CHAPTER 4
CLUSTER BACKGROUND AND PROCESS STUDY

4.1 INTRODUCTION
Agro-based industries have their distinctive characteristic of consuming energy and water to process an agricultural crop to produce diversified useful products. It also has the distinction of producing by-products that are mostly organic in nature. To ensure CP in these industries they are required to use less resource. Energy is the major resource in these industries and hence importance has to be given to energy conservation either through the adoption of better practices or through energy efficient technologies (EETs). The environmental performance of these industries mainly depends on energy consumption apart from the waste management techniques adopted. Thus, it is intended to study the energy consumption pattern and the environmental impact of the agro-based industries in this study. To achieve this objective, thorough understanding of the prevailing process practices is essential. Thus, the present chapter deals with the study of production process in the three agro-based MSME clusters. The input-output analysis is performed; energy consumption pattern, and environmental impact caused are studied.

4.2 BACKGROUND OF CLUSTERS

4.2.1 Bakery Processing Cluster of Shimoga District
Shimoga district is a part of the Malnad region of Karnataka state. Shimoga lies between the latitudes 13°27' and 14°39' North Latitude and 74 37' and 75 52’ East Longitude at mean altitude of 640 metres above sea level. The district is spread over an area of 8465 square kms. In this district 2505 agro-based industries provide employment to over 9000 people. Rice mills, foundry, wood turning, wood carving, cane and bamboo are the major manufacturing industries in the district. Like any other district in India, this district also houses a number of micro, small and medium (MSME) bakeries baking bread, cake, and other confectionery items. The exact number of bakeries in the district is not known as only few bakers have registered their firm under hotel owners association.

4.2.2 Cashew Processing Cluster of Dakshina Kannada and Udupi
Dakshina Kannada and Udupi are coastal districts of Karnataka. Geographically these two districts are between the Western Ghats on east and Arabian Sea on their west. In Dakshina Kannada district, industries such as tile, beedi, cashew kernel, coconut oil, food and beverages, apart from manufacturing units like rubber/plastic goods, wooden products
etc., have a prominent presence. Dakshina Kannada district is located at 12°27' and 13°58' North Latitude 74°35' and 74°4' East Longitude with geographical area of 477149 Hectares. After establishment of sea port at Mangalore in the seventies, there is rapid momentum in industrialization of the district. Due to the presence mega industrial units like Mangalore Refinery and Petrochemicals Ltd. (MRPL), Mangalore Chemicals and Fertilizers (MCF), Kudremukh Iron Ore Company Ltd. (KIOCL) in the district, large number of MSMEs is also coming up. Udupi district in the Karnataka state of India was created in August 1997 by bi-furcating the three taluks from the undivided parent Dakshina Kannada district. It is located at 13° 04' and 13° 59' North latitude and 74° 35' and 75° 12' East longitude with geographical area of 3565 square kms. Udupi district is basically an agrarian economy. Agricultural crops such as paddy, areca nut, coconut, rubber and cashew are the major crops being cultivated since long time. As such, Paddy and plantation crops grown in the district provide raw material for agro processing industries and is the green-field for setting up of agro-based processing activities.

4.2.3 Gangavathi Rice Mill Cluster of Koppal District
Koppal, a newborn district of Karnataka state, carved out of Raichur district, came into existence in 1998. It is a stretch of rocky terrain on one side and dry land on the other wherein agricultural crops like Jowar, Ground-nuts etc., are grown. It is located between 15. 09' 00" to 16. 03' 30" North Latitude and 75. 47' 30" to 76. 48' 10" East Longitude with geographical area of 552495 hectares and is 540 meters above mean sea level. The major exportable items from the district are Maize, Granite Blocks, Granite Tiles, and Rice. The district has varied agro-climatic regions suitable to grow many horticultural crops. The district has well established agro-processing units with godown facilities like rice mills, sugar mills and oil mills. A number of small-scale food processing industries are available in the district. The district also has well established research and extension centres viz., Agriculture Research Station, Krishi Vigyan Kendra, and District Agriculture Training Center (DATC) at Gangavathi, Sericulture Training Centre at Kushtagi and Animal Husbandry Training Centre at Koppal District.

4.3 AN OVERVIEW OF BAKERY INDUSTRY
Baking industry is the largest organised food industry in the world due to the preference given to convenient foods in the era of increasing women employment and urbanisation. The bakery industry comprises mainly of bread, biscuits, cakes and pastries manufacturing units. The contributing factors for the popularity of bakery products are
reasonable product costs, greater nutritional quality, availability of varieties with different textural and taste profiles, and better taste. With the help of technology, baking methods have changed considerably eliminating the tedious manual work and it is currently an energy intensive industry.

As reported by Food & Beverage News (FnB, 2010), India is the second largest producer of bread and baked products followed by the United States of America (USA). Over 75% of the biscuits are produced by MSME sector consisting of both factory and non-factory units. The current bread and biscuits production in the organised and unorganised sectors is estimated to be around 20 lakh tonnes and 15 lakh tones, respectively. India’s organised bakery is valued at around Rs 3,200 crore. The annual turnover at present is estimated at over 2000 crores. Though there are several large and small scale organised units, manufacturing both bread and biscuits, most of the bakery products in India are being produced by unorganised small family units. It is of interest to note that only about 26% of biscuits and 24% of bread are manufactured in large scale bakery units while the remaining 74-76% of bakery products are produced in MSMEs and family units.

4.3.1 Production Process in Bakery

The production process in a bakery is fundamentally transformation of raw dough into a light, readily digestible food product. However, it consists of several processing stages as illustrated in the figure 4.1.

Mixing

Initially the dough is to be prepared which has the ingredients mainly flour, sugar, yeast, salt, fat and other emulsifiers. The dough preparation starts with sifting flour with the help of vibratory sifter and then collected in bowl and weighed. Mixing of flour and ingredients involves hydration, blending, dough development and dough breakdown. In the hydration stage water is added in different quantities and ingredients are thoroughly mixed for 6 – 12 minutes and blended and homogenised. The dough begins to damp and sticky to aggregate into wet-mass. Further mixing develops the gluten network in the dough. Dough becomes cohesive mass that can be elastic and non-sticky. The dough is now more viscoelastic with silky, smooth and shine character. When this stage is reached, the mixing is to be stopped else it becomes increasingly soft, smooth and sticky. In mixing the flour and ingredients, mixers are used. The mixers commonly used for mixing of wheat dough are low speed mixers, or spiral mixers which can operate on either in slow or fast speed.
Intermediate Proving
It is a process which allows the dough to rise or ferment. The mixed dough is placed in metal container or in troughs to allow the dough to varying fermentation periods.
Fermentation is achieved by yeast which breaks down the sugar to carbon dioxide and ethanol. The gas produced during fermentation leavens the dough into foam. The foam structure of dough is discrete and has stability during fermentation. When fermented dough is baked, the foam structure gets converted into sponge structure that is responsible for aerated structure of breadcrumb.

**Dividing and Moulding**

After proving, the dough is divided into individual pieces either manually or with the help of divider. The weight of the dough to be taken depends on the final weight of the bread required. Generally, 12% extra dough weight is taken to compensate for the loss. Dividing should be done within the shortest time in order to ensure the uniform weight. The divided dough is moulded into desired shape. Moulding involves sheeting, which degasses the dough and sheeted dough can be easily manipulated into required shapes.

**Proving or Proofing**

Proving or proofing refers to the dough resting period in which the fermentation continues. This is achieved by placing the moulded dough pieces in pans. It is generally carried out at 30-35°C and at 85% relative humidity for a period of 50 - 60 minutes. During proofing the dough increases remarkably in volume. Temperature, humidity, and time influence proofing.

**Baking**

After proofing, the dough is subjected to heat in a baking oven. Baking temperature generally varies depending upon oven and product type and is generally kept in the range of 220-250°C. During baking, the temperature of dough centre reaches to about 95°C in order to ensure that the product structure is fully set. When the dough is placed in the oven, heat is transferred through dough by several heat transfer mechanisms such as convection, radiation, and conduction, with the occurrence of condensation of steam and evaporation of water. The baking time of bread may range from 25 - 30 minutes depending upon size of bread loaf. After baking, bread is cooled prior to packaging to facilitate slicing and to prevent condensation of moisture in the packing wrapper.

**4.4 AN OVERVIEW OF CASHEW PROCESSING INDUSTRY**

India was the largest producer and exporter of cashew kernels in the world, but for the past few years according to International Nut and Dried Fruit Council (INC), but the shortage of raw nuts keeps India’s contribution to the world market at around 30 per cent
of the total global exports, while its main competitor Vietnam consistently maintains a share of 39 per cent (Business Line, April 2014). Indian cashews are consumed in as many as 60 countries all over the world and Indian cashew kernel is well acclaimed for its good quality, taste and appearance. The world cashew market is experiencing an oversupply position in recent years following the entry of new producers, especially from Vietnam. Owing to this fact, India, which had overwhelming position in cashew trade, has come down in the world market. There are two commonly followed methods of cashew nut processing, viz., Roasting process and Steam (roasting) Cooking process. In cooking process vegetable oil is extracted from the cashew shell of the seeds, which has market in paint and adhesive industry.

As reported in The Hindu (2009), in Karnataka State, about 250 processing units employing more than 40,000 women workers in Mangalore, Udupi, Uttara Kannada, and Belgaum are processing about 1.65 lakh tonnes of raw cashew nut annually. The annual turnover of these units is about Rs. 600 crore, and about 50% comes from export earnings. They depend on procurements from Africa besides Goa and Maharashtra. While the State produces about 50,000 tonnes, nearly 80,000 tonnes is imported from African nations and the rest come from neighbouring states. Cashew industry in Karnataka, which has an edge on quality of processing, packaging and exports, faces shortage of raw cashew nuts for processing. Manual processing has placed Karnataka's cashew industry on top position in terms of quality in the market.

4.4.1 Processing of Cashew Nut

Processing of cashew nuts refers to the conversion of raw cashew nuts in shell to its blanched graded kernel form. The processing of cashew in the orchard is mainly confined to removal of raw nuts from cashew apple and drying. It is very essential to dry the nuts after harvest to prevent spoilage during subsequent storage. The processing of nuts at orchard level does not come under the purview of this study. The nuts which are required to be processed at factory should be dried again for 1-2 days to reduce and maintain the moisture level of 7% - 8%. The processing of raw nuts involves roasting, shelling, drying, peeling, grading and packing. The steps involved in commercial processing of cashew nuts are depicted below in figure 4.2.
Figure 4.2: Cashew Processing Stages

**Roasting**

Roasting of raw nut is done to separate shell from the kernel. There are three types of roasting viz., drum roasting, oil bath roasting and steam roasting. *Drum roasting* - The nuts are fed into a rotating red hot drum which will ignite the shell maintaining its temperature because of the burning of the shell liquid. The drum is kept in rotation for 3-4 minutes and the roasted nuts are discharged from the lower end of the drum. *Oil bath roasting* - In this method conditioned nuts are passed through Cashew Nut Shell Liquid
(CNSL) bath heated to 170-200°C by conveyer buckets for 1-2 minutes during which period the shell gets heated rupturing the wall and releasing the oil into the bath. The oil is recovered by continuous over flow arrangement. *Steam roasting*- The raw nuts are steam cooked at about 7 kg/mm² pressure for about 25-30 minutes. Then the nuts are allowed to cool for 24 hours and taken for shelling. Shell oil can be extracted in later stages by crushing.

**Shelling**
Cashew nuts after roasting and cooling are to be shelled to remove kernels. Processing units use either foot operated shell cutters or power operated shelling machines. After shelling the kernels and shell pieces are separated manually.

**Drying**
The kernels after shelling will have moisture content of more than 6%. The kernels are to be dried to moisture content of about 4-5% to prevent fungus attack and to facilitate peeling of testa. This is done by drying the kernels in hot chambers at $70 - 80^\circ \text{C}$ in perforated trays for about 6 - 8 hours. Uniform drying could be achieved with a cross flow drier using forced hot air circulation through the kernel layers. After drying, the kernels are kept in the moist chamber for 24 hours which facilitates easy removal of testa and minimizes broken kernels.

**Peeling**
This process involves the removal of testa (seed coat) which is loosely attached to the kernel. Peeling is done using a sharp knife or bamboo piece or by using peeling machines. Care has to be taken to avoid breakage while removing the testa.

**Grading**
Kernels are graded manually according to the size. In the International Market bold whole kernels fetch premium price. The grading standards developed in India refer to white whole kernels (undamaged) and indicate the number of kernels per lb of weight. The largest kernels come in the grade W 210 (440-460/kg) and the smallest of the seven grades is W 500 (1000-1100/kg). The white whole kernels are priced according to size. Further classification refers to broken kernels, butts, splits, pieces, small pieces and whether kernels are white or scorched.

**Packaging**
As far as possible packaging material used should be eco-friendly and recyclable and containers are hermetically sealed after filling carbon dioxide.
4.5 AN OVERVIEW OF RICE MILL INDUSTRY

Rice is the staple food for 65% of the population in India. The rice milling is the oldest and the largest agro processing industry of the country. It is the largest consumed calorie source among the food grains. Chattopadhyay (2003) reports India produces about 93 million tons of rice, accounting for about one-fifth of world production. India is the second-largest rice producing country in the world. When the paddy is milled it yields about 68-72% rice which is composed of head rice, large broken rice, and small broken rice, 8-12% bran and 20% husk. Paddy grain is milled either in raw condition or after parboiling, mostly by single hullers. Most of the tiny hullers of about 250-300 kg/hr capacities are employed for custom milling of paddy. Apart from this, double hulling units, under-run disc shellers cum cone polishers, and rubber roll shellers cum friction polishers are also present in the country. Further, over the years there has been a steady growth of modern rice mills in the country. Most of these have capacities ranging from 2 tonnes per hour to 10 tonnes per hour.

The recovery of whole grains in a traditional rice mill using steel hullers for de-husking is around 52-54%. There is excessive loss in the form of coarse and fine brokens. Further loss of large portion of endosperm layers during the de-husking operation accentuates the problem. Against it, the recovery percent of whole grains in modern rice mills using rubber roll shellers for de-husking operation is around 62-64%. The whole grain recovery percentage further enhances to 66-68% in case of milling of parboiled paddy. Thus, it can be seen that there is an overall improvement of recovery of whole grains by about 10-14% if one uses rubber roll shellers for rice milling operations. The basic rice milling processes consist of pre-cleaning, de-stoning, optional parboiling, de-husking, husk aspiration, paddy separation, whitening, polishing, length grading and sorting, blending, weighing and bagging. Many of the rice processing units are of the traditional huller type and are inefficient. Modern rice mills are having high capacity and are capital intensive, although efficient.

4.5.1 Processing of Paddy

It is a process that converts the rough rice (paddy) to edible rice by removing husk and the bran layers. Removal of husk from paddy to produce consumable rice is still done to a limited extent by hand pounding in rural areas. But rice mills are driven by power which has an advantage over hand pounding, as machines cause very little breakage of the grain
during shelling. A rice milling system can be a simple one or two step process, or a multi stage process. In a one step milling process, husk and bran removal are done in one pass and milled or white rice is produced directly out of paddy. In a two step process, removing husk and removing bran are done separately, and brown rice is produced as an intermediate product. In multistage milling, rice will undergo a number of different processing steps. Efficient rice milling has the objective of producing edible rice that is sufficiently milled and free of husks, stones, and other non-grain materials and to maximize the total milled rice recovery out of paddy minimize grain breakage.

There are two types of processing viz., raw rice processing and parboiled rice processing as represented by figure 4.3. Gelatinization helps in reducing brittleness of rice popularly known as Parboiling. Hence, percentage of broken rice during milling is very less. It also helps in retaining flavour of rice greater nutrient status, easy digestibility and less susceptible to insect attack during storage. There are around 35,000 rice mills in India. Most of the rice mills are small and use very low cost low efficiency equipments. By-products of rice milling are rice husk and rice bran. Rice husk is used as fuel for rice mill boilers and rice bran oil is extracted from bran. It is fatty oil that is edible and also can be used for the manufacture of soaps.

**Parboiled Rice Processing**
Partial cooking of grain, to impart required hardness to withstand milling operation, with husk intact, is Parboiling. There are mainly two systems of parboiling on commercial scale once steamed paddy and twice steamed paddy. In the former system, paddy is soaked in large vessels no direct steaming of paddy is done, where as in the latter system paddy is steamed both before and after soaking in vessels. In parboiling process paddy is fed into paddy cleaner to remove all dust and stones etc. The cleaned paddy is fed into vessels where it is steamed for 15-20 minutes. This is done to raise temperature of paddy initially before soaking in hot water at about 800°C. This helps to produce high quality rice. After direct steaming, hot water at 800°C is circulated into the vessels through pumps for 15 minutes to make temperature uniform throughout the tank and paddy is soaked for about 4 hours. Depending on paddy variety, optimal soaking time varies between 3 - 10 hours with soaking temperature range varying from 500°C - 700°C. After soaking the paddy, water is drained out through discharge drain. Hot and soaked paddy is steamed in the same vessels for 15 - 20 minutes at a temperature 70°C - 1000°C for closed heating
and $1000^\circ$C for open steaming. After steaming, paddy is dried to achieve uniform moisture level. Now the paddy is ready for milling.

**Figure 4.3: Rice Processing Stages**

**Raw Rice Processing**

In raw rice processing, paddy is taken to the paddy cleaner and de-stoner to remove dust, mud, stones, etc. The cleaned paddy is then dried in the driers or in the sun. The sun
drying is normally carried out in very small rice mills which remove about 6-8 % of moisture. This is an old and inefficient method of drying where percentage of moisture removal from paddy is not constant. Modern rice mills adopt hot air dryers to get correct moisture content that yields good shelling output.

**Milling**

Rice milling is the process of removing the husk and bran layer to produce white rice. Rice milling can be either done in one step where the husk and the bran are removed in one pass and white rice is produced directly from the paddy or in two-step process where the husk and the bran are removed separately to produce brown rice before white rice. Later the white rice is polished to give a smooth silky finish. In modern rice mills rice is sorted based on its colour and size to produce high quality rice before it is weighed and packed.

**4.6 SUMMARY**

The review of background of the clusters under study and processing methods followed in the cluster is studied and presented in this chapter. It is observed that the reason for the clustering is based on the availability of raw material which eventually ensured the availability of specialized workforce. This created business competition and a consortium to deal with the difficulties of the sector. Since the processing methods and operating conditions for all the units in the cluster are more less similar, we obtained a homogeneous samples for this study. In the next chapter, analysis of energy consumption pattern and associated environmental impact of the above discussed processes is presented.