SUSTAINABILITY ASSESSMENT OF SELECTED DAIRY FARMS USING SOCIAL MULTI CRITERIA APPROACH

by

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This Dissertation is Dedicated to all the Girls and Women, May They be Given Opportunities to Discover Their True Potential and Thrive.

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ABSTRACT

SUSTAINABILITY ASSESSMENT OF SELECTED DAIRY FARMS USING SOCIAL MULTI CRITERIA APPROACH

Turkish dairy industry is being modernized and there are many successful examples. Big farms are supported while ecologic and social factors can often be overlooked. Objective of the research is to quantify sustainability at dairy farm level and compare farms with different management practices. The study examined current dairy production practices on farms assessing resource and energy uses as well as management and industry structure. Based on literature and stakeholders, a sustainability assessment framework was developed. Feed management, herd management, manure management and social organization are the main components in the framework and encompass environmental, social and economic dimensions. Dairy farms were selected by purposive sampling method. Dairy farms are categorized based on the processor they sell raw milk to; industrial milk processors, co-operatives and directly to consumers. Qualitative and quantitative data is collected from eighty farms via questionnaire. Based on the questionnaire; resource, energy, water and labor criteria were quantified using both qualitative and quantitative data. Sustainability assessment was conducted using Social Multi Criteria Evaluation methodology. A snapshot of the farms was taken and their performances based on farm management and milk production practices were compared from a sustainability standpoint. NAIADE is used for final comparison of the farms. Results indicate that small cooperative member farms are more sustainable. Using the same framework, larger studies with a larger sample size are encouraged to be conducted to see if general farm population reflects results of this study. Results of the assessment aim to start discussing sustainability at farm level.

ÖZET

SEÇİLİ SÜT ÇİFTLİKLERİNİN SOSYAL ÇOKLU KRİTER YAKLAŞIMI İLE SÜRDÜRÜLEBİLİRLİK AÇISINDAN DEĞERLENDİRİLMESİ

Günümüzde Türkiye'de süt çiftlikleri modernize ediliyor ve ülke çapında bunun başarılı örnekleri bulunmakta. Ancak büyük çiftlikler desteklenirken sosyal ve çevresel faktörler göz ardı edilebiliyor. Bu çalışmanın amacı farklı yönetim pratikleri olan çiftlikleri karşılaştırmak ve süt çiftlikleri bazında sürdürülebilirliklerini ölçmek. Bu çalışma için, literatür taramasına ve paydaşlara dayanarak bir sürdürülebilirlik çerçevesi geliştirildi. Yem yönetimi, sürü yönetimi, gübre yönetimi, sosyal organizasyon bu çerçevenin ana bileşenlerini oluşturuyor ve çevresel, ekonomik ve sosyal sürdürülebilirlik boyutlarını kapsıyor. Bu çalışmadaki süt çiftlikleri, çok amaçlı örnekleme yöntemi ile seçildi. Süt çiftlikleri çiğ süt sattıkları işletme tesisine göre sınıflandırıldılar, bunlar; kooperatif, endüstriyel süt işleme tesisleri ve çiğ süt satın alan tüketicilerdi. Anket yöntemiyle seksen çiftlikten nicel ve nitel veri toplandı. Anketten toplanan bilgilere dayanarak kaynak, enerji, su ve işgücü nicel ve nitel veri olarak hesaplandı. Sürdürülebilirlik değerlendirmesi sosyal çoklu kriter metodolojisi kullanılarak hesaplandı. Çiftlik örneklemlerinden çiftlik yönetimi ve süt üretim yöntemleri sürdürülebilirlik açısından değerlendirildi. Çiftliklerin nihai karşılaştırılması için NAIADE programı kullanıldı. Değerlendirmelerin sonuçları küçük ve kooperatif üyesi çiftliklerin daha sürdürülebilir olduğunu gösterdi. Geliştirilen yöntemi kullanarak, çalışmanın genel çiftlik popülasyonu üzerinde daha büyük örneklem sayısı ile tekrarlanması ve sonuçların karşılaştırılması önerilmektedir. Bu çalışmanın sonuçlarının çiftlik seviyesinde sürdürülebilirlik tartışmalarına bir başlangıç oluşturması hedeflenmektedir.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF SYMBOLS/ABBREVIATIONS

Symbol	**Explanation**
%	Percent
CH_4	Methane
CO_2	Carbon dioxide
H_2O	Water
kg	Kilogram
L	Liter
m/v	Mass/Volume
m^3	Meter cube
MJ/da	Megajoule/Decare
ml	Millilitre
N_2O	Nitrous Oxide
pH	Potential hydrogen

Abbreviation	**Explanation**
A.Ş.	Anonim Şirketi
AHP	Analytic Hiearchy Process
AMUL	Anand Milk Union Limited
ASUD	Ambalajlı Süt Üreticileri Derneği (Packaged Milk Producers Association)
BC	Before Christ
BOD	Board of Directors
CEO	Chief Executive Officer
COE	Communication of Engagement
Co-op	Cooperative
Da/cow	Decare/cow
DDGS	Distillers Dried Grains with Solubles
EBK	Et Balık Kurumu (The Meat and Fish Authority)
EU	European Union
FAO	Food and Agricultural Organization
GHG	Green House Gas Emissions
GNP	Gross National Product

Abbreviation	Explanation
GWP	Global Warming Potential
HAYGEM	Hayvancılık Genel Müdürlüğü (General Directorate of Live Stock)
HAYKOOP	Türkiye Hayvancılık Kooperatifleri Merkez Birliği (Turkey Animal Husbandry Cooperatives Central Union)
HDI	Human Development Index
HDPE	High Density Polyethylene
Hr	Hour
IF	Independent Farmer
IDF	International Dairy Federation
IPCC	Intergovernmental Panel on Climate Change
JRC	Joint Research Centre
M	Million
Max	Maximum
MCA	Multi-Criteria Analysis
MCE	Multi-Criteria Evaluation
MGM	Meteoroloji Genel Müdürlüğü
Min	Minimum
MOTIFS	Monitoring Tool for Integrated Farm Sustainability
NAIADE	Novel Approach to Imprecise Assessment and Decision Environments
NGO	Non-Governmental Organization
NMB	National Milk Board
PE	Polyethylene
PROMETHEE	Preference Ranking Organization Method for Enrichment Evaluations
SAFA	Sustainability Assessment of Food and Agriculture
SAFE	Sustainability Assessment of Farming and Environment
SEK	Süt Endüstrisi Kurumu (Dairy Industry Institute)
SETBIR	Türkiye Süt,Et Gıda Sanayicileri ve Üreticileri Birliği
SMCE	Social Multi Criteria Evaluation
TİGEM	Tarım İşletmeleri Genel Müdürlüğü
TL	Turkish Lira
TSE	Turkish Standards Institution

Abbreviation	Explanation
TUIK	Turkish Statistical Institute
TUSEDAD	Tüm Süt Et ve Damızlık Yetiştiricileri Derneği (All Milk Meat and Breeders Association)
UHT	Ultra High Temperature
UN	United Nations
UNCSD	United Nations Commission on Sustainable Development
UNDP	United Nations Development Programme
USA	United States of America
USK	Ulusal Süt Konseyi (National Dairy Council)
WCED	World Commission on Environment and Development
YEMSAN	Yem Sanayi Türk Anonim Şirketi

1. INTRODUCTION

Dairy is a part of human history since the first domestication of animals (Vigne, 2008). Today milk is in many of the products we consume as cheese, yogurt and used as a functional ingredient in food industry such as whey protein. For all dairy products, we need the milk producer, i.e. the farmer. There are 150 million households (approximately 12-14% of world population) (WorldBank, 2013) directly involved in milk production. Milk is a highly perishable commodity and needs to be sold daily since milking cows produce milk approximately every twelve hours. Farmer is the decision maker and general assumption is he/she makes the most rational decision to maximize his/her gain. From an economic perspective, it is about maximizing economic gain, however in the face of climate change and increasing social inequality, farmer's decision to sell his/her milk to an entity becomes a sustainability question.

Dairy farmers usually lack the capability to process the milk they produce, and have a few options; they can sell the milk directly to consumers as raw milk, form a coop with other farmers and sell it to the cooperative, or sell milk to an industrial processor. The aim of this dissertation is to analyze the sustainability of milk production by comparing farms that sell their milk to these three different entities: Industrial milk processors, co-operatives or consumers. Study is limited to farms where the main commercial activity is dairy production. A snapshot of eighty farms was taken and their performances based on farm management and milk production practices were assessed from a sustainability standpoint. Sustainability of farms is assessed using multi-criteria decision analysis methodology. To our knowledge, this study is a first in Turkey, in dairy sustainability assessment incorporating a triple bottom line approach.

Objectives of this dissertation:

1) To offer a framework for sustainability assessment using social multi-criteria approach.
2) To conduct sustainability assessment of selected farms with different processing channels further classified with respect to their herd, feed, farm management practices and social organizations.

In order to explore these research questions, the chapters of the dissertation are organized as follows:

Chapter 2 focuses on dairy cycle and details the steps that make up feed production including feed ingredients and their preparation methods. Following this section, dairy sustainability assessment literature is reviewed both in the world and in Turkey. Dairy is a complex industry with many different actors and first few chapters try to map out the dairy industry structure in the world and in Turkey to provide a better analysis.

Chapter 3 provides information on objective and scope of the dissertation. Dairy Supply Chain in Turkey is discussed. In Turkey, milk production is carried out by farmers of different sizes. Farmers selling milk to three different entities were identified. Farm management practices were studied via questionnaire. Dairy farmers' management practices including agricultural land for fodder production and herd management were documented. Both qualitative and quantitative data were collected. Farm Model the study is based on is introduced. It is made up of four components: Feed Management, Herd Management, Manure Management and Social Organization. These components are the foundation of the main attributes that feed to the sustainability criteria. Five different farm alternatives that make up the criteria impact matrix are introduced.

Chapter 4 analyzes the social structures of dairy farms around the world. Turkish Dairy and Livestock policy starting from 1950's is reviewed and recent developments in Turkish dairy are presented. Cooperatives and cooperative structure in Turkey is laid out. Dairy farmer usually relies on the processor (term used here both cooperative and industrial milk processor) to collect the milk or sells it directly to the consumer. Direct selling farmer does not have continuous sales assurance from the buyers, therefore needs a backup plan if milk is not sold. On the other hand, processors provide differing advantages and disadvantages to the farmer. The initial assessment of the farmer is conducted including the pros and cons the processor and direct sales to consumer offers for the farmer.

Chapter 5 introduces Social Multi Criteria Evaluation (SMCE) approach. In SMCE complex, multi-dimensional, decision-making tasks usually involve multiple conflicting objectives. A diversity of possible outcomes and incommensurable or uncertain effects are analyzed together. Instead of maximizing a single aspect, a trade-off between the three dimensions is the main idea so rather than maximizing a single aspect, all parties can benefit from the outcome. This can best be seen in a matrix. Criteria Impact Matrix is made up of criteria and alternatives. For the study, criteria were developed based on economic, ecologic and social pillars of sustainability. Benchmark for sustainability assessment is introduced.

Chapter 6 focuses on research design and explains where this research fits in social research, ecological economics and sustainability assessment literature. Dissertation epistemological approach is explained. Framework for the sustainability assessment is developed. Assessment criteria is decided as follows: Feed management, water consumption, energy intensity, Greenhouse Gas Emissions(GHG), working hours, mediation, insurance and salaries, cash advance and farmer profitability.

Chapter 7 Field work and calculated data are presented. Statistical analysis results of the field work are shared. Different aspects of dairy farms and their placement based on surveys are presented.

Chapter 8 criteria impact matrix and pairwise comparison analysis with benchmark is completed. Results of the impact matrix are discussed.

Chapter 9 shares concluding remarks and recommendations based on the case study and research questions.

1.1. History of Dairy

First domestication and consumption of milk in fermented form took place 11,000 BC in the Fertile Crescent. Pottery pieces resembling sieves were found in agricultural sites and when these sieve like pieces were studied, milk fat molecules were found on the surface (Vigne, 2008). Evidence suggests that, milk was first consumed in fermented form. First humans did not produce lactase enzyme throughout their lives. This genetic mutation happened in 7,000 BC in different parts of the world, namely: Central Europe, East Africa, Middle East and South Asia. Today one third of the world population is lactase persistent (tolerant), which means these individuals keeps producing milk digesting lactase enzyme after the age of seven. This genetic mutation produced 19% more fertile offspring and this genetic trait is passed onto the next generation (Vigne, 2008; Leonardi et. al., 2012).

1.2. Overview of Milk Production in the World

World annual milk production reached 811 million tons in 2017 (FAO, 2018). Major producers are India, EU (27), USA and China. Figure 1.1 below shows major milk producers in the world in 2015. Turkey is in top 10 in milk production. Future growth is expected to come from Asia, Latin

America and the Caribbean (FAO, 2018). Major import demand comes from Russian Federation, Asian countries, Algeria, Mexico and Saudi Arabia. The ratio of international trade of milk and milk products to production is 7.1 percent, i.e. 42 million tons (Blasko, 2011). The share of total milk products traded internationally is only 13 percent (FAO, 2018).

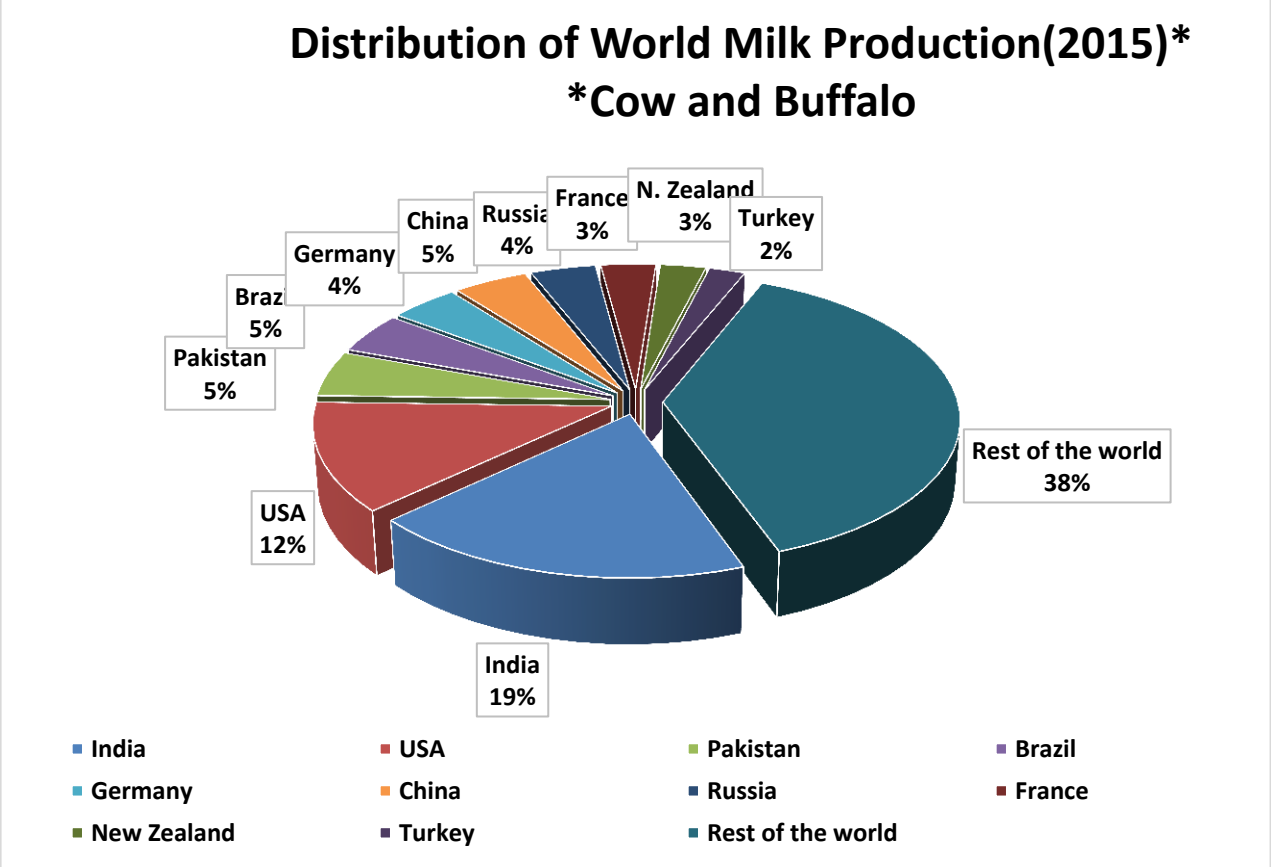


Figure 1.1. Distribution of world milk production from cows and buffalo (USK, 2018).

There are 270 million dairy cows in the world, most of them being in developing countries however, most of the production occurs in developed countries where yields per cow are higher (FAO, 2018). Historically speaking, some developing regions such as Near East, Indian subcontinent, parts of Africa and parts of Central and South America have dairying traditions and milk products have an important role in diet. Southeast Asia and tropical regions are not traditional milk producers however increasing income creates demand for milk products.

1.3. Milk Production in Turkey

Total milk production in Turkey was 18.5 million tons in 2016 (USK, 2017). Most of the milk production is from cows (90.8%) with 16.7 million tons, sheep milk production is second with 1.1million tons, equivalent to 6.3% of the production where goat milk comes third with 479,000

tons and makes up 2.6% of the total production. Buffalo milk in 2016 was 63,000 tons with 0.3% of the production. Turkish dairy farms are small operations, 67% of the industry is made up of farms with 1 to 9 animals (TUİK, 2016). These farms are mostly family operated and milk production is seen as sources of supplementary income in addition to the various produce the land owner plants. 96% of the farms have less than 50 animals (TUİK, 2016). Unrecorded milk production is a problem, given that they put animal health and food security at risk. Milk is a perishable commodity where it needs to be refrigerated to stop breeding of bacteria. There are modern establishments that operate within EU standards; however direct raw milk sales, from small producers, also called street milk (informal channel) is common in Turkey. Small farms located close to the cities bring raw milk to the city. These establishments have been upgraded and raw milk is transported in refrigerated vans and directly sold to consumers.

Milk referred to in this study is based on raw milk only as taken from the milk collection tanks. Milk collected from the cows is kept in stainless steel tanks and is mixed by a rod in the stainless steel tank and kept at 2 ^{0}C. Milk is not standardized at this stage, only stirred to prevent cream forming on top. A refrigerated truck comes and tests milk in the tank and only after satisfying results from antibiotic and alcohol test , the driver collects the milk. Further quality controls such as protein content and milk fat content are done at the processor's laboratory. Any adulteration that cannot be detected by the initial tests are detected by tests conducted at the factory. It is easy to address adulteration in individual tanks. To ensure quality in shared thanks, a sample from each poured milk jug is taken at the time of arrival and stored in the fridge at the collection point. If adulteration is detected in a shared tank, samples from each pourer are tested to pinpoint the source. The adulterer pays the total cost of milk poured into tank that day.

Milk is one of the few whole foods containing, fats, carbohydrates and protein. There are many standards for milk i.e. raw, pasteurized, and UHT standards. Since raw milk is the subject of this dissertation, cow's raw milk chemical quality minimum requirements set by Turkish Standards Institute (TSE), Turkish Standard 1018 are listed in Table 1.1 (TSE, 2002).

Table 1.1. Raw cow's milk chemical quality minimum parameters of milk (TSE, 2002).

	Protein % (m/v) minimum	Acidity (Milk acid %) (m/v)	Density (m/v)	Nonfat dry powder % (m/v)	Minimum Milk fat % (m/v)
Cow's milk	2.8	0.135-0.200	1.028	8.5	3.4

Consumption of milk as drink choices are shown in Figure 1.2. Milk as a drink is usually sold in markets in two forms; homogenized and pasturized in bottles or homogenized and treated in ultra high temperature packed in cartons. Supermarkets and authorized raw milk selling shops started selling raw milk as a new option in 2017. Raw milk producers that satisfy the criteria can package and sell cooled raw milk directly to consumers.

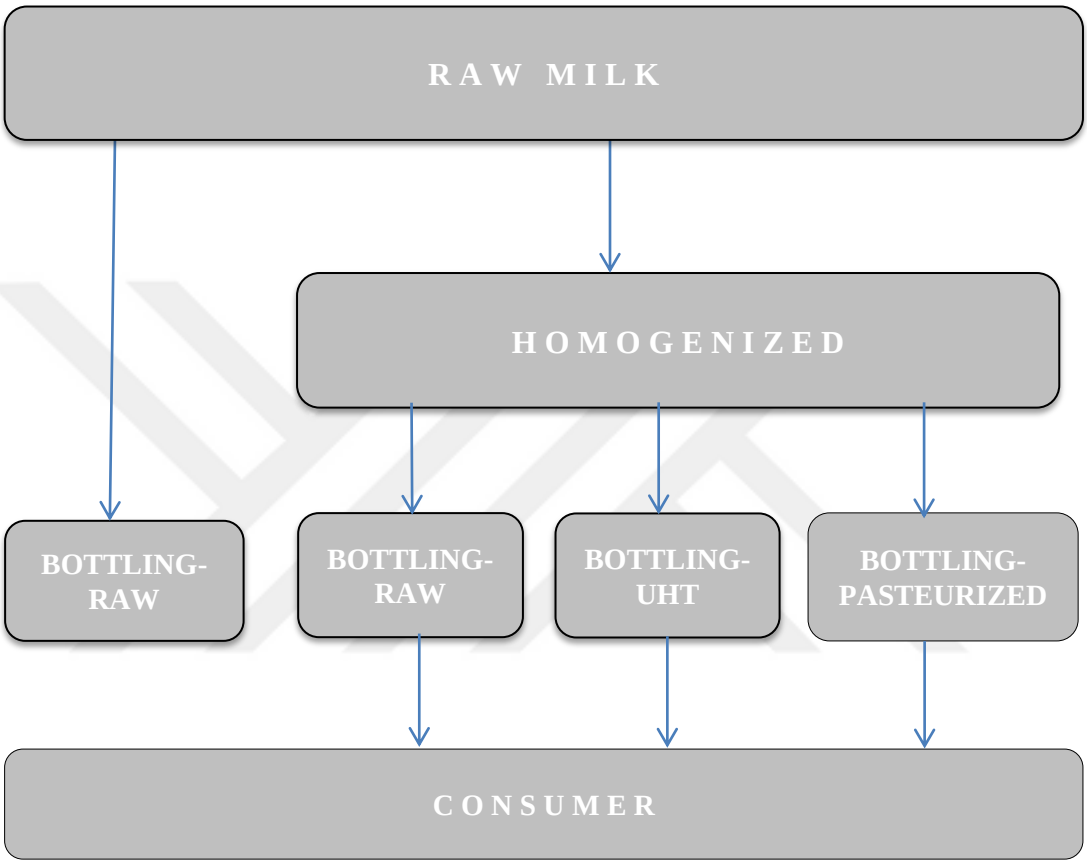


Figure1.2. Raw milk sales routes.

International average milk consumption per capita is 103.6 kg/year (Blasko, 2011). Per capita consumption in Western European countries is in excess of 300 kg per capita (Hemme and Otte, 2010). According to Turkish Statistical Agency (TUIK), Turkish consumers use of fresh milk is below international average with 47.5 kg/year whereas Ulusal Süt Konseyi (USK) report shows 37.3 kg per person. The discrepancy is due to the unrecorded milk production and sales (Gönenç and Harun, 2008). Where national average for fresh milk consumption is low, Turkish consumers compensate it in the overall dairy products consumption. According to 2013 Türkiye Süt, Et, Gıda Sanayicileri ve Üreticileri Birliği (SETBİR) report, Turkish consumption of all dairy products (including ayran and yogurt) are at 201 kg/ per person (2013, p. 21).

Milk is the main ingredient for many foodstuffs. In addition to drinking milk in pasteurized and Ultra High Temperature (UHT) form, milk is the main ingredient in; butter, cream, yogurt and all types of cheese with fermentation, whey and milk powder.

2. DAIRY CYCYLE

Before they were domesticated, cows produced enough milk to feed their young. With domestication and selective breeding, dairy cows now produce far more milk than their calf's need. Basic principles remain the same; a cow has to be pregnant to produce milk, hence two main outputs in dairy: Milk and calf. Only after birth of a calf, cow starts lactating. First milk is called colostrum and is usually reserved for the newborn calf. Lactating period of cows varies greatly lowest being in Africa and longest in developed countries. In intensive systems, average cow lactates 305 days, remaining 60 days (in yearly cycle) is called dry period (Figure 2.1).

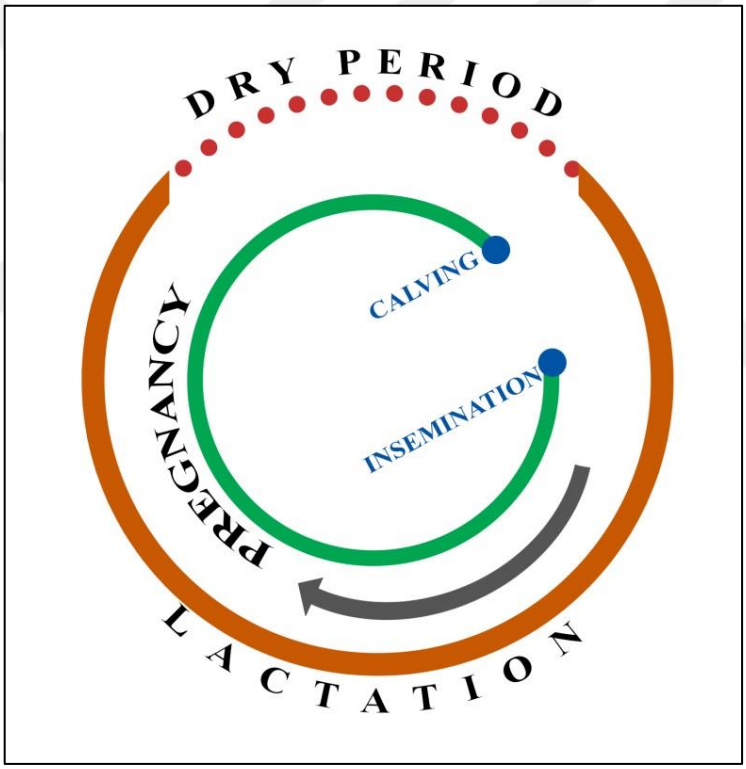


Figure 2.1. Yearly lactation cycle of a dairy cow**.**

Industrial milk production has three main outputs; Milk, heifer (female cows that have not given birth) and manure. Some farms sell the male calf within the week of their birth. A calf has to be alive for at least four months to receive the calf premium from the government in Turkey. Most dairy farms studied in this thesis, sell male calves between 12 to 18 months of age. Male calves and heifer are seen as a way to acquire capital by small farms. Heifers enter the production. Minimum age for a heifer to be pregnant by law is 15 months. Only after giving birth, a heifer is called a cow.

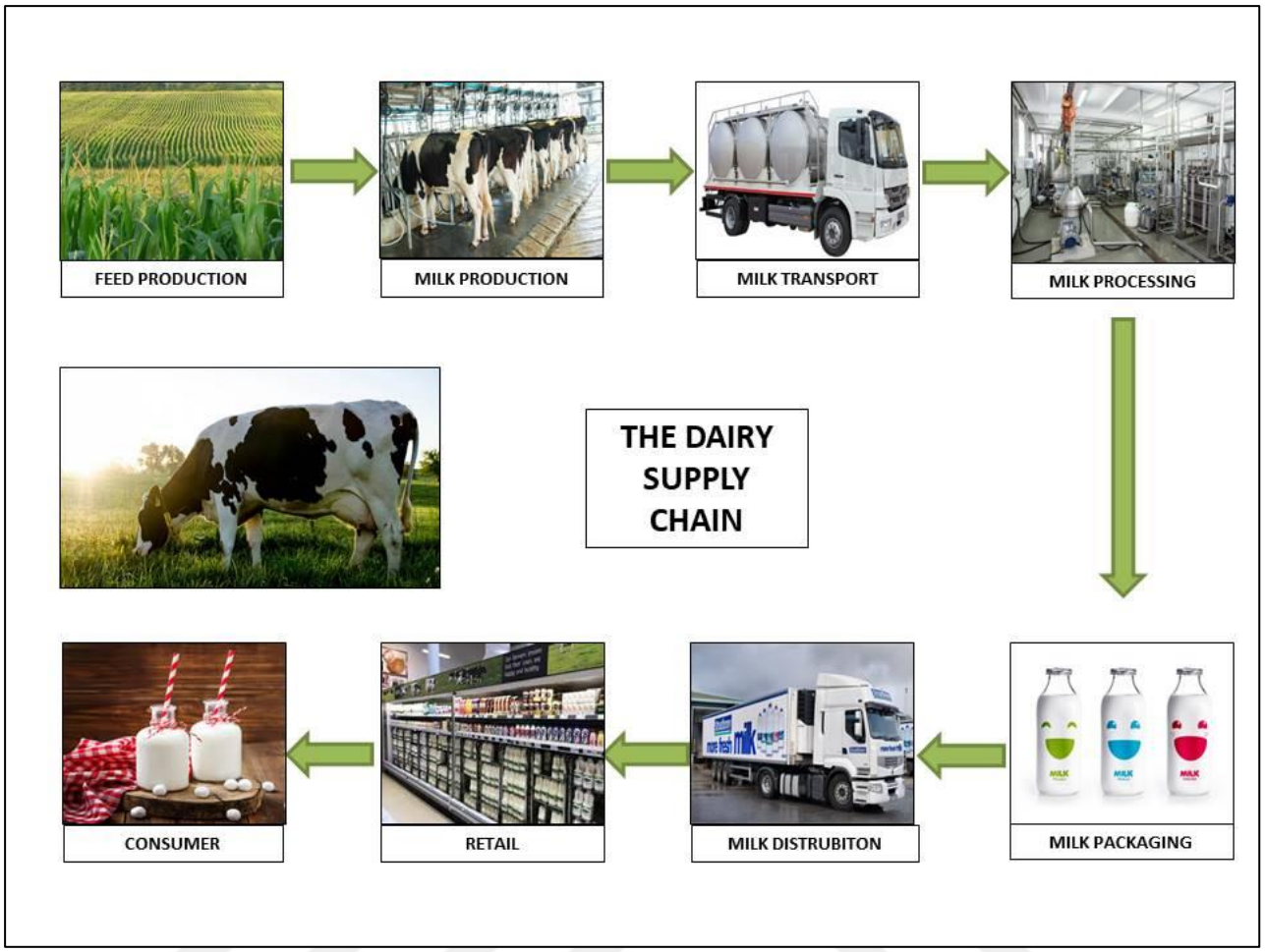


Figure 2.2. Dairy supply chain.

Dairy supply chain starts with feed production where seed, both animal based and petroleum based fertilizer, water, pesticides and herbicides are used as inputs (Figure 2.2). Feed is transferred to the farms and fed to the animals. Produced milk is transferred to processing centers.

2.1. Feed Production

Dairy production starts with feed and feed production. Dairy cows mainly consume a diet of maize, hay, wheat, barley, triticale, clover and caramba (*Lolium multiflorum*) also known as “süt otu" or “İtalyan çimi”. Ideally, dairy farmers own farming land or rent land to plant feed. Overall animals eat 7-11 kg factory feed, 15-30 kg silage, 3-5 kg hay and 2-4 kg dry grass per day. For most farms, factory feed is outsourced while silage is prepared and fermented by the farmer. Dairy cows’ dietary needs differ among different breeds and depend on their lactation. Dairy cows in this study eat 25 to 50 kg/day of feed and drink 30 to 100 L/day of water depending on size, breed and lactation.

Cambridge dictionary defines silage as; grass or other green plants that are cut and stored, without being dried first, to feed cattle in winter (Cambridge Dictionary, 2019). It is important to say that silage is fermented by anaerobic digestion and the finished product usually has a pH of 3.5 to 4.3. Most of the silage is made from fresh corn (Roth and Heinrichs, 2001). Crushed wheat (flour) or crushed barley is added to start lacto-fermentation, usually 10-15 kg per ton of corn. Mix of corn and flour are placed to an area that is close to the feeding lot. Some farms have concrete floor with 1 - 2% aim but silage can also be done on soil with a thin layer of plastic laid on the bottom and holes made in the plastic. Straw is laid with about 10cm thickness at the bottom and once the mixture is ready, it is compacted by tractors so that air is taken out. Then the mixture is covered by Polyethylene (PE) or High Density Polyethylene (HDPE) to ensure nothing gets in the mixture. Old tires are put on top to ensure airlock (Figure 2.3). Moisture content of the cut corn is the most important factor in making silage. Ideal moisture content or the fresh cut grass is 60-70% (Jones et. al., 2004; Seglar, 2015).

Dairy farmers in Turkey usually do not use starter cultures, where it is common practice in the Unites States and Europe. It usually takes 6 to 7 weeks for the silage to complete fermentation (Gözügül and Öztürk, 2008). There are also ready-made silages available for purchase, but it is not cost effective for the farmers. Once the silage package is opened, it needs to be finished within five to six months. Brown in color has an off odor or mold, should not be used to feed the animals. This is the stage where mycotoxins such as aflatoxin can form, so the pH levels needs to be watched carefully especially after opening the silage (Hayırlı, 2000). Silage usually forms one third sometimes more (depending on the moisture content) of a dairy cow’s diet.

2.1.1. Factory Feed

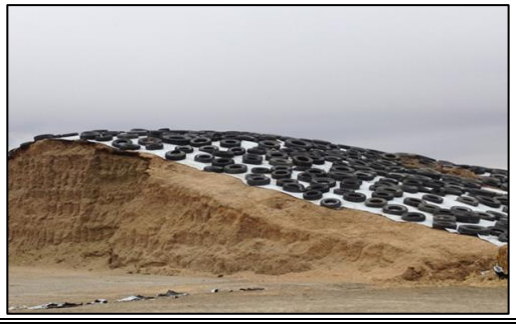
Factory feed is the main influence in increasing productivity of the breed especially milk breeds such as Holstein. Factory feed is mainly comprised of protein such as sunflower seed meal and soybeans. The feed comes in 50kg bags. A typical factory feed consists of Razmol (Byproduct of wheat milling), DDGS (Distillers Dried Grains with Solubles made from genetically modified corn), barley, sunflower seed meal, wheat, corn, nonliving yeast, rice bran, canola, full fat soy (made from genetically modified soybean and may contain (ACS-GM005-3), (MON-89788-1) and MON-04032-6) registered genes, marble dust, melas, salt, vegetable oil, lignobond (in pellet feed), active yeast (Actisaf Sc 47), manganese, iron, zinc, copper, cobalt, iodine, selenium, niacin (Figure 2.4).

Corn picked in the field and cut into smaller chunks for silage

Corn cut into smaller chunks

Corn and the silage ingredients compacted to take the air out

Silage is compacted and covered with Polyethylene. Old tires are put on top to ensure airlock.



Silage after fermentation

Ready-made silage ranges from 250kg to 750kg depending on machine.

Ready made silage ready for storage and use

Figure: 2.3. Silage making and packaging examples.

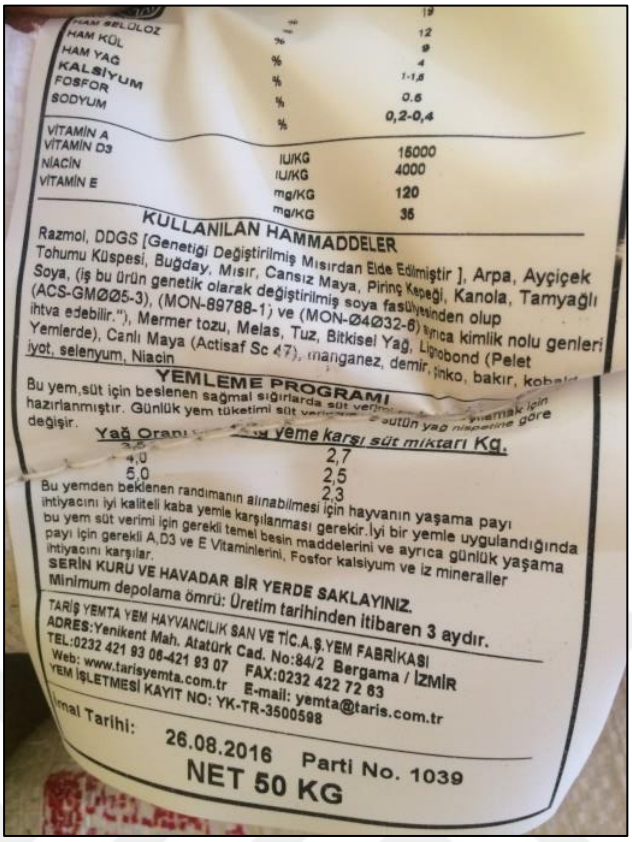


Figure 2.4. Sample factory feed label.

2.1.2. Baled Hay

It is grass that is dried and compacted for easy storage. Hay is grown specifically, and it is cut before the plant goes to seed where straw is a by-product of seed (or grain) production. Because the plant pumps nutrients into the seed or grain, hay will have more nutrients than straw.

Fresh grass varieties Caramba (Lolium multiflorum), also known as ‘Sütotu’ in Turkish, triticale, oats, clover, vicia sativa, ‘fiğ’, and turnip are planted and fed to animals as well.

2.1.3. Additional Supplements

Mix supplement is a molasses based, oil and protein added product, enriched with vitamin and minerals such as calcium, potassium, magnesium, phosphate, iron, zinc, selenium, manganese, copper, cobalt, Vitamins A, D3, E and niacin.

It is compacted salt and minerals that are placed with the feed and available at all times, usually in form of blocks. Animals lick the blocks to meet their iodine needs.

Baled hay

A bucket of mix supplement

A block of lick salt

Figure 2.5. Supplements and feed used in dairy cow diet.

2.2. Milk Production

Dairy cows are milked twice or thrice per day. Average milk production among dairy cows varies greatly due to genetics and feeding. Produced milk is cooled and after bottling it can be sold directly to consumers as raw milk or sent to processors.

2.3. Processes After Milk Production

Dairy processing is explained briefly since processing is beyond the scope of this dissertation. Raw milk is transferred to tankers and is either bottled and sold directly to consumers or it is sent to processing centers. Milk tanker driver tests milk for two parameters; antibiotic usage and alcohol test. Usage of antibiotic treated animal's milk for human consumption is prohibited. If the antibiotic test is positive milk is rejected. Alcohol test is an indicator of coagulation for thermal processing of milk. Milk has to pass the alcohol test before it can be loaded into the milk truck for further processing (Co-operative, 2017).

Milk is transferred to the factory, depending on the chemical composition, it goes into processing. First, milk goes through primary processing where cream and milk are separated. After that it is sent onto secondary processing where other dairy products such as cheese, yogurt and

whey are produced. Bottled milk and other milk products are packaged. Pasteurized milk is usually packed in 1L. glass bottles in Turkey. UHT milk is usually packed in tetra cartons. Packaging must keep the products fresh, clean and protect it from outside effects. Distributors deliver dairy products from processor to retailers. Packaged dairy products are distributed to several outlets such as supermarkets, local grocery stores, restaurants and catering establishments. Retail milk and dairy products are available in many retail outlets ready to be bought by consumers (Processor, 2017).

2.4. Dairy Sustainability and Assessment

The debate on earth's finite resources versus economic development started in 1972 with the book Limits to Growth. Written by four graduate students, the book was one of the first examples of system dynamics applied to predict a future for the earth based on actual data and forecasting. While the book was heavily criticized at the time, man-made pollution such as oil spills and human deaths due to smog did cause concern and environmental government agencies were established and regulations were enforced on industrial pollution. Around the same time, nonprofit organizations and concerns to protect the natural resources were voiced. Industry, officials and concerned citizens started to talk about an idea of living within the means of the earth. Today, sustainability refers to the triple bottom line including social, economic and ecological impact of economic activity/development. It appeared first in writing in 1987, in World Commission on Environment and Development (WCED) Brundtland Report and sustainable development was defined as 'development that meets the needs of the present without compromising the ability of future generations to meet their own needs' (WCED, 1987). Another popular definition is "development that improves the quality of human life while living within the carrying capacity of supporting ecosystems" from Caring for the Earth (Munro and Holdgate, 1991).

Once a concept is defined, new measurement techniques and indices are developed. In order to measure economic growth, Gross National Product (GNP) (UN, 1954) tool was developed and used to rank nations wealth. GNP left out critical factors such as income distribution and public safety and negative externalities are not incorporated into the index (Ness et. al, 2007). It was later recognized that monetizing all economic production is not the best indicator to measure wealth in nations and Human Development Index (HDI) (UNDP, 1990) was created. There are now numerous development indices each with different strength and weaknesses to measure sustainability.

Since the definition of sustainability, many sustainability assessment methodology and measurement tools have been developed and there are many different approaches on how to measure sustainability. Studies backed by United Nations point to a new field of interdisciplinary, multi-faceted approach called Sustainability Science. These studies emphasize the importance of integrating different disciplines (Jerneck et al., 2011).

It is a big task to quantify social, environmental and economic pillars and divide it into themes. On top of that, sustainability experts do not have (use) a common terminology therefore different levels of sustainability assessment is worded differently by experts. For example in Sustainability Assessment of Food and Agriculture Systems (SAFA) developed by FAO, the top of the hierarchical level is referred to as 'Dimension' whereas Sustainability Assessment of Farming and the Environment (SAFE) method uses the term 'Pillar' to refer to the same hierarchical level (Olde et. al., 2016; Van Cauwenbergh et. al., 2007).

There are many measurement techniques and units developed to quantify sustainability. It can be deliberated on a spatial scale such as the farm, landscape, region or nation (Acosta-Alba, 2011), claim a product oriented approach such as Life Cycle, focus on different aspects such as environment and economy and objective can vary considerably from a macro scale to micro scale (Cinelli et. al., 2014). Ness and coworkers categorize sustainability assessment tools into three main groups namely; indicators/indices, product-related assessment tools and integrated assessment tools (2007). Non-integrated tools in Ness's study refer to indicators that give manageable units of information such as United Nation's Indicators of Sustainable Development (UN, 2001). Integrated indicators such as Ecological Footprint (Wackernagel and Rees, 1998) and Human Development Index are also considered under indicators category. Product related tools are further categorized based on target approach. While some assessments take only direct impact of the target product, others such as Life Cycle span the all stages of the product (De Ridder et al., 2007; Ness et al., 2007). Integrated assessments mean the assessment tools aggregate different dimensions and are used for policy related focus both on local and global scale. Multi Criteria Analysis is an established tool within integrated assessment tools. Ness also includes monetary valuation tools in his categorization. While monetary valuation tools are not sustainability assessments by themselves, they assist other tools when monetary valuation is a must. These methods take a weak sustainability approach and try to show the value of environmental goods and services in monetary terms[1].

[1] Indigenous people and their rights, biodiversity and ecosystems are not considered in this approach.

The context sustainability is defined is crucial and adequate attention needs to be given. Are we defining sustainability in the global context or regional? Who is the intended audience; producers, consumer's maybe the ecosystem itself? Norgaard explains this from different perspectives as "…consumers want consumption sustained, workers want jobs sustained, capitalists and socialists have their –isms, while aristocrats and technocrats have their "cracies" " (Norgaard, 1994, p. 11). Sustainability assessment in this study mirrors sustainability as a reflection of dairy farmer's choices.

Research that combines all aspects of sustainability has been discussed theoretically (e.g. SAFE, MOTIFS) however its implementation is still problematic. There are different programs around the world that aim to move sustainability from interdisciplinary study to trans-disciplinary study and aims to close the gap between science and practice. Sustainability Assessment of Farming and the Environment (SAFE) framework is a hierarchical approach and proposes to encompass all three levels of sustainability, economic, ecologic and social which goes beyond production alone and is designed for three spatial levels; parcel level, farm level and landscape or state level (Van Cauwenbergh et. al., 2007).

In order to realize the sustainability of any subject, the concept of sustainability has to be made operational and appropriate methods need to be designed for its measurement (Heinen, 1994). Further looking into efforts to combine different disciplines, and validate viable methodologies used in Environmental Assessments, a project named Sustainability A-Test was commissioned by European Union under FP6-STREP Program. According to the website of the project, "The Sustainability A-Test project contributed to the EU's and national sustainable development strategies by applying a consistent and comprehensive evaluation framework to validate these tools" (Sustainability A-Test Archive, 2006). Multi-criteria Analysis is validated as a feasible environmental impact assessment method in Sustainability A-Test.

There are many studies looking how to measure sustainability in agriculture. Literature review on this subject found many different approaches. Sami et. al. uses fuzzy logic and a combination of indexes as representatives of three dimensions of sustainability (2013). Meul et. al. proposed a combined method of sustainable value approach and Monitoring Tool for Integrated Farm Sustainability (MOTIFS) to evaluate the sustainability of farming systems (2008). Van Passel, et. al. develop and use sustainable efficiency method by comparing the calculated benchmark to different forms of capital (2009). Moraine et. al. developed a social-ecological framework for integrated crop-livestock systems to support development of sustainable farming systems at the

territory level (2016). Galioto et. al., integrated carbon footprint indicators with profitability and animal welfare and used an aggregation criterion to assess eight farm's current sustainability level (2017). All of these studies analyze the farm and the farmer where this study focuses on farming practices as categorized with respect to their processors.

Many scholars prefer to develop specific indicators or adapt existing indicators to measure dairy sustainability based on different dimensions. An example to adapting existing indicators is a study conducted in Northern Italy by Gaudino et. al.(2014). Twenty-three different data from nine farms referring to farm management, cropping and livestock systems and milk production was collected. Preliminary data was used to calculate stressors on the environment and forty indicators were aggregated under four groups. Farms were compared based on these four groups, namely; farm system, cropping system, livestock system and milk production (Gaudino et. al., 2014). Another study conducted in Italy, developed a scoring system for dairy farms. European Project® assessment protocol for cattle were used for animal welfare indicators and Life Cycle Assessment was used for environmental sustainability indicators. As a third aspect, laboratory analyses on collection tank were used to evaluate microbiological and nutritional quality of milk. All three were combined to develop a multi-dimensional scoring system (Zucali et al., 2016).

Multiple methodologies are used to measure economic, social and environmental impact of dairy production. Van Calker et. al. developed a multi-attribute sustainability function by aggregating sustainability assessment criteria from social, ecologic and economic indicators (2006). Another Dutch study used Weighted Linear Goal Programming to compare sustainability indicators among conventional and organic dairy farms for all stakeholders (Van Calker et. al., 2008). A study by Mu et. al. aimed to identify a set of environmental indicators to explain the maximum variation between farms (2014). There are a number of studies that use Life Cycle Approach to calculate environmental impact of dairy production (Thomassen and de Boer, 2005; Eide, 2002; O'Brien et al., 2012) Studies on energy footprint of dairy farms are also common in Northern Europe (Meul et. al, 2007; Mikkola, 2009; Pagani et. al 2016).

Farmer processor relationship was the subject of a few studies in developing countries. Simonovska and Nilsson studied structural change and farmer processor relationship in Macedonia (2011). Falkovski et. al. looked at bargaining power of farmers with processors and suppliers and how this effects price heterogeneity at the farm gate (Fałkowski, et. al., 2017).

To our knowledge there are no previous studies that measured sustainability of different types of farms based on developed criteria. There are a number of studies in Turkey based on dairy efficiency and integrate parts of sustainable dairy. Turkish scholars studied efficiency of dairy farms based on similar criteria used in sustainability assessment (Alemdar and Yilmaz, 2011; Armagan and Süleyman, 2012). Demircan and Binici conducted a survey on 132 farms and found a positive correlation between farm size and efficiency (2009). Akcaoz and Kızılay conducted a case study in Antalya province Dairy Farming to understand decision making in dairy farmer households and their likelihood of sustainable farming activity to next generation (2009). Tatlıdil et. al. documented the correlation between farmers' education and income with respect to exposure to sustainability practices (2009). Environmental impacts of larger dairies in Balıkesir province were documented and suggestions to improve the infrastructure were listed by Aydın and Deriöz (Aydın and Derinöz, 2013). Öztürk and Ünal calculated CO^2 equiv. of dairy farms in Tire using 1996 IPCC guidelines (2011). A number of studies point to potential usage of dairy manure for biogas production (Akyürek, 2019; Eryılmaz et. al., 2015; Kızılaslan and Onurlubaş, 2010; Yılmaz and Soyer, 2017).

3. OBJECTIVE AND SCOPE

First chapter gave an overview of dairy farming operations and second chapter gave an overview of dairy supply chain and provided a literature review on sustainability assessment of dairy both in the world and in Turkey. Third chapter focuses on objective and scope of the dissertation. The objective is to offer a framework for sustainability assessment using social multi-criteria approach. As much as this thesis aims to be interdisciplinary; given limited time, resources as well as per current academic literature, this study is an environmental sciences based dissertation. The emphasis on this dissertation is on environmental attributes on farm context. Majority of the criteria being environmental indicators also emphasize this direction (Table 6.4; Table 8.1 and Table 8.3). Environmental criteria reflect the most up to date information. Data collected from farms are compared based on an assessment of the minimum amount of harm that could be inflicted on the environment while being economically feasible and socially equitable.

Scope of the dissertation is limited to dairy farming operations and the processor that collects the milk. Before going into the dynamics of dairy farming, dairy supply chain in this thesis is presented (Figure 3.1). Milk produced in the farms within the scope of this study has three ways to reach market. First route is through direct sales, second one is through cooperative and third one is through a corporation. Dairy farms are characterized based on their tank usage and processors are categorized based on enterprise type. Farms are characterized based on the combination of tank and enterprise types. This dissertation is at the nexus of farming practices and processor choice, reflecting on farm sustainability.

3.1. Model Boundaries

Based on literature review and farmer interviews, farm model on Figure 3.2 is constructed. Dairy farms generally have three components, namely; Feed, Herd and Manure Management (Rotz et. al., 2010). Social Organization is added as a fourth component to embody a complete sustainability framework of dairy operations. Feed management includes type of feed dairy herd consumes and how the feed is sourced. Herd Management defines general practices used to run a dairy farm. Veterinary practices, animal welfare, milk production and housing type are included in herd management. Manure management includes manure storage and GHG Emissions from dairy production. Social organization represents economical aspect and societal aspect of dairying.

Working conditions include working hours, salaries and insurance. Economic component is incorporated with profitability and access to credit. Social organization includes mediation among farmers as a quantitative social dimension.

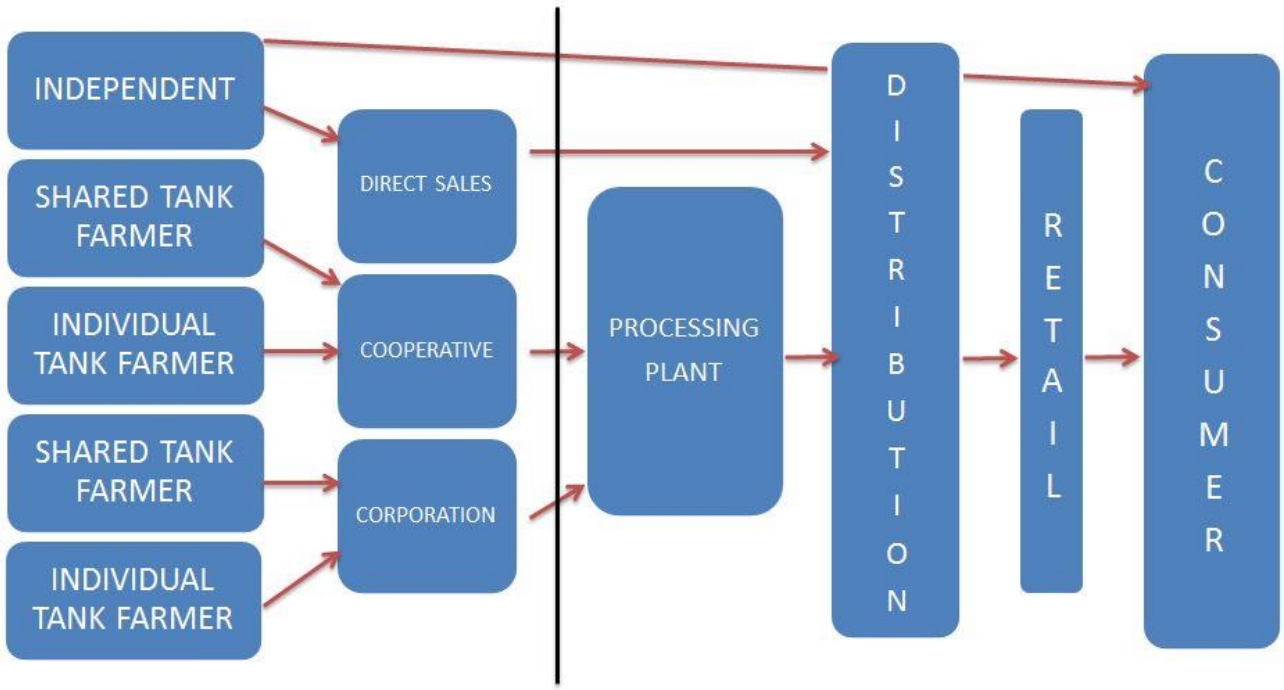


Figure 3.1. Dairy supply chain based on thesis.

Feed management uses a lot of inputs including seed, artificial fertilizers, fuel and machinery which are needed to grow animal feed. Ready bought factory feed is also part of animal diet. Water consumption of farms is included in feed management. Model includes inputs for crops grown on farmer's farmland for feed purposes, dairy cows and milking practices. Milk production outputs are raw milk, manure and heifer. Model ends at the farm door. Enterprise types are used for categorization of farms only.

Model grouped under four main headings and shown above is utilized in creating the framework to calculate sustainability of dairy farming. To measure sustainability of feed management, energy analysis method is used. All inputs to grow the feed are calculated by input energy analysis including seed, machinery, fertilizer, diesel, electricity and pesticide use. Water consumption is also calculated as part of feed management. Manure management component of the model focuses on GHG calculation. All emissions including ruminant digestion and manure management are calculated based on Tier 1and 2 2006 IPCC methodology (depending on available data) (Eggleston et.al, 2006).

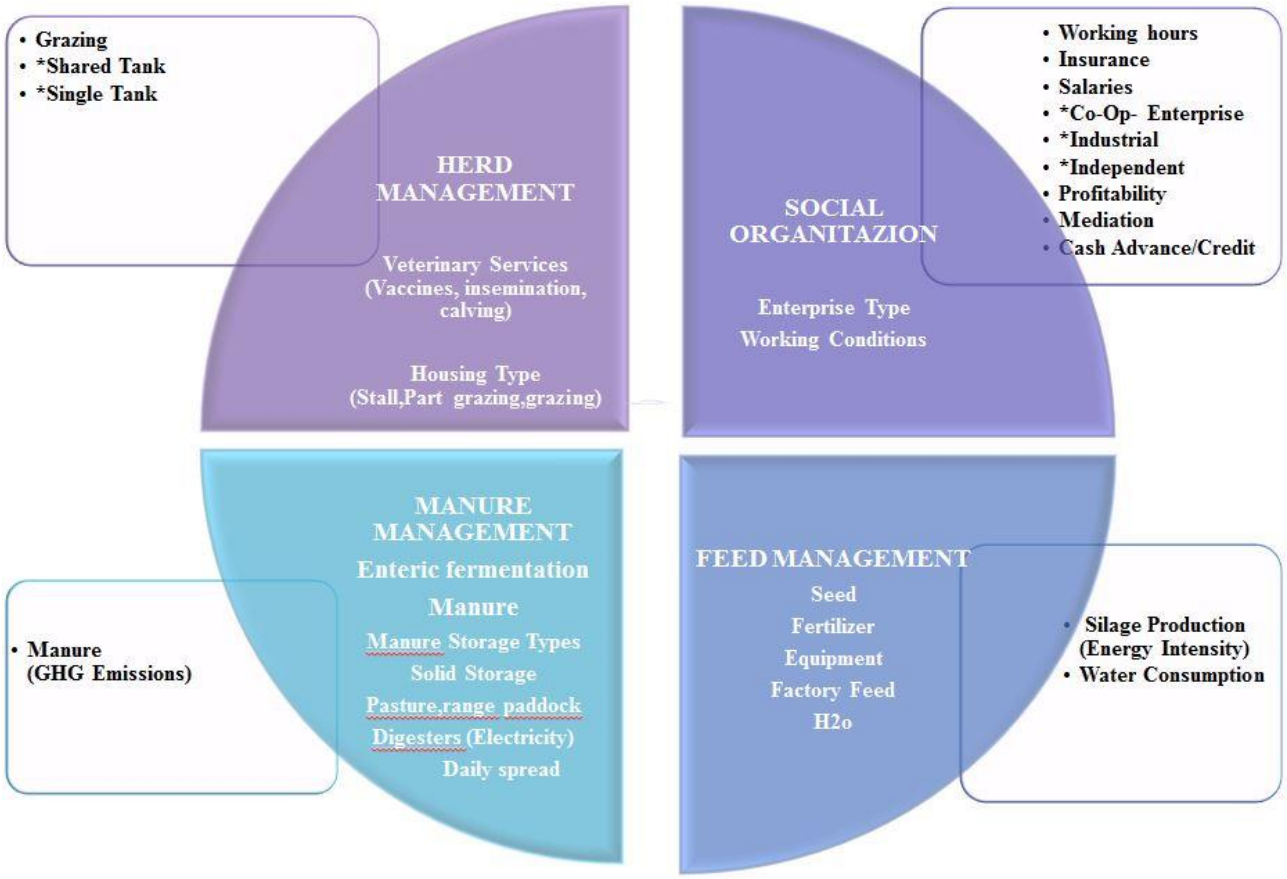


Figure 3.2. Farm model.

Milk is a highly perishable commodity with a continuous supply due to the nature of milking cows. It has a unique production cycle therefore dairy farmer needs to ensure milk is sold/used within 48 hours of milking. It has to be stored in cold chain and processed or milk is spoiled and is unfit for human consumption.

Dairy farmer usually has a few choices. He can use it for his own needs or sell it in different market channels. Namely; informal market (local market, direct sales to consumer, also called street milk), to local processors (mandıra), big processors (national or multinational) or form a cooperative and sell it to the cooperative. Legal direct sales to consumers, sales to a cooperative and corporate are included in this dissertation.

The problem with the above alternatives is similar to a classic oligopoly problem in market economics, too many sellers and limited buyers in a market give the farmer very little or no room for negotiation. Dairy farmers all over the world are encouraged to form a cooperative to sell/market their milk. Cooperative is a bigger entity with more negotiation power. Industrial processors/corporate companies usually encourage farmers to have higher milk standards where social benefits may lag behind. Oldest sales channel; selling raw milk direct to consumers is now

legalized in European Union (EU), United States and Turkey. Farmer needs to obtain necessary certifications so he or she can sell raw milk, in bottled form directly to the consumer or through a middleman. This option gives the farmer more room to set its own price given that a marketing channel is secured.

Farmer needs to make the best judgment for the sustainability of its operation weighing advantages and disadvantages of different options. To demonstrate sustainability of different farming practices, five types of farms were selected by purposive sampling method. A questionnaire was prepared and applied to eighty farms representing five types identified. Field study was conducted in two regions in Turkey.

This analysis is based on a comparison of farming practices that are designed to sell milk to three different entities namely; a multinational (corporate) company, a cooperative and directly to consumers. Multi-criteria Analysis method is used and criteria are developed to measure social, economic and environmental performances of the farms. Shared tank and single tank farms working with different processors make up the alternatives. Moreover, for environmental performance, farms differing in feeding regimes are categorized to represent different impacts.

Type of tank is used as an indicator to categorize farms. Few animals mean sharing a tank with other farmers, requiring a small investment with lower technology, fewer working hours for dairy operation and small land dedicated to feed production and housing of animals. Small farms with 20 or fewer animals usually share a tank in the nearest collection point with other small farmers while bigger farms have their own cooling tanks on the farm. In the literature farms are categorized based on the number of cows (Armagan and Süleyman, 2012). EU data collection network Farm Accountancy Data Network (FADN) categorizes farms either by animal number or by output (liter of milk). Categorizing farms based on the number of animals they own was the first intention of the author however, during the field study, it was observed that farms using shared tank also share similar farming practices. It was concluded that overall grouping under two categories of shared and individual tanks can provide more uniform results for the categorized groups. Farms were further categorized into five groups; Cooperative Shared Tank, Cooperative Individual Tank, Corporation Shared Tank, Corporation Individual Tank. Independent farmers (IF) all had an individual cooling tank. That is why there is only one type of individual farm present in the study. Five groups of farmers were generated in total. The goal is to provide a snapshot of different farm groupings and rank them on sustainability criteria based on farming practices and processor they use. As a result,

farming alternatives for the study are shown below. They are numbered in groups for easier reference for the rest of the dissertation (Table 3.1).

Table 3.1. Farm alternatives.

Farmer Alternatives	Cooperative (Shared Tank)	Cooperative (Individual Tank)	Corporation (Shared Tank)	Corporation (Individual Tank)	Independent Farmer (IF)
	Group 1	Group 2	Group 3	Group 4	Group 5
Average number of animals	17	111	21	318	104

3.2. Feed Management

General categorization by animal number plays a key role in deciding feed management. All the farms interviewed owned land and planted crops for dairy animals. This is a cost saving step in small and medium sized farms. Planted feed costs less than buying the feed and is preferred method for long time farmers. Land is planted two times per year and one crop is always corn and is used to make silage. While grazing is desired, it is almost nonexistent in big farms due to large animal numbers and the size of the required area to put the animals on pasture. There is no intention to change in stall feeding practice in big farms. Independent farms are progressive to pasture feed their cows most of the year. Cooperative members feed their cow on pasture between 2 to 5 months out of the year. A constraint for pasture grazing is the location of the farms and the planting areas. While some farms own and plant the adjacent land to the dairy farm, this is not always the case and transporting animals for grazing is not a viable option. Instead the feed comes to the herd. Different varieties of feed are planted. Full list of planted feed in the studied farms are corn, wheat, barley, oats, vetch, caramba, clover, triticale, turnip, davis flora and sorghum. For feed, a mixed ratio is seen as ideal to maximize the production (Kutlu and Uğur, 2014). Milk production is closely related to quality of the feed. All farms practice free stall feeding. 60% of the feed dairy animals eat is silage which is either planted by the farmer or sourced domestically. 20 to 25% of the feed is factory feed. Contents of factory feed are listed in the previous chapter, section 2.1.1 Factory Feed. Small and medium farmers manually mix feed every day. Larger farms use mixers powered by tractors. Industrial dairy farms use the services of a third party supplier that delivers already rationed feed on a daily basis.

3.3. Herd Management

Herd size in Turkey is less than five cows per farm (Gönenç and Harun, 2008). Farms subject to study in this dissertation average 19 dairy animals in Group 1 and 3, 210 cows in Group 2 and 4 and 104 cows in Group 5. Milk yield average in Turkey is 8.47 kg/day (TUİK, 2018) compared to 23L/day= 23L*1030kg/L=23.69kg (Sciencing.com, 2018,) the farms studied in this dissertation. Animals in this study weigh 578kg on average while Turkish dairy cows weigh 467.89kg (TUİK, 2018). Dairy animals studied are mostly Holstein and Simmental breeds (culture breeds) while Turkish dairy livestock is made up of culture and hybrid cattle (mix of culture and domestic cattle).

3.4. Manure Management

There are different manure storage systems. 2006 Intergovernmental Panel on Climate Change (IPCC) Guidelines for National Greenhouse Gas Inventories description is used (Eggleston et. al., 2006, p. 10.49) for the purposes of this dissertation. According to IPCC report, prepared by Turkish Statistical Institute, liquid system with 36.9 % is the most common storage system, followed by pasture range and paddock with 20%, are the second most common manure management systems (TUİK, 2018). Other practiced methods include solid storage with 18.4 % and daily spread with 18%. During the visits to the farms, most common method in shared tank farms was reported as pit storage and solid storage. Modern and newer establishments use scrapers and store manure in liquid system housed under animal confinement area. Separators are used to separate liquid from solid waste. While liquid is spread on the farming land, solid waste (manure) is stored outside in confined piles. Manure is hauled by tractor to the fields and spread onto soil before new planting. Similar structure was also observed in Chinese dairy farms (Powell et. al., 2008).

4. SOCIAL DEBATE ON SUSTAINABILITY OF MILK

Farm model of the dissertation is made up of four components. Namely; Feed Management, Herd Management, Manure Management and Social Organization. First three are explained in Chapter 3. The last one, Social Organization has two components; socio-economic component and the enterprise type. Background information on socio-economic aspects of dairy farming is given here. Dairy farming is one of the pioneer activities of an agricultural society going back thousands of years. Dairy products were preferred because of their nutritional quality. Dairy cow was an important asset and ensured sustenance of the farmers and its family. Today, access to animals is still one of the indicators to food sovereignty at international level (Binimelis et al., 2014).

Owning a dairy cow is seen as a way out of poverty. In developing countries landless people can own a cow where they graze on roadsides, open grazing areas or water bodies. Productivity of these animals is low (160-180 day lactation), and provide an average yield of 200-300 liters per lactation cycle. Livestock perform multiple functions as food, nutrition, income, savings, draught power, manure, transport and other social and cultural functions. Cattle are directly linked to family income, nutrition and welfare (Morgan, 2009).

Countries such as Pakistan, India and Bangladesh have a long history of milk consumption and still have strong informal rural milk marketing systems. There are many national and international projects launched to help people get out of poverty by the way of a dairy cow. United Nations Food and Agricultural Organization (FAO) and a number of other nonprofits have numerous projects especially in Asia and Africa for dairy development. There are different models and there is no one size fits all solution. Smallholder Dairy Development project was launched by FAO in 2009. Project included an in depth analysis of dairy supply chain in each country and developed tailor made solutions to unique problems. Project was launched in Bangladesh, China, India, Mongolia, Pakistan, Sri Lanka, Philippines, Thailand and Viet Nam. Each of the countries dairy market structure was assessed separately. Necessary steps were developed with the main goal being smallholder farmers moving into dairy production (Morgan, 2009).

There are a few options for smallholder dairy development depending on the current market dynamics. For social gains, best course of action is forming a cooperative structure or supporting private companies usually with a domestic partner. In Bangladesh, 1970’s India cooperative model (AMUL and Operation Flood) was used to develop Milk Vita Cooperative Model. Smallholders

work directly with cooperatives earning patronage dividends. Cooperative sells pasteurized milk to shops and consumers. Milk Vita delivers milk to more than five million urban consumers. In other countries, private companies are encouraged to form a partnership with domestic companies and establish dairy processing facilities.

Humans are social beings and acting as a group is not new however, acting as a group and functioning as a business entity is fairly new form of organization. The first cooperative was formed in England under the name of Rochdale Equitable Pioneers Society in 1844 as a consumer cooperative venture (Rochdale Equitable Pioneers Society, 2018). Their basic principles mostly apply to today's cooperatives. Capital belongs to the cooperative. Members should receive highest quality products. Market prices are charged and no credit is given. Everybody is treated equally, each member has one vote, no race or gender discrimination is allowed. Members should periodically receive statements and balance sheets (Rochdale Equitable Pioneers Society, 2018). Today this kind of relationship among members of an organization is referred as social capital and cooperative structure is seen as the best form of representation for social capital. Leenders and Gabbay define social capital as "the set of resources, tangible or intangible, that build over time to cooperative constituents through their social relationships, facilitating attainment of goals" (Leenders and Gabbay, 1999). Agricultural cooperatives are established to benefit the farmer. Friesland Campina in Netherlands, Fonterra in New Zealand, AMUL in India are all successful dairy cooperative examples.

Turkish dairy structure is similar to developing nations. Most of the farms have less than 5 cows and milk revenue helps to support cash flow of the farmer (Gönenç and Harun, 2008). Most of the farmers have mixed farms with both animal husbandry and crops. Compared to Asian countries, economic welfare of the farmers is higher since most of them own land to farm. Still, dairy sector development is seen as a major contributor to value added product development and bigger farms are supported.

Tangible components of farming are outlined in Chapter 3. This dissertation also looks into intangible assets, such as the social dimension of farming. Social dimension of dairy production has been incorporated into sustainability studies, however quantifying social indicators can be challenging. Social pillar is usually included either as a socio-economic indicator (minimum wage practices, working hours, insurance) or has been drawn out from Sustainable Development Goals (UNDP). To better understand the social circumstances in dairy communities, three different types of enterprises that farmers work with are included in the scope of the study. While incorporating

social indicators is valuable, it is important to reflect organizational difference between the buyers of milk in this pillar. By incorporating three different business enterprises, different social traits are aimed to be observed and studied. The relationship between the farmer and the buyer is both an economic and a social contract that is why social debate has been included in the scope of this research.

4.1. Turkish Livestock and Dairy Policy

After the foundation of the Turkish Republic in 1923, government wanted private sector to establish factories for processing of agricultural products. However, there being no start-up capital available, private sector failed to implement this goal. Government re-launched establishing a meat industry goal during 1936 Industrial Congress, efforts started in 1949. In 1952 Et ve Balık Kurumu (EBK) (The Meat and Fish Institution) was established by the government. At the height of its operation the Institution had 35 processing plants. In order to improve the meat and dairy industry, a feed factory named Yem Sanayi Türk A.Ş. (Yemsan) was established with government private partnership. The aim was to provide quality feed and provide a stable supply of feed. Starting in 1964 private sector founded feed factories (Et ve Süt Kurumu, 2019).

In 1984 Ministry of Agriculture was restructured and many landmark institutions were shut down. The link between the Ministry and the farmer was severely damaged during this transition. Import of animal products was allowed to control rising consumer prices which negatively affected the domestic producers. While Turkish Policy promoted private factories to industrialize agricultural products, during early 90's grazing were banned in Eastern parts of Turkey due to terror threat. This in turn reduced animal numbers and forced migration of farmer population to big cities. Turkish cow population was 16.6 million in 1980 have reduced to 15.1 million as of 2018. The number has shown increase since 2012 as a result of support policies (TİGEM, 2012).

In 1992, 28 processing plants of EBK were privatized. Instead of operating them, factories were closed and land, which was more valuable than the factory itself, was developed or sold. In 2005 the institution was taken out of privatization and was assigned a regulatory and supportive role in the animal husbandry sector in accordance with the European Union (EU) standards[2]. When milk prices are too low or meat prices are too high dairy animals are sent for slaughter therefore Meat and Fish authority is mentioned this paper. EBK name was changed to Et ve Süt Kurumu, (Meat

[2] http://www.ebk.gov.tr/ebk_tanitim-video-icerik-301-1.htm

and Milk Institution) on 27.04.2013 with article no.4553 and the institution is given a regulatory and support body to help establishing free market economy in the sector[3] (Et ve Süt Kurumu, 2019).

Similar to EBK, Süt Endüstrisi Kurumu (SEK) (Dairy Industry Authority) was founded in 1963. Its aim was threefold; to process produced milk, to encourage private sector to follow and to encourage cooperative type establishments among producers. SEK was the first company to introduce pasteurized milk, homogenized yogurt and cheese in a vacuum pack[4]. SEK was privatized in 1995 and was bought out by 164 person group made up of small producers and food merchandisers. In 1997 Koç group purchased 68% of the company. As of 2013 SEK is an operating brand of Koç group. SEK is the only example of successful transition from government to private sector. Most other government operated factories were sold to private investors; however, privatized factories were never operational. They were shut down and instead their land was sold for development.

As a way to support farmers, Rural Development Support Project was launched in 2003. The aim was to give two milking cows or 25 sheep to the farmers that prove they need assistance. These animals were given as a loan. According to different sources, animals were already sick when they arrived, coupled with poor carrying conditions for the animals, they died and left the already poor farmer with credit debt. As a result, these people were taken out of land and forced to migrate to the cities.

In efforts for integration with European Union, National Dairy Council (USK) was founded on 2006 with the 5488 numbered Agricultural law, section 11. Milk Council members are made up of industry members, farmer organizations, government officials and academic advisors. Council serves in an advisory capacity however it has become the main authority in determining milk prices. Milk price per liter, announced by the council is accepted as the minimum buying price from the farmer. Council is formed by the government and there are a number of non-profit organizations that work on different aspects of dairy industry. A list of Turkish Dairy actors, including non-profit organizations representing Turkish dairy farmers, is available on Chapter 6, Table 6.2.

[3] http://www.esk.gov.tr/tr/10097/ESK-Tarihce-ve-Genal-Bilgiler
[4] http://www.sek.com.tr/

4.2. Cooperatives in Turkey

Cooperative structure in Turkey has been largely misunderstood and two separate thoughts are formed on the mention of the word “cooperative”. First one is housing development cooperatives where a group of people come together to build houses to live in. Government provides a plot of land with cheap price so home ownership is available at a discounted price to the housing cooperative members. Second interpretation of the word cooperative is: An organization with a socialist agenda, and people do not want to associate themselves with socialism due to the country’s turbulent past in 1970’s and 80’s.

In Turkey 7.5 million people are cooperative members. Housing cooperatives are the most common type of cooperative with 27,361 different establishments and Agricultural Development Cooperatives are second with 7,201 different cooperatives with 775,563 members (Gümrük ve Ticaret Bakanlığı, 2017). Cooperative law requires having at least seven signatories and an independent building to form and run a cooperative. This ease of establishment is seen as an advantage. There are different types of Agricultural Cooperatives in Turkey, some of these are: Agricultural Loan Cooperatives (1,625), Agricultural Development Cooperatives (7,201), Irrigation Cooperatives (2,523), Agricultural Sales Cooperatives (308), Sugar beet Grower Cooperatives (31).

There are three major laws that regulate cooperatives and their financial activity; Main law is 1163 numbered Cooperatives Law, second one is 4572 numbered agricultural unions and sales cooperatives and third one is 1581 numbered Agricultural Credit and Cooperatives Union. The cooperative studied for this dissertation is chosen as a model in rural development by United Nations. Unfortunately, most of the cooperatives in agricultural sector are not farmer initiated organizations and they are not financially or structurally independent. They operate by government support. As a result, cooperative principles mentioned above are not internalized by members and cooperatives lose money under corrupt or politicized managements (Sayın and Sayın, 2004). There is also added distrust among members voiding the first rule of cooperative spirit: Trust and reciprocity (2018). A study conducted in India showed similar results and found that, when private firms are compared with cooperatives, cooperatives favor dairy farmers with land ownership due to personal relations with the cooperative managers where the main aim of the cooperative is to find the landless people that really need the support money from the government (Vandeplas et. al. 2013).

Three different types of enterprises are compared in this dissertation; Independent company, Cooperative and Corporation. Table 4.1 shows advantages different enterprises offer to farmers.

Table 4.1. Comparison of advantages provided to farmers by different enterprises.

	Individual	Cooperative	Corporation
Farming system	√	√	√
Payment	Direct	Through coop	Direct
Prerequisite to sell milk	None	Member	Contract
Bulk purchasing		√	
Processing advantages (silage making)		√	
Equipment rental		√	
Grocery store		√	
Central milking station			√
Central collection point		√	√
Milk pricing contracts		√	√

Table 4.2 shows the comparison between cooperative an enterprise based on different parameters/category.

Table 4.2. Comparison of cooperative and industrial enterprise.

Category/Parameters	Cooperative	Industrial Enterprise/Corporation
Ownership	• Legal entity for doing business, formed at least by 7 people, voluntary for mutual benefit (Economic, Social or cultural need, or a task) that would be hard to accomplish alone • Each member has equal share and is part owner • Limited liability • Shares are not transferable • New members meeting certain criteria can join anytime	• Legal entity for doing business, formed by at least 2 people that contribute a form of capital • Shareholders are represented by number of shares (can be more than one share) • Limited liability • Shares are transferable • Membership is closed after the subscription of the capital
Management	• All members have the same share of control-unless cooperative elects a Board of Directors (BOD) to run day-to-day operations • BOD can appoint a management team • BOD elections are made depending on the cooperative rules.	• Members of the board are appointed by shareholders • Centralized management under a board structure • BOD elections are made depending on the company rules. • Shareholders work in the enterprise
Capital	• More capital intensive/common purpose driven (People centered)	• Capital intensive, more interested in capital returns

Table 4.2. continued.

Organizational Structure	• More equitable form of organization • Considered “golden mean” between capitalism and socialism. (Jugale and Koli, 2005)	• Shareholder with the most shares rule
Operation area	• Regional (most)	• National/International
Politics/Society/Structure	• Has a greater chance of success in societies with high degree of honesty, integrity and transparency • In the third world, low levels of honesty and transparency and divisive politics are the culprits for failure of cooperatives. • Rigid structure	• Private company does not allow divisive political interference. • Private company uses politics for benefit of its own. • Flexible structure
Public welfare	• Some public welfare is involved (social interest by eliminating middlemen)	• No public welfare is involved.
Incentives	• There are various incentives and aids, which are offered by the Government to the co-operatives such as exemption from income tax up to a limit, exemption from stamp duty etc.	• Such exemptions and aids are not granted to companies.
Flexibility	• Can function under all economic conditions	• Cannot function if political/economic environment is too restrictive.
Employee compensation	• Since profit is not the main aim, employees are paid relatively low.	• To make profits, specialized workforce can be hired and top dollar is paid.
Transparency		
Goods and Services	• Generally limited to current "users" of the business' goods or services. (Still, may change income rights and decision rights structure and be more like a company). • In house credits may be available to users. • Farmers are protected against exploitation of traders	• Operated as a business to the general public.

Table 4.2. continued.

Overhead Cost	• Not aiming to capture the largest market share, advertisement and marketing spending is minimal. Overhead cost is minimized which enables them to supply goods to their members at fair prices.	• In order to capture market share, advertising and marketing are big expense items and this is reflected in the final sales price of the product.
Goal orientation	• Accomplish a common goal (Benefits to the users is a priority e.g. higher procurement price of milk, cheaper cattle feed, cheaper processing (of silage making). • Profit on capital plays a secondary role.	• Make profits • (Return on Investment)
Drawbacks (Limitations)	• Lack of capital • Inefficient management • Lack of unity • Limitations of size • Delays Decision-making • Public perception of cooperatives in Turkey(Perceived as a Socialist entity from 1960's) • Loyalty and co-operation of the members is a must for success. • Government intervention	• Driven by profits and growth
Dissolution	• Member approval by equal voting.	• Stockholder approval, government approval

5. METHODOLOGY

5.1. Research Map

Research map (Figure 5.1) is a schematic suggested by Creswell to better define where a researcher's methodology stems from in the literature (Creswell, 2014). It also helps to visualize where the research gaps are in the existing literature. On the research map, left section is sustainability assessment methods literature as described by Ness et. al. MCA and SMCE methodology of the dissertation is an established integrated assessment method (Ness et al., 2007). Second part of the research map shows farming assessment methods classified from the literature. This dissertation has a product based approach in mixed systems. Third contributor to the map is farmer-processor relationship. Intersection of these areas outlines the gap in the literature and how this dissertation converge these fields to fill a gap in the research.

5.2. Social Multi-Criteria Evaluation

Agricultural sustainability assessment in selected dairy operations is the overall goal of the methodology for this dissertation. There are many methods developed and used to measure agricultural sustainability. Some of these methods were summarized in Chapter 2. Social Multi-Criteria Evaluation (SMCE) Framework is used for this assessment. SMCE principles are founded from different disciplines, namely: Economics and complex systems theory (Munda, 2008). It is originally proposed as a participatory process where scientific and technical language is formulated into different scenarios and a decision on the future of a resource is made based on input from social interest groups. Some of the cases it is used are windmill construction, mining conflicts, water usage and conservation area management (Gamboa, 2006; Gamboa and Munda, 2007; Giampietro, 2003; Oikonomou, 2011). SMCE is used where scientific and economic options of development initiatives and different interest groups in a certain geographic area need to find a compromised solution. SMCE is also used to assess farming practices.

SMCE is defined as a learning process combining MCA with participatory methods (Siciliano, 2009). SMCE methodological foundations have two distinct characteristics; "reflexive complexity" and "incommensurability". Reflexive systems add new qualities and attribute that need to be taken into consideration to explain, describe or forecast their behavior (Munda, 2004).

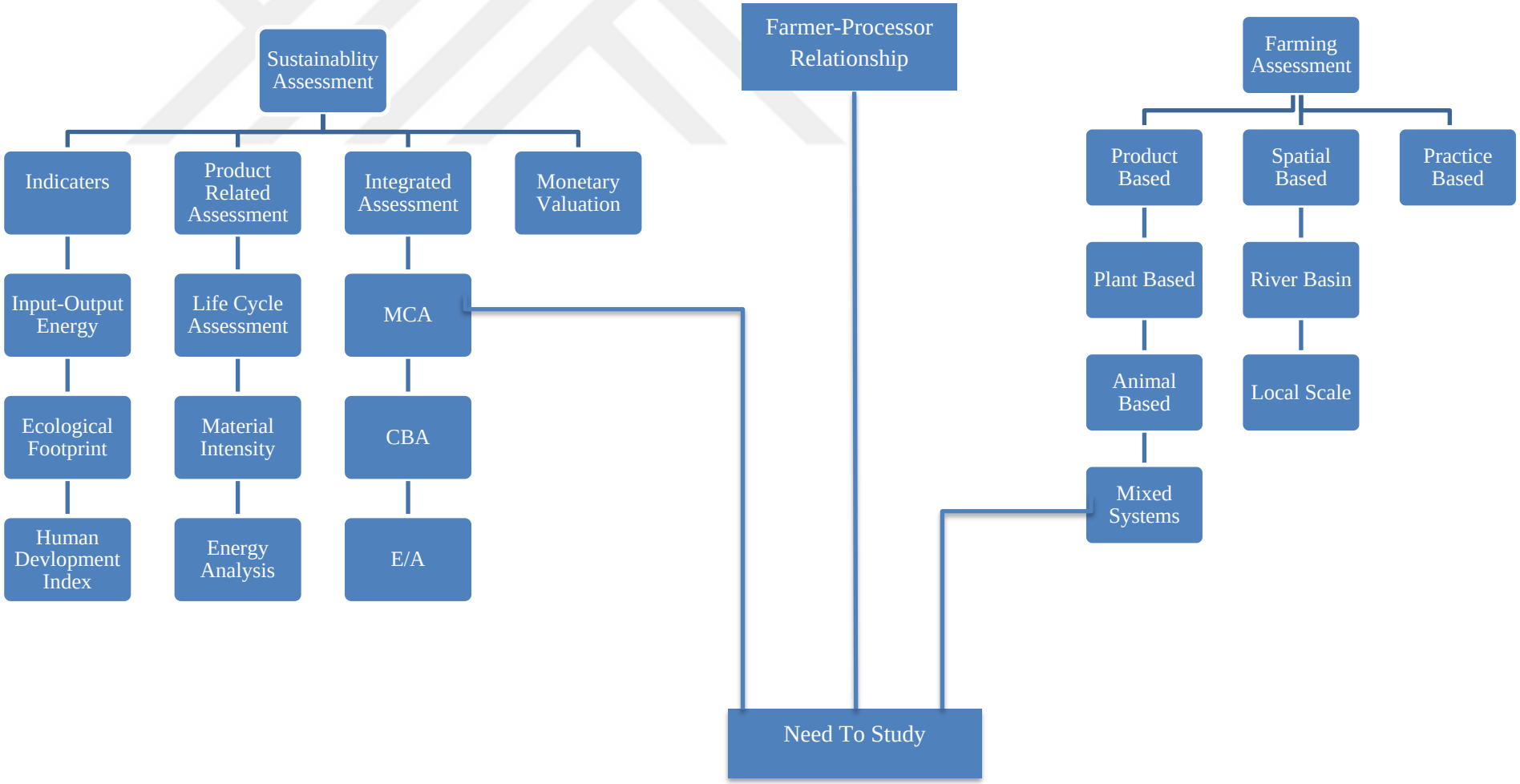


Figure 5.1. Research map of methodology -sustainability assessment categorization from (Ness et al., 2007).

MCA has been applied in decision support systems that integrate economic and noneconomic values (Newton et. al. , 2012). In SMCE complex, multi-dimensional decision-making tasks can be treated of, involving multiple conflicting objectives, a diversity of possible outcomes, with incommensurable or uncertain effects as well as many decision makers and social actors with different perceptions and values (Martinez-Alier et.al., 1998; Munda, 2004; Pereira and Quintana, 2002). In real world situations, opposing interests and perceived values will induce different alternatives and objectives, thus creating competition and conflicts (Munda, 2004; Oikonomou, 2011). The decision maker needs to decide where to place incommensurable effects and keeping in mind that rather than maximizing a single aspect or dimension, the aim is to reach a trade-off between the three dimensions. Agricultural systems are complex and multidimensional where sustainability of these systems cannot be represented by a single scientific discipline or by a single unit of measurement (Giampietro, 2003; Siciliano, 2009).

Sustainability is also referred as triple bottom line meaning economic, ecologic and social dimensions of a case (Elkington, 1999). For any human based economic activity, profitability, albeit large or small; is the first rule of survival. However, maximizing economic growth leads to material and energy intensive production and could lead to social and environmental costs. In general, only when a business makes profits, then it can observe social and environmental well-being. Economically viable farms were chosen for the study therefore social and ecologic dimensions would be given the same importance (priority).

SMCE states that real world is multidimensional and requires integration of complex systems (Munda, 2004). SMCE helps human decision makers in handling large amounts of complex information in a consistent way (Kijak and Moy, 2004). Rather than converting all criteria to a single unit, MCA and SMCE can assess criteria that have different units (tons, KwH, etc.). Both qualitative and quantitative indicators can be used. Qualitative indicators can be expressed in linguistic terms such as good, moderate, bad. According to Munda, qualitative parameters can also be used for ranking or they can be converted to cardinal parameters (Munda et. al., 1994).

5.3. Steps of SMCE

Based on the concepts outlined above, participation of relevant actors included differing dairy farming practices in use. Steps of SMCE are as follows:

1) Historical and institutional analysis

2) Identification of social actors

3) Problem definition

4) Formation of alternatives and evaluation criteria

5) Selection of MCE technique

6) Criteria aggregation

7) Sensitivity analysis

8) Interpretation of results

First step of SMCE is Institutional Analysis. Review of historical and legislative data helps identifying relevant social actors for the case and leads to problem definition (Gamboa, 2006). Munda asks the researcher to find actor's values, desires and preferences through focus groups, in-depth interviews and meetings (Munda, 2008). Actors usually represent different views in a conflict situation. Social actors represent different aspects of the case, such as technical, social, environmental and economic. This leads to generation of policy options (alternatives) and evaluation criteria. Once all the information is evaluated, Multi-Criteria Impact Matrix is formed. Chosen criteria valuation is expressed in the impact matrix. Depending on the researcher, budget of the study, actors' willingness in community related cases, an Equity Impact Matrix is formed by asking social actors their choice in the alternatives. A MCE technique is applied which is basically a mathematical procedure depending on the aggregation choice of the researcher (sample techniques are Novel Approach to Imprecise Assessment and Decision Environments (NAIADE) , Regime, Preference Ranking Organization Method for Enrichment Evaluations (PROMETHEE), Analytic Hierarchy Process (AHP) etc.) followed by sensitivity and robustness analysis (Gamboa, 2006; Munda, 2004).

Dairy farmers and several dairy industry interest groups make up the social actors for this dissertation. Equity Impact matrix portion of the method is not created for this dissertation. SMCE allows for multi-dimensional evaluation. Indicators from different disciplines can be combined allowing the problem to be studied in a multi-faceted approach.

Criterion selection is described by Gallopin as an indicator, as a variable or an aggregate of multiple related variables whose values can provide information about the conditions or trajectories of a system or phenomenon of interest. He further describes it as "an operational representation of an attribute (quality, characteristic, property) of a system" (Gallopin, 1997) as cited in (Wu and Wu, 2012). Van Passel et. al describes indicator as tools used to simplify the description of complex systems (2007). Values for indicators are derived from environmental and socioeconomic data.

Some indicators are integrative while others show a limited aspect. No indicator by itself is adequate to measure multiple dimensions of sustainability (Wu and Wu, 2012). Indicator and criteria are used interchangeably in this context.

One of the most debated properties of indicator development is Community Involvement, expressed as social actors by Munda (2008), also listed in Guy and Kibert (1998) in sustainability literature. Community Involvement acknowledges stakeholders of the problem and can also be interpreted as target audience; and brings the question, who the indicator is developed for? Is it theoretical, and can only be used by researchers to advance knowledge of farming systems or is it for farmers helping them to assess and self-evaluate farming systems? For farm level assessments, developing indicators require a lot of information and are complex in nature (Bélanger et. al., 2012). In addition to the three main themes (economic, ecologic and environmental) to develop indicators, United Nations Commission on Sustainable Development (UNCSD) 2001 guide for general framework of criteria was used.

5.4. Establishment of Reference Values for Each Indicator

Reference values are used to compare agricultural practices on value-based scales. Lancker and Nijkamp emphasize upon target values of indicators and states that, “a given indicator doesn’t say anything about sustainability, unless a reference value such as thresholds is given to it” (2000). Whether the indicators are weighted, aggregated or indexed, sustainability assessments without a reference value/threshold are criticized since a comparison is not possible without a reference or benchmark (Singh et. al., 2012). Munda states that “in order to get a set of reference values, an ‘ideal point’ can be defined by choosing the best values reached in any single indicator” (Munda, 2005). Established literature on benchmark can be found in (Yu, 1985; Zeleny, 1982).

6. RESEARCH DESIGN

A total of 80 farms were selected to demonstrate different aspects of sustainability for different farm groups. Sustainability of selected dairy farms is based on dairy farmers' farm management practices and processor choice. Gaps in the literature are identified by a research map in Figure 5.1 using sustainability assessment and farm assessment literature. Social theoretical background of the dissertation is explained and SMCE steps are presented in this chapter.

6.1. A Model for Social Research

There are different philosophical positions related to scientific enquiry leading to different epistemologies. Unfortunately, there is no consensus or an umbrella name for "a basic set of beliefs that guide to action" (Creswell, 2014; Guba, 1990, p. 17). Creswell chose the term "Worldview" where Saunders et. al. chose "research philosophy", Crotty used "epistemology and ontologies" and others called them "paradigms" (Creswell, 2014; Crotty, 1998; Lincoln et. al. 2011; Saunders et. al., 2009). The term research philosophy is used to explain basic set of beliefs. Saunders et. al. explained research philosophy as an "over-arching term relating to the development of knowledge and the nature of that knowledge" (Saunders et al., 2009, p. 128). Another definition for research philosophy is "about the world and the nature of research that a researcher brings to a study" (Creswell, 2014, p. 35). Saunders, et. al introduced the term "Research Onion", where Research Philosophy, Research Approach, Methodological Choice, Strategy, time horizon and techniques and procedures used for the research are summarized (Saunders et al., 2009). Some scholars add research design step before techniques and procedures. Figure 6.1 shows 2012 version of the Research Onion developed by Saunders et. al.

Research Philosophy followed in this dissertation based on the Research Onion is as follows:

1) Research Philosophy: Pragmatism + Post normal science

2) Research Approach: Inductive

3) Research Strategy: Grounded Theory+ Case Study

4) Research Choice: Mixed Method - Exploratory

5) Time horizon: Cross-sectional

6) Techniques and procedures: Questionnaires, in depth interview with social actors and stakeholders, literature review, qualitative and quantitative data analysis.

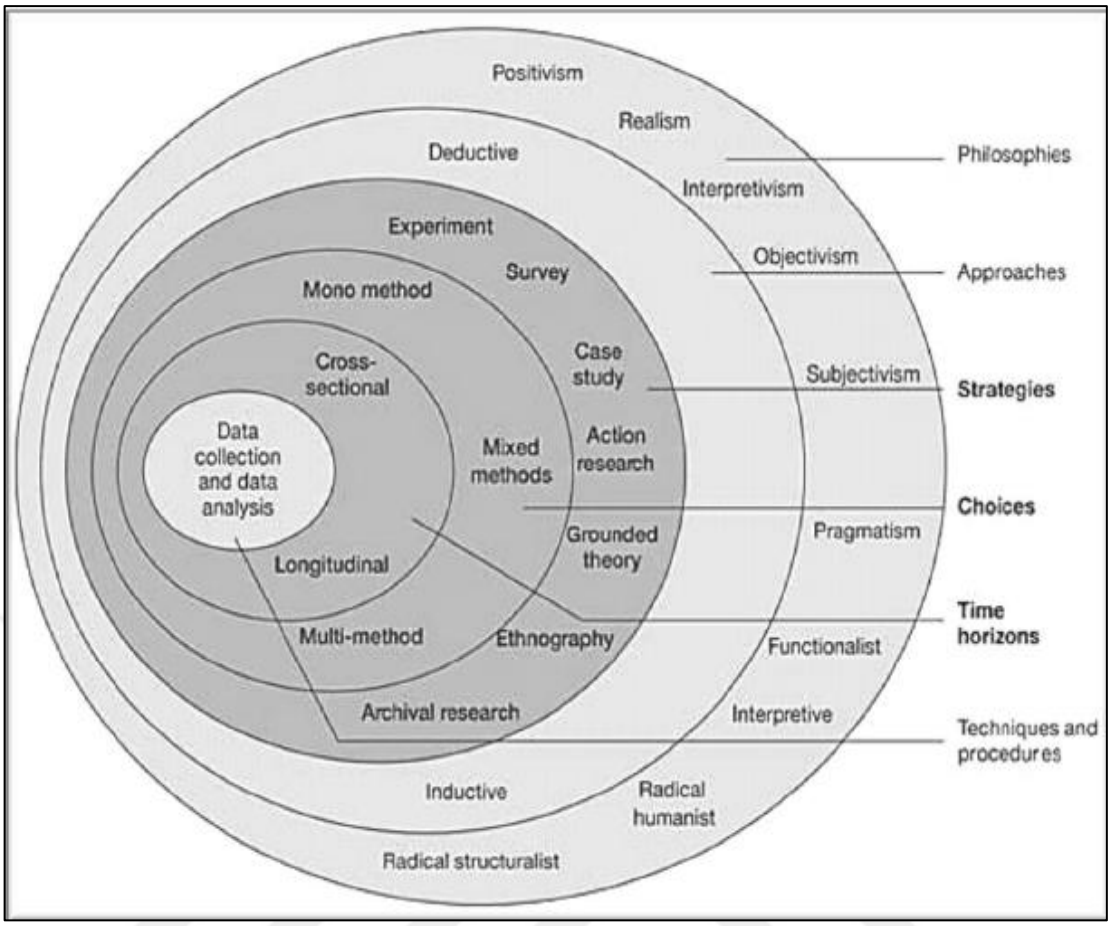


Figure 6.1. Research onion developed by Saunders et. al. (2012).

Creswell outlines essentials of pragmatism as being problem-centered, pluralistic and real world oriented (Creswell, 2014, p. 36). All these properties of pragmatist philosophy are embraced in this dissertation.

Saunders et. al. lists seven research strategies(2012). These are: Experiment, Survey, Case Study, Action Research, Grounded Theory, Ethnography and Archival Research. Dissertation strategy is Grounded Theory developed by Glaser and Strauss (1967). Grounded theory aims to formulate, test and reformulate prepositions until a theory is developed inductively from a set of data (Dudovskiy, 2016). It helps a researcher to explain behavior. Theory is grounded in continual reference to the data (Collis and Hussey, 2003). Grounded theory necessitates the researcher beginning with a completely open mind without any preconceived ideas of what will be found. It is important to note that, while inductive approach is suitable for theory development, exploratory nature of the subject makes it challenging to reach a theory at the end of this dissertation.

Research question helps with the classification of research choice. There are different opinions on defining types of research. Numerous books and articles are published on types of research,

however no two are classified the same way. Research choice can be mono, mixed and multi-method (Creswell, 1994). Research choice identifies what type of data this study will process; qualitative, quantitative or both (mixed and multi methods). Mixed method consists of qualitative and quantitative data studied together. Both qualitative and quantitative data is collected and analyzed in a sequential and/or simultaneous and rigorous manner and are integrated. Scholars claim this approach enables a greater degree of understanding (Creswell and Clark, 2011). Research choice determines the research design. Depending on the purpose of the study, research design can be exploratory, explanatory, convergent, descriptive, causal, causal-explanatory and causal predictive (Cooper and Schindler, 2014; Creswell, 2014; Dudovskiy, 2016). This dissertation is an exploratory research design and general characteristics of exploratory research are summarized below.

Exploratory research is applied to a study problem that does not have a clear definition and there are not a lot of studies or writing available. Although there is ample research in agricultural sustainability and dairy sustainability, there are limited studies including triple bottom line. Exploratory research design does not provide conclusive evidence and only determines the nature of the problem. This dissertation aims to show a snapshot of different dairy practices and how they measure based on sustainability criteria, which can be perceived as progressive rather than conclusive. Exploratory research design is flexible and adaptive. Researcher must be willing to change direction when new insight or as new data appears. Focus of the research becomes narrower as the study progresses. A good literature review, expert interviews and conducting focus group interviews are the main features to conduct exploratory research (Dudovskiy, 2016; Saunders et al., 2009). While findings may be for research level only, it can help establish research priorities and on deciding where to allocate resources. On the other hand findings cannot be generalized to the general population of the subject.

6.2. Sustainability Research Philosophy: Prudentially Conservationist vs. Environmental Preservationist

Although sustainability research is still in its infancy, there is a need to study the research philosophy of the approach and maybe set definitions for certain words. Sustainability and sustainable development are two such terms. Since the introduction of Sustainability and Sustainable Development these two terms are used interchangeably whereas suggested in the Brundtland Report, the aim of sustainable development should be to reach sustainability (or a state of equilibrium). Today, these two words are used interchangeably and real approaches to achieve

sustainability are largely ignored. Hector et. al. introduced the terms: Prudentially conservationist vs. Environmental Preservationist (2014). The main argument is that prudentially conservationists see humans above nature and rejects the interest of non-human species with a reductionist approach. They apply a positivist view of the world and detach themselves from the research problem. Environmental-preservationists recognize the systemic nature of the ecosystems and provide a critical evaluation of the world. They accept humans as part of the system and recognize that human actions can have exponential effects on systems. They engage in the full complexity of the problem and incorporate dynamic equilibrium of sustainability (Hector et al., 2014). Researcher of this dissertation is also familiar with strong vs. weak sustainability discussions, however these are not considered complete research philosophies, rather as approaches to valuation and both are derived from utilitarian approach (Faber, 2008; Spash, 2012).

Connecting theory above to this dissertation, dairy farmers and processors have a multi-layered and complex relationship with nature, dairy animals and amongst themselves and it may be too early to name a theoretical approach in sustainability research since there are numerous critiques that find sustainability and ecological economics with weak theoretical framework (Faber, 2008; Røpke, 2005; Spash, 2012). The research discussion is limited to a Pluralistic approach with a Pragmatist philosophy in view of Post Normal Science. The schools of thought(s) presented for this subject should be thought of as philosophical tendencies to provide a framework for the research of this dissertation. (Bell et. al. 2018).

6.3. Discussion on Epistemology of MCA/SMCE

SMCE methodology is rooted in post-normal science epistemology. Funtowicz and Ravetz argue that uncertainty and value conflict are better dealt with in the policy domain by the way of post-normal science (Funtowicz and Ravetz, 1993; Munda, 2004). In normal science, generalized knowledge and routine techniques are acceptable, reductionism takes center stage and views are expressed through a certain theory while others are neglected. However when system uncertainties and decision stakes are high, researcher needs complementary scientific strategies (Munda, 2004). In addition to this need for complementary strategies, most of the developed theories look at meaning and knowledge by advocating purely human centered approaches and lack the capability of governing complex problems (Munda, 2008). Post-normal science advocates openly using legitimate contrasting views to challenge scientific arguments. This can be done by democratizing the procedure and analyzing the issue from multiple perspectives (Funtowicz and Ravetz, 1993). SMCE incorporates interdisciplinary and participatory approaches enabling the researcher to

contemplate several perspectives (Gamboa, 2006). An assessment methodology needs to include triple bottom line without being reductionist. Social multi-criteria evaluation is an integrative and consistent evaluation approach in tacking sustainability issues (Munda, 2016).

6.4. Dissertation Epistemological Approach

This dissertation has an inductive approach based on pragmatic and post-normal scientific philosophy. It takes all of the information in an inductive approach and builds the framework from ground up by revisiting the research phenomena in every step of the way. Although it conducts a sustainability assessment for selected farms as part of the study, contrary to the main purpose of sustainability assessments, the aim is not to measure effectiveness of a program or a type of farm. Main purpose of the study is to produce a framework to conduct sustainability assessment of selected farms with different processing channels with respect to their herd, feed, farm management practices and social organizations. With a pragmatic worldview, it explores purposefully selected commercial dairy farms working with different processors using social multi-criteria framework. To achieve this goal, mixed method research was conducted with the aim of exploring the research phenomena. Both quantitative and qualitative data has been incorporated.

Face to face in-depth interviews included people from different institutions. In-depth interviews were conducted with two agricultural engineers from Agricultural Engineers Association in Istanbul, founder of Çiftçi-Sen (an NGO), five academics (one of them member of National Milk Board), two government officials in Ministry of Food Agriculture and Animal Husbandry in Cooperative Division, an ex-CEO of Süt Endüstrisi Kurumu (SEK), four agricultural technicians working in the field (two for cooperative and two for industrial processor), two in depth interviews with managers of the industrial processor (purchasing manager and quality control manager), three in depth interviews with the cooperative management (a Chief Executive Officer (CEO)/President, a member of board of directors and a production manager), ten in depth interviews with the farmers.

For the field work part of the study, university ethics commission permission was obtained. A working cooperative, an industrial processor and independent, legally raw milk seller farms were contacted. Both the cooperative and the industrial processor provided contact information of the farms they work with. Since this is a purposeful sampling design study, it was important to find a functioning cooperative where members are satisfied with the work of the cooperative management. Primary data is collected by the way of filling the questionnaires with the farmers. Ninety-four individual dairy farms were surveyed via face-to-face interviews using a standardized questionnaire.

Total of seventy questions were asked. It took thirty to forty-five minutes to fill each survey. Field work was conducted in two geographical areas of Turkey in different times. Cooperative is in the Aegean region and industrial processor is in Thrace region. The survey gathers information pertaining to the years 2016 and 2017. First part of the questionnaires was conducted in July-August 2016 in Aegean region and second part was conducted in October-November 2017 in Thrace region. Both industrial processor and cooperative gave permission to conduct interviews with their contracted farmers. A total of eighty questionnaires were satisfactorily filled out by the farmers. Thirty-seven of the respondents belonged to the same cooperative and thirty-seven respondents sold all of their production to the industrial processor. Six respondents were independent farmers. Small sample size for independent farmers is due to the method of sampling (purposive) and number of fewer farmers that legally sell directly to consumer**s** as a main source of income.

Rather than measuring what farmers understood from sustainability, questions were designed to gather data indirectly so that sustainability could be calculated from the data given by the farmers. Questionnaire questions were prepared in four subcategories; feed management, herd management, manure management and social criteria. Questions also included farmer's relationship with the processor/cooperative. Questionnaires were designed to start with quantitative statistical information and then moved on to feeding practices and source of the feed. This section was followed by fodder production and herd management. Amount of manure excreted, how the pens are cleaned, water usage were all questions in this section. This section also included questions on veterinary services and management of calves. Social criteria portion of the questionnaire includes economic criteria and worker compensation. Number of workers on the farm, insurance, minimum pay, number of hours worked etc. were asked. Last section is about the overall managing costs of the farm and the processor they sell to. All questionnaires were administered by the researcher. Detailed list of topics and the corresponding area covered in the questionnaire are listed in Table 6.1.

A copy of the questionnaire can be found in the Appendix A. Extensive literature review of sustainability assessment, ecological economics, business research as well as agricultural production and assessment research was conducted.

Table 6.1. List of topics covered in the questionnaire and their corresponding area in research design.

List of Topics	**Corresponding Area**
Average milk production	General statistical information
Dairy animal's health	Herd Management
Dairy animal's diet	Feed Management
Crops planted	Feed Management
Dairy hygiene	Herd Management
Manure excreted	Manure Management
Satisfaction with price	Social Debate / Economic
Payment frequency	Social Debate / Economic
Possible contracts; kind of contract	Social Debate /Economic
Membership of any dairy association	Social Debate /Economic
Assistance from the dairy processor/cooperative	Social Debate /Economic
Farmer's choice to change milk buyer	Social Debate / Economic
Working conditions	Social Debate / Economic

6.5. Identification of Social Actors

Table 6.2 refers to the main social actors (industry stakeholders) in Turkish dairy. The table of the industry organizations was generated to see the actors/influencers involved in Turkish dairy industry decision making process. To further understand the decision-making process of the farmers, main social actors were interviewed.

- Questionnaires
- Face to face in depth interviews

Questionnaires were of mixed type (open, closed and semi-open ended questions) and the information collected was both qualitative and quantitative. Cooperative, industrial processor, local farms, local branches of agricultural loan cooperative (Tarım Kredi Kooperatifleri) were contacted for the following reasons:

1) Information on general dairy practices
2) Information on farm management practices
3) Information on farmer needs and expectations
4) Information on processor
5) Collect data for the criteria evaluation (Adapted from (Siciliano, 2009))

The dairy cooperative chosen for the study is a recognized model for UN Rural Development. The industrial processor chosen for the study is an international company that is a signatory of UN Global Compact and an active member with latest self-assessment report published in 2016 with continued support for the UN Global Compact and its ten principles (2017).

Second source of information was the organizations (associations, unions, cooperatives etc.) that made up the dairy decision influencers in Turkey. A desktop study was conducted to provide an up-to-date list of the non-profit organizations, cooperatives and unions involved in dairy industry. Although this table is not a complete list, organizations detailed in Table 6.2 are all recognized dairy industry stakeholders. It is also worthwhile to note that all of the farmers included in the study are members of one or more of the organizations listed in Table 6.2. Some of the organizations listed below may not be directly involved in day to day farmer decisions on ground; however they are instrumental in receiving government premiums. As an example, small farmer has to be a member of a cooperative or a union to receive 0.07tl premium given by the government for the year 2017(Resmi Gazete, 2017). All newborn heifers are required to be registered (tagged) by the provincial branch of Turkish Cattle Breeders Union (a separate entity founded by law). The organizations and actors interact directly or indirectly to influence milk production of the farmers in the study.

Table 6.2. Social actors.

Spatial Scale	**Socio-Economic actors**	**Represents**	**Scope of action**	**Position regarding sustainability (Social/Economic/ Ecologic)**
Local	Farmers	• Self	• Self	• Profitability is a priority • Animal health
Regional	Agricultural Development Cooperatives	• Cooperative members	• All types of agricultural production activity and its marketing and sales • Usually there is a development cooperative in each village that has registered farmers and in some villages milk payments to the small farmers is made via cooperative	• Not specified

Table 6.2. continued.

Regional	Industrial Processors	• Self	• Contracted farmers • Self	• Not specified
National	SETBIR (Turkey Milk Meat Food Industry and Producers Association) (Türkiye Süt Et Gıda Sanayicileri Birliği)	• Define themselves as the roof organization and highest representation body of Turkish milk, meat and food industry members	• Industrialization in the food sector • Lobbying activities	• A signatory of UN Global Compact. In Communication of Engagement (COE), agreed to the then principles of Global Compact. Committed to publish a progress within two years of joining. (report due on 2019) report on Human Rights, Work Standards, Environment and anti-corruption and anti-bribery
National	ASUD (Packaged Milk Producers Association) (Ambalajlı Süt Üreticileri Derneği)	• Largest member organization. Most of the members are well known dairy product brands	• Sustainable development with small and big businesses • Food safety • Lobbying activities	• Participant of School Milk Project (2010 – 2015) • Sound sustainable growth is possible by improving resources and efficient use of resources. Promotes responsible corporate applications.
National	Turkey Milk Producers Central Union (Türkiye Süt Üreticileri Merkez Birliği)	• Law no.5200 Agricultural Producer Associations law, in 2005, • Has representation in 71 cities, 730 centers, 305 milk producer associations, 450,000 producers (each city has its own Milk Producers Association (Süt Üreticileri Birliği)	• Improve milk quality • Increase marketing efforts • Protect milk producers rights • Prevent informal milk production • Developed National Milk Registry System	• Developed National Milk Registry System, improved record keeping.

Table 6.2. continued.

National	National Milk Board (Ulusal Süt Konseyi)	• Founded on 18.04.2006 with 5488 Agricultural Law as a policy advisor on dairy policy	• Encompass farmer to industry to academia and government officials.	• Set price policy for raw milk purchases • Keep statistical information on milk and feed price ratios.
National with local branches	Turkish Cattle Breeders Union	• Law no 4631 Animal breed development • Form a breeding and information system on animals • Member of National Milk Board	• Keep the statistical record of herd genetic information • Tag the animals • Develop a national bull breeding program • Form countrywide genetics	
National with local branches	HAYKOOP (Turkey Animal Husbandry Cooperatives Central Union)(Türkiye Hayvancılık Kooperatifleri Merkez Birliği)		• Deploy programs to improve all animal production, process and marketing • Increase competitiveness of the industry	• Organize certification courses for National Milk Registry System
National	TUSEDAD (All Milk Meat and Breeders Association)(Tüm Süt Et ve Damızlık Yetiştiricileri Derneği)		• Be the trusted, reliable, relevant and objective information in agricultural and animal sector. • Standardization is a necessity in all aspects of the industry (feedlot, milking facility, genetics	• Works to make it possible(bring the standards up) to export meat and milk products

6.6. Formation of Alternatives

During the study it became evident that it was necessary to categorize area of study both according to farmers and processors. First farmers were divided into three groups based on number of animals on the farm, however as the study progressed and further interviews were conducted, no significant difference was observed when farmers are categorized based on animal numbers. In addition to selling to different entities, a second differentiation point among the farmers was the use of milk storage tank. Some farmers shared a milk tank with other farmers and there was another group of farmers that had their own milk tank. Alternatives needed to be five since there were pronounced differences on farmer practices of shared tank and individual tank.

During the field study it was evident that when it comes to selling milk, unfortunately farmers are not in the driver's seat. However, farmers chosen for this study have different advantages due to the processors they work with. Five types of farmers alternatives have been identified (Table 6.3).

The first two types of farmers sell milk to a coop where coop management works to maximize benefit to the coop member farmer. Milk quality is regularly tested and coop provides feedback on quality of the milk and suggestions for improvement. Farmer purchases fuel from coop's fuel station at a discounted rate. Buys feed for the cows at a discounted rate. Farmer can use short term credit to buy its needs from coop stores. Farmer can also rent equipment from the coop to make silage, to plow agricultural field used for cow feed, buy seeds at a discounted rate. The third and fourth type of farmer represents selling the milk to a privately held industrial processor. Milk quality is regularly tested and the company provides feedback on quality of the milk and gives suggestions. Farmer is treated as a stakeholder; however he is not included in the final decision process, i.e. milk prices. There is no additional support for the farmer other than on time payments per milk sold. Fifth type of farmer sells raw milk directly to consumer. Farmer is in charge of testing, packaging and marketing its own raw milk. It incurs additional cost but also receives a higher price for its milk.

Table 6.3. Farmer alternatives.

Farmer Alternatives	Description (From Farmer's perspective, characterizing the farmer).
Farmers selling milk to Co-op and Member of milk producers co-operative (shared tank)	• Farmers are member/shareholders of the Coop. • Farmer can participate in management of the Co-op. • Number of cows owned is between1 and 24. • Brings milk to collection points • Milk quality Microbial/antibiotic testing on collection point by the coop and further content analysis (Protein, acidity, dry matter, volume, dry matter (no fat) and milk fat (Gazette, 2017) by the Co-op. • Not involved in marketing or direct sales. • Has some negotiation power over selling price of milk. • Farmer owns and manages the dairy cows. • Farmer has to have a contract with the buyer (by law).
Farmers selling milk to Co-op and Member of milk producers co-operative (individual tank owners)	• Farmers are member/shareholders of the Coop. • Farmer can participate in management of the Co-op. • Number of cows is usually higher than 25 • Milk quality microbial/antibiotic testing on the farm collection point by the coop and further content analysis by the Co-op. • Not involved in marketing or direct sales. • Receives a premium for high fat content milk. • Farmer owns and manages the dairy cows. • Farmer has to have a contract with the buyer (by law).

Table 6.3. continued.

Farmers selling milk to corporation (shared tank owners)	• Company is a multinational, farmer has no stake in the company • Number of cows owned varies between 25 and 1000 • Brings milk to collection points OR farmer brings its cows to the milking station (Sütevi) for centralized milking OR has own tank. • Milk quality Microbial/antibiotic testing on collection point by the processor and further content analysis (Protein, acidity, dry matter, volume, dry matter (no fat) and milk fat (Gazette, 2017) by the processor. • Sells milk from prices set by National Milk Board (NMB). • Farmer owns and manages the dairy cows. • Farmer has to have a contract with the buyer (by law).
Farmers selling milk to corporation (individual tank owners)	• Company is a multinational, farmer has no stake in the company • Number of cows owned varies between 1 and 1000 • Farmer has own milk tank. • Milk quality Microbial/antibiotic testing on the farm collection point by the processor and further content analysis (Protein, acidity, dry matter, volume, dry matter (no fat) and milk fat (Gazette, 2017) by the processor. • Sells milk from prices set by National Dairy Council (USK). • Farmer owns and manages the dairy cows. • Farmer has to have a contract with the buyer (by law).
Farmers selling raw milk directly to consumers (individual tank owners)	• Produces and sells raw milk directly. • Farmer population is mixed from owning 10 cows to 1000 cows. • Pasture and/or graze-fed based • Does own(or outsource) microbial/antibiotic testing for somatic cell count and bacterial count (ml/milk) delivers raw milk based on TS1018 and Supplying Raw Milk (Gazette, 2017). • Has own tank. • Sets own price. • Does own bottling and marketing. • Farmer owns and manages the dairy cows. • Does not have a contract with the buyer.

6.7. Evaluation Criteria

According to Munda, evaluation criteria are "…functions that associates each single alternative with a variable indicating its desirability according to expected consequences related to the same objective" (Giuseppe Munda and Nardo, 2003). In addition to Munda's definition and SMCE literature, sustainability assessment literature was reviewed and Guy and Kibert's corresponding questions to identify indicators were utilized (Guy and Kibert, 1998). With three main themes to develop indicators, United Nations Commission on Sustainable Development (UNCSD) 2001 guide for general framework of criteria was used.

Aravossis et. al. uses an evaluation criteria tree to show which criterion belong to which theme for their study on alternative waste disposal methods (Aravossis, et. al. 2001). Based on the

aforementioned study, criteria evaluation tree is developed. This also helps visualize the hierarchical structure of the sustainability criteria.

Table 6.4. Criteria evaluation tree used for this dissertation based on the work of (Aravossis et al., 2001).

1t level of criteria (THEME)	2nd level of criteria (CATEGORY)	2nd level of criteria (SUB-THEME)	3rd level of criteria (CRITERIA)
Evaluation Method	Environmental	Feed and Manure Management	Theme Air Potection (Atmosphere)
			GHG Emissions
			Water Protection (Fresh Water)
			Water Consumption
			Resources Energy Recovery
			Energy Intensity
	Economic	Herd / Farm Management	Income
			Profitability
			Variable Cost
			Financing
			Cash Advance/ Credit
	Social	Social	Employment
			Salaries
			Working Hours
			Health
			Insurance
			Social Acceptance
			Mediation

7. FIELD WORK AND DATA

7.1. General Information

Descriptive statistics based on eighty farms surveyed are presented in this section. Statistical analysis was conducted using SPSS version 10.23. The survey questions covered different segments of farming, namely; demographic data, feed management, milk production, animal health, manure management, salaries, insurance and farm management. List of topics included in the questionnaire is available on Table 6.1. Results of the survey pertaining to sustainability are outlined in Table 7.1. The results of average milk production, land/cow ratio, feeding regime, working family members included in the farming activity, as well as subsidies and willingness to sell the dairy farm are included in Table 7.1.

Table 7.1. Characteristics of the alternatives.

	Unit	**Cooperative Shared Tank (Group 1)**	**Cooperative Ind. Tank (Group 2)**	**Corporation Shared Tank (Group 3)**	**Corporation Ind. Tank (Group 4)**	**Independent Farmer Ind. Tank (Group 5)**
Tank Ownership	Dimless	Shared	Individual	Shared	Individual	Individual
Average Milk Production	L/year	6570	6991	6333	8879	6100
Land /cow ratio	Da/cow	3.17	3.57	4.66	1.6	2.28
Feeding regime	Kg/day	38	35	30	40	33
Working as a family	%	92	71	95	50	50
Receiving Subsidy	%	100	100	84	50	50
Willingness to sell to the dairy farm	%	0	9	25	33	50

Average milk production for all farms is 6974 cow/L/year. Group 4 has the highest milk production with 29.1 L/day per cow. With a 305 day lactation period annual milk production per cow is 8879 L/yr. Compared to the rest of the world, annual milk production is higher than Western

Europe average of 6935L/year and less than 9732 L/year of US average (Wolf, 2017). The lowest production is in Group 5 with 6100 L/year. This is partly due to the breed selection in these farms. Holstein is the most common breed type and is considered most productive breed in dairy industry (Elischer, 2014). Second common in the farms is mixed breed, which means farms have both Holstein and Simmental cows in the herd. Simmental type cows whose milk have higher fat and protein content and breed is less prone to disease are the third choice for dairy farming among the sample (Metaxas et. al. , 2016). Distribution of breed selection among farms is shown in Figure 7.1.

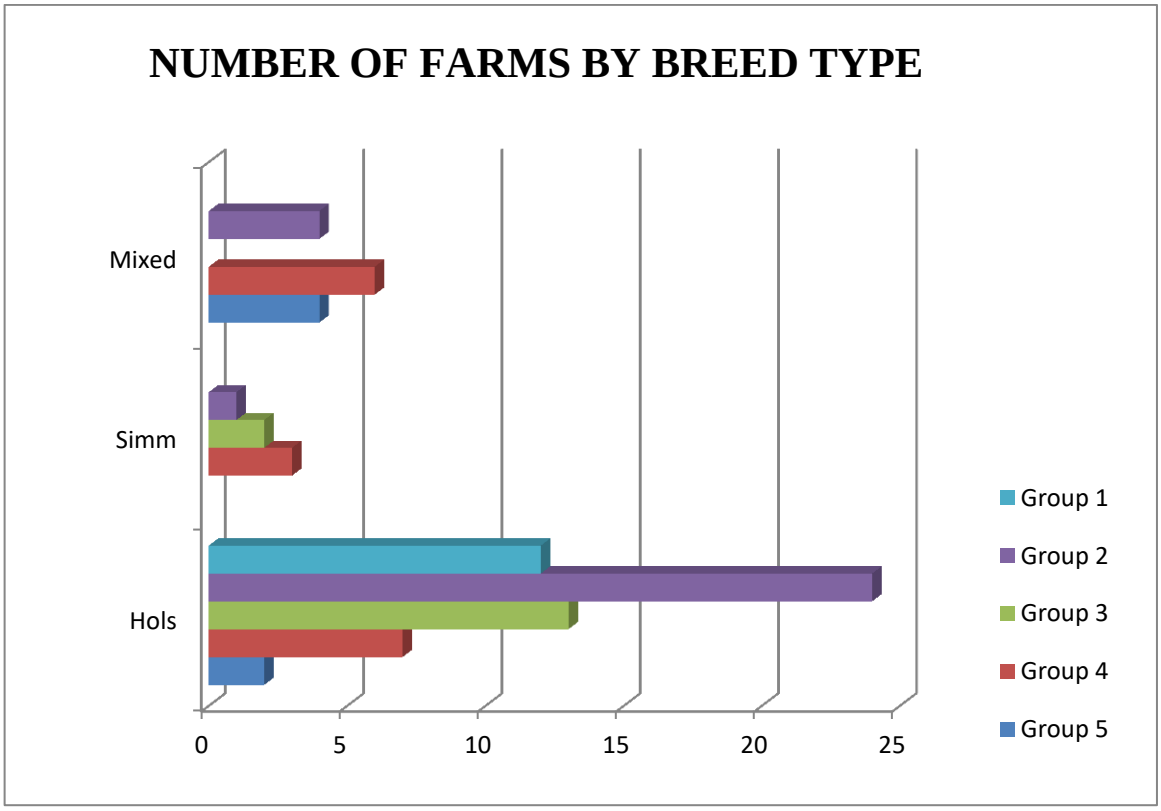


Figure 7.1. Distribution of breed selection-Number of participants: 80.

According to Hayvncılık Genel Müdürlüğü (HAYGEM), a farmer in Turkey needs 5 da of land with no irrigation or 2.5 da of land with irrigation to provide enough feed for each dairy cow (HAYGEM, 2017). Group 3 has the highest land/cow ratio with 4.66 da/cow, where Group 4 has the lowest ratio with 1.6 da/cow.

Feed management is closely related with both average cost and productivity. Average total feed per cow in studied farms is between 33 kg and 40 kg fodder (Figure 7.2). When we look at the distribution of feed, Group 1 and Group 4 both give silage in similar amounts however, they differ in factory feed. While Group 4 provides more factory feed, Group 1 compensates this by giving more dry hay. This may indicate that Group 1 is more cost conscious and/or credit constrained.

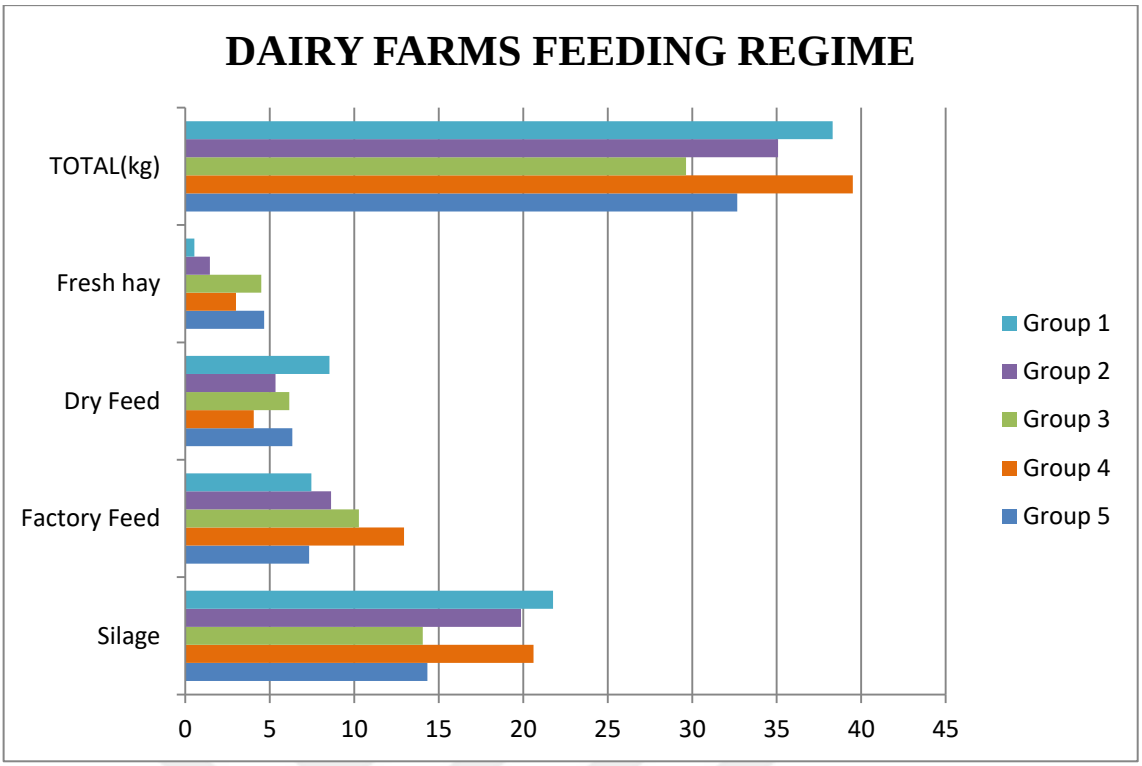


Figure 7.2. Feeding regime in dairy farms -Number of participants: 80.

The farmers were asked their willingness to sell the dairy farm in the study. Group 1 had no desire to sell where only nine percent of participants in Group 2 are willing to sell their business. Both Group 1 and 2 are cooperative members and during the survey, many stated that they see the cooperative as a guarantor of milk sales. Twenty-five percent of Group 3 farmers are willing to sell the dairy farm where in Group 4 this rate is thirty-three percent. Highest rate of willingness to sell is observed in Group 5 with fifty percent. Most of these farmers stated the volatility of cost and sales for this decision. Relatively low rate of willingness to sell the dairy farm among the cooperative farmers concur with the fact that cooperative was selected as a model for UN Rural Development. Lower degree of willingness to sell the farm may also indicate a low desire to migrate to the cities. These results may also be linked to the question of succession of the farm. Farmers were asked if they have a person or a business entity to continue the farm. Figure 7.3 show that over half of all Groups had the idea of continuing the business. Shared tank groups referred to their sons as successor where Groups 2 and 4 had a company structure and are run professionally and that ensured continuity. Group 5 had the highest rate in planning a successor for the farm.

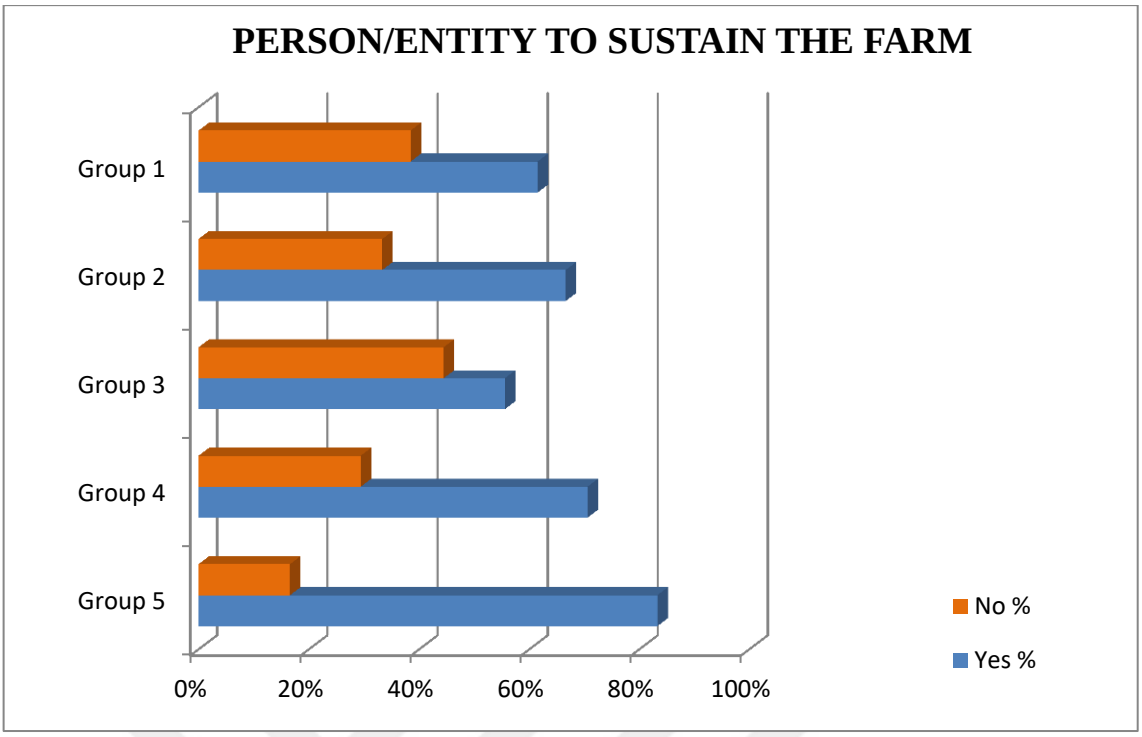


Figure 7.3. Person or entity to continue the farm -Number of participants: 78.

Most of the owner farmers are not paid a salary. While minimum wage is paid to some workers, majority of the workers in all groups except Group 3, workers are paid salaries that are above minimum wage. Distribution of wages in selected dairy farms can be found in Figure 7.4.

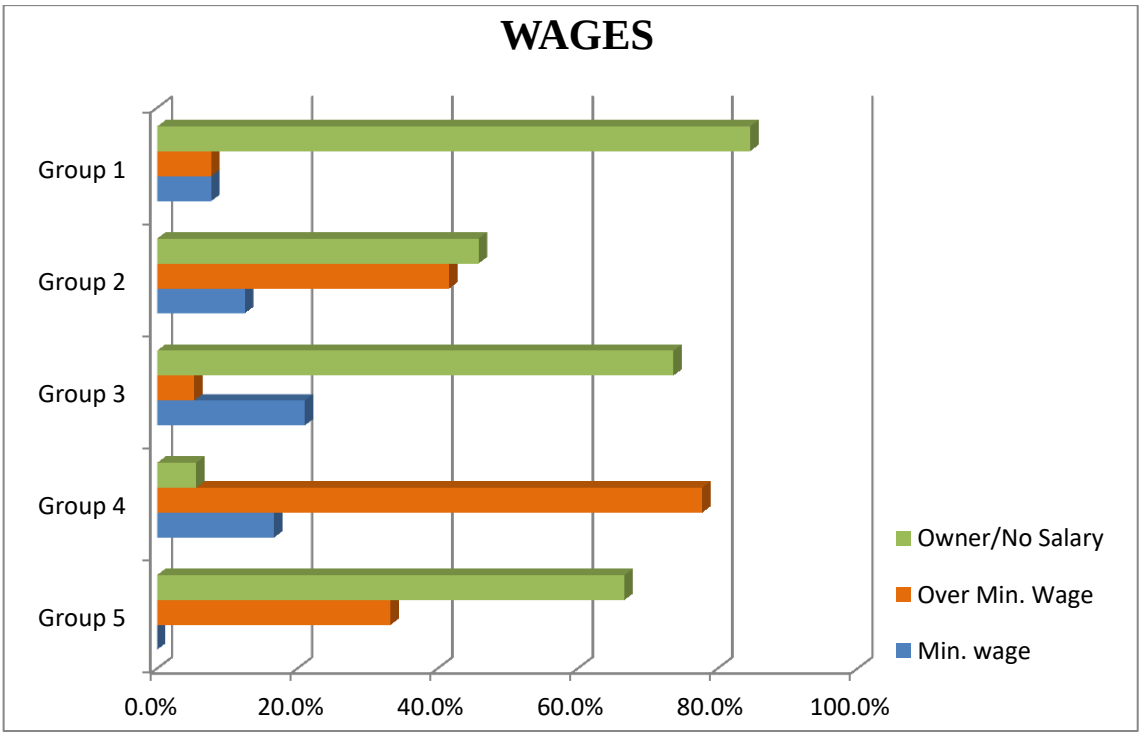


Figure 7.4. Wages in dairy farms -Number of participants: 76.

Subsidies are an important part of Agricultural Policy. Many practices can be shaped with subsidies. As an example, government does not pay heifer subsidy if it was not artificially inseminated. As a result, artificial insemination is the only way farms impregnate the cows. There are seven subsidies farmers can claim.

1- Feed and fodder production subsidy
2- Manure (spread to agricultural lands) subsidy
3- Diesel fuel subsidy (Feed and fodder, manure and diesel fuel are paid together)
4- Heifer subsidy
5- Raw milk subsidy
6- Vaccination subsidy
7- Free of zoonotic disease subsidy

First three subsidies are claimed together so does subsidies 4, 5 and 6. Subsidy seven can be claimed on its own and free of tuberculosis and free of brucellosis are the two certificates required for this subsidy. Table 7.1 shows all farmers in Groups 1 and 2 receive 100% of all subsidies they can legally claim where not all farmers in Group 3, 4 and 5 claim the subsidies. 100% success rate in Groups 1and 2 is due to the fact that cooperative management fills out the paperwork for the farmers ensuring they receive maximum subsidy payment. Types of subsidies claimed per farmer category is shared on Figure 7.5.

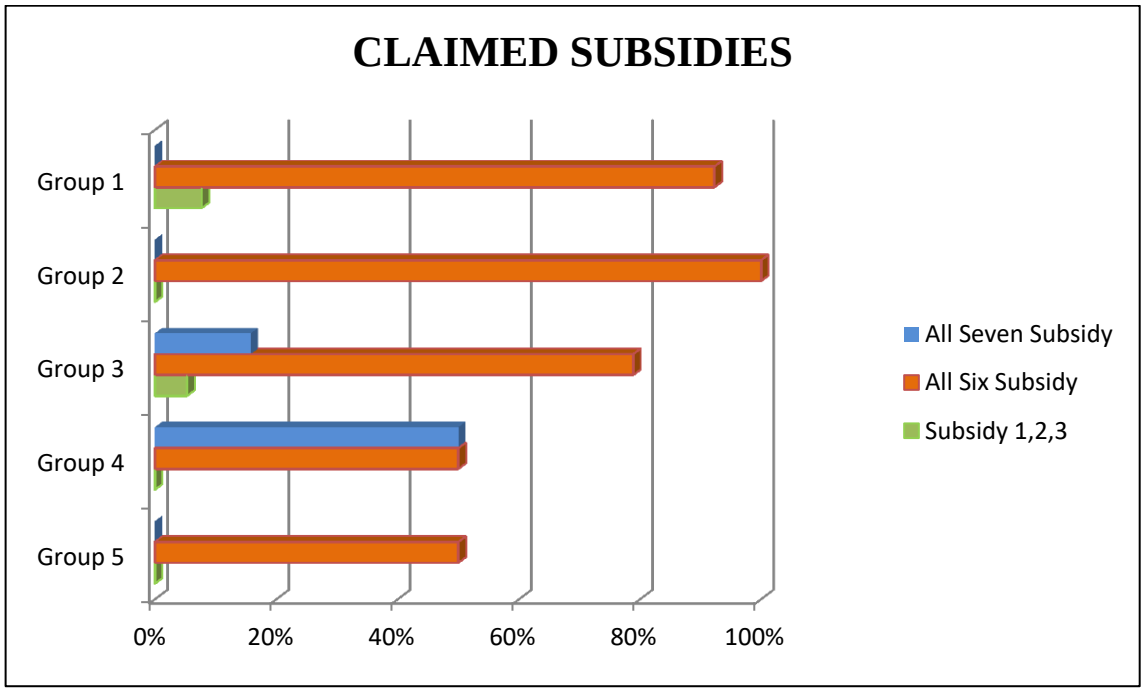


Figure 7.5. Subsidies claimed by farmers -Number of participants: 80.

Part of this study focused on farmer processor relationship. Farmers were asked their reason to work with the particular processor. Their answers were grouped under five categories; Regular payments, Price per L., Quality Product, Familiarity and Brand value. While regular payments were the most popular reason to work with the specific processor, price paid per L is the second most important factor for Group 1. The least flexible is Group 5, independent farmer. The main reason Group 5 sells directly to consumers is regular payments. For Groups 1 and 2, price per L and knowing that the processor will turn their milk into a quality product is also important. Group 4 seeks to be familiar with the processor, in other words prefers to sell to a familiar face. For all farms except Group 5, brand value does have a small impact in their reasoning to choose processor. Figure 7.6 shows farmer's criteria while deciding on a processor.

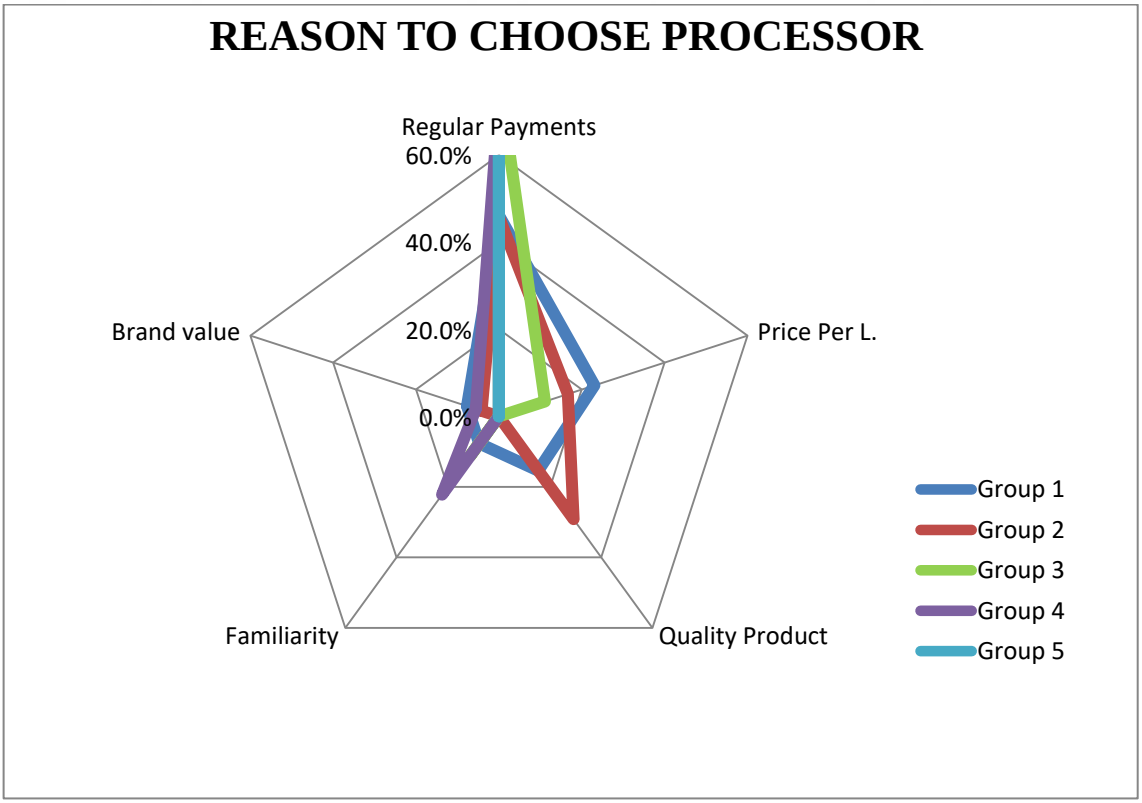


Figure 7.6. Reason to choose processor -Number of participants: 80.

Farmers were also asked about their knowledge in GHG. Most of the farmers did not know about the emissions emitted by dairy cows. Group 3 and Group 4 had the highest knowledge since there are two biogas power plants in the vicinity of the farms and some farms interviewed already sell their manure to these biogas plants. Figure 7.7 shows farmers knowledge on GHG emissions.

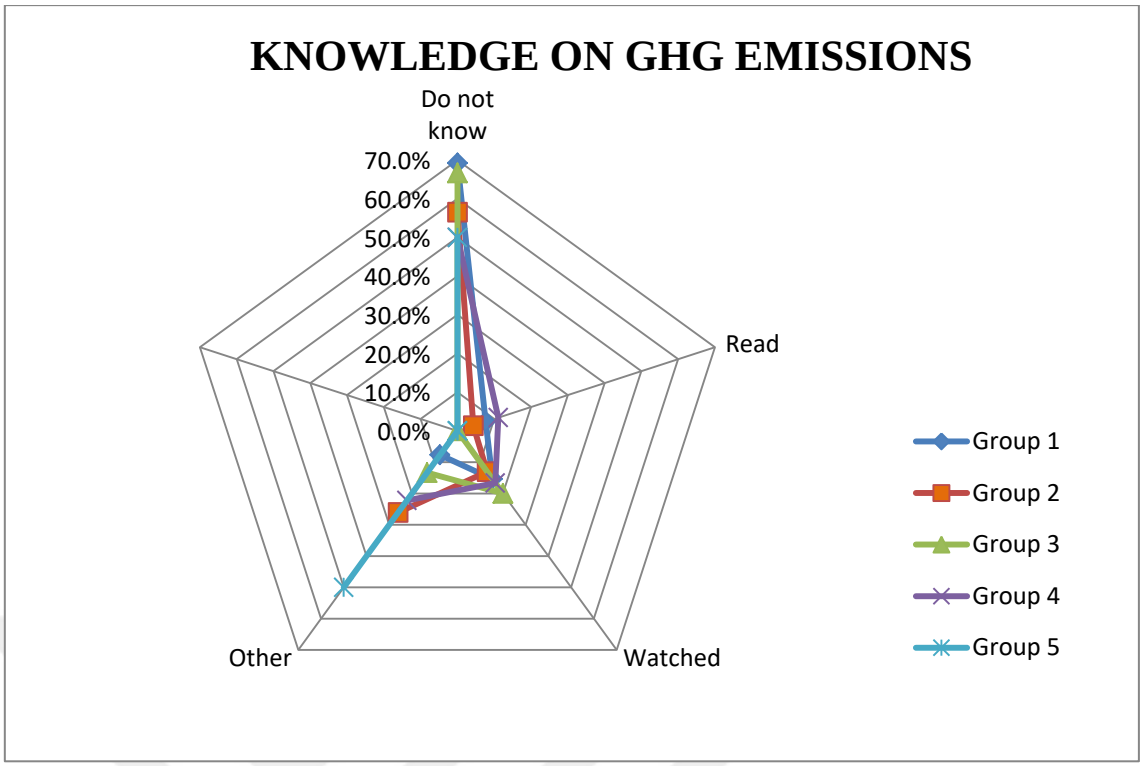


Figure 7.7. Knowledge on GHG emissions -Number of participants: 71.

Farmers change processors from time to time. Researcher wanted to look at the loyalty of farmers towards the processor. Figure 7.8 shows the past behavior of farmers, whether they sold to other entities in the past. Majority of farmers in all groups sold to other entities in the past.

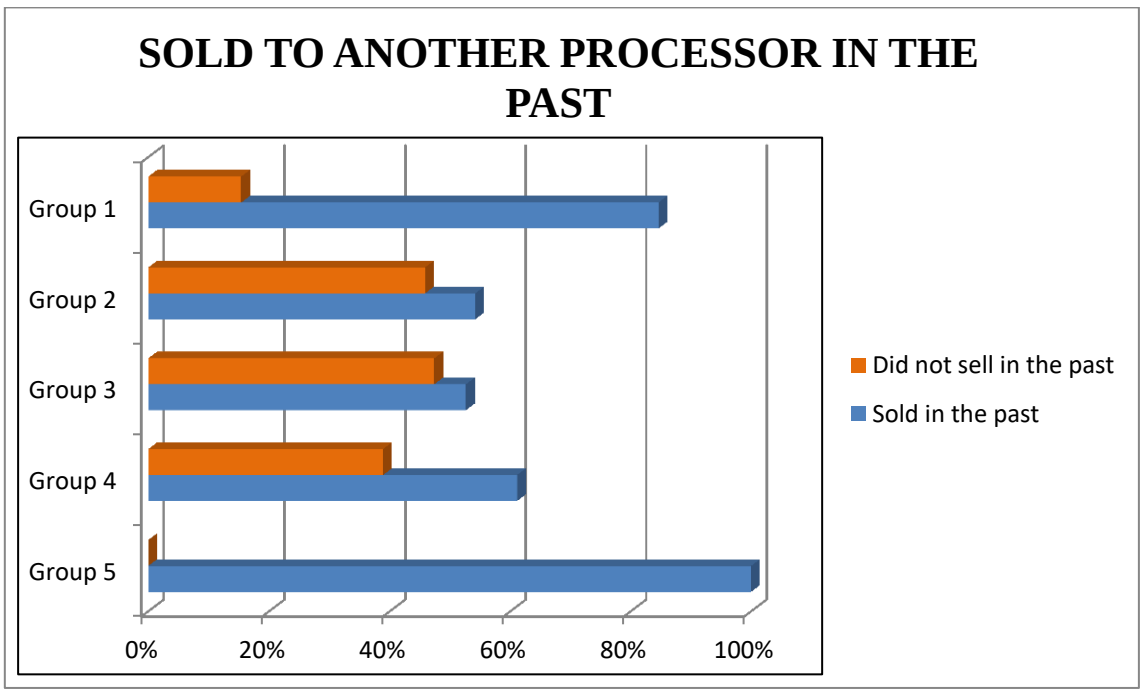


Figure 7.8. Sold to other entities in the past -Number of participants: 76.

It was also asked if the farmers are planning to change processor in the near future. This question corresponds to willingness to sell the dairy farm row in Table 7.1. Figure 7.9 provides a detailed analysis and shows that members of both Groups 1and 2 are satisfied with the cooperative where Group 5 is willing to change processors if a better option is presented.

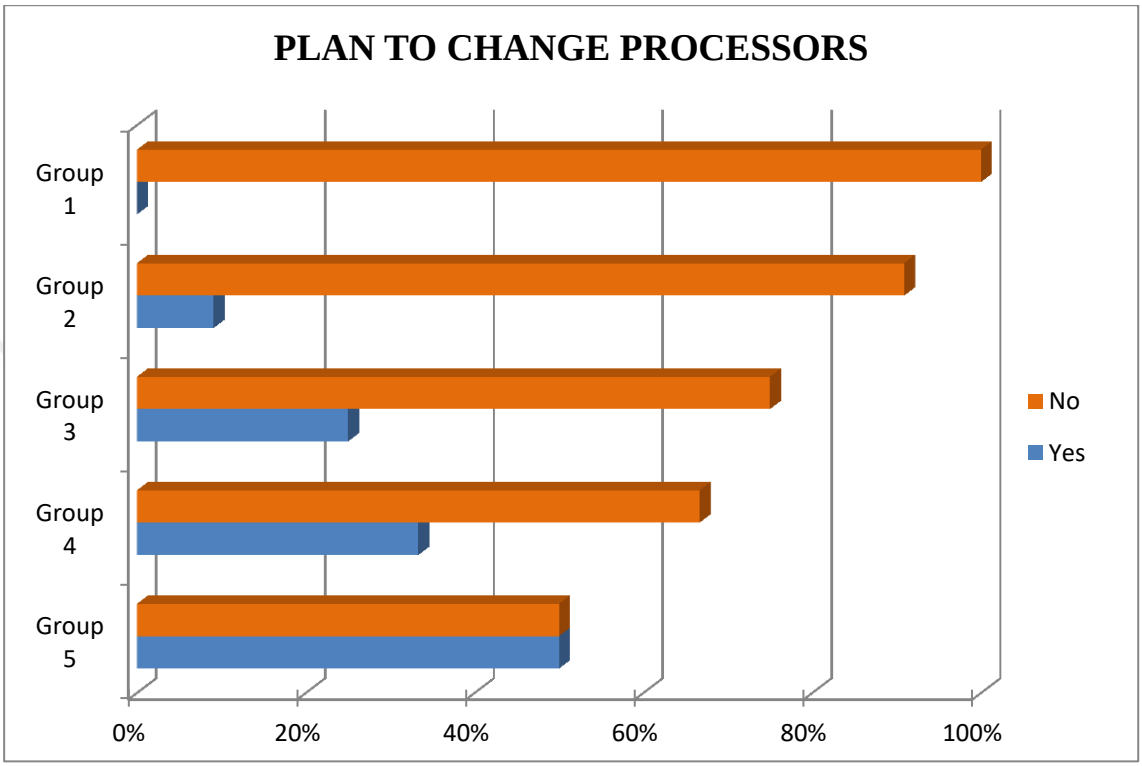


Figure 7.9. Plan to change processors-Number of participants: 71.

Male heifer sales are an important indicator on how farmers view their business. Keeping the male heifer in the herd is seen as an investment for small farmers (shared tank), where industrial farms (individual tank) sell male heifer as soon as possible due to space issues as well as not to lose their focus on dairy animals. Farmers in Group 4 fit this description since majority sells male heifer within ten days. Group 5 also prefers to focus on dairy production rather than spending resources on the heifer and is sold either within ten days or after six months. Group 2, individual tank farmers seem to be exception since majority of the farmers in Group 2 keep the male heifer until maturity. Graph 7.10 shows the distribution of male heifer sales among farms.

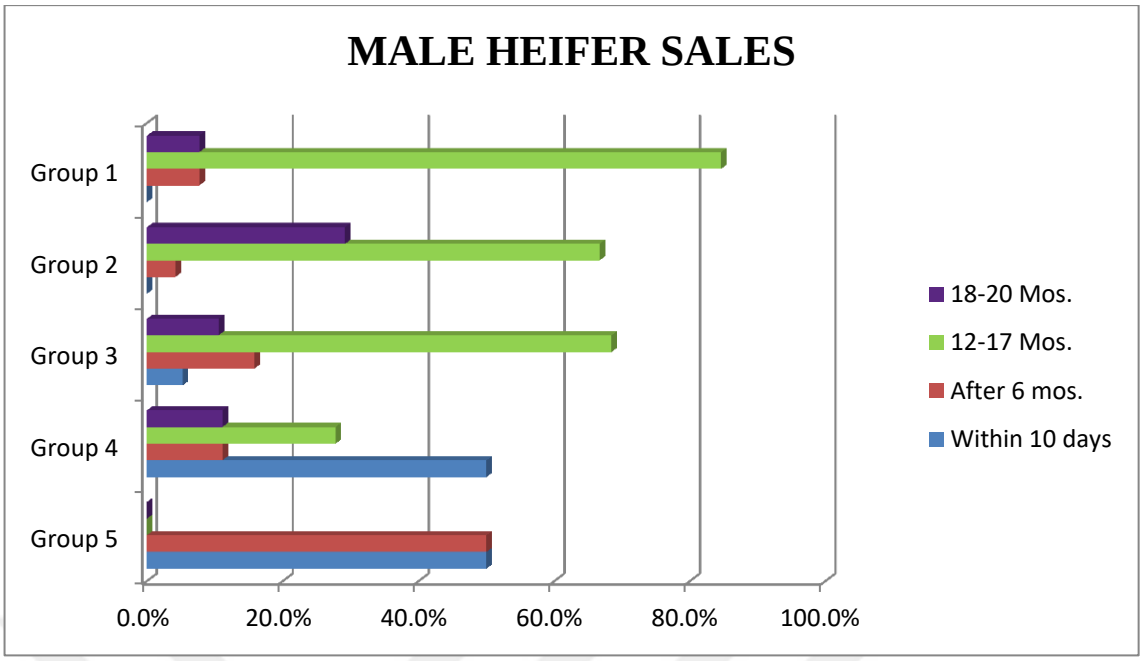


Figure 7.10. Male Heifer sales -Number of participants: 76.

As part of animal health, most common diseases were asked to farmers. Mastitis was a common problem for all farmer groups where nail disease was the second most common. Unsuccessful insemination was the third common problem among farmers. Both Groups 1and2 had cases of tuberculosis. Where cooperative is not responsible from the health of the animals, with both group of farmers belonging to the cooperative, could indicate the need for increased screening for tuberculosis among the cooperative members. Figure 7.11 shows the most frequent diseases in the farms.

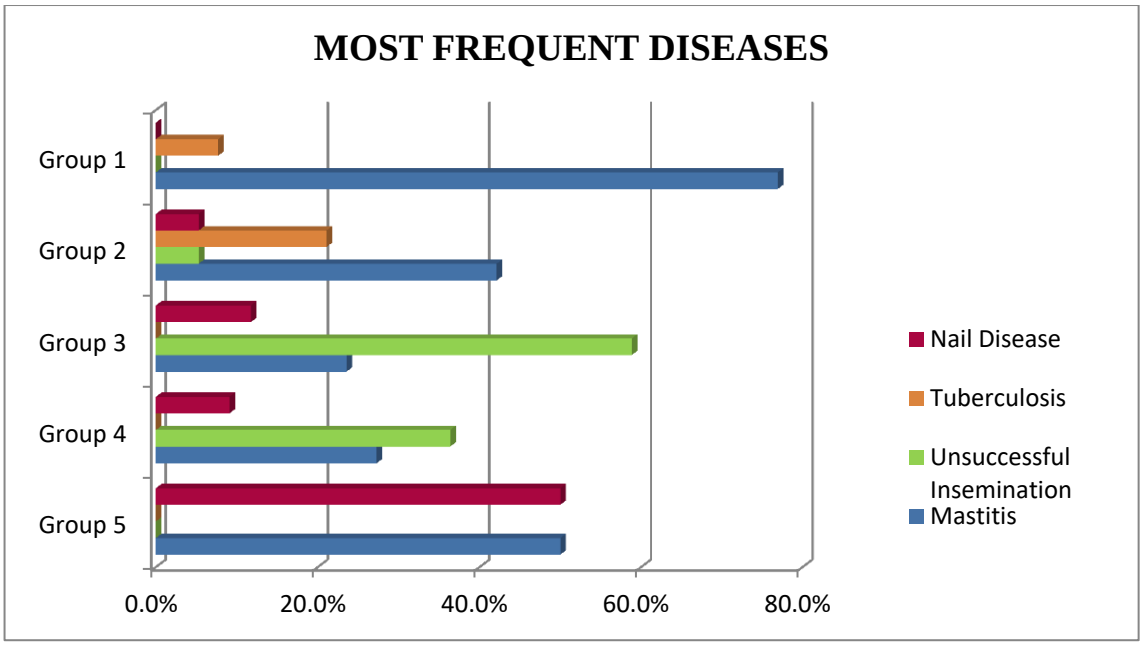


Figure 7.11. Most frequent diseases -Number of participants: 70.

8. SMCE MATRIX AND ANALYSIS OF FARMS

8.1. General Information

Formation of the evaluation criteria and evaluation tree was presented in Chapter 6, Table 6.4. In this chapter, SMCE criteria scores and SMCE impact matrix are formed. SMCE impact matrix analysis and sensitivity analysis are performed. NAIADE results are summarized and preliminary analyses, as well as general farm characteristics are presented.

8.2. Identification of the Evaluation Criteria and Criterion Scores

De Montis et. al. states that criteria is one of the most important elements and instruments for the decision making process in multi-criteria methodologies (2000). In Table 6.4 Evaluation Tree is presented. Criteria satisfied at least one or more of the MCE reasoning, including social actors, institutional actors, main aim of the research or it was based on the observations during in-depth interviews. Criteria selection is cross checked to ensure the suitability to be used for selective dairy farms. Table 8.1 provides a detailed explanation on the identification of the evaluation criteria. The columns show the components that contribute to the criteria decision. The check mark indicates that the evaluation criterion corresponds to a finding/identification in that particular component (e.g. Social actors, Institutional actors…). The criteria are drawn in part during in-depth study of the area from social and institutional actors (dairy farmers, dairy associations and administrators) and in part from the main aim of the research. Criteria developed in this study are meant to be understood by farmers however some calculations require extensive literature review and expert knowledge.

8.3. Definition of Criteria

8.3.1. Feed Management

Feed management is one of the four main characteristics introduced as part of the assessment in this study. Farms included in the study had mixed type of feeding regimes. Feeding regimes of dairy animals affect everything from GHG Emissions in an environmental context to additional costs in economic context. It also has a human health aspect since feeding cows a diet with more pasture based feed is associated with increased unsaturated fatty acid concentration in milk, which is considered beneficial for human health (Benbrook et al., 2018; Elgersma, 2015). For the criteria,

feed management is interpreted as percent of pasture and fresh grass included in dairy cow's diet. Criterion information is based on the survey. The number of months animals are grazed on pasture and the amount of grass provided for animal feeding determines the percentage of grass fed to animals.

Table 8.1. Identification of the evaluation criteria.

Theme (Dimensions)	Criteria	Social actors (local people, farmers)	Institutional actors (administration, agricultural and environmental associations)	Main aim of the research (farmer choosing the most sustainable option to sell it's milk)	Observations of researcher during in-depth study
Environmental	Feed Management		√	√	√
	Water consumption	√		√	√
	Energy intensity	√		√	
	GHG Emissions	√	√	√	√
Social	Working hours	√			
	Mediation				√
	Insurance	√	√		√
Economic	Salaries	√	√		
	Profitability			√	
	Cash advance/short term credit				√

8.3.2. Water Consumption

Fresh drinking water is a scarce resource and expected to become scarcer with climate change for Turkey (Sowers et. al., 2011). Water is used for irrigation of crops during summer months, for cows' to drink and for cleaning purposes after milking. While an estimated L/day/cow is available in the literature, no prior studies reported on actual water consumption in the farms. Given that 85% of milk is water, consumption rate is an important criterion for the sustainability of the industry. On the other hand, per capita available water in Turkey is 1500m^3 and this is expected to decrease to 1000m^3 in the next 30 years which is the threshold showing water stress in a country (Mengü et. al, 2008). This could affect agricultural systems. Water consumption data on farms is based on farmer responses and are meant to be estimates of water consumption on dairy farms.

Average rain in Marmara and Aegean region are 662.3 mm/year and 592.2 mm/year respectively. Turkey has twenty-five water basins. Lüleburgaz is in Meriç-Ergene water basin and Tire is in Küçük Menderes water basin. Based on Integrated Water Resource Management paradigm, River Basin Management Planning is recognized as an effective tool in sustainable water resource use (Özonat, 2013). This information is taken into account in suggestions regarding water management.

8.3.3. Energy Intensity

Energy intensity is calculated by the energy required for the cultivation of barley and corn. The criterion produces a measure of energy intensity for farming practices (Siciliano, 2009). Criterion score was calculated using the information based on literature and from farmer responses to the survey. Primary energy contents of inputs is available on Appendix B. Seed, fertilizer, herbicide, and fuel usage data was used to calculate energy intensity for feed production of barley and corn representing a yearly rotated crop production for dairy farmers.

8.3.4. Greenhouse Gas (GHG) Emissions

Agricultural sector emissions make up 12-14% of Total GHG Emissions (Global warming potential over 100 years: GWP100) (Pachauri et al., 2014; Del Prado, 2018). More than 5% of World's total emissions are caused by livestock and manure activity alone. Dairy cows emit high volumes of CO_2, CH_4 and N_2O. CO_2 Emission criterion figures are calculated by using IPCC 2006 formulations (Tier 1and2) in agriculture and livestock and data for calculation was collected from farms in the study (Eggleston et al., 2006). CO_2 emissions per dairy cow is calculated. IPCC formulas are available in Appendix C and calculations are available in Excel worksheet.

Aegean and Thrace differ in climate. According to Köppen-Trewartha Climate Classification, Kırklareli-Lüleburgaz is Type D and subtype Do, meaning Maritime Temperate Climate where İzmir, Tire is Type C and subtype Cs, meaning Subtropical dry summer and Mediterranean Climate regions (MGM,2018).

Average temperature by month and yearly average temperature in both regions are available in Table 8.2. According to IPCC 2006 guidelines, average temperature of the regions is used to apply different coefficients in IPCC formulations for accurate calculation of GHG (Eggleston et al., 2006, p. 10.77). IPCC guidelines categorize annual average temperature as cool, temperate and warm.

Lüleburgaz, where corporation and independent farms are located, has an annual average of 13.1 ^{0}C and cool climate coefficients apply. Tire, where Cooperative farms are located has an annual average temperature of 16.6 ^{0}C where temperate climate coefficients apply.

Table 8.2. Average temperature data of Lüleburgaz and Tire regions[5].

Lülerbugaz Average Temperature													
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**	**Year Av.**
Av. Temp. (°C)	**3.4**	**4.7**	**7.2**	**11.9**	**16.6**	**20.5**	**22.4**	**22.1**	**18.9**	**14.1**	**9.8**	**5.6**	**13.1**
Tire Average Temperature													
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**	
Av. Temp. (°C)	**7.6**	**8.5**	**10.9**	**15**	**19.6**	**23.8**	**26.3**	**25.8**	**22.6**	**17.6**	**12.6**	**8.9**	**16.6**

8.3.5. Working Hours

Farmers work between 6 to 12 hours a day depending on the season and size of the farm. Criterion data are collected during the survey. Criterion aimed to measure the difference between farms in terms of working hours.

8.3.6. Mediation

Farmers interact with many of their peers and other social actors every day, conflicts and disagreements do occur. This criterion was a result of observation in the field. It is important to have someone all parties involved in conflict can trust to act as a mediator to resolve the situation.

Mediation is an option (but not always totally voluntary). Mediation in this context is not always confidential. Although in literature, it is stated that mediation involves a neutral third party, in this case, mediator is not an outside person, rather it is from the cooperative and acts as a facilitator to settle a dispute. The mediator simply encourages the parties to reach agreement

[5] Official climate data did not include town specific data therefore an alternative website was used to be more accurate in GHG calculations. Temperature data found is in line with the average temperature information of the provinces of Kırklareli and Izmir. Data Source: https://tr.climate-data.org/location/7424/ and https://tr.climate-data.org/location/21643/

(Trenczek et. al., 2016).Cooperative managers act as a mediator to settle a dispute. Corporation does not get involved in dispute resolution. If there is a dispute, they acknowledge it, however they do not act as a mediator to settle any dispute among farmers. Independent farmer is a little more inclined towards mediation since they view other farmers as neighbors and are inclined to be more involved in community relations.

8.3.7. Insurance

Worker insurance in agricultural sector has always been challenging to quantify. Data was collected during the survey. It is a legal requirement to ensure basic healthcare for the workers. Criterion aimed to identify how much of the working population on the farm was insured. When all male workers on the farm were insured the score was Moderate. When all male and female workers on the farm were insured score was More or Less Good. Seasonal workers are excluded in this criterion.

8.3.8. Salaries

Working wage on farms determines living standards. Data was collected during the survey. The actual pay was not asked, rather the salaries were categorized based on Minimum Wage or above.

8.3.9. Cash Advance/Credit

Farmer needs additional financial resources or credit from time to time to buy supplies for the farm, to buy feed for the animals and other needs. System in Turkey and most of the world is to use a financial institution such as a bank to get credit to increase cash flow. In order to secure a loan from the bank, a deed to a property is needed and this is very difficult for small farmers that have small land or no land. Cooperative provides certain services such as seed for planting, fertilizer for the fields, feed for animals and equipment rental without requiring cash up front. Corporation does not provide this service. Farmer selling to corporation and Independent farmer (Group 3, 4and 5) has access to this type of resource only via bank loan. Criterion data was gathered during the survey. Criterion aims to view the kind of financial tools farmers can utilize.

8.3.10. Farmer Profitability

Farmers were asked the cost of 1L. of raw milk. Their selling price was also determined. While this is not a complete accounting of the farm profit or loss, it is based on variable cost calculations of the farmer. Information is obtained from farmers. Calculation is available in Excel worksheet.

Profitability Formula = ((Revenue - Cost of Goods Sold) ÷ Revenue) x 100
Farm Profitability = ((Farmgate sales price of 1L Raw Milk - Cost of 1L Milk) ÷ Farmgate sales price of 1L Raw Milk) x 100

8.4. Criterion Scores

On the basis of participatory process and taking into dairy industry dynamics, evaluation criteria is listed based on three themes, environmental, social and economic. Table 8.3 provides an overview of sustainability evaluation criteria, their short definition and criterion scores.

Table 8.3. Sustainability evaluation criteria and criteria scores.

	Criteria	**Definition and Importance**	**Criterion Scores**
ENVIRONMENTAL	Feed Management: Grazed	Percentage of grazing in the animal diet. Intensive feeding uses a lot of resources. Grazing is preferred, should be maximized.	Direction: Maximize (grass) Unit: % mass
	Water Consumption	Total water consumed by a cow per day	Direction: Minimize Unit: Cow/L/Day
	Energy intensity	Energy required for the cultivation of animal feed considering direct and indirect inputs. Direct inputs include: Fuel and lubricant consumption. Indirect inputs include: The amount of fertilizers used and the amount of seeds used for production of animal feed. Energy intensity: First crop energy intensity + second crop energy intensity	Direction: Minimize Unit: MJ/da
	GHG Emissions	Dairy cow digestion and manure are both sources of CO_2, CH_4 and N_2O emissions. GHG is calculated by using IPCC 2006 methodology (Eggleston et al., 2006).	Direction: Minimize Unit: kg. CO_2 Equiv./L of milk

Table 8.3. continued.

SOCIAL	Working Hours	Working hours are a major proxy of proper working conditions. Even if agricultural production is characterized by long work days and that most farm workers are not covered by labor standards, too many working hours per week can affect workers' welfare.	Direction: Minimize working hour/day: hours
	Insurance	Family is insured however no. of insured family members is low	Qualitative Direction: Maximize
	Mediation	Ability to resolve conflict (Qualitative)	Qualitative Direction: Maximize
ECONOMIC	Salaries	Self, min.wage, above min. wage	Qualitative Direction: Maximize
	Ease of cash advance/short term credit(in-house advantages)	Farmer's access to cash or resources needed to run the farm	Qualitative Direction: Maximize
	Farmer Profitability	(Raw milk production cost - farm gate price)ac	Direction: Maximize Unit: TL/L milk

8.5. Criteria Aggregation

Multi-criteria analysis is performed on the impact matrix. Discrete multi-criteria model NAIADE (Novel Approach to Imprecise Assessment and Decision Environments) (JRC, 1996; Munda, 1995) is used due its capability to handle qualitative and quantitative data. Model enables use of crisp and fuzzy numbers in addition to stochastic uncertainty. Qualitative data is treated as fuzzy numbers. According to Munda, the comparison of the alternatives is made up of four steps.

1) Construction of the impact matrix
2) Pairwise comparison of alternatives by preference relations
3) Criteria aggregation procedure
4) Ranking of alternatives

After the construction of the impact matrix, Preference relations are defined. Criteria scores are compared in each pair of alternatives by means of semantic distance. User expresses preference relations which can be between 0 and 1(credibility index) with incremental increases defined by six functions (much better, better, approximately equal, equal, worse and much worse). For sustainability studies using benchmarking approach such as this one, Munda suggests setting the credibility index at 0.5 (α=0.5) (Munda, 2006). In case of benchmark values, lowest or highest (depending on the direction the criterion) scores make up the benchmark values. Compensation degree among criteria is set by τ. Compensation refers to the relation among criterion. Higher

compensation means a bad performance in a criterion is compensated by a good performance in another criterion. Compensation degree can be set between 0 (minimum compensation) and 1 (maximum compensation). NAIADE does not assign weights to the criteria, themes are considered to have equal weights. A total of ten criteria are presented in this study, four criteria makes up environmental theme, three criteria make up social theme and three make up economic theme which basically distributes the weights almost equally indicating all criteria have equal importance and a low compensability degree is used.

8.5.1. Impact Matrix and the Benchmark of Analysis

The impact matrix in Table 8.4 shows the impact of each alternative based on three themes. First column shows the Assessment Criteria that has been selected as part of the impact matrix. The second column shows the unit of measurement of the evaluation criteria. Third column shows the ideal direction we want each criterion to go. Fourth column shows the benchmark values that should be targeted to achieve sustainability of respective criterion. Remaining five columns show qualitative and quantitative values of each evaluation criteria based on the dairy group.

Table 8.4. Criteria impact matrix.

Assessment Criteria	Measurement Unit	Direction	Benchmark	Group 1	Group 2	Group 3	Group 4	Group 5
Feed Management	% Mass Graze	Max.	65	42%	35%	11%	6%	65%
Water consumption	L/cow/day	Min.	73	75	73	80	76	75
Energy Intensity	Mj/da	Min.	4678	4678	5431	9043	10518	7597
GHG Emissions	CO_2 Equiv./L milk	Min.	0,53	0,71	1,86	1,72	1,13	0,53
Working hours	Hr/day	Min.	6	6	7	8	12	12
Mediation	Dimensionless	Max.	Very Good	Very Good	Very Good	Moderate	Moderate	More or Less Good
Insurance	Dimensionless	Max.	More or Less Good	Moderate	More or Less Good	Moderate	More or Less Good	More or Less Good
Salaries	Dimensionless	Max.	Good	More or Less Good	Good	More or Less Good	Good	Very Good
Cash advance/Credit	Dimensionless	Max.	Very Good	Very Good	Very Good	Bad	Moderate	More or Less Good
Farmer Profitability	%	Max.	47%	18%	7%	22%	12%	47%

8.5.2. Pairwise Comparison Analysis with Benchmark

Since this assessment is conducted with a benchmark, pairwise comparison analysis is done against the benchmark, aka, ideal farm. Degree of truth is for which an alternative is better, indifferent or worse compared to one another. Benchmark is α: 0.50 and compensation degree is set at ϒ: 0.20. Pairwise comparison analysis is done by interpreting the criteria analysis on the indifferent and worse portions (middle and lowest part) of the results. All five groups of farms are compared to the ideal farm.

Results of Group 1 compared to Benchmark Farm is doing perfectly well on C3 and C5, more or less well in C4, C8 and C9 and could be improved. Group 1 needs to give priority to C1, C2, C6, C7 and C10.

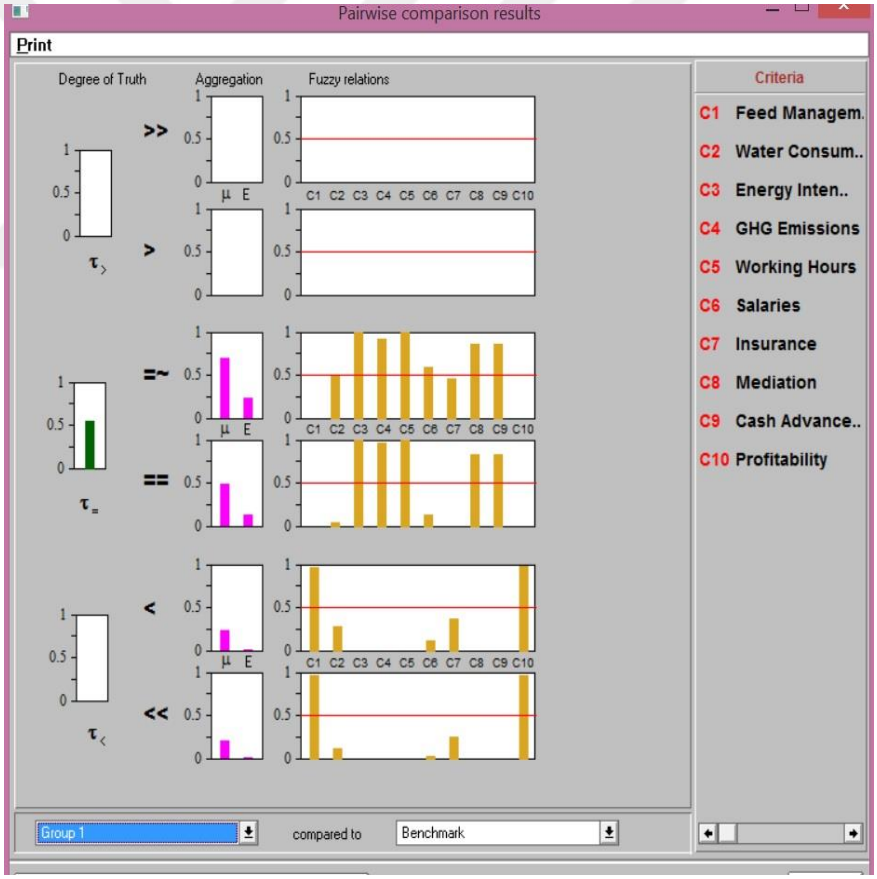


Figure 8.1. Results of the pairwise comparison between Group 1 and ideal farm.

Results of Group 2 compared to Benchmark Farm shows that Group 2 is doing perfectly well on C2 and very well on C8 and C9. Group 2 need to give priority to C1, C3 and C10.

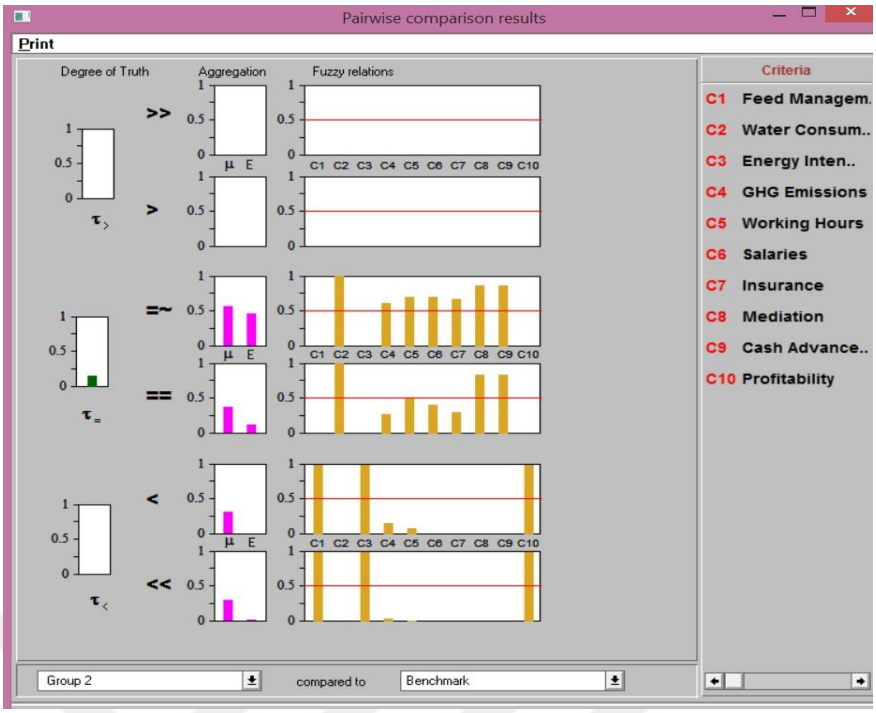


Figure 8.2. Results of pairwise comparison between Group 2 and ideal farm.

Results of Group 3 compared to Benchmark Farm shows that while Group 3 is doing more or less well in C4, C5 and C6, analysis suggests areas of improvement in C2, C7, C8 and C9. Priority should be given to C1, C3 and C10 with less emphasis on C2, C8 and C9.

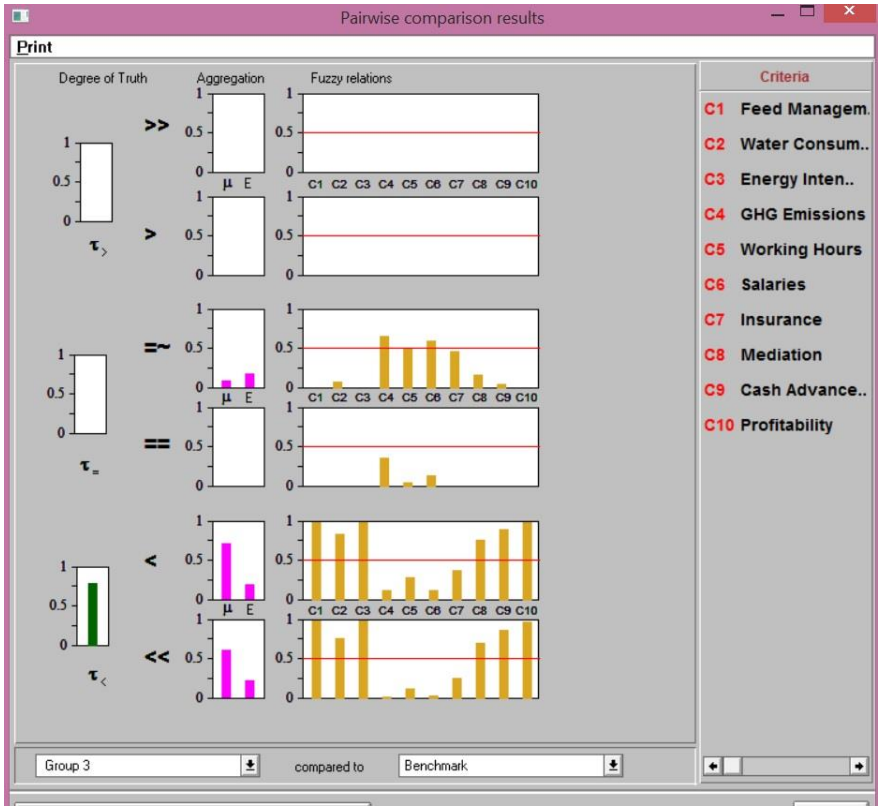


Figure 8.3. Results of pairwise comparison between Group 3 and ideal farm.

Results of Group 4 compared to Benchmark Farm shows that Group 4 is doing well on C4 and more or less well in C6 and C7. Group 4 could improve in C2, C5, C8 and C9. Priority should be given to C1, C3, C10.

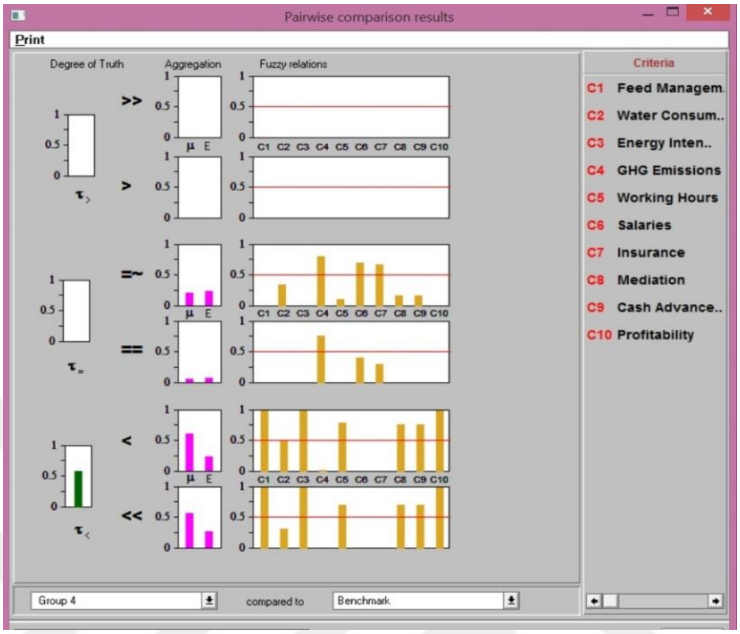


Figure 8.4. Results of pairwise comparison between Group 4 and ideal farm.

Results of Group 5 compared to Benchmark Farm shows that Group 5 does perfectly well on C1, C4 and C10 and more or less well in C6 and C7. Areas of improvement are suggested in C2, C5, C8 and C9. Priority should be given to C3, C5 and C8.

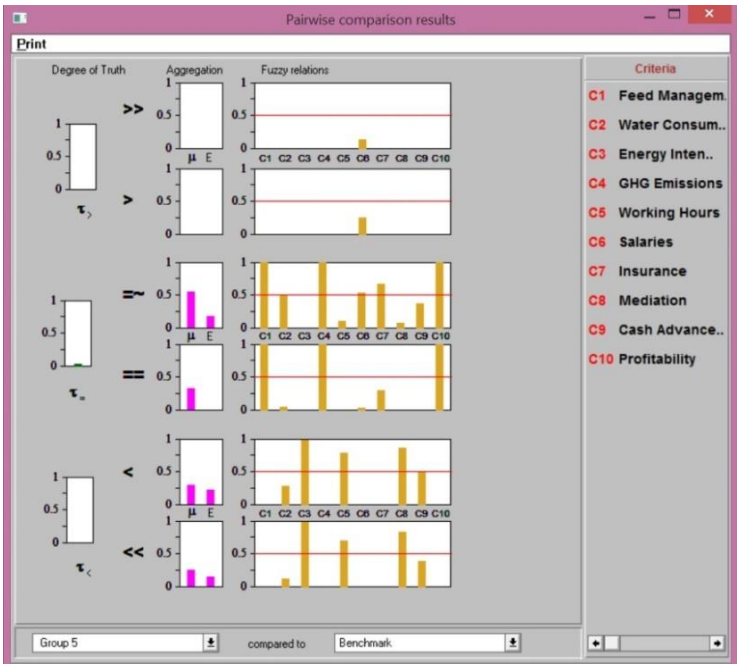


Figure 8.5. Results of pairwise comparison between Group 5 and ideal farm.

8.5.3. Criteria Aggregation with Benchmark Farm

For a comprehensive sustainability assessment, establishing a form of threshold values are common in literature (Sala et. al., 2015). Munda suggests setting goals and reference points for sustainability policies (Munda, 2006). This is achieved in NAIADE by setting a benchmark farm where an "ideal farm" is defined by choosing the best values reached in any single indicator and setting preference level α: 0.50. Criteria Impact Matrix with Benchmark farm is available in Figure 8.6.

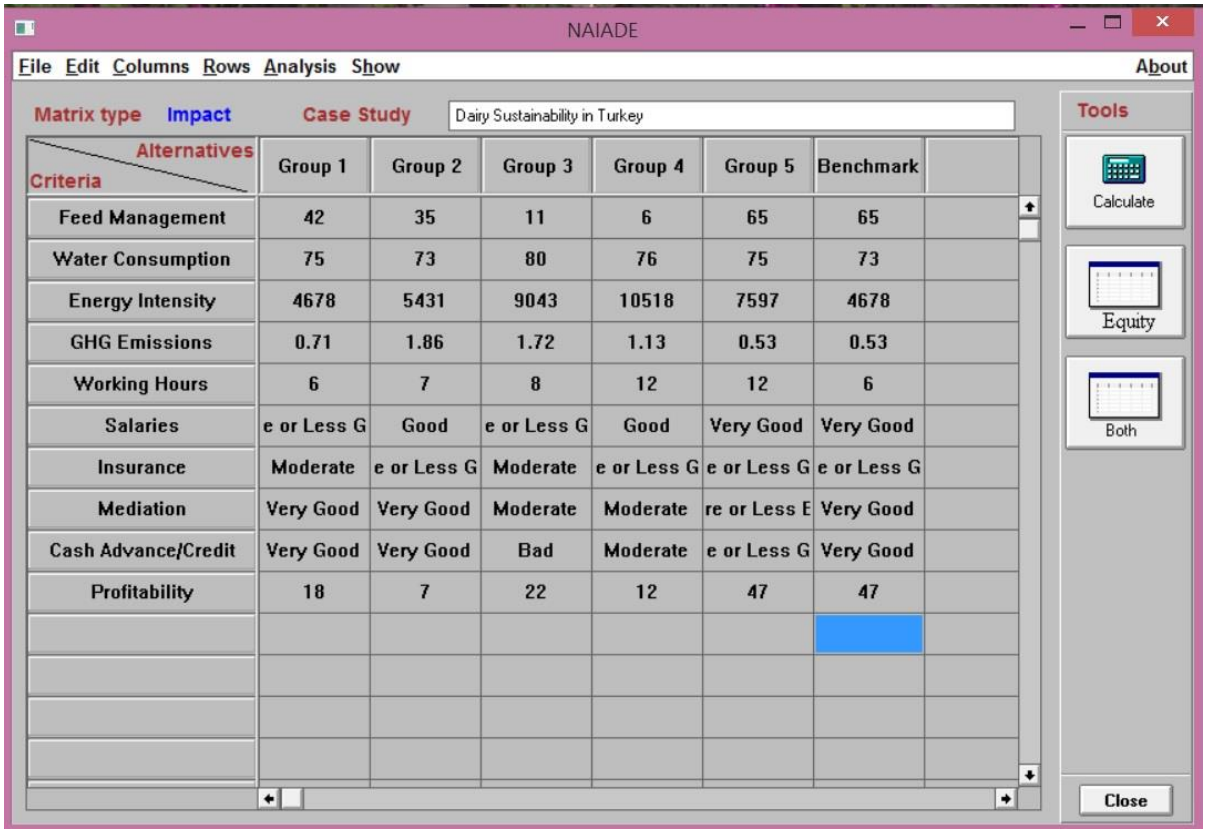


Figure 8.6. NAIADE impact matrix with benchmark farm.

8.5.4. Ranking of Alternatives

The parameters for sustainability threshold are set at α: 0.50 and compensation degree is set at ϒ: 0.20. Criteria aggregation is carried out by an aggregation algorithm by determining the degree of truth where an alternative is better, indifferent or worse with respect to another. NAIADE lists the final ranking of the alternatives. Group A is seen as the most sustainable option followed by Group E. Output of software is shown on Figure 8.7. Output of software with Benchmark farm is shown on Figure 8.8.

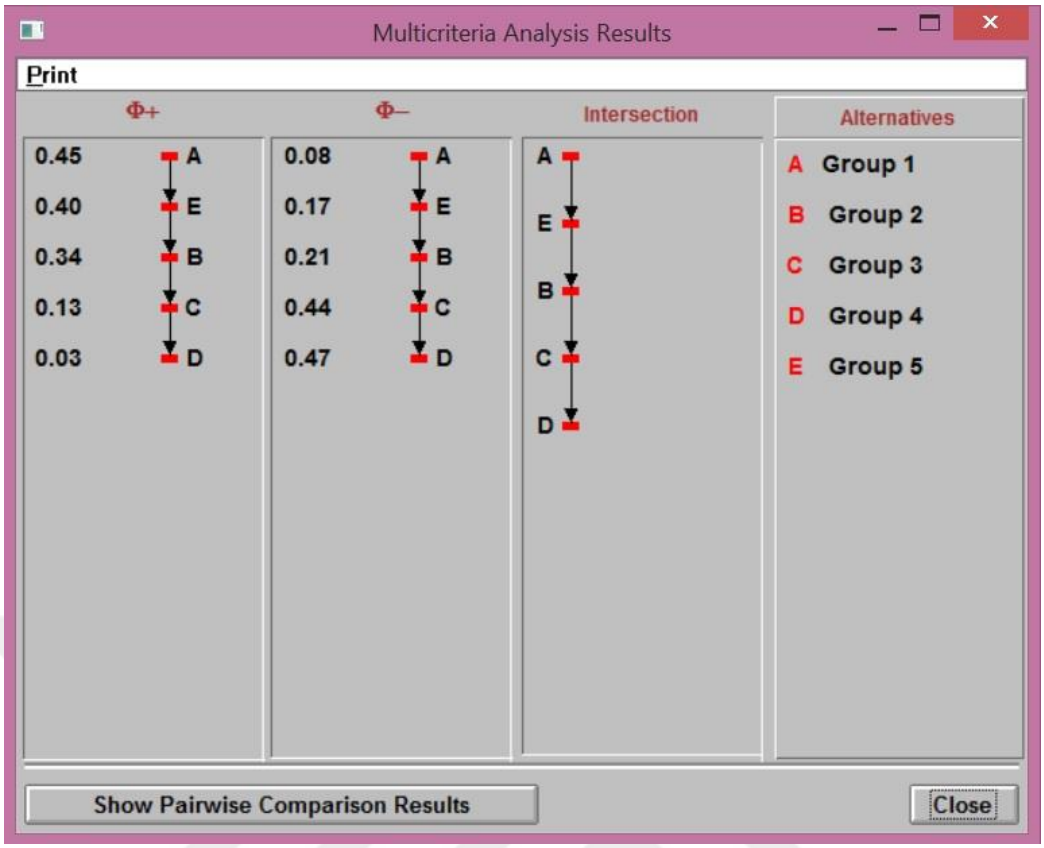


Figure 8.7. Ranking of alternatives without benchmark farm.

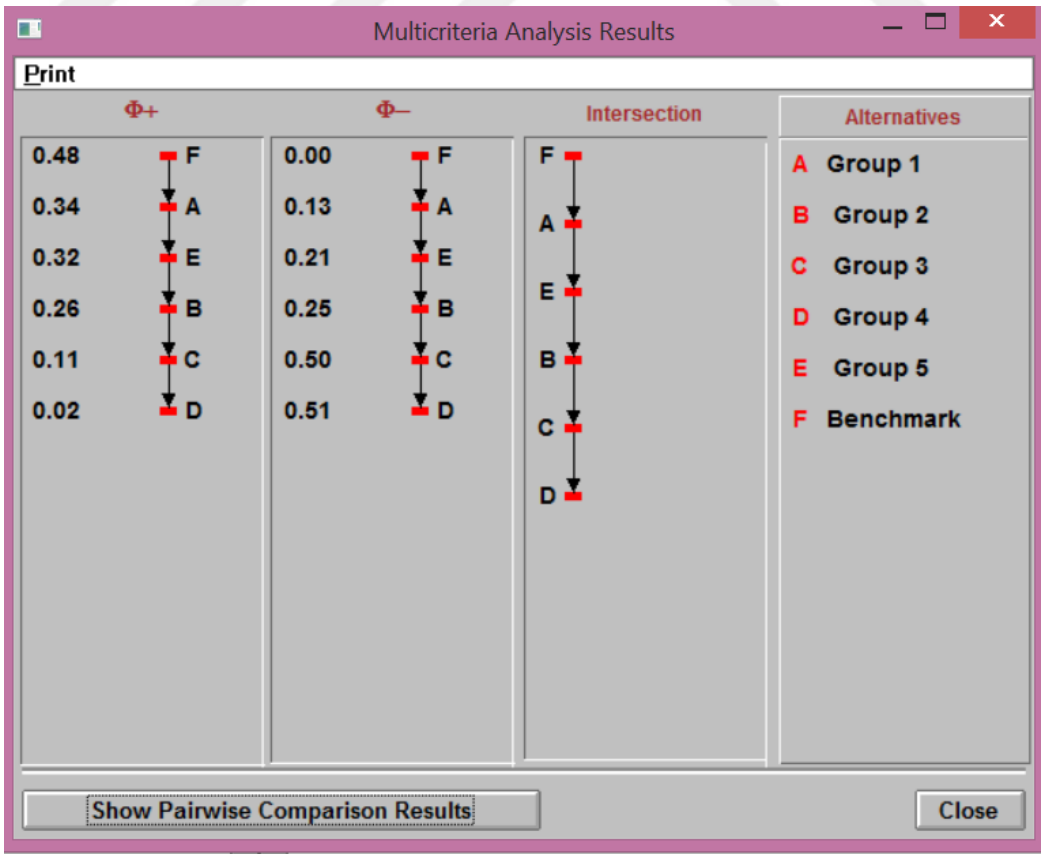


Figure 8.8. Ranking of alternatives with benchmark farm.

8.6. Sensitivity Analysis

Since quantitative criteria are difficult to condense into one number, sensitivity analysis is suggested to assess robustness of the evaluation (Gamboa, 2006). Sensitivity Analysis is performed by Crossover values. Since sustainability threshold is suggested at α: 0.50, sensitivity analysis is conducted by setting different compensation degrees for this parameter ϒ: 0.20 on Zimmerman-Zysno operator. ϒ levels of 0.50, 0.70 and 0.90. Ranking does not change when ϒ levels change. Figure 8.9 shows the output of the program at ϒ 0.50, in Figure 8.10 the output of the program is set at ϒ: 0.70 and Figure 8.11 shows the output at ϒ: 0.90.

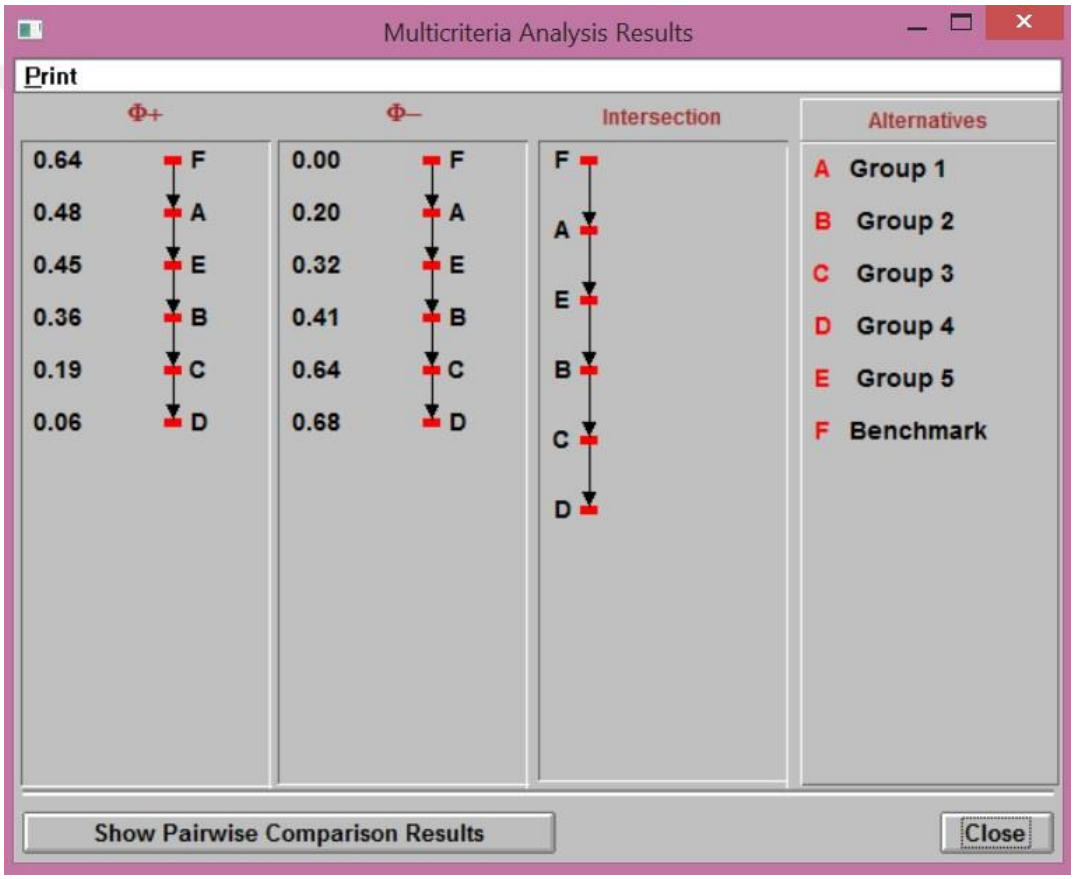


Figure 8.9. Zimmerman-Zysno operator set at α:0.50 ϒ:0.50.

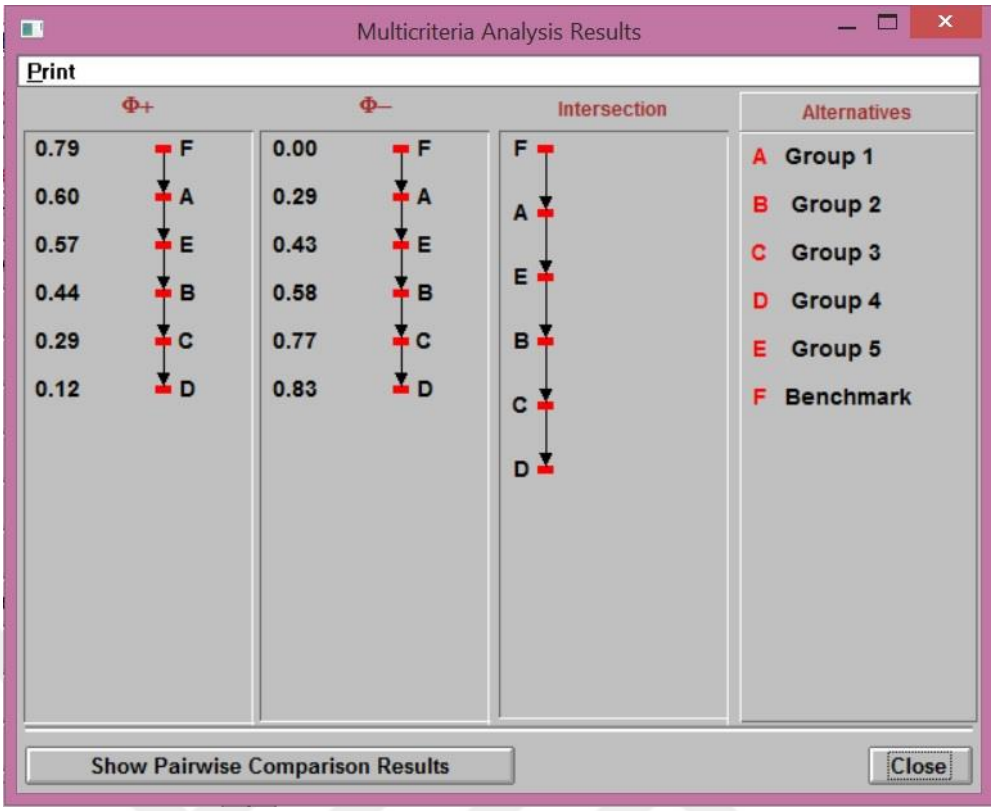


Figure 8.10. Zimmerman-Zysno operator set at α:0.50 ϒ:0.70.

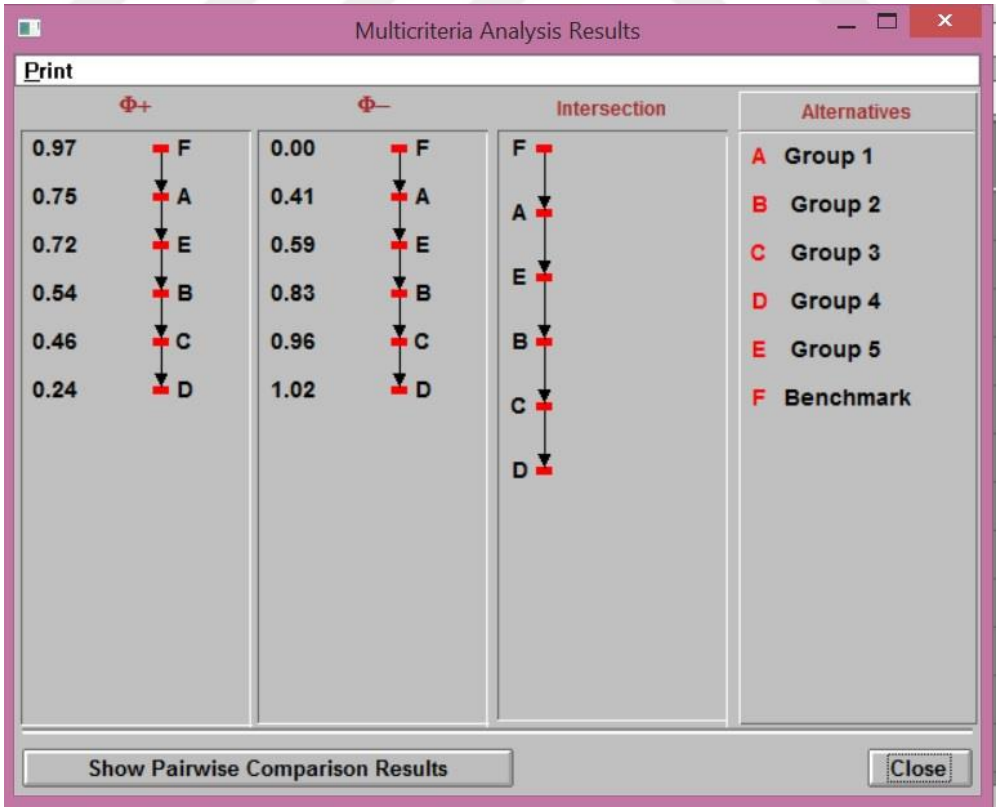


Figure 8.11. Zimmerman-Zysno operator set at α:0.50 ϒ:0.90.

Detailed sensitivity analysis is provided in Figure 8.12, 8.13 and 8.14. Model is stable.

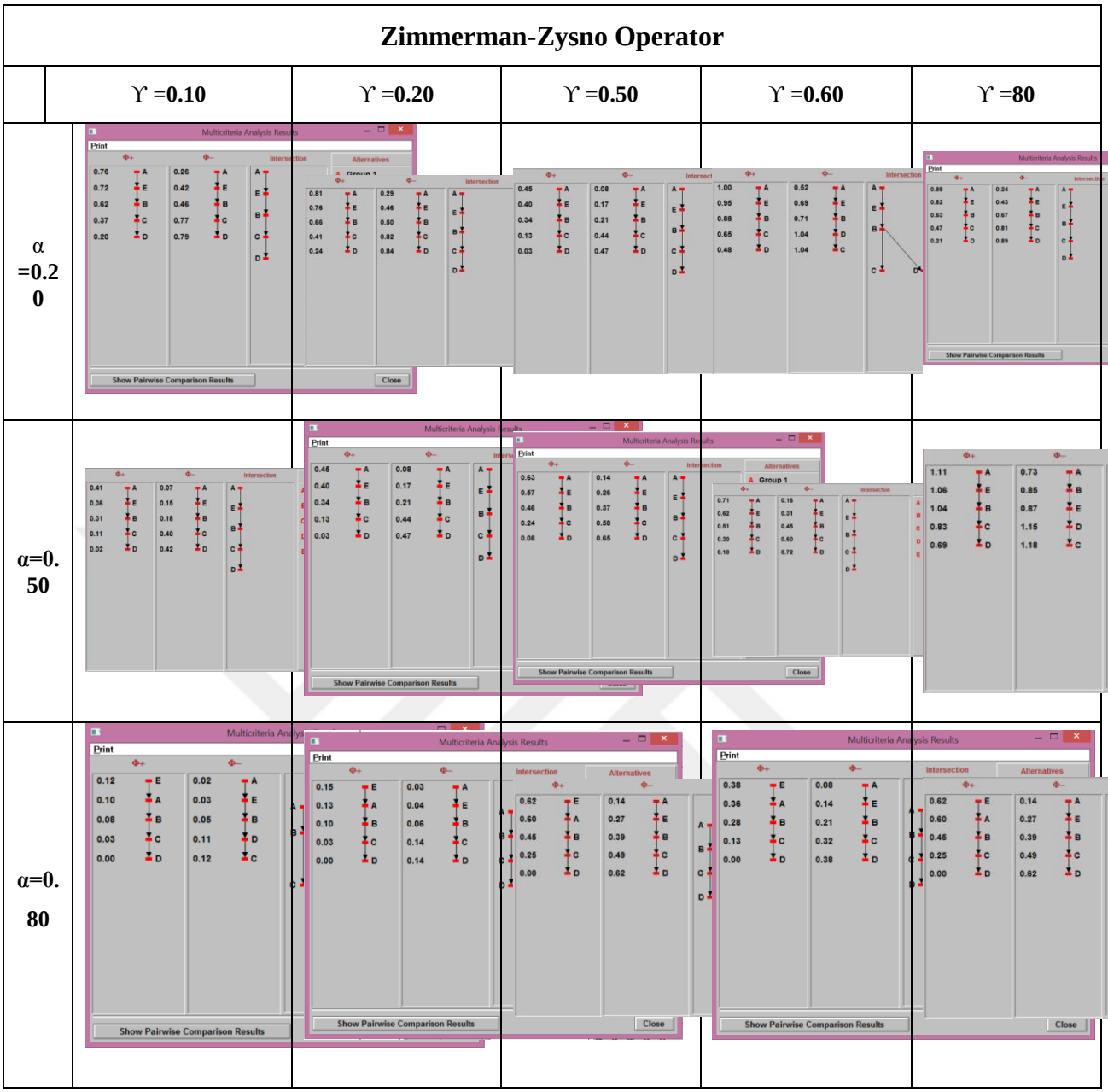


Figure 8.12. Sensitivity analysis with Zimmerman-Zysno operator.

8.7. Observations of SMCE

Based on the NAIADE analysis, Group A is the most sustainable option followed by Group E and B. Cooperative and Independent farms ranked on top probably due to advantages provided by the working cooperative. This result is also supported by low value of willingness to sell. Group E, Independent farmer ranked second mostly due to high grazing percentage and low GHG Emissions and high profitability. A word of caution for independent farmer option is that, even though they are twice as much profitable than the closest competitor, they have the biggest risk. They do not have a sales contract with the consumer and they run the risk of not selling the milk especially in summer

months when people leave the city for vacation areas. A contingency plan and possibly a processor that is willing to work with the farmer is a must for independent farmers to be profitable.

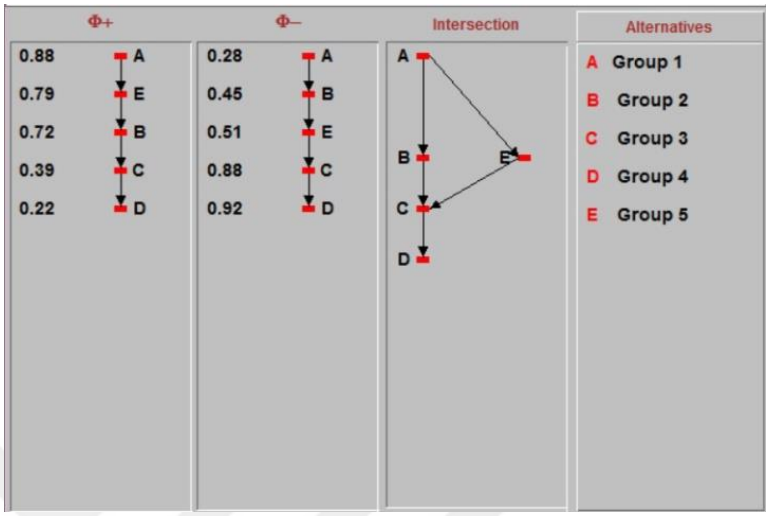
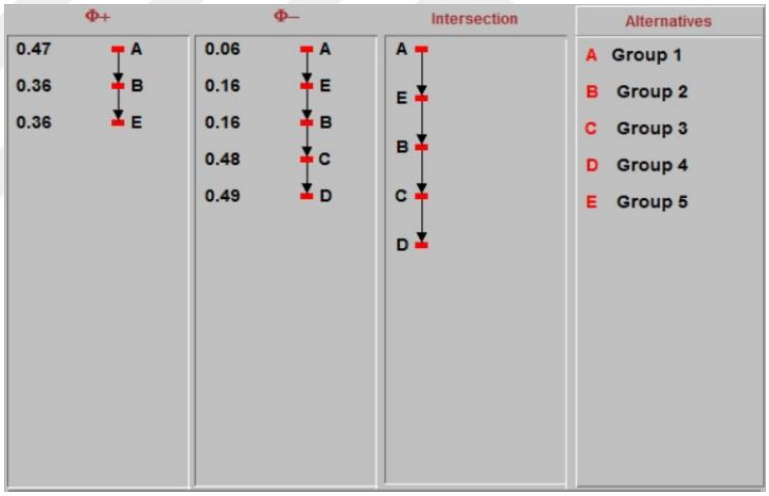
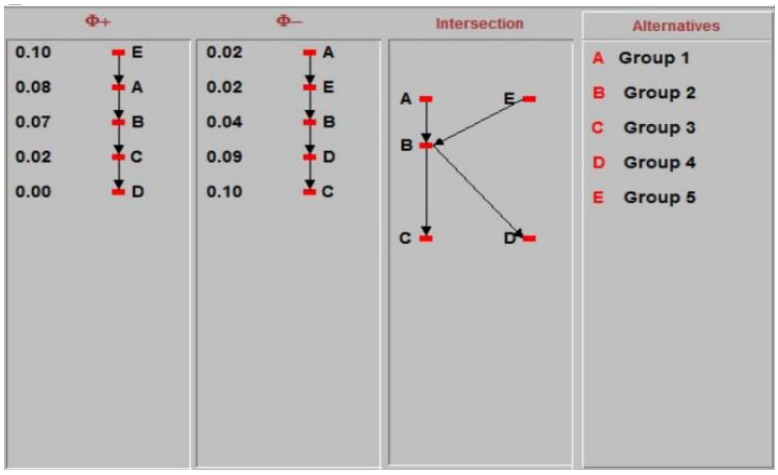
Minimum Operator	
α=0.20	
α=0.50	
α=0.80	

Figure 8.13. Sensitivity analysis with minimum operator.

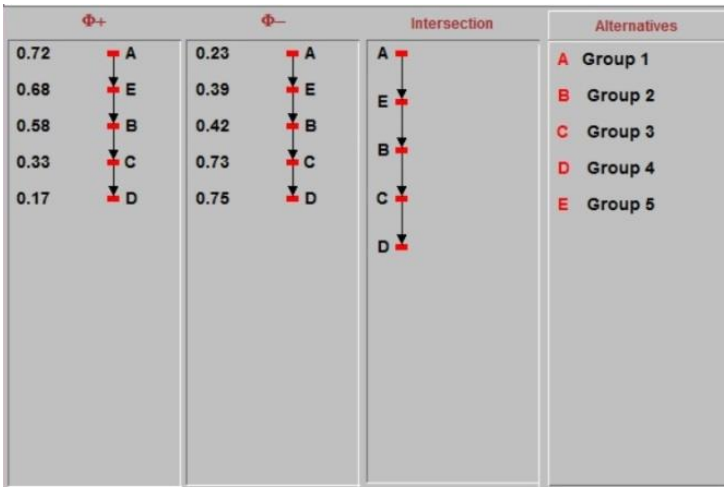
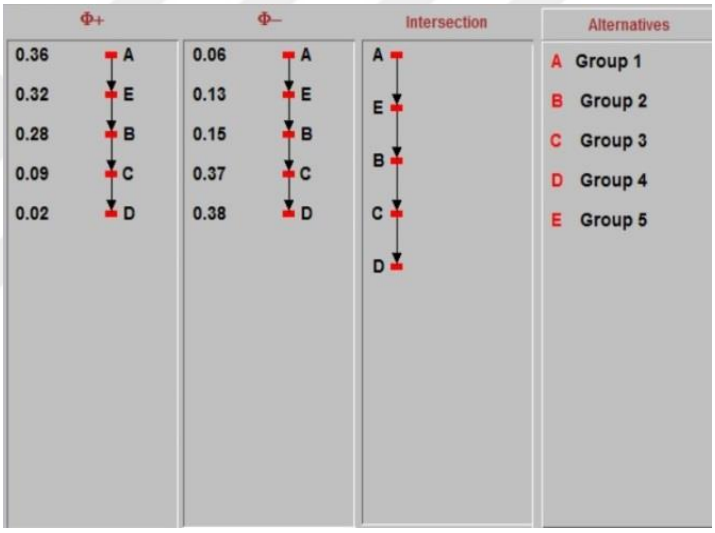
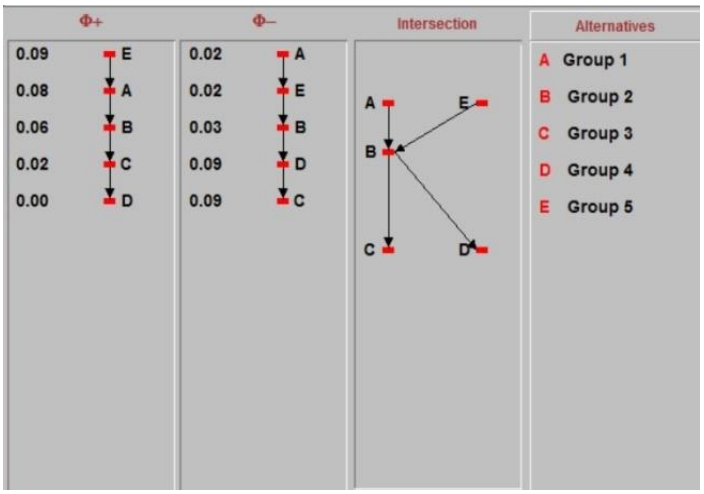
Simple Product	
α=0.20	
α=0.50	
α=0.80	

Figure 8.14. Sensitivity analysis with simple product.

9. CONCLUSION

The main objective of this dissertation was to develop a framework on dairy assessment tool that encompasses social, economic and environmental themes for dairy farms using SMCE methodology. Sustainability Assessment and ranking of the alternatives was completed with NAIADE (JRC, 1996; Munda, 1995) program. In addition to the criteria listed in SMCE analysis, study showed additional characteristics among farmers and different processors. Results based on the criteria are discussed below.

Feed Management: Grazing as much as possible made a difference in the ranking of Group 5, which also lowers GHG emissions.

Water usage: There are no previous studies in Turkey on water usage of dairy cows. While at first glance water usage among farms many not seem significant, when per cow consumption is multiplied by total number of cows in a farm, the output reaches to tons/day very quickly. Survey also asked about any efforts on reclaiming cleaning water (gray water) for farms and none of the farms reclaimed gray water. Another option for improvement is rain water harvest which is also not applied in the farms. Water usage levels among farms aims to start a discussion on efficient water usage and river basin management. As long as its price is zero, climate predictions show Turkey to be a water stress country in the next 30 years, efficient water management could be included in policy discussions. Water usage can also be applied to crop production side of dairy farming. None of the farms applied drip irrigation or ground cover techniques when planting crops. Both techniques help keep soil moisture and reduce the need for watering resulting in both lower water and energy use.

Energy Intensity: Lower energy intensity levels are due to lower use of chemicals. While crop production is not calculated in GHG emissions, lowering energy intensity levels will have a positive impact in reduction of GHG emissions. Lower use of chemical fertilizers will prevent run offs to nearby streams and rivers reducing eutrophication.

GHG Emissions: Results of GHG in the study vary greatly from 0.53 CO_2/L to 1.86 CO_2/L milk. Main difference comes from two sources. First one is weight of the cows and second one is the region the farms are located. Cooperative farms are located in a warmer climate zone, contributing to Group 2 ranking highest in GHG Emissions. Corporation and independent farms are

located in a cooler climate zone resulting on smaller multiplier effects for GHG. The emission amounts are higher than Turkish national averages due to the fact that almost all farms use Holstein cows which are much bigger compared to indigenous Anatolian and hybrid breeds. Manure management practices also play an important role in released GHG amount. Environmental effects of manure is still not fully understood by farmers and run off which can leach into underground water or contaminate nearby surface waters, is not seen as a big problem by the farmers. There is room for capacity building for effective manure management methods.

Working hours: This criterion depends on size of the farm. Small farms require less work therefore fewer work hours are spent on the farm. Larger farms require more work hours that is why in larger farms 12 hour factory shift rule is applied. Most farm workers are paid above minimum wage, yet retaining the workforce on the farm is still a problem. Owners of dairy farms work as much, sometimes more than the workers.

Insurance: Assigning values for insurance criteria was a difficult task since small farms that work on the farm as a family. While husband is the only insured in owner husband and wife team, assigning a value gets more complicated when children join the workforce on the farm. Male children are insured before they get married. Women are still covered with some type of insurance from their husband, however her work goes unrecognized and she is deprived of retirement benefits. Practice of insuring both working men and women are more commonplace in larger farms.

Mediation: Cooperative managers act as a mediator to settle a dispute, that is why Very Good score is given to both cooperative group of farmers. Corporation does not get involved in dispute resolution. If there is a dispute, they acknowledge it, however they do not act as a mediator to settle any dispute among farmers. Their score was Moderate. Independent farmer is a little more inclined towards mediation since they view other farmers as neighbors and are inclined to be more involved in community relations. Their score was More or Less Good. Cooperative is believed to work for the benefit of the farmer. Management does this by being in equal distance to all farmers and treating both cooperative employees and members equally. That is why cooperative management is trusted among members and management is also trusted for conflict management.

Cash advance and credit availability: Cooperative has many advantages especially for small farmer that has low cash flow. Cooperative lets the farmers use advances for feed, supplies and even household needs that are purchased from cooperative grocery store. Farmer pays this debt by selling milk to the cooperative. A balance sheet is shared with the farmer at the end of the month.

Independent farmer and industrial farmer do not have an umbrella system and need to use a bank or find alternative ways to support cash flow. It is important to note that the cooperative was chosen based on its success and not all cooperatives are the same. Transparency and accountability of cooperative management are very important in member farmer trust.

Profitability: Results indicate independent farmer as the most profitable since their costs are similar to the other farmer groups and yet they sell directly to consumer at a premium. They incur the cost of packaging and marketing and this effort seems to pay off. The biggest risk they run is consumer loyalty and seasonal change in consumer demand especially in summer months where everybody goes on vacation. Independent farmer needs to have a contingency plan for the times where milk production is stable yet milk demand is low. This can be a processor that is willing to take the milk for a certain period of time. Or farmer can set up their own processing plant incurring additional investment cost.

Conclusions based on farmer types are as follows:

Individual Farmers

- They usually represent highest quality by being free of zoonotic diseases.
- They fare better in environmental criteria so could be modeled by bigger corporations.
- They need a contingency plan for seasonal changes in sales.
- There are not enough independent farmers, they may need to form an umbrella organization to represent themselves.

Cooperative

- Results suggest that a control mechanism should be in place to improve trust in cooperatives.
- It can be recommended to invest in environmental capacity building and sustainable farming practices with emphasis on water usage.
- It has been observed that cooperative has expanded to areas that directly benefit the farmer.
- Cooperative structure could be expanded to include farmers, restaurateurs and consumers (multi-stake holder) to improve accountability and transparency.
- Cooperatives decrease dependency on bank loans by providing farmers needs in house.
- Supporting small farmers will increase social sustainability by slowing migration to cities.

Corporations

- They focus on end product, high quality milk and need to improve on process.
- Corporations are open for technological improvement like automated milking systems.
- They have a higher environmental footprint, need to take precautions to lower their footprint.

Other findings from the study:

- Certifications are not common (E.g. milk hygiene, worker safety). Small farmers are not aware of certifications where in big farms worker safety training was provided only if there is a forklift on the premises. Milk Hygiene and Worker Safety certifications may improve worker welfare and milk quality.
- People's perception of cooperatives is closely related with their experiences and that is closely related with management of coop: The cooperative studied has a positive association, however not all cooperatives are trusted. Farmer also does not like when they are politicized and act as a promoter of a political party.
- Individual tank farmers value feedback on milk quality. It is harder to talk about milk quality when 20 farmers share one tank. With independent tanks, both cooperative and corporation pay an additional premium for high quality milk. High quality is usually defined by high fat content and low microbial count.
- This study provides a foundation for the relationship of dairy farmers and milk processors. It also provides a background on farm management and sets a benchmark for capacity building in farmer training for environmental and social aspects of sustainability.
- Findings may serve as one of the keystones for policy discussions. Field data provided useful information on documenting differences in farm management.
- Future studies may look into the farmer mandıra relationship. Another area of study could be on scenario development for sustainable dairy farms to improve triple bottom line.
- SMCE is an adequate methodology in sustainability assessment of dairy farms.
- Sets a benchmark for capacity building in farmer training on environmental and social aspects of sustainability.
- The farmer-processor relationship has been studied and a framework using SMCE is developed.

- Results of this study suggest supporting small farmers and organizing them under a cooperative structure.
- Government support and guidelines are suggested to improve to favor the small farmer.
- Independent farmers selling raw milk are in a better position than farmers selling to the corporation.
- This study can be applied to general farm population and depending on the results it may be a guideline to reshape agricultural policy in favor of the small farmer and a different approach to an agricultural sector that is in decline.

Future Studies

- MCA Approach with a larger diverse group applying same or similar framework could be conducted. Due to the sampling method, further studies are needed to understand if the results of this study will be reflected in the general farm population.
- Inclusion of other types of dairy processors (Mandıra).
- A study focusing on different types of agricultural cooperatives and their pros and cons could be of value.
- Scenario development for sustainable dairy farms would improve triple bottom line.

Limitations of the study

- Milk quality is assumed to be standard in each type of farmer.
- It is not an in-depth study of animal welfare.
- Investment cost is not taken into consideration.

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APPENDIX A: QUESTIONNAIRE APPLIED TO DAIRY FARM OWNERS

Boğaziçi Üniversitesi Çevre Bilimleri Enstitüsü Doktora Araştırması
Sütün Sürdürülebilirliği Çiftçi Anketi

Bu anket / görüşme Boğaziçi Üniversitesi Çevre Bilimleri Enstitüsü doktora tezi saha araştırması amacıyla yapılmaktadır. İsminiz ve bu bilgiler tamamen gizli tutulacaktır. Çalışmaya katılmanız tamamen isteğe bağlıdır. Sizden ücret talep etmiyoruz ve size herhangi bir ödeme yapmayacağız. Ankete verdiğiniz cevaplar ileride başka çalışmalar için de kullanılabilir.
Bu anketi doldurmak en çok onbeş dakikanızı alacaktır. Bu formu imzalamadan önce, çalışmayla ilgili sorularınız varsa lütfen sorun.
Bana anlatılanları ve yukarıda yazılanları anladım. Çalışmaya katılmayı kabul ediyorum.
Katılımcı Adı-Soyadı:……..
İmzası: ……
Tarih (gün/ay/yıl):...../...../.....
A N K E T Ç A L I Ş M A S I S O R U L A R

SÜT

1) Toplam kaç tane ineğiniz var?

2) Kaç tanesi şu anda süt veriyor?

3) İneklerinizin cinsi nedir?

4) Bu cins ineği seçmenizin özel bir nedeni var mı?
a) Devlet destekli aldım b) Buranın koşullarına uygun hayvan bu c) Diğer: .....

5) Bir inek günde ortalama kaç litre süt veriyor?

6) Günde kaç kere sağım yapılıyor?

7) Sağım nasıl yapılıyor?
a) Elle b) Yarı-otomatik makineyle c)Tam otomatik makineyle

8) Sağılan süt günde kaç kere toplanıyor? Nerede saklanıyor?

9) Süt işleme tesisine kaç km uzaktasınız?

10) Ortalama bir inek kaç kilo geliyor?

11) İnek gününü nerede geçiriyor? (Ahır / Mera / Tarla vb.)

12) Bir inek günde toplam kaç kilo ot/yem yiyor? (Kurudaki ve sağılan inek olarak belirtiniz)

13) İneği ne ile besliyorsunuz? Birden fazla seçenek işaretleyebilirsiniz
a) Mera b) Ot c) Hazır Yem d) Kendi yaptığım silaj e) Diğer Lütfen belirtiniz

14) Hayvanın yediği taze ota yem(ya da silaja yem oranı) oranı yüzde kaç? Örnek: %20 taze ot, %30 yem, %50 silaj

15) İnek yemi için ekim yapıyor musunuz? Cevabınız evet ise ne ekiyorsunuz?

16) 15. Soruya cevabınız evet ise ekilen alanın büyüklüğü nedir?

17) 15. Soruya cevabınız evet ise ekilen alan
a)Kendimin b) Kira

18) Ektiğiniz alana gübre kullanıyor musunuz? Evet ise lütfen miktar ve cins (inek gübresi/ suni gübre) belirtiniz.

19) Ektiğiniz alana ilaç (herbisit/pestisit) kullanıyor musunuz? Evet ise lütfen miktar belirtiniz.

20) Ektiğiniz alana sulama yapıyor musunuz? Evet ise ne sıklıkta ve ne kadar süre ile lütfen belirtiniz.

21) Hazır yem kullanıyorsanız tercih ettiğiniz bir marka var mı?

22) İneklere ek besin (supplement/destek, Örnek: Mavi su) veriyor musunuz? Veriyorsanız miktarı nedir? Ne sıklıkta?

23) Bir inek günde ortalama kaç litre su içiyor?

24) İneğin istediği zaman suya ve ota erişimi var mı?

25) İneklerin beslenmesi konusunda değiştirmek istediğiniz bir uygulama var mı?

26) Elinizde olsa yaşadığınız çevrede nasıl bir değişiklik yapmak isterdiniz?

a)Doğal alanları arttırmak b)Otlama alanlarını/ineklere alanları arttırmak c) Ekim alanlarını arttırmak d) İnekleri satıp şehirde yaşamak e)Diğer .....

27) Ekilen alanın bakımı dahil işletmede toplam ne kadar mazot kullanıyorsunuz?

28) İşletmenin ortalama elektrik tüketimi ne kadar? (Aylık ödediğiniz elektrik faturası)

29) İşetmenin işleri için kullandığınız alet ve ekipmanı listeleyiniz.

30) İşletmenizi sizden sonra devam ettireceğini düşündüğünüz aile ferdi ya da kişiler var mı?

31) Bir inek ortalama kaç kilo gübre çıkarıyor? (Hayvan toplamı üzerinden yıllık rakam da verilebilir). Kurudaki ve sağılan olarak belirtiniz.

32) Hayvandan çıkan gübreyi ne yapıyorsunuz?

a) Günlük ahırdan süpürülüyor ve çukur toplama alanına bırakılıyor b) Ahırdan toplanan gübre dışarıda bir yerde depolanıyor c)Diğer: Lütfen belirtiniz .....

33) İnek gübresi ve temizlikte kullanılan su için arıtma / yeniden kazanma var mı?

34) Sağım makinelerinin ve ekipmanın temizliğini nasıl yapıyorsunuz?

35) Temizlik için ne kadar su kullanıyorsunuz?

36) Tüm operasyon için ne kadar su kullanıyorsunuz?

37) Suyun kaynağı nedir?

a)Şebeke suyu b) Kuyu suyu veya artezyen c) Diğer.....

38) Tarım Bakanlığı veterinerleri işletmenize düzenli olarak geliyor mu? Geldiklerinde ne gibi uygulamalar yapıyorlar?

39) Kendi veterineriniz var mı? Ne sıklıkta işletmeye geliyor? En sık görülen hastalık nedir?

40) İneklerde gebelik için tercih ettiğiniz yöntem

a) Doğal tohumlama b) Suni tohumlama

37. soruya suni tohumalama olarak cevap verdiyseniz, tercih nedeninizi belirtiniz.

41) Doğan buzağılar nasıl besleniyor?

a) Annesinden emiyor b) Annesinden ayrı süt içiyor c) Annesinden ayrı karışım mama ile biberondan besleniyor

42) Buzağı nerede kalıyor?

a) Annesi ile ahırdab) Annesinden ayrı bir ahırda c) Annesiyle aynı ahırda ayrı bir bölmede

43) Erkek buzağıyı ne zaman satıyorsunuz?

44) Yanınızda kaç kişi çalışıyor?

45) Ailenizden işletmede çalışan var mı? Maaş alıyorlar mı? Kendi adlarına sosyal güvenceleri var mı?

46) Sürekli çalışanların sosyal güvenceleri var mı?

47) Asgari ücretle mi çalışıyorlar?

48) Çalışanlar günde ortalama kaç saat çalışıyorlar?

49) Mevsimlik işçi var mı?

50) Çalışanların dinlenme alanları var mı?

51) Çalışan ailesiyle birlikte mi çalışıyor?

52) Çalışanlara işe başlarken eğitim veriyor musunuz? İşe başladıktan sonra eğitimlere gönderiyor musunuz?

53) İşinde ilerleme fırsatı veriliyor mu?

54) Çalışanlara dönemlik (ya da senelik) performans değerlendirmesi yapılıyor mu?

55) Çalışanların senede kaç gün izin hakkı var?

56) İşletmeye toplam hizmet verdikleri süre ortalama ne kadar?

57) 1lt. sütün maliyeti nedir?

58) Süt üretimi için gereken harcamalarda en çok neye para harcıyorsunuz? (En büyük gideriniz nedir?)

59) Ne tür teşvik alıyorsunuz?

60) Verilen teşvikler sizce yeterli mi?

61) Sütünüzü sattığınız işletmeden (kooperatif) memnun musunuz? Olumlu ya da olumsuz nedenlerini sayınız.

62) Geçmişte sütünüzü başka işletmelere sattınız mı? Gelecekte sütünüzü başka işletmelere satmayı düşünür müsünüz?

63) Sütünüzü satmayı seçtiğiniz işletmede aradığınız özellikler nelerdir? Lütfen önem sırasına göre sıralayınız (1 en önemli neden, 7 en az önemli neden olarak).

a) Süte litre başına ödenen fiyat
b) İşletme sahibini tanımam
c) Ödemeyi düzenli yapması
d) Ürünümü iyi işleyip, kaliteli mal satması
e) İşletmenin bir marka olması

f) İşçilerine saygılı, sosyal hakları gözetmesi
g) Çevreye saygılı olması

64) Sizce Kooperatif üyesi olmanın avantajları var mıdır? Varsa lütfen sıralayınız.

65) Bölgenizde sosyal hizmet amaçlı yaptığınız bir faaliyet var mı?

66) Sizce bu işletmenin çevrede yaşayanlara pozitif etkileri nelerdir?

67) Sizce bu işletmenin çevrede yaşayanlara negatif etkileri nelerdir?

68) Yukarıda saydıklarınızı iyileştirmek önümüzdeki 5 yıllık planlarınıza dahil mi?

69) Besiciliğin (eti veya sütü için beslenen hayvanlar) küresel iklim değişikliğine (küresel ısınma) etkilerini biliyor musunuz?

a) Bilmiyorum b) Gazetelerden okuyorum c) Televizyonda dinledim e) Diğer

70) 70. Soruya b,c,ya da d olarak cevap verdiyseniz, sığırların iklim değişikliğine etkilerini azaltacak uygulamalar hakkında bilgi sahibi olmak ister misiniz?

APPENDIX B: ENERGY INTENSITY

Formula: Energy Intensity Inputs: Fuel, lubricant, nitrogen, phosphorus, Potassium, Seeds, Herbicides (Siciliano, 2009)				
Inputs	Unit	Barley (MJ/unit)	Maize (MJ/unit)	Sources
Machinery	h	64.8	64.8	Kızılaslan, Singh
Lubricant	kg	84	84	Siciliano, 2009 (Jarach, 1985)
Fertilizers				
Nitrogen	kg	60.6	60.6	Singh, 2002; Gündoğmuş, 2006; Bilalis, 2013)
Phosphorus	kg	11.1	11.1	Singh, 2002; Gündoğmuş, 2006; Bilalis, 2013)
Potassium	kg	6.7	6.7	Singh, 2002; Gündoğmuş, 2006; Bilalis, 2013)
Chemical(Pesticides)	kg	101.2		Yaldız et. al, 1993; Gökdoğan and Sevim, 2016
Herbicides	kg		263	(mean value of different herbicides, Clements et. al, 1995, Bilalis, 2013)
Insecticides	kg		199	Gündoğmuş, 2006; Bilalis, 2013)
Fungicides	kg		92	Gündoğmuş, 2006; Bilalis, 2013)
Manure	ton	303.1	303.1	Yaldız et. al, 1993; Kızılaslan, 2009
Diesel fuel	lt.	56.31	56.31	Singh, 2002; Demircan, 2006; Gökdoğan, 2016
Seed	kg	14	104	Mobtaker et. al, 2010; Özkan et. al, 2004; Baran, 2014) Corn:Patzek, 2004; Bilalis et. al, 2013)
Total	kg			Da Silva et. al, 2010 (East Brazil+West Brazil mean to Rotterdam port (12634+6999)/2 MJ for 1000kg of soybean

APPENDIX C: GHG CALCULATION FORMULAS BASED ON IPCC 2006 (Eggleston et al., 2006)

GHG Calculations (IPCC 2006 Inventory for GHG)		
Tier 2 characterization methodology aims to define 1)Animal productivity 2)Diet quality 3)Management circumstances for an accurate estimate of feed intake to calculate methane production.		
Feed intake:		
Equation 10.3 Net energy maintenance(NEm): Cfi * (Weight)^0.75 MJ day^{-1}		
Coefficient corresponding to net energy for maintenance(Cfi)(table 10.4)v ***All animals in the farm are considered female and at lactating age for simplification		
Non-lactating cow	0.322	None
Lactating cow)	0.386	Total animal number in the farm-lactating cow in the farm***At the time of the survey
Lactating cow(20% higher)	0.463	Later on, during Eq. 10.13 for lactatng cows, (80% of the mature cows go thrpugh gestation in a year is calculated)
Equation 10.4 Net energy for animal activity (Ne_a): C_a*NE_m, MJ day^{-1}		
Ca:Activity Coefficient corresponding to animal's feeding situation (MJ day^{-1} kg^{-1})		
Coefficient corrresponding to animal's feeding situation(Table 10.5)		
Stall	0	
Pasture	0.17	
Grazing large area	0.36	
Equation 10.6 Net energy needed for Growth(NEg): 22.02*(BW/(C*MW)^0.75*WG^1.097		
BW:Average Live Body weight of the animals in the population, kg (ankette, her ciflik için ineklerin ortalama ağırlığını yazdığımdan, satisfies the criteria)		
C: Coefficient with a value of 0.8 for females and 1.2 for bulls (given in the formula)		
MV:Mature live body weight of an adult female in moderate body condition kg		
WG:Average daily weight gain of the animals in the population		

Equation 10.8 Net energy for lactation (NE_1): Milk*(1.47+0.4*Fat) MJ day^{-1}								
Milk: Amount of milk produced, kg of milk day^{-1}								
Fat:Content of milk, % by weight (need to average seasonal changes) averaged it to 0.4(industry standart)								
Equation 10.13 Net Energy for pregnancy(Ne_p):$C_{pregnancy}$*NE_m(Eq. 10.3) MJ day^{-1}								
$C_{pregnancy}$: Pregnancy coefficient (Table 10.7)								
Cattle and buffalo:		0.1						
Ne_m:Net energy required by the animal for maintanence (Equation 10.3) MJ day^{-1}								
Equation 10.14 Ratio of Net Energy Available in a diet for Maintenance to Digestible Energy Consumed: REM= [1.123-(4.092*10^-3*DE%)+[1.126*10^-5*(DE)^2]-(25.4/DE%)]								
REM:Ratio of net energy available in a diet for maintenance to digestible energy consumed								
DE%:Digestible energy expressed as a percentage of gross energy (digestibility Table 10.2 page 10.14)								
Feedlot animals fed with >90% concentrate diet: 75-85%								
Pasture fed animals:55-75%								
Animals fed low quality forage:45-55%								
Stall hayvanlarının DE'sini 80, pastureları 65 ve independent farmerları 75 aldım, aynısını bütün DE olan yerlere uygulamam gerekiyor. Formül 10.4'te stall ve meraya çıkan hayvanların ayrımını yapmıştım, oradan devam ettim.								
Equation 10.15 Ratio of Net Energy Available for growth in a diet to digestible energy consumed: REG:[1.164-(5.160*10^-3*DE%)+[1.308*10^-5*(DE%)^2]-(37.4/DE%)]								
REG:Ratio of net energy available for growth in a diet to digestible energy consumed								
DE%:Table 10.2 Digestible energy expressed as a percentage of gross energy(digestibility)								
Feedlot animals fed with >90% concentrate diet: 75-85%								
Pasture fed animals:55-75%								
Animals fed low quality forage:45-55%								
Equation 10.16 Gross Energy for Cattle/Buffalo and Sheep: GE=[((NE_m+NE_a+NE_1+NE_{work}+NE_p)/REM)+((NE_g+NE_{wool})/REG)]/[(DE%/100)]								
GE: Gross Energy, MJ day^{-1}								
NE_m:Net energy required by the animal for maintenance (Eq 10.3), MJ day^{-1}								
NE_a:Net energy for animal activity(Eq. 10.4 and 10.5)								
NEl:Net energy for lactation(Equations 10.8, 10.9 and 10.10)								
NE_{work}:Net energy for work (Equation 10.11), MJ day^{-1}								
NE_p:Net energy required for pregnancy (Equation 10.13), MJ day^{-1}								
REM:Ratio of net energy available in a diet for maintenance to digestible energy consumed (Equation 10.14)								
NE_g:Net energy needed for growth (Equations 10.6 and 10.7), MJ day^{-1}								
NE_{wool}:Net energy required to produce a year of wool(Equation 10.12), MJ day^{-1}								
REG:Ratio of net energy available for growth in a diet to digestible energy consumed(Equation 10.15)								

DE%:Digestible energy expressed as a percentage o gross energy(typically 45-55% for low quality forage)
Equation 10.17 Dry Matter intake for growing and finishing cattle: DMI:BW^$^{0.75}$*[(0.244*NE_{ma}-0.0111*NE_{ma}^2-0.472)/NE_{ma}]
DMI:Dry matter intake, kg day^{-1}
BW:Live body weight, kg
NE_{ma}:Estimated dietary net energy concentration of diet OR default values in Table 10.8, MJ kg^{-1}
Diet type
High grain die t>90% : 7.5 - 8.5
High quality forage: 6.5 - 7.5
Low quality forage: 3.5 - 5.5
OR can be estimated with formula: Nema=REM*18.45*DE%/100
Equation 10.18b Estimation of Dry Matter Intake for mature dairy cows:DMI=[((5.4/BW)/500)/((100-DE%)/100)]
DMI:Dry matter intake, kg day^{-1}
BW:Live body weight, kg
DE%:Digestible energy expressed as a percentage o gross energy (typically 45-55% for low quality forage)
Equation 10.21 CH_4 Emission factors for enteric fermentation from a livestock category: EF=[(GE*(Y_m/100)*365)/55.65]
EF:Emission factor, kg CH_4 $head^{-1}$ yr^{-1}
GE:Gross energy intake, MJ $head^{-1}$ day^{-1}
Y_m: Methane conversion factor, per cent of gross energy in feed converted to methane
The factor 55.65 (MJ/kg CH_4) is the energy content of methane
Equation 10.22 CH_4 Emission from manure management: $CH_{4Manure}$=($EF_{(T)}$*$N_{(T)}$)/10^6
$CH_{4Manure}$=CH_4 emissions from manure management, for a defined population, Gg CH_4 yr^{-1}
$EF_{(T)}$=Emission factor for the defined livestock population, kg CH_4 $head^{-1}$ yr^{-1}
$N_{(T)}$=The number of head of livestock species/category *T* in the country
T=Species/category of livestock
Equation 10.23 CH_4 Emission Factor from manure management: $EF_{(T)}$=($VS_{(T)}$*365)*[$B_{o(T)}$*0.67kg/m^3*ΣS,k($MCF_{S,k}$/100)*$MS_{(T,S,k)}$]
$EF_{(T)}$:Annual CH_4 emission factor for livestock category *T*, kg CH_4 $animal^{-1}$ yr^{-1}
$VS_{(T)}$:Daily volatile solid excreted for livestock category *T*, kg dry matter $animal^{-1}$ day^{-1}
365:basis for calculating annual VS production, days yr^{-1}
$B_{o(T)}$:maximum methane producing capacity for manure produced by livestock category *T*, m^3 CH_4 kg^{-1} of VS excreted

Eggleston, S., Buendia, L., Miwa, K., Ngara, T., and Tanabe, K. (2006). IPCC guidelines for national greenhouse gas inventories (Vol. 4): Institute for Global Environmental Strategies (IGES) Hayama, Japan.

APPENDIX D: NAIADE PROGRAM

Developed by Munda (1995) and Joint Research Centre (1996), NAIADE ranks the alternatives by means of pairwise comparisons, in order to find out the best alternative according to each criterion. NAIADE does not use weights to avoid the problems that come with choice of weights. This means that all criteria have the same weight, which implies that the weight is given to each dimension, such as the environmental, the social and the economic sphere, by the number of criteria belonging to it. In other words, the more criteria are attributed to one dimension, the more weight is provided to that dimension. This factor must be taken into account in the problem structuring.

The last step of NAIADE is to define **parameters** and **operators**. The most important parameter that has to be decided is **α**, that is, the minimum requirement for fuzzy relations. The choice of the operators determines the degree of **compensability** among criteria. Three kinds of operators can be chosen: the simple product, the minimum operator and the Zimmermann- Zysno operator. The first one allows the greatest degree of compensability, the second one implies no compensability at all and the third one permits a certain compensability, which is determined by the parameter γ (γ ranges from 0 to 1).

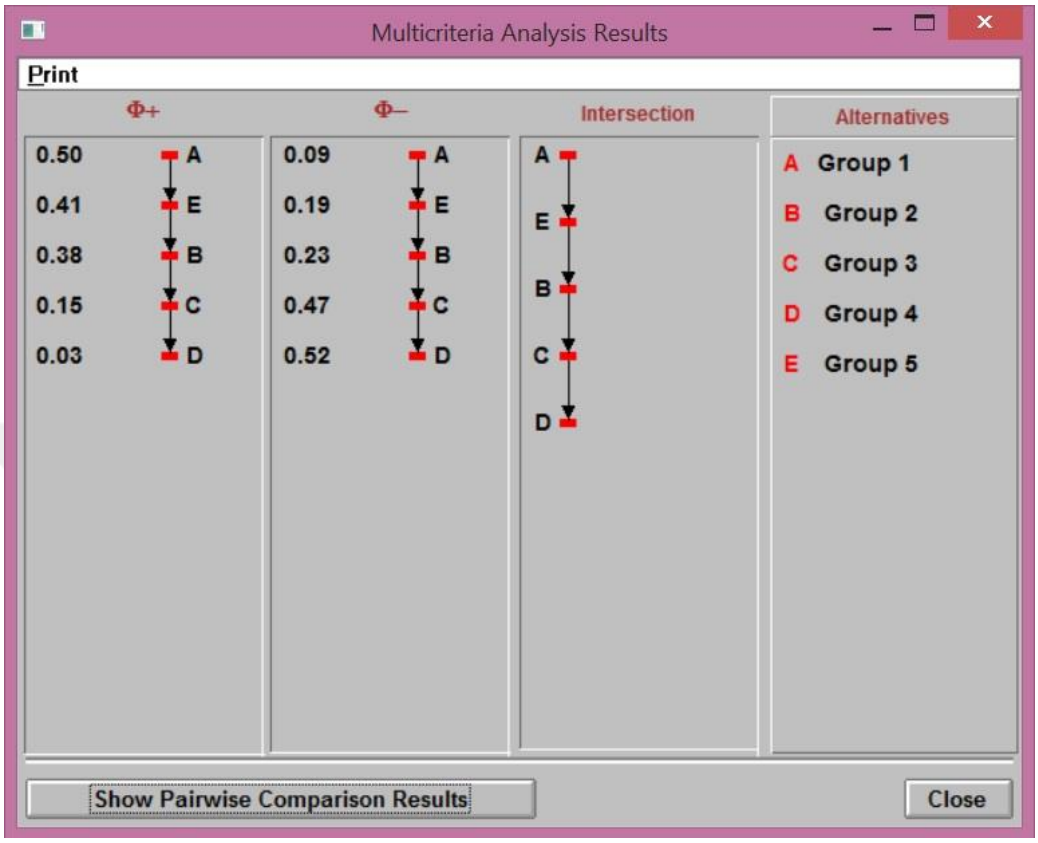
Following Gamboa (2003), instead of choosing a parameter and an operator, and then to try to modify them in order to see how robust the result is, the different possible outcomes are presented considering various combinations of parameters and operators. In fact, the main objective of the SMCE is not to give a final ranking of the alternatives but to show different rankings at different degree of compensability.

The final ranking of the alternatives is strongly dependent on the problem framing firstly in the definition of alternatives and criteria, secondly in the distribution of weights says this despite it says above eliminates weights(the three dimensions), and thirdly in the aggregation procedure, including the choice of the parameters.

This section is to explain how NAIADE works: The criteria are compared using **preference relations**, which indicate the degree of credibility (depending on the distance between alternatives) of the fact that an alternative is “much better”, “better”, “approximately equal”, “equal”, “worse” and “much worse” than another one. The **crossover values** are the points where the preference

relation reaches 0.5 (where it begins to be sufficiently credible). For example, stating that the crossover value for the preference relation “much better” is 500 € means that if the PV equipment costs 47.5 thousand € and the traditional electric grid costs 47 thousand € (the difference being 500 €) the credibility that traditional electricity is much preferred to solar energy is 0.5. In other words, the crossover value for the relation “much better” establishes the distance that makes sufficiently credible that one option is much better than another one according to the analyzed criterion. The same reasoning holds for the other preference relations. Once the credibility index is calculated for each pair of options according to each criterion, the information must be aggregated in order to build a ranking of the alternatives. In order to do that, the **preference intensity** index is used, which is obtained taking into account the number of criteria in favour of each alternative and the intensity of preference. A parameter α indicates the minimum requirement of the credibility indexes: the criteria are included in the aggregation procedure only if their credibility indexes are above α

APPENDIX E: RANKING AFTER SALARIES CRITERION IS REMOVED,



α: 0.50, Compensation 0.20.