic Fish. The estimations reveal that a total of 147700400 Cubic Meters of water is wasted due to the waste of milk at the household level. The waste of sub-commodities Wheat, Rice, Chicken, Mango, Maize, Beef, and Oil generates 32862666, 29102840, 2860330, 22365516, 20812505, 16679416, and 15166116 million thousandcubic meters are wasted per year respectively. 2892398, 1790049 million thousand cubic meters are wasted per year due to the waste of apple ad Potatoes respectively. Onion waste generates 287424 thousand cubic meters of waste per year. However, results show that there is no Bluewater Footprint generated by all three types of fish: Freshwater Fish, Demersal Fish, and Pelagic Fish.

4.2.2. Carbon, land, Blue-water Footprints of Commodity Groups:

The following mentioned figure no. 4.6 depicts the C02-ton/year, HA eq./Ton/year, andM3eq./Ton/year of 4 major commodity groups: Meat and Animal Products (Milk Chicken, and Beef), Cereals and Pulses (Wheat, Rice, and Maize), Roots, Tubers, and Oil-Bearing Crops (Oil and Potato), Fruits and Vegetable (Mango, Apple, and Onion).On the X-axis groups are placed and, on the Y-axis, the percentage of all footprints individually is placed. The estimation shows that the Meat and Animal Products group emits the largest amount of carbon emission of 577040.1 C02-ton/year. Cereals and Pulses and Roots, Tubers, and Oil-Bearing Crops groups generate 119532.6 and 27756C02-ton/year respectively. Group Fruits and

Vegetable emits 35721.4 C02-ton/year. The results further show the largest amount of land is wasted due to the waste of Meat and Animal Products household waste which is 3161176.2 HA eq./Ton/year. After that, 21733.2, 5551.2, and 3247.4 HA eq./Ton/year are wasted due to the generated waste of Cereals and Pulses, Roots, Tubers, and Oil-Bearing Crops, and Fruits and Vegetable groups respectively. Moreover, the estimations show the largest amount of groundwater or blue water is wasted due to the waste of Meat and Animal Products household waste which is 141650800.2 M3eq./Ton/year. 33094230.3, 20589400.3, 8660815.8 M3eq./Ton/year are wasted due to the generated waste of Cereals and Pulses, Roots, Tubers, and Oil-Bearing Crops, and Fruits and Vegetable groups respectively.

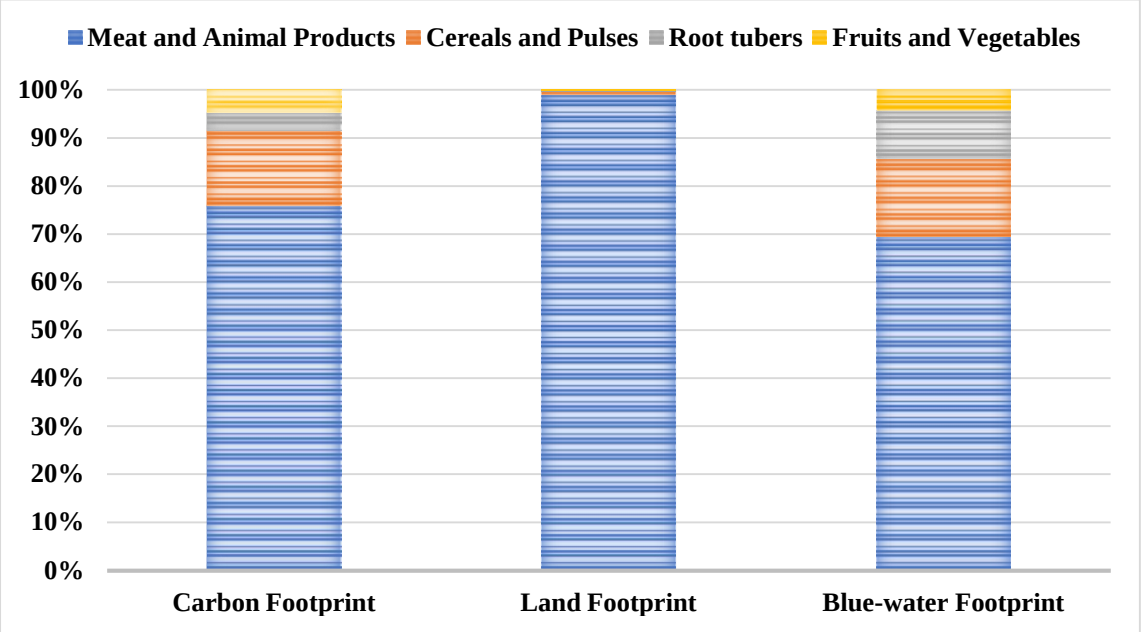

Figure No 4. 6:Carbon, land, Blue-water Footprints of Commodity Groups

4.3. Nutritional Loss:

This study has also estimated the average nutritional loss in terms of calories (kcal) of each commodity. There are 14 sub-commodities included whose nutritional loss has been estimated. This loss is calculated in Billion Tons of Calories. According to the estimated results portrayed in Figure

No: 4.7, through Milk total of 731.5 billion tons of calories are wasted per year at the household level in Pakistan. Furthermore, the results show that Wheat and Pelagic Fish are at second and third number in nutritional loss with a total of 82.7 and 81.5 billion tons/year calories respectively. Beef and Chicken accounts loss of 34.3 and 52.5 billion tons/year respectively. The total nutritional loss caused by

Freshwater Fish, Demersal Fish, Mango, Onion, Apple, and Oil is 28.2, 58.2, 22.5-, 11.6-, 32.6-, and 51.5-billion-ton calories/year respectively. Commodities like Potato, Rice, and Maize have recorded the lowest nutritional loss with 2.5, 0.02, and 0.0041 billion-tons-calories/year respectively.

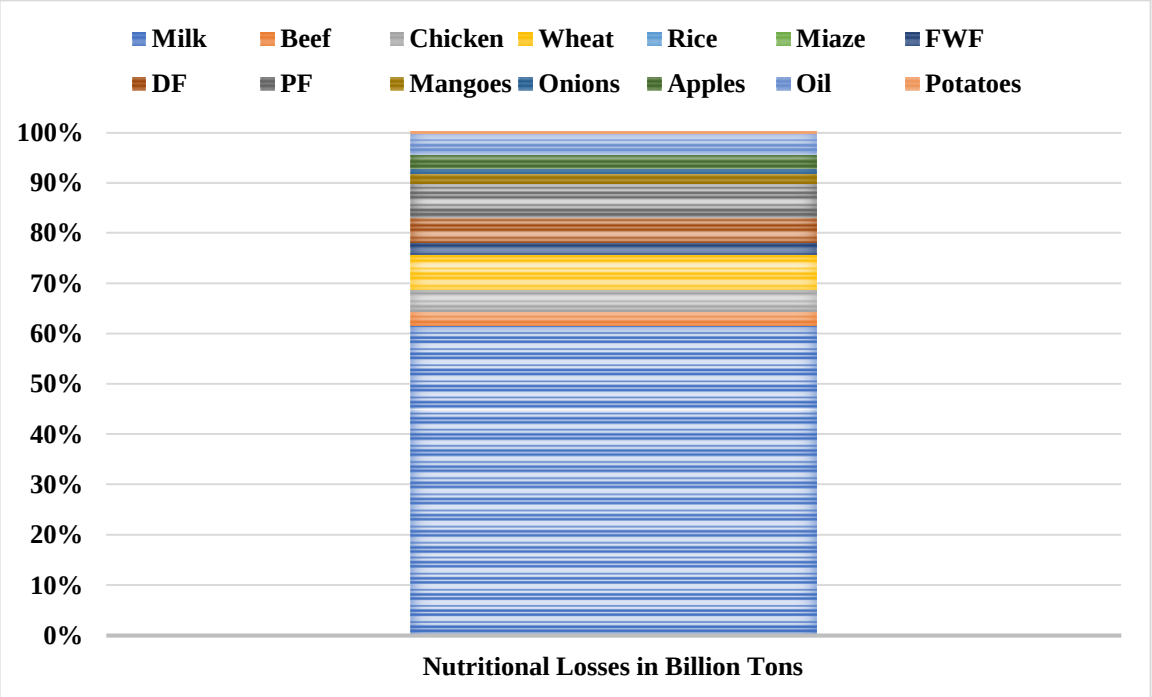

Figure No 4. 7:Nutritional Losses

4.4. Economic Losses:

Another objective of this study is to estimate the economic loss caused by food waste by the household of Pakistan. Like the other results, this objective has also included the same 14 sub-commodities. The following

mentioned figure no 4.8 depicts the percentage of economic loss in billion/year which is mentioned on the Y-axis of the figure. The X-axis represents all 14 sub-commodities. Results show that Milk waste causes 72.5 billion/year. Mango, Beef, Freshwater Fish, and Maize generate an economic loss of 13.3, 13.2, 10.4, 10.3 billion/year respectively. The commodities Chicken, Apple, and Rice cause 5.6, 5.1, and 5 billion/year monetary loss to the countryrespectively. Moreover, Potato, Onion, Pelagic Fish, and Demersal Fish generate 1.9, 0.1, 0.01, and 0.003 billion/year respectively.

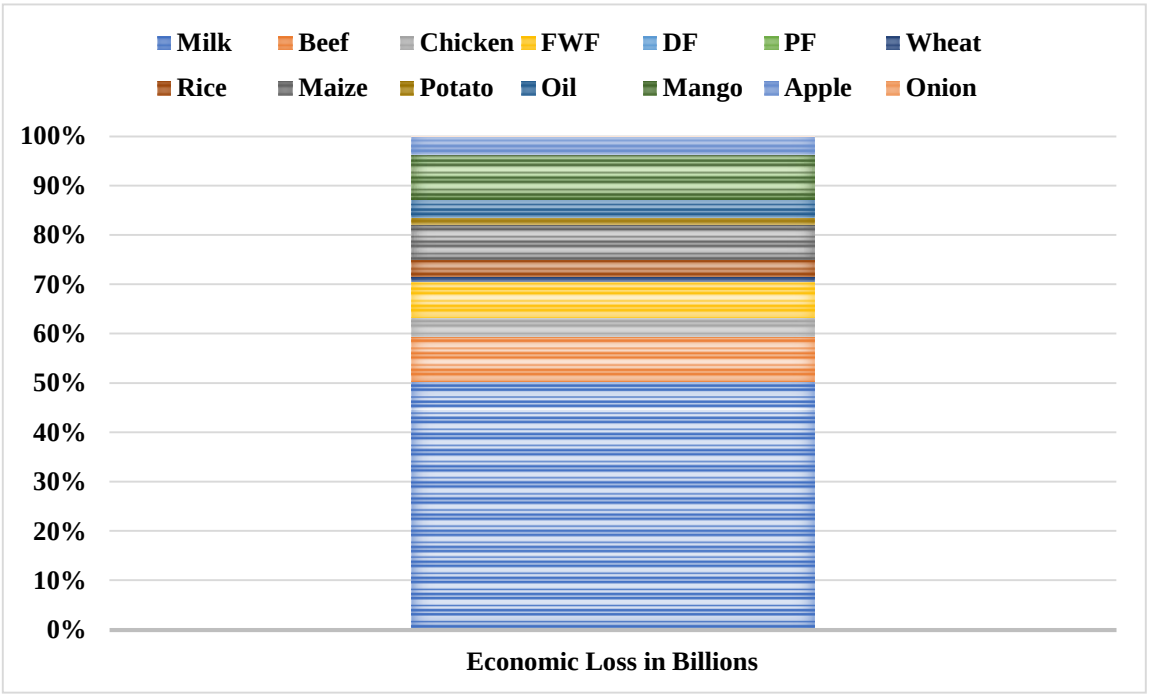

Figure No 4. 8:Economic Loss

4.5. Social Drivers and their Impacts on Household Food Waste:

Table No 4. 1:Social Drivers and their Impacts on Household Food Waste

HFW	Coef.	t	P>|t|
Age of KH	.017545	2.02	**0.044**
Education of HH Years	.0954232	3.06	**0.002**
Meals	.2228176	2.19	**0.029**
Total Fam Members	.0788932	5.52	**0.000**
Monthly Income	5.75e-06	3.25	**0.001**
Storage Refrigerator	.3179242	1.85	**0.065**
Storage Deep freezer	.1375441	0.65	**0.515**
Storage Plastic Container	.2411001	1.71	**0.089**
Storage Metallic Container	-.5797566	-4.50	**0.000**
Storage Wooden Shelves	.1724523	0.87	**0.386**
_cons	**-3.767776**	**-7.43**	**0.000**

The above-mentioned table no 4.1 portrays the main social drivers and their impacts on the household waste of Pakistan. The result narrates that the variable age of the kitchenhead has a positive impact on food waste and is statistically significant. The second

variable education in the household is also a statistically significant variable with a positive impact on the generated waste. The variables number of meals prepared in a day and monthly income of the household are both positively related to the generation of food waste and the analyzed results also show that they both are statistically significant as well. The variables, total family members, and storage through metallic containers also happen to have a positive and perfectly significant relation which shows that the higher the number of family members the higher amount of food tends to be wasted. The four variables storage through the refrigerator, storage through the deep freezer, storage through wooden shelves, and storage through plastic containers have a positive relation with waste but

they are statistically insignificant which means they don't have any impact on the food waste.

Summary:

The study shows that on average 0.25, 0.05, 0.03,0.03, and 0.01 million tons/year are wasted from the food categories meat and products, cereals and pulses, toot tubers, fruits and vegetables, and fish products respectively. Although 16% of the population is food insecure according to the Pakistan Bureau of Statistics latest FIES report, each year on average 272.8 billion tons kcal is wasted from animals and meat products category. Cereals and pulses, fruits and vegetables, and root tubers categories' 27.6, 22.2, and 27 billion tons/kcal are wasted every year respectively. Due to the fish and products category 56 billion tons/kcal/year are wasted. The study calculated that each year 243, 101, 38, 66, and 228 billion are wasted due to the reported loss of meat and animal products, cereals and pulses, fish products, root tubers, and fruits and vegetable categories respectively. The econometric model describes that food waste is positively related to household income, education, number of meals, family members.

4.6. Descriptive Statistics:

Descriptive statistics includes a graphical representation of the facts and figures of this research regarding the questionnaire-based survey done. This is further categorized into three different parts. The first part contains a graphical representation of the respondents' profiles. The second part has graphs and their explanation of Purchasing Patterns of the selected food items. Followed by the second part, the last part of this chapter describes the patterns of discarding wasted food items.

4.6.1. Respondents' Profile:

Age and Gender of Respondents:

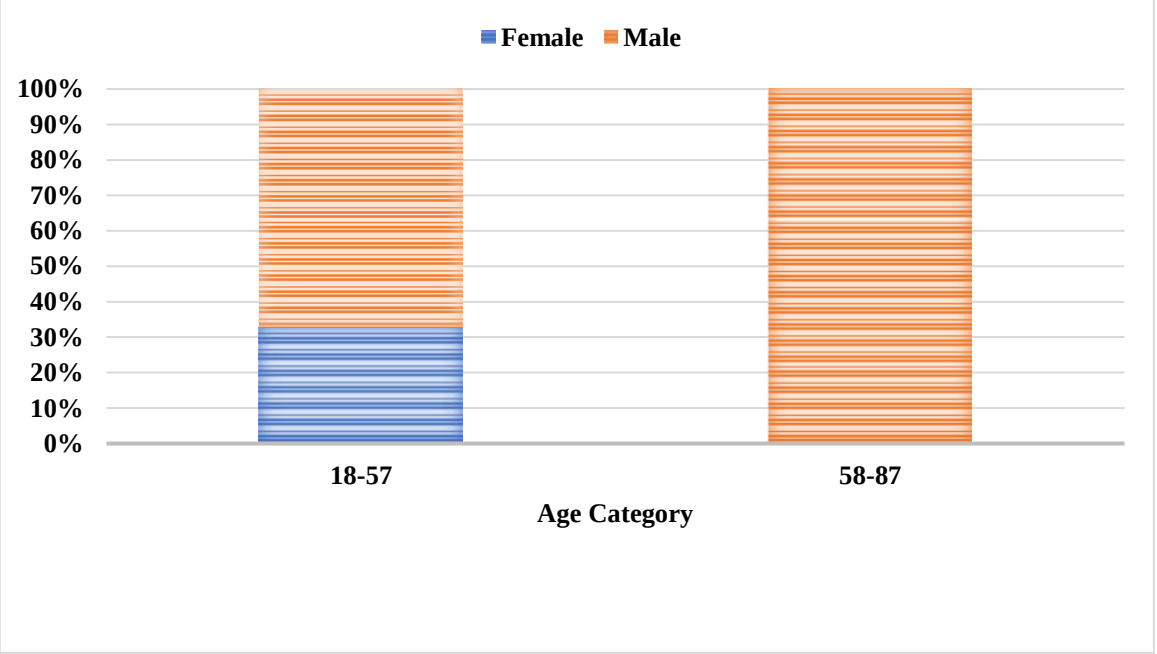

Figure No 4. 9:Age and Gender of Respondents

Figure 4.9 above sets out the image in front of us about the respondents' profile. This figure is about the number of respondents and gender and age of respondents. On the X-axis we have the gender and age category of respondents and on the Y-axis, we have put the numbers of respondents percentage-wise we got from the research. As highlighted in the graph the two major age categories are 18-57 and 58-57 the blue color is for females

and gray is for males. The results that we got are that we have a maximum number of males overall about 95% of the respondents are males and the remaining 5% are females. The graph shows that there are 0 females in the first age category and only19 in the latter one.

Provinces and Regions:

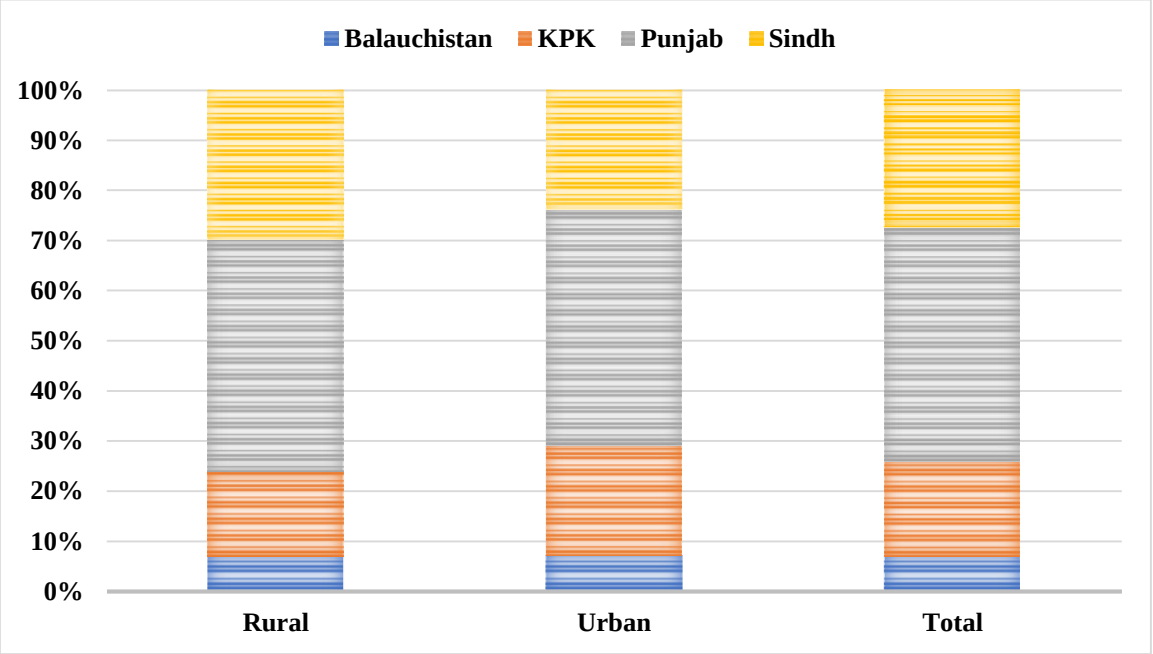

Figure No 4. 10:Province and Region

In this above-mentioned figure 4.10, the number of respondents and their provinces are shown addition to that their region is also mentioned if they are from urban or rural areas. The number of respondents percentage-wise is put on Y-axis whereas on X-axis we have Provinces and Regions. The results analyzed from the figure are; there were 16 respondents from rural areas and 11 respondents from urban areas in Baluchistan. In KPK there were 39 respondents from rural areas whereas there were 34 respondents from urban areas. When talking about Punjab we have had the highest number of both respondents from urban areas as well as rural areas. It is

shown that in Punjab there were 107 respondents from rural areas and 73 from urban areas. Finally, from Sindh, there are 69 respondents from rural areas and 37 respondents from urban areas were interviewed.

Description of the Respondent:

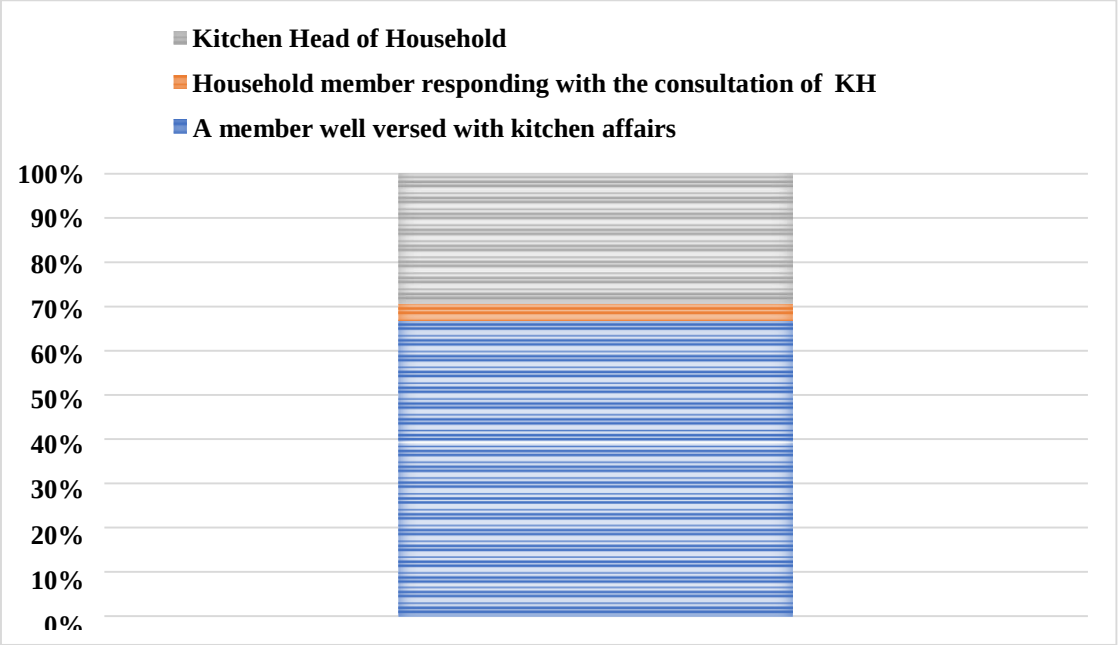

Figure No 4. 11:Description of Respondents

The above-mentioned figure 4.11 narrates the number of respondents and the description of respondents. There are three categories in which the respondents are described, first one is 'a member well versed with kitchen' second category that we have is 'household member responding with the consultation of kitchen head' and the last category is 'kitchen head of household'. The number of respondents is denoted onY-axis and the X-axis description of the respondent is denoted. 258 respondents fall in the category 'a member well versed with kitchen'. Only 15 respondents are found in the second category that is 'household member responding with the consultation of kitchen head' and finally in the last category that is 'kitchen head of household' 113 respondents were found.

4.6.2. Purchasing Pattern of Food Items:

Purchasing Patterns of Cereal and Pulses Category:

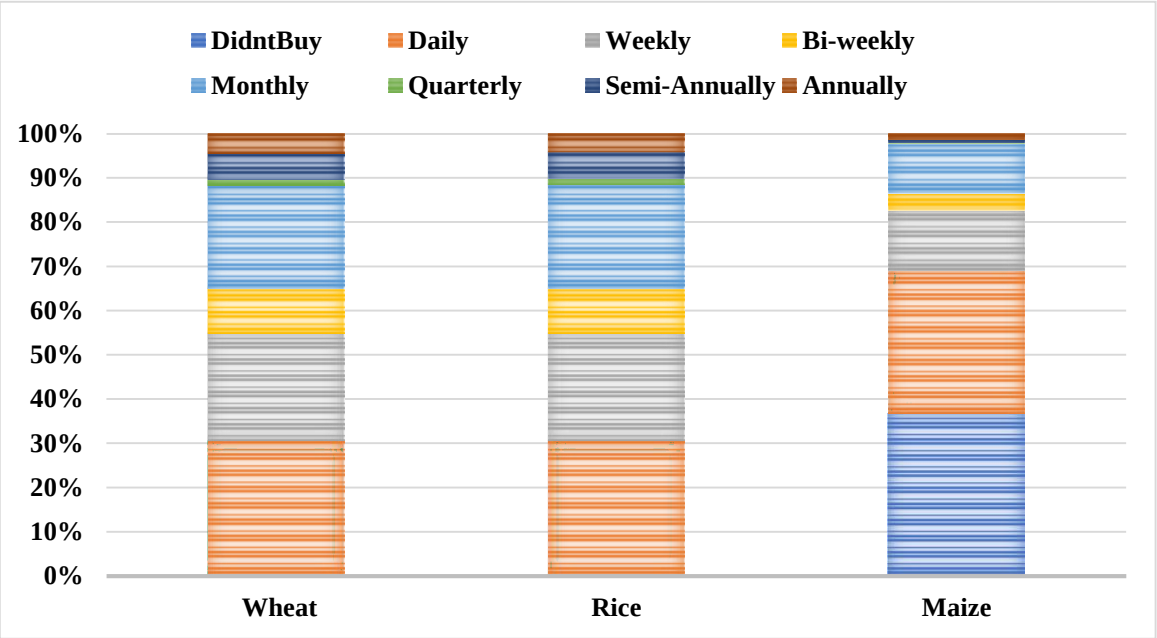

Figure No 4. 12:Purchasing Pattern of Cereals and Pulses Category

This above-mentioned figure 4.12 is the outline to purchasing patterns of cereals and pulses category furthermore, in detail, cereals and pulses are categorized in three types are wheat, rice and maize and these were questioned that these things are purchased on which basis, if is purchased daily, weekly, bi-weekly, monthly, quarterly, semi- annually, or annually or if they don't buy cereals and pulses. On X-axis we have categories (daily, weekly, bi-weekly, monthly, quarterly, semi-annually, or annually, and/or don't buy) while on Y-axis we have the number of respondents interviewed. Zero respondents fall into the category of didn't buy wheat and rice but on the other hand, 142 respondents are purchasing maize. The graph shows the maximum number of respondents who buy all three food items on daily basis. At the second and third weekly and monthly purchases stand respectively. After that, bi-weekly, semi-annually, and annually

purchasing patterns have a few respondents sequence-wise. Results show that there are only 11 people who are purchasing these food items quarterly.

Purchasing Patterns of Meat and Animal and Products Category:

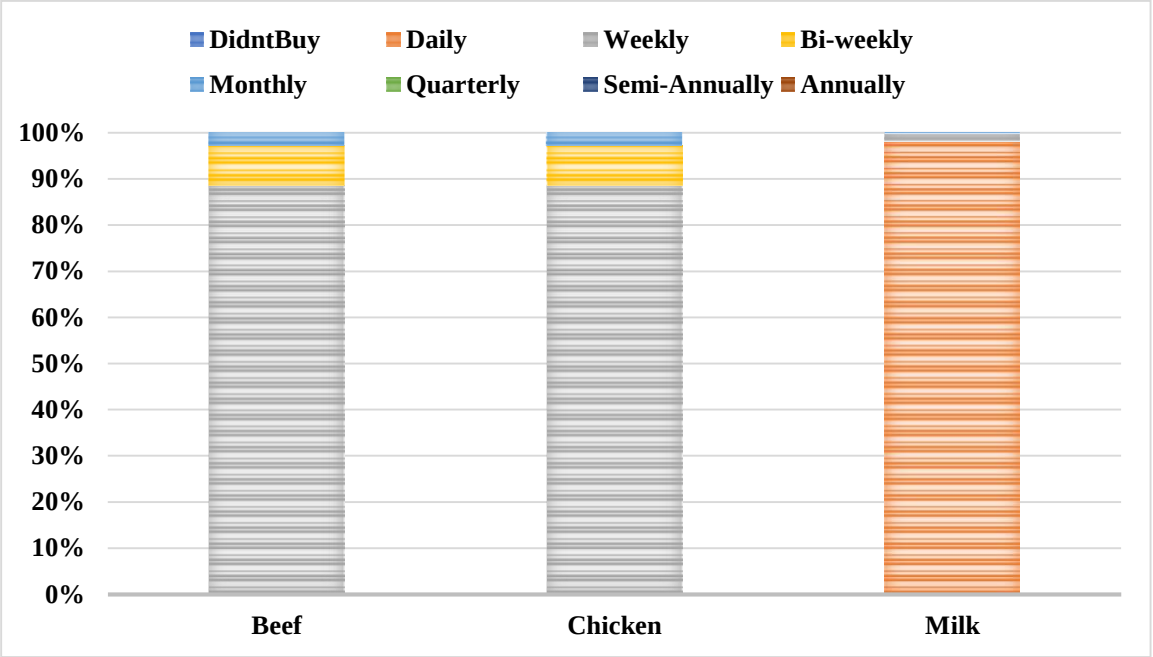

Figure No 4. 13:Purchasing Patterns of Meat and Animal Products Category

The above-mentioned figure 4.13 displays the purchasing patterns of the meat and animal products category. On the X-axis categories are displayed, categories are (daily,weekly, bi-weekly, monthly, quarterly, semi- annually, annually, and didn't buy) withthis on the Y-axis number of respondents is represented. It can be seen from the above- mentioned figure that milk is mostly purchased only daily basis as 379 respondents purchase milk on daily basis. On the other hand, there are only 6 respondents who purchase milk on weekly basis. Unlike milk, chicken, and beef according to the graph are purchased mostly on the weekly basis. The graphs narrate that there was zero number of respondents reported in the purchasing categories: didn't buy, quarterly, semi-annually, and annually.

Purchasing Patterns of Roots, Tuber, and Oil-Bearing, and Others Category:

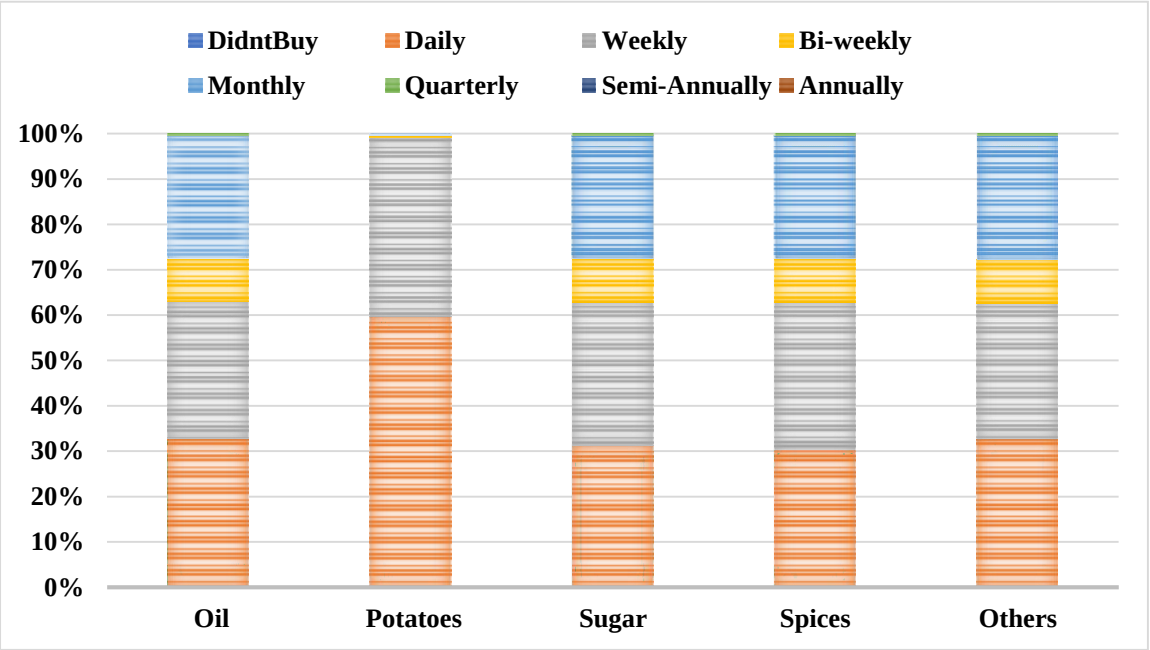

Figure No 4. 14:Purchasing Patterns of Roots, Tubers, and Oil-Bearing Crops, and Other Categories

Figure 4.14 is showing the purchasing patterns of the root, tubers, and oil-bearing products, and other categories on again daily, weekly, bi-weekly, monthly, quarterly, semi-annually, annually, and didn't buy basis. On X-axis, these categories are based and on the Y-axis number of respondents is based. The graph shows that all the food commodities are purchased daily by a maximum number of respondents. After daily, respondents purchased weekly, monthly, bi-weekly and quarterly. The results showed that the remaining categories didn't buy, semi-annually and annually have zero numberof respondents.

4.6.3. Patterns of Discarding Wasted Food Items:

Patterns of Discarding Waste of Raw and Cooked Beef, Chicken, and Vegetables:

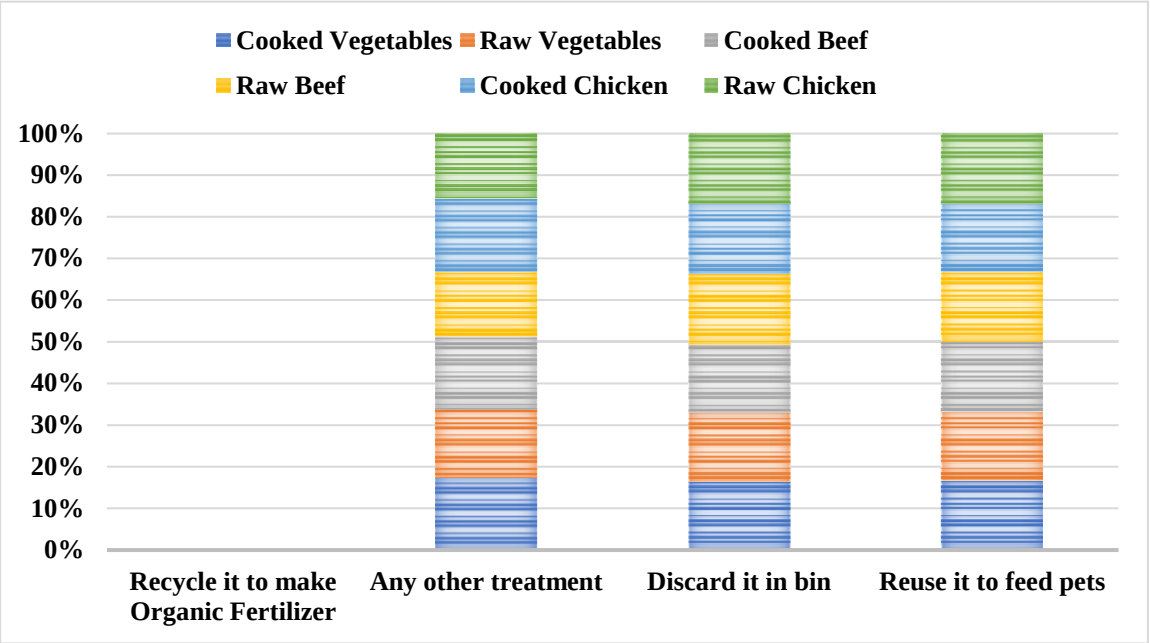

Figure No 4. 15:Patterns of Discarding Waste of Raw and Cooked Beef, Chicken, and Vegetables

The above figure 4.15 explains the pattern of discarding waste of raw and cooked beef, chicken, and vegetables are elaborated. It is categorized in a way that four categories are; the first category is for 'Recycle it to make Organic Fertilizer, the second category is to 'any other treatment', the third category is 'discard it in the bin' and the last category decided was to 'refuse it to feed pets'. On the X-axis categories are placed while on the Y-axis number of households are represented. Outcomes that are shown and are concluded are; In the first category there were not any respondents reported, in the second category, a pretty good response was reported from the respondents, the respondents have other treatments (giving the extra or leftover food to house workers or other people) to not to waste all these items, Very heart wrecking response was reported in the third category that is to 'discard it in the bin' after the first category, the maximum number of respondent reported in this category or pattern of discarding waste. In the last category that is 'refuse it to feed pets', mediocre results are found.

Patterns of Discarding waste of Wheat, Rice, Maize, Fruits, Oil, Sugar, Spices, and
others:

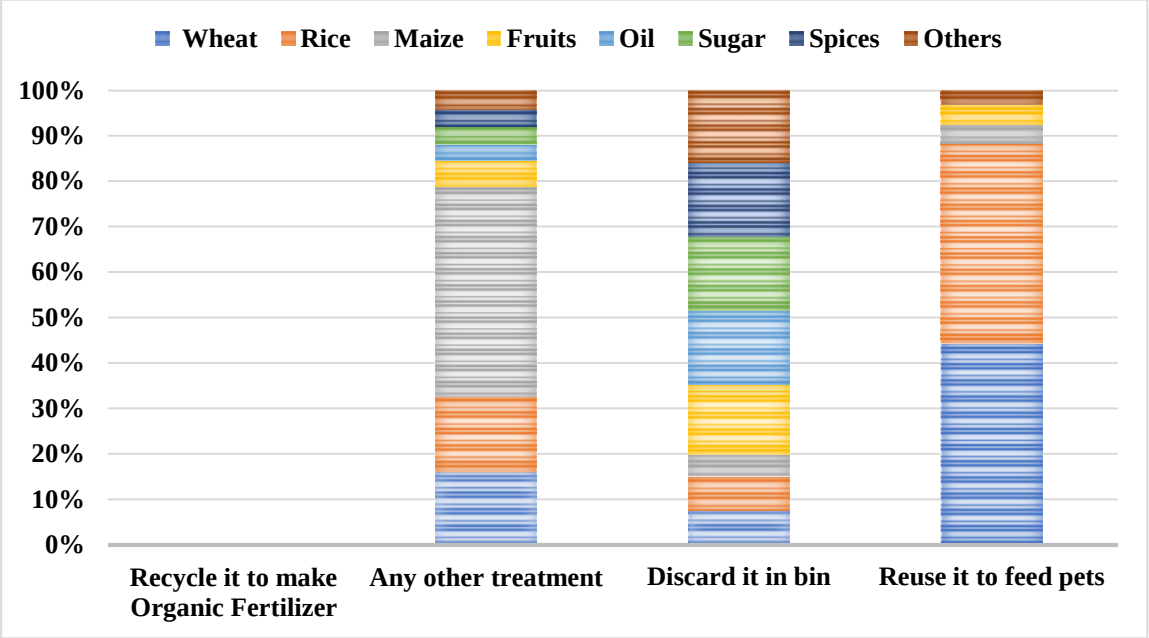

Figure No 4. 16:Patterns of Discarding waste of Wheat, Rice, Maize, Fruits, Oil, Sugar, Spices,
and other

In this last figure 4.16, Patterns of Discarding waste of Wheat, Rice, Maize, Fruits, Oil, Sugar, Spices, and others. This figure is categorized into four different categories these are, the First category is for 'Recycle it to make Organic Fertilizer' the second is 'any other treatment', the third is 'discard it in the bin' 'reuse it to feed is the last one. On the X-axis categories are placed while on the Y-axis number of households are represented. In conclusion, the total maximum number of respondents have reported the discarding pattern as discarding it in the bin for all commodities. Followed by reusing it to feed pets and any other treatment. There was not any respondent who reported to the category recycle it to make organic.

Chapter Five

A Systematic Literature Review: To Manage Household Food Wasteunder Circular Economy Model

This qualitative chapter provides systematic literature review to answer the research question and to suggest/recommend possibly best policy options for Pakistan's food waste management in the light of the circular economy model.

The circular economy is the best alternative to a linear economy in times of a thriving population, growing economic growth and development coupled with the drasticdepletion of natural resources. A circular economy is itself a vast concept that is spreadout with multiple techniques to not only manage waste but to reutilize that waste to generate monetary resources, renewable energy resources, and eco-friendly products the substitutes of harmful products.

5.1. Model Specification:

The methodology is consisted of research questions, Eligibility Criteria, Search Strategy, and search documentation.

5.1.1. Research Questions:

Following are the research questions of this systematic review:

- How circular economy models work through 3 R's: reduce, re-use and re-cycle.
- What are the major techniques to manage food waste done at the household level through the circular economy model?
- What are the effective, efficient, and adaptable food hierarchy steps under the light of the circular economy model for Pakistan's household food wastemanagement?

5.1.2. Eligibility Criteria:

Inclusion Criteria:

The following five mentioned statements explain the inclusion benchmark for the studies. Studies that have met these criteria have been included in the descriptive systematic review:

- Studies have been written/published in the English language.
- Studies have been focused on food waste management only.
- Studies have been focused on FW management using the circular economy model only.

Exclusion Criteria:

The following four mentioned statements explain the exclusion benchmark for the studies. Studies that have met these criteria have been excluded in the systematic review:

- Studies conducted/published in any native language.
- Studies focused on overall solid waste management through the circular economy at the household level.
- Studies that focused on food waste management at any other stage of the food supply chain i.e., production, transportation, distribution, consumption (commercial: hotels, marriage halls, etc.)
- Studies that have focused on other aspects of household food waste (impacts and behaviors of society)

5.1.3. Search Strategy:

The search strategy of this review is explained through 4 W's: Which, Where, what, and when. The search string is formed through the keywords taken from research questions that were listed and searched using BOOLEAN Search Tools (AND, OR).

Keywords:

Following are keywords used on e-databases to search the studies:

Circular economy, household food management, household food waste management Pakistan. Circular economy developing countries, circular economy developed countries, waste to energy, re-use, re-cycle, food hierarchy.

5.2. Results:

5.2.1. Study Selection and Data Extraction:

Initially, a total of 84 studies were searched through the above-mentioned searched engines. Among the total of 28 studies were found duplicated. After the removal of repeated studies total of 56 studies were left for screening which includes a review of titles and abstracts of the studies. At the screening level, 15 studies were removed leaving behind 41 studies for full-text review. At this stage total of 36 studies were excluded based on exclusion criteria and 5 studies were selected for the final review. 3out of 5 studies were conducted in China and the remaining two were from Norway andGermany. After the screening of all gathered studies and selection of a total of 5 studies for final data analysis. Full-text readings were done to extract the required data for analysis. This review has collected data based on 3 major categories which are: a) objective of the studies, b) Methodologies of the studies, and c) Outcomes/Findings ofthe studies.

5.2.2. Data Quality Assessment and Data Synthesis:

Since this is a qualitative/descriptive systematic review, the tool for data quality assessment is a short checklist based on CASP Appraisal Checklist. This questionnaire has three main domains: a) Thoroughness of methodological approaches to design and carry out research questions and objectives, b) Credibility of the findings/outcomes of the selected studies, and c) Relevance and Impact of those outcomes on the society and how useful those results are to the society as well as to researchers for future research. The nature of this study is a descriptive systematic review, the framework for data synthesis has been made based on a theoretical approach. The tool which is used to synthesize data is narrative synthesis. A thorough review of the selected study and its interpretation is done in tabulation form.

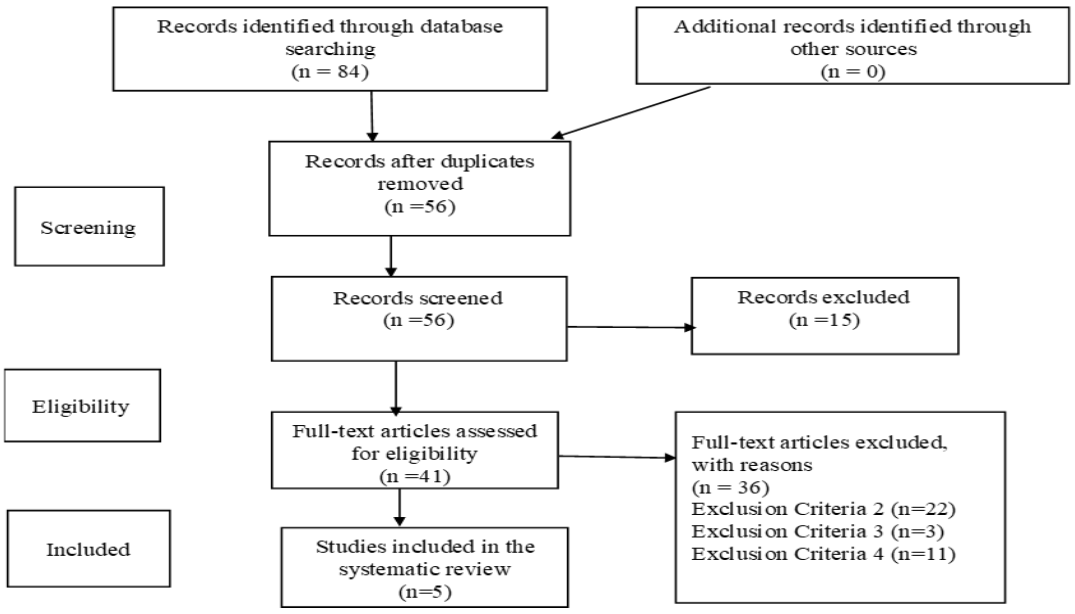

Figure No 5. 1:Prisma Flow Diagram

Table No 5. 1:Summary of Included Studies

S.No.	Author(s)	Year of Publication	Country	Title
1	(de Sadeleer et al., 2020)	2020	Norway	Waste prevention, energy recovery or recycling -Directions for household food waste management in light of circular economypolicy
2	(Negri et al., 2020)	2020	China	Anaerobic digestion of food waste for bio-energy production in China and Southeast Asia: A review
3	(Awasthi et al., 2020)	2020	China	Changes in global trends in food waste composting: Research challenges and opportunities
4	(Loizia et al., 2019)	2019	Germany	The concept of circular economy strategy in food waste management for the optimization of energy production through anaerobic digestion
5	(Yu et al., 2015)	2015	China	Conversion of food waste into biofertilizer for The biocontrol of root-knot nematode by Paecilomyces lilacinus

5.2.3. Narrative Analysis:

The first study's (de Sadeleer et al., 2020)major objective was to analyze and compare the environmental benefits of the two most used and focused circular economy's waste management patterns: Anaerobic Digestion and Incineration through the review and comparison of three indicators energy efficiency, recycling rate, and GHG emissions. The methodology used was material flow assessment and life cycle assessment models. The results showed that in terms of recycling rates and GHG emissions anaerobic digestion was more beneficial than incineration and in terms of energy efficiency incineration process tends to have a positive impact. However, the prevention of food waste was found overall more impactful and beneficial to the environment than the recycling patterns. The second and third studies' (Negri et al., 2020) (Awasthi et al., 2020)focus was on Anaerobic digestion and Co-compositing intervention method to manage food waste to mitigate its environmental impacts. The second study's objective was to keenly analyze key factors which affect anaerobic

digestion working mechanisms and the impact on the yield of biogas. To do so, the methodology of the

study includes a comparison of one stage and two stages of anaerobic digestion on theexisting plant along with the co-digestion and pre-treatment of food to compare the yield of biogas. The results showed that one-stage anaerobic digestion with thermal andphysical pre-treatments of food waste increased the yield of biogas production, and theresidue of the process can be converted into the biofertilizer for the crops.

The third study's objective was to highlight the economic and environmental benefits and challenges of the compositing method. The study has highlighted the challenges creation of odors which further generates adversity in the environment and tools like co-compositing to overcome them in the methodology. The results showed that even though composting is indeed a feasible option in terms of monetary expenses as well as in environmental aspects it generates unpleasant hazardous odors. Furthermore, the study suggests technologically advanced tools like pre-treatment of the organic with in combination with different operational variations, different types of additives and bulking materials, and/or microbial inoculums can harper down such impacts.

The second last study (Loizia et al., 2019) also has focused on the waste-to-energy process. This study aimed to test and run an experimental approach of up-flow anaerobic sludge blanket reactor methodology. The study has used an experimental approach to generate biogas from food waste/organic waste along with slaughterhousefluid waste and manure waste. The results of the study give an efficient way to manageurban waste to generate biogas.

The last study (Yu et al., 2015) is also on the waste-to-energy intervention method. The objective of this study was to analyze the generation of nematocidal biofertilizer from food waste by using an experimental approach: surface methodology. The results described that this technique generates a high quality of biofertilizer if the food waste is timely fermented.

Chapter Six

Conclusion and Policy Recommendation

6.1. Conclusion:

Prosperity always comes with its cost. So, the growth and development of the economies go hand in hand with its side effects as well. The linear economy is rooted all around the globe. With time, it has taken more than what it has given to societies. Global increment of population and economic growth has increased not only the demand for food but unfortunately, it has also increased both the food loss and waste. Pakistan is a developing nation, though in developing nations food loss at earlier stages of the supply chain is happening to be more, it doesn't mean that at the consumption stage there is no such problem. This study has tried to shed light on the consumption stage's household level of the country. The study has calculated the amount of food waste and its environmental impacts such as carbon emissions, waste of land, and bluewater in the country. The nutritional and economic loss has also been calculated. On the quantitative side, this study has also included a descriptive systematic review of existing literature on food waste management through circular economy models. The purpose of the systematic review was to give the best policy options to manage such waste and mitigate its environmental and societal losses in the context of Pakistan. The mathematical model of the study shows that there is an impactful amount of food waste happening at the household level of the nation.

The meat and animal products category is wasted higher with an overall 2 MT/Year. Fruits and Vegetables account for the overall waste of the

category 1.11 MT/Year. The overall category waste of cereals and pulses, and root tubers categories is 0.9 MT/Yearand 0.51 MT/Year respectively.

The study further shows that in environmental losses, meat and animal products and cereals and pulses are at first and second positions in the generation of higher Carbon, Land, and Blue-water footprints. However, Roots and tubers stand in the third numberin the generation of Carbon and Bluewater footprints, but it is at the last number in the generation of Land footprint. Similarly, the Fruits and vegetable category generate the least Carbon and Bluewater footprints, but Land footprint results show that it is in the third number. The econometric model shows that higher education level, income, total family members, and meals prepared in a day impact positively on the generation of food waste.

The meat and animal products category cause nutritional loss of a total of 2182 BT/Kcal/Year. Whereas Fruits and Vegetables account for the total nutritional loss of 822 BT/kcal/Year. The category waste of cereals and pulses, and roots and tubers account for a total nutritional loss of 496 BT/kcal/Year, and 486 BT/kcal/Year respectively. The meat and animal products category causes an economic loss of a total of 243 billion/Year. Whereas Fruits and Vegetables account for the total economic loss of 228 billion/year. The category waste of cereals and pulses, and roots and tubers account for a total economic loss of 101 billion/year and 66 billion/year respectively.

In the qualitative part of the study, the result of the systematic review suggests that to mitigate such huge environmental and societal impacts, anaerobic digestion is an effective way to treat the waste and cut down its

harmful impacts, but prevention of food waste is the first and best wat to harper such adversity.

6.2. Policy Recommendation:

The study has suggested some policy recommendations under the light of the circular economy model and food hierarchy. The suggestion of policy options is done through the outcome, policy tools, and adaptation.

6.2.1. Policy Option A:

Prevention of Avoidable Food Waste Outcome:

The most effective and adaptable policy option for the relevant ministry is to prevent food waste. Prevention means the avoidable waste which is happening should be prevented or halted immediately. It can be seen from the results of this study food waste is affecting our economy, society, and environment in three dimensions to great extent, if this waste is prevented without any side effects or by-products it can reduce all such adverse impacts. This policy option is feasible to both stakeholders' citizens and the government as well.

Policy Tools:

The study has suggested two policy instruments to adapt and implement the policy option successfully: Information based, and expenditure-based. The relevant ministry should create awareness both online and in-person depending on the audience through technological assistance like social media, digital and print media by creating polls, webinars, a documentary about food waste and its impacts, and how to prevent that waste.

Adaptation:

Prevention is economical, administratively, environmentally feasible, and adaptable too. It will be easy for the administration of the areas to run campaigns accordingly to the nature of the audience in person or online. Economically though it will cost some expenses to the administration or relevant ministry, it will cut down the consumer side of expenses. In the context of the environment, if there will be no waste there will be no harmful impacts on our environment.

6.2.2. Policy Option B

Anaerobic Digestion Treatment of Food Waste. Outcome:

The second option this study has suggested is the management of food waste through treating it in anaerobic digestion plants. Anaerobic digestion is the treatment to recycle the waste and turn it into renewable energy and biofertilizers for qualitative agricultural production. Organic waste or food waste tends to be more effective for anaerobic digestion to generate biogas from waste. This policy option discourages the direct dumping of food waste and will mitigate the environmental impacts and in economic terms, it will reduce the cost of inorganic fertilizers. Biofertilizers are the by-products of the anaerobic digestion process to convert waste into energy.

Policy Tools:

Like the other policy option, this study has suggested two policy instruments to adapt and implement the policy option successfully: Information based, and expenditure- based on this as well. The installment of sorting machines in the existing waste management, and in upgrading human capital as well as existing infrastructure like trucks, huge community bins, etc. Enhancement of human capital can be done through information-based policy tools. Creating awareness about anaerobic digestion and its related things like sorting out the waste etc. can be achieved through awareness workshops and pieces of training.

Adaption:

Administratively, this policy option can be challenging to some extent but environmentally it can cut down the GHG emissions and it can reduce

the impact on soil fertility and yield and nutrients of agricultural products through the generation of biogas and bio-fertilizers.

6.3. Limitations of the study:

The limitation of the study is written below:

Due to the time, resources constraints the data sample of the study was selected 400and collected through a telephonic survey.

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Appendices:

Appendix A: Systematic Review Details:

Study Protocol:

The study protocol of this systematic literature review is based on PRISMA-P 2020 Checklist. The study protocol is made up of components that describe the study design/plan. The following mentioned components describe this systematic literature review's study design.

Rationale: A basic background about the topic of systematic review

Research Questions/Objectives: A well-defined set of structured research questions based on the (PICO) Population, Intervention, Comparison, and Outcome of theselected studies.

Eligibility Criteria: A set of structured statements used for the purpose of inclusion andexclusion of studies to be reviewed.

Information Sources: Sources or databases through which studies will be searched andobtained for the review.

Search Strategy: Development and listing of keywords from the research questions, development of search string based on 3 W's Which, Where, What, and When, and documentation of studies. Assessment is done through quality assessment tools/checklists/form. This study has used a quality assessing form to elevate biases andto ensure the validity of included studies. This quality assessing form is based on the objectives, methodologies, and findings of the studies.

Data Extraction: Tools like data extraction form are used to extract detailed informationon objectives, methodology, and findings of the included studies for the analysis/reviewto justify and explain the research questions.

Data Synthesis: The evaluation and interpretation are done at this stage. This

systematicreview is done in a descriptive manner. A qualitative analysis has been done in this

review study.

Research Questions Framework based on PRISMA-P 2020 PICO

Population	**Existing Literature of managing household food waste through circular economy.**
Intervention	**Circular economy model as techniques to manage food waste.**
Comparison	Different Techniques based on food hierarchy to manage waste. For instance, re-use, re-cycle; food valorization, waste to energy, etc.
Outcome	How such techniques affect the surrounding of the research area: household. What are the effects of those techniques on the environment and society?

Search Strategy Framework:

	An automated approach has been used in this systematic review. A Computerizedbased search has been carried out in this review.
	Only e-databases have been used to find the studies. Total 6databases; JSTOR, SpringerLink, Taylor and Francis Journal, ELSEVIER, Emerald, and Research Gatehave been used along with the grey literature. Apart from that, a backward snowballing search (search through the list of references)has been also done

	Literature on household food management has been searched and used to conduct thisdescriptive systematic review
	It took around total of 1 and half months to search and gather the data for the review.

Documenting the Search:

Data Source	Documentation
HEC Digital Library	Name of database: Taylor and Francis Journal Search Strategy for the database: random forward and backwardsnowballing strategy. Name of database: JSTOR Search Strategy for the database: random forward and backwardsnowballing strategy. Name of database: SpringerLink Search Strategy for the database: random forward and backwardsnowballing strategy. Name of database: Emerald Search Strategy for the database: random forward and backwardsnowballing strategy.
Google Scholar	Name of database: ResearchGate Search Strategy for the database: random forward and backwardsnowballing strategy.

Appendix B: Sample Framework:

Province	Expenditure Group	Numbers in Sampling Frame			Proportional Allocation		
		Rural	Urban	Overall	Rural	Urban	Overall
Punjab	Upto 1000	199	95	294	8	4	12
	>1000 to 2000	515	146	661	22	6	28
	>2000 to 3000	665	310	975	28	13	41
	>3000 to 4000	464	284	748	19	12	31
	>4000 to 5000	333	301	634	14	13	27
	>5000 to 6000	98	144	212	4	6	9
	>6000 to 7000	98	109	207	4	5	9
	>7000 to 8000	77	90	167	3	4	7
	>8000 to 9000	33	69	102	1	3	4
	>9000 to 10000	58	64	122	2	3	5
	>10000 and above	67	111	178	3	5	7
	Sub Total	2607	1723	4300	109	72	180
Sindh	Upto 1000	32	16	48	1	1	2
	>1000 to 2000	438	124	562	18	5	24
	>2000 to 3000	461	215	676	19	9	28
	>3000 to 4000	366	188	494	15	8	21
	>4000 to 5000	187	170	357	8	7	15
	>5000 to 6000	57	67	124	2	3	5
	>6000 to 7000	41	46	87	2	2	4
	>7000 to 8000	26	30	56	1	1	2
	>8000 to 9000	13	27	40	1	1	2
	>9000 to 10000	12	13	25	1	1	1
	>10000 and above	25	41	66	1	2	3
	Sub Total	1658	937	2535	69	39	106
KP	Upto 1000	22	10	32	1	0	1
	>1000 to 2000	153	43	196	6	2	8
	>2000 to 3000	327	153	480	14	6	20
	>3000 to 4000	255	156	411	11	7	17
	>4000 to 5000	161	145	306	7	6	13
	>5000 to 6000	45	53	98	2	2	4
	>6000 to 7000	38	42	80	2	2	3
	>7000 to 8000	21	24	45	1	1	2
	>8000 to 9000	9	19	28	0	1	1
	>9000 to 10000	10	12	22	0	1	1
	>10000 and above	21	35	56	1	1	2
	Sub Total	1062	692	1754	44	29	73
Balochistan	Upto 1000	56	27	83	2	1	3
	>1000 to 2000	54	15	69	2	1	3
	>2000 to 3000	77	36	113	3	2	5
	>3000 to 4000	80	49	129	3	2	5
	>4000 to 5000	57	52	109	2	2	5
	>5000 to 6000	28	33	61	1	1	3
	>6000 to 7000	12	13	25	1	1	1
	>7000 to 8000	11	12	23	0	1	1
	>8000 to 9000	3	6	9	0	0	0
	>9000 to 10000	6	6	12	0	0	1
	>10000 and above	4	6	10	0	0	0
	Sub Total	388	255	643	16	11	27
Pakistan	Upto 1000	309	148	457	13	6	19
	>1000 to 2000	1160	328	1488	49	14	62
	>2000 to 3000	1530	714	2244	64	30	94
	>3000 to 4000	1165	677	1842	49	28	75
	>4000 to 5000	738	668	1406	31	28	59
	>5000 to 6000	228	297	495	10	12	21
	>6000 to 7000	189	210	399	8	9	17
	>7000 to 8000	135	156	291	6	7	12
	>8000 to 9000	58	121	179	2	5	7
	>9000 to 10000	86	95	181	4	4	8
	>10000 and above	117	193	310	5	8	13
	Sub Total	5715	3607	9322	239	151	386

Appendix C: Questionnaire

Pakistan's Food Waste and its Management under Circular Economy

I'm Aqsa Noor Shaikh, student of MPhil Environmental Economics at Pakistan Institute of Development Economics, Islamabad. Currently, I am doing research to estimate the volume of Food wasted at household level. For this purpose, I am conducting telephonic survey at household level. This survey will help to find out the volume of food wastage. Kindly helps us to find out the wastage of food at household level. I assure you the information will be kept highly confidential, and will be used only for the purpose of research. Basically, we need information from your Kitchen head about the food wastage. If you and kitchen head are ready to participate in this survey, I will appreciate your effort.

Note: Kindly note that

1) Kitchen head is that member of family who is responsible for cooking and other kitchen related activity.
2) In this survey, I will ask questions about food wastage at your house in the last one week from the available food.

* Required

1. Do you or your kitchen head have 10-15 minutes for this survey? *

   Mark only one oval.

   - ◯ Yes *Skip to question 4*
   - ◯ No

2. Is your Kitchen head is near to you, for giving us response? *

   Mark only one oval.

   - ◯ Yes *Skip to question 4*
   - ◯ No *Skip to question 3*

Untitled Section

3. Are you (on behalf of your kitchen head) or your family kitchen head willing participate in this survey? *

(Please note: if Respondent is not a kitchen head of the family, then respondent should share the verified information from kitchen household head)

Mark only one oval.

- ◯ Yes *Skip to question 4*
- ◯ No

Respondent's Profile

4. Description of Respondent *

Mark only one oval.

- ◯ Kitchen Head of Household
- ◯ A member well versed with kitchen affairs
- ◯ Household member responding with the consultation of kitchen head
- ◯ Other: _____

5. Name of the respondent *

_____

6. Gender of the respondent *

Mark only one oval.

- ◯ Male
- ◯ Female
- ◯ Other: _____

7. Age of the respondent *

_____

8. Province *

Mark only one oval.

- ◯ Balochistan
- ◯ KPK
- ◯ Punjab
- ◯ Sindh

9. Region *

Mark only one oval.

- ◯ Rural
- ◯ Urban

10. Area of household *

Mark only one oval.

- City
- Town
- Suburbs
- Village
- Hamlet
- Other: _____

Socio-Demographic Variables

11. Who is responsible for kitchen? *

Mark only one oval.

- Cook
- Yourself
- Another family member
- Other: _____

12. Gender of Kitchen Head *

Mark only one oval.

- Female
- Male
- Other: _____

13. Age of Kitchen Head

_____

14. Education of Kitchen Head *

Mark only one oval.

- ◯ No schooling
- ◯ Primary
- ◯ Middle
- ◯ Secondary
- ◯ Higher secondary
- ◯ Graduation and above
- ◯ Other: _____

15. Total number of household members *

_____

16. Total household members in age category (Up to 5 Years) *

Number of children in the household up to 5 years age, add zero if there is no family member up to 5 in house who share kitchen.

_____

17. Total household members in age category (6 to 10 Years) *

Number of children in the household from 6 to 10 years age, add zero if there is no family member from 6 to 10 years in house who share kitchen.

_____

18. Total household members in age category (11 to 19 Years) *

Total number of teenagers in the household from 11 to 19 years age, add zero if there is no family member from 11 to 19 years in house who share kitchen.

_____

19. Total household members in age category (20 to 35 Years) *

Total number of young adults in the household from 20 to 35 years, add zero if there is no family member from 20 to 35 years in house who share kitchen.

_____

20. Total household members in age category (36 to 50 Years) *

Total number of middle-aged adults in the household from 36 to 50 years, add zero if there is no family member from 36 to 50 years in house who share kitchen.

_____

21. Total household members in age category (51 and above years) *

Total number of old-aged adults in the household from 51 and above years, add zero if there is no family member from 51 and above years in house who share kitchen.

_____

22. Number of educated household members *

Add zero if no one in the family is educated who shares kitchen.

_____

23. Highest level of education in the household *

Mark only one oval.

- ◯ Noeducation
- ◯ Primary
- ◯ Middle
- ◯ Secondary
- ◯ Higher secondary
- ◯ Graduation and above
- ◯ Other: _____

24. Average monthly Income of the household from all sources including remittances of all members (share kitchen) *

All income sources: from all the occupations (like; Agriculture, Wages/Salary, Rental or others) household members are involved in.

_____

25. Number of income earners in the household *

Insert "0" if no one is reported as income earner in the household.

_____

26. Total expenses of kitchen food items *

_____

27. Share of total income on kitchen expenses *

Insert the percentage of total income used for kitchen expenses

_____

28. Through which way you store your food? *

Check all that apply.

- [ ] Referigerator
- [ ] Deep freezer
- [ ] Plastic containers
- [ ] Metallic containers
- [ ] Plastic bags
- [ ] Wooden shelves with doors
- [ ] Other: _____

Purchasing Pattern of Food Items

29. No. of meals cooked per day *

Meals: "How many times you cook food in a day"

_____

30. In which pattern you mostly purchase the following mentioned food item? *

Mark only one oval per row.

	Annually	Semi-annually	Quarterly	Monthly	Bi-weekly	Weekly
Wheat						
Rice						
Maize						
Tomatoes						
Cauliflower						
Okra						
Milk						
Beef						
Chicken						
Oil						
Potatoes						
Sugar						
Spices						
Others						

31. Through which way you mostly discard your kitchen waste? *

Mark only one oval per row.

	Reuse it to feed pets	Recycle it to make organic fertilizer	Discard it in bin	Any other treatment
Wheat				
Rice				
Maize				
Vegetables cooked				
Raw vegetables				
Raw Beef				
Cooked Beef				
Raw Chicken				
Cooked Chicken				
Milk				
Oil				
Sugar				
Spices				
Fruits				
Others				

Food Items

Animal Products

32. Did your household have milk in last week? *

Mark only one oval.

- ◯ Yes *Skip to question 33*
- ◯ No *Skip to question 36*

33. How many liters of milk were available to your household in last week? *

The answer to this question requires the total amount of milk available for use in the last week.

_____

34. Approximately how many percentage of that milk was wasted in last week? *

In case no waste is reported, insert 0%.

_____

35. Reason of waste

Ask only if waste is reported in above written question.

Check all that apply.

- [ ] Accidentally lost (e.g. slipped by hand).
- [ ] Leftover milk in children' feeder waste due to negligence.
- [ ] Expired due to negligence so we threw it away.
- [ ] Lost during boiling of milk.
- [ ] We could not use it on time due to unusual circumstances and therefore had to throw it (as eaten from outside).
- [ ] We had to throw it away because we bought the quantity more than it was required.
- [ ] Rotten (damaged) due to unknown reasons so he had to be thrown.
- [ ] It was still usable but we threw it away because we didn't want to use it any more.
- [ ] It was still usable but we gave it to someone else because we didn't want to use it any more.
- [ ] It was unusable so we gave it to animals; like dogs, cats, birds, and cattle to feed.
- [ ] My reason does not meet the reasons given in the list mentioned.
- [ ] Other: _____

Beef

Meat Products:

36. Did Beef was available to your household in last week? *

Mark only one oval.

- ◯ Yes *Skip to question 37*
- ◯ No *Skip to question 41*

B1

37. How many Kgs of Beef was available to your household in last week? *

The answer to this question requires the total amount of beef from available for use to your household in last week.

_____

38. Approx. how many percentage of that Beef in raw form was wasted in last week? *

In case no waste is reported, insert 0%.

_____

39. Approx. How many percentage of cooked beef was wasted in last week? *

In case of no waste reported, insert 0.

_____

40. Reason of waste

Ask only if waste is reported in both or any one of above written 2 questions.

Check all that apply.

- [ ] Rotten (spoiled) due to negligence so we threw it away.
- [ ] Due to the freezer/refrigerator was not working properly.
- [ ] We could not use it on time due to unusual circumstances and therefore had to throw it (as eaten from outside).
- [ ] We had to throw it away because we bought the quantity more than it was required.
- [ ] Rotten (damaged) due to unknown reasons so he had to be thrown.
- [ ] It was still usable but we threw it away because we didn't want to use it any more.
- [ ] It was still usable but we gave it to someone else because we didn't want to use it any more.
- [ ] It was unusable so we gave it to animals; like dogs, cats, birds, and cattle to feed.
- [ ] My reason does not meet the reasons given in the list mentioned.
- [ ] Other: _____

Chicken

41. Did Chicken was available to your household in last week? *

Mark only one oval.

- ◯ Yes *Skip to question 42*
- ◯ No *Skip to question 46*

42. The answer to this question requires the total amount of Potatoes available for use to your household in last week.

The answer to this question requires the total amount of Chicken available for use to your household in last week.

_____

43. Approx. how many percentage of that Chicken in raw form was wasted in last week? *

In case no waste is reported, insert 0%.

_____

44. Approx. How many plates were wasted in last week? *

In case of no waste reported, insert 0.

_____

45. Reason of waste

Ask only if waste is reported in both or any one of above written 2 questions.

Check all that apply.

- [ ] Due to the freezer/refrigerator was not working properly
- [ ] Rotten (spoiled) due to negligence so we threw it away.
- [ ] We could not use it on time due to unusual circumstances and therefore had to throw it (as eaten from outside).
- [ ] We had to throw it away because we bought the quantity more than it was required.
- [ ] Rotten (damaged) due to unknown reasons so he had to be thrown.
- [ ] It was still usable but we threw it away because we didn't want to use it any more.
- [ ] It was still usable but we gave it to someone else because we didn't want to use it any more.
- [ ] It was unusable so we gave it to animals; like dogs, cats, birds, and cattle to feed.
- [ ] My reason does not meet the reasons given in the list mentioned.
- [ ] Other: _____

Root Tubers and Oil Bearing

Potatoes

46. Did Potatoes were available to your household in last week? *

Mark only one oval.

- ◯ Yes *Skip to question 47*
- ◯ No *Skip to question 50*

47. How many Kgs of Potatoes were available to your household in last week? *

The answer to this question requires the total amount of Potatoes available for use to your household in last week.

_____

48. Approx. how many percentage of Potatoes was wasted in last week? *

In case no waste is reported, insert 0%.

_____

49. Reason of waste

Ask only if waste is reported in above written question.

Check all that apply.

- [ ] Due to the freezer/refrigerator was not working properly
- [ ] Rotten (spoiled) due to negligence so we threw it away.
- [ ] We could not use it on time due to unusual circumstances and therefore had to throw it (as eaten from outside).
- [ ] We had to throw it away because we bought the quantity more than it was required.
- [ ] Rotten (damaged) due to unknown reasons so he had to be thrown.
- [ ] It was still usable but we threw it away because we didn't want to use it any more.
- [ ] It was still usable but we gave it to someone else because we didn't want to use it any more.
- [ ] It was unusable so we gave it to animals; like dogs, cats, birds, and cattle to feed.
- [ ] My reason does not meet the reasons given in the list mentioned.
- [ ] Other: _____

Oil

50. Did Oil was available to your household in last week? *

Mark only one oval.

- ◯ Yes *Skip to question 51*
- ◯ No *Skip to question 54*

51. How many Liters of Oil were available to your household in last week? *

The answer to this question requires the total amount of Oil available for use to your household in last week.

_____

52. How many percentage of purchased oil was wasted in last week? *

In case no waste is reported, insert 0%.

_____

53. Reason of waste

Ask only if waste is reported in above written question.

Check all that apply.

- [ ] Accidentally lost (e.g. slipped by hand).
- [ ] We had to throw it away because we bought the quantity more than it was required.
- [ ] Rotten (damaged) due to unknown reasons so he had to be thrown.
- [ ] It was still usable but we threw it away because we didn't want to use it any more.
- [ ] It was still usable but we gave it to someone else because we didn't want to use it any more.
- [ ] It was unusable so we gave it to animals; like dogs, cats, birds, and cattle to feed.
- [ ] My reason does not meet the reasons given in the list mentioned.
- [ ] Other: _____

Cereals

Wheat

54. Did Wheat was available to your household in last week? *

Mark only one oval.

- ◯ Yes *Skip to question 55*
- ◯ No

55. How many Kgs of Wheat were available to your household in last week? *

The answer to this question requires the total amount of Wheat available for use to your household in last week.

56. Approx. how many percentage of wheat in raw form was wasted in last week? *

In case no waste is reported, insert 0%.

57. How many numbers of cooked wheat (Roti) were prepared yesterday? *

In case of no roti prepared in last week, insert 0.

58. Approx. How many (Roti) were wasted in last week? *

In case no waste is reported or 0 reported in above mentioned question, insert 0.

59. Reason of waste

Ask only if waste is reported in both or any one of above written 2 questions.

Check all that apply.

- [ ] Accidentally lost (e.g. slipped by hand).
- [ ] Rotten (spoiled) due to negligence so we threw it away.
- [ ] Due to the freezer/refrigerator was not working properly.
- [ ] We could not use it on time due to unusual circumstances and therefore had to throw it (as eaten from outside).
- [ ] We had to throw it away because we bought the quantity more than it was required.
- [ ] Rotten (damaged) due to unknown reasons so he had to be thrown.
- [ ] It was still usable but we threw it away because we didn't want to use it any more.
- [ ] It was still usable but we gave it to someone else because we didn't want to use it any more.
- [ ] It was unusable so we gave it to animals; like dogs, cats, birds, and cattle to feed.
- [ ] My reason does not meet the reasons given in the list mentioned.
- [ ] Other: _____

Rice

60. Did Rice was available to your household in last week? *

Mark only one oval.

- ◯ Yes *Skip to question 61*
- ◯ No *Skip to question 65*

61. How many Kgs of Rice were available to your household in last week? *

The answer to this question requires the total amount of Rice available for use to your household in last week.

_____

62. Approx. how many percentage of Rice in raw form was wasted in last week? *

In case no waste is reported, insert 0%.

_____

63. Approx. How many plates were wasted in last week? *

In case no waste is reported, insert 0.

_____

64. Reason of waste

Ask only if waste is reported in both or any one of above written 2 questions.

Check all that apply.

- [ ] Accidentally lost (e.g. slipped by hand).
- [ ] Rotten (spoiled) due to negligence so we threw it away.
- [ ] We could not use it on time due to unusual circumstances and therefore had to throw it (as eaten from outside).
- [ ] We had to throw it away because we bought the quantity more than it was required.
- [ ] Rotten (damaged) due to unknown reasons so he had to be thrown.
- [ ] It was still usable but we threw it away because we didn't want to use it any more.
- [ ] It was still usable but we gave it to someone else because we didn't want to use it any more.
- [ ] It was unusable so we gave it to animals; like dogs, cats, birds, and cattle to feed.
- [ ] My reason does not meet the reasons given in the list mentioned.
- [ ] Other: _____

Maize

65. Did Maize was available to your household in last week? *

Mark only one oval.

- ◯ Yes *Skip to question 66*
- ◯ No *Skip to question 70*

66. How many Kgs of Maize were available to your household in last week? *

The answer to this question requires the total amount of Maize available for use to your household in last week.

_____

67. Approx. how many percentage of Maize in raw form was wasted in last week? *

In case no waste is reported, insert 0%.

_____

68. Approx. How many plates were wasted in last week? *

In case no waste is reported, insert 0.

_____

69. Reason of waste

Ask only if waste is reported in both or any one of above written 2 questions.

Check all that apply.

- [ ] Accidentally lost (e.g. slipped by hand).
- [ ] Rotten (spoiled) due to negligence so we threw it away.
- [ ] Due to the freezer/refrigerator was not working properly kneaded dough of maize flour was rotten.
- [ ] We could not use it on time due to unusual circumstances and therefore had to throw it (as eaten from outside).
- [ ] We had to throw it away because we bought the quantity more than it was required.
- [ ] Rotten (damaged) due to unknown reasons so he had to be thrown.
- [ ] It was still usable but we threw it away because we didn't want to use it any more.
- [ ] It was still usable but we gave it to someone else because we didn't want to use it any more.
- [ ] It was unusable so we gave it to animals; like dogs, cats, birds, and cattle to feed.
- [ ] My reason does not meet the reasons given in the list mentioned.
- [ ] Other: _____

Fruits and vegetables

Fruits: Mangoes

70. Did Mangoes were available to your household? *

Mark only one oval.

- ◯ Yes *Skip to question 71*
- ◯ No *Skip to question 74*

71. How many Kgs of Mangoes were available to your household in last week? *

The answer to this question requires the total amount of Mangoes available for use to your household in last week.

_____

72. Approx. how many percentage of purchased mangoes were wasted? *

In case no waste is reported, insert 0%.

_____

73. Reason of waste

Ask only if waste is reported in above written question.

Check all that apply.

- [ ] Accidentally lost (e.g. slipped by hand).
- [ ] Rotten (spoiled) due to negligence so we threw it away.
- [ ] We could not use it on time due to unusual circumstances and therefore had to throw it (as eaten from outside).
- [ ] We had to throw it away because we bought the quantity more than it was required.
- [ ] Rotten (damaged) due to unknown reasons so he had to be thrown.
- [ ] It was still usable but we threw it away because we didn't want to use it any more.
- [ ] It was still usable but we gave it to someone else because we didn't want to use it any more.
- [ ] It was unusable so we gave it to animals; like dogs, cats, birds, and cattle to feed.
- [ ] My reason does not meet the reasons given in the list mentioned.
- [ ] Other: _____

Onions

74. Did Onions were available to your household in last week? *

Mark only one oval.

- ◯ Yes *Skip to question 75*
- ◯ No *Skip to question 78*

75. How many Kgs of Onions were available to your household in last week? *

The answer to this question requires the total amount of Onions available for use to your household in last week.

_____

76. Approx how much percentage of onions was wasted in last week? *

In case no waste is reported, insert 0%.

_____

77. Reason of waste

Ask only if waste is reported in above written question.

Check all that apply.

- [ ] Due to the freezer/refrigerator was not working properly.
- [ ] Rotten (spoiled) due to negligence so we threw it away.
- [ ] We could not use it on time due to unusual circumstances and therefore had to throw it (as eaten from outside).
- [ ] We had to throw it away because we bought the quantity more than it was required.
- [ ] Rotten (damaged) due to unknown reasons so he had to be thrown.
- [ ] It was still usable but we threw it away because we didn't want to use it any more.
- [ ] It was still usable but we gave it to someone else because we didn't want to use it any more.
- [ ] It was unusable so we gave it to animals; like dogs, cats, birds, and cattle to feed.
- [ ] My reason does not meet the reasons given in the list mentioned.
- [ ] Other: _____

Apples

78. Did Apples were available to your household in last week? *

Mark only one oval.

- ◯ Yes *Skip to question 79*
- ◯ No *Skip to question 82*

79. How many Kgs of Apples were available to your household in last week? *

The answer to this question requires the total amount of Apple available for use to your household in last week.

_____

80. Approx. how many percentage of Apples was wasted in last week? *

In case no waste is reported, insert 0%.

_____

81. Reason of waste

Ask only if waste is reported in above written question.

Check all that apply.

- [ ] Due to refrigerator was not working properly.
- [ ] Rotten (spoiled) due to negligence so we threw it away.
- [ ] We could not use it on time due to unusual circumstances and therefore had to throw it (as eaten from outside).
- [ ] We had to throw it away because we bought the quantity more than it was required.
- [ ] Rotten (damaged) due to unknown reasons so he had to be thrown.
- [ ] It was still usable but we threw it away because we didn't want to use it any more.
- [ ] It was still usable but we gave it to someone else because we didn't want to use it any more.
- [ ] It was unusable so we gave it to animals; like dogs, cats, birds, and cattle to feed.
- [ ] My reason does not meet the reasons given in the list mentioned.
- [ ] Other: _____

Fish products

Fresh water fish

82. Did Fresh Water Fish was available to your household in last week? *

Fresh Water Fish: (Rohu, Morakha)

Mark only one oval.

- ◯ Yes *Skip to question 83*
- ◯ No *Skip to question 87*

83. How many Kgs of Fresh Water Fish: (Rohu, Morakha) were available to your household in last week? *

The answer to this question requires the total amount of Fresh Water Fish: (Rohu, Morakha) available for use to your household in last week.

84. Approx how many percentage of fresh water fish (Rohu, Morakha) in raw form was wasted in last week? *

In case no waste is reported, insert 0%.

85. Approx How many plates of cooked fresh water fish (Rohu, Morakha) were wasted in last week? *

In case no waste is reported, insert 0.

86. Reason of waste

Ask only if waste is reported in both or any one of above written 2 questions.

Check all that apply.

- [ ] Due to refrigerator was not working properly.
- [ ] Rotten (spoiled) due to negligence so we threw it away.
- [ ] We could not use it on time due to unusual circumstances and therefore had to throw it (as eaten from outside).
- [ ] We had to throw it away because we bought the quantity more than it was required.
- [ ] Rotten (damaged) due to unknown reasons so he had to be thrown.
- [ ] It was still usable but we threw it away because we didn't want to use it any more.
- [ ] It was still usable but we gave it to someone else because we didn't want to use it any more.
- [ ] It was unusable so we gave it to animals; like dogs, cats, birds, and cattle to feed.
- [ ] My reason does not meet the reasons given in the list mentioned.
- [ ] Other: _____

Demersal Fish

87. Did Demersal Fish (Khaga, Sonaf) was available to your household in last week? *

Demersal Fish: (Khaga, Sonaf)

Mark only one oval.

- ◯ Yes *Skip to question 88*
- ◯ No *Skip to question 92*

88. How many Kgs of Demersal (Khaga, Sonaf) were available to your household in last week? *

The answer to this question requires the total amount of Demersal Fish (Khaga, Sonaf) available for use to your household in last week.

89. Approx how many percentage of Demersal in raw form was wasted in last week? *

In case no waste is reported, insert 0%.

90. How many plates of cooked Demersal were wasted in last week? *

In case no waste is reported, insert 0.

91. Reason of waste

Ask only if waste is reported in both or any one of above written 2 questions.

Check all that apply.

- [ ] Due to freezer/refrigerator was not working properly.
- [ ] Rotten (spoiled) due to negligence so we threw it away.
- [ ] We could not use it on time due to unusual circumstances and therefore had to throw it (as eaten from outside).
- [ ] We had to throw it away because we bought the quantity more than it was required.
- [ ] Rotten (damaged) due to unknown reasons so he had to be thrown.
- [ ] It was still usable but we threw it away because we didn't want to use it any more.
- [ ] It was still usable but we gave it to someone else because we didn't want to use it any more.
- [ ] It was unusable so we gave it to animals; like dogs, cats, birds, and cattle to feed.
- [ ] My reason does not meet the reasons given in the list mentioned.
- [ ] Other: _____

Pelagic Fish

92. Did Pelagic Fish was available to your household in last week? *

Pleagic Fish: (Palla, Mohr)

Mark only one oval.

- ◯ Yes *Skip to question 93*
- ◯ No *Skip to question 97*

93. How many Kgs of Pelagic Fish (Palla, Mohr) were available to your household in last week? *

The answer to this question requires the total amount of Pelagic Fish (Palla, Mohr) available for use to your household in last week.

_____

94. Approx how many percentage of Pelagic Fish (Mohr, Palla) in raw form was wasted in last week *

In case no waste is reported, insert 0%.

_____

95. Approx how many plates of cooked Pelagic Fish were wasted in last week? *

In case no waste is reported, insert 0.

_____

96. Reason of waste

Ask only if waste is reported in both or any one of above written 2 questions.

Check all that apply.

- [ ] Due to freezer/refrigerator was not working properly.
- [ ] Rotten (spoiled) due to negligence so we threw it away.
- [ ] We could not use it on time due to unusual circumstances and therefore had to throw it (as eaten from outside).
- [ ] We had to throw it away because we bought the quantity more than it was required.
- [ ] Rotten (damaged) due to unknown reasons so he had to be thrown.
- [ ] It was still usable but we threw it away because we didn't want to use it any more.
- [ ] It was still usable but we gave it to someone else because we didn't want to use it any more.
- [ ] It was unusable so we gave it to animals; like dogs, cats, birds, and cattle to feed.
- [ ] My reason does not meet the reasons given in the list mentioned.
- [ ] Other: _____

Others

Spices

97. Did Spices were available to your household in last week? *

Spices: (Packaet or Khula Masala; Dhaniya, Mirch, Garam Masala)

Mark only one oval.

- ◯ Yes *Skip to question 98*
- ◯ No *Skip to question 101*

98. How many grams of Spices (Packaet or Khula Masala; Dhaniya, Mirch, Garam Masala) were available to your household last week? *

The answer to this question requires the total amount of Spices (Packaet or khula Masala; Dhaniya, Mirch, Garam Masala)available for use to your household in last week.

_____

99. Approx. how many percentage of purchased spices was wasted in last week? *

In case no waste is reported, insert 0%.

_____

100. Reason of waste

Ask only if waste is reported in above written question.

Check all that apply.

- [ ] Accidentally lost (e.g. slipped by hand).
- [ ] Rotten (spoiled) due to negligence so we threw it away.
- [ ] We could not use it on time due to unusual circumstances and therefore had to throw it (as eaten from outside).
- [ ] We had to throw it away because we bought the quantity more than it was required.
- [ ] Rotten (damaged) due to unknown reasons so he had to be thrown.
- [ ] It was still usable but we threw it away because we didn't want to use it any more.
- [ ] It was still usable but we gave it to someone else because we didn't want to use it any more.
- [ ] It was unusable so we gave it to animals; like dogs, cats, birds, and cattle to feed.
- [ ] My reason does not meet the reasons given in the list mentioned.
- [ ] Other: _____

Sugar

101. Did Sugar was available to your household in last week? *

Mark only one oval.

- ◯ Yes *Skip to question 102*
- ◯ No *Skip to question 105*

102. How many Kgs of sugar were available to your household in last week? *

The answer to this question requires the total amount of Sugar available for use to your household in last week.

_____

103. Approx. how many percentage of sugar was wasted in last week? *

In case no waste is reported, insert 0%.

_____

104. Reason of waste

Ask only if waste is reported in above written question.

Check all that apply.

- [ ] Accidentally lost (e.g. slipped by hand).
- [ ] Rotten (spoiled) due to negligence so we threw it away.
- [ ] We could not use it on time due to unusual circumstances and therefore had to throw it (as eaten from outside).
- [ ] We had to throw it away because we bought the quantity more than it was required.
- [ ] Rotten (damaged) due to unknown reasons so he had to be thrown.
- [ ] It was still usable but we threw it away because we didn't want to use it any more.
- [ ] It was still usable but we gave it to someone else because we didn't want to use it any more.
- [ ] It was unusable so we gave it to animals; like dogs, cats, birds, and cattle to feed.
- [ ] My reason does not meet the reasons given in the list mentioned.
- [ ] Other: _____

Groundnuts

105. Did Groundnuts were available to your household in last week? *

Mark only one oval.

- ◯ Yes *Skip to question 106*
- ◯ No

106. How many Kgs of groundnuts were available to your household for last week in last week? *

The answer to this question requires the total amount of groundnuts available for use to your household in last week.

_____

107. Approx how many percentage of groundnuts were wasted in last week? *

In case no waste is reported, insert 0%.

_____

108. Reason of waste

Ask only if waste is reported in above written question.

Check all that apply.

- [ ] Accidentally lost (e.g. slipped by hand).
- [ ] Rotten (spoiled) due to negligence so we threw it away.
- [ ] We could not use it on time due to unusual circumstances and therefore had to throw it (as eaten from outside).
- [ ] We had to throw it away because we bought the quantity more than it was required.
- [ ] Rotten (damaged) due to unknown reasons so he had to be thrown.
- [ ] It was still usable but we threw it away because we didn't want to use it any more.
- [ ] It was still usable but we gave it to someone else because we didn't want to use it any more.
- [ ] It was unusable so we gave it to animals; like dogs, cats, birds, and cattle to feed.
- [ ] My reason does not meet the reasons given in the list mentioned.
- [ ] Other: _____

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