Understanding constraints to the development of the agricultural sector in Oman: An application of the Theory of Planned Behaviour

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DECLARATION

I confirm that this is my own work and the use of all material from other sources has been properly and fully acknowledged

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DEDICATION

O'Allah Almighty! All praise and gratitude be to you.

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Abstract

Oman's agriculture sector currently plays a small role in Oman's economy, accounting for around 3% of GDP and 6% of labour force, and comprising in the main farmers with very small landholdings. Yet though it has a relatively small share of GDP, the agricultural sector is an important element of government policy, particularly with respect to increasing food production as part of the government's overarching strategy to transform the national economy away from its single sector dependence on oil.

The Government's vision for agriculture includes increased land and water productivity, reduced costs or production, increasing employment opportunities, improving agricultural trade balance, and protecting the environment. Increased production is seen as an important part of increasing self–sufficiency in domestic food production in Oman. For while Oman is a net exporter of fishery products, it is currently a net importer of agricultural products, with own-production accounting for around 36% for poultry, 31% milk, 21% meat, 57% vegetables, 68% fruit and 45% eggs, promoted mainly through relatively low customs tariffs.

To improve agricultural productivity, the government has focused on a number of areas, from improved seed, the use of inorganic fertiliser, modern irrigation, greater agricultural mechanization, and greater use of greenhouse production. In addition, agricultural cooperatives have for many decades been an important element of the government's agriculture strategy, in part used to encourage adoption of new technologies. Despite these efforts by the Omani government, the reality of Oman's agriculture sector is one where water scarcity is a key problem and soil fertility is poor, and farmers have not fully embraced the government's vision of modernisation.

This study is guided by a number of research questions that address the challenges faced by smallholder farmers in Oman; the key influences and influencers that lead to farmers adopting new management approaches and technologies; and the role of cooperatives. The study is centred around the theory of planned behavior, which focuses on farmers' attitudes and what influences those attitudes. The findings from this study thus provide insights into the choices Oman's farmers make, particularly why they have not fully embraced management approaches including those that enhance water management,

through the adoption of modern irrigation; and those that enhance soil fertility, through the increased use of inorganic fertiliser. The study focuses on these two specific technologies because they have been identified as critical for the country with regards to modernizing the agricultural sector. By comparing farmers who belong to a cooperative with those that do not, this study contributes to the on-going policy discussion in Oman as to whether the government should promote the development of new agricultural cooperatives around the country.

A lack of suitable land dominated farmers' discussions over the challenges they faced, attributed to water shortages, low soil fertility, and soil and water salination, which together reduce yields. But farmers also discussed poor access to markets and the small size of landholdings. Using the theory of planned behavior revealed some important insights into why farmers are not adopting technologies that would help them address these key soil and water challenges. With respect to low levels of adoption of inorganic fertilizer, farmers receive mixed messages as to whether inorganic fertilizer is beneficial or harmful. Farmers belonging to a cooperative were more positive about inorganic fertilizer and more likely to use it, reflecting either the cooperative playing a role in generating a more positive attitude, or a younger more educated demographic. In contrast, all respondents tended to have a positive attitude towards modern irrigation. Low rates of adoption were found to be driven by difficulties in accessing water, irregular supplies of electricity, and in the very high cost of installation.

These findings suggest different roles for government with respect to these two technologies. For fertilizer, the data suggest a stronger and consistent message from extension agents is needed, combined with more detailed training on how to use inorganic fertilizer. With respect to modern irrigation, some form of financial help, and better knowledge on how to maintain the systems could help. But this would only be effective if there were reliable water and electricity.

Because the profile of farmers differs considerably depending on whether or not they belong to a cooperative, isolating the role of cooperatives in the adoption of new technologies and management approaches proved tricky. Cooperative farmers in Oman are in the main younger and less experienced farmers, but better educated than those who are not members. One approach for the government could be to encourage farmers to join cooperatives so as to facilitate awareness, education, and opportunities with respect to new farming approaches and technologies. Cooperatives might also play a larger role in facilitating access to resources, whether ensuring the availability of key inputs, or helping farmers to fund larger-scale capital investments such as modern irrigation.

Finally, this thesis has provided the first application of the theory of planned behavior in the context of the agriculture sector in Oman. Thus for the first time, detailed knowledge concerning Omani farmers' attitudes and behavior towards using modern technologies and management approaches has been generated and explained. The government of Oman has relatively good knowledge with respect to which technologies are required for the agricultural sector to modernize and increase its role in economic diversification and food security, yet not how to encourage farmers to adopt the approaches. This study has provided important, novel, and timely insights into how the government can improve the uptake of these technologies, and thus move closer to reaching the potential of the agricultural sector.

Table of contents

FIGURES

TABLES

LIST OF ABBREVIATIONS

A: Attitude Towards Behaviour

AC: Agricultural Cooperative

AGMECH: Agricultural Mechanization

AOAD: Arab Organization for Agricultural Development

EU: European Union

FAO: Food Agricultural Organization

GCC: Gulf Cooperation Council

GDP: Gross Domestic Product

GMHT: Genetically Modified Herbicide Tolerant

Ha: Hectares

HCA: Hierarchical Cluster Analysis

ICA: International Cooperative Alliance

ICARDA: International Centre for Agricultural Research in the Dry Area

KMO: Kaiser Meyer Olkin

MCM: Million Cubic Meters

MOAF: Ministry of Agriculture and Fisheries

MOI: Ministry of Information

MONE: Ministry of National Economics

MOSD: Ministry of Social Development

MRMWR: Ministry of Regional Municipalities and Water Resources

NCBA: National Cooperative Business Association

NCFC: National Council of Farmer Cooperatives

NGOs: Non-Governmental Organizations

NCSI: National Centre for Statistics and Information

OMR: Omani Rial

PAMAP: Public Authority for Marketing of Agricultural Products

PBC: Perceived Behavioural Control

PCA: Principal Component Analysis

R & D: Research and Development

SN: Subjective Norm

SPSS: Statistical Package for the Social Sciences

TPB: Theory of Planned Behaviour

TRA: Theory of Reasonable Action

UAE: United Arab Emirates

UNCTAD: United Nations Conference on Trade and Development

UoR: University of Reading

US: United State

USDA: United States Department of Agriculture

WTO: World Trade Organization

Chapter 1 Introduction

1.1 Background to this thesis

Agriculture and fishing were the main sources of income for Omani people before the appearance of oil and gas in the late 1960s. The importance of the agricultural sector then decreased gradually, reflecting structural changes in the Omani economy because of oil revenues and young people's unwillingness to work in the agricultural sector. The economy now depends heavily on oil and gas products (Shideed, 2008). Yet the government still recognises the importance of the agricultural sector for food security and self-sufficiency, so the government has paid great attention to this vital sector in economic development. For example, the government represented in the Ministry of National Economy (MONE) put in mind the development of the agricultural sector in the strategic development plan, which is a long-term plan (vision 1996-2020), comprising distinct five-year plans. The government aims to increase the contribution of agriculture and manufacturing industries in the gross domestic product GDP during that period from 2.8% to 5%, and 7% to 29% respectively (MOAF, 2009). Oman's agriculture sector currently has annual growth topping 4.5% and 6% of labour force. These two sectors, agriculture and manufacturing, are seen to have an active role in providing food and increasing income (economy) in the Sultanate of Oman. This income assists in the contribution of gross domestic product (GDP), which contributed to providing job opportunities and a source of foreign exchange earnings.

At present, around 90% of agricultural holdings are less than five acres (2.1 hectares). Water scarcity is considered one of the most important issues and barriers farmers encounter (MOAF, 2013b), and, along with increased soil salinity in coastal areas a key explanation for the poor performance of the agricultural sector (Shideed, 2008). Yet despite its small and decreasing share of total GDP, agriculture is seen an important sector in the economy because of Oman's food security objective. Though Oman is a net exporter of fishery products, it is a net importer of agricultural products with food security promoted mainly through relatively low customs tariffs on imports. The Government assists agricultural producers by offering basic infrastructure (e.g. drainage and irrigation facilities), soft loans, and free provision of inputs, such as new and high quality seed varieties, fertilisers, and chemicals (MOAF, 2015b).

The aims of the Oman government include increasing food self-sufficiency as part of the government's overarching strategy to transform the national economy away from its single sector dependence on oil. The government of Oman’s vision includes main goals of increased unit of land and water productivity, reduced costs of production, protecting the environment, improving agricultural trade balance, and increasing employment opportunities. The government in particular believes that vegetable production is important for agricultural development, and contributes to the provision of food needs of the population and inputs to agro-processing industries. Thus, the support of a food security goal is believed to contribute to food security and expand the potential of the national economy as well as raise the standard of living.

The Sultanate based on previous policies and programmes aimed at improving the productivity of smallholder through the provision of various production inputs such as fertiliser, herbicide, insecticides and hybrid seeds; promoting modern irrigation and greenhouses projects on a large scale, aimed at transform small farming to commercial agriculture. Oman's agriculture policy reflects its overall economic policy, which emphasizes diversification of the production base. Development efforts in agriculture have included promoting intensified farming, increasing food production and conservation, and further developing existing agricultural resources.

The government is currently preparing a sustainable development strategy for the agricultural sector project until 2040 (MOAF, 2013b). The agricultural census 2012/2013 project will contribute to the next five-year plan and a strategy of Oman 2020/2040. The census results show that the Sultanate requires a greater use of modern technologies in increasing productivity, through the use of modern technologies, including greenhouses, irrigation systems, with help from agricultural extension. The Oman 2020/2040 strategy will focus on increasing output per unit area of land, and expansion of agricultural land, while using water resources sustainably(MOAF, 2013b). The government believes that cooperatives may contribute to farmers intensifying their agricultural production through greater use of modern technology. Yet little is understood about the role, if any, of agricultural cooperatives. Oman has a history of cooperatives in its agricultural sector, with 20 government-supported cooperatives functioning in the 1980s. However, today only a few are operating, after the government changed track in the mid-1980s. Currently, the Omani Ministry of Agriculture and Fisheries (MOAF) is discussing increased subsidies and support of agricultural cooperatives, encouraging farmers to work collectively in the areas of production, marketing, and processing, as part of its on-going policy making. One agricultural cooperative that has endured is the Al Batinah cooperative, which is discussed in detail in Chapter 3 which also provides a historical perspective on Oman's agricultural cooperatives.

1.2 Food security in the Arab and GCC Region

The agricultural sector is considered one of the importance vital sectors of the mission in the world, due to its important role in the provision of basic and key consumer needs, overcoming poverty, fostering food security, which are crucial for the continuity of life(Asfaw et al., 2012, FAO, 2014). It plays a strategic role in the economic development process of a country. This sector has already made a significant contribution to the economic prosperity of developed and developing countries (ICARDA, 2012). (Godfray et al., 2010) demonstrated that agricultural can be the backbone of an economy which provides the basic ingredients to human and raw material for industrialisation. This reflects the vital role of this sector in the social stability and development in other sectors that contribute to economic growth.

FAO (2012a) defined food security is a situation that exists when all people at all times have physical, social and economic access of sufficient, and nutritious food that meets their dietary needs and food preferences for an active and healthy life. The availability of food security is one of several conditions necessary for a population to be health (Fasoyiro and Taiwo, 2012). The Arab Organization of agricultural Development noted that the concept of food security should be based on three pillars: the abundance of food commodities; the existence of food commodities in the market permanently; and that commodity prices are accessible to citizens (AOAD, 2013).

Increases in the volatility of food prices and a heavy reliance on international markets for their foods can make countries less food secure (Kotagama et al., 2014). The Arab region is generally wealthy yet still suffers food insecurity issues, with poverty and inequality, some rich countries along with some poor countries (AOAD, 2013). Gulf Cooperation Council (GCC) countries express a sense of national vulnerability in regards to the lack of water and food availability. Strategic reserves of food and water provide evidence of these countries' concerns (Howard, 2015).

Oman is a sub-tropical country with limited water resources, low soil fertility, constraining food production and volatile weather. Nowadays, food security in Oman is maintained through a combination of domestic production, substantial government support and food imports (Howard, 2015). The Sultanate meets similar challenges and obstacles to domestic food and water security as its Gulf Cooperation Council (GCC) countries, exacerbated by increases in population. Further, many people in Oman shifted from employment in the agriculture sector to other sectors after the discovery of oil. Food security in the broader sense can address inclusiveness of agricultural research, and various stakeholders in the government and non-government sectors of the agricultural values chain (ICARDA, 2012 , Howard, 2015).

According to the Ministry of National Economy (MONE), Oman largely relies on international markets to assure food supply. It imported 44% of the food consumed, including more than 90% of cereals (rice and wheat) between 2005 and 2007 (MONE, 2011). Around 31% of the total income of household is on the expenditure of food and about 12% of the Omani households are classified as poor compared to 8% in 1999/2000 (MONE, 2010a).

1.2.1 Contribution of agriculture in Oman

Agriculture, in addition to being central to the provision of food and nutrition, provides employment opportunities for the population in rural areas, and can control migration to the cities thereby reducing pressure on facilities and services (FAO, 2006). Most governments aim for increased productivity and the use of improved modern agricultural technologies, improved varieties of plant and animal, better pre and post-harvest processes, and more efficient water use (Tielkes, 2008). Agriculture provides the basic essentials for living: food, cloths, materials, enhancing and improving country's infrastructure and can be linked to investment in environmentally sound practices (CObasi et al., 2013).

Table 1 demonstrates the annual contribution of agricultural exports and imports for some Arab Countries during the period 2012 to 2014 (AOAD, 2014).

Table 1:Value of Arab agricultural imports, exports and trade (1000R.O), 2012-2014

Year	2012			2013			2014		
Country	Imports	Exports	Trade	Imports	Exports	Trade	Imports	Exports	Trade
Jordan	268,789	409,226	678,015	316,227	754,675	1,070,902	174,315	493,198	667,513
Tunisia	62,151	161,495	223,646	64,314	150,427	214,741	91,242	128,636	219,878
Oman	267,070	128,851	395,921	353,179	291,876	645,055	400,522	279,145	679,667
Yemen	163,223	58,925	222,148	163,083	62,436	225,520	163,083	62,454	225,538

Source: Arab Organization for Agricultural Development (AOAD, 2014)

Table 2 and Table 3 clarify the value of Arab specific agricultural commodity importsand exports (1000 RO) during the period 2002 and 2014

Table 2: Value of Arab agricultural imports (1000 RO), 2012-2014

Country	Year	Cereals	Oil Seeds	Oil	Pulses	Roots	Veg.	Fruits	Life animals	Meat	Milk & dairy outputs	Sugar	Others
Jordan	2012	505	7,366	48,407	518	933	21,893	47,758	34,479	8,887	46,827	38,480	12,737
	2013	27,353	11,993	43,379	268	1,426	21,856	57,642	67,123	8,832	48,339	27,572	445
	2014	549	1,001	26,626	2,710	6,598	16,385	40,925	3,257	605	41,965	33,250	445
Tunisia	2012	1,148	7,655	549	171	803	3,041	1,526	15	117	537	783	45,806
	2013	653	9,077	629	130	-	2,198	1,442	-	44	528	330	49,282
	2014	969	10,275	1,172	887	32	2,613	748	-	163	1,045	21,577	51,760
Oman	2012	18,190	218	13,578	79	7,528	10,949	30,403	49,145	21,560	66,942	18,968	29,510
	2013	23,032	775	17,461	5,148	5,299	17,114	38,334	44,669	26,868	126,728	19,214	28,502
	2014	22,248	863	21,578	6,670	8,888	28,294	175,681	54,122	35,112	113,593	20,052	28,805
Yemen	2012	51,578	1,500	3,072	398	59	908	7,175	18,536	2,725	24,019	9,098	44,115
	2013	49,591	1,679	4,161	544	63	940	7,652	20,400	2,839	23,350	8,686	43,180
	2014	49,591	1,679	4,161	544	63	940	7,652	20,400	2,839	23,350	8,686	43,180

Source: Arab Organization for Agricultural Development (AOAD, 2014)

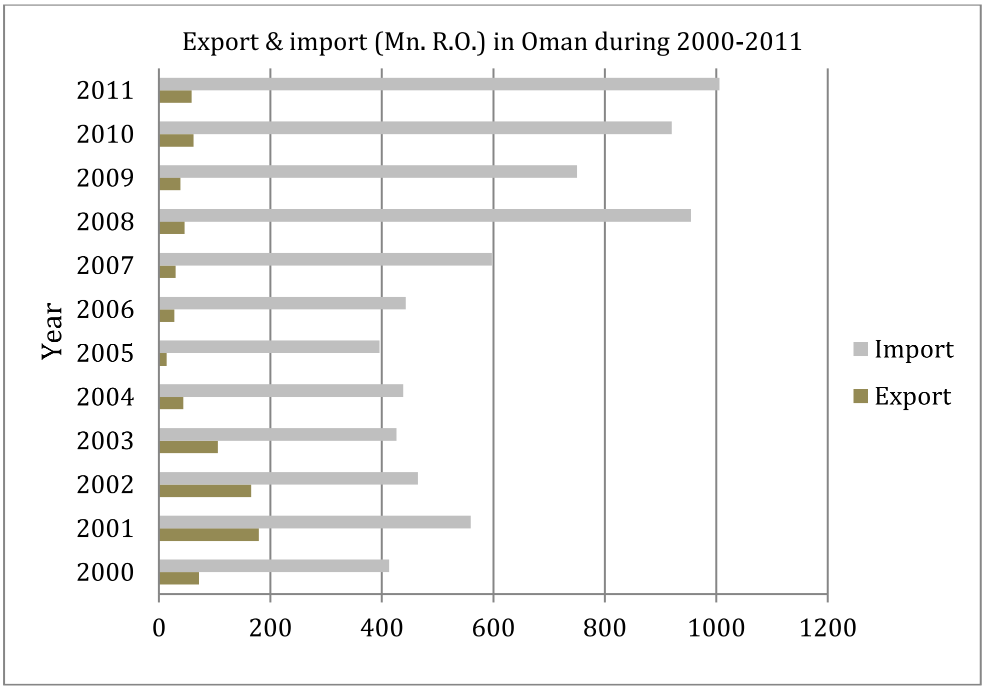
Table 3: Value of Arab Agricultural Exports (1000 R.O), 2012-2014

Country	year	Cereals	Oil Seeds	Oil	Pulses	Roots	Veg.	Fruits	Life animals	Meat	Milk and dairy products	Sugar	Others
Jordan	2012	-	585	7,809	2,105	1,637	147,880	67,296	53,075	3,839	12,369	-	112,630
	2013	1,081	161	5,149	2,699	2,715	164,705	57,642	9,038	8,832	48,339	-	444,583
	2014	3,928	-	3,323	2,940	2,752	219,798	42,837	73,172	5,640	13,349	-	125,459
Tunisia	2012	463	32	75,839	383	493	20,381	37,595	592	700	17,076	120	7,823
	2013	728	4	47,835	418	168	19,170	47,113	675	445	22,745	110	11,016
	2014	1,101	1,227	32,543	1,186	1,126	10,675	52,595	597	684	16,316	335	10,251
Oman	2012	2,442	-	1,384	31	-	20,038	2,715	9,919	38	86,121	17	6,146
	2013	71,049	-	69,507	-	116	15,786	6,033	6,464	33,764	87,402	193	1,562
	2014	27,002	-	79,367	2	44	19,180	5,003	21,527	19,162	101,828	393	5,598
Yemen	2012	7,082	77	1,132	29	29	3,900	10,516	-	26,273	3,187	924	5,777
	2013	6,912	82	1,167	34	28	4,267	10,727	-	28,123	3,272	1,226	6,597
	2014	6,912	82	1,167	34	28	4,267	10,727	-	28,123	3,272	1,226	6,597

Source: Arab Organization for Agricultural Development (AOAD, 2014)

Figure 1 demonstrates the contribution of agricultural trade in Oman during 2000-2011. From this figure, it is clear that the Sultanate of Oman relies on imports more than exports, and increasingly so over time. Given the definition of food security, this increasing dependence on imports suggests that Oman may be becoming less food secure, emphasising further the need for the country to improve its food security in part through a more dynamic and “modern” domestic agricultural sector.

Figure 1. Export & import (Mn. R.O.) in Oman during 2000-2011



Source: Central Bank of Oman (CBO, 2002, 2005, 2007, 2010, 2011)

Table 4 and Table 5 demonstrate the exports and imports of key agricultural output in Oman during the period from 2003 to 2013. Table 4 shows that in agricultural products, Oman imported more field crops such as wheat, maize and barley rather than vegetables, in part due to water requirements. The main agricultural crops that are exported to the border country (UAE) is alfalfa, in addition to, field and fruit (dates) crops.

Table 4: Imported of main agricultural products (tons) in Oman during 2003-2013

Type of product	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Garlic	193	267	275	91	87	94	266	115	117	77	110
Onions	21	66	60	66	73	62	282	65	169	226	705
Potatoes	1,750	251	254	947	904	613	1,001	397	227	180	384
Tomatoes	753	2,821	3,155	480	1,216	5,804	3,297	4,961	9,659	6,577	10,056
Wheat	15,157	12,545	10,263	8,833	6,034	14,108	3,243	2,854	6,221	1,867	0
Barley	5,456	296	74	3	3	0	231	602	409	165	17
Maize	374	8	3	1	158	979	2,720	4,944	2,413	98	0
Alfalfa	107,364	6,905	13,741	1,720	1,047	295	15	1,005	7,434	32,412	36,364
Dates	4,691	4,752	4,080	4,097	9,368	6,995	7,333	6,782	7,171	5,815	8,992
Meat, chicken	2,665	851	7,066	2,770	4,740	9,386	31,262	12,174	11,800	8,740	9,613
Meat livestock	2,854	11,602	10,645	13,992	9,427	10,341	7,589	7,610	6,652	6,236	4,569

Source: Organization for Economic Cooperation and Development (OECD) and Food Agriculture Organization (OECD/FAO, 2016)

Table 5: Exported of main agricultural products (tons) in Oman during 2003-2013

Type of product	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Garlic	193	267	275	91	87	94	266	115	117	77	110
Onions	21	66	60	66	73	62	282	65	169	226	705
Potatoes	1,750	251	254	947	904	613	1,001	397	227	180	384
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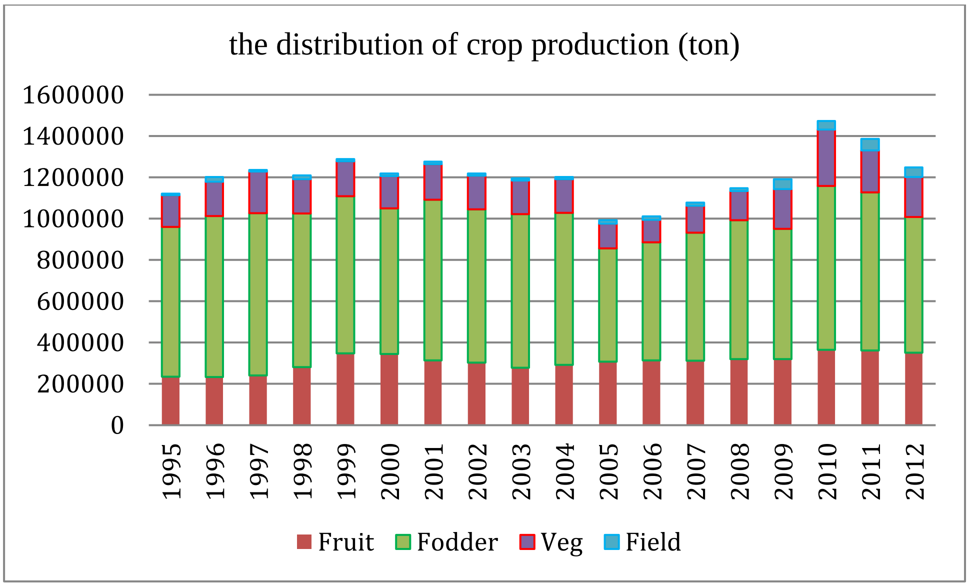
Wheat	15,157	12,545	10,263	8,833	6,034	14,108	3,243	2,854	6,221	1,867	0
Barley	5,456	296	74	3	3	0	231	602	409	165	17
Maize	374	8	3	1	158	979	2,720	4,944	2,413	98	0
Alfalfa	107,364	6,905	13,741	1,720	1,047	295	15	1,005	7,434	32,412	36,364
Dates	4,691	4,752	4,080	4,097	9,368	6,995	7,333	6,782	7,171	5,815	8,992
Meat, chicken	2,665	851	7,066	2,770	4,740	9,386	31,262	12,174	11,800	8,740	9,613
Meat livestock	2,854	11,602	10,645	13,992	9,427	10,341	7,589	7,610	6,652	6,236	4,569

Source: Organization for Economic Co-operation and Development (OECD) and Food Agriculture Organization (OECD/FAO, 2016)

In Oman, the agricultural sector continues to play an important role in providing livelihood to scores of people in the rural areas along with fisheries and poultry farming, which employ about 338,180 people, with close to 17 percent of total labour (AOAD, 2016). Recently Oman's agricultural sector has demonstrated good growth rates: agricultural GDP increased from 224.1 million OMR in 2014 to 236 million OMR in 2015, implying a growth rate of 5.8 percent (MOAF, 2015b). Agricultural exports increased by 0.84 %, from 233.06 million OMR in 2005 to 235 million OMR in 2014 (AOAD, 2016). Domestically the country is now able to provide around half the food requirements of the population: the proportion of self-sufficiency of vegetables is 68 percent; animal products 51 percent for red meat, 43 percent for poultry meat; 48 percent for eggs; and 51 percent for milk (MOAF, 2013b). These figures reflect efforts by public and private sectors in the establishment and implementation more than 18 food projects. However, over the longer term, there has been little evidence of a consistent growth in output (figure2).

Figure 2: Crop production (tons)

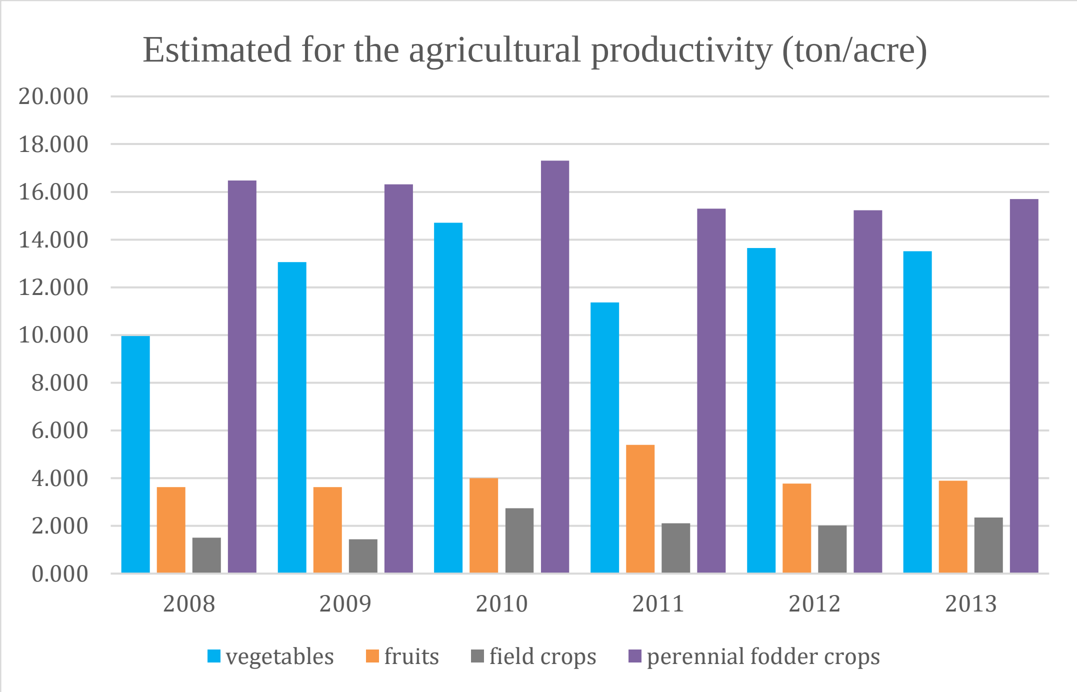


Source : (MOAF, 1997, 2000, 2003, 2006b, 2009, 2012)

1.3 Continuing low productivity in Oman

Agricultural productivity growth has been the subject matter of intense study over the last decades and is considered vital by the government to grow the sector at a sufficiently rapid rate to face the demand for food and raw materials resulting from steady population growth (Coelli and Rao, 2005). There are several factors that influence productivity such as weather (drought, rainfall, winds, salinity), the capacity of a given farm (water, fertiliser), farm management system, available of agricultural equipment and infrastructure in addition to the supply and demand in the market (Gornall et al., 2010). Figure 3 reveals the average agricultural productivity (ton per acre) in Oman.

Figure 3: Oman's agricultural productivity (ton/acre)



Source: Ministry of agriculture and fisheries (MOAF, 2009, 2012, 2014)

Figure 3 shows the productivity of crops during years 2008 through 2013. These data suggest that there has been little change in productivity across the different agricultural sectors, despite the emphasis of the government on encouraging new farm management approaches by farmers, including using new technology such as improved seeds, agricultural equipment, modern irrigation, and support for agricultural marketing in addition to the establishment of agricultural cooperatives (MOAF, 2014).

Oman has not been able to reach its potential in food production because of a lack of investment in agricultural equipment, the small scale of production, salinity in water and soil, and a challenging climate with much drought and wind (Ruane and Sonnino, 2011). The issue of food shortage is resulting in high food imports, and high prices (Dobermann et al., 2013). A key objective of the government of Oman is to produce healthy food, using more environmentally-friendly techniques which preserve soils and do not generate excessive pollution. This implies the use of farming practices which conserve (or enhance) the quality of soils and water. Soil conservation is one of the main issues addressed by exponents of sustainable agriculture. Although soil erosion and degradation are most acute in developing countries, they are a cause for concern world-wide (Fasoyiro and Taiwo, 2012). The government also is concerned with enhancing food security and the links between agriculture and social and economic heritage, agriculture's contribution to job creation and the stability of rural communities in the various governorates of the Sultanate (MOAF, 2013a).

1.4 Marketing challenges

Agricultural marketing is one of the final stages in the agricultural value chain, with agricultural produce transported from farm to consumers or manufactures and it's a key instrument in the agricultural sector development (Emmyson et al., 2015). Emmyson also mentioned that there are certain challenges and issues that encountered farmers according to physical access to markets; the markets structure; and skills and lack of experience in addition to lack of information and organization. The competition from foreign produce to local and monopoly from foreign sellers and buyers drive farmers forced to sell their produce cheaply and discontinuity in farming. Moreover, Omani farmer faces other difficulties, including the high cost of agricultural inputs such as seeds, fertilisers and other agricultural equipment, a specialisation in the post-harvest operations, and limited agricultural marketing (FAO, 2008). Non-application of various processes from farmers of pre and post-harvest, in pre-harvest such as irrigation, fertilisation, spraying and remove grass, and in post-harvest as washing, sorting, packing, cooling and transporting. In addition, lack organization in market because of the government absence and monitoring lack moreover the absence of laws and regulations that ensure unification of commodity prices (price index), especially major crops.

1.5 Motivation, objectives, and research questions

Three general observations stimulate this research. The first observation is that there are low rates of adoption of farm management practices being promoted by the government, in particular with relation to water and soil fertility management in rural Oman. Second is the observation in the literature that whether a farmer takes on new management practices is complex, and depends on farmers' opinions, perception and behavioural attitudes. Third, is the emphasis that the government has put on cooperatives as having a role in promoting the modernisation of the agricultural sector in Oman.

Thus the overarching objective of this thesis is to identify and improve understanding of constraints to farmers' modernisation of their agricultural management practices, so that the government can improve the agricultural policy environment and Oman's overall food production. To achieve this broad objective, a number of key research questions are asked. First, what are the challenges faced by smallholder farmers in Oman. Second, what are the key influences and influencers that lead farmers to use the modern technologies promoted by the government in their attempt to improve food security through self-sufficiency. Third, to what extent can and do agricultural cooperatives contribute to agricultural sector growth in Oman.

These research questions are complemented by a number of specific research hypotheses, that link directly to the quantitative analysis undertaken in the thesis. The first cluster of hypotheses tested addresses the extent to which farmers' use of inorganic fertiliser and modern irrigation is affected by attitudes, norms, and perceived behavioural controls. Thus the null hypothesis is that attitudes, norms, and perceived behavioural controls do not affect farmers' adoption of inorganic fertiliser and modern irrigation. The second cluster of hypotheses tested addresses the extent to which farmers in cooperatives and non-cooperatives differ with respect attitudes towards and adoption of these technologies. The null hypothesis tested is that farmers belonging to cooperatives and those not belonging to cooperatives have similar attitudes toward benefits of inorganic fertiliser and modern irrigation.

The first cluster of hypotheses is motivated by the literature, as detailed in the following section, in which there is evidence that individuals' decisions to adopt technology depend on more than the characteristics of the technology itself and the characteristics of the individual. That is, the decision of an individual as to whether to adopt a new technology may also be influenced by the broader environment in which the individual is living, and specifically the attitudes and actions of people in the community whose opinion the individual values. The second cluster of hypotheses is motivated by the specific situation in Oman. The number of agricultural cooperatives in the country has declined considerably, as detailed in Chapter 3. Yet the government is looking to introduce new cooperatives. It is therefore instructive, in the context of this thesis, to explore whether farmers in cooperatives have different attitudes, norms, and beliefs with respect to modern technologies, from those farmers not in cooperatives.

1.6 Understanding why farmers adopt new technologies

This section explores how understanding of adoption of agricultural technologies has evolved in the literature. According to Rogers (1962) adoption at the individual farmer level is defined as the use of modern agricultural technology in the long-run equilibrium when the farmer has information on the potential of this technology (1962). This definition is compatible with Morton and Schwartz (1975) and (Feder et al., 1985), and similar to Kilima et al. (2010), which defines adoption as a process where potential adopters go through technical evaluation of the technology in relation to the economic and social factors associated with using the technology. Some technologies are continuously modified, for example, modern techniques in irrigation. However, in most instances, agricultural technologies are presented in packages that contain numerous components such new varieties, fertilisers, and agricultural practices.

Doss (2006) demonstrated that defining adoption might be further complicated by the complexity of defining the technology being adopted. In defining adoption, the first thing is to consider whether adoption is discrete with binary variables or whether adoption is continuous. There are many research use measures of the proportion of land allocated to new technologies as the adoption measure. Many studies use a simple dichotomous variable approach, for example, a farmer maybe defined as adopter if (s)he found to be growing any improved materials. This method is most appropriate and fitting to when farmers typically plant either local variables or improved varieties such as a wholly new crop adoption, or when the practice of management is cannot be particularly implemented. The first research using modern technologies in agriculture understood the hybrid corn seed adoption in the US by Ryan and Gross (1943) and how this crop came to attention and which led farmers to adopt the new technologies. Rogers (1958) built upon Ryan and Gross's classification of adopters, and divided adopters of an innovation into five categories: innovators, early adopters, early majority, late majority and laggards.

Understanding and evaluating technology adoption has evolved considerably over the past decades (Tamrat, 2007, Hall et al., 2009, Johnson et al., 2010, Sulo et al., 2012). Feder et al. (1985) found that farms with be best physical environmental typically exhibited the highest adoption rates. The quality of soil and water increase the expected utility from adopting new technologies and therefore increase the likelihood of a farmer introducing the technology.

Feder et al. (1985) suggest that farmers' adoption of a new technology, such as improved maize seeds, is a choice between traditional and new technology. Farmers' decisions to adopt or not to adopt are have been found to be based on the profitability and risk associated with the new technology. Before adoption, farmers have to be assured of the expected marginal gains and associated risk. The farmers' concern with marginal gains and risk in turn affects the adoption of the new technology. Kaliba et al. (2000) found that farmers are typically risk averse and follow a technological ladder in the process of adoption. They adopt the more simple components and then move to complex ones, and from cheaper to costlier technologies, and this process allows farmers to evaluate available alternatives sequentially and incrementally.

Pannell et al. (2006) suggest that agricultural technology adoption depends on a combination of personal, social, cultural and economic factors, as well as on the characteristics of the innovation itself. Prokopy et al. (2008) shows that education levels, capital, income, farm size, access to information, positive environmental attitudes, environmental awareness and utlilisation of social networks are generally positively, associated with the adoption of best management practices. Miller and Tolley (1989) show that market interventions such as price supports can increase the adoption of new technologies.

Numerous more recent studies continue to attempt to understand and explain adoption of new agricultural technology. Many of these in the past have focused on farmer, farm, and farm productivity characteristics. For example, irrigation and soil fertility may be linked though the evidence is mixed (Gebregziabher and Holden, 2011). Farmers may not invest in using modern technology if the harvest is not profitable (Yilma and Berger, 2006). Coughenour and Chamala (2007) found the use of modern technology to be higher in vegetables. Imoru and Ayamga (2015) in their study found that older farmers are more conformist and less likely to adopt modern technology in agriculture because of a lack of knowledge and fear of the risks associated with these new technologies. Aregay and Minjuan (2012) explore the impact of household size on technology adoption, highlighting how a larger family requires a greater output to meet the needs of the family, and has more available labour that can reduce the total input costs. Some studies found out that permanent workers of farm have positive impact on inorganic fertiliser and modern irrigation use (Hurst et al., 2005). Conversely, farmers may be tempted to address a shortage of labour due perhaps to a lack of permanent workers through the application and use of modern technology (Yilma and Berger, 2006); or farmers may perceive that permanent workers lack the necessary skills to apply inorganic fertilisers and modern irrigation (Visser and Ferrer, 2015). Several studies have suggested that the more educated a farmer is the more he or she will use and adopt modern agricultural inputs (Croppenstedt et al., 2003). Karim et al. (1990) demonstrated that the fertiliser uses in the agricultural sector increases with the improvement in the quality of road. Yet studies such as these typically cannot offer useful guidance to policy makers as to how to increase the use of modern technologies that can help a country such as Oman to increase overall food production.

Wauters and Mathijs (2013) suggest that farmers motivated by conservation may increase their desire to adopt such practices. Yet attitudes towards specific practices have not been investigated in the agricultural economics literature as much as in other fields such as sustainable food consumption (e.g. Saba and Vassallo (2002), (Vermeir and Verbeke, 2008), leisure choice (Ajzen, 1991, Conner and McMillan, 1999), and health behaviour (Sheeran et al., 2001). Where the literature has been developed, some is directed towards environmental issues rather than dealing with farmers' attitudes, or towards specific issues such as pesticides use (Wauters and Mathijs, 2013). Burton (2004), Sambodo and Nuthall (2010) demonstrate that understanding rural attitudes improves understanding of technology adoption choices.

Staub and Blase (1974) found that numerous empirical studies noted and found out that the use of technology has a role in alleviation and reducing the agricultural operations performed and carried out by the farmer, particularly on massive farms with the emergence of demand significantly, for example, e.g. Greene (1973) reported that overcome to small size of holdings in Thailand by hiring and using of technology services in the beginning same as large farms), in addition, Mlote et al. (2013) similarly find that technology adoption is influenced by perceptions of technology attributes including benefits derived from the technology's use. Tey and Brindal (2012) emphasized that there are factors affecting the agricultural technologies: socio-economic, agro-ecologies (land, farmland size, farm management, farming system), informational and institutional factors, in addition to perception and behaviour of farmers and technologies factors.

In contrast, Yang and Fang (2015) suggest that farmers' knowledge of agricultural practices and where it comes from is crucial in understanding why they adopt new technologies. Knowledge is often created by a combination of education and experience and farmers use their broadly-gained knowledge to arrive at decisions that influence agricultural management practices. Furthermore, an understanding of farmers' knowledge is useful for understanding changes that occur in the landscape at a local level, especially the terms of changes in land-use and cultural practices.

Considerable attention has been paid in the literature to the adoption of organic fertiliser and organic farming practices in general. FAO (2002) finds that organic agriculture adoption permits farmers to obtain access to the fastest growing sector of the international food market and obtain a premium price for their produce. Lee (2005), (Badgley et al., 2007, Scialabba, 2007, Schoonbeek et al., 2013, Wollni and Andersson, 2014, Ayuya et al., 2015), in addition to economic aspects, identify additional factors that might influence the willingness of farmers in lower-income countries to adopt organic farming including reducing soil degradation, conservation of natural resources, food self-sufficiency and sustainable rural development. Additional literature addressing the adoption of organic farming includes Issa (2016), (Darnhofer et al., 2005, Kallas et al., 2010, Khaledi et al., 2010, Lapple and Kelley, 2010, Iliopoulou et al., 2011, Latruffe et al., 2013, Delbridge, 2014).

1.6.1 Perceptions, attitudes and beliefs

Perception, attitudes, beliefs, values, intentions and behaviour are sometimes used interchangeably. Homer and Kahle (1988) demonstrated that behavioural factors can be used to understand farmers' psychology, and these factors may play a particularly important role in decision making when an innovation does not offer direct benefits.

Calkins and Thant (2011) illustrate that intention has been assumed to the process of adaptive decision making, especially with regard to environmental related behaviours. Calkins and Thant (2011) illustrate that intention has been assumed to be part of the process of adaptive decision making, especially with regard to environmental related behaviours. There have been a number of studies examining the factors that influence farmers' attitudes and behaviour with regard to the adoption of technology. These are frequently based on social psychology models using a defined framework to provide a thorough understanding of the attitudes and behaviour behind the motivation to adopt. Early papers that have addressed such issues include Homer and Kahle (1988), who demonstrated that behavioural factors are used to understand the farmers' psychology, and these factors play particularly important role in decision making when an innovation does not offer direct benefits. Ajzen (1991) demonstrated that intention can be represented either by an ordinal variable of likelihood or a dummy variable of willingness to adopt agricultural technologies. This can depend on non-motivational factors, for example, time and financial liquidity. Sunding and Zilberman (2001) explore issues of control over behaviour.

1.6.2 Theory of planned behaviour and the adoption literature

The theory of reasoned action (TRA) and theory of planned behaviour (TPB) have been used to understand and predict individual behaviours. These theories and models focus on people's intention to engage in a certain behaviour such as the adoption and use of new technologies. The theory of planned behaviour has been applied to various studies in varied sectors to study consumer behaviour such as Effects of Perceived Behavioural Control on the Consumer Usage Intention of E-coupons. Sparks et al. (1992) and used TPB in evaluating the role of identification with '' green consumerism'', Godin et al. (1992) in the predictors of smoking behaviour , Bhattacherjee (2000) in acceptance e-commerce services in brokerages , in addition, Tonglet et al. (2004) used TPB in investigating the determinants or recycling behaviour in Brixworth, UK. Various Cross- cultural studies have been conducted to show that theory of planned behaviour can be applied to explain behaviour intentions in both Eastern and Western cultures. In Indian context, some of the researchers adopted this TPB model to study environmentally sustainable products (Kumar, 2012), Bond et al. (2009) used in understanding farmers' pesticide use in India.

TRA and TPB in agricultural technology research includes studies that examine the factors that influence farmers' attitudes and behaviour with regard to the adoption and use of technology. These are frequently based on social psychology models using a defined framework to provide a thorough understanding of the attitudes and behaviour behind the motivation to adopt. For example, Garforth et al. (2006) used the theory of reasoned action to explore dairy cow farmers' attitudes to a new technology. They found that farmers did not adopt the recommended technologies because they trusted their own expertise and that of their vets. Farmers attitudes had a strong influence on intentions to adopt.

In this vein, this thesis applies the Theory of Planned Behaviour (TPB) which is used to understand and predict individual behaviours to explore, understand, and explain why farmers are, or are not, willing to participate in modern management practices with respect to water management and soil fertility. This theory is an extension of the theory of reasonable action (TRA) carried out by Icek Ajzen in 1985. The TRA is based on two considerations, the attitude towards behaviour, and the criterion of personal (Ajzen and Fishbein, 1980). The first consideration is individual nature and is dealing with personal feeling. This means, there is a pro and con evaluation of the farmer's behaviour. The second factor is dealing with social pressure that influences the farmer whether to perform or not perform an action. Ajzen added perceived behavioural control: that self-efficacy and the ability of an individual's behavioural and beliefs are determined by the power of investigation and achievement of the behaviour (Ajzen, 2006).

The theory of planned behaviour suggests that adoption decisions are influenced across three key elements: behavioural beliefs (attitudes towards the technology); subjective norms (social pressure through the adoption decisions of others), and control beliefs (reasons or circumstances that make it difficult or easy to adopt the technology). TPB explores these issues quantitatively, representing the strengths of each of these dimensions as numbers. In summary, according to the theory, human behaviour is guided by three kinds of considerations: beliefs about the likely outcomes of the behaviour and the evaluations of these outcomes, beliefs about the normative expectations of others and motivation to comply with these expectations, and beliefs about the presence of factors that may ease or obstruct performance of the behaviour and the perceived power of these factors.

Additionally, each determinant may be measured indirectly (Francis et al., 2004). The attitudinal construct may be measured from two components including: beliefs about consequences of the behaviour (behavioural beliefs) and the corresponding judgments about these consequences (outcome evaluations). Subjective norms may be measured from beliefs about how other people who are considered important to the person would like them to behave (normative beliefs) and the motivation to comply with those normative beliefs (motivation to comply). The perceived behavioural control also has two components: beliefs about factors that make it ease or difficult to perform the behaviour (control beliefs) and the corresponding power of these factors to influence the behaviour (influence of control beliefs).

Attitude towards the behaviour is based on the person‘s belief that the behaviour will lead to certain outcomes. The person will evaluate outcomes as to whether it is for or against that behaviour. The person‘s perceptions may be influenced by family members and friends who are likely to think about the behaviour and the extent of the person to comply with others. Subjective norm refers to the person‘s subjective judgment for a given behaviour. The concept of behaviour intention states that an individual‘s motivation to engage in behaviour is defined by that individual‘s attitudes and beliefs. It also indicates the level of commitment of a person to perform such behaviour; that is, the higher the commitment, the more likely is the person to perform the behaviour. Perceived behavioural control refers to a person‘s perceptions of how easy or difficult it is to engage in the particular behaviour. It addresses both internal control (e.g., person‘s abilities) and external constraints (e.g., opportunities) needed to perform the behaviour (Ajzen, 1991).

TPB is one of the most influential and the popular social-psychological model for explaining and forecasting human behaviour in specific conducts. In order to understand different behaviour, many researchers have applied the TPB in varied situations to explain the agricultural technologies. For example, a study conducted by the use of TPB to figure out the importance of agricultural information in utilization for successful farming and the constraints that influence the low productivity of farmers using this technology by rural farmers. This condition might be according to the traditional beliefs of farmers, social pressure and lack of communication channels. Lynne et al. (1995) used and applied this theory to calculate and predict adoption of water saving technology and technology investment behaviour for Florida strawberry farmers. This study emphasised the perceived behavioural control has a role and a significant influence in the agricultural decision-making in addition to the actual control. Evgenia. (2013) applied the TPB to figure out the influence of financial policy decision of the Greek in the sustainability growing vine. This study illustrated the strategies to enhance social change as the provision of channels and local marketing outlets, as well as facilitating access to decision-making centres. Moreover, Lapple and Kelley (2010) illustrated that the consideration of the conservation behaviour of farmers, attitude of environment is a significant to understand the behavioural adoption. One example, Defrancesco et al. (2008) disclosed that opinions of farmers with respect to practices of environmentally friendly have a significant impact on the technology adoption. Areal et al. (2012) demonstrated the genetically modified herbicide tolerant (GMHT) adoption maize and oilseed rape in European Union (EU). This study concluded that a positive attitude towards the use of new technology as GMHT crops adoption include financial liquidity of farmers, ease of use and environmental benefits. In addition, large-holding farmers are more likely to consider GMHT adoption crops than smallholder. Some authors have also reported on economic issues to explain adoption of technology in farming. Grant et al. (2006) clarified that the more favourable an individual performing a particular behaviour, the more likely he or she will intent to perform the behaviour. Furthermore, Wang and Ritchie (2012) suggest that TPB is useful to test psychological factors because it not only covers most of these psychological factors, but also helps to identify the determinants of behaviour.

Some authors explain the important of using TPB in technology such as for online learning, for example, Knabe (2012) to understand public relations faculty intentions of teaching online. This study reveals that subjective norms were the strongest influence of intention. In addition, there were no significant relationships between the demographic variables as age, gender and past experience teaching public relations and intentions to teach a public relations course online, as well as continued research and highlighting in this field by both academics furthering the TPB and institutional leadership trying to make technological advances. While, Greaves et al. (2013) use this theory to determine the intention of environmental behaviour in the workplace. This study demonstrates the influence of previous beliefs of TPB (behaviour beliefs, normative beliefs and control beliefs) to understand more clearly the behavioural intention and why employees engage or not engage in particular environmental behaviour. Furthermore, this study might be useful in the application of regulatory environments to determine how employees can participate in the organization 's efforts to become more environmentally sustainable.

Some scholars claim that the theory of planned behaviour is based on cognitive processing and have criticised the theory on those grounds. However, there is nothing in the theory that states that attitudes are formed consciously or that evaluation of beliefs, for example is not influenced by emotion. The theory says nothing about where beliefs and their evaluations come from (Costa Font, 2011), hence claims that it excludes emotion are without foundation. Nevertheless, critics continue to make these complaints. Clearly, many behaviours may be largely influenced by emotion. However, this is not necessarily a drawback for predicting these behaviours, contrary to some complaints. Strong emotions are relevant to this model because they can influence beliefs and other constructs in this model. Poor predictability for health-related behaviour in previous health research may be attributed to poor application of the model, associated methods and measures.

In this thesis, this TPB exercise is undertaken both for farmers who are part of a cooperative and those who are not. In doing so this study also can contribute to the improvement of the Omani agriculture sector by shedding light on whether and how agricultural cooperatives can and do contribute to agricultural intensification through greater adoption of modern technologies and management approaches. The study identifies and explores smallholder farmers' perceptions of modern farming approaches, particularly the use of modern irrigation systems; how soil fertility is managed; agricultural mechanization; and improved breeding crops; to identify the factors influencing farmers' choices to participate in upgrading their agricultural technology, and whether farmers in cooperatives make different choices, and why.

A number of distinct analyses are undertaken. First is a qualitative analysis of the farmers' characteristics in the areas of study, in order to form the general background of the study and describe the study areas, demographic of farmer and socio-economic characteristics. Second is an assessment of government perceptions on approaches to and the benefits of supporting agricultural cooperatives. Third, an in-depth analysis of farmer's perceptions, subjective norms, and behaviour controls, of using new agricultural technology.

The theory of planned behaviour suggests that adoption decisions are influenced across three key dimensions: behavioural beliefs (attitudes towards the technology); subjective norms (social pressure through the adoption decisions of others), and control beliefs (reasons or circumstances that make it difficult or easy to adopt the technology). TPB explores these issues quantitatively, representing the strengths of each of these as numbers. TPB clarifies to understanding and explanation of human behaviour, and processes involving humans and their actions; Prediction of such behaviours and processes, for purposes of planning or commerce; and find out the Solution of problems that face society, and can be mitigated through knowledge of human behaviour. In general, the more positive an individual performing a particular behaviour, the more probable will intent to perform the behaviour (Grant et al., 2006). Furthermore, Wang and Ritchie suggested that TPB is useful to test psychological factors because it not only covers most of these psychological factors, but also helps to identify the determinants of behaviour (2012).

Behaviour intention is the capability personality indication to perform a given behaviour. This intention is based on attitude towards behaviour (A), subjective norm (SN) and perceived behavioural control (PBC). In addition, it aims to understand all probability indicators for it’s important in the relation to the behaviour. In the behaviour intention, the researcher asks questions, for example: do you intend to plant perennial or annual crops this year? will you continue in the future in agricultural activities?

Many applications of the TPB regress the general constructs on the behavioural measure to assess their relative contribution to behavioural prediction. Such analysis is valuable and meaningful where the general and behavioural measures are similar—for example, six or seven-point likelihood scales.

The main theoretical framework used to evaluate farmers’ willingness to use modern agricultural technology is that of the Theory of Planned Behaviour (TPB). A behavioural theory was chosen as an appropriate method based on the suggestion of Howley et al.

(2012) that behavioural methods are adequate for analysis agricultural issues. Between several behavioural theoretical frameworks that were examined, the Theory of Planned Behaviour, which is explained in detail in Chapter (4), was chosen in particular because: (i) It provides a structured approach to both qualitative and quantitative methods of analysis; (ii) It incorporates perception of factors that are beyond the individuals' power that can significantly affect their decision making; and (iii) It is flexible in incorporating additional factors to the model without diminishing the importance of its three main behavioural factors (attitude, norms and control).

1.7 Thesis outline

This chapter has provided a brief overview of agriculture in Oman, and a general background of the thesis, highlighting the continuing low productivity in the country, and setting out the thesis, motivation, objectives and research questions. The rest of the thesis is as follows. Chapter two demonstrates the state and development of agriculture in the Sultanate, in particular key challenges and potential opportunities. It emphasises issues that are central to constraining the development of the agricultural sector: lack in water, salinity of water and soils, degradation of agricultural land, and crawling population. Chapter three focuses on agricultural cooperatives in Oman. This chapter looks at the theoretical rationales for agricultural cooperatives and explores the rationale for cooperatives in Oman and why so few have lasted. Chapter four provides detail of the central methodological approach taken in this thesis, in particular the theory of planned behaviour, and how it is applied and analysed. It describes both the secondary data and primary data collection, including unstructured interviews with key government officials and individuals currently involved in the remaining cooperatives to produce a case study narrative. Chapter five presents key insights into farmers' attitudes, norms, and behaviours, with respect to the adoption of modern irrigation and inorganic fertiliser, through a qualitative approach, using Nvivo to analyse the transcripts of a set of semi-structured interviews. As such, the chapter provides novel insights into the theory of planned behaviour (TPB) using qualitative methods. Building on this, Chapter six presents a rigorous quantitative analysis, using the theory of planned behaviour, to provide insights into what influences farmers to use modern irrigation and inorganic fertiliser and the differences between farmers who are members of the Al-Batinah cooperative and those that are not. This chapter considers in detail each variable of TPB and their influence in the adoption of inorganic fertiliser and modern irrigation. The thesis concludes in Chapter seven.

Chapter 2 Challenges and opportunities in Oman's agricultural sector

2.1 Introduction

There are many issues and problems faced farmers in the world. Some of these problems may have a short-term impact, while the other may be going on for a long time. The current problems facing farmers in Oman include small farms; low uptake of inorganic fertiliser, insecticide, herbicides and pesticides; lack of modern water irrigation; water and soil salinization; soil erosion; high temperature/humidity; poor agricultural marketing; renting land to foreigners; and the rising prices of production inputs. Other issues that have been identified include farmers' willingness to continue in agriculture and education and skills (Benckiser and Schnell, 2006). This chapter highlights some of the key challenges and constraints encountered farmers and the agriculture sector in the Sultanate of Oman.

According to the geographic of the Sultanate, there are two types of farming system in Oman (MOAF, 2014): the coastal plains intensive farming system; and mountain system. The coastal plains intensive farming system contributes a very high share of its specialized products, particularly field fodder crops, vegetables and greenhouse crops. The specialisation in crops under free market arrangements (greenhouses, field vegetables and fodder crops) are specific characteristics, as are the extremely good infrastructure for input supply and market access and the high importance of off-farm employment across the farm size classes. The larger holdings are oriented towards vegetables and fodder crops cultivation for their economies of scale and calculable return due to fixed prices.

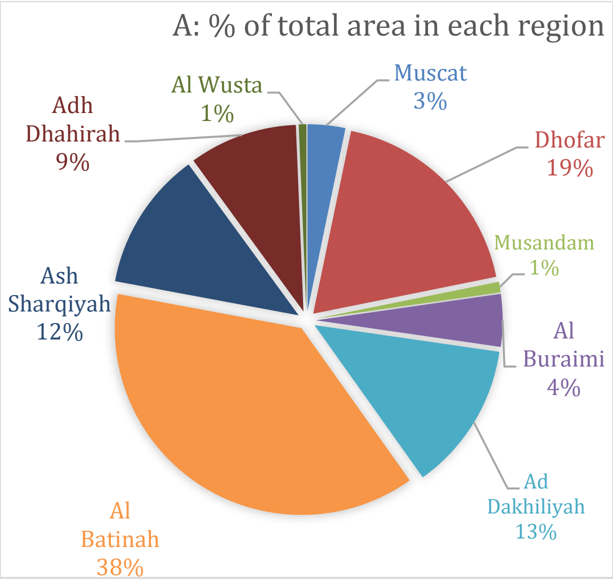
In the aflaj and mountains farming system, lower annual rainfall with relatively little variability, sloping terrain, and a high share of perennials crops (fruits and fodder) characterize the system. Basic farming systems characteristics are the smallholder structure based on tree crops, with a high reliance on off-farm income and little livestock presence particularly in the aflaj areas due to lack of grazing areas. However, the number of livestock has increased somewhat (Table 6). Limiting production factors are the small holding sizes on slopes with narrow areas on shallow agricultural soil and the reliance on rainfall for the dominant perennials (mostly palm, citrus and mango trees). In the mountainous and downhill farming systems, agricultural remains vital to the livelihood of many families, despite the importance of non-agricultural income. According to the census of agriculture 201/2013, 90 percent of Oman's farm holdings equal or less than two hectare(MOAF, 2013b).

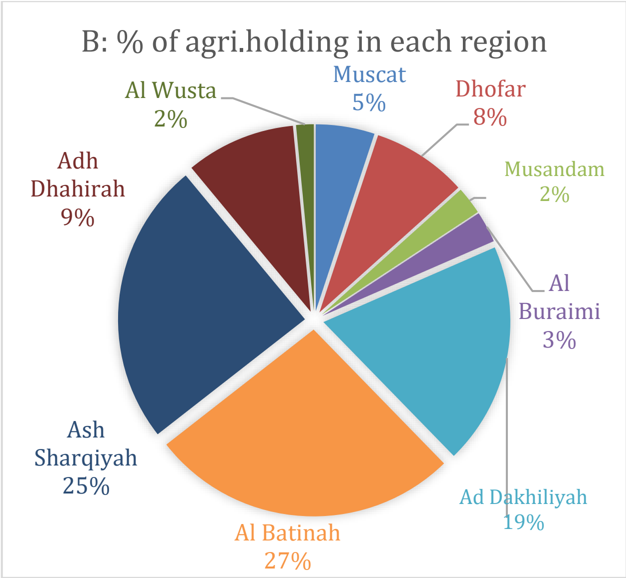
Oman's agricultural sector is particularly challenged by water shortage, water salinity, and poor soil quality and soil erosion, but also by weak markets. Common farming practices in intensive agriculture can be serious causes of water and soil quality degradation, depending on the interaction between physical vulnerability of the farmland and farmers' behaviours in practicing farming. Al-Batinah region suffers from a proliferation of weeds. Many crops suffer from pests and agricultural diseases particularly Dobbas and palm weevil (MOAF, 2014). However, relevant information is highly limited in Oman.

Many farming families in Oman are involved in subsistence farming in which family requirements determine the scale of production. Traditionally, many families have cultivated small areas in mountain and aflaj areas using a watering channel. Family farming uses mainly family labour which could be increased with slight hiring of labour and labour exchanges with other farmers at peak seasons. The provision of land, water, labour in addition to the capital of the basic and crucial factors of production within the household.

Mountains and deserts represented about 97 percent of the total area of the Sultanate, while, the remaining (3 percent) is distributed between the coastal plains of Al-Batinah in the north, Salalah in the south, and the interior plains (MOI, 2016). The Ministry of Agriculture and Fisheries carried out a survey in 1990 which revealed that only about 7.4 percent of the total area of Oman is suitable for agricultural production (FAO, 2012b). The results of agricultural census 2012/2013 showed that the cultivated area is even less than this at 355 thousand acres (<1% of the total land area) of which 38 percent is in the Al-Batinah region (producing almost 60% of the total agricultural production in the country) and the remaining percentage is distributed across the other regions (MOAF, 2013b), see Figure 4.

Figure 4 : Percentage of total area and agri. holdings in each region in the Sultanate





Source: agricultural census, Ministry of Agriculture and Fisheries (MOAF, 2013b)

Table 6: Number of holding reporting livestock and total number of animals by type of animal in agri. census 2004/5 and 2012/3

Agri. census	2004/5		2012/3	
Types of livestock	No. of holdings	No. of animals	No. of holdings	No. of animals
Cattle	40,861	301,558	30,389	359,507
Camels	14,947	117,299	18,048	242,833
Goats	69,940	1,557,148	64,707	2,085,206
Sheep	28,398	351,066	33,356	548,231

Source: agricultural census, Ministry of Agriculture and Fisheries (MOAF, 2005, 2013b)

There are many challenges associated with the global toll on food security which have contributed to the lack of development in the agricultural sector in the Sultanate of Oman (FAO, 2008). Development of Oman's agricultural sector is also constrained by lack of improved seeds, use of traditional inputs, inappropriate cultural practices, cropping patterns and use of chemicals, and outbreak of plant and animal pests and diseases, which have resulted in low crop and animal productivity. Moreover, the weak extension system and the limited marketing and post-harvest as well as the lack of infrastructure have been identified as key problems for the sector (MOAF, 2015b). Agricultural development in Oman is also facing constraints resulting from relatively limited current capacities of MOAF to design and implementation development strategies and agricultural policies. The rest of this chapter details some of the key challenges and potential opportunities for this sector. Section 2.3 concludes.

2.2 Key challenges and potential opportunities

A growing population and changing food consumption patterns are predicted to increase demand for food production in Oman. Irrigated agriculture is a crucial component of agriculture, and the area of irrigated land is increasing across the glove (Howell, 2001); Stevens, 2007). Yet in Oman the expansion of irrigated agriculture has historically been limited due a challenging climate, particularly a scarcity of water (Zhou et al., 2010). The government, whilst aiming to increase food production therefore needs to consider issues such as the environmental impacts of irrigated agriculture, insufficient water, and indigenous water rights, in addition to other issues including poor quality soil, isolation and distance from the markets centres, as well as lack in skills and knowledge of workers (Dobermann et al., 2013).

The use of modern irrigation and inorganic fertilisers, as part of a package of technologies and management practices, are seen as important elements for raising productivity and farmer income. These two technologies were mentioned by farmers during the qualitative field work, and raised during discussions of soil fertility with farmers and key informants. Farmers appeared to agree on the benefits of irrigation with respect to increasing production; but there was less of a consensus with respect to inorganic fertiliser and its links to soil fertility.

Given the concerns over water and soil quality and availability of water, these two technologies appear to provide an interesting case study to explore the role of attitudes, social norms, and behavioural controls in the adoption of agricultural technologies, one for which there appears consensus over its benefits, and the other where qualitative fieldwork suggested that opinions were divided. The technologies link directly to water and soil management, which have been described as key tools to stimulate economic growth and rural development through more efficient and sustainable agricultural production (Dyck, 2012).

A number of constraints and barriers are the challenges facing the government and many states worldwide in the development and increased production within the agricultural sector. Here a number of challenges for Oman's agriculture sector are outlined.

2.2.1 Water shortages and water management options

Water is essential for socio-economic development and for maintaining healthy ecosystems. As population increases and development calls for increased allocations of groundwater and surface water for the domestic, agricultural and industrial sectors (Al Mamary and Al Kalabani, 2010). Oman lies in an arid and semi-arid region, where water scarcity is an important reality, and limited water resource is by far the major constraint for expansion of agricultural production in Oman. Except for Dhofar mountains, which enjoy a tropical monsoon climate, the rest of the country is characterized by a subtropical desert climate. Crop production therefore has to depend entirely on irrigation from wells (312 thousand acres[1]) and aflaj (47.4 thousand acres) (MOAF, 2013b). Aflaj, singular falaj, is a canal system dug in the earth and flowing with water (aflaj water source is groundwater found in the subsoil or valleys), which provides to the farmers' community for domestic and agricultural use (MRMWR, 2010). Even with an additional 8 million cubic meters (MCM) daily from desalinization and 30 MCM annually from sewage treated water, the national total available water estimated at 1048.9 MCM annually falls short by 381.92 MCM of the total water used (1430.22 MCM), and the deficit exceeds recharge by about 25%. Agriculture accounts for about 92 percent of total water use(MRMWR, 2013). Over-pumping of into new areas.

One acre=4200sq. meters [1]

Water management is a vital eelement of irrigated crop production. Both efficient irrigation systems and management of water practices may assist increase farm profitability and reduce higher cost supplies of water Hemdan (2014). Improved water management is seen as a key opportunity for Oman's agriculture sector. There are two key types of irrigation systems that Omani farmers use in farming: the traditional irrigation system (using water canals that come from mountains) and modern irrigation system (using technology and water from wells). According to the agricultural census results 2012/2013, 163 thousand acres (99 thousand traditional and 64 thousand modern irrigation) are irrigated in the Sultanate (MOAF)(Table 7). The government has encouraged the use of modern irrigation, yet to date there has been insufficient adoption, despite the new technologies being known.

Table 7 : Distribution of cropped area (acres) by irrigation system

Irrigation system	Perennial forage crops		Dates and other fruit trees		Veg. crops		Field crops		Total	
	area	%	area	%	area	%	area	%	area	%
Traditional	5288	3.2	10578	6.5	21848	13.4	61406	37.7	99120	60.8
Modern	22287	13.7	2824	1.7	26902	16.5	11913	7.3	63926	39.2
Total	27575	16.9	13402	8.2	48750	29.9	73319	45.0	163046	100

Source: agricultural census (MOAF, 2013b)

The main traditional (flood) irrigation method is called 'falaj' which is a system that uses water canals where water flows from the source in the mountains, relying on gravity. This method is used for distributing water for domestic uses and for animals and crops irrigation. In the past using traditional irrigation helped in spreading green areas all around Oman. The water coming from the falaj is distributed between people in the Omani villages based on shares that are sold or leased to people by the 'Areef' (director of the falaj) who also holds responsibility for the maintenance of the falaj through the money he gets from people (Al-ghafri et al., 2001). These shares are measured in units of time spent watering. Farmers can buy the shares that they consider enough for their lands from the Areef or from other farmers who have more shares. This system is still being used all around Oman. However, using traditional irrigation methods in agriculture causes frequent wastage of water aflaj and wells, high evaporation and leakage.

Modern irrigation systems help to reduce water consumption, and increase the level of ground water, compared with using traditional irrigation systems, and so increase water efficiency, production, and economic output (Al Mamary and Al Kalabani, 2010). There are different types of modern irrigation that farmers use to irrigate their crops, such as sprinkler irrigation which is used in fodder and field crops. A fountain or bubbler irrigation is a system used to water perennial and permanent crops (trees), whereas drip irrigation is used to irrigate vegetables and legumes. The 2012/2013 agricultural census showed that the modern irrigation system is used to irrigate around 64 thousand acre (18%) of the total area of agricultural lands in Oman (MOAF).

Most of the wells that use modern irrigation system belong to individual farmers who individually adopt modern irrigation. Modern irrigation is widely used nowadays by many farmers, with many benefiting from programmes from the government to introduce modern irrigation into traditionally irrigated aflaj areas. The government's own findings suggest that its programmes have had a positive impact on farmers' awareness and knowledge of better ways for more efficiency in agriculture. Figure 5 demonstrates the developing traditional irrigation in aflaj areas using modern irrigation. The government found increased in productivity through the use of greenhouses and crop breeding, and an increase in production per unit area of agricultural land crops that require irrigation like tomatoes, cucumbers, sweet peppers. Moreover, the government reports that improved irrigation has an impact on other areas such as reducing water consumption, increasing farmers' household income, increasing the availability of crops in local markets, as well as contributing to increasing total output (MOAF, 2011). The technology may well have a postive impact on livelihoods and the environment. Yet adoption rates are lower than the government aims for, and no independent study has been undertaken to understand why farmers might, or might not, adopt modern irrigation. This study therefore provides the first exploration into farmers' perceptions of modern technologies promoted by the government, such as modern irrigation, including reasons why farmers choose whether or not to use these technologies in Oman, and so fills an important gap in the literature.

Figure 5: Developing traditional irrigation in aflaj areas using modern irrigation

Control system

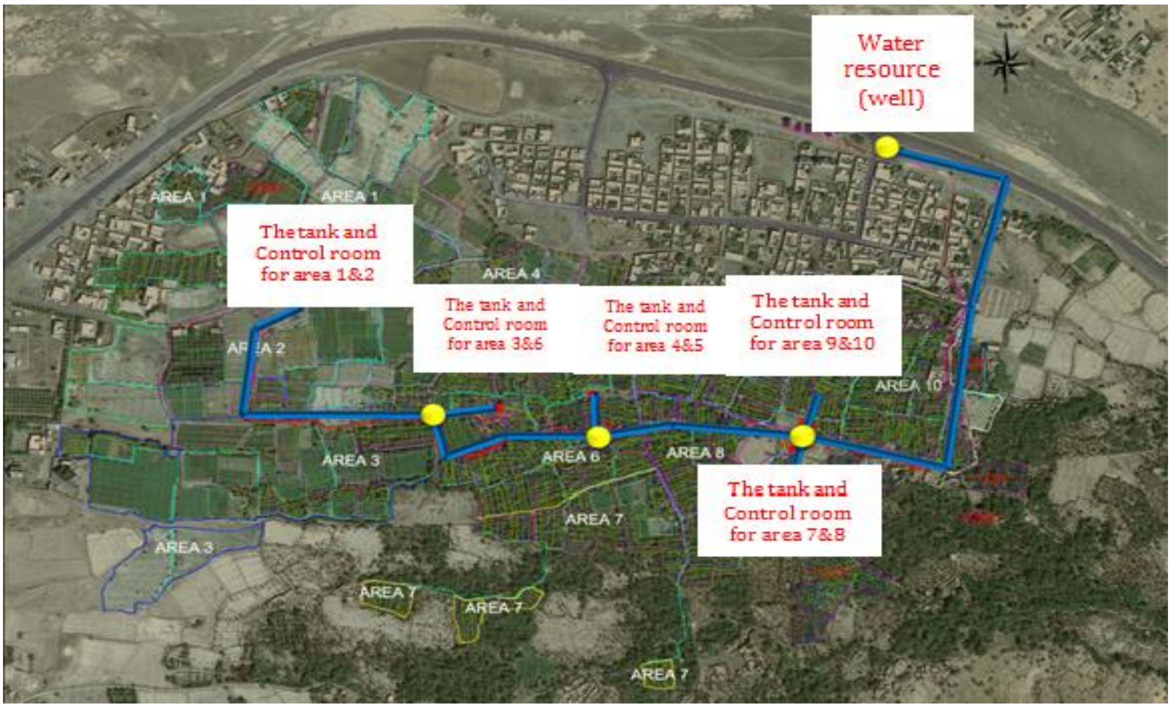
Reservoir (well)

Sprinkler irrigation

control unit (main pipes)

Main and branch pipes

Fountain irrigation



The distribution of water from the water source to the 5 reservoirs (each reservoir cover 2 zones area)

Source: Ministry of agriculture and fisheries (MOAF, 2015b)

2.2.2 Soil fertility and soil management

Soil fertility is low in many localities and the limited cultivated land has been subject to degradation, risk of desertification as well as loss of biodiversity. Soil fertility is considered a key determinant in farming. It contributes greatly to the quality improvement of crops as well as reduce the costs in the fertilisers use and supplements (Cardoso and Kuyper, 2006). In addition, a good soil structure is important for ease of root penetration into soil, good ventilation, easy water access to root and thus activity in plant (Bronick and Lal, 2005) . And because of the factors that have been previously mentioned whether by nature or human interventions, it influenced the soil fertility depletion. There are many human and natural factors that influence soil fertility, such as soil structure, water quality, plantation, and natural disasters such as climate change). These factors have an impact on soil fertility both positive and negative. Positive impacts can result from crop rotation use (mitigate and minimize weed, disease and pest, utilize from other crop beneficial effects, and reduced erosion and salinity), good quality of water, etc. In contrast, climate change leading to drought, wind erosion and salinity are negative factors on the fertility of soil (Verhulst et al., 2012).

Fertiliser is regarded as crucial for crop production by small-scale farmers (Zhou et al., 2010, McCarthy et al., 2014) .The influence of fertiliser and application of organic fertiliser on organic matter status and properties of soil physical are of importance to agricultural sustainability (Haynes and Naidu, 1998). Fertiliser can contribute and develop soils to improve their properties and structures and can be solid, powder, liquid, or granular (Beedell and Rehman, 2000). Fertiliser is vital for soil fertility and supplying nutrients to plants. With time soil loses much of its natural fertility and there is a need to compensate this loses and restores soil fertility. Using fertilisers directly enhances agricultural production and quality (Fonte et al., 2009). Many of Oman's farmlands lack sufficient fertility, either due to having gravel or sand or salinization of soil and water as well as soil erosion. There are two main types of fertilisers: organic and inorganic, which are classified and divided according to their element components.

Organic fertilisers are produced from animal and fish waste, plant decomposition, and products from processing of waste (Dao et al., 2001). Aguilera et al. (2013) demonstrated that there is increasing interest in the organic fertiliser application to soil dunof using organic fertilisers in agriculture, such as fragmenting and dismantling of the soil, absorption of salt, increasing the crop productivity, water conservation, enhance root growth due to better soil structure, increasing in the vegetative of plant, improving soil properties, and increasing the strength of the crop. On the other hand, the use organic fertilisers also has a number of drawbacks, such as transferring insects and pests to plant and soils, transferring weed seeds in soils, the difficulty to use in modern irrigation systems (Petersen et al., 2003, Wiens et al., 2008), lack of knowledge of the actual requirement of the plant, lack in the nutrient content, in addition to difficulty analyses in short term (Snyder et al., 2009, Tirado et al., 2010, Aguilera et al., 2013)

Inorganic fertilisers are industrially produced, whereas Omani farmers tend to use organic fertiliser either before or during the period of crop growth. However, many farmers consider inorganic to be more effective compared to organic fertiliser and it is often used as a supplement to organic fertiliser (MOAF, 2013a). Omani farmers use two types of inorganic fertilisers that provide major elements, such as nitrogen, potassium and phosphorus, and are spread directly on the soil; and minor element, such as zinc, boron and iron, that are applied on the leaves. Hothongcum et al. (2014) demonstrated that inorganic fertilisers have played an essential role by offering nutrients to plant, increasing agricultural productivity and the reduction of land for agriculture use the deterioration of the soil quality in cultivated land have resulted in a steady increase in its use. Inorganic fertiliser technology is considered a new technology that is being promoted and fostering to assist farmers' knowledge and attitudes of relevant practices.

According to Oman's agricultural census 2012-2013 around 10 % of total farms are using inorganic fertiliser compared to 6 % in census of agriculture 2004-2005 (MOAF, 2013b). This is the result of the vertical expansion of production using high quality seeds and greenhouse and farmers' awareness of the importance of inorganic fertilisers combined with organic to assist plants to absorb the nutrients in combination with the ease of modern irrigation system use. Yet the government has also been attempting to implement strategies to reduce the amount spent on fertiliser to lower crop production costs. Several such strategies have been proposed, including encouraging farmers to use high quality seeds, modern irrigation system and hydroponic production to increase the efficiency of fertiliser and to reduce the cost of production and to increase yield. Enyong et al. (1999) demonstrated that using modern technology is more preferable than the traditional approach to obtaining higher yields and reducing the fertilisation cost. Yet there is a recognition that information about farmers' knowledge and attitudes towards modern technology is essential for better understanding farmers' beliefs and attitudes towards the introduced soil fertility encouragement (Hothongcum et al., 2014)

There are various methods farmers in Oman use that help to reduce or minimize the use of chemical fertilisers, such as the use of organic fertilisers, the use of leguminous crops (including alfalfa, beans and parsley, coriander), crop rotation, crop diversity, using a greenhouse, using wheat resistance, sugar beet, using the modern irrigation system and the introduction of agricultural mechanization (AGMECH). These kinds of processes and technologies for crops are there to increase soil fertility and maintain the strength of the soil, high quality and quantity of crops, and reduce water use and weed burdens.

2.2.3 Small division area

In addition, the size of holding poses further challenges to development. Holding size is sharply skewed towards small farms whereby almost 90% of the 150 thousand holdings in Oman are less than 5 acres in size (MOAF, 2013b). Holdings of more than 10 acres in size constitute only 5% of the total number of holdings but occupy around two thirds of the total area. Smallholders are unable to realize economies of scale for input purchases and marketing of product. They also face competition from imports and may therefore choose to migrate or leave agriculture (Pretty, 2008). In Oman, 10% of the total holdings represent around three quarters of the total area (MONE, 2007), which is one of the major reasons that saw the government has setup agricultural cooperatives. Small agricultural areas in the regions of aflaj are shrinking due to population crawl and exploitation in other areas of non-farm, whether for residential construction or other expansions such as the expansion of infrastructure and use it for industrial purposes. Furthermore, the use of migrant labour to the farmland without the existence of any regulation or oversight has impacted negatively on the degradation of the natural resources of soil and water, as has the indiscriminate use of pesticides and fertilisers in large quantities to quicken profits (Shideed, 2008).

2.2.4 Labour

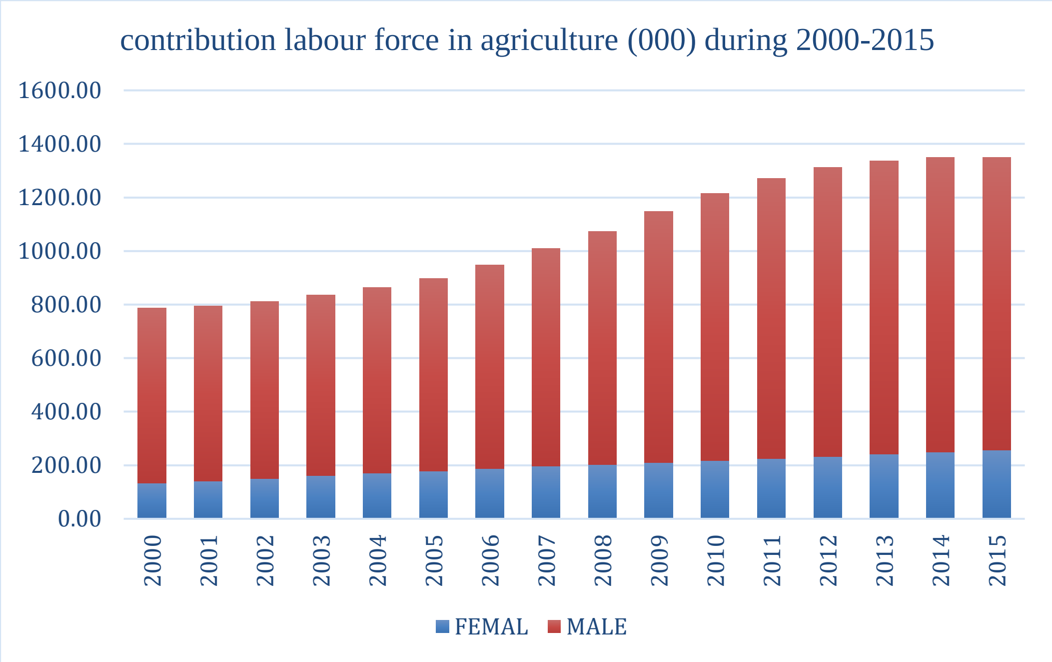
Agricultural workers are considered one of key factor in agricultural development and increase production and thus sustainability in agriculture, especially skilled and experienced at work and overcome the lack of technology. The expatriate workers in the agricultural sector keep wages for Omani's workers down and so may lower the costs of agricultural production. Agricultural census 2012/2013 showed there are around 138 thousand foreign workers compared to 72 thousand in census 2004/2005 (MOAF, 2014). However, that farm productivity is often low where farms are rented out, in part because migrant workers are poorly paid.

In the sample, both tenant and owner-farmers were interviewed, and sampled purposively. In Oman, the individual farming the land is considered the major driver in the farm management. Those who own and manage their farms themselves, because it is often the main source of household income, and an asset for the future, are seen as more likely to look after the farm over the long term. Farmers who rent agricultural land may have a shorter-term perspective, because they do have a long-term vested interest in the land. Thus, for example, they may be more willing to allow soil fertility to decline, and water resources to be depleted.

Those workers who are uneducated and low-skilled may struggle to apply new agricultural technology. Abdul-Rahman et al. (2012) found foreign employments have negative impact in economy and social communities. Another factor is the migration the young people and their reluctance to work in the agricultural sector, and a preference working to cities whether in the government or private sector where the living standards and wage rates are higher, as well as learning and finding a good position and source income (Christofides et al., 2007). This reality may contribute to the depletion of natural resources, water and soil salinization and pollution of the environment with pesticides and fertilisers, which adversely impacted on production.

Statistical information by the UNCTAD showed that there was an increase in agricultural workers in the agriculture sector during the period 2000 and 2015 Figure 6 (UNCTAD, 2015), but this growth in agricultural population has slowed and indeed there has been little change since 2013.

Figure 6: Agricultural force from 2000 to 2015



Source: United Nations Conference on Trade and Development (UNCTAD, 2015)

2.2.5 Mechanisation

Mechanisation is an important element of modern agriculture, and important for the Omani government. This might variously include machines and equipment for ploughing, harvesting, or spraying crops against insects and diseases (Piesse and Thirtle, 2010). Mechanised post-harvest operations include sorting, washing, packaging, as well as cooling and transporting. The results of the Oman agricultural census 2012/2013 showed that there are different types of agricultural equipment used by farmers. Most important are hand plough, tractors, combine harvester, pumps (traditional and modern irrigation), cold transport vehicle, irrigation water desalination equipment, dates equipment (pit remover, grinding, packing, pressing, moisturizing distribution), and agricultural residues shredder (MOAF).

2.2.6 Government initiatives

In the area of date palm, the government provides seedlings using tissue culture, and provides support for many farmers and small and medium enterprises to obtain packaging, as well as implementation of many custom rooms for drying dates (MOAF, 2014). Also, the government is making considerable efforts to market and manufacture dates by finding marketing outlets for small and medium enterprises. The government provides agricultural public goods such as aerial spraying for pest control and ground spraying against insect Dobbas palms and locust control and has undertaken a red palm weevil campaign(MOAF, 2015b). The Ministry has established a reference laboratory phytosanitary to contribute to determining the safety of agricultural and animal products and ensuring that these are free from pesticide residues and various diseases.

The government also encourages the use of natural methods to control insects such as the use of the protective covers (sheets) and traps (pheromone, lighting and glue traps), that have been recognised in the literature as being important for increasing production and reducing costs (MOAF, 2014).

The Sultanate, like other countries in the Arabian Peninsula, is located in an arid and semi-arid part of the globe, where it is warm and sunny in winter and very hot in summer, with changeable degrees of humidity, from very humid in the coastal areas to dry in the interior regions. Accordingly, water supply is scarce in Oman because the rainfall is low, irregular, and undependable, small farm holder size (90%). Therefore, the use of protected plastic or shaded houses - refered to as greenhouses – has become very important to Omani farmers in order to overcome harsh ambient conditions and hence provide a microclimate with controlled environment suitable for cultivating certain crops and increasing productivity vertically (Al-Ismaili and Jayasuriya, 2016). In these greenhouses, the farmer can better control the amount of water used, the internal cooling system, and pests and crop disease, and reduce labour demand (MOAF, 2013b, 2015b). Greenhouses are part of government strategic support to the agricultural sector in Oman. The government of Oman distributes greenhouse at no cost to most regions, particularly in the areas affected by the drought and water shortage. According to agricultural census 2012/3 there were 3700 units compared to 1700 units in 2004/5 (MOAF, 2013b).

2.3 Concluding thoughts

This sector has revealed a number of the key challenge that face Oman's agriculture sector. Many stem from the agro-ecological challenges faced by a country dominated by a landscape not conducive to farming, with little land available for agriculture, a shortage of water, and low-fertility soils. The government recognises these challenges, and thus much policy emphasis is on dealing with soil fertility and improving water management. However, other challenges remain, such as improving agricultural marketing. Several key points emerge from this chapter with respect to soil and water management. First, modern irrigation appears to be seen as wholly positive, for farmers and for water management. Second, managing soil fertility is more complicated. Both inorganic fertiliser and organic fertiliser are used and valued by farmers and the government. Inorganic fertilisers are seen as essential for increasing yields, an important element of the government's strategy to increase crop production and food self-sufficiency. Yet increasing inorganic fertilisers use adds costs to farming and may have negative impacts on the environment. Third, soil and water management are linked. These insights suggest that farmers are likely to be getting consistent messages about the advantages of using modern irrigation, but mixed messages about fertiliser use. These "simultaneous conflicting attitudes" Costa Font (2011)may influence the extent to which Oman's farmers are adopting modern farming technologies and management practices. This issue is explored in the later chapters of the thesis.

Chapter 3 Cooperatives and their role in Oman's agricultural sector

3.1 Introduction

Cooperation is defined as a socio-economic system support organizing individuals' efforts in cooperative societies and consumer, and services' cooperatives, all working in accordance with principles and rules, systems and socio-economic and technical, to regulate production processes, lending, marketing, and providing the production requirements and consumption (Axelrod, 2006). The International Cooperative Alliance (ICA, 2009) defines a cooperative as ''an independent association of individual united voluntarily to each other in order to meet their requirement of economic, social and cultural, through a jointly owned enterprise and collective collectively management''.

Oman has long encouraged agricultural cooperatives (ACs). Moreover, to meet the challenges by agriculture in Oman, the Sultanate is currently encouraging farmers and workers to join forces and work collectively through the establishment of agricultural cooperatives including in the areas of production, marketing, and processing. The Sultanate of Oman government is promoting the use of agricultural cooperatives as organization that could assist fostering and enhancing small-scale farmers' development and other communities (MONE, 2009b), based on the Royal Degree No. (14) of 2000, promulgating the law to regulate non-governmental organizations (NGOs), to be under Ministry of Social Development (MOSD) administratively supervision (MOSD, 2010).

This chapter provides insights into the role of cooperatives in promoting linkages contributing to agricultural sector development, with particular reference to Oman, though a historical lens. This chapter attempts to understand and reveal whether agricultural cooperatives are the appropriate vehicle to help facilitate access of small-scale farmers in Oman to input and product markets that could promote their development. The next part of the chapter is based on a review of the literature to give an overview and viewpoints and definition of cooperatives, particularly agricultural cooperatives. The chapter then focuses specifically on agricultural cooperatives in Oman, considering the challenges and problems associated with agricultural cooperatives.

3.2 Principles and typology of cooperatives

The seven internationally recognized cooperative principles are: voluntary and open membership; democratic member control; member economic participation; autonomy and independence; provision of education, training and information; cooperation among cooperatives; and concern for the community. Basically, the cooperative is a user-owned and controlled business that distributes benefits on the use basis and sponsorship (Ortmann and King, 2007a). These principles and the roles they play in the operation and success of the cooperative. The US-based National Cooperative Business Association (NCBA, 2005) describes a principle called ''business-at-cost'' in which a farmer member who accounts for five percent of the volume of agricultural products delivered to the cooperative would receive five percent of the net earnings derived from the handling, processing and marketing of those products. Alternatively, profit may be distributed to members based on how much they use and share the cooperative, not how much they have invested in it. The NCBA (2005) also demonstrated the characteristics of cooperatives as: 1) they are owned and democratically controlled by their members; 2) they return surplus income to members in proportion to their use or patronage of the cooperative; 3) they motivate and encourage farmers by providing a service to satisfy requirements of members for affordable and quality goods/services; and 4) cooperatives pay taxes the retained on investment income and reserves. The revenue surplus is returned, according to the auspices of individuals who pay taxes on that income. Additionally, NCFC (2005) clarified other benefits of cooperatives as: a) strengthen bargaining power; b) maintain access to competitive markets; c) capitalise on new market opportunities; d) improve income opportunities; e) reduce costs; and f) manage risk.

Agricultural cooperatives can take several and many forms. United States Department of Agriculture (USDA, 1995) defines agricultural cooperative as a group of owners offerings services and commodities to consumers and their members as supply marketing and processing, credits and use sound financial practices. Agricultural cooperatives have been described as a significant pillar in paving the way for food security and rural development and can play a crucial role in reducing poverty and improving food security and generating employment opportunities (Kumar et al., 2015).

In general, agricultural cooperatives can be classified into three categories according to their main activity, namely: 1) marketing cooperatives, which may bargain for better prices, handle, process or manufacture, and sell farm products; 2) farm supply cooperatives, which may purchase in volume, manufacture, process or formulate, and distribute farm supplies and inputs such as seed, fertiliser, feed, chemicals, petroleum products, farm equipment, building supplies, etc.; and 3) service cooperatives, which provide services such as storage, ginning, grinding, drying, artificial insemination, irrigation, credit, utilities, etc. (USDA, 2004, Ortmann and King, 2007a).

Cooperative societies have a vital and an important role in the promotion of access to agricultural markets, as well as fiscal benefits during the twentieth century. Operations may use modern inventions (fabrications) and innovations in agriculture, such as the use of plants, fertiliser and animal husbandry, as well as the use of agricultural mechanization and use of electric power (Aref, 2011). Ortmann and King (2007a) illustrate that farmers have often attempted to organize their work into agricultural cooperatives in developing countries, but most have failed in spite of the presence of the ingredients and the ability to provide agricultural inputs and products in the markets, which is necessary for the development (evolution) of agricultural development.

3.3 Benefits and drawbacks of agricultural cooperatives

Many benefits of agricultural cooperatives have been identified in the literature. At a broad level they have been described as part of the dynamic environment that has helped agricultural sectors to develop (Prakash, 2000, Aref, 2011). Indeed, (Webb, 1990) suggests that they can be one effective structure for farmers in terms of cost and implementation to improve their economic situation. Agricultural cooperatives can provide some of the basic and important elements to assist the efforts of smallholder farmers providing input and output marketing services on large scale (Tesfay and Tadele, 2013). Pinto (2009) writes that cooperatives can support smallholders and producers by empowering their members socially and economically. Additional benefits identified by Majurin (2012) include providing agricultural information to members, and introducing new technologies, education and training encouraging effective participation in meeting and membership of committees and leadership positions, and providing employment opportunities (Emana, 2009). Hermida (2008) demonstrated that agricultural cooperatives played an active role in rural Asia, helping to promote the self-sufficiency of basic foods, and strengthen the agricultural economy by facilitating access to markets and technological innovations.

Prakash (2005) clarify that agricultural cooperatives have an active role in the development process in both economic and or in rural communities as an important part of the community, where they encourage decision-making for the development of leadership skills and education. Whereas Fan and Chan-Kang (2005) demonstrate that agricultural cooperatives played an active role in rural Asian, and became one element in the community contributing to the increase agricultural production base, promotion of self-sufficiency of basic foods, strengthening of the agricultural economy domestic by facilitating access to markets and competitiveness, technological innovations and agricultural leadership development and education. (FAO, 2012a) illustrates that agricultural cooperatives regulate and organise so as to assist in reducing production cost, increase yield, offer service, market agro-products and assist to obtain fair price to farmers. Furthermore, they socially empower their members to trust other and build mutual understanding for the betterment of the community. USDA (1990) clarified that cooperatives also build trust among members and work as a team to achieve common goals, promote and enhance democratic notion in decision making and empower and educate members to become leaders.

Agricultural cooperatives are part of a dynamic environment and have played vital role in rural development through development of agriculture (Aref, 2011). In addition, they are considered to be one of the most important organization that pay attention and attempt to support the rural development in general and the agricultural development particular, some hold guide symposiums for the farmers to acquire them with the necessary knowledge and skills about the agricultural new methods that aim at increasing the agricultural production and, therefore, promoting the rural society (Burt, 2004). Additionally, cooperatives can enhance their members' "farmers" to participate in the social and environmental activities that lead to developing the rural society (Mohamed, 2004).

However, agricultural cooperatives have been encountering numerous challenges and constraints as a result of the agricultural industrialization process. Numerous agricultural cooperatives are small and lack sufficient economies of scope and scale to effectively compete with the often larger investor-owned businesses (Green, 2001). Likewise, lack of common mission among members, lack of commitment by members, time cost associated with group decision making and barriers to entry into and exit from the cooperative are all problems faced by cooperatives (Rogna, 2012). Samaratunga (2007) demonstrated general constraints meet by agricultural cooperatives: 1) lack financial; 2) lack of efficient management; 3) lack of unity among members; and 4) political interference. Moreover, there are other constraints that face cooperatives such as lack of involvement and support of the government, financial liquidity, limited resources, inefficient management, conflict in attitudes and behaviours of farmers, absence of motivation and encouragements, and lack of secrecy (Valentinov, 2005).

Agricultural cooperatives differ in terms of purpose, ownership and control, and benefits distribution. They also may play a significant role in strengthening market access and competitive returns, adoption of agricultural technological innovations, for example, including the use of agricultural equipment, plant and livestock breeding, fertilisers, new information systems, etc. (Aref, 2011).

Rhoades (1984) pointed out that for the majority of rural people in developing countries, agriculture is considered the main source of income as well as a means of assuring their food security. Samaratunga (2007) and (Zoephel, 2011) demonstrate that they are plenty of issues addressed by farmers. For example, particularly small scale farmers are: a) trapped in the vicious cycle of poverty due to poor agro management skills; b) lack knowledge about the market; c) lack information regarding price and demand; d) have to deal with poor infrastructure; e) have poor marketing skills; and f) have a lack of entrepreneur skills which lead to high production cost and low profit. The lack of access to agricultural extension services is another issues and one of the problems that small-scale farmers face in developing countries. Due to this, small scale farmers may be: i) unable to gain necessary technological and agricultural information; ii) unable to educate themselves regarding new methods of farming; iii) incapable of building relationships or links with different actors in the market; and iv) the services do not reach to all farmers and the quality of the services, which governments provide extensive agricultural services to the farmers (Thevarajah, 2013). Kibet (2011) mentioned that the above factors act as an obstacle for small scale farmers to transform the mode of farming from subsistence to new farming. This prevents farmers from ensuring household food security, increasing income and reducing poverty. Another constraint related to marketing the agro products is crucial problem that prevents small scale farmers from earning fair profit. These due to: 1) poor marketing infrastructure; 2) lack of marketing skills; and 3) high transportation costs make the farmers vulnerable to sell their products for lower prices to brokers (Stringer et al., 2008). As most of the farmers are in rural areas, it is difficult for them to access market information such as demand and prices.

From the obstacles and barriers that have been mentioned previously, Schiller (1969) demonstrated the main limitation of the economic scale. For example, using agricultural equipment such as machinery in small holdings are dramatically ineffective due to small area of holdings and plots. This influences farmers to purchase or rent this type of equipment with high cost and relatively low benefit. For example, in Oman, the government is implementing programmes for the protection of major crops such as palm trees from pests (Dobbas) (MOAF, 2010) that require large-scale machinery. Watering is key constraints and barrier that faces farmers. The economic scale of using modern irrigation systems in large units is greater than in small scale. In a small area, there is also relatively higher evaporation and leakage of the water than large scale.

FAO (2012a) points out the role of agricultural cooperative in maintaining and establishing a functional agribusiness, furthermore, and how can the cooperatives play role in agribusiness, and providing information to their memberships. FAO suggests that cooperatives have significant roles in increasing and achieving food security, providing employment opportunities in addition to contribute in the GDP of the country.

3.4 Characterising different types of agricultural cooperatives

Burt (2004) suggests that the agricultural cooperatives can be classified using various criteria as their purpose, functions or the commodity they handle: 1) supply; 2) marketing and processing; 3) services; 4) credit; and 5) agricultural cooperative that provide specialist services.

3.4.1 Supply cooperatives

These types of cooperative are often referred as purchasing cooperatives. Ortmann and King (2007b) write that the sole purpose of supply cooperatives is to offer agricultural inputs to members at a reasonable and competitive price such as seeds, pesticides, feed of livestock and plant, fertiliser and agricultural equipment. The benefits members obtain from these cooperative types are based on cooperatives ability to provide stable supplies at a reasonable price (Burt, 2004).

3.4.2 Marketing and processing cooperatives

The major purpose of marketing and processing cooperatives is to market and distribute members' processed or non-processed agricultural products. According to the farmers' needs, sometimes agricultural products can be processed to produce and create value-added products to increase the profit (Samaratunga, 2007). Rogna (2012) notes that as most of the farmers do not have marketing skills, in marketing and processing cooperatives the members hire marketing specialists or experts to market their products by accumulating capital. Marketing cooperatives can use several methods to pay their members who deliver their products to cooperatives. They may pay their members at market price when they deliver their agricultural outputs to cooperatives or may pay a pooled amount. Additionally, some cooperatives only facilitate farmers to market their products without claiming the ownership of the agro-products and in this case, members will be charged a particular amount of money for the service of the cooperatives. Members will receive additional amounts of money if the cooperatives profit exceeds the cost (Baarda, 2006).

3.4.3 Service cooperatives

An agricultural cooperative may be formed to offer services to members such as credit (Burt, 2004). Hofmann (2007) mentions that facilities to develop and improve farming practices, training about new farming methods, and education regarding technological advancement in farming are some of the specialty services that are provided by some service cooperatives. Furthermore, there are cooperatives that offer and serve multiple purposes, for instance, assisting farmers to market their output in addition to offering agricultural extension and services.

3.4.4 Agricultural credit cooperatives

The fourth type of agricultural cooperatives is credit cooperatives. The main purpose of this type of cooperative is to offer credit facilities to its members to enable them to purchase essential agricultural inputs. With this kind of cooperatives, farmers are able to obtain loans for different purposes, for example, marketing outputs, production and selling agricultural equipment (Thevarajah, 2013).

3.4.5 Agricultural cooperatives that provide specialty services

The last kind of cooperatives is a cooperative that provide facilities and services with purpose of saving the time, labour or money of their members and making farming easier. Hofmann (2007) illustrates that are several services that could be offered, that might include: a) soil testing; b) advice on better farm management; c) training regarding new farming practices; e) cleaning of seed; f) offering instruments and agricultural equipment and farm vehicle for rent; and g) training for pesticides applications. Prakash (2005) pointed out that Japan has the strongest agricultural cooperatives structure in the world. The key significant purpose of this cooperative is guidance of farm with improving the farm management in addition to encouraging the adoption of production technologies. Another example in Indian is a farmers' cooperative produces and supplies chemical fertilisers and educates farmers regarding farming by conducting promotional and educational programmes, e.g. field days, crop seminars, conferences demonstrations, etc. (Prakash, 2005).

3.5 Historical perspective on agricultural cooperatives in Oman

Long ago, co-operation in a traditional form had been customary in the Sultanate, and the roots of cooperation have been formed by the peoples' beliefs, faith, traditions, and culture. Omani civil society in the modern sense was born and raised in the confines of the state, which has taken upon itself the leadership of the development process and the development of society and state institutions since the early seventies. Just as the state has supported the private sector, it has championed the non-government sector also.

The first non-governmental organization was founded in the Sultanate of Oman in 1972. With the issuance of the Royal Decree on the organization of clubs and cooperatives in

1973, the number of cooperatives has grown and diversified in terms of areas of work. Women have been at the forefront of cooperatives in Oman. Women's cooperatives number about 47 and have about 3,600 members scattered in various governorates of the Sultanate (MOSD, 2010).

The existence and development of agricultural cooperatives have undoubtedly contributed a significant role to agricultural production and rural development. At present, most agricultural cooperatives concentrate on providing the agricultural inputs to their members such as irrigation, input supplies, etc. In the past, several old style cooperatives were dissolved or liquidated due to the management and economic problem. The data revealed that the number of agricultural cooperatives varied greatly by district. This probably due to the different number of administrative units (village and communes) among the districts. The cooperative in Al Batinah region provided farm households with quite diversified services, focusing on support such as irrigation, field protection services, fertiliser and pesticides, marketing, and credit (MONE, 2009a). Management of the irrigation systems is one of the most important activities because without a certain level of collaboration, irrigation systems cannot be maintained properly. In general, the cooperative focuses on the timely supply of fertiliser, pesticide and credit to strengthen crop production at their members' farms.

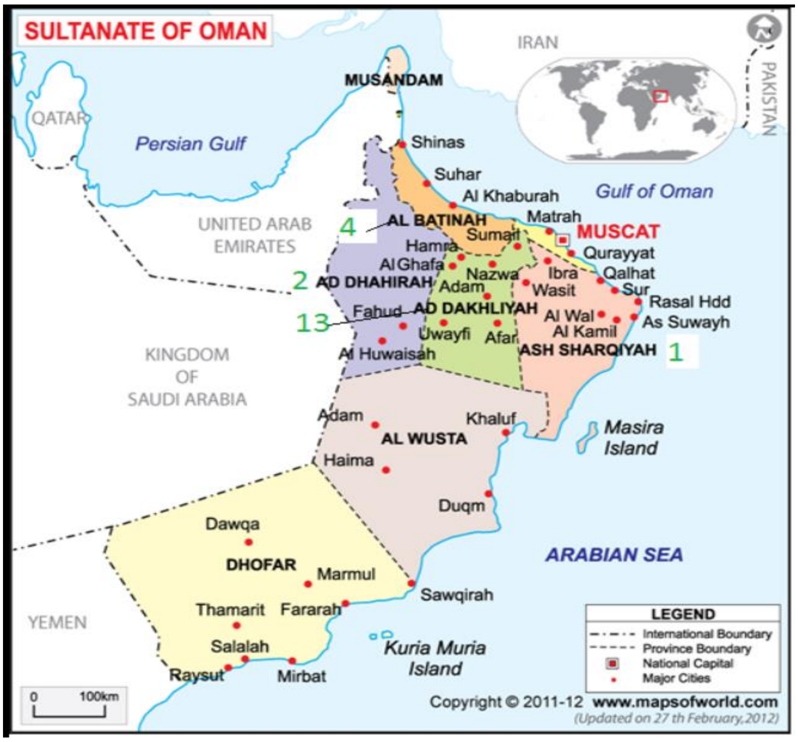
Many governments worldwide have implemented some programmes for technology subsidy and support to raise the level of the use of new technology by small-holder farmers (Yawson et al., 2010). The Omani government's focus is to stimulate farmers to create and join agricultural cooperatives in order to solve such problems, and problems including depletion of water and the degradation of agricultural land due to salinity of the water, soil, and expand the use of agricultural land, especially in aflaj areas (Shideed, 2008). This may contribute to increase agricultural production and support agricultural marketing as well as to increase overall farmers' income (MOAF, 2015b). One aim for the cooperatives is that they will introduce and increase the use of modern agricultural technology in farming.

3.5.1 First phase (1973-1980)

After the issuance of the royal decree on the organization of clubs and cooperatives in 1973, agricultural cooperatives were approved within the cooperative laws in 1974. It was hoped that these agricultural cooperatives would be able to address the numerous challenges and constraints that the Sultanate of Oman's experience regarding agriculture, including inadequate information about market competitive conditions, the continuation of the government's presence as the main provider of services to the farmers, poor marketing and distribution system, and, above all, high cost of agricultural inputs, particularly technology (FAO, 2009).

In total there were 20 agricultural cooperatives until the early 1980s. 13 in Ad-Dakhiliyah, 4 in Al-Batinah, two in Ad-Dhahirah, and one in Ash-Sharqeyah (see Figure 7). It is possible that some regions may have more cooperatives due to greater agricultural potential or commercial activity, or maybe this spatial distribution reflects an absence of study and advanced planning by the government, which could be one main reason for the decline of the cooperatives. Probably, cooperatives were poorly supported by the ministry of agriculture, which lacked sufficient staff with the right expertise to assist the cooperatives, particularly given the high level of illiteracy among farmers (FAO, 2008).

Figure 7: Distribution agricultural cooperatives in Oman regions, 1970s.



Numbers in green refer to number of cooperatives in each area in the 1970s
Source: Ministry of Information (MOI, 2013)

3.5.2 Second phase (1981-2000)

In 1982 the government changed its policy of supporting cooperatives and instead set up the Public Authority for the marketing of agricultural products (PAMAP), after studying the volume of agricultural production and marketing as well as the situation of local agricultural products of vegetables and fruit. The public authority for marketing of agricultural products during the eighties played an active role in agricultural marketing in the Sultanate, where it was distributing a quarter of the total production of vegetables and fruits (date, lemon, banana and papaya). The commission has provided during that period good prices for farmers and thanks to the support provided by the government towards costs. This was supposed to encourage and enhance farmers in agricultural cultivation as well as providing agricultural outputs to the local markets. The government organised seminars, and produced newsletters, and brochures to spread awareness among farmers and illustrate all agricultural processes from the beginning of production up to marketing (FAO, 2008). However, this public initiative unfortunately was not successful due to lack of sufficient financial subsidy from government, difficulty of agricultural marketing products, low prices of local crops, and competition from imported agricultural products (WTO, 2008). The negative impact of this was felt by farmers who had little bargaining power with traders and so faced low prices. As a result of the continuing deterioration of the commission, in 1999 the government abolished the Public Authority for Marketing of Agricultural Products, and the Sultanate gained accession to a number of international trade agreements such as the World Trade Organization (WTO). The agricultural calendar between the Arab States was also terminated, which led to the flow of agricultural products to the Sultanate of all countries of the world. The agricultural calendar is considered as a reference to farmers and investors to determine the main crops, which are imported and exported to neighbouring countries according to the agricultural season by raising the tax for those products during the given period. This strategy has greatly helped in the local products provision in the markets with a reasonable price. Oman's accession to the WTO, has led to the difficulty of the application and control of this calendar because of the completion from foreign agricultural products (FAO, 2013). These changes drove the Sultanate towards the re-establishment of agricultural cooperatives to support farmers particularly with respect to enhancing the use of new technology and improving marketing, which was considered one of the most important problems faced by farmers since the abolition of the Commission, in addition to the absence of specialized units in post-harvest operations (FAO, 2008).

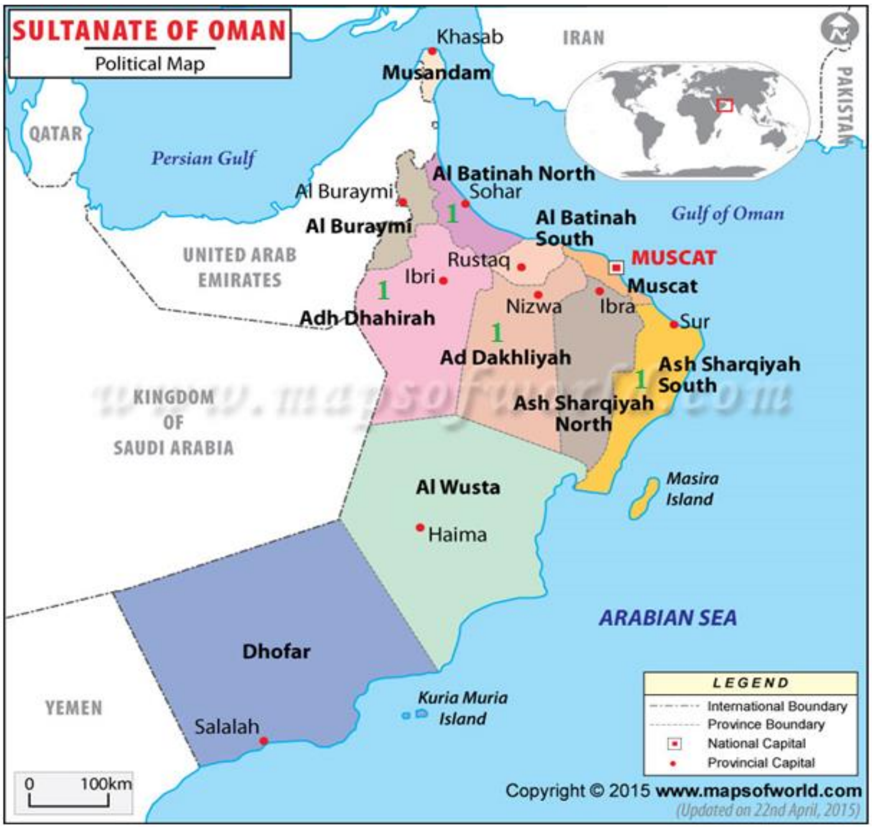
The aspiration was that these cooperatives would: raise the income of farmers and livestock breeders and fishermen level; reduce production cost and raise production efficiency; increase the adoption and use of modern technology and the provision of agricultural and fishery inputs in order to increase production quality and quantity; offer collective representation of farmers, livestock breeders and fishermen with the concerned government authorities to resolve and overcome the obstacles and problems they face; contribute to obtain special services, such as loans or grants from various institutions and to provide appropriate bail to the farmer and the fisherman with the concerned authorities; improve holding capacity and the development of skills and knowledge among members of the construction from the cooperative principle; determine production methods and the consequent rationalization of the use of production inputs wisely to ensure the conservation of natural resources and the sustainability of agricultural production and fish process; and provide marketing and promotion of agricultural and fishery products services inside and outside the Sultanate and open new markets for product marketing cooperative members (FAO, 2015).

3.5.3 Third phase (after 2000)

In 2009, the government has declared the first of what was planned as a new wave of agricultural cooperatives located in Al Batinah. This cooperative in the Al Batinah region represents the backbone of agriculture (farming and animal) in terms of the diversity of agricultural crops in addition to livestock. Al Batinah is a major and famous region that grows a wide variety of agricultural crops because of good soil fertility and larger than average farm size areas. It represents around 28% of the number of agricultural holdings in both agricultural census 2004 and 2013, and around 44% of the total area in agricultural census 2004 compared to 38% in 2013 in the Sultanate (MOAF, 2013b). This cooperative has a solid base and objectives for the development of agriculture, and has a reputation for using and adopting modern agricultural technology, finding solutions to barriers and constraints that meet farmers, and how to tackle that issues; enhancing farmers' appropriate use of agro-chemicals, and finding marketing outlets for agricultural products to members inside and outside the Sultanate (MOSD, 2010).

In the current there are only 4 active agricultural cooperatives, one AC in each of Ad-Dakhiliyah, Al-Batinah, Ad-Dhahirah, and Ash-Sharqeyah (Figure 8). Table 8 summarise the numbers, the location, the types and the numbers of cooperatives that are still operating, and that are now closed.

Figure 8: Distribution agricultural cooperatives in Oman regions, 2016s.



Numbers in green refer to number of cooperatives in each area

Source: Food and Agriculture Organization (FAO, 2008)

Table 8: Type and number of cooperatives in Oman

Location	Types of Coop.	Closed	Successful	
			Operating	Name of Coop.
Ad Dakhiliyah (Nizwa Al Jabal Al Akhdar)	Agricultural and marketing	13	1	Pomegranates Association
Al Batinah (As Suwaiq)	Agricultural and marketing	4	1	Al Batinah Growers Association
Ash Sharqiyah (Ibra)	Agricultural and marketing	1	1	Ash Sharqiyah Growers Association
Adh Dhahirah (Ibri)	Agricultural and marketing	2	1	Adh Dhahirah Growers Association
Total		20	4	

Source: Ministry of agriculture and Fisheries (MOAF, 2015b)

3.5.4 Al Batinah cooperative

Because there are now so few cooperatives operating currently in Oman, it is not possible to pick a "representative" cooperative. However, Al Batinah cooperative provides a useful population of farmers to study, and to compare with the majority of Oman's farmers that are not members of a cooperative. Al Batinah cooperative provides farmers with many services, including: helping farmers generally to overcome obstacles they face; providing agricultural inputs; helping farmers to adopt modern agricultural technology; enhancing the use of environmentally friendly pesticides and reducing the use of harmful chemicals; and finding marketing outlets for agricultural products to members inside and outside the Sultanate (MONE, 2009a).

The author's own survey of key informants, including farmers'who are members of the cooperative, the president of cooperative, and official staff from the MOAF, identified the most important challenges and obstacles addressed by the growers of Al Batinah cooperative to be:

1. Marketing concentration for citrus fruit and vegetable market and the lack of a distributor for these products.
2. Foreign competition from the Gulf and Levant countries, especially of vegetables and potatoes in particular, dates.
3. Poor access to foreign markets for Oman's agricultural products.
4. Agricultural skilled labour shortage.
5. Lack of incentives for exporters of agricultural products.
6. Import duties and customs duties imposed by other countries on Oman's agricultural exports, making them unable to compete with other countries' products.

3.6 Challenges for agricultural cooperatives in Oman

The Ministry of Agriculture and Fisheries is responsible for managing and coordinating efforts for the development of the agricultural sector as well as the supervision of the work on agricultural cooperatives, fisheries and cooperatives for agricultural marketing and that with regard to the field of counselling and agricultural services, plant protection and other activities undertaken by agricultural cooperatives. One purpose of government is to enable improved access to relevant agricultural advice and support to appropriate technologies, and an agricultural research system that reflects their needs (FAO, 2013, MOAF, 2015b). The following is a brief review of the most important services provided by the Ministry of Agriculture and Fisheries for agricultural cooperative associations.

The Ministry of Agriculture and Fisheries provides many methods of technical support for the agricultural cooperative associations for the purpose of upgrading and improving the level of services provided by the member farmers. The government supports experts in the field of agricultural cooperation and rural development, which visit cooperatives to determine the obstacles that hinder their development and to find appropriate solutions, providing statistical data and help concerning agricultural crops and agricultural investment opportunities (MOAF, 2015c). The government provides financial and in-kind support for agricultural pests control, introducing new technology in water conservation and increasing the efficiency of fertilisers, provision of agricultural extension, veterinary services for livestock, as well as marketing support. Agricultural research funded by the government aims to provide scientific results derived from laboratory and practical experiments in order to increase crop production and improve livestock breeds by conducting research and drawing conclusions. Furthermore, the receipt of various samples and examined laboratory with a visit the fields to determine the symptoms and the processing possibility (MOAF, 2014).

The government provides training for farmers assisting them in building their scientific capacity and the knowledge expansion in the agricultural field. It holds seminars and workshops in partnership with relevant authorities to raise awareness of the importance of agricultural cooperatives and their role in improving the economic and social levels. The government also strives to develop and enhance cooperatives by granting land to build and set up the necessary infrastructure for a collaborative, and leases land at nominal prices, facilitates the procedures for import the needs of agricultural equipment and inputs and spare parts as well as facilitate the procedures for transactions with other actors(MOAF, 2014).

3.1 Concluding thoughts

Improving agricultural productivity is one of Oman's policy priorities. In this respect, farmers' cooperatives are expected to play an important role in achieving better growth in the sector, and indeed the government once again is encouraging and supporting the establishment of farmers' cooperatives in the country. One of the key aims for Oman's cooperatives is for farmers to use modern technologies and management approaches to increase production of food in a sustainable manner. Yet whether or not cooperatives contribute in this respect is not sufficiently understood. In the following chapters, using the theory of planned behaviour, this is explored in more detail with respect to two management approaches that have important implications for productivity and the environment – the use of modern irrigation, which increases water efficiency; and the use of inorganic fertiliser that increases production but may have negative environmental impacts. The following chapters explore whether farmers in cooperatives are indeed using these technologies, and what influences their choice to use them.

Chapter 4 Methodological approach

4.1 Introduction

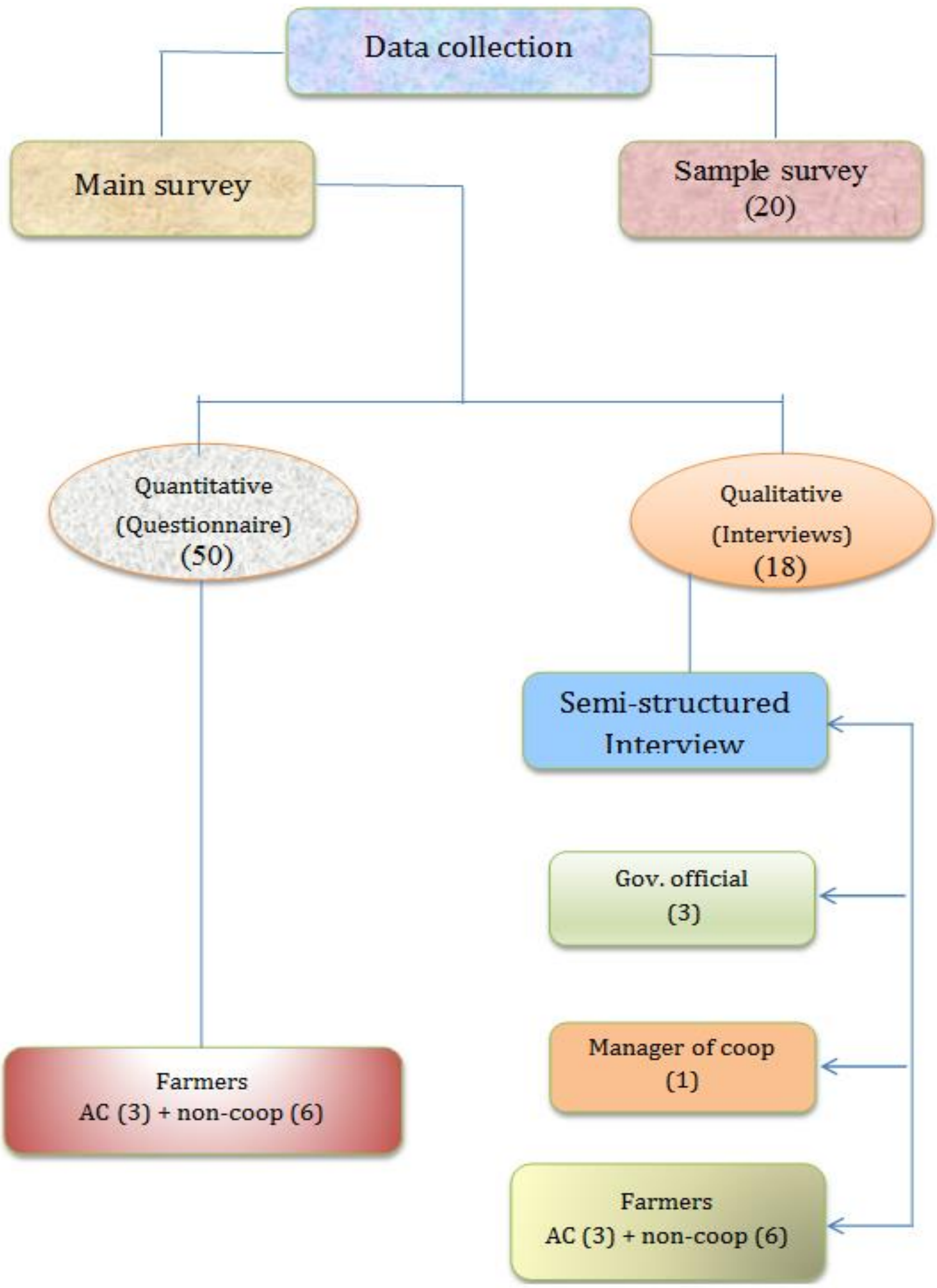
This chapter presents the methodology used for this thesis. It discusses the approaches and methods used for data collection and its analysis, as well as the procedures followed in the fieldwork and challenges faced during the research. To gain a better understanding of what motivates farmers in Oman to use modern farming approaches a number of methodological approaches were used. These methods combine quantitative and qualitative approaches for a fuller understanding than is possible using either method alone. This study thus employed a triangulation process, which relies on the use of multiple sources for verification, support and self-confidence, in addition to the quality of their data (Bryman and Cramer, 2001). The information collected was based on mutual trust between the researcher and the respondents (farmers - agricultural cooperatives and government officials). Data were collected using documentary review, questionnaires, focus group discussions and personal observations. Quantitative data were analysed by using SPSS, while qualitative data were analysed using NVivo software.

The following section in this chapter provides details on how data collection was organised. Section 4.3 provides detail on the main study area, Al Batinah. The fourth section discussions the data analysis, providing particular detail on how TPB was applied and analysed to improve our understanding of why Oman's farmers have, or have not, chosen to use inorganic fertiliser and modern irrigation. The final sections address the ethics and limitations of the fieldwork.

4.2 Data collection

Stakeholder interviews and a quantitative survey were all undertaken in Oman to provide the qualitative and quantitative data needed for thesis. This took place over two fieldwork periods with initial interviews, secondary data collection and a series of preliminary sample survey interviews taking place in the first period of fieldwork in 2014, and further interviews and the main survey taking place during the second period of fieldwork in 2015. A summary of the data collection approaches and its organisation is provided in Figure 9.

Figure 9: Framework of sample and main survey



4.2.1 Qualitative data collection

In the first stage of the data collection, key stakeholder interviews were held with individuals from various Government Ministries and those involved in the management of cooperatives in Oman.

During initial interviews with government officials' secondary data were collected and obtained from the following official sources:

- Ministry of Information (MOI) who provided data and information of the geography and governance of Oman, including location, area, climate, topography, and the administrates structure through governorates.
- Ministry of National Economy (MONE) provided data and information on the population of Oman.
- Ministry of Agriculture and Fisheries (MOAF) including the General Directorate of Planning and Development, and General Directorate of Agriculture. They provided information from the agricultural census which takes place every 10 years. This provides on the background of agriculture in Oman, total agricultural holdings and total cropped area (acres), the number of livestock. Further information is provided on production levels in different location, as well as food price indices.
- Ministry of Social Development (MOSD) provided information on cooperatives within Oman. Additional information from the Food and Agricultural Organization (FAO) provided detail on the history of cooperatives.

Some additional secondary data was also obtained, through interviews, for three cooperatives, the Al Batinah Cooperative, the Water Cooperative and the Palm Tree Cooperative.

This was followed by a sample survey study involving a series of interviews with farmers regarding the issues they face within the agricultural sector and to gain an understanding of the respondents' perspectives on the availability, accessibility and use of agricultural technology, focusing on fertiliser, as well as the role of cooperatives in improving productivity and marketing.

The questionnaire of the first version was tested using a smaller sample survey to: develop and test the adequacy of research instruments; to identify any possible omissions or vagueness; to evaluate whether the protocol of research is realistic and applicable; to discard all unnecessary, difficult or ambiguous questions; to correct any possible mistakes; and to find out if the needed of time to complete the questionnaire was sufficient.

In the smaller sample study 20 farmers were selected through a random selection in coordination with help from the departments of agricultural development (see Figure 9), in Nizwa (14 farms) and Al-Jabal Al-AKhdar (6 farms) with these areas chosen to represent the full range of Sultanate topography, plain and mountain area respectively. In the first stage the researcher visited the agricultural extension department and met with the official staff and interpreted the goal of survey; explained the purpose of survey; and noted any feedbacks to improve the questionnaire before collecting data. The second stage was translating the questionnaire from English to Arabic to facilitate the communication between the researcher and the participants.

The third stage was coordinating with the owners of agricultural holdings, which was done by the agricultural officials because of the strong relationship and continuous communication they have with farmers. The fourth stage involved collecting data of farm, farmers, agricultural marketing and issues facing the agricultural sector in Oman. This initial survey was conducted in the period from mid of February to the end of April 2014. Face-to-face interviewing was done using the semi-structured questionnaire with some open questions.

The questionnaire was structured into three parts (see appendix 1). The first part of the questionnaire asked for general information about the farm and farmers and was divided in three sections. The first section covers farm characteristics including location, area (total and cropped area), labour, agricultural equipment and infrastructure, and irrigation. The second section covers farmer characteristics including gender, household size, age education, and participation in agricultural cooperatives. The final section asks questions about agricultural marketing including the sources of agricultural information and what happened to and where the agricultural produce was sold. The second part of the questionnaire focused on issues encountered within the agricultural sector in Oman and potential solutions. This part deals with the knowledge and grasp of the farmer's behaviour and perception of agricultural processes and modern technologies used in farming. In addition, this part is linked to the theory of planned and behaviour (TPB) which forms the third part of the questionnaire. This final part focuses on the use of inorganic fertiliser, and respondent' attitudes and beliefs regarding this fertiliser, their thoughts on the extent of control they have in its use, for example easy or not to use, available to purchase at reasonable cost. The instruments used for data analysis sample survey are excel and SPSS 22 software.

The questionnaires were undertaken by the researcher. The average time required for completion of the smaller sample questionnaire was 40 minutes, similar to that for the main survey, despite the changes that were made.
The finding of the smaller sample survey led to shaping and deciding the focus of the main study, in particular the decision to focus on soil fertility and water management and it also guided the final content for the TPB questions as outlined in Table 9, Table 10, and

Table 11.

Table 9: Variables and factors affecting by TPB (Attitude towards behaviour) using modern technologies

Inorganic fertiliser	**Modern irrigation system**
Increased yield	Increased yield
Increased income	Increased income
Reduced water consumption	Reduced water consumption
Improved soil structure	Reduced water salinity
	Reduced soil erosion
	Reduced labour requirement

Table 10: Variables and factors affecting by TPB (Subjective norm) using modern technologies

Inorganic fertiliser and modern irrigation	
Family	Agricultural extension
Neighbours	Government

Table 11: Variables and factors affecting by TPB (Perceived behavioural control) using modern technologies

Inorganic fertiliser	Modern irrigation system
Availability in the market	Availability of water
The cost of fertiliser	Availability of electricity
The location of agricultural market	The cost of equipment and maintenance
Availability of water	Time
Control availability of financial liquidity, skills and knowledge	

4.3 Study site Al Batinah region

For the main study, the decision was made to focus on the Al Batinah region based on its contribution to the agricultural sector within Oman and the existence of its cooperative. Al Batinah region is considered one of the major and vital important regions of the Sultanate. It is located in the north-east of the Sultanate of Oman and is close to the beach and on the borders of UAE. It is bordered to the North by Khatmat Malahah; to the West by the Al Hajar Mountains, to the South by the Ras Al-Hamra, and to the West by the Gulf of Oman (MOI, 2013). It covers a total of 12,500 square kilometre surface area representing 4.04 percent of the country's land area. Al Batinah region was split into Al-Batinah North governorate and Al-Batinah South governorate. It is divided into 12 provinces (Wilayat) named Sohar, A'Rustaq, Shinas, Liwa, Saham, Al-Khabourah, A'Suwaiq, Nakhal, Wadi-Almawil, Al-Awabi, Al-Muusana'a and Barka (MOI, 2013)(Table 12).

Table 12: Names of provinces in Al-Batinah region and agricultural holdings

Wilayat	Area (acre)	No of Holdings
Sohar	18806	6995
A'Rustaq	4231	10528
Shinas	7341	2149
Liwa	3665	1674
Saham	16223	4839
Alkhaburah	10341	3402
A'Suwaiq	28742	4883
Nakhal	1696	2325
Wadi almawil	1309	1103
Alalwabi	701	1324
Almusana'a	15430	2326
Barka	25618	2989
Total	134103	44537

Source: agricultural census (MOAF, 2013b)

According to the population census 2010, the Al Batinah region has a total population of 772.590 representing 27.86 percent of the country's total (MONE, 2010b). Al Batinah region is considered as one of the main significance in the farming regions of the Sultanate, due to the presence of large areas of agricultural plain area, fertility of the agricultural soils, diversity of crops and livestock production. It represents about 38% of the total agricultural area and 27% of total number of holding in addition to 60% of total agricultural production. Agriculture is considered to be the main activity in Al-Batinah region as for fertile lands, it has totalled 134103 acre[1] (56322 Hectare) from 355010 acre (MOAF, 2013b).

The most important crops cultivated in Al Batinah are palm trees, banana, mango, citrus, papaya and grapes fruit trees. Vegetables also form a large part of production such as tomatoes, peppers, cucumbers, cucurbits. In the field there are cultivated legumes, wheat, barley and corn, in addition to alfalfa and Rhodes grass in perennial fodder crops. It has various types of animals including goats (23.5% of the total population in Oman) , sheep (32.7%), cattle (25.1 %) and camels (7.4%) as recorded by last agricultural census (MOAF, 2013b). From the above information it can be argued that Al Batinah region play a vital role in the agricultural sector in the Sultanate, where it clearly contributes to the income increase and thus contribute to the gross domestic product (GDP) of the Sultanate. Moreover, the agricultural cooperative, Al Batinah Cooperative, is located there. Thus this region is an ideal location for this thesis.

4.3.1 Al Batinah Cooperative

Al Batinah cooperative has many objectives for the development of agriculture, including adoption of modern agricultural technology; finding some solutions to barriers and constraints that face farmers; enhancing farmers' use of environmentally friendly pesticides, and adoption of integrated pest management; encouraging responsible use of agro-chemicals; and finding marketing outlets for agricultural products to members inside and outside the Sultanate. It also promotes improved water management by urging its farmers to purchase modern irrigation systems. The cooperative also encourages farmers to keep their agricultural holdings rather than rent them to the expatriate workforce. Post-harvest activities include a focus on post-harvest sorting, grading and mobilizing the required specifications for the market (MOSD, 2010).

The cooperative faces a number of challenges and constraints. It has struggled to find a distributor for citrus products. It faces foreign competition from the Gulf and Levant countries, especially for vegetables, potatoes and dates; and exporting is constrained because of customs duties on Omani agricultural products in countries such as Jordan, Lebanon, Syria and the lack of reciprocity in these countries. There is also a shortage of agricultural skilled labour. Despite these challenges, Al Batinah Agricultural Cooperative is considered the most important in providing agricultural products (approximately 60 % of products) (MOAF, 2006a, MOAF, 2014). For example, Table 13clarifies the amount of main crops (tons) exported during years 2008-2011.

Table 13: Main crops exported by Al Batinah cooperative during 2009-2001(tons)

Crop	2008/2009	2009/2010	2010/2011
Beans	474	494	353
Pepper	58	62	274
Tomatoes	35	37	21

Source: Al-Batinah cooperative (MOAF, 2014)

Table 14 provides additional summary data for the cooperative with respect to cultivated area (ha), production (ton), markets (local and abroad) in addition to the average price (RO).

Table 14: Cultivated area (Ha), production (ton), place of marketing, and average price (RO/kg) in Agri. coop. during 2008/9-2013/4.

	2008/9	2009/10	2010/11	2011/2	2012/3	2013/4
Area (ha)	43	45	40	45	45	40
Production (ton)	474	494	353	515	534	492
Export to Japan	321	340	282	414	362	227
Local market	153	154	71	102	172	265
Average price(japan)	0.5	0.5	0.5	0.6	0.65	0.65
Average price (local, Omani Rial)	0.14	0.16	0.15	0.175	0.18	0.275

Source: Al Batinah cooperative (MOAF, 2014)

4.3.2 Qualitative data collection

In a further stage of qualitative data collection, and during the second period of fieldwork in 2015, additional stakeholder interviews were undertaken with government officials and the management of the Al Batinah cooperative. This was supplemented by some detailed interviews with a small number of farmers both within and outside the cooperative framework to provide additional qualitative commentary. Currently the government of Oman is re-engaging with cooperatives as a vehicle to enhance agricultural productivity. The purpose of the interviews with government officials was to provide in-depth information on the government attitudes and beliefs concerning the role of agricultural cooperatives, particularly with respect to improvements in agricultural productivity. The questions were designed to elicit answers as to the extent to which and how MOAF officials see agricultural cooperatives contributing to the agricultural sector growth in Oman, and the role of government in this. Three individuals were selected for interview, two engineers responsible for livestock and agricultural planning, and plant production; and one individual involved in animal research. Questions that were asked included the following: What facilities and services do farmers get from the Ministry in order to sustain farming productivity? What are the obstacles, if any, that influence the failure and/or the success of agricultural cooperative? Do you have any future plans for developing and activating agricultural cooperatives? To what extent do you think that agricultural cooperatives can contribute to the agricultural sector growth in Oman?

It was important to have a discussion with the manager of the main cooperative in the region, the Al Batinah cooperative (AC). The interview focused on the role of the cooperative and the extent of its contribution to agriculture. Questions included: What services does AC provide to its members? How you can encourage farmers to adopt agricultural technologies in their farms? Is there any cooperation with other private and public sectors? Do you receive any support from government? How do you differentiate your AC members from other non-members? What are the barriers that affect the AC development and how can outcome that barrier?

Farmers who are members of the Al Batinah cooperative (3) and those that are not (6) were also interviewed. This was to allow a comparison of the perception, beliefs, and norms of members and non-members of the cooperative through qualitative approaches.

4.3.3 Quantitative data collection

For the main study, the focus was on surveying farmers within the Al Batinah region covering those who are members of the Al Batinah cooperative and those that are not. It was also important to engage respondents from different areas of the region – plain, mountain and coastal. The survey took place between May and August 2015. In total there were 68 responses to the questionnaire from 18 members and 50 non-members of the cooperative (see figure 9). The agricultural extension services of Al Batinah region provided a list of farmers and from this list a random sample of 50 farmers not involved in the cooperative were chosen. For the smaller agricultural cooperative sample, the method of snowballing was adopted. Burton et al. (2008) have demonstrated that though this method has been criticised in the past because of the scope for selection bias, in this case, given the relatively small size of the cooperative community, it was an appropriate approach. Table 15 clarifies percentage by the size (small, medium, large) of agricultural holdings in the Sultanate, Al Batinah region (from the agricultural census 2021/3) and main survey. From this table it can be seen that the survey sample over-samples larger farms and under-samples smaller farms. Given the relatively small sample size, and the dominance of small farms in the region, this sampling bias ensured sufficient larger farms in the sample.

Table 15: The size of agricultural holdings

Type of agri. holding	Country (%)	Al Batinah region (%)	Sample (%)
Large (< 30 acre)	1.4	2.4	17.6
Medium (10-30 acre)	3.3	6	36.8
Small (> 10 acre)	95.3	91.6	45.6

Source: agricultural census (MOAF, 2013b)and main survey 2015

The quantitative questionnaire was designed to elicit information required to undertake TPB analysis and this is further explained in the data analysis section that follows. The questionnaire contained 145 questions divided into two parts. The first part provided background information about the farm and farmer and their marketing. The second part, using TPB focused on the beliefs of attitudes, subjective norms and perceived behavioural controls in relation to decisions regarding the adoption of inorganic fertiliser and modern irrigation. The survey was structured as follows.

The first part includes questions related to the general information of farm, farmer, agricultural marketing and coop. (see Appendix 2). This part consisted of 18 questions providing general information about the household's farm, including the area of land, the crops grown, labour, the type of irrigation used, use of organic and inorganic fertiliser, the agricultural equipment used, and the general agricultural infrastructure. There were 17 questions on the characteristics and demographic of farmer, including gender, age, education level, household member, years of farming experience, occupation, income resources, agricultural information sources, and sources of loans. Finally, there were 9 questions on agricultural marketing including distance to nearest market and agricultural shops, product use and place where product is sold.

The second part of the survey comprises the specific theory of planned behaviour questions. This section included 101 questions related to their behaviour. The purpose of these questions is to determine the participants' perspectives on the availability, accessibility, and use of agricultural technology, as well as the role of agricultural cooperatives. On availability, farmers were asked, among others, to express their thoughts on the type of technology availability. Regarding use of subsidized technology, farmers were asked to express their thoughts on the support services to purchase the subsidized technology (e.g. assistance or information from extension officers), their knowledge of using technology in farming, effects of technology use on the yield of their crops, etc. Relevant follow-up questions were asked, whenever necessary, to either clarify or confirm a point.

4.4 Qualitative analysis

There are a number of qualitative approaches that can be taken in research, including Phenomenologists, Ethnomethodologists, and Symbolic interactionists. In this research, the Phenomenologists approach is used. This is an interpretivism approach, the focus of which is to understand and interpret how people think and behave and what drives their beliefs and actions (Bryman, 2012). Specifically in this case, the researcher attempts to see things from the point of view of the farmers in order to understand their experience, specifically how aware are farmers of what drives their decisions to use certain technologies and management approaches (Marshal and Rossman, 2011). This is something that cannot be measured through quantitative approach (Denscombe, 2014).

The data collected from all the interviews were analysed through content analysis using the NVIVO software. NVIVO is a software programme that is frequently used in qualitative data analysis (Leech and Onwuegbuzie, 2011). This programme links to the collection, organization, analysis and interpretation of the content from interviews. It allows the researcher/user to classify, sort and arrange information, and combine this with analysis. Several alternative methods and software are available to analyse qualitative data. These include QDA Miner, ATLAS.ti, Hyper RESEARCH, MAXQDA, Qiqqa, XSight, Quirkos, Dedoose, webQDA, f4analyse, and Annotations. Nvivo is designed to assist researchers in analysing qualitative data such as interviews and focus group discussions after initial manual sorting. Further, it helps to interrelate ideas and to place codes into a 'tree' format in order that the data segments and code connections can be easily retrieved (Bryman, 2012). It is useful for managing big data sets, especially if there are many interviews and focus group discussions, as in this study. The main drawback of NVivo is that it is time consuming to get acquainted with how to use it. In this research, NVivo software was used to revise the manual coding where relevant and produce reports used to structure writing up. The focus group discussions and interviews were all inserted into the programme for the analysis process (Walsh, 2003).

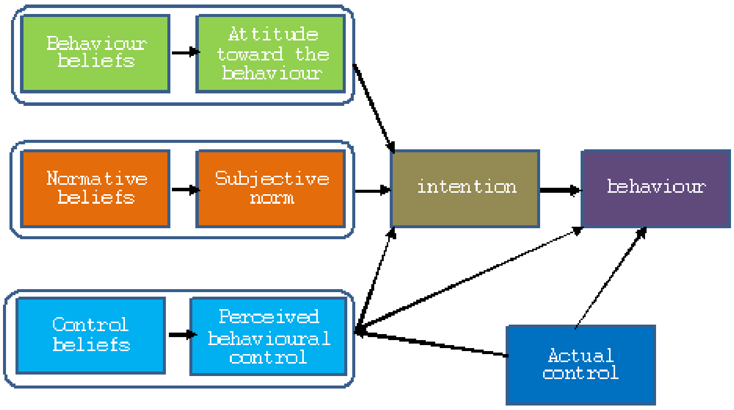
Using Nvivo, the first process was to allocate a separate file for each interview. Each interview is a theme with the name of the interviewee/respondent and their location. In the first stage an initial reading of the responses from the respondents came up with a number of subject areas focusing on fertiliser, irrigation – the two technologies of interest – and the role of cooperatives in terms of supporting production and marketing. The software allows nodes to be created for each subject area, and each node can then include a sub-node. Each sub-node gives more specific for each node, for example, irrigation: availability of water, how use, price, water consumption, soil, water and yield. The researcher can then obtain and examine information on the subject areas with reference to the nodes and sub nodes – including the number of times a reference is made to a subject area and what is being said. This can then easily be download into a word document. Additional detail on the Nvivo analysis is provided in Appendix 4.

4.5 Quantitative analysis

The quantitative data analysis is centred around the theory of planned behaviour. The components of this are given in Figure 10. The theory of planned behaviour is an extension of the Theory of Reasoned Action (TRA) and was established to overcome the limitation of that Theory (Ajzen and Fishbein, 1977, 2005). TPB was developed by Ajzen (1991) and it aims at explaining human behaviour. According to the Theory, behavioural intention is the main construct that a person would behave rationally and to their beliefs regarding a particular behaviour, which are divided into three groups: behavioural beliefs, normative beliefs and control beliefs (Davis et al., 2002, Wang and Ritchie, 2012). Behavioural beliefs are considered to be the personal beliefs of a person towards the evaluation of a behaviour, normative beliefs are related to an individual's perception of social pressure to perform a specific behaviour, and control beliefs regarding to a person's perception of the factors the difficulty or ease of performing the person's control over the behaviour. Behavioural beliefs lead to approving or not approving personal attitudes towards a behaviour, normative beliefs lead to subjective norms and control beliefs produce perceived behavioural control which, according to Ajzen (1991)(see

Figure 10), are the three factors that influence a person intention to behave in a particular way. Behavioural intentions in combination with actual behavioural control are best predictors of a person's actual behaviour. Yet, sometimes perceived behavioural control is considered instead of actual behavioural control. because the actual difficulties are often forced by the behaviour itself.

Figure 10: The theory of planned behaviour, framework (Ajzen, 1991)

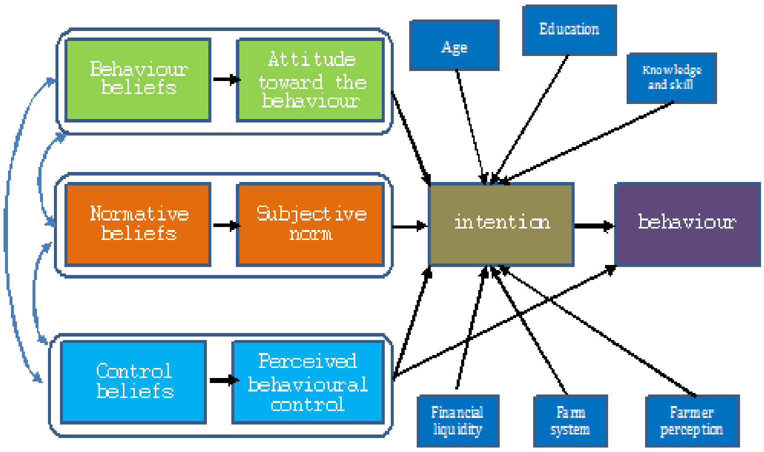


Source: adopted from (Ajzen, 1991)

The theoretical framework for studying farmers' intentions to participate in RD schemes was based on the Theory of Planned Behaviour. The hypotheses tested were that farmers' intentions depend on their perception and behavioural attitudes towards the modern technologies use, the farming systems, and their personal characteristics.

To grasp the perceptions and behavioural attitudes of the participants, they were asked and measured on fully anchored 5-point unipolar Likert-type scales with a range from 1 to 5 their endorsement and non-endorsement with a number of statements designed to detect and understand their views, which again were interpreted in the framework of the TPB. Based on the hypothesis a set of factors are combined in the approach of theory: education, age, household size, knowledge and skill, farm system, financial liquidity and farmers' perception (Poppenborg and Koellner, 2013). Figure 11 illustrates the theoretical framework of farmers' willingness to use modern technology.

Figure 11: theoretical framework scheme achievable of farmers willing to engage in the survey



Source: adopted from (Ajzen, 1991)

The methodological processes that are used to identify the three components of the theory within farmers' responses included content analysis of the in-depth interviews and non-linear Principal Component Analysis of the farmers' responses in the second section of the questionnaire.

The theory of planned behaviour (TPB) (Ajzen, 1991) measures intentions to involve in a behaviour on three constructs: attitudes towards the behaviour (A), subjective norms (SN) and perceived behavioural control (PBC). Questions are built based on psychosocial determinants of the using agricultural technology (inorganic fertiliser and modern irrigation system) and the role of cooperative in developing farming in Oman. The study sample contained a group of farmers as a whole who belonged to one of two analysis groups: those who are in the Al Batinah agricultural cooperative and those who are not part of a cooperative. Cooperative farmers tend to be younger, with less years of experience, but more educated. The more educated farmers are also those with irrigation systems. The cooperative members rely more on agriculture for their income with a tendency for a larger farm size and cultivated area. They also have more permanent workers, including more family members involved, and use more modern technologies. Table 16 provides a summary of farmers' attitudes towards modern technologies, based on the smaller sample survey.

Table 16: Summary of attitudes towards modern technologies

Type of Tech	Farmers	Findings
Modern irrigation	Both group	- Farmers agree that modern irrigation can increase yield, and has benefits for reducing soil and water salinity, and reducing water consumption. - Access to water is more important than access to electricity, and these are more important than cost of the irrigation and its maintenance. - Farmers are influenced positively by others regarding the use of modern irrigation. - The high cost of installation and the on-going cost of maintenance. - It is primarily based around perceived behavioural control. - The cost of fertiliser, and the cost of installation and maintenance of the irrigation system – may be a significant barrier to adoption for most farmers.
	Coop.	- Cost is seen as low, particularly for the cooperative farmers, and is also seen as more affordable by coop members. - Slightly more positive in terms of potential benefits, for yield, income, water consumption and soil preservation then the non-cooperative farmers, but all see benefits - The cost of installation is perceived as less prohibitive than for the non-cooperative group.
	Non-coop	- More concern over the availability of water and electricity
Inorganic fertiliser	Both group	- Farmers agree that inorganic fertiliser can increase yield, but do not see it as beneficial for the soil and water. - Water is a more important concern than the soil. - Fertiliser is seen as not always available in markets, often too far away and at too high a cost. - High cost and affordability are barriers to adoption - A central finding from this analysis is that for inorganic fertiliser it is a combination of the aspects of attitude, subjective norm and perceived behavioural control that appear to limit uptake
	Coop.	- Cooperative farmers perceive low value from this technology (as reflected in their intention scores) - Farmers are influenced positively by others regarding inorganic fertiliser use - Family are important influencers - Slightly more positive than non-coop farmers in terms of potential benefits, for yield, income, water consumption and soil preservation.
	Non-coop	- Influenced negatively by others regarding inorganic fertilizer use. - Extension officers have an important role in farmers' decisions. - Access to water in its use is a constraint and this can be more important than its cost.

Sources: Authors' survey 2015

There is greater willingness from the cooperative farmers for adoption of fertiliser and slightly more so for modern irrigation, although both groups are positive. Thus social pressures and social culture have been shown to play a role in decisions regarding using modern irrigation and inorganic fertiliser. (for more detail see section 6.9)

Each of the questions uses a five points unipolar Likert scale (1-5) that converts qualitative statements, such as strongly disagree to strongly agree, into quantitative values with a range from 1 to 5. For example, (1) strongly disagree; (2) disagree; (3) neutral (Neither agree nor disagree); (4) agree; and (5) strongly agree (Johns, 2010). In this specific example, TPB demonstrates three key elements: First, behavioural beliefs (attitudes towards the technology, A) related to farmers' beliefs concerning the positive or negative impact of using technology on productivity, soil characteristics, quality of water, and income. Second, subjective norms (social pressure through the adoption decisions of other, SN), for example, consider household members, neighbours, or extensional officers, and the extent to which they encourage or discourage using the specific technology. Third, control beliefs or perceived behavioural control (factors or circumstances that make it impede or easy to adopt the technology, PBC) such as availability of water and fertilisers, equipment or financial liquidity, and facilitation to purchase and use (see Appendix 2).

To grasp and know the farmer's point of view on the attitude towards behaviour and assessment that attitude, the researcher asked the farmers to answer some questions such as "To what extent do you agree or disagree with these statements: using inorganic fertiliser/irrigation increases yield, using inorganic fertiliser/modern irrigation increases my farm income." The farmer will answer by selecting one of the five scales points ''strongly disagree" to "strongly agree''. These questions attempt to reveal beliefs and behavioural attitudes of farmers to some variables that affect the use of technology and the degree of those variables (b). Another set of questions addressed the evaluation and importance effect of farmers using that technology (e). For example: "increased yields are important for my household, reduced water consumption is important for my farm and household." The farmer answers also based on the five scale points: "strongly disagree" to "strongly agree". In addition, there are set of questions to understand which variable is more important than the other by comparison process between them by asking "how much more important is the outcome on the left hand side compared to the outcome on the right hand side". Farmers answer by selecting from: "much less important" to "much more important".

Using the theory of planned behaviour can evaluate all the predictions by asking questions to the participants using a set of variables to assist the researcher in their study to analyse the data. Moreover, the position of the individual behaviour is to compare and standardise the behaviour of the individual. In another meaning, there is a strong intention of behaviour based on the assessment of the positive results for the performance of behaviour, and the influence of people surrounding a farmer are determined by social norms related to behaviour as well as volitional control of the performance of behaviour.

Subjective norm results from the strength of how other people who are considered important to the person to affect his/her behaviour (n) and the motivation to conform their beliefs (m). It measures the second element that used TPB by asking farmers to answer a set of questions. To understand the situation and appreciated by others who influence the potential for the use or not use technology (whether most people who are important to them would totally encourage or discourage). In this component, the researcher asks the farmer to "what extent do you agree or disagree with these statements: my family or neighbours think(s) that I should use inorganic fertiliser/modern irrigation (n)." The farmer answers by selecting from: "strongly disagree" to "strongly agree." The second set of questions address if that most individual or people who are important to them think that they motivate to conform their beliefs, for example, "your family or neighbours strongly motivates you to use inorganic fertiliser/modern irrigation (m)." Farmer answers by selecting from: "strongly disagree" to "strongly agree". In addition, another set of questions seek to understand which variable is more important than the other by comparison process between them by asking "how much more important is the group on the left hand side compared to the group on the right hand side?" The participant answers by selecting from: "much more important" to "much less important".

The last element that is used in TPB is perceived behavioural control (PBC). Two sub-elements are used. The first sub-element is depending on the control beliefs strength of farmer himself to perform or not perform the behaviour to introduce and use technology by asking the farmer "Is inorganic fertiliser/modern irrigation available in the market, the price of inorganic fertiliser or the equipment of modern irrigation…" (c). the second sub-element is to reveal if that variables make it difficult or easy to use technology (p) such as, "I know how to use inorganic fertiliser, I can afford to purchase sufficient inorganic fertiliser".

There are certain factors influencing farmers to introduce modern technology. The cost of technologies is considered an important obstacle facing farmers, especially small farmers, and so "price" is included in the analysis. Control beliefs and power control.

Control belief (self-efficacy) encompasses a level of ease or difficulty that is required to perform the behaviour, for example, "I can afford to purchase sufficient inorganic fertiliser"; "I can afford to install and operate modern irrigation"; and ''I cannot afford the maintenance costs''. The second variable is control beliefs or (controllability) refers to outside factors and one's belief that they personally have control over the performance of the behaviour, for example, ''the cost of inorganic fertiliser /modern irrigation is low'' on a five-point likert scale from ''strongly disagree' to ''strongly agree''. The PBC component reflects that price is a crucial factor influence farmer to adopt modern technologies: the technology is available in the markets, but it is difficult to obtain due to the high price. In Oman, interviews reveal that cost also appears to be a key issue that hinders farmers' use of inorganic fertiliser.

Another set of questions seek to understand which variable is more important to farmer than the other by comparison process between them by asking "How much more important is the outcome on the left hand side compared to the outcome on the right hand side?" The farmer will answer by selecting from: "much more important" to "much less important". Behaviour intention is the capability personality indication to perform a given behaviour. This intention is based on attitude towards behaviour (A), subjective norm (SN) and perceived behavioural control (PBC). In addition, it aims to understand all probability indicators for it's important in the relation to the behaviour. In the behaviour intention, the researcher asks questions, for example: "Do you intend to plant perennial or annual crops this year? Will you continue in the future in agricultural activities?"

4.6 Theoretical framework

The classification of the farm systems based on the following;

a) The structure of the farms: structural characteristics include the size of farm and the proportion of rented land, land fragmentation, farm infrastructure, access to road, trailing systems;

b) The main purpose of the farms: this is explained by whether or not the main income of the household comes from the farm, the reasons of becoming a vine grower, the intention to maintain and expand the vineyard in the future and the identification of a successor for the vineyard;

c) The production activities: production activities are explained by the practice or not of organic farming, irrigation practices, keeping of farm operation files, use of agricultural equipment;

d) Production diversity: meaning the combination with more than one crop and/or livestock;

e) Geographical occurrence: land formation (plain, slope, terraces), location of vineyard within the region. these factors can, consequently explain the adaptation to climate, the sensitivity to pests and diseases and the timing of farming activities. They can also be explanatory factors of the intention to abandon or continue vine-growing;

f) Intensity of production, in term of yields;

g) Dependency on external factors: agreements with buyers, other farmers, binding government directives, lack of alternative markets and regional characteristics and infrastructure (remoteness, proximity to communities);

h) Labour: family and hired labour, permanent and seasonal labour;

i) Off farm income and main occupation of the head of farm;

j) Geographic location: geographic location indicates which geographic and administrative region the farms are located in.

4.6.1 Descriptive analysis

This section discusses the nature of the socio-economic and demographic characteristics of farmers that influence their involvement in using modern agricultural technology. Preliminary data statistical involving descriptive statistics provide a summary of the data set. As discussed earlier in this chapter, the study was based on data obtained from 68 farmers. This discussion in this section mainly compares two groups of farmers: cooperative's members and non-cooperative.

4.6.2 Models

To evaluate the relationship between the likelihood of adoption and its factors, it is important to know how much each factor affects the farmers' choice. This study was used two broad categories of data analysis, namely descriptive statistics such as mean, standard deviation frequency and percentage. These summaries are mainly to provide an initial description of the data as a part of a more extensive statistical analysis and econometric like probit regression models. During the analysis SPSS version 22 software package was used.

4.6.3 Mean

The mean $(\overline{x})$, also known as the average, is obtained using a standard formula by dividing the sum of observations, say x, by the number of observations say, n.

$$\overline{x} = \left(\sum_{i=1}^{i=n} \mathrm{xi}\right)/\mathrm{n} \tag{4.1}$$

This equation is applicable when the number of observations and the error associated with data measurements are known. Where the number of observations and the error associated with data are unknown the weighted average which incorporates standard deviation is used.

4.6.4 Median

The median $(\tilde{x})$ is the middle values of the data set containing odd number of observation values or the average of the two middle values for set of data that contain even number of observations.

4.6.5 Standard deviation and variance

Standard deviation indicates how close the entire set of data is to the average value. A very small value of standard deviation indicates tightly grouped data and large values of standard deviations indicate data have spread out over a wide range of values. The standard deviation is given by:

$$\sigma = \sqrt{\frac{1}{n-1}\sum_{i=1}^{i=n}(x_i - \overline{x})^2} \tag{4.2}$$

and variance;

$$\sigma^2 = \frac{1}{n-1}\sum_{i=1}^{i=n}(x_{i-}\overline{x})^2 \tag{4.3}$$

The standard deviation is the square root of the variance and it can be used to estimate the true value variance of data. Standard deviation and variance of continuous random variable measure dispersion, or the degree at which the variable is spread.

According to the theory, human behaviour is guided by three kinds of considerations in adoption or not adoption modern technologies: beliefs about the likely outcomes of the behaviour and the evaluations of these outcomes, beliefs about the normative expectations of others and motivation to comply with these expectations, and beliefs about the presence of factors that may facilitate or impede performance of the behaviour and the perceived power of these factors. Before starting to analyse that considerations, order and find out the influences' variables in each consideration. By using multiple regression or structural equation analyses, we can decide the comparative contributions of attitudes, subjective norms, and perceptions of behavioural control to the prediction of intentions. We can determine the comparative contributions of intentions and perceptions of control to the prediction of behaviour. Furthermore, the questionnaire also evaluates behavioural beliefs in beliefs strength and evaluations of outcome), normative beliefs in strength of norm and motivation to respond, and control beliefs in strength of control and strength of perceived power.

The questionnaire covered that consideration. Behavioural beliefs create a positive or negative attitude toward behaviour. Normative beliefs are variables that can illustrate the effect of some social pressure such as family, neighbours, extensional offices, or other farmers.

A strong intention depends on a positive assessment of the performance behaviour, and the personality of people can play a role in the behavioural beliefs. Consequently, attitudes are identified by the belief strength of outcome (b) about the probability of subjective that given behaviour will result a particular outcome. The outcome of evaluation (e) mirrors the usefulness obtained from the appearances of that outcome, and n_the total number of characteristics a person considers That means both measures are multiplied to find out the behaviour attitudes ($A = \sum_{i=1}^{n} b_i e_i$). In s same process, subjective norm (SN) are resulted from the multiplied the strength of normative beliefs (n) and motivation of respond (m) ($SN = \sum_{i=1}^{n} n_i m_i$).

The third element is perceived behavioural control. This element consists of the strength of control belief (c) multiplied by perceive power control (p) and totality the results of PBC ($PBC = \sum_{i=1}^{n} c_i p_i$). Furthermore, also part of the TPB are links describing interactions between attitudes, control factors and social norms as well as factors summarized under ‘actual behavioural control. Wauters. et al. studied the behaviour adoption of soil conservation by used multiple items to measure intention, attitude toward behaviour, subjective norm and perceived of behavioural control (2010).

Ajzen (1991) highlights attitude towards the behaviour (A), subjective norms (SN), and perceived behavioural control (PBC). A strong intention depends on a positive assessment of the performance behaviour. Attitudes are determined by two factors (variables) of the outcome belief strength (b) about the subjective probability that a given behaviour (i) will produce a certain outcome, and the evaluation of outcome which mirrors the measurement evaluation of person (A= bi*ei). A positive result demonstrates a positive attitude to the behaviour and, in part, the potential strength of adoption, and vice versa for a negative result (Knabe, 2012). The following examples illustrate the type of statements used for inorganic fertiliser and modern irrigation in relation to attitude: “Using inorganic fertiliser/modern irrigation increases yield; (b) and increased yields is important for my household (e).”

Likewise, subjective norms are calculated from multiplying normative belief strength (n) and motivation to comply (m) (SN=ni*mi). A positive result suggests that subjective norms will have a beneficial influence on adoption regarding the behaviour and is the second part in determining the potential strength of adoption. The following examples illustrate the type of statements used for inorganic fertiliser and modern irrigation in relation to subjective norms: “My family thinks that I should use inorganic fertiliser (n) and your family strongly motivates you to use inorganic fertiliser (m);” and “My family thinks that I should use modern irrigation (n), and your family strongly motivates you to use modern irrigation (m).”

Finally, perceived behavioural control obtained from control belief strength (c) timed control perceived power (p) (PBC=ci*pi). The following examples illustrate the type of statements used for inorganic fertiliser and modern irrigation in relation to perceived behavioural control: “The cost of inorganic fertiliser is low (c), and I can afford to purchase sufficient inorganic fertiliser (p);” and “Water is readily available (c) and I can easily access water for irrigation (p).” If a respondent scored 5 (strongly agree), then the maximum value for the intention to adopt the behaviour is 25 (5 multiplied by 5 for each of A, SN and PBC).

The measurement calculation of these constructs follows an expectancy-value calculus, which multiplies one belief based measure with one personal estimation degree. Therefore, attitudes are determined by two factors (variables) of the outcome belief strength (b) about the subjective probability that a given behaviour (i) will produce a certain outcome, and the evaluation of outcome which mirrors the measurement evaluation of person (A= bi*ei). Likewise, subjective norms are calculated from multiplying normative belief strength (n) and motivation to comply (m) (SN=ni*mi). Finally perceived behavioural control obtained from control belief strength (c) timed control perceived power (p) (PBC=ci*pi).

An overall measure of A, SN and PBC are calculated by taking a mean of each element scores. second section of the questionnaire.

demonstrates the components of TPB. To evaluate the relationship between the likelihood of adoption and its factors, it is important to know how much each factor affects the farmers’ choice. This study used two broad categories of data analysis, namely descriptive statistics such as mean, standard deviation frequency and percentage. These summaries are mainly to provide an initial description of the data. During the analysis SPSS version 22 software package was used. As a part of the broader TPB approach, principal component analysis was undertaken. The data analysis took place in three steps: the first step was descriptive statistics assessment in order determine any correlation among variables. Those variables that were highly correlated were discarded.

4.6.6 Correlation analysis

Correlation analysis measures the relationship between two or more variables. Variables are said to be correlated when they vary together in a certain period of time. It can either be positive or negative. Hoover (2003) argued, on evidence from correlation Reinchenbach's principle of common cause, that when two variables x and y are correlated, then either x causes y, y causes x or x and y are effects of common cause. Positive correlation is associated with variables say x and y, so that an increase in x causes an increase in y while negative correlation indicates that an increase in x causes a decrease in y.

The correlation coefficient between the two variables (r) is given by:

$$r=\Sigma(x-\bar{x}).\,(y-\bar{y})/\sqrt{}\Sigma(x-\bar{x})^2.\,\Sigma(y-\bar{y})^2 \quad (4.4)$$

For variable x and y, the correlation coefficient can only tell if the variables vary together in a certain period of time but cannot tell whether y affects x or x affects y.

Although first correlation analysis is widely used, it is well known that values obtained between quantities vary with time, and are highly closely correlated in such a way that it is difficult to attach any significance meaning under ordinary tests, therefore correlation coefficient results are certainly significant (Johansen, 2007). Correlation coefficients arising from analysis that involves time series data which is non-stationary with stochastic trends can lead to spurious regression. It is highly recommended that results should be qualified empirically, so that characteristics and data properties process of can be established in economic models that can describe data variation in a reasonable way (Granger, 1981).

The following techniques are used to analyse the data: Linear regression model with a dummy variable, probit regression analysis, and principal component analysis (PCA).

4.6.7 Principle component analysis

Principle component analysis is a data reduction technique that represents a set of variables by a smaller number of variables called principal components. These principal components are uncorrelated, and therefore, measure diverse, unrelated characteristics or proportions of the data (Härdle and Simar, 2007). The focus for the analysis here was the first part of the questionnaire. I will derive first principal component and group it into two parts using its mean or median value. The group having value less than the mean value is given a value 0 and the other group having a greater value is giving the value 1. It is taken as dependent variables and region, age of farmer, gender, education and the size of agri. land are taken as independent variables. This study then used a binary dependent variable model (the probit model) to estimate the effect of the different attitudes of the farmers in using inorganic fertiliser and modern irrigation system in farming. An ordered probit model is used, with five outcomes for participate in each scheme; dummy variables (0,1), non-linear principal component analysis, and the use of Cronbach's alpha to assess the internal consistency of the constructs within a questionnaire (Ajzen, 2006).

4.6.8 Probit model regression

The probit model is normally used when the dependent variable is qualitative, indicating responses in one or two categories, and when individuals are required subjected to make choices. The model from different literature such as Koop (2012) follows the normal linear regression model and is expressed as:

$$y_i^* = x_i^* \beta + \varepsilon_i \tag{4.5}$$

Following the pattern adopted in Koop et al. (2007), the relationship between the observed response yi and latent variable $yi*$ is expressed as:

$$\Pr(yi=1|xi'\beta)=\Pr(xi'\beta+\varepsilon i>0) = \Pr(\varepsilon i>-xi'\beta)=\Phi(xi'\beta) \text{ and}$$
$$\Pr((yi=0|xi'\beta)=1-\Phi(xi'\beta) \tag{4.6}$$

Where yi is the individual's observed choice and $\Phi(.)$ is the cumulative standard normal distributions function (Koop et al., 2007).

The econometric model is shown in the following equation

$$Y_i = \beta_0 + \beta_1 X_1 + \beta_1 X_2 + \ldots + \beta_1 X_k + \delta D_i + \varepsilon \quad (4.7)$$

$$D_i = \begin{cases} 1 & \text{if the farmer is on the co-operative group} \\ 0 & \text{otherwise} \end{cases}$$

$$Y_i = \begin{cases} 1 & \text{if the farmer is using modern technology} \\ 0 & \text{otherwise} \end{cases}$$

Also

$$Y_i = \begin{cases} 1 & \text{if the farmer is using traditional irrigation} \\ 0 & \text{otherwise} \end{cases}$$

X_i : a set of characteristics of the farm and farmers such as age, cultivated area, education, occupation, income, experience. It also includes the other variables such as (region, age, education, family size, member of coops or not.)

ε is the error term which is independent and identically distributed (i.i.d) normally with mean equals to 0 and Variance given as $\sigma 2$ i.e., $\varepsilon i \sim (0, \sigma 2)$, $yi*$is the unobserved latent data, xi is the ith observation on kx1 vector of attributes or socio-economic characteristics including the intercept term (i.e. $x1$ is implicitly set to 1) and β is the kx1 vector parameters (β=$\beta 1$,$\beta 2$...βk). ε is a vector Nx1 (i = 1,... N, N is the number of observations) of random error terms, assumed to have zero mean and known variance equal to one; this assumption normalises and identifies the model, i.e. $\varepsilon i \sim N$ (0,1).

The coefficient of x (β's) makes the outcome of 1 more or less likely.

β is considered a key or the indication of dependent variable. If the sign of β is positive that means significantly more likely between farmers of cooperative members or not, and there are differ in the adoption of technology. In contrast, if the sign of β is negative that means significantly less likely between farmers of cooperative members or not, and there are no differ in the adoption of technology.

$$H_0 : \beta_1^{(1)} = \beta_1^{(2)} = \ldots = \beta_1^{(k)}$$

Here, the concentration is on the cooperative membership importance – when compared with personal characteristics and other socioeconomic factors – in the modern technology use. Features and factors considered include age, educational level, household members, experience and income source. These variables have been identified in the literature as a significant influence factors on decisions to the level use, and the objective is to study whether or not influence on use decisions than membership of cooperatives.

The third step was a Hierarchical Cluster Analysis (HCA). It consists of classifying the observations according to the distance between them. Hierarchical cluster analysis starts by seeking the two observations that are closer to each other and merging into one cluster, and the procedure continues until all observations are incorporated in one cluster. During the analysis, the clusters remain unchanged, meaning that each cluster contains the clusters created before it.

The most common distance used in the Euclidean distance given by the formula:

Eucledian distance = rX(Xi − Yi)2i (4.8)

This method was implemented by using the Ward method and Euclidean distance criterion.

4.7 Explanation of key variables

There are number of variables that are believed to influence farmers' performance for the agricultural services which can be included in the models to explain variables in inorganic fertiliser and modern irrigation. These variables which are being considered as important have been cited in several literatures (Defrancesco et al., 2008, Mariano et al., 2012, Carlisle, 2016).

A total of 8 key variables were selected top be included in the models to explore the determinants on farmers' perception using inorganic fertiliser and modern irrigation. The selected variables included the categories concerning farm, farmers and their household characteristics and socio-economics variables: age, number of family member, educational level of the household head, farming experience of farmer, farmer's occupation household income from agriculture, labour availability (permanent and household) and cultivated area. The definition of these variables are presented in

Table 17 below.

4.7.1 Household characteristics:

Age: Experience linked to age may increase the knowledge of farmers with respect to the application of production inputs and expected returns. On the other hand, older farmers may be conformist and undecided in the non-use of modern technology in agriculture due to a possible lack of knowledge and fear of the associated risks (Imoru and Ayamga, 2015).

Education level: Several studies have suggested that the more educated a farmer is the more he/she will use and adopt modern agricultural inputs (Croppenstedt et al., 2003). There may therefore in this study be found a direct correlation between the level of education and the conservation of natural resources as well as development and improvement in the productivity of agriculture using modern agricultural technology.

Household size: Inorganic fertiliser and modern irrigation system applications typically increase productivity. Accordingly, household with a large size might be inclined to use agricultural inputs and outputs to increase production in order to meet the needs of family (Aregay and Minjuan, 2012).

Workers: Some studies have found that having permanent workers on a farm can have a positive impact on inorganic fertiliser and modern irrigation use (Hurst et al., 2005). However, the use of agricultural technology is may reduce employment. Farmers may be tempted to address the potential impact of the absence and lack of permanent workers on the production through the application and modern technology use. (Yilma and

Berger, 2006). On the other hand, permanent workers may have negative impact on agriculture because of lack of skills and experience of various agricultural processes such as the inorganic fertiliser use and irrigating crops. This method affects the natural resources quality and yield (Visser and Ferrer, 2015). Moreover, those farmers who grow lucrative crops such as vegetables, might choose to use modern technology while preserving the natural resources of soil and water, to reduce the contamination risk. In addition to selecting good employment, which has experience in various agriculture field.

Household annual income: Household income or financial return, whether from agricultural, monthly salary or other sources is considered a prime influence in agriculture development. Households with higher annual income tend to have more capacity to invest in modern technology. Because the availability of sufficient money increases the likelihood to purchase productive inputs, a positive relationship is expected.

Farm characteristics

Farm size: The effect of farm size on inorganic fertiliser and modern irrigation use is uncertain. Some studies have shown positive relationship between the probability of adoption modern technology and size, while a negative relationship has been found in others (Gebregziabher and Holden, 2011). In some cases, farmers may utilize their small sized farm in a more productive way to achieve the maximum return in order to fulfil the household needs. In other cases, if farmer has alternative source of income than agriculture, it could lead to the small sized farms neglect and focus on alternative jobs more productive. Farmers may not invest in using modern technology if the harvest is not profitable (Yilma and Berger, 2006).

Crop type: The use of modern technology may vary with the choice of crops. In this case, assuming the application of modern technology is higher in vegetable crops. In terms of plant production cycle is shorter and therefore can be grown more than once per year. Therefore, it is expected that the use of modern technology is higher in vegetables (Coughenour and Chamala, 2007).

Table 17 demonstrated the main variables.

Table 17: main variables' description and expected signs

Variables	Description	Expected sign	Explanation
Age of respondent	Household head's age	+ve	It is continuous variable. Household's age may return positive because older farmers have more expertise in cultivation and they are likely to adopt in agriculture to obtain high return
Household size	Number of people in the household	Ambiguous	It is a continuous variable If people are active and assist in agriculture, then they will be a positive sign and vice versa. If the family member is not active or productive at work, then they will be a negative sign
Education level	Schooling years of household head	+ve	It is a discrete variable as ''0'' represents an illiterate farmer, ''1'' represents a farmer who can read and write. If the farmer was educated. This assists to understand agricultural operation and increase their output and income. That means a positive sign.
Farming experience	Years of experience	+ve	It is a continuous variable. If the farmer has a good experience, this assists to be active and productive work to develop their farmland.
Income	Resource to the household and farm	Ambiguous	It is a continuous variable. If the farmer has another income rather than agriculture may assist and support them to improve their farm.
Farm holding size	refers to total farm size possessed by the farmer	Ambiguous	It is a continuous variable. If the land is tapped well, it positively affects sign. And if it's untapped well, it negatively impacts sign.
Workers	Number of worker in the farm	Ambiguous	It is a continuous variable. If they are active in their farm with a good skills and knowledge that means a positive sign (they are contributed to improve their farm and increase the output and income and vice versa if they inactive.
Cultivated area	Total cultivated area with crops in the last year	+ve	It is a continuous variable. If the land was utilized properly such as crops diversity, soil and water resources preservation.

4.8 Ethical consideration

The ethical and legal considerations are important in the work of any study or survey, since the responsibility to conduct the study, the researcher is granting ethical clearance. The University of Reading (UoR) granted ethical clearance for the researcher during the study period, between May and August 2015. The ethical clearance form was sent to the relevant authorities (Ministry of Agriculture and Fisheries) in the Sultanate of Oman to take the necessary measures to facilitate and provide the required researcher during the period of survey, in addition to coordination with officials involved in interviewing. The researcher explained to the participants the objectives of the study and the data that would be collected, and its confidentiality. Personal data was deleted and replaced them with a specific code.

4.9 Limitations of the Study

No study can be without any constraints or barriers facing research and researcher. This study faced a number of challenges especially concerning access to government documents and other publications from organisations in Oman. For example, some significant documents from government and agricultural cooperatives and the containing important information and data were not readily available. Lack of and poor record saving as well as the unavailability of database in agricultural technology contributes much of the study to support some of the facts, and influence a negative impact to the researcher. A second limitation is that the findings of this study cannot be generalised. Another limitation is that the study did not include any female farmers since all the farmers in Oman are males.

Any search or experiment is not without drawbacks that limit the survey during the given period: there were some barratries that faced the researcher through data collection. Firstly, rise in the temperature: featuring summer in the Sultanate of Oman at high temperature degrees, which sometimes reach more than 50 degrees celsius. This factor impacts the researcher when he continues to work for prolonged periods. Secondly, the researcher had to cover considerable distances to reach the sample of farmers. Finally, it was not always possible to find the relevant staff and farmers, such as during the official vacation times.

4.10 Conclusion

This chapter has described the methodology used in this study. The study uses a mixed method of quantitative and qualitative to obtain the behaviour and perception of farmers in and outside an agricultural cooperative with respect to technologies and management practices that the government is encouraging them to use so as to increase food production in the country. The next chapters provide the results of these approaches.

Chapter 5 Qualitative insights into Omani farmer attitudes, norms and behaviours

5.1 Introduction

This chapter presents the findings and insights from the qualitative interviews that were analysed using NVIVO. The interviews were undertaken during the second stage of fieldwork, which involved the three Government officials, the manager of Al Batinah cooperative, and three farmers within and six outside of that cooperative. The interviews were conducted around a number of themes which included a discussion on the productivity of the agricultural sector and the role of technology, and the role of cooperatives. There was particular emphasis on the use of fertiliser, irrigation, issues in production, and marketing. The interviews, though general in their format, were designed to complement the quantitative Theory of Planned Behaviour analysis, and as such the distinct themes of attitudes, norms, and behaviours are highlighted.

The information in this chapter is presented as follows. First, the key elements of a general discussion with the respondents are presented, that cover the respondents' thoughts on the role of technology in general and their intentions to continue farming. Second, detail is provided on the respondents' observations and thoughts concerning (i) productivity and environmental impact linked to inorganic fertilisers and irrigation (attitudes); (ii) the influence of wider society on the farming community (subjective norms); and (iii) fertiliser and water availability and costs involved (perceived behavioural control). Finally, the respondents' perceptions concerning marketing and the role of cooperatives are provided.

5.2 General insights from participants

Discussion started with the current problems faced by farmers. The issues that were most mentioned by the farmers were the small size of their holdings; access to and use of chemicals (fertiliser, insecticide, herbicides and pesticides); water and irrigation; water and soil salinization; soil erosion; high temperature/humidity; crawl population of farmland; issues in agricultural marketing; renting land to foreigners; and the rising prices of production inputs.

The majority of respondents who were interviewed expressed the opinion that technological progress had a role in and increasing the yield and quality of crops. This would come from increased mechanization, the availability of various inputs in crop and animal production, including the rapid development of inorganic fertilisers, pesticides and plant breeding, but requires the availability and provision of more finance and skilled labour, although labour on farms overall may have declined. Key general comments from the government and cooperative managers who were interviewed are provided in Table 18.

Table 18: General comments from government and cooperative managers

Interviewee	Comment
Government official	"There are prepared strategies and services by the MOAF to farmers to improve their level and situation either increasing agricultural production, increasing the income or improving their living standards, for example, developing small farms by introducing modern irrigation systems or building protective walls on the sides of valleys in the farming villages to irrigate farms"
Government official	"There are programs set by the government to increase the productivity by using modern technology as modern irrigation system, hybrid seeds and greenhouses (with soil and hydroponic)"
Government official	"There is vital project to be implemented by the MOAF for farmers to increase the irrigated area in aflaj areas by grouping falaj water in the ground tanks, and pumping through an integrated network of modern irrigation. This project aims to develop the management of water distribution system, reduce the time and effort to irrigate crops and improving farm incomes".
Cooperative manager	"I motivate and fostering to introduce modern technology in agricultural to reduce water consumption and improve the quantity and quality of crops as well as the increase in production per unit area"

Source: Stakeholder interviews 2015

Farmers perceived both positive and negative impacts on both soil and water. Specifically mentioned was soil salinization, soil fertility and soil erosion. It was commented that farmers in the cooperatives are characterised as using "modern agricultural technology such as seeds, modern irrigation, greenhouses, and a wider range of agricultural equipment". In contrast, farmers outside of the cooperatives "cultivated smaller area", and mostly cultivated fruit such as "palm tree, citrus, fodder crops and leafy crops".

Further comments were made on and by the farmers' regarding their own intentions and willingness to continue in agriculture. This was linked to their interest in both improving agricultural productivity and protecting the environment. Some farmers have the intension and desire to continue in agriculture because it is the main source of income. Farmers also suggested that they would be more likely to also continue if they can use modern technology and plant a greater diversity of crops. For cooperative farmers in particular the role of modern technology was mentioned. In contrast, reasons for farmers who do not have the intention and desire to develop their farms were high salinity in the soil and water, l was a summary of the farmer comments are given in Table 19.

Table 19: Farmer views on continuing in agriculture

Interviewee	Comment
Farmer, not member of cooperative	''I have a desire continuing and sustainability with diversity of crops, and using modern technology in agriculture with the help of workers'
Farmer, not member of cooperative	''I do not have desire to continue in agriculture because of high salinity in soils and water, dependence on the monthly salary, and lack of support from the government''
Farmer, cooperative member	"I have desire to continue in the coming period in agriculture by the seasonal crops cultivation, ambition and intend to develop the introduction of modern agricultural technology''

Source: Stakeholder interviews 2015

Benckiser and Schnell (2006) similarly state that there are many factors which have a role and influence on agricultural output and sustainability. They state that the most important of these are: farmers' willingness to continue in agriculture, water availability, soil fertility, soil and water devoid of salinity, cultivated areas and diversity in agricultural crops, services and agricultural infrastructure's availability, education and skills, availability of agricultural production inputs in addition to existence of marketing outlets for agricultural products. These findings similarly exemplify those of Mariano et al. (2012), the importance of continuity and sustainability in agriculture for farmers to be interested in and willing to adopt new technologies. Many farmers commented on increased productivity, and its links to managing soils and water. Comments that specifically emphasised inorganic fertiliser are detailed in Table 20.

Table 20: Farmer views on inorganic fertiliser

Interviewee	Comment
Farmer, not member of cooperative	"Inorganic fertiliser is useful and assists soil conservation, plant and productivity improvement using modern technology and applying post-harvest process"
Farmer, cooperative member	"Inorganic fertiliser increased my yield, I use the quality types of fertilisers and absence of any residues. In addition, using modern technology as hybrid seeds, modern irrigation system, hydroponics".
Farmer, not member of cooperative	"Inorganic fertiliser useful to increase yield if used properly".
Farmer, cooperative member	''Inorganic fertiliser has important element of the farm if used properly in agriculture by using a soluble fertiliser of a good quality type and soil conservation properties as well as assists in increasing yield and income''
Farmer, cooperative member	''Inorganic fertiliser is a complementary to organic fertiliser, increasing the amount used will affect to soil and crops''
Farmer, cooperative member	''Inorganic fertiliser affect the soil degradation, whether the salinity increase or the presence of sediment toxicity and residues of certain compounds, particularly when the traditional irrigation use''.

Source: Stakeholder interviews 2015

5.3 The Role of Attitudinal Factors

In terms of agricultural output, farmers agreed that vegetable crops are a relatively profitable crop in Oman, with yields and profitability influenced by mechanization, types of seeds, fertilisers, soils structure, and salinity of soils and water. Farmers also stated that increasing the productivity and diversity of agricultural crops will have a positive influence in the markets and for household income. All interviewed farmers agree that increasing yield and income are considered important for farm and household, in addition to reducing the need for labour by using new technology. The government respondents emphasized that there are programmes to increase farm productivity by using new technology such as hybrid seed, inorganic fertiliser, and modern irrigation.

5.3.1 Attitudes to fertiliser

Farmers generally believed that inorganic fertilisers assist to increase the yield and productivity of crops, so long as high quality fertilisers are used, there is an absence of any residues, and that they are used properly. However, some of the respondents also commented that the use of inorganic fertilisers in farming has a negative effect on the environment and health: "Inorganic fertilisers have a role in the soil properties especially increasing soil salinity, in addition inability and capability of the plant to absorb essential elements". Furthermore, farmers commented that inorganic fertiliser can increase soil degradation, whether through increased salinity or the presence of sediment toxicity and residues of certain compounds, particularly when traditional irrigation is used. Moreover, it was suggested that inorganic fertiliser has a negative impact in terms of its requirement for plenty of water: "inorganic fertiliser requires more water than organic due to the composition and nature of fertiliser". One farmer also mentioned that ''inorganic fertilisers do not assist to reduce the amount of water consumption, but rather depends on the climate change and use times''.

The responses in the interviews suggested that there were some differences in the perceptions and behaviour of farmers who belonged to the agricultural cooperative and those who were outside the cooperative. Farmers who belong to an agricultural cooperative are characterized by the cultivation of various vegetables such as chili, sweet, tomato crops. They plant various types of crops and illustrated that the crops' diversity assists agricultural land to maintain soil fertility. The farmers also stated that the use of a rotation or agricultural cycle has an important role in maintaining soil fertility and increasing productivity. On the other hand, small holder farmers who are not members of the cooperative mentioned that they face problems with productivity because of a lack of diversity in agricultural crops combined with limited availability and shortage of water. Due to these constraints these farmers were more likely to plant fruit trees and fodder crops in addition to leafy crops, rather than vegetables. These areas are mostly concentred in mountain and aflaj regions.

All farmers outside of the cooperative spoke about the importance of the use of organic fertilisers in agriculture for several reasons. The first of these reasons is its role in the broader farming system. Many farmers are breeding animals in their homes or on farms, so the manure is being utilized as fertiliser in agricultural crops. The second factor is their dependency on irrigation of crops using traditional irrigation. This is what they inherited and have used since ancient times to irrigate their farms. The third factor is salinization of soil which is seen as one of the dilemmas and issues facing agriculture, especially in coastal areas. Problems with salinization are most commonly associated with excessive water application and poorly drained fields, rather than with too little water. The presence of salinity in the soil has a role in poor harvest and low productivity. Farmers supported the use of organic fertilisers to minimize and lessen the salinity of soil. It was recognised that most farmers use organic fertilisers in their farm, especially before planting (flipping/ploughing the land), while the use of chemical fertilisers are at different stages of the life of the crop (planting, flowering and fruiting). Farmers will also minimize their use of chemical fertilisers through the use of leguminous crops (alfalfa, beans and parsley, coriander, etc.), crop rotation and crop diversity.

5.3.2 Attitudes to irrigation

Farmers clearly expressed the opinion that irrigation is an essential input to crop production in Oman as the average annual rainfall is not sufficient to support crop production in most areas. Farmers in Oman use wells to augment their surface water supply with groundwater and aflaj to watering their crops. In some areas, wells have enhanced agricultural productivity substantially, while in others the sustained use of poor-quality shallow groundwater has increased the pace of soil salinity reducing aggregate productivity in areas close to the sea. The irrigated areas in mountains and aflaj are much smaller, but these areas produce a substantial proportion of agricultural output. Many farmers in Oman have installed wells and pumps to gain access to the nation's limited groundwater supplies. Over pumping of groundwater is threatening the sustainability of irrigated agriculture in some portions of the country.

Modern irrigation is seen by the interviewed farmers as having a positive role in increasing farm productivity, both quantity and quality, and thus income, and that it also has a role in improving the households' livelihood. Both groups of farmers agreed that this system has a positive influence in reducing water consumption, salinity of soil and water, the spread of weeds, and labour requirement. The farmers that adopt modern irrigation systems are those that use water wells. There is a desire to encourage farmers to introduce and adopt modern irrigation system due to benefits that have been mentioned. The government is keen to introduce this technology, modern irrigation, to farmers by their strategy and policy to improve their level and situation through increasing agricultural production, increasing the income or improving their living standards.

Modern irrigation is seen to have a key role in reducing water consumption and improving soil conservation through more optimal use. Water salinization is seen as one of the obstacles and barriers facing agricultural holdings and farmers, especially in coastal areas. Water quality has a significant role in crop output and the quality of arable crops, and has a negative effect on the land and plant in general: ‘’Reduced salinity water assists in the diversity of agricultural crops and increased productivity’’ and vice versa “water salinity has a negative impact on the deterioration of the crops productivity".

Soil salinity was also referred to. Soil is considered the environment in which plants live. The characteristics and components of the soil have an active and key role in the types of the crops that are cultivated. It was stated that the majority of farmers who use modern irrigation systems reduce soil erosion and salinity. Comments on soil salinity and its links to modern irrigation can be found in Table 21.

Table 21: Comments on soil salinity and links to irrigation

Interviewee	Comment
Farmer, not member of cooperative	"Good composition and structure of soil in addition to free of soil salinity have a role in increasing the yield".
Farmer, not member of cooperative	"Increased salinity in water has a negative impact on the soil and deterioration of the agricultural crops productivity".
Farmer, not member of cooperative	"Modern irrigation assists improving the production and income, reducing the water consumption, soil salinity and erosion in addition to labour requirement"
Farmer, cooperative member	"Modern irrigation system assists to increase yield and income reducing water consumption, salinity of soil and water, weeds spreads, and labour requirement"
Farmer, cooperative member	"Reducing salinity of water assists in the diversity of agricultural crops and increase the productivity"

Source: Stakeholder interviews 2015

Comments were also made on traditional irrigation, called falaj and found in aflaj areas, where it is used to irrigate fruit and fodder crops. This system is based on the distribution of water according to the share (quota) of each farmer. Farmers mentioned a number of drawbacks in its, particularly high evaporation in summer and leakage, increased pests and diseases, difficult uses in any time, the teenager's reluctance to use this system, and reliance on expatriate labour. In this situation, the government strive to overcome this issue by introducing modern irrigation system in aflaj areas by grouping falaj water in the ground tanks, and pumping through an integrated network of modern irrigation. This project aims to increase the efficiency of water use and develop the management of water distribution systems, reduce the time and effort to irrigate crops and thus improve farm incomes.

5.4 The Influence of Subjective Norms

In the interviews farmers noted that social and cultural factors have an important role in the use of inorganic fertiliser and modern irrigation systems, and that people close to the farmers have a major impact on the decision-making towards the use and introduction or not of agricultural production inputs and outputs in agriculture. This decision may have a positive effect and helps to develop the ranch or adversely affect the farm and farmer.

The interviewees generally approved of the use of inorganic fertilisers, but it was recognised that this use is influenced by traditional lifestyles and social interdependence and the use of organic fertilisers within a mixed livestock and cropping system. Furthermore, there is some social pressure not to use inorganic fertilisers, part of the reason being tradition, lack of understanding on how it can be used, and the fact that some farmers disapprove of the use inorganic fertiliser because it may be seen as needing more water and could be difficult to use in traditional irrigation properly.

For irrigation one farmer stated that ''Traditional irrigation has a negative effect on water consumption and increase the evaporation and leakage'' and that the people who influence farmers, whether family, other farmers or agricultural extension and agricultural shops will motivate them to use modern irrigation in agriculture because of its considerable importance in agriculture.

5.5 The Role of Perceived Behavioural Control

A number of areas emerged focused on the ability to use inorganic fertiliser properly, the availability and cost of inorganic fertiliser, and the availability of water and costs associated with irrigation. For fertiliser one respondent stated that the benefit of fertiliser is linked to a farmer's skills and experience ''The use of inorganic fertiliser is important and useful to the soils and plant if used in the right way''.

The most important issue raised was the high costs for the purchase of inorganic fertilisers from agricultural stores, with low domestic price for the product, which has a subsequent negative role in the continuity and continuation of farmers in agriculture, particularly smallholder farmers. The availability of fertilisers was also seen as an issue. It was also reiterated that despite availability in agricultural shops it has a high price, and that there is not sufficient quantity available, or sufficient quantity could not be purchased due to cost.

There was divergent opinion on the availability of water. Several opinions were provided. For example, ''Water is available and can be obtained in sufficient quantity to irrigate their agricultural crops', as well as "Water will be readily available if all use it in the property way". Whereas some of the respondents suggested that there was a 'lack of water regularly and often scarce in summer and this had an influence on farmers' adoption especially traditional irrigation using aflaj water''.

Farmers also mentioned that knowledge of how to use irrigation systems also had an impact, particularly the need to recognise the role of periodic maintenance in averting problems associated with the system, and the need for skilled workers to help with this. The high cost of installing a modern irrigation was also recognised. However, the cost of water in the more traditional system was also suggested as an obstacles and challenge faced by farmers due to irregularity and high cost of irrigation in the summer season. Finally, accessible and available electricity was seen as relevant, and issues with consistency of supply was seen as one problem, alongside cost.

5.6 The Role of Markets and Cooperatives

Agricultural marketing is a key and decisive stage because it is considered the final stage within agriculture. Farmers recognised that the location of a farm in relation to its market was of key importance in the value of the product to the farmer. There is increasing importance placed on local markets, but the existence of competition in agricultural commodity products and the dominance of some segments in the market has significant influence on this. This has led to concerns over the risk of a drop in commodity prices particularly where there has been both specialisation and also low volume, and farmers competing to supply the same local markets. In addition, there is the presence of strong competition from imported products. However, one interviewee suggested that ''this situation is normal on the external competition existence for agricultural products, but the farmer is capable of growing high quality crops using modern technology to compete with those foreign agricultural outputs''.

In Al Batinah farmers contribute significantly to the provision of basic crops for the local market such as tomatoes, carrot, and cucumber. Commodity prices vary according to season and availability in market, in addition to the foreigner product existence which advisedly affect the prices of local outputs. Some farmers explained the dominant and monopoly of sellers in market "foreign dealers monopolize markets and price control by storing large quantities of products displayed at the start of the season and during non-availability of the products to hit and the elimination of the local product''. The manager of cooperative emphasized and clarifies that additionally, often lower prices drives to abandon the farmer or change its activity. Comment was also made on the role of contracts in mitigating price fluctuations.

5.7 Concluding thoughts

Overall, there are factors and barriers that affect agricultural productivity in Oman that were discussed by the interviewees during interviews. Some of the key points are summarised here. Productivity may decline over time in regions with brackish or saline groundwater where the supply of higher quality surface water is not sufficient to leach salts from the root zone. The degradation of soil and water resources that has occurred over a long period in Oman has probably contributed to the declining rates of growth in productivity. The problems of salinity particularly in coastal regions and shortage of water in aflaj areas are a concern for the government. The sustained use of saline groundwater for irrigation has probably accelerated the pace of soil salinization in some areas, contributing to the declining rates of growth in crop yields. Poor quality groundwater, low fertiliser efficiency and increased losses to weeds and diseases have contributed to slower growth rates in crop yields. The increase in areas affected by salinity and the decline in soil fertility in some areas have probably contributed to the declining rates of growth in crop yields. Inappropriate nutrient applications may also have contributed to declining productivity growth rates. These problems are in part the result of leakage of water from large, earthen canals; the extensive use of saline groundwater; and the inefficient use of water and fertiliser on farms.

Successful efforts to reverse the declining growth rates will require policies and programmes that promote wiser use of limited resources, while maintaining the output required to sustain the livelihoods of rural residents and provide food supplies for urban areas. Success will depend on farmers choosing and being able to adopt technologies and management approaches that are promoted, either directly, or via cooperative management.

Chapter 6 Quantitative insights into Omani farmer attitudes, norms and behaviours

6.1 Introduction

This chapter present results from the main survey quantitative survey. The following section 6.2 summarises background detail of the farmers, both cooperative and non-cooperative members who were interviewed. Farmers' decisions to participate in cooperatives' affairs and the intensity of their participation in a given period of time is hypothesized to be influenced by a combined effect of various factors of household and agricultural holding characteristics, and the socio-economic environment in which the members are operating. Based on the brief literature review in this study a total of 8 variables are hypothesized to explain participation. Section 6.3 then addresses the findings from the Theory of Planned Behaviour analysis.

6.2 Descriptive analysis of variables

This section clarifies the definition and nature of the socio-economic and demographic characteristics of the households that affect their participation in the affairs of agriculture. As discussed earlier in the methodology part, the study was based on cross sectional data obtained from 68 respondent households. The discussions in this section mainly compare the two agricultural groups of farmers: non-coop and coop members.

6.2.1 Household characteristics

Age of respondent is a number of completed years of the household head. It is continuous variable. Older farmers may be more experienced with respect to knowledge concerning the application of production inputs and expected returns. On the other hand, elder farmers may be more conformist, uncertain over the use of modern technology due lack of knowledge and fear of the risks associated with using it (Imoru and Ayamga, 2015). Thus the head of household's age may link to the adoption of inorganic fertiliser and modern irrigation system use.

Level of education represents the level of formal schooling completed by the household head. It is a discrete variable as ''0'' represents an illiterate farmer, ''1'' represents a farmer who can read and write. Educated members are familiar with their duties and rights in agriculture and might be expected to have active participation experience. Several studies have suggested that the more educated a farmer is the more he/she will use and adopt modern agricultural inputs (Croppenstedt et al., 2003). Thus there is an expectation that there is a direct correlation between the level of education and the conservation of natural resources, as well as development and improvement in the productivity of agriculture using modern agricultural technology.

Family size is number of individuals in the household. It is a continuous variable. Because inorganic fertiliser and modern irrigation can increase productivity, larger households might be inclined to use agricultural inputs and outputs to increase production in order to meet the needs of family. However, the use of family members on the farm may reduce costs and purchasing of inputs and outputs requirements, which could be used to purchase other household necessities (Aregay and Minjuan, 2012). In this case, large size of family may be having influence and role in the continuity or not in agriculture to increase the production scale and improve family income.

Some studies find that permanent workers on a farm have a positive impact on inorganic fertiliser and modern irrigation use (Hurst et al., 2005). The anticipated influence of household agricultural labour on the inorganic fertiliser and modern irrigation system use could be a little bit ambiguous. This is because the use of such technology enhances the weeds' growth reduction and water consumption, implying that the use of agricultural technology can reduce labour demand.

Temporary farmers who carry out additional work other than agriculture whether in the on or off production season may be a significant factor in the improvement of agriculture in addition to income. Temporary agricultural workers may also have demonstrable effect in agricultural processes that require more workers, particularly crops that harvest multiple times, such as tomatoes, beans, cucumber, pepper. Farmers may be also tempted to address the potential impact of the absence and lack of permanent workers on the production through the application and modern technology use (Yilma and Berger, 2006). On the other hand, permanent workers may have negative impact on agriculture because of lack of skills and experience of various agricultural processes such as the application of inorganic fertiliser and irrigating crops which affects quality and yield (Visser and Ferrer, 2015). Moreover, those farmers who grow lucrative (profitable)crops such as vegetables are likely to use modern technology in agricultural while preserving the natural resources of soil and water, to reduce the contamination risk.

Household income represents the income obtained from different activities including agriculture. It is a continuous variable. Household income or financial return, whether from agriculture, monthly salary, or other sources is considered the prime mover in the agriculture development with respect to the capital endowment of the farmers. Households with higher annual income have more capacity to invest in modern technology. The availability of sufficient money may also increase the likelihood to purchase productive inputs, and is thus expected to have a positive relationship.

6.2.2 Farm characteristics

Farm holding size refers to total farm size possessed by the farmer. It is a continuous variable. The effect of farm size on inorganic fertiliser and modern irrigation use is uncertain. Some studies have shown positive relationship between the probability of adoption modern technology and the productivity, while a negative relationship is found in other cases (Gebregziabher and Holden, 2011). In some cases, farmers may utilize their small sized farm in a more productive way to achieve the maximum return in order to fulfil the household needs. In other cases, if farmer has alternative source of income than agriculture, it could lead to the small sized farms neglect and focus on alternative more productive jobs. Farmers may not invest in using modern technology if the harvest is not profitable (Yilma and Berger, 2006). Land represents an important farm asset that can enhance the capacity of the members to involve in every aspect of marketing activities of cooperatives.

Type of crop refers to the crops growing in the farmland. The use of modern technology may vary with the choice of crops. In this case, a prior assumption is that the application of modern technology is higher in vegetable crops. In terms of plant production, vegetable cycles are shorter and therefore more than one crop can be grown per year. Therefore, it is expected that the use of modern technology is higher in vegetables (Coughenour and Chamala, 2007).

6.3 Analysis of variables

Table 22 presents the size of household and age of agricultural groups. It shows that the majority (94% and 86%) respondent's age of coop and non-cooperative farmers respectively lied between 35 and 64 years' groups. The mean difference between the two age group respondents was statistically significant (t=4.695, p=0.0001). Older households are expected to have more experience in the agricultural input utilization and marketing output through cooperatives.

Table 22: Family size and age of agricultural groups

	Non-coop, N = 50		Coop, N = 18		Total, N=68	
	responses	percent	responses	percent	responses	percent
Family size						
1-5	14	28 %	4	22.2 %	18	26.5 %
6-10	21	42 %	11	61.1 %	32	47.1 %
11-15	14	28 %	2	11.1 %	16	23.5 %
Above 15	1	2 %	1	5.6 %	2	2.9 %
Age						
< 25	0		0		0	0
25-34	2	4 %	2	11.1 %	4	5.9 %
35-44	15	30 %	13	72.2 %	28	41.2 %
45-54	14	28 %	2	11.1 %	16	23.5 %
55-64	14	28 %	0	0	14	20.6 %
Above 64	5	10 %	1	5.6 %	6	8.8 %

Source: Author's survey 2015

The education level of householder is presented in Table 23. The table represents that 76% of the household members of non-cooperative have basic and medium level and 61% in cooperative members. This indicator reflects that there is interest by the farmers learning and the knowledge expansion. It is important to determine the educational needs of small farmers in order to provide educational programming that is relevant to their operations. Furthermore, how farmers obtain information to broaden his/her knowledge in agriculture and any new technology may assist developing farming.

Table 23: Education level of householder

	Non-coop, N = 50		Coop, N = 18		Total, N=68	
	responses	percent	responses	percent	responses	percent
Education level						
Illiterate	8	16 %	1	5.6 %	9	13.2 %
Basic level	17	34 %	5	27.8 %	22	32.4 %
Medium	21	42 %	6	33.3 %	27	39.7 %
High level	4	8 %	6	33.3 %	10	14.7 %

Source: Author's survey 2015

Table 24 demonstrates the farming experience (years), occupation and income. This reveals there is slight change in farming experience between two groups. Depending of the household, the household income consists of agriculture, non-agriculture activities, public sector, remittances and other resources. Around a half of non-cooperative farmers are work in agriculture and 62 % of their main income resource is from outside agriculture. However, 89% of cooperatives members work in agriculture sector and 77% of their income is from agriculture. This results that the majority farmers of cooperative rely on agriculture unlike non-cooperative.

Table 24: Farming experience, occupation and income

	Non-coop, N = 50		Coop, N = 18		Total, N=68	
	respondents	percent	responses	percent	responses	percent
Farming experience (years)						
1-10	10	20%	5	27.8%	15	22.1%
11-20	12	24%	5	27.8%	17	25.0%
21-30	11	22%	7	38.9%	18	26.5%
Over 30	17	34%	1	5.6%	18	26.5%
Occupation						
Agriculture	27	54%	2	11.1%	29	42.6%
Other	23	46%	16	88.9%	39	57.4%
Income (main source)						
Agriculture	19	38%	14	77.8%	33	48.5%
Other	31	62%	4	22.2%	35	51.5%

Source: Author's survey 2015

Table 25shows the permanent and household workers. 30% of non-cooperative farmers do not have permanent employment. 70% and 56% of the non-cooperative and cooperative farmers respectively have permanent workers of between 1 and 10. 44% of cooperative farmers have more than 10 permanent workers. More than three quarters of non-cooperative farmers do not have workers from their household. 83% of cooperative have their family members working (4 or more) in agriculture with them.   This indicator reflects the benefits and interest by the household of cooperative in agriculture.

Table 25: Permanent and household workers

	Non-coop, N = 50		Coop, N = 18		Total, N=68	
	respondents	percent	responses	percent	responses	percent
Permanent labour						
Without	15	30%	0		15	22.1%
1-10	35	70%	10	55.6%	45	66.2%
11-20	0	0	2	11.1%	2	2.9%
over 20	0	0	6	33.3%	6	8.8%
Household workers						
0	38	76%	0		38	55.9%
1-3	10	20%	3	16.7%	13	19.1%
4-6	1	2%	5	27.8%	6	8.8%
Over 6	1	2%	10	55.6%	11	16.2%

Source: Authors' survey 2015

Table 26 presents the total and cultivated area of each group. The distribution illustrates that the majority of non-cooperative respondents indicated 10 acres or less of cultivated and land area (76% and 62% respectively). By contrast, a majority of cooperative respondents indicated more than 20 acres' land and cultivated area (94% and 87% respectively). These results indicate and reflect that small farmers are concentrated in the respondents of non-cooperative. Likewise, members of cooperative are likelihood to cultivate and grow crops and use/adopt new agricultural technology more than non-cooperative.

Table 26: distribution of total and cultivated area of sample respondents

	Non-coop, N = 50		Coop, N = 18		Total, N=68	
	respondents	percent	respondents	percent	respondents	percent
Total area (acre)						
≤ 10	31	62 %	0	0	31	45.6 %
11-20	13	26 %	1	5.6 %	14	20.5 %
21-30	4	8 %	7	38.9 %	11	16.2 %
≥ 31	2	4 %	10	55.6 %	12	17.6 %
Cultivated area						
≤ 10	38	76 %	0	0	38	55.9 %
11-20	10	20 %	3	16.7 %	13	19.1 %
21-30	1	2 %	5	27.8 %	6	8.8 %
≥ 31	1	2 %	10	55.6 %	11	16.2 %

Source: Authors' survey 2015

6.3.1 Comparison of cooperative and non-cooperative samples

No significant difference was noted regarding the number of dependent household members, age of the household and the farming experience of the household between the two groups. Moreover, irrigators had significantly higher education levels than non-irrigators.

On average, cooperative had larger farm sizes and higher cultivated areas than non-cooperative. However, these differences are not statistically significant. A slightly higher proportion of cooperative perceived that they own good quality land. Cooperative had significantly higher land productivity than non-cooperative. Also, the total value of assets owned by cooperative is significantly higher than that of non-cooperative.

6.4 Validity and reliability

Creswell and Miller (2000) refer to validity as the degree which the evaluation measures what it is intended to measure. The significant test of any qualitative study is its quality (a good qualitative research may assist to recognise a situation that would otherwise be confusing or unknowable. This study uses the triangulation process, which relies on the use of multiple sources for verification and confidence and the quality of data (Bryman and Cramer, 2001); and built mutual trust between the researcher and the respondents (farmers - agricultural cooperatives and government employees), all of which contributes to increased reliability of the data.

Bashir et al. (2008) defined reliability as a concept used for testing or assessing quantitative research. Cronback alpha is a tool that is used for measuring validity and reliability within quantitative analyses. Sarmah and Hazarika (2012) defined reliability is the consistency and repeatability through a different and series steps of measurement (Cronbach). In this thesis if the quantitative results are compatible and consistent with the qualitative findings, the analysis is considered to have a conceptual validity.

6.5 Theory of Planned Behaviour quantitative findings – Inorganic fertiliser

This section is concerned with the intention of farmers in relation to the importance of modern agricultural technology in the use of inorganic fertilisers and modern irrigation by using the social-psychology theory of planned behaviour. There are three key components of the theory: the attitudes towards the behaviour, individual and collective criteria that have a significant impact on farmer in the decision to use inorganic fertiliser and modern irrigation, as well as perceived behavioural control that has an impact and ability of farmers in the performance and execution of whether or not it can be used in agriculture.

6.5.1 Farmers' attitude towards the use of inorganic fertiliser

An individual's attitude towards using inorganic fertiliser behaviour has a role in the farmer's belief in the importance of inorganic fertiliser. A person who has strong values is likely to accept the importance of inorganic fertiliser. The following set of variables and factors that influence the attitudes and perception of farmers' behaviour using inorganic fertiliser as yield and income, water and soil structure. These factors play a role in farmers' behaviour. The first four questions related to the farmers' belief on the importance of inorganic fertiliser. For example, the first question posed was ''do you think that using inorganic fertiliser increases yields?''. Positions one (strongly disagree) to five (strongly agree) correspond to the degree of priority given to the various factors on a scale of one to five as shown in the first column of Table 27. The values in the table are the percentage of respondents in each question. Question five to eight related to the outcome to the importance of inorganic fertiliser to farm and household as ''do you think that using inorganic fertiliser increased yield?''

Table 27: Factors influencing the attitude toward the farmer's behaviour use in inorganic fertiliser

(% respondents) Coop, n = 18	Non-coop, n= 50								
		α	1	2	3	4	5	Mean	St.Dev.
Using inorganic fertiliser increases yields	Non-coop	.905	4.0	8.0	8.0	34.0	46.0	4.1	1.11
	Agri.coop	.757	16.7	5.6	27.8	33.3	16.7	3.3	1.32
Using inorganic fertiliser increases my farm income	Non-coop	.907	4.0	10.0	6.0	32.0	48.0	4.1	1.15
	Agri.coop	.765	5.6	22.2	5.6	50.0	16.7	3.5	1.20
Using inorganic fertiliser reduces demand for water	Non-coop	.909	18.0	44.0	18.0	10.0	10.0	2.5	1.20
	Agri.coop	.767	38.9	22.2	16.7	16.7	5.6	2.3	1.32
Using inorganic fertiliser preserves soil structure	Non-coop	.907	22.0	44.0	14.0	12.0	8.0	2.4	1.20
	Agri.coop	.791	38.9	16.7	11.1	22.2	11.1	2.5	1.50
Increased yield is important for my household	Non-coop	.906	2.0	0.0	0.0	32.0	66.0	4.6	0.70
	Agri.coop	.765	5.6	5.6	11.1	27.8	50.0	4.1	1.18
Increased farm income is important for my household	Non-coop	.906	0.0	0.0	0.0	30.0	70.0	4.7	0.46
	Agri.coop	.764	0.0	11.1	0.0	27.8	61.1	4.4	0.98
Reduced water consumption is important for my farm and household	Non-coop	.907	0.0	0.0	0.0	32.0	68.0	4.7	0.47
	Agri.coop	.765	0.0	11.1	0.0	16.7	72.2	4.5	0.99
Improved soil structure is important for my farm and household	Non-coop	.907	0.0	0.0	4.0	24.0	72.0	4.7	0.55
	Agri.coop	.767	0.0	11.1	0.0	16.7	72.2	4.5	0.99

Source: Authors' survey 2015

Attitudes in the farmers' behaviour towards inorganic fertiliser in agriculture has a role in their belief. There is difference in the view point and perception between farmers of cooperative and non-cooperative. 80% of the non-coop's farmers agree and strongly agree that using inorganic fertilisers increase yield and income. While found represents 50% and 67% with coop's farmers agree and strongly agree that assist increase yield and income respectively. More than a half of farmers in both groups do not agree that the inorganic fertiliser has a role in reducing the water use and preserve soil structure. Whereas their consent to increase yield and income, reduce water consumption as well as improve soil structure important to farm and household's farmer indicating that generally, the attitude of farmers towards fertiliser use was unfavourable. Attitude, like knowledge and skill, determine the use of new innovations. Farmers' attitudes are more likely to correspond with their behaviours (Okoedo-Okojie and Aphunu, 2011).

6.5.2 Comparison (benchmarking) in the importance between the outcomes of inorganic fertiliser

Farmers were asked to consider pairwise which aspects of farming, linked to the use of inorganic fertiliser, were more important to them. Their responses are summarised in Table 28. Farmers were asked, for example, whether “improved yield” or “increased income” was more important. The results are given for farmers who are members of cooperatives and those that are not.

Table 28: Pairwise comparison of farming attributes with respect to inorganic fertiliser

Question: How much more important is the outcome on the left hand side compared to the outcome on the right hand side? 5 represents strongly agree (much more important), 1 represents strongly disagree (much less important)

(% respondents) Coop, n = 18	Non-coop , n= 50								
		α	1	2	3	4	5	Mean	St.Dev.
Improved yield-increased income	Non-coop	.920	12.0	16.0	24.0	22.0	26.0	3.3	1.3
	Agri.coop	.934	0.0	0.0	27.8	5.6	66.7	4.4	0.9
Improved yield-Reduced demand for water	Non-coop	.919	22.0	14.0	24.0	24.0	16.0	3.0	1.4
	Agri.coop	.935	5.6	11.1	16.7	27.8	38.9	3.8	1.4
Improved yield-Preserved soil structure	Non-coop	.918	30.0	16.0	16.0	30.0	8.0	2.7	1.4
	Agri.coop	.932	16.7	11.1	5.6	27.8	38.9	3.6	1.5
Increased income-Reduced demand for water	Non-coop	.919	26.0	12.0	20.0	34.0	8.0	2.9	1.4
	Agri.coop	.932	5.6	5.6	38.9	22.2	27.8	3.6	1.1
Increased income-Preserved soil structure	Non-coop	.919	26.0	10.0	18.0	32.0	14.0	3.0	1.4
	Agri.coop	.931	16.7	11.1	22.2	16.7	33.3	3.4	1.5
Reduced demand for water-Preserved soil structure	Non-coop	.920	14.0	10.0	34.0	28.0	14.0	3.2	1.2
	Agri.coop	.932	11.1	5.6	33.3	16.7	33.3	3.6	1.3

Source: Authors’ survey 2015

Table 28 shows the difference between the attitude towards the behaviour and the outcome of that result using inorganic fertilisers between coop and non-coop’s farmers. Perhaps surprisingly, both groups of farmers agreed (4)/ strongly agreed (5) that improved yield was more important than income, with around a quarter of farmers considering both more or less equally important (3). With regard to improved yield and reduced demand for water, 67% of coop’s members agreed that improved yield was more important than reduced demand for water. They explained during qualitative discussions that increased yield was the goal of farmers, whereas water consumption can be reduced by using various modern agricultural technologies in farming processes. On the other hand, farmers who were not part of a cooperative were more split. Some agreed with the cooperative farmers, but others believed that reduced demand for water is more important because water is always difficult to find in sufficient quantities. Similarly the data suggest differences in pairwise comparisons for improved yield versus preserved soil structure. Around half of both cooperative and non- cooperative farmers agreed that increased income is more important than preserved soil structure; whereas around a third felt the opposite.

6.5.3 Subjective norms

Normative beliefs refer to how other people who are considered important to the person would like to confirm the behaviour, and it is this dimension of TPB that links closely to motivation to comply. For example, ''my family/extension service thinks that I should use inorganic fertiliser/modern irrigation in farming''. Motivation to comply is the motivation to conform with those normative beliefs i.e. the motivation to comply with significant others' views. For example, farmers answer ''to what extent do you think that your family/extension service strongly motivates you to use inorganic fertiliser/modern irrigation in farming'' on a five-point scale ranging from '' strongly disagree'' to ''strongly agree''.

In the literature a number of authors have found a link between subjective norms and attitudes towards behaviour. For example, Bonne et al. (2007) show that religion can affect consumer attitudes and behaviour and food purchasing decision and eating habits in particular. Similar links have been found with respect to buying organic food (Tarkiainen and Sundqvist, 2005). Fielding et al. (2008) reported that group norms and intergroup perceptions were significant predictors of intentions to engage in sustainable agricultural practices in Australia, thereby providing support for the inclusion of social identity concepts in the theory of planned behaviour. People who have positive attitudes towards the behaviour, think that there is normative support for performing the behaviour, and perceived that they can easily perform the behaviour.

Subjective norms relate to understanding social pressures to perform or not perform a behaviour. The effect of social culture and pressure close to farmers have a role to approve or disapprove using inorganic fertiliser. These individuals or people mirror their beliefs about others who are important to them and they may have a strong influence to their behaviour. Theory points out that persons tend to adopt a behaviour's performance that is considered willingness by the individuals or group close to farmer and this can influence inorganic fertiliser use or not use (see Table 29).

Table 29: Factors influencing subjective norm of the farmer's behaviour use in inorganic fertiliser

(% respondents) Coop, n = 18	Non-coop, n= 50								
		α	1	2	3	4	5	Mean	St.Dev.
My family thinks that I should not use inorganic fertiliser	Non-coop	.908	22.0	16.0	16.0	28.0	18.0	3.0	1.4
	Agri.coop	.765	50.0	16.7	0.0	16.7	16.7	2.3	1.6
My neighbours think that I should not use inorganic fertiliser	Non-coop	.904	16.0	14.0	30.0	14.0	26.0	3.2	1.4
	Agri.coop	.781	55.6	5.6	5.6	22.2	11.1	2.3	1.6
Extension service providers think that I should not use inorganic fertiliser	Non-coop	.905	12.0	8.0	22.0	24.0	34.0	3.6	1.4
	Agri.coop	.758	27.8	11.1	16.7	33.3	11.1	2.9	1.5
The government thinks that I should not use inorganic fertiliser	Non-coop	.905	14.0	10.0	30.0	16.0	30.0	3.4	1.4
	Agri.coop	.756	27.8	16.7	16.7	27.8	11.1	2.8	1.4
Your family strongly motivates you to use inorganic fertiliser	Non-coop	.905	14.0	26.0	6.0	24.0	30.0	3.3	1.5
	Agri.coop	.776	38.9	33.3	0.0	22.2	5.6	2.2	1.4
Your neighbours strongly motivate you to use inorganic fertiliser	Non-coop	.904	14.0	14.0	24.0	24.0	24.0	3.3	1.4
	Agri.coop	.765	38.9	22.2	16.7	0.0	22.2	2.4	1.6
Extension service providers strongly motivate you to use inorganic fertiliser	Non-coop	.903	12.0	16.0	14.0	22.0	36.0	3.5	1.4
	Agri.coop	.760	44.4	5.6	16.7	16.7	16.7	2.6	1.6
The government strongly motivates you to use inorganic fertiliser	Non-coop	.903	10.0	10.0	28.0	16.0	36.0	3.6	1.3
	Agri.coop	.761	44.4	11.1	16.7	5.6	22.2	2.5	1.7

Source: Authors' survey 2015

Table 29 demonstrates the extent and magnitude of the social pressure influence for people surrounding farmer. The questions from 1 to 4 addressed farmer's belief on the impact of people who are close in decision-making with respect to using or not using inorganic fertiliser. It is clear that group close coop's farmers as family (67%), neighbours (61%), agricultural services (39%) and the government (45%) are likely not to use inorganic fertiliser. In contrast, there are some people close to farmer influence to using inorganic fertiliser as family and neighbours (33%), extension service (44%) and government (39%). While there is a difference in the impact to approve and non-approve of non-cooperative farmers by people close to them with respect to inorganic fertiliser use. This may be due to the farmers' awareness and belief of people close to them the importance of inorganic fertiliser use. On the other side, farmers of non-cooperatives think that family (46%), neighbours (40%), agricultural services (58%) and the government (46%) should use inorganic fertiliser. While some people disagree to using inorganic fertiliser as family (38%), and neighbours (30%), perhaps because of the lack of agricultural information on the inorganic fertiliser importance in agriculture. The question from 5 to 8 addressed farmer's motivation from people who are close in decision-making to use inorganic fertiliser. From the results there is a clear influence between the two groups. People close to cooperative farmers, their family (72%), neighbours (61%), agricultural services (50%) and the government (55%) not motivated farmers to use inorganic fertiliser. The high percentage is maybe due to awareness of farmers and people in the inorganic fertiliser importance and knowing how to use it properly. By contrast, people close to non-cooperative farmers, their family (54%), neighbours (48%), agricultural services (58%) and the government (52%) motivated these farmers. Lack of motivation and encouragement of the people close to farmers could be outcome weakness of the agricultural awareness of the agricultural importance of using it, the lack of visit and follow-up by the agricultural services, small size area in addition to using traditional irrigation in watering crops.

6.5.4 Comparison in the importance between the outcomes

Again, this time for subjective norms, farmers were asked pairwise comparisons with respect to who is important to them when considering information that can influence the use of inorganic fertiliser (Table 30).

Table 30: Pairwise comparison of influencers with respect to inorganic fertiliser

Question: How much more important is the outcome on the left hand side compared to the outcome on the right hand side?

	(% respondents) Coop, n = 18		Non-coop, n= 50					
		α	1	2	3	4	5	Mean	St.Dev
Your family-your neighbour	Non-coop	.920	4.0	18.0	20.0	22.0	36.0	3.7	1.3
	Agri.coop	.934	5.6	5.6	11.1	5.6	72.2	4.3	1.2
Your family-agricultural extension	Non-coop	.919	14.0	22.0	14.0	32.0	18.0	3.2	1.4
	Agri.coop	.933	11.1	5.6	38.9	5.6	38.9	3.6	1.4
Your family-government	Non-coop	.920	16.0	14.0	22.0	28.0	20.0	3.2	1.4
	Agri.coop	.933	16.7	5.6	27.8	16.7	33.3	3.4	1.5
Your neighbours-agricultural extension	Non-coop	.921	12.0	32.0	30.0	12.0	14.0	2.8	1.2
	Agri.coop	.934	16.7	5.6	33.3	11.1	33.3	3.4	1.5
Your neighbours-government	Non-coop	.921	16.0	16.0	32.0	22.0	14.0	3.0	1.3
	Agri.coop	.935	5.6	11.1	38.9	16.7	27.8	3.5	1.2
Agricultural extension-government	Non-coop	.920	0.0	2.0	50.0	34.0	14.0	3.6	0.8
	Agri.coop	.934	5.6	5.6	44.4	11.1	33.3	3.6	1.2

Source: Authors' survey 2015

Table 30shows the comparison in the importance between two results. From the table above it is clear that a farmer's family is more influential than neighbours, agricultural extension services, and the government, particularly for the cooperative farmers. For the non-cooperative group, it is worth noting that extension officers are also an important influence.

6.5.5 Perceived behavioural control

Perceived behavioural control concerns a farmer's perceptions of their ability to perform a given behaviour, i.e. the farmer's beliefs about the presence of factors that may facilitate or hinder performance of the behaviour (see Table 31).

Table 31: Perceived behavioural control (PBC) of inorganic fertilisers

(% respondents)	Coop, n = 18		Non-coop, n= 50						
		α	1	2	3	4	5	Mean	St.Dev.
Inorganic fertiliser is available on the market	Non-coop	.907	4.0	4.0	6.0	36.0	50.0	4.2	1.0
	Agri.coop	.761	16.7	16.7	16.7	16.7	33.3	3.3	1.5
The market where fertiliser is sold is not too far away	Non-coop	.908	4.0	14.0	4.0	42.0	36.0	3.9	1.2
	Agri.coop	.763	22.2	11.1	5.6	38.9	22.2	3.3	1.5
The cost of inorganic fertiliser is low	Non-coop	.911	42.0	36.0	4.0	10.0	8.0	2.1	1.3
	Agri.coop	.744	38.9	16.7	27.8	11.1	5.6	2.3	1.3
Water is important for the application of inorganic fertiliser	Non-coop	.907	0.0	0.0	4.0	30.0	66.0	4.6	0.6
	Agri.coop	.746	5.6	0.0	5.6	5.6	83.3	4.6	1.0
I know how to use inorganic fertiliser	Non-coop	.904	4.0	0.0	2.0	42.0	52.0	4.4	0.9
	Agri.coop	.733	0.0	0.0	0.0	38.9	61.1	3.7	1.5
I can easily obtain fertiliser from market	Non-coop	.904	2.0	2.0	6.0	42.0	48.0	4.3	0.8
	Agri.coop	.735	11.1	16.7	22.2	33.3	16.7	3.3	1.3
I can afford to purchase sufficient inorganic fertiliser	Non-coop	.904	2.0	8.0	8.0	46.0	36.0	4.1	1.0
	Agri.coop	.738	22.2	5.6	11.1	33.3	27.8	3.4	1.5
I have ready access to water	Non-coop	.905	40.0	44.0	6.0	10.0	0.0	4.2	0.9
	Agri.coop	.741	0.0	0.0	11.1	38.9	50.0	2.4	1.3

Source: Authors' survey 2015

Table 31 illustrates the behavioural intention to sustainable and continues in agriculture. 80% and 67% of farmers in non-cooperative and cooperative respectively agree that they intend to plant perennial crops this year. Most farmers planting perennial crops particularly fruit trees such as citrus and mango in addition to forage crops as alfalfa and rhodsgrass. The second question deals with the farmers' intention to plant annual (seasonal) crops. All farmers whose belong to the cooperative and 86% non-cooperative agree and strongly agree that they intend to plant annual crops. Farmers in cooperatives' members are cultivated annual crops, particularly commercial vegetables crops such as tomatoes, sweet pepper and cucumber. In contrast, farmers outside the cooperative especially whose their farms are in the mountain and aflaj areas they cultivated fodder and leafy crops and some of them are grown limited amounts of vegetables and non-commercial as tomatoes, garlic, onion, cucumber in small area. The third question about the continuity and sustainability of farmers in the future in the agricultural activities. 94% and 82% of farmers in cooperative and non-cooperative respectively they had desire to continue in the future in agriculture activities. This may be agriculture is considered the main income's source to the most farmers as well as a cover part of the household's costs. More than 70% of farmers in the cooperative and 60% in non-cooperative in question four they had future targets other than agriculture. These farmers have ambitious and targets for example in trade, business assist to increase their income, cover the families' cost, in addition to the farming's expansion with the provision of the necessary supplies as input and output production. On the other hand, 26% of farmers in non-cooperative are unsure and hesitant those have other target/s than agriculture, this may be due to old age, poor learning (uneducated) as well as their adherence to the land. In the question about if the farmer intend to develop their farm in near future, all farmers belong the cooperative and 84% of farmers in non-cooperative agree that they want to develop their farm. Any farmer aspires to develop his/her farm by the physical ability with the support by the government. The majority (more than 95%) of farmers in both groups agree that they already used organic fertiliser and intend continue use it in the future because of their knowledge of its importance to the land and plant. Whereas, the question about using inorganic fertiliser, 94% and 66% of farmers in cooperative and non-cooperative respectively agree that they intend to use it and around a quarter of non- cooperative are disagree to use it. This is probably because most farmers know the importance of inorganic fertilisers in agriculture and know how to use it properly. While some of farmers are concerned and reluctant to use it whether in terms of good knowledge lack of how to use it properly or because of the high price. 77% and 44% of farmers in cooperative and non-cooperative respectively disagree intend to use traditional irrigation in agriculture. This maybe because of the high evaporation and leakage in addition to the unavailable water in any time. 44% of farmers in non-cooperative agree to continue use it in the future because is the main source to irrigate their crops. The majority (more than 95%) of farmers in both groups intent to use modern irrigation system in the future. In the last question if the farmer do not have modern irrigation installed, and intend to install modern irrigation in the future. 83 % farmers of cooperative disagree that they not had a modern irrigation system (they all had modern irrigation system and will continue to be used in the future). On the other hand, a half (50%) of farmers in non-cooperative agrees that he/she not had modern irrigation installed, and intend to install it in the future. In addition, 48% of them they had modern irrigation and will continue to be used in the future.

6.5.6 Comparison in the importance between the outcomes

Table 32: Pairwise comparison of behavioural controls with respect to inorganic fertiliser

Question: How much more important is the outcome on the left hand side compared to the outcome on the right hand side?

(% respondents) Coop, n = 18	Non-coop, n= 50								
		α	1	2	3	4	5	Mean	St.Dev.
How to use inorganic fertiliser-easily obtain fertiliser from market	Non-coop	.924	6.0	18.0	10.0	20.0	46.0	3.8	1.4
	Agri.coop	.937	0.0	0.0	11.1	22.2	66.7	4.6	0.7
How to use inorganic fertiliser-afford to purchase sufficient inorganic fertiliser	Non-coop	.925	6.0	22.0	12.0	22.0	38.0	3.6	1.4
	Agri.coop	.937	0.0	5.6	11.1	33.3	50.0	4.3	0.9
How to use inorganic fertiliser-ready access to water	Non-coop	.921	16.0	34.0	18.0	10.0	22.0	2.9	1.4
	Agri.coop	.935	11.1	0.0	22.2	33.3	33.3	3.8	1.3
Easily get fertiliser from market -afford to purchase sufficient inorganic fertiliser	Non-coop	.923	4.0	22.0	32.0	24.0	18.0	3.3	1.1
	Agri.coop	.934	0.0	16.7	27.8	27.8	27.8	3.7	1.1
Easily obtain fertiliser from market - ready access to water	Non-coop	.920	22.0	34.0	20.0	12.0	12.0	2.6	1.3
	Agri.coop	.934	16.7	22.2	27.8	16.7	16.7	2.9	1.3
Afford to purchase sufficient inorganic fertiliser-ready access to water	Non-coop	.919	28.0	28.0	16.0	16.0	12.0	2.6	1.4
	Agri.coop	.935	16.7	22.2	27.8	27.8	5.6	2.8	1.2

Source: Authors' survey 2015

Table 32 demonstrates the comparison between two factors that one of them is more important and influence to farmer than another. 89% and 66% of farmers in cooperative and non-cooperative respectively agree that how to use inorganic fertiliser is more important than easily obtaining fertiliser from market. How to use inorganic fertiliser properly is vital factor that assists in preserve the environment. 83% of cooperative farmers and 60% of non-cooperative agreed that how to use is more important than being able to afford to purchase sufficient amount of inorganic fertiliser. Further, 50% of non-coop's farmer and 11% of coop agreed that ready access water is more important than how to use it, maybe due to water being a key input in agriculture. There is a convergence in the farmer's responses because both factors are important.

6.5.7 Behavioural intention

Behavioural intention concerns a farmer's perceptions and indication of their ability to perform a given behaviour. It is based on the attitude towards the behaviour, subjective norm and perceived behaviour control with each predictor weighted for its importance in relation to the behaviour of farmers Table 33.

Table 33: Behavioural intention

(% respondents) Coop, n = 18 Non-coop, n= 50									
		α	1	2	3	4	5	Mean	St.Dev.
I intend to plant perennial crops this year	Non-coop	.908	8.00	2.00	10.00	22.00	58.00	4.3	1.07
	Agri.coop	.768	11.11	0.00	22.22	11.11	55.56	3.8	1.65
I intend to plant annual crops this year	Non-coop	.909	8.00	0.00	6.00	34.00	52.00	4.5	0.89
	Agri.coop	.768	0.00	0.00	0.00	11.11	88.89	3.8	1.47
I will continue in the future in agricultural activities	Non-coop	.906	2.00	0.00	16.00	18.00	64.00	4.6	0.70
	Agri.coop	.768	0.00	0.00	5.56	5.56	88.89	4.3	1.13
I have future target/s other than agriculture	Non-coop	.909	4.00	10.00	26.00	16.00	44.00	3.9	1.22
	Agri.coop	.769	0.00	11.11	11.11	16.67	61.11	4.0	1.14
I intend to develop my farm in near future	Non-coop	.907	0.00	2.00	14.00	26.00	58.00	4.6	0.67
	Agri.coop	.794	0.00	0.00	0.00	11.11	88.89	4.3	0.89
I intend to use organic fertiliser	Non-coop	.907	0.00	0.00	4.00	26.00	70.00	4.7	0.56
	Agri.coop	.778	0.00	0.00	0.00	11.11	88.89	4.8	0.55
I intend to use inorganic fertilise	Non-coop	.905	14.00	10.00	10.00	26.00	40.00	4.3	1.13
	Agri.coop	.770	0.00	5.56	0.00	16.67	77.78	3.0	1.57
I intend to use traditional irrigation	Non-coop	.913	24.00	22.00	10.00	18.00	26.00	2.5	1.58
	Agri.coop	.769	66.67	11.11	11.11	0.00	11.11	3.2	1.58
I intend to use modern irrigation	Non-coop	.907	2.00	4.00	2.00	38.00	54.00	4.4	0.95
	Agri.coop	.777	0.00	0.00	0.00	0.00	100.00	4.3	0.97
I do not have modern irrigation installed, I intend to install modern irrigation in the future	Non-coop	.914	30.00	18.00	2.00	18.00	32.00	2.2	1.64
	Agri.coop	.767	83.33	0.00	0.00	0.00	16.67	3.9	1.53

Source: Authors' survey 2015

Table 33 illustrates the behavioural intention to plant crops in the future and to use either modern or traditional technologies. Farmers in cooperatives are more likely to cultivate annual crops, particularly commercial vegetables crops such as tomatoes, sweet pepper and cucumber. In contrast, farmers outside the cooperative especially those whose farms are in the mountain and aflaj areas, mainly cultivate fodder and leafy crops, while some of them grow limited amounts of non-commercial vegetables including tomatoes, garlic, onion, and cucumber. Most farmers whether or not in a cooperative had desire to continue in the future in agriculture. However, more than 70% of farmers in the cooperative and 60% in non-cooperative in question four they had future targets other than agriculture. These farmers have ambitious and targets for example in trade, business assist to increase their income, cover the families' cost, in addition to the farming's expansion with the provision of the necessary supplies as input and output production. On the other hand, 26% of farmers in non-cooperative are unsure and hesitant. This may be due to old age, poor learning (uneducated) as well as their adherence to the land.

Most farmers intend to develop their farm in near future. The majority (more than 95%) of farmers in both groups stated that they already used organic fertiliser and intend to continue to use it in the future because of their knowledge of its importance to the land and plant. Whereas, the question about using inorganic fertiliser, 94% and 66% of farmers in cooperative and non-cooperative respectively agree that they intend to use it and around a quarter of non- cooperative are disagree to use it. This may be because most farmers know the importance of inorganic fertilisers in agriculture and know how to use them properly. However, some of farmers are concerned and reluctant to use it whether in terms of good knowledge lack of how to use it properly or because of the high price. 77% and 44% of farmers in cooperative and non-cooperative respectively prefer not to use traditional irrigation in agriculture, this may be because of the high evaporation and leakage in addition to the unavailable water during some periods The majority (more than 95%) of farmers in both groups intent to use modern irrigation system in the future.

6.6 Theory of Planned Behaviour quantitative findings – Modern irrigation

This section is concerned with the intention of farmers in relation to the importance of modern agricultural technology in the use of modern irrigation by using the social-psychology theory of planned behaviour. Consensus on the farmers' importance to use modern irrigation system in agriculture. Personal attitude: attitude is the accumulation of belief about certain behaviours measured by the evaluation of these beliefs, or as psychological tendency to evaluate the entity or behaviour, positive or negative feelings towards a person's behaviour in the workplace. If someone has a positive attitude towards irrigation behaviour, then that person will have a high intention to behave in such and will eventually do so.

6.6.1 Farmers' attitude towards the use of modern irrigation

There are differences in beliefs farmers about the benefits and importance of modern irrigation use in agriculture. Of the merits of the Table 34, noted that the obvious difference extent in the farmer's belief in using modern irrigation system.

Table 34: Attitude toward the use of modern irrigation

(% respondents) Coop, n = 18	Non-coop, n= 50								
		α	1	2	3	4	5	Mean	St.Dev.
Using modern irrigation increases yields	Non-coop	.908	2.0	6.0	10.0	14.0	68.0	4.4	1.0
	Agri.coop	.735	5.6	5.6	11.1	16.7	61.1	4.2	1.2
Using modern irrigation increases my farm income	Non-coop	.907	2.0	0.0	6.0	16.0	76.0	4.6	0.8
	Agri.coop	.735	5.6	0.0	5.6	27.8	61.1	4.4	1.0
Using modern irrigation reduces water consumption	Non-coop	.907	0.0	0.0	2.0	18.0	80.0	4.8	0.5
	Agri.coop	.761	0.0	0.0	0.0	16.7	83.3	4.8	0.4
Using modern irrigation reduces water salinity	Non-coop	.907	0.0	0.0	6.0	20.0	74.0	4.7	0.6
	Agri.coop	.765	11.1	11.1	0.0	16.7	61.1	4.1	1.5
Using modern irrigation reduces soil erosion	Non-coop	.907	0.0	2.0	6.0	20.0	72.0	4.6	0.7
	Agri.coop	.785	5.6	5.6	11.1	11.1	66.7	4.3	1.2
Using modern irrigation reduces labour requirement	Non-coop	.907	0.0	2.0	6.0	24.0	68.0	4.6	0.7
	Agri.coop	.771	0.0	0.0	0.0	22.2	77.8	4.8	0.4
Increased yield is important for my household	Non-coop	.907	0.0	0.0	0.0	22.0	78.0	4.8	0.4
	Agri.coop	.758	0.0	0.0	5.6	22.2	72.2	4.7	0.6
Increased farm income is important for my household	Non-coop	.907	0.0	0.0	0.0	24.0	76.0	4.8	0.4
	Agri.coop	.765	0.0	0.0	5.6	16.7	77.8	4.7	0.6
Reduced water consumption is important for my household	Non-coop	.907	0.0	2.0	0.0	20.0	78.0	4.7	0.6
	Agri.coop	.772	0.0	0.0	5.6	11.1	83.3	4.8	0.5
Reduced water salinity is important for my farm	Non-coop	.907	0.0	0.0	0.0	24.0	76.0	4.8	0.4
	Agri.coop	.765	0.0	0.0	0.0	16.7	83.3	4.8	0.4
Reduced soil erosion is important for my farm	Non-coop	.907	0.0	0.0	0.0	22.0	78.0	4.8	0.4
	Agri.coop	.765	0.0	0.0	5.6	16.7	77.8	4.7	0.6
Reduced labour requirement is important for my farm	Non-coop	.908	0.0	2.0	2.0	24.0	72.0	4.7	0.6
	Agri.coop	.765	0.0	0.0	5.6	22.2	72.2	4.7	0.6

Source: Authors' survey 2015

Table 34clarifies the attitude of farmers toward the modern irrigation behaviour. The questions from 1 to 6 were addressed attitude of farmer's belief. It is clear that the belief and feeling farmers that using modern irrigation had a positive impact in agriculture and that clear through large finding by farmers. More than 90% in both groups of farmers they agreed that using modern irrigation increases yield and income, reduces water consumption, water salinity, soil erosion and labour requirement. These thinking and feeling of the farmer importance system has a positive role in the desire to use it. The questions from 7 to 12 were illustrated the outcome of farmer's belief. It is clear that majority (more than 90%) farmers were agreed that modern irrigation has a role and a positive influence for holding agriculture and household. Increased yield and income are important to farm by increasing production and thereby increase the physical returns. Reduced water consumption, water salinity, soil erosion and labour requirement are important for farm and household. These factors are vital in conserving and maintaining natural resources, soil and water. Using this system maybe reduce the cost of farmer and thereby preserve the environment. Farmer aim to reduce expense as much as possible was using this technology.

6.6.2 Comparison in the importance between the outcomes using modern irrigation

Table 35 reveals the comparison between two factors in terms of importance and influence to farmer. 72 % and 60 % respectively of cooperative farmers and non-cooperative farmers believe that increased yield is more important than increased income. This due to increase yield assists to increase the productivity and thereby increase income. More than 40 % of farmers in both groups likely that increased yield is more important than reduced water consumption, maybe because of using modern agricultural technology in the production inputs as seeds, greenhouses, and agricultural equipment. A third (33 %) of cooperative farmers and 28 % of non-cooperative farmers answered that both factors are important to increase yield and reduced water consumption. Increased yield and reduced soil erosion both are important; this was shown in the table.

Table 35: Pairwise comparison of farming attributes with respect to modern irrigation

Question: How much more important is the outcome on the left hand side compared to the outcome on the right hand side?

(% respondents) Coop, n = 18	Non-coop, n= 50								
		α	1	2	3	4	5	Mean	St.Dev.
Increased Yields-Increased income for my farm	Non-coop	.924	0.0	18.0	18.0	28.0	36.0	3.8	1.1
	Agri.coop	.933	5.6	5.6	16.7	27.8	44.4	4.0	1.2
Increased Yields-Reduced water consumption	Non-coop	.917	18.0	14.0	26.0	28.0	14.0	3.1	1.3
	Agri.coop	.933	5.6	16.7	33.3	11.1	33.3	3.5	1.3
Increased Yields-Reduced water salinity	Non-coop	.919	12.0	14.0	20.0	34.0	20.0	3.4	1.3
	Agri.coop	.935	5.6	5.6	27.8	11.1	50.0	3.9	1.3
Increased Yields-Reduced soil erosion	Non-coop	.919	16.0	18.0	20.0	30.0	16.0	3.1	1.3
	Agri.coop	.937	5.6	38.9	11.1	0.0	44.4	3.4	1.5
Increased Yields-Reduced labour requirement	Non-coop	.919	10.0	6.0	22.0	32.0	30.0	3.7	1.3
	Agri.coop	.935	5.6	0.0	33.3	22.2	38.9	3.9	1.1
Increased Income-Reduced water consumption	Non-coop	.918	20.0	22.0	22.0	26.0	10.0	2.8	1.3
	Agri.coop	.935	5.6	22.2	27.8	11.1	33.3	3.4	1.3
Increased Income-Reduced water salinity	Non-coop	.918	16.0	14.0	18.0	38.0	14.0	3.2	1.3
	Agri.coop	.936	5.6	0.0	27.8	27.8	38.9	3.9	1.1
Increased Income-Reduced soil erosion	Non-coop	.919	22.0	14.0	20.0	24.0	20.0	3.1	1.4
	Agri.coop	.934	5.6	27.8	22.2	5.6	38.9	3.4	1.4
Increased Income-Reduced labour requirement	Non-coop	.918	8.0	8.0	26.0	36.0	22.0	3.6	1.2
	Agri.coop	.934	5.6	0.0	22.2	27.8	44.4	4.1	1.1
Reduced water consumption-Reduced water salinity	Non-coop	.919	6.0	2.0	38.0	34.0	20.0	3.6	1.0
	Agri.coop	.933	5.6	0.0	27.8	22.2	44.4	4.0	1.1
Reduced water consumption-Reduced soil erosion	Non-coop	.919	6.0	8.0	42.0	20.0	24.0	3.5	1.1
	Agri.coop	.934	5.6	11.1	33.3	11.1	38.9	3.7	1.3
Reduced water consumption-Reduced labour requirement	Non-coop	.920	6.0	8.0	24.0	40.0	22.0	3.6	1.1
	Agri.coop	.933	0.0	0.0	27.8	16.7	55.6	4.3	0.9
Reduced water salinity-Reduced labour requirement	Non-coop	.920	12.0	32.0	32.0	12.0	12.0	2.8	1.2
	Agri.coop	.936	5.6	33.3	16.7	16.7	27.8	3.3	1.4
Reduced soil erosion-Reduced labour requirement	Non-coop	.921	4.0	22.0	26.0	26.0	22.0	3.4	1.2
	Agri.coop	.935	5.6	16.7	33.3	0.0	44.4	3.6	1.4
Reduced water salinity-Reduced soil erosion	Non-coop	.921	2.0	20.0	28.0	18.0	32.0	3.6	1.2
	Agri.coop	.934	0.0	0.0	33.3	22.2	44.4	4.1	0.9

Source: Authors' survey 2015

Table 35shows that more than 60% in both groups were agreed that increased yield is more important than reduced labour requirement. 67 % and 52 % of cooperative farmers and non-cooperative respectively that increased income is more important than water salinity. This may be due to using this system assists to reduce and limits the increase salinization. Increased income and reduced soil erosion both are important. 72 % of cooperative farmers and 58 % of non-cooperative were answered that increased income is more important than reduced labour requirement, perhaps because farmer can more easily control the watering crops by using this system. More than 50 % of farmers in both groups were agreed that reduced consumption is more important than reduced water salinity, whereas, 38 % and 28 % of non-cooperative farmers and cooperative were answered that both of them are significant. This could be reduced water salinity has a role in the production improvement. Both factors reduced water consumption and soil erosion are important to land and farmers, because reducing both of them influence and maintain the natural resources of soil and water and thus minimizing from costs. 44% of cooperative farmers were agreed that reduced salinity of water is more important than reduced labour requirement and 39% likely reduced labour requirement is more important than reduced soil erosion. This maybe because skill worker has a role in reducing water salinity and therefore preserving soil structure. Whereas, non-coop' farmers outweigh the reduction of labour requirement is more important than reduced water salinity. This may be of skill and an experience of labour has a role to preserve salinity of water, and around a third (32 %) of farmers were answered that both factors are important to maintain natural resources and minimize household's cost. More than 40 % of farmers in both groups were agreed that reduced soil erosion is more important than reduced labour requirement. This may be of using traditional irrigation and farm location in the mountains and cliffs. Around a third of farmers likely that both factors are significant in land and farmer. 66% and 50% of cooperative farmers and non-cooperative were outweighed that reduced water salinity is more important than reduced soil erosion. This could be increased water salinity affect to the system, land and plant. 33 % and 28% of farmers in cooperative and non-cooperative respectively were answered that both of factors are important to land and famer.

6.6.3 Subjective norm of modern irrigation

Subjective norms relate to understanding social pressures to perform or not perform a behaviour. The effect of social culture and pressure close to farmers have a role to approve or disapprove using modern irrigation (see Table 36).

Table 36: Subjective norm (SN) of Irrigation

		(% respondents) Coop, n = 18			Non-coop, n= 50				
		α	1	2	3	4	5	Mean	St.Dev.
My family thinks that I should use modern irrigation	Non-coop	.905	2.0	2.0	2.0	22.0	72.0	4.6	0.8
	Agri.coop	.768	0.0	11.1	11.1	33.3	44.4	4.1	1.0
My neighbours think that I should use modern irrigation	Non-coop	.904	2.0	2.0	12.0	18.0	66.0	4.4	0.9
	Agri.coop	.768	5.6	11.1	16.7	22.2	44.4	3.9	1.3
Extension service providers think that I should use modern irrigation	Non-coop	.906	2.0	0.0	4.0	26.0	68.0	4.6	0.8
	Agri.coop	.765	5.6	5.6	0.0	27.8	61.1	4.3	1.1
The government thinks that I should use modern irrigation	Non-coop	.906	2.0	0.0	10.0	22.0	66.0	4.5	0.8
	Agri.coop	.768	5.6	5.6	0.0	27.8	61.1	4.3	1.1
Your family strongly motivates you to use modern irrigation	Non-coop	.905	2.0	2.0	2.0	28.0	66.0	4.5	0.8
	Agri.coop	.765	0.0	16.7	11.1	27.8	44.4	4.0	1.1
Your neighbours strongly motivate you to use modern irrigation	Non-coop	.905	2.0	2.0	6.0	22.0	68.0	4.5	0.9
	Agri.coop	.765	0.0	16.7	16.7	27.8	38.9	3.9	1.1
Extension service providers strongly motivate you to use modern irrigation	Non-coop	.906	0.0	0.0	4.0	26.0	70.0	4.7	0.6
	Agri.coop	.765	0.0	5.6	0.0	22.2	72.2	4.6	0.8
The government strongly motivates you to use modern irrigation	Non-coop	.906	0.0	0.0	8.0	24.0	68.0	4.6	0.6
	Agri.coop	.765	0.0	5.6	5.6	27.8	61.1	4.4	0.9

Source: Authors' survey 2015

Table 36 demonstrates the extent and magnitude of the social pressure from those people close to farmers. The questions from 1 to 4 address farmer belief concerning whether they believe that those close to them think that they should the technology. From the table above, it is clear that majority (more than 90%) of farmers' beliefs in both groups were answered that groups close to them thinks that they should be use modern irrigation system.

The question from 5 to 8 addressed farmer's motivation from people who are close in decision-making to use modern irrigation. From the results in the table above, it is a clear that majority (more than 80 %) in both groups were answered that groups motivated farmers to use modern irrigation system. The high percentage is maybe due to awareness of farmers and people in the significant of modern irrigation and knowing how to use it properly.

6.6.4 Perceived behavioural control of modern irrigation system

Perceived behavioural control addresses farmer's perceptions of their ability to perform a given behaviour, i.e. the farmer's beliefs about the presence of factors that may facilitate or hinder performance of the behaviour, here with respect to modern irrigation (Table 37).

Table 37: Perceived behavioural control (PBC) of irrigation

	(% respondents) Coop, n = 18				Non-coop, n= 50				
		α	1	2	3	4	5	Mean	St.Dev.
Water is readily available	Non-coop	.907	6.0	14.0	6.0	36.0	38.0	3.9	1.2
	Agri.coop	.768	5.6	11.1	11.1	39.9	33.3	2.5	1.5
Electricity is readily available	Non-coop	.907	2.0	2.0	4.0	32.0	60.0	4.5	0.8
	Agri.coop	.768	0.0	0.0	5.6	22.2	72.2	3.3	1.6
The cost of modern irrigation is low	Non-coop	.910	24.0	38.0	16.0	16.0	6.0	2.4	1.2
	Agri.coop	.767	27.8	22.2	16.7	27.8	5.6	2.5	1.3
The cost of maintenance is high	Non-coop	.909	6.0	26.0	18.0	28.0	22.0	3.3	1.3
	Agri.coop	.770	11.1	22.2	22.2	27.8	16.7	3.1	1.3
I can access water for irrigation	Non-coop	.906	6.0	4.0	4.0	26.0	60.0	4.3	1.1
	Agri.coop	.767	0.0	0.0	0.0	11.1	88.9	3.8	1.4
I can afford electricity for irrigation	Non-coop	.905	6.0	4.0	4.0	28.0	58.0	4.3	1.1
	Agri.coop	.768	0.0	0.0	0.0	22.2	78.8	2.8	1.4
I can afford to install and operate modern irrigation	Non-coop	.906	6.0	32.0	8.0	22.0	32.0	3.4	1.4
	Agri.coop	.768	0.0	16.7	16.7	27.8	38.9	3.1	1.3
I cannot afford the maintenance costs	Non-coop	.913	8.0	38.0	12.0	28.0	14.0	3.0	1.3
	Agri.coop	.768	0.0	33.3	27.8	33.3	11.1	2.9	1.4

Source: Authors' survey 2015

The questions from 1 to 4 shows the power control that make ease or difficult to farmers using modern irrigation in agriculture. 74% and 73% of farmers' beliefs of non-cooperative farmers and cooperative members respectively were outweighed that water is readily available in a sufficient amount. The majority (more than 90%) of farmers in both groups beliefs that electricity is readily available. Both water and electricity availability are vital using modern irrigation. 62% and a half (50%) of farmers of non-cooperative and cooperative respectively thinking and feeling that the cost of modern irrigation is high. This may be because the purchase of the system is high if there is no support from the government. The questions from 5 to 8 show the individual ability control by farmers that influence in the performance to use it or not use. The first and second questions concern whether a farmer can access water and afford electricity for irrigation. All cooperative members (100%) and 86% of non-cooperative farmers answered that they can access water and afford electricity for irrigation. This may be because water is key resources for watering plant and electricity, particularly farmer who using modern irrigation and water pump for pulling water. This leads significant of water and electricity and farmer provided as its potentials and capabilities in order of continuity and sustainability in agriculture.

The third question is the farmer's ability to install and operate modern irrigation. Two third (67%) of cooperative's farmers agreed that they had ability and afford to purchase and use modern irrigation properly. This because farmer adopt modern technology on their farm to reduce the various agricultural processes costs and provided water in time. Only 17% were not sure that modern irrigation system was not so expensive. However, there is an inconsistency in the non-cooperative farmers' views on their ability to purchase and use modern irrigation properly. 54% of the total percentage answered that can afford and had the physical ability to buy it, because they relied on use in watering, and 32% answered they not being able and afford to purchase modern irrigation. The last question is around affordability and maintenance cost of the system. There is a conflict in the perception of farmers. Around 40 % in both groups they agreed that can afford costs of the maintenance maybe because they know how to use it properly, have the appropriate skills, and can follow-up with ongoing maintenance from the farmer. 38% and 33% of non-cooperative farmers and cooperative members respectively answered that they cannot afford the maintenance costs. This may be of a high maintenance cost, the presence of salinity in water and soil affect the system, absence in follow-up by farmer or workers as well as weakness in the labour skill.

6.6.5 Comparison in the importance between the outcomes

Similar to above, this comparison explores pairwise which factors are more important (Table 38).

Availability of water is more important than electricity for both cooperative (67%) and non-cooperative (72%) farmers. Availability of water is more important than the cost of modern irrigation for both cooperative (72%) and non-cooperative (76%) farmers. Availability of water is more important than the cost of maintenance for both cooperative (67%) and non-cooperative (84%) farmers.

Table 38: Pairwise comparisons with respect to modern irrigation

Question: How much more important is the outcome on the left hand side compared to the outcome on the right hand side?

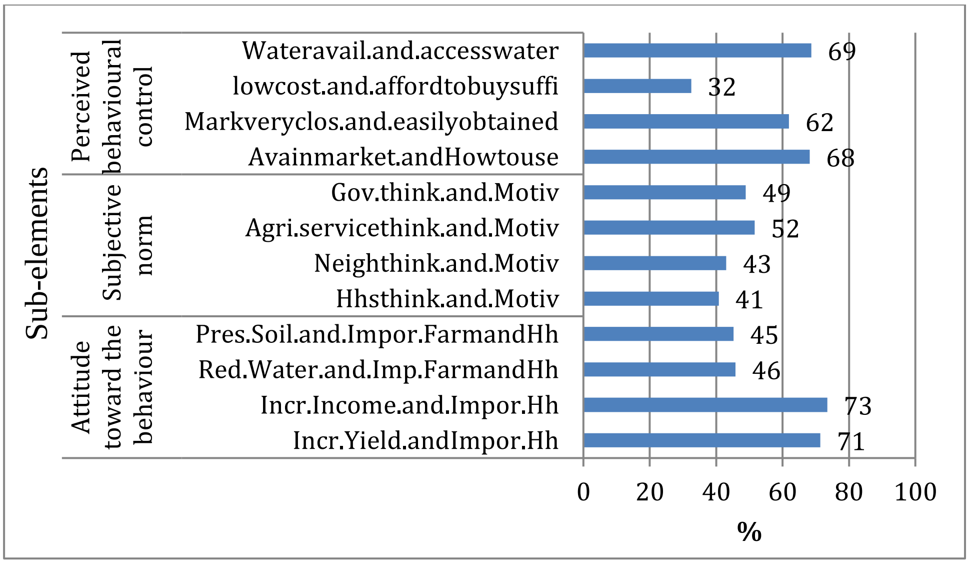
(% respondents) Coop, n = 18 Non-coop, n= 50										
		α	1	2	3	4	5	Mean	St.Dev.
Availability of water-Availability of electricity	Non-coop	.920	2.0	2.0	24.0	28.0	44.0	4.1	1.0
	Agri.coop	.935	0.0	0.0	33.3	16.7	50.0	4.7	0.8
Availability of water-The cost of modern irrigation	Non-coop	.922	2.0	2.0	16.0	32.0	44.0	4.1	1.1
	Agri.coop	.935	0.0	0.0	27.8	27.8	44.4	4.8	0.7
Availability of water-The cost of the maintenance	Non-coop	.922	2.0	4.0	10.0	34.0	50.0	4.3	0.9
	Agri.coop	.935	0.0	5.6	27.8	22.2	44.4	4.7	0.8
Availability of electricity-The cost of modern irrigation	Non-coop	.920	4.0	0.0	20.0	24.0	52.0	4.2	1.0
	Agri.coop	.935	0.0	0.0	27.8	5.6	66.6	4.2	1.0
Availability of electricity-The cost of the maintenance	Non-coop	.921	2.0	10.0	12.0	24.0	52.0	4.1	1.1
	Agri.coop	.934	0.0	5.6	27.8	11.1	61.1	4.1	1.3
The cost of modern irrigation-The cost of the maintenance	Non-coop	.920	2.0	12.0	30.0	22.0	34.0	3.7	1.1
	Agri.coop	.934	0.0	0.0	44.4	11.1	44.4	4.3	0.9

Source: Authors' survey 2015

Similarly, the availability of electricity is more important than the cost of modern irrigation for both cooperative (72%) and non-cooperative (76%) farmers. Availability of electricity is more important than the cost of maintenance for both cooperative (72%) and non-cooperative (76%) farmers. Finally, the cost of modern irrigation is more important than the cost of maintenance for both cooperative (56%) and non-cooperative (56%) farmers, but this is only by just over a half.

6.7 Theory of planned behaviour and strength of intentions

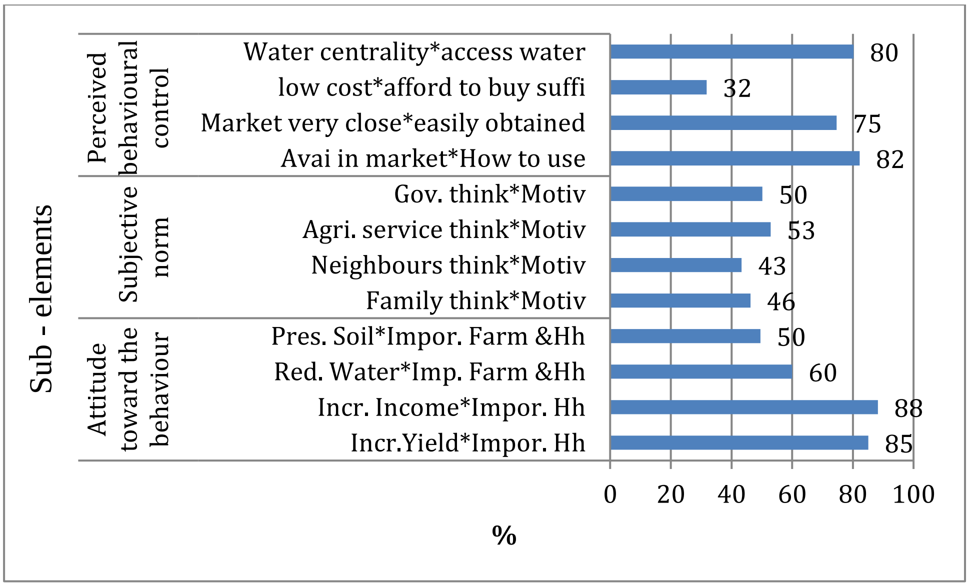
This part presents the results for the three elements in relation to the percentage of farmers who agreed with the given statements. The greater the number that agreed with a particular statement the more likely that adoption would take place. The results are presented for both inorganic fertiliser and modern irrigation, for the group of framers as a whole, and then split between those that are in the Al Batinah agricultural cooperative and those that are not part of a cooperative.



Source: Authors' survey 2015

Figure 12: Intentions towards using inorganic fertiliser, all farmers

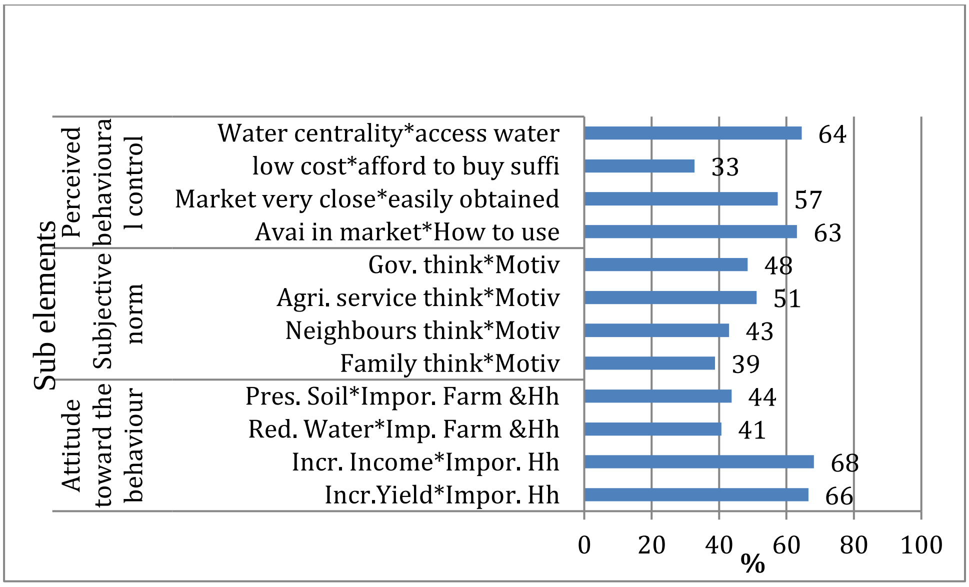
Figure 12 shows the percentage of farmers that are positive towards the intention to adopt inorganic fertiliser based on their Attitude (A), the influence of Subjective Norms (SN), and Perceived Behavioural Control (PBC). The figure shows that there are some differences in the perceptions of farmers on the use of in-organic fertiliser in agriculture. In relation to attitude, the majority of farmers agree that inorganic fertiliser increases yield and income and that this is important to the agricultural holding and household. There are fewer consensuses on the role of inorganic fertiliser in reducing water consumption and preserving soils. The factors of social pressure, subjective norm, surrounding the farmer have a role and influence regarding the use of inorganic fertiliser in farming. The results suggest that the group are split on this influence, with agricultural extension and then government having the greatest influence but only for half of the respondents. In terms of perceived behavioural control, the majority of farmers, more than 60%, perceive inorganic fertiliser as available and accessible in market, but only one third of these think that the cost of the fertiliser is not prohibitive.



Source: Authors' survey 2015

Figure 13: Intentions towards using inorganic fertiliser, cooperative farmers

Figure 13 shows the percentage of farmers in cooperatives that are positive towards the intention to adopt inorganic fertiliser based on their Attitude (A), the influence of Subjective Norms (SN), and Perceived Behavioural Control (PBC). As with the group as a whole, the majority of farmers, and a slightly greater number in this case, agree that inorganic fertiliser increases yield and income and that this is important to the agricultural holding and household. There is greater more positive consensus for this group of farmers regarding the role of inorganic fertiliser in reducing water consumption and preserving soil. There is little difference in relation to the influence of subjective norm between all farmers and the cooperative farmers with both groups similarly split on this influence. As with attitude, the cooperative farmers are also more positive in relation to the elements of perceived behavioural control, with a greater percentage perceiving the fertiliser as an available and accessible product, although the same percentage, one third of farmers, see the cost of fertiliser as prohibitive.

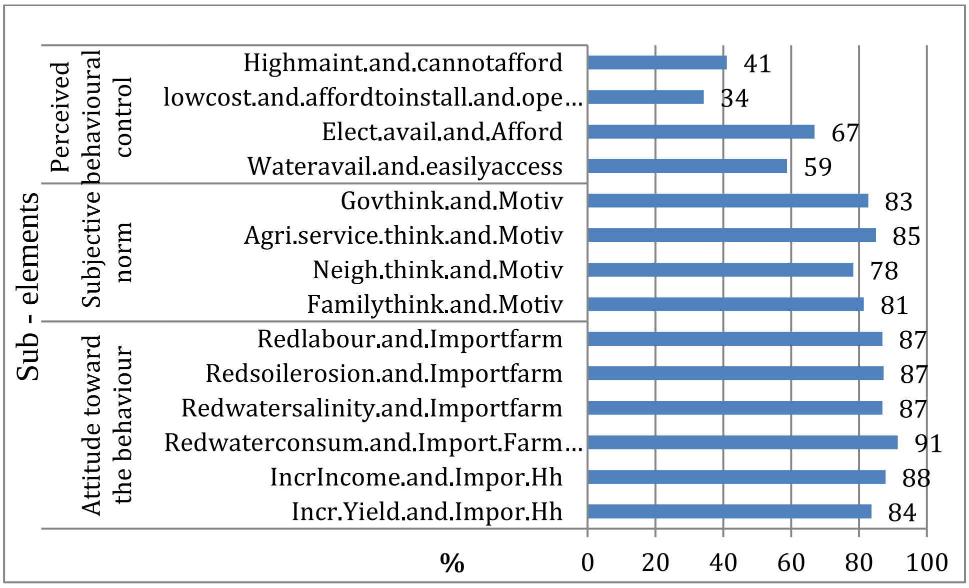


Source: Authors' survey 2015

Figure 14: Intentions towards using inorganic fertiliser, non-cooperative farmers

Figure 14 shows the percentage of non-cooperative farmers, the group that are not in a cooperative, that are positive towards the intention to adopt inorganic fertiliser based on their Attitude (A), the influence of Subjective Norms (SN), and Perceived Behavioural Control (PBC). As with the whole group and the cooperative farmer group, the majority of farmers in the non-cooperative group agree that inorganic fertiliser increases yield and income and that this is important to the agricultural holding and household, although in this case it is a lower percentage of farmers that think this. In terms of reducing water consumption and preserving the soil the non-cooperative farmers are similar in their responses to the whole group for preserving soil, with a slightly lower percentage for reducing water consumption. There is little difference in relation to the influence of subjective norm between all farmers and also the cooperative farmers with all groups similarly split on this influence. As with attitude, the non-cooperative farmers are less positive in relation to the elements of perceived behavioural control, with a slightly smaller percentage perceiving the fertiliser as an available and accessible product, and again as with the cooperative farmers, the same percentage, one third of farmers, see the cost of fertiliser as prohibitive.

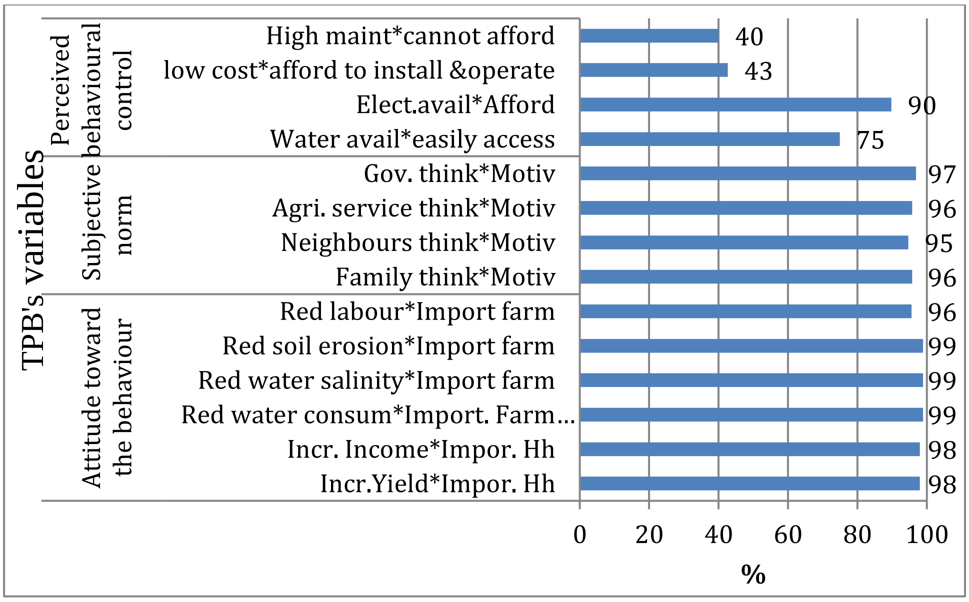
The results of the three groups of farmers show that there are some differences in the perceptions and behaviour of farmers on the use of inorganic fertiliser in agriculture. It is clear that one of the main fundamental factors that may influence the adoption of inorganic fertiliser for all groups is the perceived. There is a suggestion that the cooperative farmers see it as more readily available, and are slightly more positive in terms of potential benefits, for yield, income, water consumption and soil preservation then the non-cooperative farmers.



Source: Authors' survey 2015

Figure 15: Intention towards using modern irrigation, all farmers

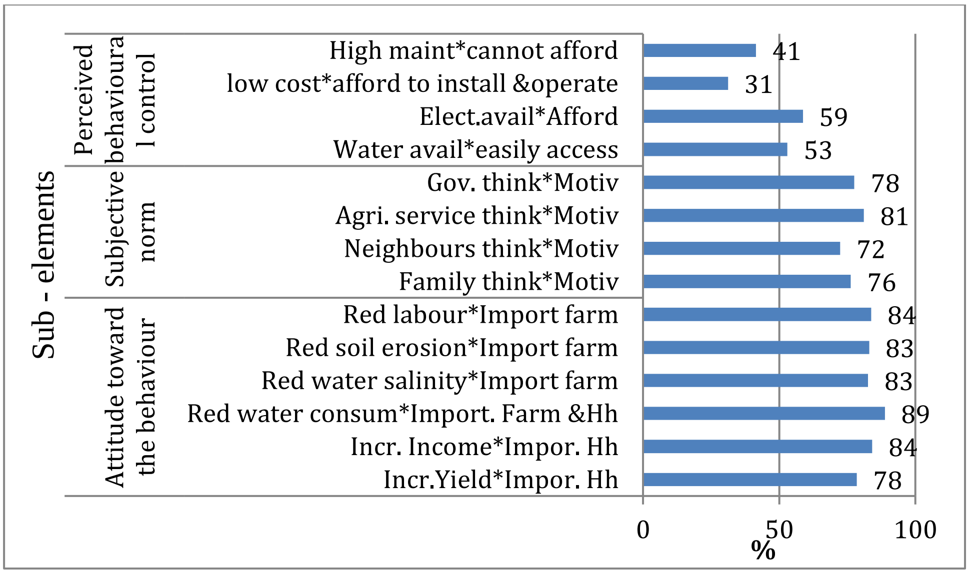
Figure 15 shows the percentage of all farmers that are positive towards the intention to adopt modern irrigation based on their Attitude (A), the influence of Subjective Norms (SN), and Perceived Behavioural Control (PBC). In terms of attitude it is clear that, the majority of farmers (more than 80%) think that using modern irrigation in agriculture is beneficial for a number of reasons including increasing yield and income, reducing water consumption, salinity and erosion of soil, and labour requirement, and that these are important to the farm and household. In terms of subjective norm, the key influencers, agricultural extension, government, family and neighbours are also positive motivators for the use of modern irrigation. In terms of perceived behavioural control, a lower percentage of respondents were positive. Although the majority of respondents were positive towards electricity and water availability, affordability and accessibility, they were much less positive towards the cost of installation and maintenance and the ability to pay for this and run the system.



Source: Authors' survey 2015

Figure 16: Intentions towards using modern irrigation, cooperative farmers

Figure 16 shows the percentage of farmers within the Al-Batinah cooperative that are positive towards the intention to adopt modern irrigation based on their Attitude (A), the influence of Subjective Norms (SN), and Perceived Behavioural Control (PBC). It is clear in terms of attitude that a greater majority of farmers in this group (more than 95%) think that using modern irrigation is beneficial. Similarly, a greater majority of farmers in this group believe that in terms of subjective norm the influencers are also more positive regarding modern irrigation. For perceived behavioural control, a lower percentage are positive regarding these factors, although for electricity and water availability they are again more positive than the all farmer group. Similarly, although less than half are positive about the cost to install, they are still more positive than the all farmer group. They are, however, similar regarding maintenance cost and its affordability with an almost identical percentage of farmers seeing this as prohibitive.



Source: Authors' survey 2015

Figure 17: Intentions towards using modern irrigation, non-cooperative farmers

Figure 17 shows the percentage of farmers not in a cooperative that are positive towards the intention to adopt modern irrigation based on their Attitude (A), the influence of Subjective Norms (SN), and Perceived Behavioural Control (PBC). It is clear that in terms of attitude the majority of farmers (more than 77%) think that using modern irrigation in agriculture is beneficial, although this is lower than both the all farmer group and the cooperative group of farmers. Similarly, a slightly lower majority of farmers in this group, compared to both the all farmer group and more so the cooperative farmer group, believe that in terms of subjective norm the influencers are also more positive regarding modern irrigation. For perceived behavioural control, as with the other two groups a lower percentage of farmers are positive regarding these factors, and as with attitude and subjective norm, the farmers are also less positive regarding the factors here than the all farmer and cooperative farmer groups. They are, however, similar regarding maintenance cost and its affordability with an identical percentage of farmers to that of the all farmer group seeing this as prohibitive.

The results for the three groups of farmers show that there are some differences in the perceptions and behaviour of farmers on the use of modern irrigation in agriculture. It is clear that one of the main fundamental factors that may influence the adoption of for all groups is the perceived high cost of installation and the ongoing cost of maintenance, although for the cooperative farmer group the cost of installation is perceived as less prohibitive than for non-cooperative group and thus all farmer group.

Compared to the results for inorganic fertiliser, all farmers, cooperative and non-cooperative, are more positive regarding their attitude towards the benefits of modern irrigation and also much more positive regarding the influence of subjective norm. They were slightly less positive regarding availability and accessibility compared to inorganic fertiliser and similar in response in terms of cost and affordability to install, although the cooperative farmers were slightly more positive on this front, and all farmers were more positive regarding the affordability and cost of ongoing maintenance.

A central finding from this analysis is that for inorganic fertiliser it is a combination of the aspects of attitude, subjective norm and perceived behavioural control that limit uptake, whereas for irrigation it is primarily based around perceived behavioural control.

6.8 TPB Minimum, Average and Maximum values of beliefs

This section presents the results for the three elements in relation to the minimum, average, and maximum values of each sub-element, providing further insight into the differences in the perceptions and behaviours of farmers in terms of their ability to adopt inorganic fertiliser and modern irrigation.

The results are presented for the group of framers as a whole, and then split between those that are in the Al Batinah agricultural cooperative and those that are not part of a cooperative (see Table 39).

Table 39: The average value of beliefs for Min,Av and Max

	Inorganic fertiliser			Modern irrigation		
	Min.	Av.	Max.	Min.	Av.	Max.
All group	1	12	25	4	22	25
Coop.	6	16	25	16	22	25
Non-coop	2	10	25	4	15	25

Table 39 demonstrates the main points of minimum, average and maximum intentions scores for modern technologies:

6.8.1 Inorganic fertiliser

All groups: There is a wide range within the individual elements. The average scores reflect the pattern demonstrated by the percentages in the previous sections, with more positive responses for the elements of attitude regarding yield and income, and for perceived behavioural control regarding availability and accessibility, with less positive responses in terms of attitude for environmental factors, the subjective norms, and the cost in perceived behavioural control.

Member of agricultural cooperative: The low maximum value for cost is worth noting suggesting that this group perceive this could be an important barrier to the adoption of inorganic fertiliser.

Not member of cooperative: The average values tend to be lower reflecting the percentage values shown in the previous sections regarding the attitude, subjective norm and perceived behavioural control elements.

6.8.2 Modern irrigation

All groups: The averages within both attitude and subjective norm are high indicating a high willingness to adopt. The minimum values for attitude and subjective norm also tend to be higher when compared to those for inorganic fertiliser, again indicating a greater willingness to adopt. For the perceived behavioural control elements, the low averages for cost of installation and maintenance cost reflect the percentages in the previous section, indicating that this is where the barrier to adoption arises.

Member of agricultural cooperative: The minimum values for the attitude and subjective norm elements are much higher than for the all farmer group, and the average values are very close to the maximum, both indicating a much greater intention to adopt. For the perceived behavioural control elements, it is worth noting that the minimum and average values for water availability and accessibility are slightly higher for this group, with the minimum value for electricity availability and affordability being much higher. It is also worth noting that although the minimum and average values for installation and maintenance cost are similar to the all farmer group, the maximum values are lower again suggesting that this group perceive this could be an important barrier in the intention to adopt.

Not member of cooperative*: There is a similar pattern to the all farmer group, but the average values tend to be lower reflecting the percentage values shown in the previous sections regarding the attitude, subjective norm and perceived behavioural control elements. For more detail see appendix 6*

6.9 Principal Component Analysis

6.9.1 Introduction

The main purpose of a principal component analysis – PCA – is the analysis of data to identify patterns and finding patterns to reduce the dimensions of a dataset with minimal loss of information. The following sections outline the steps taken for this analysis. This section shows the results from a probit regression analysis and principal component analysis

6.9.2 Probit Regression Analysis

Modern technology is the main dependent variable in this thesis, and was measured by rate of use. In the survey, respondents were asked if they used that technology, in this case inorganic fertiliser and modern irrigation. For the independent variables, cooperative membership was measured using farmers' response to the relevant questions in the interview schedule. In addition, socio-economic factors considered are age group, level of education, household size, experience, occupation and income. Descriptive statistics were used to obtain the analyses of the variables. Using SPSS, probit regression analyses were undertaken to evaluate the combined effects of the independent variables (cooperative membership and socio-economic characteristics) on the predictor variable (on use modern technology). Standardized Beta coefficients were used to obtain the combined effects of the independent variables on the dependent variable. Analysis of variance was used to assess the overall significance of the model used using $p < .05$ as criteria of significance. In addition, we obtain the adjusted R^2 value to find the contribution of our model to the overall variance in technological uptake.

A probit regression analysis is used in order to mitigate the potential impact of endogenous variables. The analysis results are summarized in Table 40 and Table 41 for inorganic fertiliser and Table 42 and Table 42 for modern irrigation

Table 40: Probit model – inorganic fertiliser

Variable	Coef	Std.Err	T-value	p-value
Inorganic fertiliser				
using inorganic fertiliser increases yields and increased yields is important for my household				
Income	-3.169259	1.806324	-1.75	0.084
using inorganic fertiliser increases my farm income and increased farm income is important for my household				
Occupation	-1.295252	.6853429	-1.89	0.064
Experience	-.1988125	.0863801	-2.30	0.025
using inorganic fertiliser reduces demand for water and reduced water consumption is important for my household				
Crop area	.0327837	.0143009	2.29	0.025
Age group	-2.35458	1.200205	-1.96	0.054
Education level	-2.335836	1.173069	-1.99	0.051
my family thinks that I should use inorganic fertiliser and they strongly motivate you to use it				
Occupation	2.133686	.9540082	2.24	0.029
my neighbours think that I should use inorganic fertiliser and they strongly motivate you to use it				
Occupation	2.173045	.9804622	2.22	0.030
extension service providers think that I should use inorganic fertiliser and they strongly motivate you to use it				
Crop area	.0346769	.0199115	1.74	0.087
Experience	-.2524897	.1228178	-2.06	0.044
the government thinks that I should use inorganic fertiliser and the government strongly motivates you to use it				
Experience	-.2260812	.1253833	-1.80	0.076
Income	-5.252669	2.380972	-2.21	0.031
inorganic fertiliser is available on the market and I know how to use inorganic fertiliser				
Income	-4.788351	1.887946	-2.54	0.014
water is important for the application of inorganic fertiliser and I have ready access to water				
Income	-4.218901	1.909841	-2.21	0.031

Table 41: Probit model – inorganic fertiliser

Inorganic fertiliser	Coef	Std. Err	z	P-value
Age group	.3199226	.3047002	1.05	0.294
Education	.0490818	.2781121	0.18	0.860
Occupation	-.0313382	1758734	-0.18	0.859
Farming experience	0064192	.0212181	0.30	0.762
household sizze	0024466	-.0515438	-0.05	0.962
Income source	.9567524	.4045835	2.36	0.018
cons	-3.691352	1.725905	-2.14	0.032

Source: actual survey 2015

Here, income of household is significant and positive at 5% level. This indicates that the farmers that have income from other source are more likely to use organic fertiliser. All other variables such as age of head, education of head, occupation of head, experience and household size are not significant.

Table 42: Probit model – modern irrigation

Variable	Coef	Std.Err	T-value	p-value
Modern irrigation				
using modern irrigation reduces soil erosion and reduced soil erosion is important for my household				
Occupation	-1.325327	-1.325327	-2.15	0.035
using modern irrigation reduces labour requirement and reduced labour requirement is important for my household				
Occupation	-1.387686	.5451768	-2.55	0.014
water is readily available and I can easily access water for irrigation				
Experience	-.1866839	.1005451	-1.86	0.068
Income	-9.087608	1.909306	-4.76	0.000
electricity is readily available and I can afford electricity for irrigation				
Experience	-.2059565	.1008737	-2.04	0.046
Income	-9.342929	1.915546	-4.88	0.000
the cost of modern irrigation is low and I can afford to install and operate modern irrigation				
Education level	2.74767	1.206453	2.28	0.026
Income	-4.580892	1.722753	-2.66	0.010
my family thinks that I should use modern irrigation and they strongly motivate you to use it				
Experience	-.2351491	.0867632	-2.71	0.009
Income	-2.977838	1.647594	-1.81	0.076
my neighbours think that I should use modern irrigation and they strongly motivate you to use it				
Experience	-.2523511	.0963218	-2.62	0.011
extension service providers think that I should use modern irrigation and they strongly motivate you to use it				
Experience	-.2024373	.0746593	-2.71	0.009
the government thinks that I should use modern irrigation and the government strongly motivates you to use it				
Experience	-.2380269	.0821575	-2.90	0.05

Source: actual survey 2015

Table 43: Probit model – modern irrigation

Traditional irrigation	Coef	Std. Err	z	P-value
Age group	.2521097	.2912548	0.87	0.387
Education	-.3943646	.2736905	-1.44	0.150
Occupation	.1770384	.1786739	0.99	0.322
Farming experience	-.0509506	.0233674	-2.18	0.029
household sizze	.1444488	.0656955	2.20	0.028
Income source	-.9259623	.3864717	-2.40	0.017
coop	-.2202277	.5067024	-0.43	0.664
cons	1.075884	1.684742	0.64	0.523

Source: actual survey 2015

The result shows that the variables experience (p-value = -2.18), and source of income (p-value = -2.40) are significant and negative while the variable household size is significantly positive (p-value = 2.20). It indicates that higher the experience it is less likely to use traditional irrigation method. Similarly, if a household is earning its income from other sources reduces the probability of using traditional method of irrigation. Also, higher the household size, higher is the probability of using the traditional method of irrigation. The finding also shows that the variable co-operative (p-value = -0.43) is not statistically significant. This implies that a farmer being a co-operative member or not affect the probability of using traditional irrigation method.

6.8 Theory of Planned Behaviour quantitative findings – Inorganic fertilizer

This section is concerned with the intention of farmers in relation to the importance of modern agricultural technology in the use of inorganic fertilisers and modern irrigation by using the social-psychology theory of planned behaviour. There are three key components of the theory: the attitudes towards the behaviour, individual and collective criteria that have a significant impact on farmer in the decision to use inorganic fertiliser and modern irrigation, as well as perceived behavioural control that has an impact and ability of farmers in the performance and execution of whether or not it can be used in agriculture.

6.9.1 Farmers' attitude towards the use of inorganic fertiliser

Attitudes in the farmers' behaviour towards inorganic fertiliser in agriculture has a role in their belief. There is difference in the view point and perception between farmers of cooperative and non-cooperative.

Figure 18: Factors influencing the attitude toward the farmer's behaviour use in inorganic fertiliser

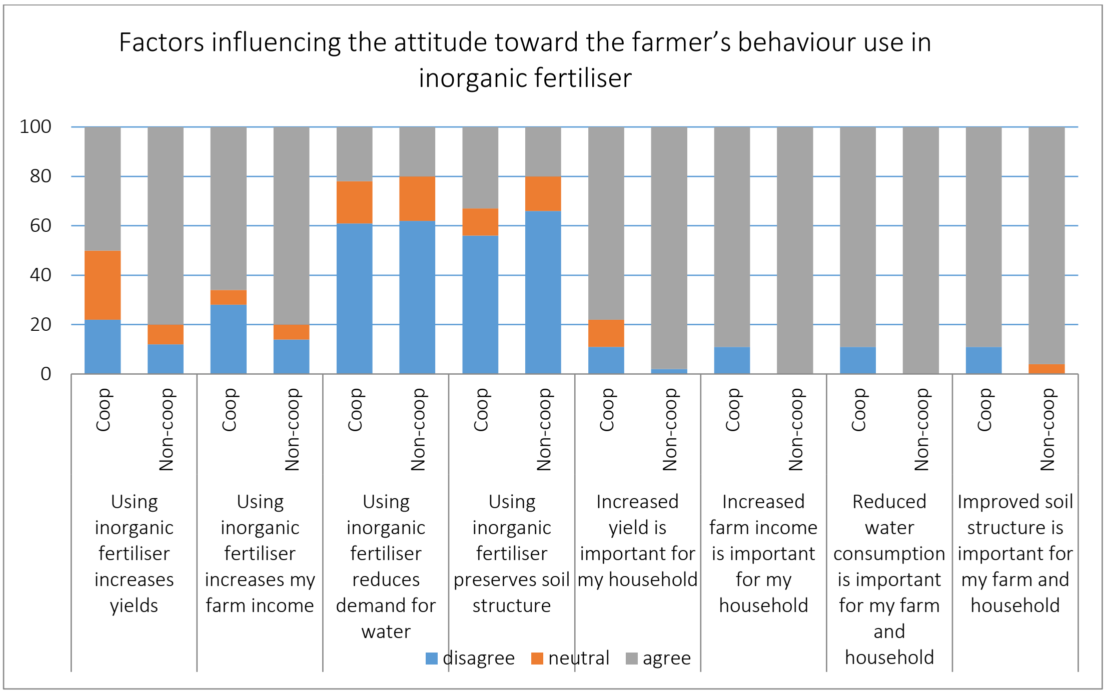


Figure 18 shows that the majority of farmers in both groups agree that inorganic fertilisers assist to increase yields and household's income, their consent to increased yield and income are important for household, and reduced water consumption approved soil structure are also important for household. In the other hand, more than a half of farmers in both groups do not agree that the inorganic fertiliser has a role in reducing the water use and preserve soil structure indicating that generally, the attitude of farmers towards fertiliser use was unfavourable.

6.9.2 Subjective norms

Subjective norms related to understand social pressures to perform or not perform a behaviour. The effect of social culture and pressure close to farmers have a role to approve or disapprove using inorganic fertiliser. These individuals or people mirror their beliefs about others who are important to them and they may have a strong influence to their behaviour (figure 19).

Figure 19: Factors influencing subjective norm of the farmer's behaviour use in inorganic fertiliser

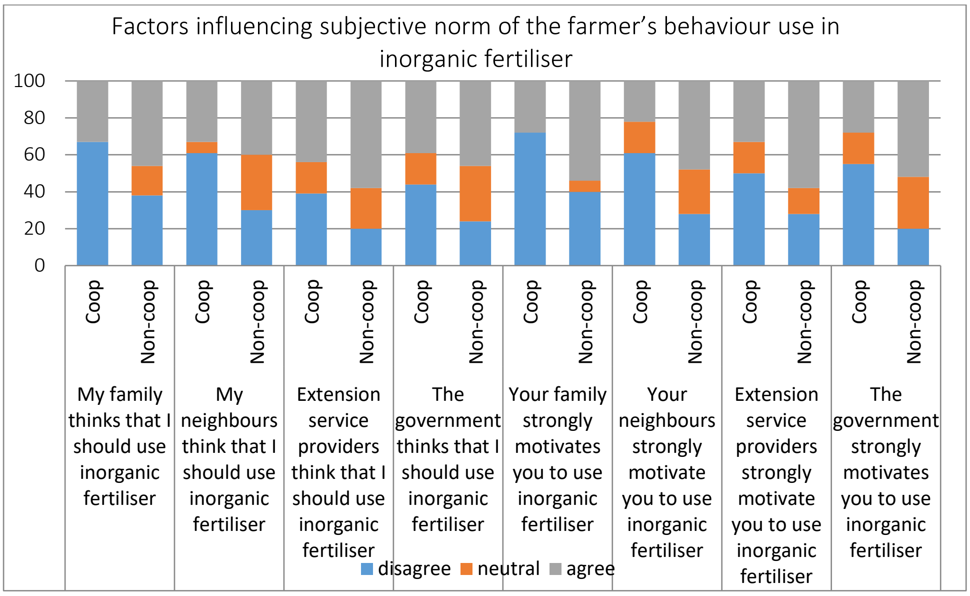


Figure 19 demonstrates the extent and magnitude of the social pressure influence for people surrounding farmer. From the figure, it is clear the role and influence of people who are close in decision-making with respect to using inorganic fertiliser. Group close coop' farmers as family, neighbours are likely not approve and fostering to use inorganic fertiliser. While agricultural extension services play a role in non-coop's farmers by people close to them with respect to use it. This may be because of the farmers' awareness and belief to them the importance of inorganic fertiliser use. In contrast, farmers of non-cooperative think that people close to them should not use inorganic fertiliser, maybe due to the lack of agricultural information on the importance of inorganic fertiliser in farming. The results also clarify the influence of people between two groups. People close to cooperative farmers motivated farmers not to use inorganic fertiliser and this perhaps because of farmers' awareness and people in the importance of inorganic fertiliser and knowing how to use it properly. Whereas people close to non-coop farmers motivated them to use inorganic fertilise . Lack of motivation and encouragement of the people close to farmers could be outcome weakness of the agricultural awareness of the agricultural importance of using it, the lack of visit and follow-up by the agricultural services, small size area in addition to using traditional irrigation in watering crops.

6.9.3 Perceived behavioural control

Perceived behavioural control concerns a farmer's perceptions of their ability to perform a given behaviour, i.e. the farmer’s beliefs about the presence of factors that may facilitate or hinder performance of the behaviour (figure 20).

Figure 20: Perceived behavioural control (PBC) of inorganic fertilisers

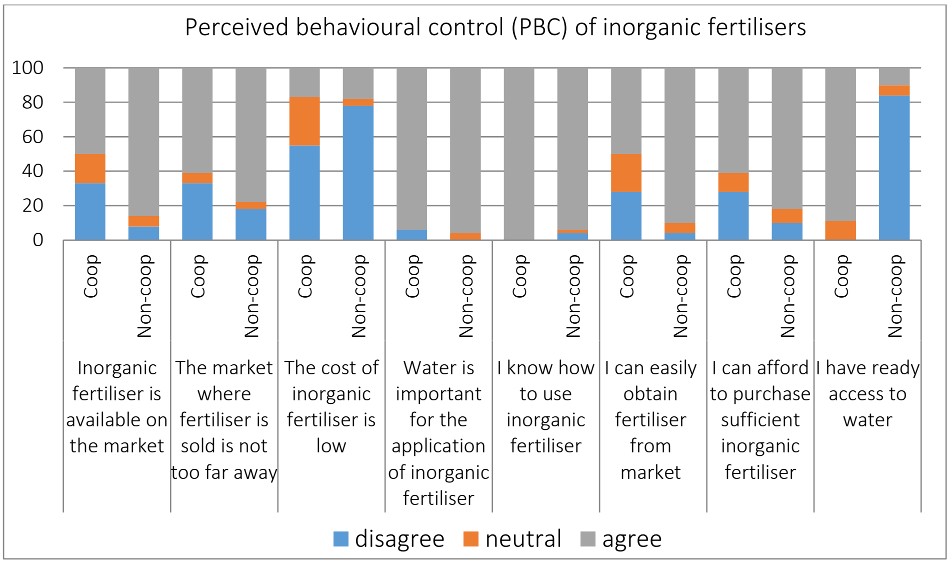


Figure 20 illustrates the factors that affect farmer's perceptions concerning the ease or difficult to perform of using inorganic fertiliser. There are certain factors influence to purchase and use inorganic fertiliser in farming. The majority of farmers in both groups agree that inorganic fertiliser is not available in sufficient amount on the market/agricultural shops. This factor could affect the ability of farmers to apply inorganic fertiliser at the correct time during the cropping cycle. This is particularly important for annual crops such as tomatoes, and cucumber. The situation where inorganic fertiliser is sold is significant, it may have had a negative influence to farmer especially who live far from the agricultural shops as in the mountain, desert, valleys and they did not have means of transport. In addition, both groups agree that water is a vital for the inorganic fertiliser application. Water is significant in agriculture and without water it may has a negative impact on the ground and plant. Both groups agree that the cost of inorganic fertiliser is high especially soluble and individual element as N, P, K, Fe, Zn. Although, some farmers agreed that is fertiliser not costly maybe because they purchase in whole sale and large quantities. The last fourth questions demonstrate the extent the capability of the farmer to use inorganic fertilser properly and provide the essential requirements for the inorganic fertiliser use in farming. In both groups, the majority of farmers agree that they know how to use inorganic fertiliser properly, cannot easily obtain it from the market and cannot afford to purchase sufficient amount. It is could be of a high price and farmer unable to purchase that amount, particularly soluble inorganic fertiliser, or not available in the market in sufficient quantities during that time. Furthermore, non-coop's farmers answered that cannot ability access to water, maybe because most farmers had used traditional irrigation, which not available in any time and in sufficient amounts. Yet, farmers of coop. answered that they had ability access to water due to availability of water in their farm, using modern technology in agriculture as seeds, greenhouse and modern irrigation.

6.9.4 Behavioural intention

Figure 21: Behavioural intention

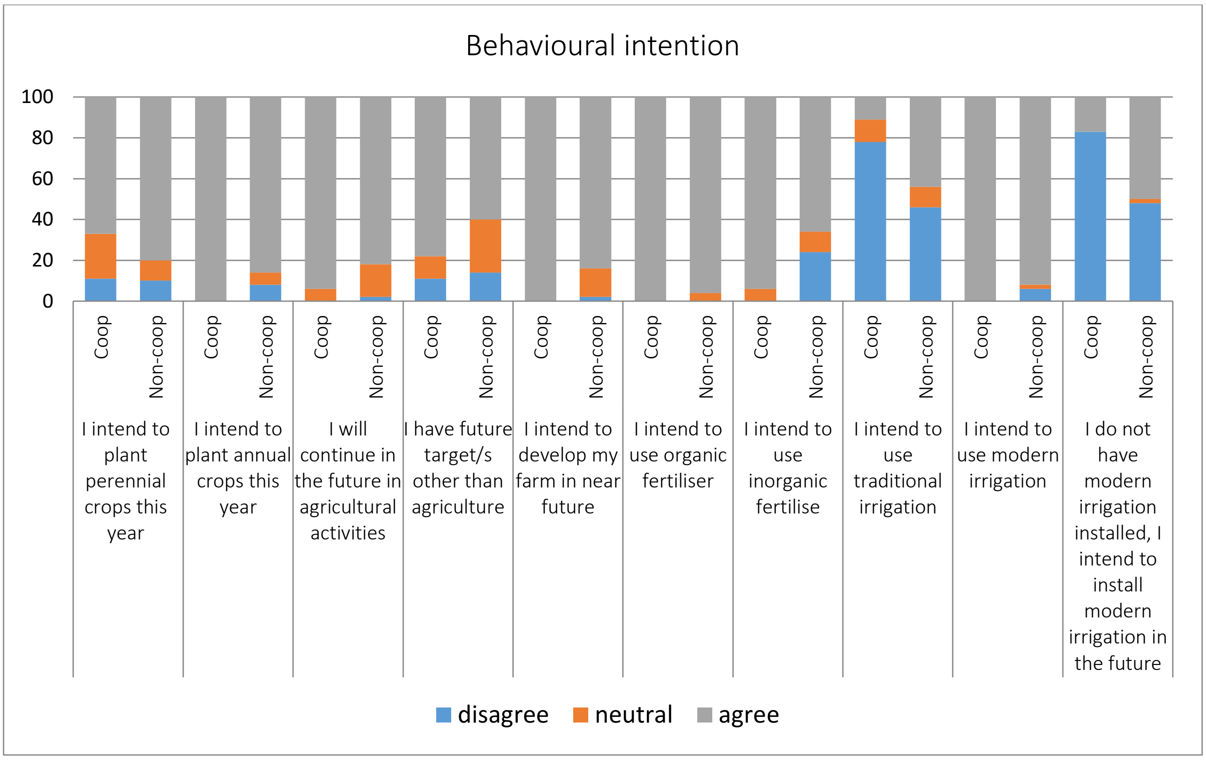


Figure 21 shows the behavioural intention to continue in agriculture. The majority farmers in both groups agree that they intend to plant annual and perennial crops this year, and they had desire to continue in the future in the agricultural activities, however they had future targets other than agriculture. Most farmers whether belong to a cooperative or not agree they want to develop their farmland. Organic fertiliser is a vital source in soil fertility and most farmers in both groups recognised the importance of such fertiliser and plan to continue use it in the future. The majority of farmers in both groups intend to use inorganic fertiliser in the future. Most farmers in both groups intend to use traditional irrigation in farming, bur recognise problems of high evaporation and leakage, and that it is not always available, in addition to high cost of water and service. Yet, they replied that they intend to use modern irrigation in the future because they recognise benefits including the efficiency of water and thus the potential to reduce the water consumption.

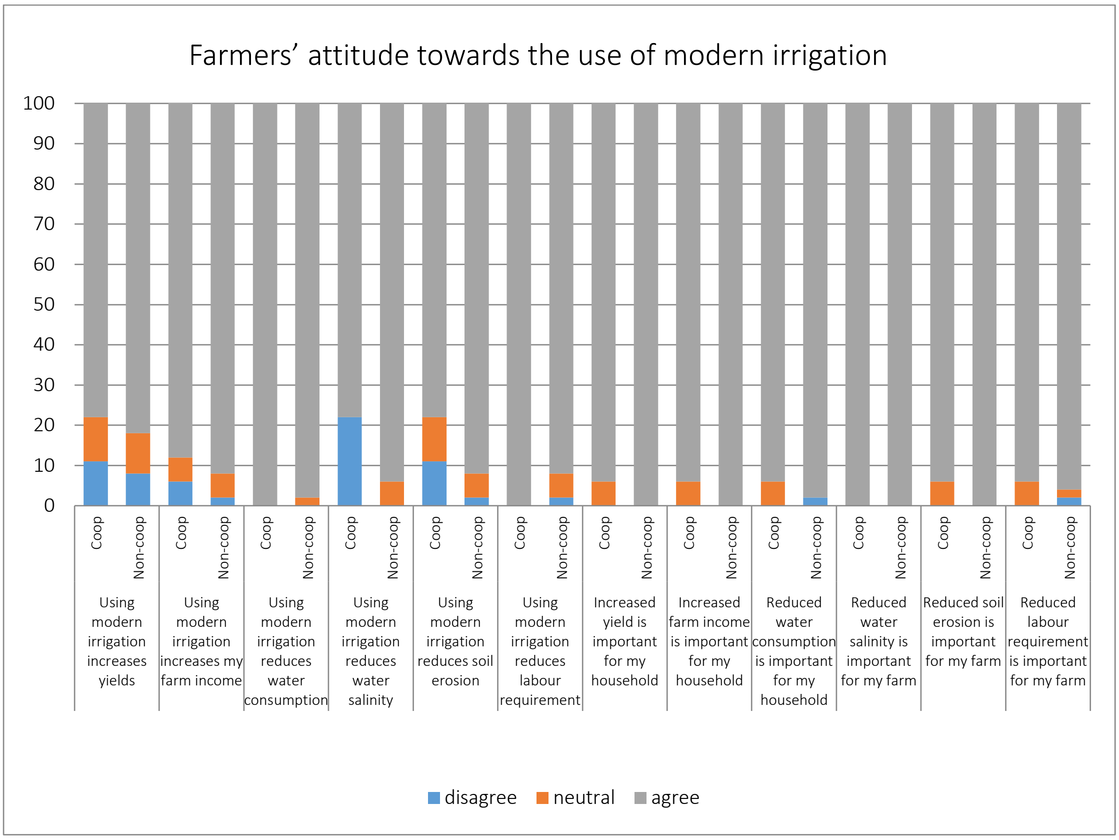
6.10 Theory of Planned Behaviour quantitative findings – Modern irrigation

In this section, the quantitative findings from the TPB analysis are brought together: attitudes, subjective norms, and perceived behavioural control. Together, these data provide insights into what influences farmers' choices of agricultural technologies.

6.10.1 Farmers' attitude towards the use of modern irrigation

Figure 22 elucidates the attitude of farmers toward the modern irrigation behavior. The first six questions were addressed attitude of farmer's belief. It is clear from both groups that the belief and feeling farmers that using modern irrigation had a positive influence in agriculture and that clear through large finding by farmers. Mostly in both groups of farmers they agreed that using modern irrigation increases yield and income, reduces water consumption, water salinity, soil erosion and labour requirement. Other questions were demonstrated the farmer's belief outcome. The majority of farmers agree that modern irrigation has a role and a positive effect for holding agriculture and household. Increased yield and income are important to farm by increasing production and thereby increase the physical returns. Reduced water consumption, water salinity, soil erosion and labour requirement are important for farm and household. Using this system one of the importance technology in farming and this system maybe reduce the cost of farmer and thereby preserve the environment.

Figure 22: Attitude toward the use of modern irrigation



6.10.2 Subjective norm of modern irrigation

Subjective norms relate to understanding social pressures to perform or not perform a behaviour. The effect of social culture and pressure close to farmers have a role to support and approve or disapprove using modern irrigation.

Figure 23: Subjective norm (SN) of Irrigation

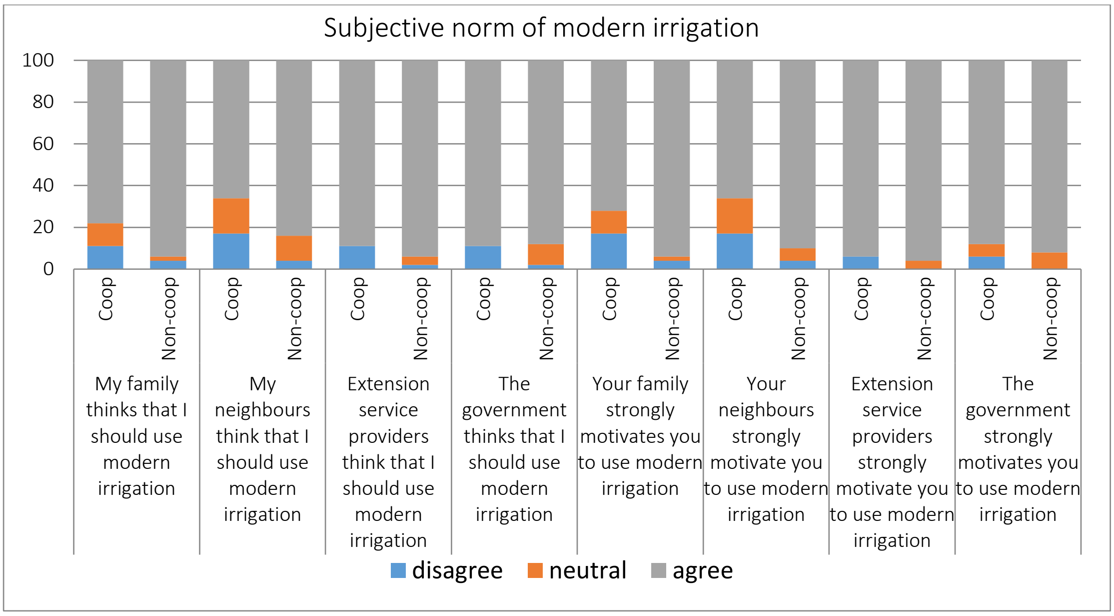


Figure 23 reveals the extent and magnitude of the social pressure from those people close to farmers. From the figure above, it is clear that the majority of farmers' beliefs in both groups were answered that people (e.g. family, neighbours, extension service) close to them thinks that they should be use modern irrigation system. In addition, that people motivated farmers to use modern irrigation system. This high percentage perhaps because of farmers' awareness and people in the modern irrigation significant and knowing how to use it properly.

6.10.3 Perceived behavioural control of modern irrigation system

Perceived behavioural control addresses farmer's perceptions of their ability to perform a given behaviour, i.e. the farmer’s beliefs about the presence of factors that may facilitate or hinder performance of the behaviour, here with respect to modern irrigation (Figure 24).

Figure 24: Perceived behavioural control (PBC) of irrigation

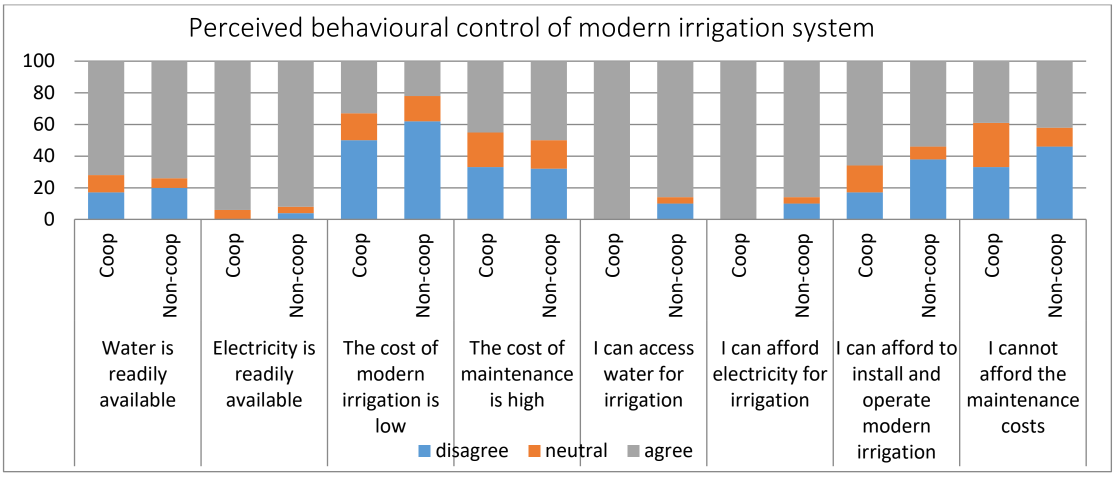


Figure 24 illustrates the factors that affect farmer's perceptions concerning the ease or difficult to perform of using modern irrigation. Farmers in both groups agree that water is readily available in a sufficient amount and they belief that electricity are available in their farmland. Furthermore, farmers' beliefs of non-cooperative and cooperative members that the cost and the maintenance of modern irrigation is high. This may be due to the purchase of the system is high if there is no support and subsidise from the government. The majority of farmers in both groups answered that can access water and afford electricity for irrigation. This could be because water is a vital resources for watering crops and introducing electricity, particularly farmers who using modern irrigation and pulling water by water pump. This drives substantial of water and electricity and farmer provided as its potentials and capabilities in order of continuity and sustainability in farming. The individual ability control by farmers that influence in the performance to use it or not use. Most farmers in both groups answered that they had ability and can afford to install and operate modern irrigation. This because farmer adopt modern technology on their farm to reduce the various agricultural processes costs and provided water in time. Around half of farmers in both groups agreed that they cannot afford to maintenance costs the system. This perhaps due to a high maintenance cost, the salinity presence in water and soil and their impact on the system, absence in follow-up by farmer or workers as well as weakness in the labour skill.

6.11 Theory of planned behaviour and strength of intentions

This part presents the results for the three elements in relation to the percentage of farmers who agreed with the given statements. The greater the number that agreed with a particular statement the more likely that adoption would take place.

6.11.1 Intentions towards using inorganic fertiliser

Figure 25: Intention towards using inorganic fertiliser

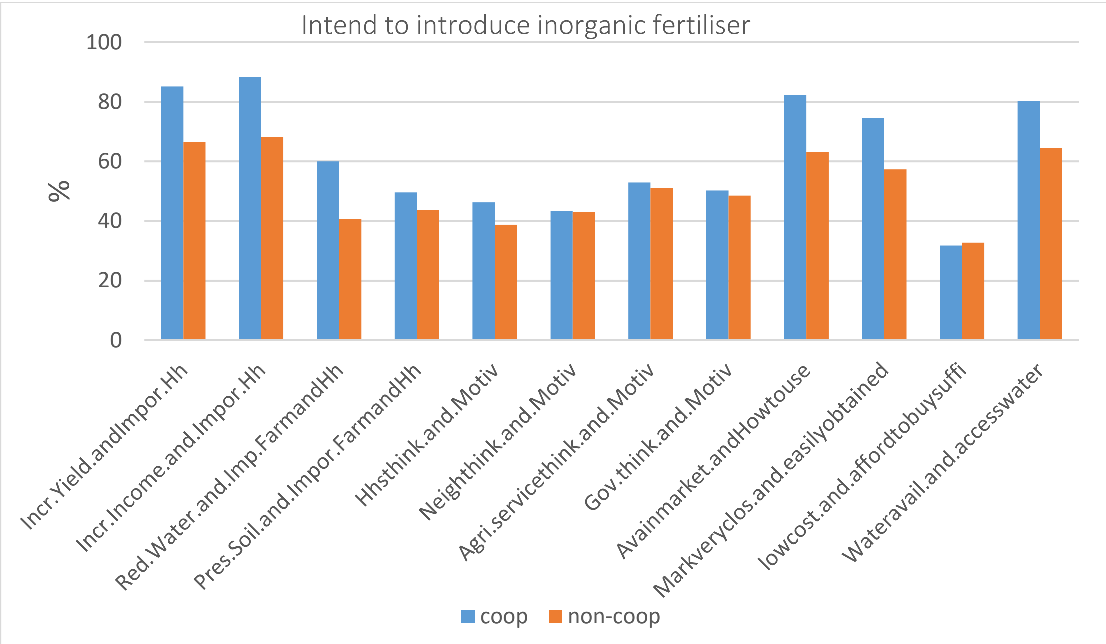


Figure 25 shows the percentage of farmers in both groups (cooperative and non-cooperative) that are positive with respect to intention to adopt inorganic fertiliser based on their Attitude, the Subjective Norms influence and Perceived Behavioural Control. Farmers in both groups answered that inorganic fertiliser increases yield and income and that this is Cooperative farmers are more positive than non-cooperative farmers with respect to the role of inorganic fertiliser in reducing water consumption and preserving soil. However, there is little difference in relation to the influence of subjective norm between all farmers and the cooperative farmers with both groups similarly split on this influence. There is little difference in relation to the influence of subjective norm between non-cooperative farmers and the cooperative farmers with both groups similarly split on this influence. As with attitude, the cooperative farmers are also more positive in relation to the elements of perceived behavioural control, with a greater percentage perceiving fertiliser as an available and accessible product, although the same percentage, one third of farmers, see the cost of fertiliser as prohibitive.

The results of the three groups of farmers show that there are some differences in the perceptions and behaviour of farmers on the use of inorganic fertiliser in agriculture. It is clear that one of the main fundamental factors that may influence the adoption of inorganic fertiliser for all groups is the perceived. There is a suggestion that the cooperative farmers see it as more readily available, and are slightly more positive in terms of potential benefits, for yield, income, water consumption and soil preservation then the non-cooperative farmers.

6.11.2 intentions towards using modern irrigation

Figure 26: intention towards using modern irrigation

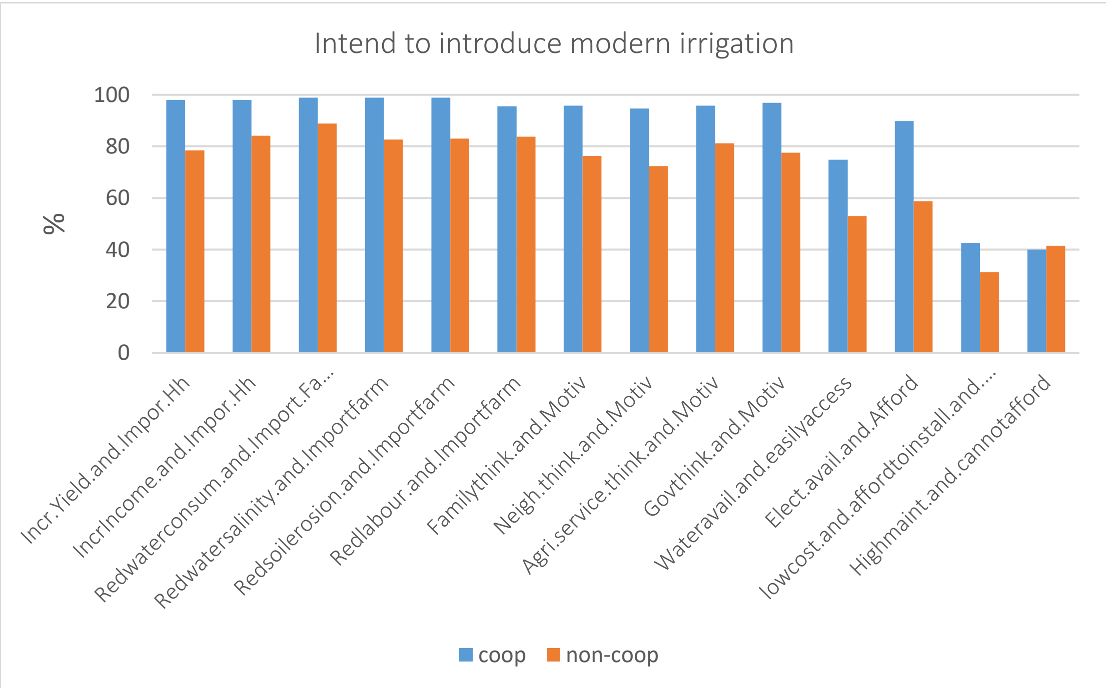


Figure 26 clarifies the percentage of farmers within the Al Batinah (coop and non-coop) that are positive towards the intention to adopt modern irrigation based on their Attitude (A), the influence of Subjective Norms (SN), and Perceived Behavioural Control that are positive towards the intention to adopt modern irrigation based on their Attitude, the influence of Subjective Norms, and Perceived Behavioural Control. It is clear in terms of attitude that a greater majority of farmers in both groups think that using modern irrigation is beneficial. Likewise, a greater majority of farmers in both groups believe that in terms of subjective norm the influencers are also more positive regarding modern irrigation. For perceived behavioural control, a lower percentage are positive regarding these factors, although for electricity and water availability they are again more positive than non-coop. They are, however, similar regarding maintenance cost and its affordability with an almost identical percentage of farmers seeing this as prohibitive.

The results for both groups of farmers show that there are some differences in the perceptions and behaviour of farmers on the use of modern irrigation in agriculture. It is clear that one of the main fundamental factors that may influence the adoption of for all farmers is the perceived high cost of installation and the ongoing cost of maintenance, although for the cooperative farmer group the cost of installation is perceived as less prohibitive than for non-cooperative group.

A central finding from this analysis is that for inorganic fertiliser it is a combination of the aspects of attitude, subjective norm and perceived behavioural control that limit uptake, whereas for irrigation it is primarily based around perceived behavioural control.

6.12 Concluding comments

This chapter has provided insights into farmers' attitudes, norms, and behaviours, with respect to two important technologies, inorganic fertiliser, and modern irrigation, throught a quantitative analysis using the theory of planned behaviour. Each of these technologies is important for improving yields, and for improving soil quality and water management. The chapter was guided by the research questions and hypotheses posed in Chapter 1. In particular, this quantiative analysis addresses the two clusters of hypotheses conerning technology adoption.

The first null hypothesis posed was that attitudes, norms, and perceived behavioural controls do not affect farmers' adoption of the two technologies. The findings of this chapter suggest that in fact, farmers are influenced by these different dimensions, as discussed in more detail below, thus suggesting a rejection of the null hypothesis. Importantly, the influencing factors differ considerably depending on the specific technology and its attributes. The second null hypothesis posed was that farmers belonging to cooperatives and those not part of a cooperative hae similar attitudes, norms, and perceived behavioural controls towards the benefits of the technologies. Again, this analysis revealed some important differences, again suggesting a rejection of the null hypothesis.

The study sample contained a group of farmers as a whole who belonged to one of two analysis groups: those who are in the Al-Batinah agricultural cooperative and those who are not part of a cooperative. Cooperative farmers tend to be younger, with less years of experience, but more educated. The more educated farmers are also those with irrigation systems. The cooperative members rely more on agriculture for their income with a tendency for a larger farm size and cultivated area. They also have more permanent workers, including more family members involved, and use more modern technologies.

For inorganic fertiliser, cooperative and non-cooperative farmers agree that inorganic fertiliser can increase yield, but do not see it as beneficial for the soil and water. Each group of farmers as a whole are equally unfavourable towards it. In the pairwise comparison the importance of water comes out from the non-cooperative farmers, and for both groups, water is a more important concern than the soil. Cooperative farmers are influenced positively by others regarding inorganic fertiliser use, non-coop farmers are influenced negatively. For cooperative farmers it is clear that family are important influencers. For non-cooperative farmers it is apparent that extension officers have an important role in their decisions. The control that farmers have over accessing inorganic fertiliser is also relevant. Inorganic fertiliser is seen as not always available in markets that are too far away and at a cost that can be not affordable. From the pairwise comparison it is evident that access to water in its use is a constraint for the non-cooperative farmers and that this can be more important than its cost.

These findings are reinforced (enhanced) when calculating the strength of intentions. Cooperative are slightly more positive in terms of potential benefits, for yield, income, water consumption and soil preservation then the non-cooperative farmers. All farmers indicate that high cost and affordability is a barrier, reinforced by the cooperative group with their low maximum value for this factor in their intention scores. Cost could also thus be an important barrier to the adoption of inorganic fertiliser.

For modern irrigation, cooperative and non-cooperative farmers agree that modern irrigation can increase yield, and has benefits for reducing soil and water salinity, and reducing water consumption. In the pairwise comparison yield is important, more so than reducing water consumption. Both cooperative and non-cooperative farmers are influenced positively by others regarding the use of modern irrigation. The control that farmers have over using irrigation is also relevant. Both water and electricity is seen as available, but not always accessible to their farmers, this is more of a concern for the non-cooperative farmers. Modern irrigation cost is seen as low, less so for the non-cooperative farmers, and is also seen as affordable, but again less so for the non-cooperative farmers. From the pairwise comparison it is evident that access to water, is more important than access to electricity, and these are more important than cost of the irrigation and its maintenance.

These findings are reinforced when calculating the strength of intentions. Cooperative are slightly more positive in terms of potential benefits, for yield, income, water consumption and soil preservation then the non-cooperative farmers, but all see benefits. All farmers indicate the high cost of installation and the ongoing cost of maintenance, although for the cooperative farmer group the cost of installation is perceived as less prohibitive than for the non-cooperative group. What is evident for the non-cooperative farmers is the importance of access to water and electricity in using modern irrigation systems.

A central finding from this analysis is that for inorganic fertiliser it is a combination of the aspects of attitude, subjective norm and perceived behavioural control that limit uptake, whereas for irrigation it is primarily based around perceived behavioural control.

Comparing cooperative and non-cooperative farmers it is evident that in terms of the intentions regarding both inorganic fertiliser and modern irrigation there is greater willingness from the cooperative farmers for adoption of fertiliser and slightly more so for modern irrigation, although both groups are positive. A further finding is that for cooperative famers family are a key influence, and that for non-cooperative farmers' extension officers may have a role, particularly for changing attitudes regarding inorganic fertiliser – it may be that these individuals may need to be convinced first. Thus social pressures and social culture have been shown to play a role in decisions regarding using modern irrigation and inorganic fertiliser. The results also suggest that cost – the cost of fertiliser, and the cost of installation and maintenance of the irrigation system – may be a significant barrier to adoption for most farmers.

The theory of planned behaviour links adoption decisions to three distinct elements: beliefs; subjective norms; and control beliefs. The findings from this chapter suggest that farmers in Oman similarly are influenced by these, though to different extents, and depending on the particular technology. Lynne et al. (1995) find that perceived behavioural control is particularly important for farmers' decisions to adopt water saving technology in Florida. The analysis here suggests that this is so also for Omani farmers adopting modern irrigation – a water saving technology. Costa Font (2011) highlights possible conflicting attitudes towards some technologies. Similarly in this quantitaive analysis there is less clarity over the adoption of inorganic fertiliser. Thus the analysis confirms findings from the literature, yet provides additional insights. These findings and their implications for Oman's agriculture sector are addressed in more detail in the following Chapter 7.

Appendix 7 provides additional analysis through Principal Component Analysis. The main purpose of a principal component analysis – PCA – is the analysis of data to identify patterns and finding patterns to reduce the dimensions of a dataset with minimal loss of information.

Chapter 7 Conclusion

7.1 Introduction

This thesis is centred around the theory of planned behaviour, to explore the technology adoption decisions of farmers, specifically with respect to modern irrigation and inorganic fertiliser. These are two technologies that are important to the country with regards to the modernisation of the agricultural sector. The theory of planned behaviour focuses on farmers' attitudes towards technology and what influences their attitudes. Considerable attention was given to farmers who are members of the Al Batinah agricultural cooperative and those that are not, because the government of Oman is taking seriously the option of once more promoting the development of more agricultural cooperatives around the country. Given that the hope is that farmers in cooperatives will farm in a more "modern" way, that can move the country closer to its aims of increased food supplies both for home consumption and for export, thus diversifying the economy away from oil, this thesis is particularly timely.

This final section of the thesis is devoted to summarizing the main findings of this study in response to the research questions set out in chapter one. It also presents the contribution to knowledge and its limitations; implications for decision makers in the Ministry of Agriculture; and some suggestions for future studies.

7.2 Summary of the Findings

This study was guided by a number of research questions, which together aimed to provide insights into increasing the adoption of modern technologies by farmers in Oman, and whether agricultural cooperatives might play a role.

Question 1: What are the challenges faced by small holder farmers in Oman?

It is evident from both the secondary data collection and the primary data collection through the stakeholder interviews and surveys, that there are a number of concerns. As a starting point, is the difficult farming environment within Oman, linked to climate and availability of suitable land, with concerns over water shortage, soil fertility and issues of salinity in both soils and water. The degradation of both soil and water resources that has occurred over a long period of time has probably contributed to the declining rates of growth in productivity. Under these conditions and without any support from the government or private sector (Hemdan Mohamed, 2014) examined that these factors have a negative impact on desired level of productivity and yield, and are difficult to achieve. The problems of salinity particularly in coastal regions and shortage of water in aflaj areas where small holder farms predominate are a concern for the government. Increasing level of sea and coastal lands flooding driving to salinity and pollution of water and agricultural lands; this variations will in turn cause existing ecosystems deterioration Hemdan Mohamed, Nahla.(2014). For small holder farmers the issue of salinity is not helped by the use, where it occurs, of the traditional irrigation systems and where the sustained use of saline groundwater probably accelerates the pace of soil salinization. The management of the soil resource is also not helped by inappropriate nutrient applications and poor use of inorganic fertiliser suggested by some respondents in the interviews (see Ch. 5 section 5) and (Olayide et al., 2011).

Both inorganic and organic fertilisers are seen as valuable resources, more so for small holder farms with mixed livestock and cropping farming systems. The suggestion from the survey is that the small holder farmers are less likely to be in a cooperative, and although they see the benefits of inorganic fertiliser in terms of yield, this is less evident than for the cooperative farmers where there is a tendency for larger farm sizes. Similarly, small holder farmers also appear more slightly concerned about the potential damaging impacts of inorganic fertiliser on their soil and water resources. The survey results also suggest that small holder farms are also less likely to be using modern irrigation, which is seen to have benefits in terms of both reduced water consumption and leading to a reduction in soil and water salinity. For the small holder farmers, those not in the cooperative, the lack of access to water and electric is an issue, with the former being the more important concern.

Further barriers for farmers, that were studied in less detail in this thesis, are access to markets and small land size. According to census of agriculture 2012-2013, there are around 90% of holdings which are less than 5 acres (MOAF, 2013b) and this has a role in lower productivity and crops diversification, particularly in the mountains area and land that is irrigated by aflaj. Hurst et al. (2005), (Olayide et al., 2011) demonstrated that small farm holders are a crucial in developing countries especially in the poverty alleviation areas and food security and income based in part on sale of crops and livestock and on wage employment. Access to markets, whether that be for input purchase, or commodity sale, is compromised for farmers, and the results of this study suggest that the small holder farmers, who tend to be those not in the cooperative, face greater constraints in both accessing inputs, such as inorganic fertiliser and being able to implement modern irrigation systems, and then in the opportunity to market their produce.

Question 2: What are the key influences and influencers that lead farmers to use the modern technologies promoted by the government in their attempt to improve food security through increased self-sufficiency?

The adoption of modern technologies is influenced by a number of factors, illustrated through the use of the theory of planned behaviour. First, are the attitudes to a particular technology, second is the influence of others (subjective norm), and finally, how much control over access and use of a technology that a person believes they have. The study of inorganic fertiliser, a variable input to the system, and modern irrigation, requiring some initial capital investment first, illustrate how these different factors can facilitate or hinder adoption in different ways.

The results from both the interviews and survey suggest that for inorganic fertiliser it is a combination of the aspects of attitude, subjective norm and perceived behavioural control that limit uptake, whereas for irrigation it is primarily based around perceived behavioural control.

For the adoption of inorganic fertiliser in Omani agriculture, it is the mixed messages about it benefits that it can provide that are a barrier. The farmers see benefits in terms of yield but have concerns over the impact of its use on water resources and soil quality. This is evident for both those farmers in the cooperative and those that are not, although the cooperative is overall more positive in their attitude to inorganic fertiliser. This could suggest that cooperative membership has had a role in generating a more positive attitude towards inorganic fertiliser or, alternatively, that the younger more educated came with that attitude already established. In terms of subjective norm, the traditional reliance on organic fertiliser within mixed livestock and cropping systems, and thus the influence of that traditional lifestyle and social interdependence could also be a barrier to the adoption of inorganic fertiliser. The results suggest that those people who influence adoption of inorganic fertiliser by farmers have similar attitudes to the farmers. For cooperative farmers it is clear that family are important influencers and in some cases it is evident that family member are also key participants in the farming activity. For non-cooperative farmers it is apparent that extension officers may also have an important role in their decisions (Leng et al., 2015). The analysis in this thesis revealed that for farmers social and cultural factors have significant role in the use of inorganic fertiliser and modern irrigation. Respondents' approval of inorganic fertiliser use is influenced by lifestyle and social interdependence, yet also some farmers disapprove of the use inorganic fertiliser because it may be seen as needing more water and could be difficult to use in traditional irrigation properly.

If extension officers are clear about the benefits of inorganic fertilisers and demonstrate fewer concerns about the potential negative impacts on the environment, then they may have a role in the adoption of inorganic fertiliser. The final barrier to adoption concerns the use of inorganic fertiliser and there are a number of issues. There are concerns over whether it is used appropriately, it seen as requiring more water, and for all farmers – cooperative members and non-cooperative farmers – there are concerns over availability and cost, particularly where low commodity prices may not justify its use. These findings suggest that there is a role for education of farmers and others in terms of promoting the benefits of inorganic fertiliser if the government wish to promote its use, and in part this should start with extension officers. There is also a need to facilitate availability of the product and affordability

For the adoption of irrigation in Omani agriculture, it is the access to available good quality water that is of concern and the need to move away from over-used poor quality shallow groundwater, to facilitating access to deep well and more efficient water use through modern irrigation systems that is required. All respondents tended to have a positive attitude towards modern irrigation and suggested that the people that they are influenced by also have a similar positive attitude. Barriers emerge in a number of areas. For some water is available and accessible, for others this is not always the case and can be a major barrier, this can particularly be the case in the summer months. Availability and access to a consistent supply of electricity was also suggested as a barrier, but less so that for water. For the cooperative farmer group, there areas were more of a concern than for the non-cooperative group. A key barrier is that cost is prohibitive, it is too expensive for many farmers to install initially, and then also maintain. It is also suggested that the knowledge of how to maintain modern irrigation systems may be lacking and this can influence cost of both maintenance and operation. These findings suggest that there is a need for some form of financial help to establish modern irrigation systems, alongside making sure water and electricity are consistently accessible, and the education in operation and maintenance may be available.

Question 3: To what extent can and do agricultural cooperatives contribute to the adoption of technology.

It is difficult from this study to determine the exact role of cooperatives in contributing to the adoption of technology. What is evident from the primary data collection is that those farmers within cooperatives are more likely to have a positive attitude towards a modern technology and that the people that influence them are also more likely to have a positive attitude. The cooperative farmer members in this study were younger and less experienced farmers but more well educated and thus perhaps more likely to be willing to adopt to change. Some studies found a positive correlation between additional formal education and increased adoption of technologies (Areal et al., 2012). They also had larger farms with more crop diversity.

It suggested that on this basis it may be worth encouraging non-cooperative members to join cooperatives to facilitate awareness and education regarding new technologies, if cooperatives are able to provide a programme of training and networking opportunities.

For the control factors cooperatives may also have a role. Both cooperative members and non-cooperative farmers saw access to resources and cost as prohibitive to adoption of technology, in this case both inorganic fertiliser and modern irrigation. This was less so for the cooperative farmers. It is not known whether this is as a result of better income levels for the cooperative farmers, information not collected due to its sensitive nature. It could be that the cooperative farmers were generally better off financially or the fact that as members of cooperatives they had better access to financial resources.

It is suggested that on this basis that if non-member farmers are encouraged to join cooperatives, that part of the role of the cooperative should be in facilitating access to resources, whether that be in terms of just ensuring adequate availability of inputs such as inorganic fertiliser, or providing additional support in terms of some sort of grant or financial incentive to fund capital expenditure or purchase an input. What can be said about cooperatives is that do appear to have a role and should continue to have a role in providing better access to a competitive market place.

7.3 Contribution to Knowledge

This study has contributed to our knowledge in more than one level. At the contextual level, it has created a clear picture of using inorganic fertilisers and modern irrigation system in the Omani context and its effectiveness. At the theoretical level, it has implemented the TPB theory in a new context, the Omani context, and thereby has identified and explained for the first time Omani farmers' attitudes and behaviour towards using modern technology through this theory. TPB focuses on measuring attitudes to alternative behaviours, suggesting that those individuals with the most favourable attitude for each option are likely to perform in that way (Ajzen, 1991). Nevertheless, Carr (1988) proposes this may give misleading results, the individual the most favourable attitude of one option may have a more favourable attitude for another option. A better correlation with behaviour should be realised by collecting the individual's attitude to the options of all, which resonates with the approach taken in this thesis. The behaviour of farmers to use modern irrigation was most correlated to the overall positive attitude combined with their concern that using inorganic fertilisers can influence natural resources, soil and water, and environment (Feder et al., 1985, Gebregziabher and Holden, 2011).

Good et al. (1993) demonstrated that extension services expose farmers to new technologies, new techniques and practices which would contribute to improvements in efficiency. Farmers can purchase inputs with credit availability which relaxes cash constraints. A lack of credit unavailability can seriously hamper a farmer as failure to purchase inputs, like fertiliser and irrigation water, for his standing crops may cause irretrievable output loss (Nyanga et al., 2016).Therefore, an efficiency analysis should incorporate extension services and credit facilities. Productivity growth involves two major components: technical change and technical efficiency.

7.4 Limitations

First, the use in the study of a cooperative and non-cooperative farmer sample can only demonstrate the differences that occur between the two groups. There may however be two explanations. It is most probable, but requires further investigation, that the two groups of farmers are different and this shows itself in that one group are members of the cooperative. They are larger farms, grow a wider variety of crops, employ more people, and the cooperative facilitates marketing and other aspects of the production such as access to inputs. The alternative, is that in joining the cooperative they have become large, more diverse and thus able to employ more people as a result of the access they have been given to inputs and markets. The cooperative allows them to grow.

Second, this study did not address gender differences because all the participants who agreed to participate in the study were males. Selection of the sample should be representative of the population. However, there are some customs and traditions may limit the female involvement in doing interviews. This may have biased the results of research.

Third, the study also focused on one particular region in Oman due to the limitations of resources. The Sultanate's geography varies from one area to another and may have a role to learn some of the influential factors in agriculture as well as knowledge of features of each region.

Fourth, another limitation could be that all the interviewed farmers participated voluntarily who could be considered a limitation since their opinions could represent only theirs but not the others farmers' perceptions. The participant may have a role in the results, it may be positive and know that it is aimed at the development of science, agriculture and thus giving precise statements. On the other side, some farmers perhaps do not want to give the correct information. The clarification of the research objectives has the role in giving the information correctly with existence of mutual trust between the researcher and respondent.

The last point, is that the researcher holds a position in the Ministry of Agriculture, which could have affected the participants' responses although they were assured that their opinions were treated with highly confidentiality and tried to build repertoire with them.

Knowing the function of the researcher by respondents may create some bias, and raises issues of positionality, whereby the respondent gives a shaded and incorrect information. This in turn affects the quality of the information and results obtained from the search.

7.5 Implications

Agriculture in Oman can increase the socio-economic security of the country and thus it needs to receive more attention and support by policy makers. The concern by the government of the agriculture importance and its role in improving the social and economic situation, and supporting the agricultural sector and private sector will contribute significantly to the increase in the cultivated area, in that they represent only 3% of the total area, and therefore there are vast areas can benefit from the work of various projects that serve the community (MOI, 2016). Also there are some schemes the government intends to work a distribution of agricultural pieces include a number of new technologies designed to take advantage of the work of profitable investment projects accrue to farmers and consumers by providing agricultural crops as well as help in finding jobs (MOAF, 2015a).

Policy makers in Oman should consider a clear framework for raising the awareness of farmers on the benefits of using modern technology. The government long ago began to introduce new agricultural technologies into farming through support for farmers. These technologies included high quality seeds, modern irrigation system, greenhouse, hydroponic farming, and agricultural equipment, amongst others. The government particularly focused on introducing modern irrigation systems in aflaj areas that support farms in areas affected by acute rain scarcity, and to reduce water consumption due to high temperature and the use of concrete and soil irrigation channels (MOAF, 2015a).This research should assist further the government's efforts to increase the efficiency of modern irrigation and provide water to all farm parts.

The government is currently discussing setting up additional cooperatives focusing on services and marketing. The presence and the provision of services, and agricultural supplies appropriately with the support by the government can have a positive effect for farmers, investors and consumers (MOAF, 2015a). The diversity of activities and services that are offered either for farmers or consumers the existence of multi-purpose cooperatives and goals such as cooperatives providing services, agricultural supplies, marketing of agricultural products, animal products, marketing, and cooperatives providing material support and loans(MOAF, 2015b). This will undoubtedly contribute to the development of agriculture.

The government could provide more support for farmers that includes financial, technical and advisory support. In all farming systems, liquidity constraints and the lack of access to crop finance is a serious constraint to all poor and many medium income households. Offering a functioning credit market could be an important first step to revive the rural economy and to increase the profitability of production for the considerable share of the producers who pay very high capital costs to finance their farming operations.

There remains a need of education to improve the ability of farm households to obtain and understand agricultural resources information regarding modern technology. Thus the government could implement an agricultural education policy so that the younger farmers can obtain appropriate knowledge. Older farm households, who have had limited educational opportunities, can be assisted with adequately trained extension advisers (Khanal and Gillespie, 2011, Leng et al., 2015).

There is also a need to provide labs in rural areas that deal with daily issues farmers face like analysing soil and water and deciding the suitable crops to grow. One of the important things that the government should pay attention to them and make them available are specialized in soil and water, disease and toxins laboratories. These laboratories will contribute significantly to reducing the problems of farmers and their concentration in certain places, and also not available in agricultural circles. In addition to the price rise in conducting laboratory tests in particular examine toxicity and that have a role to determine the allowable percentage presence in the fruit. Government should take the necessary towards providing laboratories and facilitate measures in order to encourage agriculture and improve production quality, knowledge and find appropriate solutions that hinder agriculture.

To pay more attention to follow up local markets and the quality and characteristics of the products and main crops sold there (Issa, 2016). One of the challenges that hinder agriculture is the marketing, so the existence of competition from other agricultural products, which adversely impacted on the local product. Therefore, the government should encourage domestic product by supporting the provision of supplies needed and to improve its quality to compete with external product through the introduction of modern technology in agriculture, both agricultural production inputs, and various agricultural operations, especially post-harvest as sorting, packaging and cooling in addition to the product in the domestic market, marketing at a good price. This in turn will encourage farms on agriculture, despite water scarcity. Farm management by recoding costs and benefits of inputs and outputs to figure out the revenue. In addition, to find out the economic crops that have a material return and do not influence the natural resources, soil and water as well as the environment.

7.6 Suggestions for further studies

A larger study of technology, using the theory of planned behaviour, and considering additional technologies, could build on this thesis. Results from a large survey covering several regions and the comparison of the results across different areas can further improve the predictive power of the theory. This study is the first of its kind for the Sultanate, and so there is plenty of scope for similar studies.

In addition to better understanding technology adoption, there remains a considerable need to increase the understanding of the role of governmental and private sector in shaping farmers' attitudes towards marketing their products. The research and development process does not come only through the work of precise and focused studies aimed at developing various fields. This research could be supported and funded by both the government and the private sector. Since marketing could be part of a virtuous circle, it requires detailed study, with respect to supplies and agricultural production inputs, facilitating agricultural lending procedures, finding marketing outlets inside and outside the Sultanate, training and educating farmers on the importance of agriculture, in addition to the method and how to use modern technologies and management so as not to damage the environment and natural resources.

People and organizations in developed countries and in developing countries can exchange useful information and ideas to solve problems related to sustainability of agriculture. Likewise, scientists and policy makers can learn from farmers and vice versa.

Researcher and farmer partnerships and peer-to-peer exchanges among farmers could facilitate incorporation of local knowledge, making use of the best-available scientific process-level understanding, and enabling learning and developing knowledge systems to build the local capacity for improving agricultural sustainability (Hall et al., 2009).

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Appendix 1.: Questionnaire (sample survey)

Section 1: farm, farmer and agricultural marketing

No ___________ Date:- __________________

1- <u>General information for farm continent</u>

i- Region _____________ Willayat:_____________

ii- Total area ___________ acre

iii- Type of farm crops☐ livestock ☐ poultry ☐ mixed ☐

iv- Land tenure system private ☐ rental ☐ partnership ☐ shareholding ☐ endowed land ☐

v- Space owned by the holder_______ acre

vi- Leased land area____________ acre

vii- Annual rent value of the leased space_________ OR

viii- Area cropped last year _____________ acre

ix- Livestock and poultry

Are there any livestock/poultry in the farm? Yes ☐ No ☐

Type	Heads	Type	Heads
Cattle		Sheep	
Camel		Goats	
Poultry			

2- Demographic information to the holder

i- Gender male ☐ female ☐

ii- Place of birth ___________ current residence ____________

iii- Age:-

less than 25☐ 25-34 ☐ 35-44 ☐

45-54 ☐ 55-64 ☐ more than 65 ☐

iv- Numbers of your household (your family**)** ___________

v- Education level Uneducated☐ reading and writing ☐ elementary☐ preparatory☐ secondary/diploma ☐ medium/technical college☐ BS/BA ☐ higher education ☐

vi- The occupation of the holder Agricultural☐ Government ☐ Private sector☐ Private non-agricultural activity☐ other ☐

vii- How many years of farming experience in agriculture do you have? ______year(s)

viii- The main resource of your household agriculture☐ other☐

ix- Will you continue in the future in agricultural activities?

Yes ☐ No ☐ maybe ☐ N/A ☐

x- Have you other targets in the future rather than agriculture?

Yes ☐ No ☐ maybe ☐ N/A ☐

xi- Do you intend to develop your farm in the near future?

Yes ☐ No ☐ maybe ☐ N/A ☐

3- Labours

Do you have any labourers working on the farm? Yes ☐ No ☐

i- Permanent workers-wage

types of workers	from farmer's members	others

	Number	Salary/month (OR)	Number	Salary/month (OR)
Administrators				
techniques				
workers				

ii-Number of workers unpaid from your family __________

Type of irrigation system used to irrigate crops (✓)

crops type	irrigation method		
	traditional	modern	both
vegetables			
fruits			
field crops			
perennial fodder crops			
leafy greens			
greenhouse	--------------		------------

4- Buildings and structures

Is there any agricultural constructions? Yes ☐ No ☐

type of building	No. of building/structure	type of building	No. of building/structure
administration		feed store	
housing workers		produce store	
equipment store		general store	
shed seedlings		generator room	
barn animals		other (specify)	

5- Agricultural machinery/equipment (machinery ownership)

Do you have agricultural machinery/equipment? Yes ☐ No ☐

type	number	type	number	type	number

6- Irrigation

i- Irrigation system

traditional ☐ modern ☐ both ☐

ii- Irrigation sources in the farm:

well within farm □ well outside farm □ falaj □
water treatment □ water desalination □ other □

iii- The main irrigation source in the farm (choose one)

well within farm □ well outside farm □ falaj □
water treatment □ water desalination □ other □

iv- Power source for water pumps used (choose one)

electricity □ diesel □ benzene □
electricity, diesel and benzene □ not applicable □

7- Agricultural Marketing and cooperatives

a- Agricultural marketing

i- Distance to nearest market is

less than 5km 6-10 □ 11-15 □ 16-20 □ more than 20km □

ii- Distance to nearest agricultural shop is

less than 5km 6-10 □ 11-15 □ 16-20 □ more than 20km □

iii- The use of the production (choose one or more) family consumption □
marketing inside country □ export □ manufacturing □

iv- The main use of the production (choose only one) family consumption □
marketing inside country □ export □ manufacturing □

v- Sale of production site farm gate □ Willayat market □
another Willayat □ Mawaleh market □ outside country □

vi- Most main sale of the production (only one) farm gate □ Willayat market □
another Willayat □ Mawaleh market □ outside country □

vii- Source of agricultural information agricultural officers □ newspapers □
magazines □ TV □ radio □ internet
other famers □ other □

viii- Sources of credit/loans (choose one or more) ODB □ other banks □
other sources □ N/A □ project support □ livelihoods □

ix- The main sources of credit/loans (choose one): ODB □ other banks □
other sources □ N/A □ project support □ livelihoods □

b- Name and type of cooperative

Are you a member of an agricultural cooperative? Yes □ No □

If yes,what type of Coop.?

agricultural □ marketing □ agricultural/marketing □

Section 2: Issues and solutions

Organic fertilsers

Do you use organic fertilsers in your farm?	Yes ☐	No ☐
What are the advantages of organic fertilsers? 1-____________________________ 2-____________________________ 3-____________________________		
What are the disadvantages of organic fertilsers? 1-____________________________ 2-____________________________ 3-____________________________		
Are there individual/groups who approve your use of organic fertilsers? 1-____________________________ 2-____________________________ 3-____________________________	Yes ☐ Who?	No ☐
Are there individual/groups who disapprove your use of organic fertilsers? 1-____________________________ 2-____________________________ 3-____________________________	Yes ☐ Who?	No ☐
Are there any factors/circumstances that enable you to use organic fertilsers? 1-____________________________ 2-____________________________ 3-____________________________	Yes ☐ What?	No ☐
Are there any factors/circumstances that make it difficult for you to use organic fertilsers? 1-____________________________ 2-____________________________ 3-____________________________	Yes ☐ What?	No ☐

Inorganic fertilsers

Do you use inorganic fertilsers in your farm?	Yes ☐	No ☐
What are the advantages of inorganic fertilsers? 1-_____________________ 2-_____________________ 3-_____________________		
What are the disadvantages of inorganic fertilsers? 1-_____________________ 2-_____________________ 3-_____________________		
Are there individual/groups who approve your use of inorganic fertilsers? 1-_____________________ 2-_____________________ 3-_____________________	Yes ☐ who?	No ☐
Are there individual/groups who disapprove your use of inorganic fertilsers? 1-_____________________ 2-_____________________ 3-_____________________	Yes ☐ who?	No ☐
Are there any factors/circumstances that enable you to use inorganic fertilsers? 1-_____________________ 2-_____________________ 3-_____________________	Yes ☐ what?	No ☐
Are there any factors/circumstances that make it difficult for you to use inorganic fertilsers? 1-_____________________ 2-_____________________ 3-_____________________	Yes☐ what?	No ☐

Crop rotation

Do you do crop rotation in your farm?	Yes ☐	No ☐
What are the advantages of crop rotation? 1-______________________________ 2-______________________________ 3-______________________________		
What are the disadvantages of crop rotation? 1-______________________________ 2-______________________________ 3-______________________________		
Are there individual/groups who approve your use of crop rotation? 1-______________________________ 2-______________________________ 3-______________________________	Yes ☐ who?	No ☐
Are there individual/groups who disapprove your use of crop rotation? 1-______________________________ 2-______________________________ 3-______________________________	Yes ☐ who?	No ☐
Are there any factors/circumstances that enable you to use crop rotation? 1-______________________________ 2-______________________________ 3-______________________________	Yes ☐ what?	No ☐
Are there any factors/circumstances that make it difficult for you to use crop rotation? 1-______________________________ 2-______________________________ 3-______________________________	Yes ☐ what?	No ☐

Leguminous crops

Do you do leguminous crops in your farm?	Yes ☐	No ☐
What are the advantages of leguminous crops? 1-___________________________ 2-___________________________ 3-___________________________		
What are the disadvantages of leguminous crops? 1-___________________________ 2-___________________________ 3-___________________________		
Are there individual/groups who approve your use of leguminous crops? 1-___________________________ 2-___________________________ 3-___________________________	Yes ☐ who?	No ☐
Are there individual/groups who disapprove your use of leguminous crops? 1-___________________________ 2-___________________________ 3-___________________________	Yes ☐ who?	No ☐
Are there any factors/circumstances that enable you to use leguminous crops? 1-___________________________ 2-___________________________ 3-___________________________	Yes ☐ what?	No ☐
Are there any factors/circumstances that make it difficult for you to use leguminous crops? 1-___________________________ 2-___________________________ 3-___________________________	Yes ☐ what?	No ☐

Crops diversity

Do you do crops diversity in your farm?	Yes ☐	No ☐
What are the advantages of crops diversity? 1-________________ 2-________________ 3-________________		
What are the disadvantages of crops diversity? 1-________________ 2-________________ 3-________________		
Are there individual/groups who approve your use of crops diversity? 1-________________ 2-________________ 3-________________	Yes ☐ who?	No ☐
Are there individual/groups who disapprove your use of crops diversity? 1-________________ 2-________________ 3-________________	Yes ☐ who?	No ☐
Are there any factors/circumstances that enable you to use crops diversity? 1-________________ 2-________________ 3-________________	Yes ☐ what?	No ☐
Are there any factors/circumstances that make it difficult for you to use crops diversity? 1-________________ 2-________________ 3-________________	Yes ☐ what?	No ☐

Agricultural Mechanization

Do you use mechanization in your farm? 1-____________________________ 2-____________________________ 3-____________________________	Yes ☐ what kind?	No ☐
What are the advantages of mechanization? 1-____________________________ 2-____________________________ 3-____________________________		
What are the disadvantages of mechanization? 1-____________________________ 2-____________________________ 3-____________________________		
Are there individual/groups who approve your use of mechanization? 1-____________________________ 2-____________________________ 3-____________________________	Yes ☐ who?	No ☐
Are there individual/groups who disapprove your use of mechanization? 1-____________________________ 2-____________________________ 3-____________________________	Yes ☐ who?	No ☐
Are there any factors/circumstances that enable you to use mechanization? 1-____________________________ 2-____________________________ 3-____________________________	Yes ☐ what?	No ☐
Are there any factors/circumstances that make it difficult for you to use mechanization? 1-____________________________ 2-____________________________ 3-____________________________	Yes ☐ what?	No ☐

Irrigation system

What kind of irrigation systems do you use in your farm? Traditional ☐ modern ☐ both ☐

First:- traditional irrigation

What are the advantages of traditional irrigation? 1-__________ 2-__________ 3-__________		
What are the disadvantages of traditional irrigation? 1-__________ 2-__________ 3-__________		
Are there individual/groups who approve your use of traditional irrigation? 1-__________ 2-__________ 3-__________	Yes ☐ who?	No ☐
Are there individual/groups who disapprove your use of traditional irrigation? 1-__________ 2-__________ 3-__________	Yes ☐ who?	No ☐
Are there any factors/circumstances that enable you to use traditional irrigation? 1-__________ 2-__________ 3-__________	Yes ☐ what?	No ☐
Are there any factors/circumstances that make it difficult for you to use traditional irrigation? 1-__________ 2-__________ 3-__________	Yes ☐ what?	No ☐

Second: - Modern irrigation

What kind of modern irrigation do you use in your farm? Sprinkler ☐ trickle ☐ drip ☐ other ☐		
What are the advantages of modern irrigation? 1-________________ 2-________________ 3-________________		
What are the disadvantages of modern irrigation? 1-________________ 2-________________ 3-________________		
Are there individual/groups who approve your use of modern irrigation? 1-________________ 2-________________ 3-________________	Yes ☐ who?	No ☐
Are there individual/groups who disapprove your use of modern irrigation? 1-________________ 2-________________ 3-________________	Yes ☐ who?	No ☐
Are there any factors/circumstances that enable you to use modern irrigation? 1-________________ 2-________________ 3-________________	Yes ☐ what?	No ☐
Are there any factors/circumstances that make it difficult for you to use modern irrigation? 1-________________ 2-________________ 3-________________	Yes ☐ what?	No ☐

Breeding crops (Hybrid)

Do you plant breeding crops (hybrid & GM) in your farm?	Yes ☐	No ☐
What are the advantages of hybrid crops? 1-____________________ 2-____________________ 3-____________________		
What are the disadvantages of hybrid crops? 1-____________________ 2-____________________ 3-____________________		
Are there individual/groups who approve your use of hybrid crops? 1-____________________ 2-____________________ 3-____________________	Yes ☐ who?	No ☐
Are there individual/groups who disapprove your use of hybrid crops? 1-____________________ 2-____________________ 3-____________________	Yes ☐ who?	No ☐
Are there any factors/circumstances that enable you to use hybrid crops? 1-____________________ 2-____________________ 3-____________________	Yes ☐ what?	No ☐
Are there any factors/circumstances that make it difficult for you to use hybrid crops? 1-____________________ 2-____________________ 3-____________________	Yes ☐ what?	No ☐

GM crops

Do you plant GM in your farm?	Yes ☐	No ☐
What are the advantages of GM crops? 1-____________________ 2-____________________ 3-____________________		
What are the disadvantages of GM crops? 1-____________________ 2-____________________ 3-____________________		
Are there individual/groups who approve your use of GM crops? 1-____________________ 2-____________________ 3-____________________	Yes ☐ who?	No ☐
Are there individual/groups who disapprove your use of GM crops? 1-____________________ 2-____________________ 3-____________________	Yes ☐ who?	No ☐
Are there any factors/circumstances that enable you to use GM crops? 1-____________________ 2-____________________ 3-____________________	Yes ☐ what?	No ☐
Are there any factors/circumstances that make it difficult for you to use GM crops? 1-____________________ 2-____________________ 3-____________________	Yes ☐ what?	No ☐

Greenhouse

Do you have any greenhouse in your farm?	Yes ☐	No ☐
What are the advantages of greenhouse? 1-__________________ 2-__________________ 3-__________________		
What are the disadvantages of greenhouse? 1-__________________ 2-__________________ 3-__________________		
Are there individual/groups who approve your use of greenhouse? 1-__________________ 2-__________________ 3-__________________	Yes ☐ who?	No ☐
Are there individual/groups who disapprove your use of greenhouse? 1-__________________ 2-__________________ 3-__________________	Yes ☐ who?	No ☐
Are there any factors/circumstances that enable you to use greenhouse? 1-__________________ 2-__________________ 3-__________________	Yes ☐ what?	No ☐
Are there any factors/circumstances that make it difficult for you to use greenhouse? 1-__________________ 2-__________________ 3-__________________	Yes ☐ what?	No ☐

- What are the main benefits of your products?
- 1-________________________________
- 2-________________________________
- 3-________________________________
- 4-________________________________
- What are the main issues faced in your farm?
- 1-________________________________
- 2-________________________________
- 3-________________________________
- 4-________________________________
- Is it possible to find a solution to those problems?
- Yes ☐ How? No ☐ I don't know ☐
- 1-________________________________
- 2-________________________________
- 3-________________________________
- 4-________________________________
- Do you do the process of post harvesting for your products? Yes ☐ what? No ☐
- Sorting ☐ leaning ☐ category ☐ cooling ☐ packing ☐
- Do you sell/advertise your products in market? Yes ☐ where? No ☐
- 1-________________________________
- 2-________________________________
- 3-________________________________
- Do you face any competition from imported products? Yes ☐ what? No ☐
- 1-________________________________
- 2-________________________________
- 3-________________________________
- 4-________________________________
- Have you visited department/centre of agriculture? Yes ☐ No ☐
- Do you get any services from MoAF? Yes ☐ what? No ☐
- 1-________________________________

- 2-______________________________
- 3-______________________________
- 4-______________________________

Appendix 2. TPB Questionnaire

Section 1: farm, farmer, agricultural marketing and cooperative

No:- __________ Date:- ________________

General information of the farm

x- Region ____________ Wilayat:____________

xi- Total area __________ acre

xii- Type of farm crops☐ livestock ☐ poultry ☐ mixed ☐

xiii- Area cropped last year ____________ acre

xiv- Do you intend to plant…. this year?

Perennial crops Yes ☐ No ☐ Maybe ☐ N/A ☐

Annual crops Yes ☐ No ☐ Maybe ☐ N/A ☐

Demographic information to the holder

xii- Gender Male ☐ Female ☐

xiii- Age less than 25 ☐ 25-34 ☐ 35-44 ☐

45-54 ☐ 55-64 ☐ 65 or more ☐

xiv- Household size __________

xv- Education level Uneducated☐ Reading and writing ☐

Elementary ☐ Preparatory ☐ Secondary/diploma ☐

Medium/technical college☐ BS/BA ☐ Higher education ☐

xvi- The occupation of the holder Agricultural ☐ Government ☐

Private sector☐ Private non-agricultural activity☐ Other ☐

xvii- How many years of farming experience do you have? ______year(s)

xviii- The main resource of your household agricultur☐ other ☐

xix- Will you continue in the future in agricultural activities?

Yes ☐ No ☐ Maybe ☐ N/A ☐

xx- Do you have future targets other than agriculture?

Yes ☐ No ☐ maybe ☐ N/A ☐

xxi- Do you intend to develop your farm in the near future?

Yes ☐ No ☐ Maybe ☐ N/A ☐

Labours

Do you have any labourers working on the farm? Yes ☐ No ☐

iii- Permanent workers ____________

iv- Number of unpaid workers from your family __________

Agricultural equipment

Do you have agricultural machinery/equipment? Yes ☐ No ☐
What type of equipment do you have? ____

Agricultural infrastructure

Do you have any agricultural construction?
What type of constructions do you have? _____________________________________

Irrigation

v- Irrigation system
Traditional ☐ Modern ☐ Both ☐

vi- Water sources in the farm:
Well within farm ☐ Well outside farm ☐ Falaj ☐ Other ☐

vii- Power source for water pumps used (choose one)
Electricity ☐ Diesel ☐ Benzene ☐
Electricity, diesel and benzene ☐ N/A ☐

Fertiliser

Type of fertiliser use:
Organic ☐ inorganic ☐ both ☐ N/A ☐

Agricultural marketing and cooperatives

Agricultural marketing

x- Distance to nearest market is

Less than 5km ☐ 6-10 1☐-15 1☐-20 ☐ore than 20 km ☐

xi- Distance to nearest agricultural shop is

Less than 5km 6-☐0 1☐-15 16☐20 ☐ore than 20 km ☐

xii- Product use (choose one or more) Family consumption ☐

Marketing inside country ☐ Export ☐ Manufacturing ☐

xiii- Place where product is sold Farm gate ☐ Willayat market ☐

Another Willayat ☐ Mawaleh market ☐ Outside country ☐

xiv- Source of agricultural information agricultural officers ☐ newspapers ☐

Magazines ☐ TV ☐ Radio ☐ Internet

Other famers ☐ Other ☐

xv- Sources of loans (choose one or more) ODB ☐ Other banks ☐

Other sources ☐ N/A ☐ Project support ☐ Livelihoods ☐

Type and name of cooperative

Are you a member of an agricultural cooperative? Yes ☐ No ☐

If yes,what type of cooperative?

Agricultural ☐ Marketing ☐ Agricultural/marketing ☐

Name of cooperative: ______________________________

☐

Section 2: TPB on inorganic fertiliser and modern irrigation system

Fertiliser

Attitude toward the behaviour (A)

i. Behavioural belief strength (b)

To what extent do you agree or disagree with these statements?

Strongly disagree	1	2	3	4	5	Strongly agree
Using inorganic fertiliser increases yields						
Using inorganic fertiliser increases my farm income						
Using inorganic fertiliser reduces demand for water						
Using inorganic fertiliser preserves soil structure						

ii. Outcome evaluation (e)

To what extent do you agree or disagree with these statements?

Strongly disagree	1	2	3	4	5	Strongly agree
Increased yield is important for my household						
Increased farm income is important for my household						
Reduced water consumption is important for my household						
Improved soil structure is important for my household						

How much more important is the outcome on the left hand side compared to the outcome on the right hand side?

much more important	5	4	3	2	1	much less important
Improved yield						Increased income
Improved yield						Reduced demand for water
Improved yield						Preserved soil structure
Increased income						Reduced demand for water
Increased income						Preserved soil structure
Reduced demand for water						Preserved soil structure

Subjective norm (SN)

Normative belief strength (n)

To what extent do you agree or disagree with these statements?

Strongly disagree	1	2	3	4	5	Strongly agree
My family thinks that I should use inorganic fertiliser						
My neighbours think that I should use inorganic fertiliser						
Extension service providers think that I should use inorganic fertiliser						
The government thinks that I should use inorganic fertiliser						

Motivation to comply (m)

To what extent do you agree or disagree with these statements?

Strongly disagree	1	2	3	4	5	Strongly agree
Your family strongly motivates you to use inorganic fertiliser						
Your neighbours strongly motivate you to use inorganic fertiliser						
Extension service providers strongly motivate you to use inorganic fertiliser						
The government strongly motivates you to use inorganic fertiliser						

How much more important is the outcome on the left hand side compared to the outcome on the right hand side?

much more important	5	4	3	2	1	much less important
Your family						Your neighbours
Your family						Agricultural extension
Your family						Government
Your neighbours						Agricultural extension
Your neighbours						Government
Agricultural extension						Government

Perceived behavioural control (PBC)

Control belief strength (c)

To what extent do you agree or disagree with these statements?

Strongly disagree	1	2	3	4	5	Strongly agree
Inorganic fertiliser is available on the market						
The market where inorganic fertiliser is sold is not too far away						
The cost of inorganic fertiliser is low						
Water is important for the application of inorganic fertiliser						

Control belief power (p)

To what extent do you agree or disagree with these statements?

Strongly disagree	1	2	3	4	5	Strongly agree
I know how to use inorganic fertiliser						
I can easily obtain inorganic fertiliser from market to farm						
I can afford to purchase sufficient inorganic fertiliser						
I have ready access to water						

How much more important is the outcome on the left hand side compared to the outcome on the right hand side?

much more important	5	4	3	2	1	much less important
How to use inorganic fertiliser						Easily obtain fertiliser from market to farm
How to use inorganic fertiliser						Afford to purchase sufficient inorganic fertiliser
How to use inorganic fertiliser						Ready access to water
Easily obtain fertiliser from market to farm						Afford to purchase sufficient inorganic fertiliser
Easily obtain fertiliser from market to farm						Ready access to water
Afford to purchase sufficient inorganic fertiliser						Ready access to water

Irrigation

Attitude toward the behaviour (A)

Normative belief strength (n)

To what extent do you agree or disagree with these statements?

Strongly disagree	1	2	3	4	5	Strongly agree
Using modern irrigation increases yields						
Using modern irrigation increases my farm income						
Using modern irrigation reduces water consumption						
Using modern irrigation reduces water salinity						
Using modern irrigation reduces soil erosion						
Using modern irrigation reduces labour requirement						

Outcome evaluation (e)

To what extent do you agree or disagree with these statements?

Strongly disagree	1	2	3	4	5	Strongly agree
Increased yields for my farm						
Increased income for my farm						
Reduced water consumption						
Reduced water salinity						
Reduced soil erosion						
Reduced labour requirement						

How much more important is the outcome on the left hand side compared to the outcome on the right hand side?

much more important	5	4	3	2	1	much less important
Increased yields						Increased income for my farm
Increased yields						Reduced water consumption
Increased yields						Reduced water salinity
Increased yields						Reduced soil erosion
Increased yields						Reduced labour requirement
Increased income						Reduced water consumption
Increased income						Reduced water salinity
Increased income						Reduced soil erosion
Increased income						Reduced labour requirement
Reduced water consumption						Reduced water salinity
Reduced water consumption						Reduced soil erosion
Reduced water consumption						Reduced labour requirement
Reduced water salinity						Reduced soil erosion
Reduced water salinity						Reduced labour requirement
Reduced soil erosion						Reduced labour requirement

Subjective norm (SN)

Normative belief strength (n)

To what extent do you agree or disagree with these statements?

Strongly disagree	1	2	3	4	5	Strongly agree
My family thinks that I should use modern irrigation						
My neighbours think that I should use modern irrigation						
Extension service providers think that I should use modern irrigation						
The government thinks that I should use modern irrigation						

Motivation to comply (m)

To what extent do you agree or disagree with these statements?

Strongly disagree	1	2	3	4	5	Strongly agree
Your family strongly motivates you to use modern irrigation						
Your neighbours strongly motivate you to use modern irrigation						
Extension service providers strongly motivate you to use modern irrigation						
The government strongly motivates you to use modern irrigation						

Perceived behavioural control

Control belief strength (c)

To what extent do you agree or disagree with these statements?

Strongly disagree	1	2	3	4	5	Strongly agree
Water is readily available						
Electricity is readily available						
The cost of modern irrigation is low						
The cost of maintenance is high						

Control belief power (p)

To what extent do you agree or disagree with these statements?

Strongly disagree	1	2	3	4	5	Strongly agree
I can easily access water for irrigation						
I can afford electricity for irrigation						
I can afford to install and operate modern irrigation						
I cannot afford the maintenance costs						

How much more important is the outcome on the left hand side compared to the outcome on the right hand side?

much more important	5	4	3	2	1	much less important
Availability of water						Availability of electricity
Availability of water						The cost of modern irrigation
Availability of water						The cost of the maintenance
Availability of electricity						Availability of water
Availability of electricity						The cost of the maintenance
The cost of modern irrigation						The cost of the maintenance

Behaviour intention (BI)

Strongly disagree	1	2	3	4	5	Strongly agree
I intend to plant perennial crops this year						
I intend to plant annual crops this year						
I will continue in the future in agricultural activities						
I have future target/s other than agriculture						
I intend to develop my farm in near future						
I intend to use organic fertiliser						
I intend to use inorganic fertiliser						
I intend to use traditional irrigation						
I intend to use modern irrigation						
I do not have modern irrigation installed, I intend to install						

Appendix 3. Appendix: official letter

Researcher: Juma S K Alanbari

E-mail: j.s.k.alanbari@pgr.reading.ac.uk

Supervisor: Prof. Elizabeth Robinson

E-mail: e.j.robinson@reading.ac.uk

Approved consent- (Information/consent sheet for non-anonymous survey)

Project title: Agricultural technology and the role of cooperatives- the case of Oman.

The researcher has given me a brief explanation of the goals of the project, and asked me to answer some questions through an interview. He explained to me that all personal information and responses are confidential and restricted to scientific study only and will be destroyed after the end of the study. I agree to the arrangements described in the information sheet in so far as they relate to my participation.

I understand that the interviews will be recorded.

I know that the participation is voluntary and that I have the right to withdraw from the project or to reject the participation without giving any reasons or sending an apology.

I have received a copy of the attached form and agree to the information sheet.

I have received a copy of this consent form and agree to the accompanying information sheet.

I consent to being interviewed: ☐

Name: ______________________ Address:-__________________________

Signed: _________________

Date:__________________

This project has been subject to the ethical review, according the procedures specified by the University Reading's. Ethics committee and has been allowed to proceed.

Date: 20/03/15

Mr. Musallam Al Amri Head of Cultural Attached in London respected

After greeting

Peace be upon you and God's mercy

Subject: - Conduct a detailed survey for a sample of farmers, agricultural cooperatives, and staff of the Ministry of Agriculture and Fisheries in the Sultanate of Oman.

With reference to the above subject, my name is Juma Said Khalfan Alanbari and I am a PhD student at the University of Reading in the Department of Food Economics and Marketing. As a part of my study I am planning to carry out a detailed survey of farmers, agricultural cooperatives and staff of the Ministry of Agriculture and Fisheries in Oman. The aim of the survey is to explore the contribution of the agricultural sector, and in particular agricultural cooperatives, in contributing to food security.

The data collection is programed to happen between April and July 2015. The sample for the survey will be 80 farmers in Al-Batinah region (members and non-members in Agricultural cooperative) as well as government official staff of MoAF.

I would be most grateful if I could have your assistance in contacting the General Director of Planning and Development at the Ministry of Agriculture and Fisheries to facilitate my work in the survey whilst I am in Oman. I am happy to answer any queries you may have on the project; please do not hesitate to contact me.

With many thanks

Yours Sincerely

Juma Said Khalfan Alanbari

PhD Researcher
Agriculture and Food Economics
University of Reading
New Agriculture Building
Berkshire
United Kingdom
Tel:-+44751363072, +447513699191
E-mail J.S.K.AlAnbari@pgr.reading.ac.uk

School of agriculture, policy and development
Agriculture building. Early Gate, whitenight
PO Box 237, Reading. RG6 6AR. UK
Phone +44(0)118 378 5038
Fax +44(0)118 926 1244

Interview (MoAF)

Eng. \ Director General of Planning and Development

Eng.\ Director General of Marketing and Agricultural Investment and Animal

Eng.\ Director General of Agriculture and development in the Ministry of Agriculture and Fisheries respected.

Dear DGs,

My name is Juma Said Khalfan Alanbari and I am a PhD student at the University of Reading's Department of Food Economics and Marketing. I am interested in the agricultural sector in Oman, given its importance for the country in terms of food production and employment generation, and due to the important challenges it faces from population growth, farmland decline, pressure on water resources and the characteristics of the landscape of the Sultanate.

As part of my study I would like to interview some officials in the Ministry of agriculture and Fisheries. I would like to invite the MoAF to contribute to this study as it is the ministry responsible for the agricultural sector in the Sultanate. My focus on government officials is due to their direct importance to the research, which deals with the role and importance of the agricultural sector, programs and projects that provide service to farmers and the development to their farms, in addition to the contribution of the agricultural sector to the national income of the country. These officials will include general managers and directors of departments because they are the officials that implement the programs and decision-makers. Participation in the survey is voluntary, and participants have the right to withdraw without having to explain why. The data collected is confidential, and will be destroyed after the completion of the study.

There are several benefits for the government from this research, such as having information regarding perceptions of farmers and proposals for the development of the agricultural sector through the creation of agricultural cooperatives of various kinds in the Sultanate; better development and marketing of agricultural products; and enhanced use of modern technology in agriculture in order to increase agricultural production and raise the income of farmers in addition to the protection of farmland and the environment.

I would be very grateful for your support for this study. I and my supervisor's contact details are detailed below. Please do not hesitate to contact us should you have any queries or require more information.

Researcher's contact: Juma Said Khalfan Alanbari School of agriculture, policy and development
E-mail: J.S.K.AlAnbari@pgr.reading.ac.uk Agriculture building. Early Gate, whitenight
Research supervisor's contact: Elizabeth J Z Robinson PO Box 237, Reading. RG6 6AR. UK
E-mail: e.j.robinson@reading.ac.uk Phone +44(0)118 378 5038

Kind regards,
Juma Said Khalfan Alanbari

Interview (Agri.Coop.)

Mr/ President of Agricultural cooperative in Al-Batinah
respected
After greeting
Peace be upon you and God's mercy

My name is Juma Said Khalfan Alanbari and I am a PhD student at the University of Reading's Department of Food Economics and Marketing. As part of my study, I am interested in the agricultural sector in Oman, given its importance for the country in terms of food production and employment generation, and due to the important challenges it faces from population growth, farmland decline, pressure on water resources and the characteristics of the landscape of the Sultanate.

As an important part of my study I would like to invite members from the Agricultural cooperative in Al-Batinah to take part in a number of interviews that will cover topics on programs and projects that provide service to farmers and the development to their farms, with a particular interest in the role of agricultural cooperatives to the Sultanate's agricultural sector. I am especially pleased to invite the agricultural cooperative in the Batinah region as it is the first private agricultural cooperative in the Sultanate and located in the biggest agricultural lane in Oman. Moreover, its members are the most knowledgeable about the implementation of programs and of decision-making in cooperative.

I assure you that none of the participants will be identifiable to anyone other than the researcher. Participation in interviews is voluntary, and participants have the right to withdraw without having to explain why at any time during the study. If you want to withdraw, please contact Juma Alanbari (detail below) to be excluded from the research project. The data collected is confidential, and will be destroyed after two years of data collection. This project has been reviewed by the University Reading's Ethics Committee.

I would be very grateful for your support for this study. I and my supervisor's contact details are detailed below. Please do not hesitate to contact us should you have any queries or require more information.

Researcher's contact: Juma Said Khalfan Alanbari School of agriculture, policy and development
E-mail: J.S.K.AlAnbari@pgr.reading.ac.uk Agriculture building. Early Gate, whitenight
Phone:- +96899453541 or +96895241250
Research supervisor's contact: Elizabeth J Z Robinson PO Box 237, Reading. RG6 6AR. UK
E-mail: e.j.robinson@reading.ac.uk Phone +44(0)118 378 5038

With kind regards,
Juma Said Khalfan Alanbari

Farmer Interview (questionnaire)

Dear, Directorate-General for Agriculture and Livestock in Al-Batinah
respected
After greeting

My name is Juma Said Khalfan Alanbari and I am a PhD student at the University of Reading's Department of Food Economics and Marketing (United Kingdom), under the supervision of Prof. Elizabeth Robinson and Dr. Alison Bailey. I am interested in the agricultural sector in Oman.

I want to invite you to take part in a survey for farmers in Al-Batinah region. The survey will ask some questions and involve a short discussion about your farming activities and about the agricultural cooperatives or government programs that you may know about and your views on them. The interviewer will be someone from Ministry of Agriculture and Fisheries.

You were selected randomly according to your region and the town where you live, but your participation in the interview is voluntary, and you can withdraw at any time without having to explain why. The information you give us is confidential and your name or any other identifiable information will not be revealed. If you want to withdraw at any stage, please contact the researcher Juma Alanbari (detail below). The data we collect will be used for statistics and results may be published in scientific journals, but this will not affect the confidentiality of the information. After two years the data will be destroyed. The University of Reading has given ethical approval for this study.

By answering the questionnaire you acknowledge that you understand the terms of participation and that you consent to these terms.

My details and details of my supervisor are:

Researcher's contact details
Juma Said Khalfan Alanbari
P.O.Box 60 PC 611
Nizwa. Sultanate of Oman
E-mail
J.S.K.AlAnbari@pgr.reading.ac.uk
phone:+968 99453541or +96895241250

Research supervisor's contact details:
Elizabeth J Z Robinson
+44 (0)118 378 5039
E-mail: e.j.robinson@reading.ac.uk
http://www.reading.ac.uk/apd/staff/e-j-robinson.aspx

You can contact us for more information or to later withdraw from the study, using the code number of your questionnaire, which will be given to you during the survey.

Appendix 4. Details of Nvivo analysis

Nvivo is a software programme that researcher uses especially in qualitative data analysis. This programme abbreviated your work (manner) in collecting, organizing and analysing content from interviews. In addition, it allows researcher/users to classify, sort and arrange information, combine analysis with linking. In this software can use social media data, images, you tube videos and web pages. Nvivo gives the researcher quickly organize and manage his/her work, more efficiency, save time, store and recover data. There are tools that allow researcher to ask questions in a more effective way.

Summary of approach:

- The work of each interview in a separate file using word.
- Open Nvivo software (open new project file - named title and any description. information, choose the place to save it and save it in computer).
- Choose external data from tool bar.
- Click documents to obtain the file.
- Click ok to write the new name and description for each file (each interview).
- Do that step for all files.
- All new files be in the place called sources.
- This sources include all interviews (each interview called theme).
- Create a new node by click in create from tool bar and to node (name, description and colour it.
- I done that step for all nodes.
- Start open first theme (interview) by click twice.
- Press edit from the top for any correction in the theme.
- Highlight any information then drag it to the specific node.

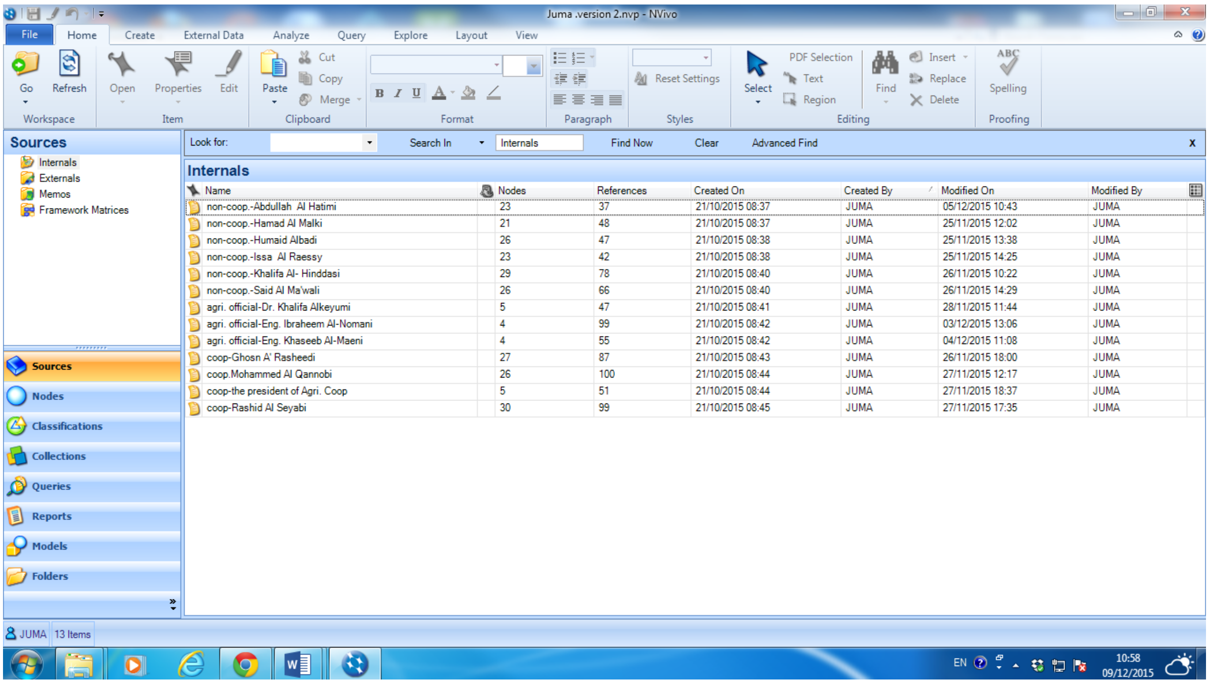


Figure: Sources (interviews)

The above figure illustrates names of source, nodes, references, and date of created, name of creator, modified date and by whom. This figure makes a summarize or general information for each theme.

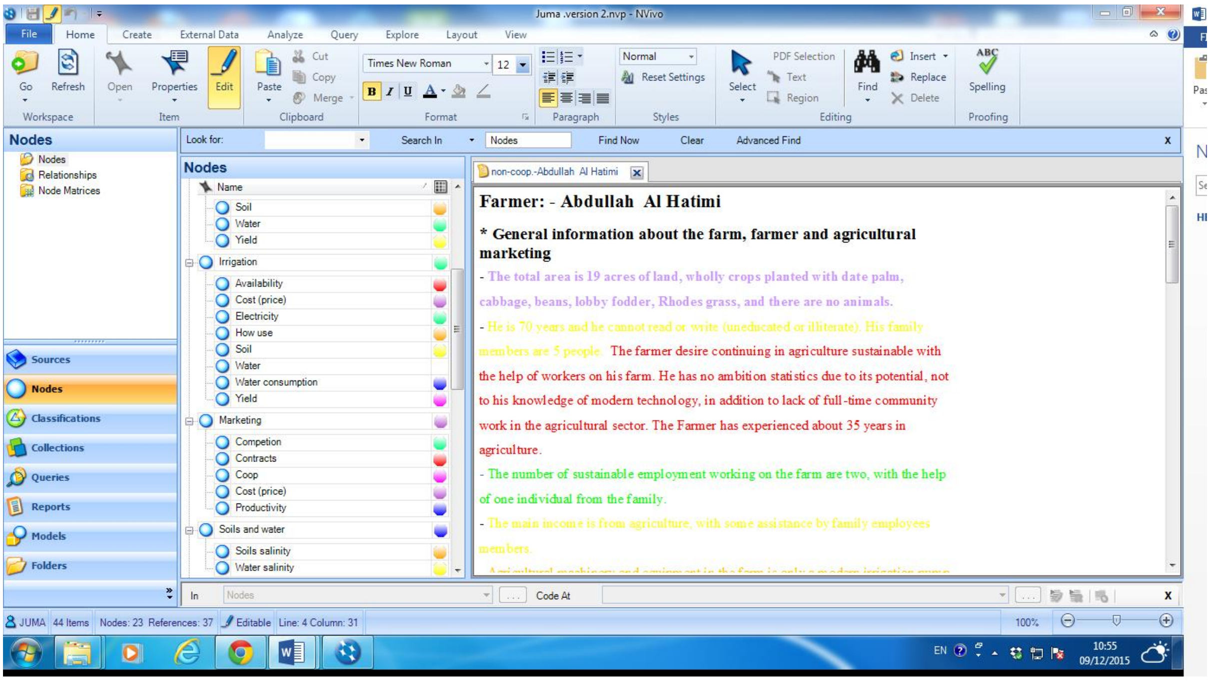


Figure: Name of nodes

The above figure clarifies the name of nodes and sub-nodes. Main nodes such as fertilisers, irrigation, availability of water and soil as well as sub nodes in each node for example in irrigation availability, how use, cost, water consumption. This give more specific for each node who said that information and organize it according to the source.

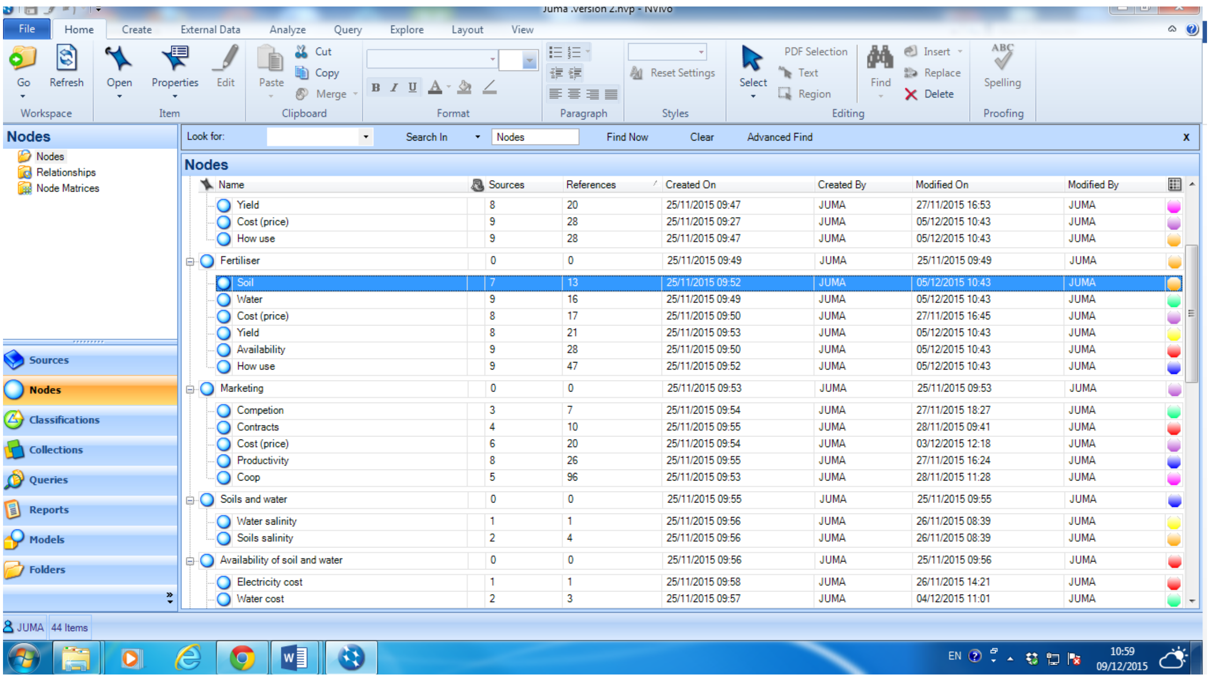


Figure: Name of notes

The above figure demonstrates names of nodes and sub-nodes, number of sources and references in addition to the date of created and modified and by whom. This give summarize for each node and sub-nodes. Any extra information only click to it.

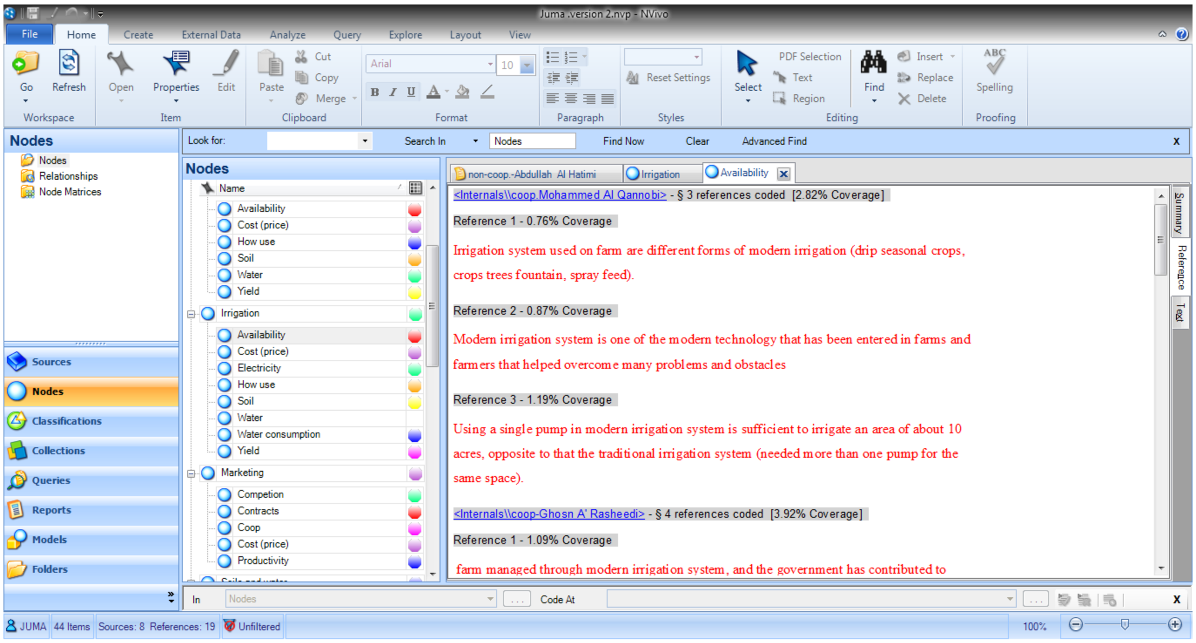


Figure: Availability of irrigation

The above figure shows information of all nodes and sub-nodes (left sides). In right side reveals node of irrigation's availability. In the top some details for each resource This make a smooth to the researcher to figure out all information for each node.

After done all theme. I opened a new word folder to transform all information from Nvivo software to word by open each node and sub-node and make copy and paste to word. Any modification can easy in word document.

One main obstacles that I faced and attempted to overcome is difficulty to change information in node or sub-node only by delete it and do all steps from the beginning.

Like the rest of programmes, there are a lot of properties that is characterized by this software. Researcher takes the information he/she wants without use all tools.

Appendix 5. Additional detail for TPB analysis

The percentage of components' magnitude of TPB, average, min and max of multiple sub-element of agri. group- Inorganic fertiliser

Elements	Sub-elements	Multiply sub elements	%	Average	Min	Max
A_F	Incr.Yield*Impor. Hh	$\sum b_{F1} * e_{F1}$	71	18	1	25
	Incr. Income*Impor. Hh	$\sum b_{F2} * e_{F2}$	73	18	4	25
	Red. Water*Imp. Farm &Hh	$\sum b_{F3} * e_{F3}$	46	11	2	25
	Pres. Soil*Impor. Farm &Hh	$b_{F4} * e_{F4}$	45	11	2	25
SN_F	Family think*Motiv	$\sum n_{F1} * m_{F1}$	41	10	1	25
	Neighbours think*Motiv	$\sum n_{F2} * m_{F2}$	43	11	1	25
	Agri. service think*Motiv	$\sum n_{F3} * m_{F3}$	52	13	1	25
	Gov. think*Motiv	$\sum n_{F4} * m_{F4}$	49	12	1	25
PBC_F	Avai in market*How to use	$\sum c_{F1} * p_{F1}$	68	17	1	25
	Market very close*easily obtained	$\sum c_{F2} * p_{F2}$	62	15	1	25
	low cost*afford to buy suffi	$\sum c_{F3} * p_{F3}$	32	8	1	25
	Water centrality*access water	$\sum c_{F4} * p_{F4}$	69	17	3	25

The percentage of components' magnitude of TPB, average, min and max of multiple sub-element of agri. group- Modern irrigation

A_{ir}	Incr.Yield*Impor. Hh	$\sum b_{Ir1}*e_{Ir1}$	84	21	4	25
	Incr. Income*Impor. Hh	$\sum b_{Ir2}*e_{Ir2}$	88	22	4	25
	Red water*Import. Farm &Hh	$\sum b_{Ir3}*e_{Ir3}$	91	23	10	25
	Red water salinity*Import farm	$\sum b_{Ir4}*e_{Ir4}$	87	22	4	25
	Red soil erosion*Import farm	$\sum b_{Ir5}*e_{Ir5}$	87	22	5	25
	Red labour*Import farm	$\sum b_{Ir6}*e_{Ir6}$	87	22	10	25
SN_{Ir}	Family think*Motiv	$\sum n_{Ir1}*m_{Ir1}$	81	20	1	25
	Neighbours think*Motiv	$\sum n_{Ir2}*m_{Ir2}$	78	20	1	25
	Agri. service think*Motiv	$\sum n_{Ir3}*m_{Ir3}$	85	21	4	25
	Gov. think*Motiv	$\sum n_{Ir4}*m_{Ir4}$	83	21	4	25
PBC_{Ir}	Water avail*easily access	$\sum c_{Ir1}*p_{Ir1}$	59	15	1	25
	Elect.avail*Afford	$\sum c_{Ir2}*p_{Ir2}$	67	17	1	25
	low cost*afford to install &operate	$\sum c_{Ir3}*p_{Ir3}$	34	9	2	25
	High maint*cannot afford	$\sum c_{Ir4}*p_{Ir4}$	41	10	1	25

The percentage components' magnitude of TPB, average, min and max of multiple sub-element of Coop-Inorganic fertiliser

Elements	Sub-elements	Multiply sub elements	%	Average	Min	Max
A_F	Incr.Yield*Impor. Hh	$\sum b_{F1}*e_{F1}$	85	21	10	25
	Incr. Income*Impor. Hh	$\sum b_{F2}*e_{F2}$	88	22	10	25
	Red. Water*Imp. Farm &Hh	$\sum b_{F3}*e_{F3}$	60	15	4	25
	Pres. Soil*Impor. Farm &Hh	$\sum b_{F4}*e_{F4}$	50	12	3	25
SN_F	Family think*Motiv	$\sum n_{F1}*m_{F1}$	46	12	2	25
	Neighbours think*Motiv	$\sum n_{F2}*m_{F2}$	43	11	2	25
	Agri. service think*Motiv	$\sum n_{F3}*m_{F3}$	53	13	2	25
	Gov. think*Motiv	$\sum n_{F4}*m_{F4}$	50	13	2	25
PBC_F	Avai in market*How to use	$\sum c_{F1}*p_{F1}$	82	21	12	25
	Market very close*easily obtained	$\sum c_{F2}*p_{F2}$	75	19	4	25
	low cost*afford to buy suffi	$\sum c_{F3}*p_{F3}$	32	8	2	16
	Water centrality*access water	$\sum c_{F4}*p_{F4}$	80	20	12	25

The percentage components' magnitude of TPB, average, min and max of multiple sub-element of coop- Modern irrigation

A_{ir}	Incr.Yield*Impor. Hh	$\sum b_{Ir1} * e_{Ir1}$	98	25	16	25
	Incr. Income*Impor. Hh	$\sum b_{Ir2} * e_{Ir2}$	98	25	16	25
	Red water*Import. Farm &Hh	$\sum b_{Ir3} * e_{Ir3}$	99	25	20	25
	Red water salinity*Import farm	$\sum b_{Ir4} * e_{Ir4}$	99	25	20	25
	Red soil erosion*Import farm	$\sum b_{Ir5} * e_{Ir5}$	99	25	20	25
	Red labour*Import farm	$\sum b_{Ir6} * e_{Ir6}$	96	24	10	25
SN_{Ir}	Family think*Motiv	$\sum n_{Ir1} * m_{Ir1}$	96	24	16	25
	Neighbours think*Motiv	$\sum n_{Ir2} * m_{Ir2}$	95	24	16	25
	Agri. service think*Motiv	$\sum n_{Ir3} * m_{Ir3}$	96	24	16	25
	Gov. think*Motiv	$\sum n_{Ir4} * m_{Ir4}$	97	24	16	25
PBC_{Ir}	Water avail*easily access	$\sum c_{Ir1} * p_{Ir1}$	75	19	5	25
	Elect.avail*Afford	$\sum c_{Ir2} * p_{Ir2}$	90	22	15	25
	low cost*afford to install &operate	$\sum c_{Ir3} * p_{Ir3}$	43	11	2	20
	High maint*cannot afford	$\sum c_{Ir4} * p_{Ir4}$	40	10	3	20

The percentage components' magnitude of TPB, average, min and max of multiple sub-element of non-cooperative Inorganic fertiliser

Elements	Sub-elements	Multiply sub elements	%	Average	Min	Max
A_F	Incr.Yield*Impor. Hh	$\sum b_{F1}*e_{F1}$	66	12	1	25
	Incr. Income*Impor. Hh	$\sum b_{F2}*e_{F2}$	68	13	4	25
	Red. Water*Imp. Farm &Hh	$\sum b_{F3}*e_{F3}$	41	7	2	25
	Pres. Soil*Impor. Farm &Hh	$b_{F4}*e_{F4}$	44	8	2	25
SN_F	Family think*Motiv	$\sum n_{F1}*m_{F1}$	39	7	1	25
	Neighbours think*Motiv	$\sum n_{F2}*m_{F2}$	43	8	1	25
	Agri. service think*Motiv	$\sum n_{F3}*m_{F3}$	51	9	1	25
	Gov. think*Motiv	$\sum n_{F4}*m_{F4}$	48	9	1	25
PBC_F	Avai in market*How to use	$\sum c_{F1}*p_{F1}$	63	12	1	25
	Market very close*easily obtained	$\sum c_{F2}*p_{F2}$	57	11	1	25
	low cost*afford to buy suffi	$\sum c_{F3}*p_{F3}$	33	6	1	25
	Water centrality*access water	$\sum c_{F4}*p_{F4}$	64	12	3	25

The percentage components' magnitude of TPB, average, min and max of multiple sub-element of non-coop Modern irrigation

A_{ir}	Incr.Yield*Impor. Hh	$\sum b_{Ir1}*e_{Ir1}$	78	14	4	25
	Incr. Income*Impor. Hh	$\sum b_{Ir2}*e_{Ir2}$	84	15	4	25
	Red water*Import. Farm &Hh	$\sum b_{Ir3}*e_{Ir3}$	89	16	10	25
	Red water salinity*Import farm	$\sum b_{Ir4}*e_{Ir4}$	83	15	4	25
	Red soil erosion*Import farm	$\sum b_{Ir5}*e_{Ir5}$	83	15	5	25
	Red labour*Import farm	$\sum b_{Ir6}*e_{Ir6}$	84	15	10	25
SN_{Ir}	Family think*Motiv	$\sum n_{Ir1}*m_{Ir1}$	76	14	1	25
	Neighbours think*Motiv	$\sum n_{Ir2}*m_{Ir2}$	72	13	1	25
	Agri. service think*Motiv	$\sum n_{Ir3}*m_{Ir3}$	81	15	4	25
	Gov. think*Motiv	$\sum n_{Ir4}*m_{Ir4}$	78	14	4	25
PBC_{Ir}	Water avail*easily access	$\sum c_{Ir1}*p_{Ir1}$	53	10	1	25
	Elect.avail*Afford	$\sum c_{Ir2}*p_{Ir2}$	59	11	1	25
	low cost*afford to install &operate	$\sum c_{Ir3}*p_{Ir3}$	31	6	2	25
	High maint*cannot afford	$\sum c_{Ir4}*p_{Ir4}$	41	8	1	25

Appendix 6. TPB Minimum, Average and Maximum values of beliefs

Figure A 6.1: Minimum, average and maximum intention scores for inorganic fertilisers, all farmers

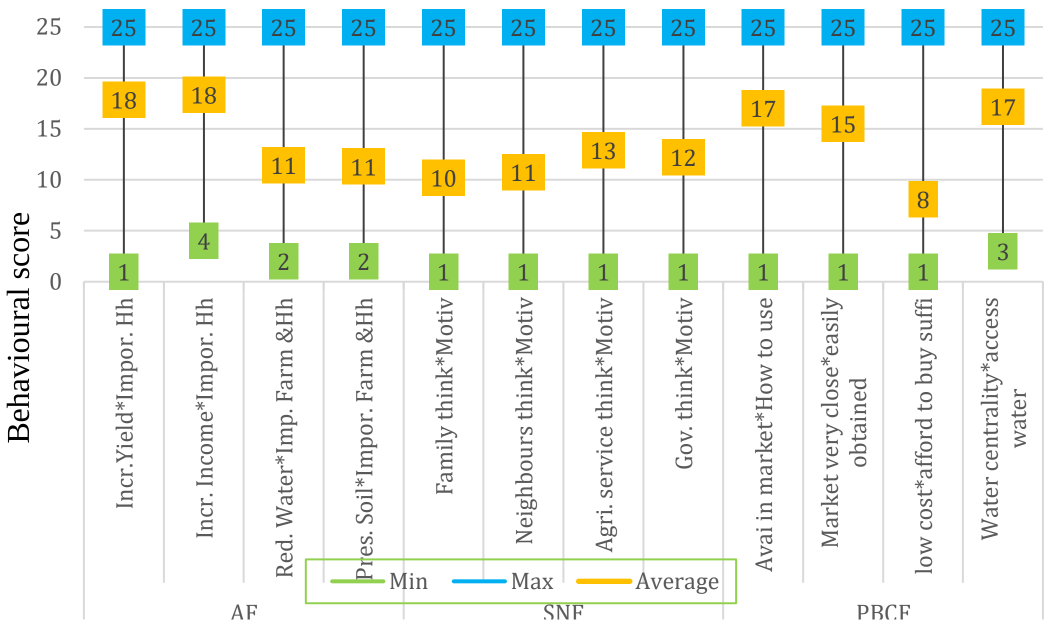


Figure A 6.1 shows the intention score for the all farmer group in relation to inorganic fertiliser, with a range in most factors from 1 to 25, showing the wide range within the individual elements. The average scores reflect the pattern demonstrated by the percentages in the previous sections, with more positive responses for the elements of attitude regarding yield and income, and for perceived behavioural control regarding availability and accessibility, with less positive responses in terms of attitude for environmental factors, the subjective norms, and the cost in perceived behavioural control.

Figure A 6.2: Minimum, average and maximum intention scores for inorganic fertilisers, cooperative farmers

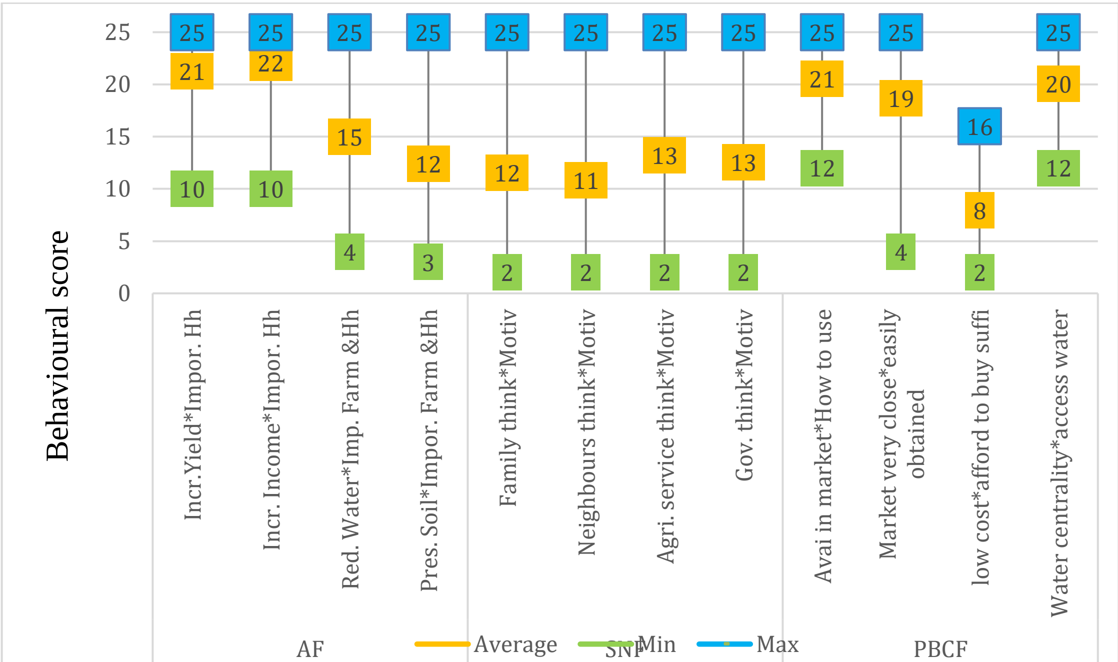


Figure A 6.2 shows the intention score for the cooperative farmer group. There is a similar pattern to the all farmer group, but the minimum values tend to be higher reflecting the percentage values shown in the previous sections regarding perceptions of yield and income benefits, and availability and accessibility in the market place. The low maximum value for cost is worth noting suggesting that this group perceive this could be an important barrier to the adoption of inorganic fertiliser.

Figure A 6.3: Minimum, average and maximum intention scores for inorganic fertilisers, non-cooperative farmers

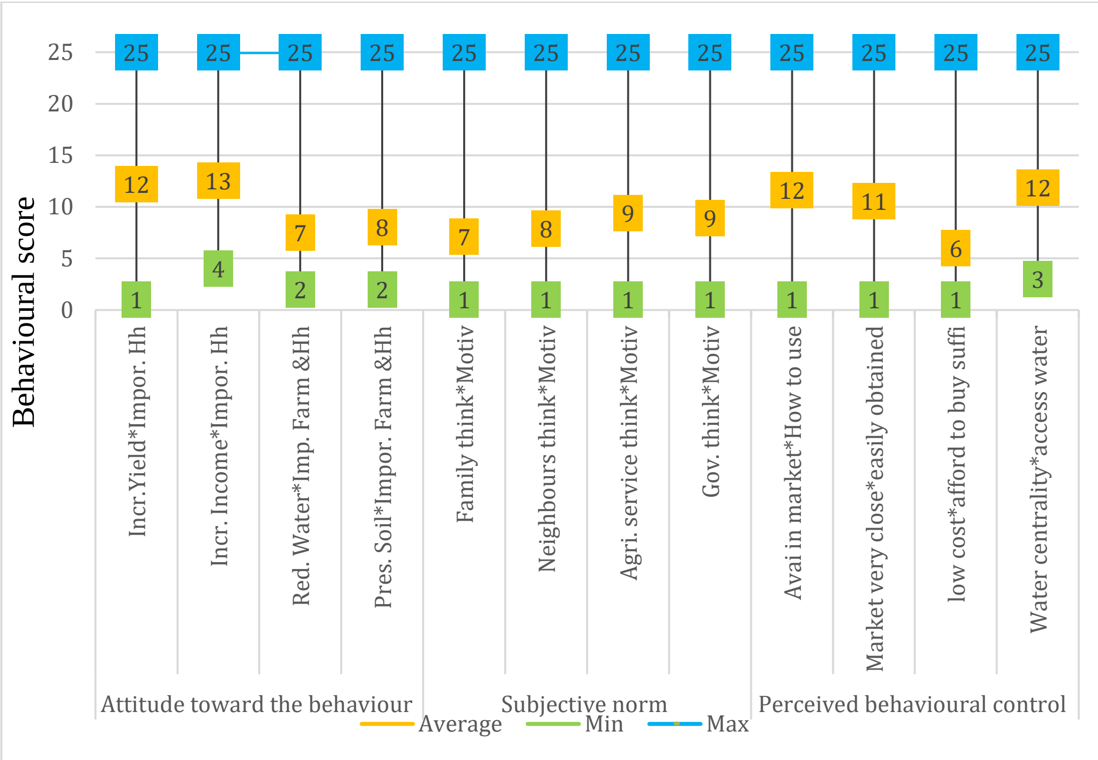


Figure A 6.3 shows the intention score for the non-cooperative farmer group. There is a similar pattern to the all farmer group, but the average values tend to be lower reflecting the percentage values shown in the previous sections regarding the attitude, subjective norm and perceived behavioural control elements.

Figure A 6.4: Minimum, average and maximum intention scores for modern irrigation, all farmers

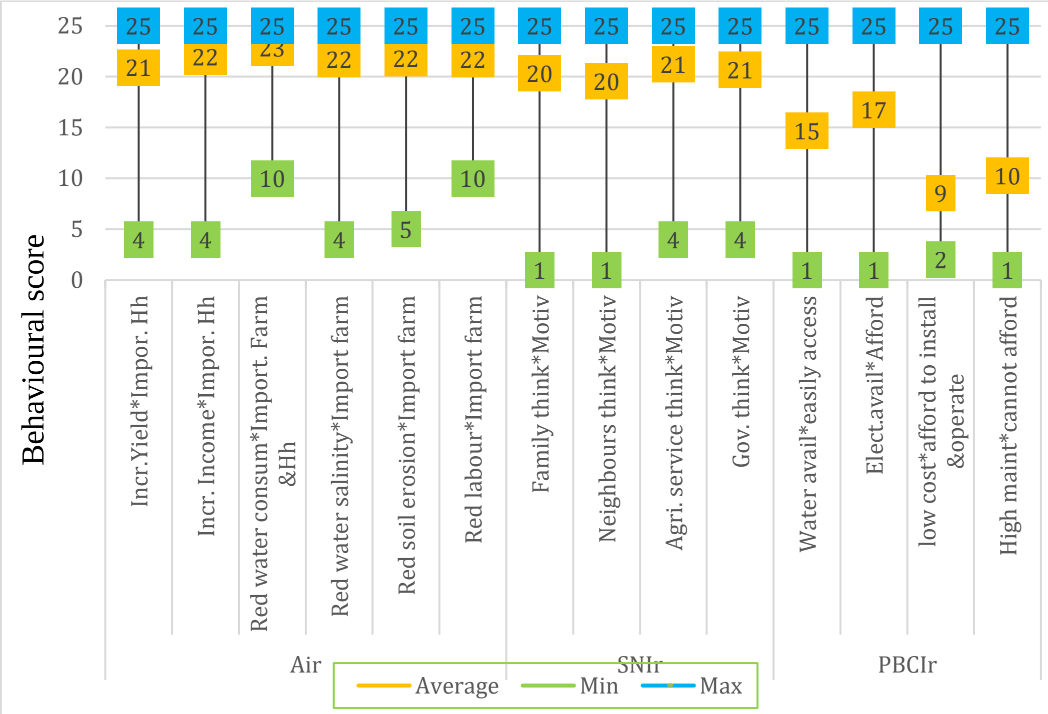


Figure A 6.4 shows the intention score with regard to modern irrigation for all farmers, and although wide ranging, with minimum values ranging from 1 to 10 for the different elements, the averages within both attitude and subjective norm are high indicating a willingness to adopt. The minimum values for attitude and subjective norm also tend to be higher when compared to those for inorganic fertiliser, again indicating a greater willingness to adopt. For the perceived behavioural control elements, the low averages for cost of installation and maintenance cost reflect the percentages in the previous section, indicating that this is where the barrier to adoption arises.

Figure A 6.5: Minimum, average and maximum intention scores for modern irrigation, cooperative farmers

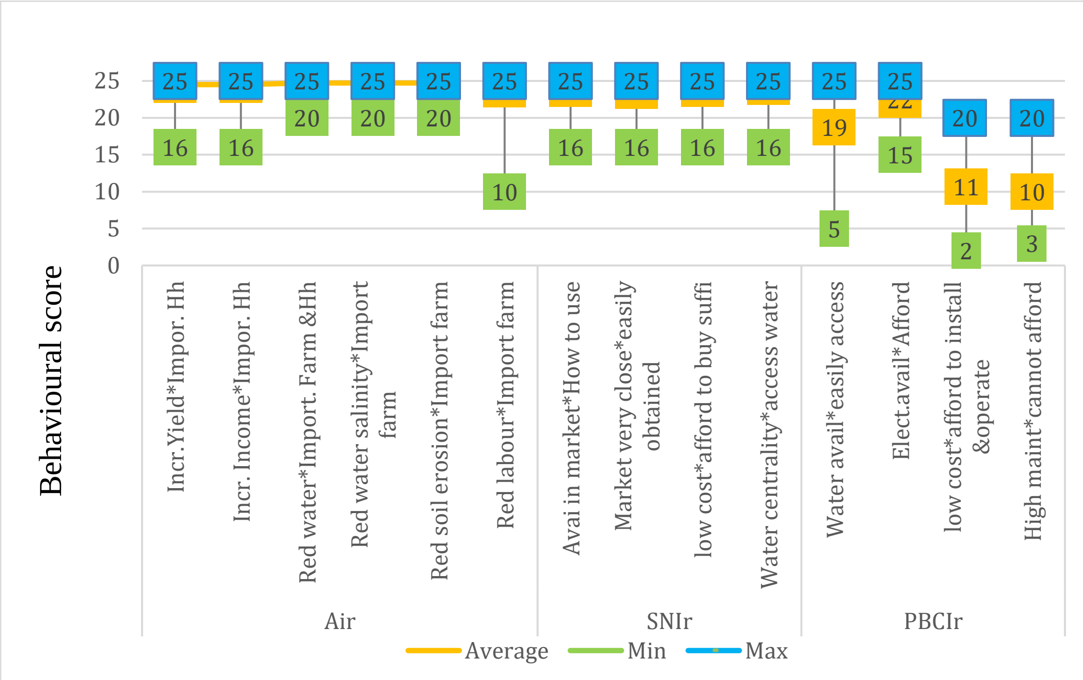


Figure A 5.5 shows the intention score for the cooperative farmer group. What is evident for this group is that the minimum values for the attitude and subjective norm elements are much higher than for the all farmer group, and the average values are very close to the maximum, both indicating a much greater intention to adopt. For the perceived behavioural control elements, it is worth noting that the minimum and average values for water availability and accessibility are slightly higher for this group, with the minimum value for electricity availability and affordability being much higher. It is also worth noting that although the minimum and average values for installation and maintenance cost are similar to the all farmer group, the maximum values are lower again suggesting that this group perceive this could be an important barrier in the intention to adopt.

Figure A6.6: Minimum, average and maximum intention scores for modern irrigation, non-cooperative farmers

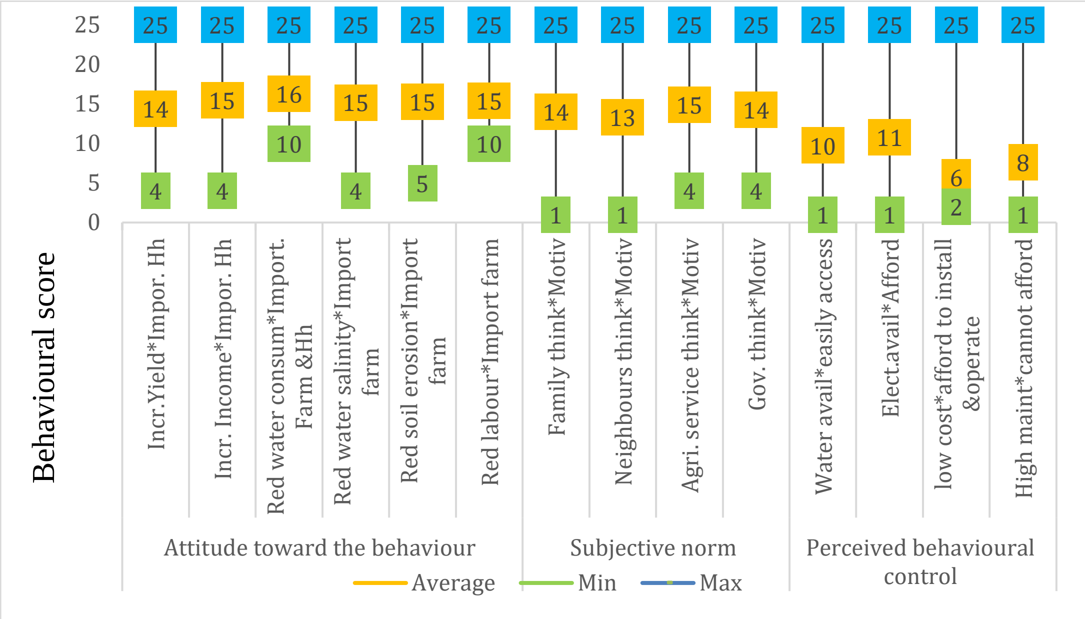


Figure A 6.6 shows the intention score for the non-cooperative farmer group regarding modern irrigation. There is a similar pattern to the all farmer group, but the average values tend to be lower reflecting the percentage values shown in the previous sections regarding the attitude, subjective norm and perceived behavioural control elements.

In looking at the minimum, average and maximum values, it is evident that the responses linked to the adoption of inorganic fertiliser are more wide ranging than those for modern irrigation, and that the averages also tend to be lower indicating less willingness in the intention to adopt the use of inorganic fertiliser when compared to irrigation. The values suggest that the different elements within all three areas – attitude, subjective norm and perceived behavioural control – may all have an influence in terms of inorganic fertiliser use. For modern irrigation, the range is still widespread but not to the same extent of inorganic fertiliser. It is in the values for the perceived behavioural control elements that suggest this is the area which is the greatest barrier to the intention to adopt modern irrigation. Comparing cooperative and non-cooperative farmers it is evident that in terms of the intentions regarding both inorganic fertiliser and modern irrigation there is greater willingness from the cooperative farmers, but for both fertiliser and irrigation the cooperative farmers have a lower maximum value for cost when compared to non-cooperative farmers which suggests that cost – the cost of fertiliser, and the cost of installation and maintenance of the irrigation system – may be a significant barrier to adoption for most farmers.

Appendix 7. Principal Component Analysis:

Principal Component Analysis: Inorganic Fertiliser

Mean and std. deviation

In Table A 7.1 the means and variance from the TPB exercise are reproduced. To find the directions that maximizes the variance of dataset, the table below shows the Min and Max values using standard deviation, as well as, mean of dataset. The lowest variation (close to 1) is to provide a solid platform of dataset, meaning that, the behavioural attitude towards inorganic fertilisers are convergent.

Min value

Min values to1

Table A 7.1. The mean vs. the std. deviation of inorganic fertiliser

Items	Mean	Std. Deviation	Analysis N
Using inorganic fertiliser increases yields	3.88	1.216	68
Using inorganic fertiliser increases my farm income	3.94	1.183	68
Using inorganic fertiliser reduces demand for water	2.44	1.226	68
Using inorganic fertiliser preserves soil structure	2.43	1.273	68
Increased yield is important for my Hh	4.47	.872	68
Increased farm income is important for my Hh	4.62	.647	68
Reduced water consumption is important for my farm and Hh	4.63	.644	68
Improved soil structure is important for my farm and Hh	4.63	.689	68

Max value

Max values to1

Correlation matrix

A correlation matrix (Table A 7.2) is presented to demonstrate the extent to which “attitudes” towards inorganic fertiliser in farming are correlated.

Table A 7.2. Correlation matrix for inorganic fertiliser

		F_b -Using inorganic fertiliser				F_{e-} ↑ yield	↑ Farm income	↓ Wtr consump	Impro soil structure
		↑ yield	↑ income	↓ Demand for water	Preserves soil structure	Import. For my Hh	Import. For my Hh	Import. For my Hh	Import. For my Hh
Correlation	F_b -Using inorganic fertiliser increases yields	1.000	.701	.175	.139	.475	.359	.287	.322
	F_{b-} Using inorganic fertiliser increases my farm income	.701	1.000	.172	.057	.317	.224	.147	.229
	F_b - Using inorganic fertiliser reduces demand for water	.175	.172	1.000	.298	.068	.084	.189	.195
	F_b - Using inorganic fertiliser preserves soil structure	.139	.057	.298	1.000	.032	.056	.103	.079
	F_e - Increased yields is important for my Hs	.475	.317	.068	.032	1.000	.853	.764	.764
	F_e - Increased farm income is important for my Hh	.359	.224	.084	.056	.853	1.000	.911	.885
	F_e - Reduced water consumption is important for my farm and Hh	.287	.147	.189	.103	.764	.911	1.000	.868
	F_e - Improved soil structure is important for my farm and Hs	.322	.229	.195	.079	.764	.885	.868	1.000
Sig. (1-tailed)	F_b -Using inorganic fertiliser increases yields		.000	.076	.129	.000	.001	.009	.004
	F_{b-} Using inorganic fertiliser increases my farm income	.000		.080	.324	.004	.033	.115	.030
	F_b - Using inorganic fertiliser reduces demand for water	.076	.080		.007	.290	.248	.061	.056
	F_b - Using inorganic fertiliser preserves soil structure	.129	.324	.007		.399	.325	.202	.260
	F_e - Increased yields is important for my Hh	.000	.004	.290	.399		.000	.000	.000
	F_e - Increased farm income is important for my Hh	.001	.033	.248	.325	.000		.000	.000
	F_e - Reduced water consumption is important for my farm and Hh	.009	.115	.061	.202	.000	.000		.000
	F_e - Improved soil structure is important for my farm and Hh	.004	.030	.056	.260	.000	.000	.000	

a. Determinant = .003

Low corr. variables

High corr variables

Low p_value

High p_value

Kaiser Meyer Olkin (KMO) and Bartlett's Test

Whilst the correlation matrix provides a simple correlation between various variables, KMO is used to measure the strength of relationship among the variables. It measures the adequacy of sampling which should be greater than 0.5 to analyse the factors favourable to continue.

The KMO statistic varies between 0 and 1. A value of 0 indicates that the sum of partial correlations is large relative to the sum of correlations, indicating diffusion in the pattern of correlations. A value close to 1 indicates that patterns of correlations are relatively compact and so factor analysis should yield distinct and reliable factors.

Bartlett's test measures the null hypothesis that the correlation matrix is an identity matrix (matrix in which all of the diagonal elements are 1) and all off diagonal elements (term explained above) are close to 0, if it is significant or not (to reject the null hypothesis).

Table A 7.3. KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.790
Bartlett's Test of Sphericity	Approx. Chi-Square	379.392
	df	28
	Sig.	.000

KMO of 0.79 indicates that the variables are sufficiently correlated

7.4 Communalities

This clarifies how much of the variance (value should be > 0.5) to be considered for further analysis. Table A 7.4 demonstrates the communalities of variables. 94.8% of the variance in “Using increased farm income is important for my household”, while 64% of the variance in “Using in-organic fertiliser reduces demand for water”.

Max

Min

Table A 7.4. The communalities of the inorganic fertiliser dataset

	Initial	Extraction
F_b -Using inorganic fertiliser increases yields	1.000	.845
F_b- Using inorganic fertiliser increases my farm income	1.000	.863
F_b - Using inorganic fertiliser reduces demand for water	1.000	.640
F_b - Using inorganic fertiliser preserves soil structure	1.000	.664
F_e - Increased yields is important for my household	1.000	.837
F_e - Increased farm income is important for my household	1.000	.948
F_e - Reduced water consumption is important for my farm and household	1.000	.913
F_e - Improved soil structure is important for my farm and household	1.000	.883
Extraction Method: Principal Component Analysis.		

Comm. indicate that over 60% of each variable’s variance is explained by the factors, which is a satisfactory result

Total variance explained

Table A 7.5 below illustrates components (factors), initial Eignvalues, Extraction sums of Squared Loadings and Rotation Sums of squared Loadings. In this table for analysis and interpretation purpose only concerned with Extracted Sums of Squared Loadings. The first factor accounts for 48.90% of the variance, the second factor accounts 18.60% and the third factor accounts 14.92%. All the remaining factors are not significant.

Table A 7.5. The Total Variance Expected of Inorganic Fertiliser

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings[a]
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total
1	3.912	48.895	48.895	3.912	48.895	48.895	3.744
2	1.488	18.602	67.497	1.488	18.602	67.497	2.137
3	1.193	14.915	82.412	1.193	14.915	82.412	1.413
4	.707	8.839	91.251				
5	.299	3.744	94.995				
6	.206	2.572	97.567				
7	.130	1.625	99.193				
8	.065	.807	100.000				

Extraction Method: Principal Component Analysis.

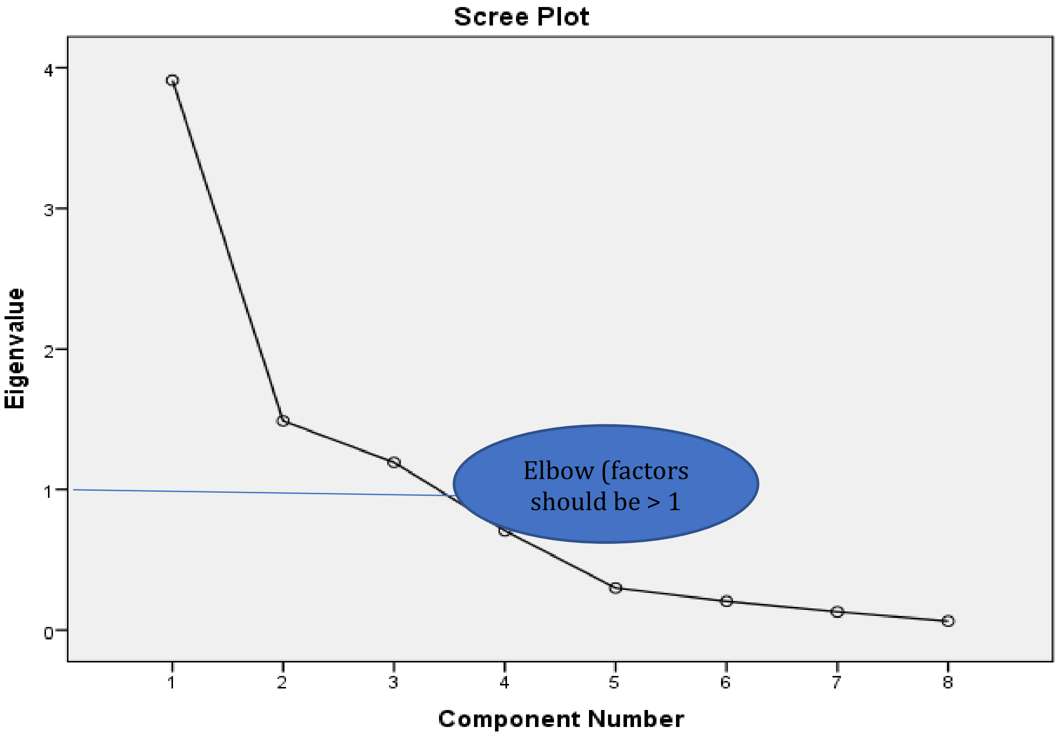
a. When components are correlated, sums of squared loadings cannot be added to obtain a total variance.

Overall, 3 factors are extracted explaining 82.412% of the total variables

Scree plot

The scree plot is a graph of the Eigenvalues against all the factors. The graph is useful for determining how many factors should be retained in an analysis (The point of interest is where the curve starts to flatten), which must be greater than 1. Figure 1 shows how many components should be retained in an analysis.

Figure A 7.1. Scree plot of in-organic fertiliser



Component matrix

The higher the absolute value of the loading, the more the factor contributes to the variable.

Table A 7.7 clarifies the values in each factor (see table)

Factor1: using In-org. Fert.

Table A 7.7: Component Matrix of inorganic fertiliser dataset.

Component Matrix[a]			
	Component		
	1	2	3
F_b -Using inorganic fertiliser increases yields	.934	-.276	
F_b- Using inorganic fertiliser increases my farm income	.906	-.230	
F_b - Using inorganic fertiliser reduces demand for water	.898	-.289	.155
F_b - Using inorganic fertiliser preserves soil structure	.897	-.133	-.125
F_e - Increased yields is important for my household	.442	.705	-.412
F_e - Increased farm income is important for my household	.578	.633	-.332
F_e - Reduced water consumption is important for my farm and household	.145	.398	.696
F_e - Improved soil structure is important for my farm and household	.243	.450	.616
Extraction Method: Principal Component Analysis.			
a. 3 components extracted.			

F_2:Satisfaction with increased Hh's income

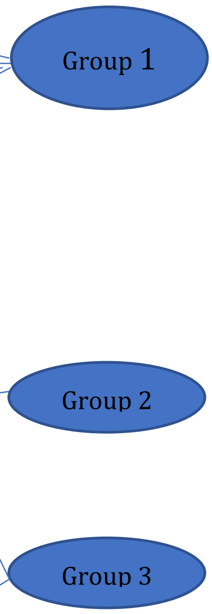
F_3:statisfaction with farm & Hh

Rotated component matrix

Rotation makes the interpretation of the analysis easier. Looking at the Table A 7.8 below, are first 4 variables are substantially loaded on factor 1, while varibles 5 and 6 are substantially loaded on factor 2. All the remaining variables (7 & 8) are substantially loaded in factor 3. These factors can be used as variables for further analysis. These factors explained relatively large amounts of variance (see table A 7.8)

Table A 7.8. Rotation Component Matrix of inorganic fertiliser dataset.

	Component		
	1	2	3
F_b -Using inorganic fertiliser increases yields	.973	.299	
$F_{b\text{-}}$ Using inorganic fertiliser increases my farm income	1.948	.208	.184
F_b - Using inorganic fertiliser reduces demand for water	.938	.278	.170
F_b - Using inorganic fertiliser preserves soil structure	.894	.440	
F_e - Increased yields is important for my household	.226	.926	.123
F_e - Increased farm income is important for my household	.379	.913	.182
F_e - Reduced water consumption is important for my farm and household			.813
F_e - Improved soil structure is important for my farm and household	.147	.193	.796



Extraction Method: Principal Component Analysis.
Rotation Method: Oblimin with Kaiser Normalization.

Component Correlation Matrix

Table A 7.9 demonstrates if any correlate between factors. It is clear there is no correlation between factors.

Table A 7.9 Component Correlation Matrix

Component	1	2	3
1	1.000	.313	.126
2	.313	1.000	.141
3	.126	.141	1.000

Not sig.
P_value > 0.05

Principal Component Analysis: Inorganic Fertiliser

Component Correlation Matrix

To find the directions that maximizes the variance of dataset. Table A 7.10 below shows the Min and Max values using standard deviation, as well as, mean of dataset. The lowest variation (close to 1) is to provide a solid platform of dataset. Meaning that, the behavioural attitude towards modern irrigation system convergent.

Table A 7.10 The mean vs. the std. deviation of modern irrigation system

Min values to1

Descriptive Statistics

Min values

		Std. Deviation	N
Using modern irrigation increases yields	4.35	1.076	68
Using modern irrigation increases my farm income	4.57	.852	68
Using modern irrigation reduces water consumption	4.79	.442	68
Using modern irrigation reduces water salinity	4.51	.938	68
Using modern irrigation reduces soil erosion	4.53	.872	68
Using modern irrigation reduces labour requirement	4.63	.644	68
Increased yields is important for my household	4.75	.469	68
Increased farm income is important for my household	4.75	.469	68
Reduced water consumption is important for my farm and household	4.75	.557	68
Reduced water salinity is important for my farm	4.78	.418	68
Reduced soil erosion is important for my farm	4.76	.461	68
Reduced labour requirement is important for my farm	4.66	.614	68

Max values

Max values to1

This table shows that a bare minimum of the mean value is between 4.35 and 4.51 from 5. While Max value is 4.79. This result is farmers' consensus and an indication of their perception and grasp in the importance of the modern irrigation system adoption.

Standard deviation indicates that the data points are spread out over a narrow range of values.

Correlations

Table A 7.11 below illustrates the correlation of attitude towards farmers' behaviour using modern irrigation system in agriculture, to figure out any correlation between each variable. It is clear that there is a strong correlation between variables, and this indicator means the modern irrigation is a significant in farming in increasing yield and income, reducing water consumption, soil salinity and erosion as well as reducing labour requirement. All of these factors have a role in maintaining the farm components, and therefore the task of farm and household to increase the yield and income.

Table A 7.11 The mean vs. the std. deviation of modern irrigation system

Correlations

		b_{Ir1}	e_{Ir1}	b_{Ir2}	e_{Ir2}	b_{Ir3}	e_{Ir3}	b_{Ir4}	e_{Ir4}	b_{Ir5}	e_{Ir5}	b_{Ir6}	e_{Ir6}
Using modern irrigation increases yields	Pearson Correlation	1	.786**	.531**	.586**	.593**	.492**	.473**	.532**	.349**	.574**	.561**	.410**
	Sig. (2-tailed)		.000	.000	.000	.000	.000	.000	.000	.004	.000	.000	.001
Using modern irrigation increases my farm income	Pearson Correlation	.786**	1	.635**	.615**	.690**	.526**	.625**	.588**	.370**	.612**	.615**	.405**
	Sig. (2-tailed)	.000		.000	.000	.000	.000	.000	.000	.002	.000	.000	.001
Using modern irrigation reduces water consumption	Pearson Correlation	.531**	.635**	1	.511**	.558**	.568**	.539**	.611**	.394**	.639**	.637**	.399**
	Sig. (2-tailed)	.000	.000		.000	.000	.000	.000	.000	.001	.000	.000	.001
Using modern irrigation reduces water salinity	Pearson Correlation	.586**	.615**	.511**	1	.684**	.392**	.432**	.466**	.336**	.408**	.457**	.307*
	Sig. (2-tailed)	.000	.000	.000		.000	.001	.000	.000	.005	.001	.000	.011
Using modern irrigation reduces soil erosion	Pearson Correlation	.593**	.690**	.558**	.684**	1	.484**	.474**	.438**	.431**	.448**	.574**	.451**
	Sig. (2-tailed)	.000	.000	.000	.000		.000	.000	.000	.000	.000	.000	.000
Using modern irrigation reduces labour requirement	Pearson Correlation	.492**	.526**	.568**	.392**	.484**	1	.481**	.531**	.364**	.582**	.509**	.323**
	Sig. (2-tailed)	.000	.000	.000	.001	.000		.000	.000	.002	.000	.000	.007
Increased yields is important for my household	Pearson Correlation	.473**	.625**	.539**	.432**	.474**	.481**	1	.864**	.614**	.781**	.828**	.531**
	Sig. (2-tailed)	.000	.000	.000	.000	.000	.000		.000	.000	.000	.000	.000
Increased farm income is important for my household	Pearson Correlation	.532**	.588**	.611**	.466**	.438**	.531**	.864**	1	.557**	.781**	.828**	.635**
	Sig. (2-tailed)	.000	.000	.000	.000	.000	.000	.000		.000	.000	.000	.000
Reduced water consumption is important for my farm and household	Pearson Correlation	.349**	.370**	.394**	.336**	.431**	.364**	.614**	.557**	1	.594**	.640**	.754**
	Sig. (2-tailed)	.004	.002	.001	.005	.000	.002	.000	.000		.000	.000	.000
Reduced water salinity is important for my farm	Pearson Correlation	.574**	.612**	.639**	.408**	.448**	.582**	.781**	.781**	.594**	1	.734**	.520**
	Sig. (2-tailed)	.000	.000	.000	.001	.000	.000	.000	.000	.000		.000	.000
Reduced soil erosion is important for my farm	Pearson Correlation	.561**	.615**	.637**	.457**	.574**	.509**	.828**	.828**	.640**	.734**	1	.612**
	Sig. (2-tailed)	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000		.000
Reduced labour requirement is important for my farm	Pearson Correlation	.410**	.405**	.399**	.307*	.451**	.323**	.531**	.635**	.754**	.520**	.612**	1

Correlation matrix

Table A 7.12 below clarifies the correlation coefficients of attitude towards behaviour of farmers using modern irrigation system in farming between a single variable and every other variable in the observation. The correlation coefficient between a variable and itself is always 1.

This table demonstrates that using modern irrigation in yield is directly proportional to income. In addition, they have a role in reducing soil erosion, a task of the farm, and the reduction of the household's expenses as well as supplement their income. On the another hand, reducing water consumption does not have a big role and impact on household of reducing the salinity of soils and labour requirement.

High corr variables

Low corr variables

Table A 7.12. Correlation matrix

Correlation Matrix

		Using modern irrigation						↑ yields	↑ income	↓ water consumption	↓ water salinity	↓ soil erosion	↓ labour requirement
		↑ yields	↑ income	↓ water consumption	↓ water salinity	↓ soil erosion	↓ labour requirement	Important for my household		Important for my farm and household	important for my farm		
Correlation	b (Using modern irrigation ↑ yields)	1.000	.786	.531	.586	.593	.492	.473	.532	.349	.574	.561	.410
	b (Using modern irrigation ↑ my farm income)	.786	1.000	.635	.615	.690	.526	.625	.588	.370	.612	.615	.405
	b (Using modern irrigation ↓ water consumption)	.531	.635	1.000	.511	.558	.568	.539	.611	.394	.639	.637	.399
	b (Using modern irrigation ↓ water salinity)	.586	.615	.511	1.000	.684	.392	.432	.466	.336	.408	.457	.307
	b (Using modern irrigation ↓ soil erosion)	.593	.690	.558	.684	1.000	.484	.474	.438	.431	.448	.574	.451
	b (Using modern irrigation ↓ labour requirement)	.492	.526	.568	.392	.484	1.000	.481	.531	.364	.582	.509	.323
	e (↑ yields is important for my household)	.473	.625	.539	.432	.474	.481	1.000	.864	.614	.781	.828	.531
	e (↑ farm income is important for my household)	.532	.588	.611	.466	.438	.531	.864	1.000	.557	.781	.828	.635
	e (↓ water consumption is important for my farm and household)	.349	.370	.394	.336	.431	.364	.614	.557	1.000	.594	.640	.754
	e (↓ water salinity is important for my farm)	.574	.612	.639	.408	.448	.582	.781	.781	.594	1.000	.734	.520
	e (↓ soil erosion is important for my farm)	.561	.615	.637	.457	.574	.509	.828	.828	.640	.734	1.000	.612
	e (↓ labour requirement is important for my farm)	.410	.405	.399	.307	.451	.323	.531	.635	.754	.520	.612	1.000

Sig. (1-tailed)	b (Using modern irrigation ↑ yields)		.000	.000	.000	.000	.000	.000	.000	.002	.000	.000	.000
	b (Using modern irrigation ↑ my farm income)	.000		.000	.000	.000	.000	.000	.000	.001	.000	.000	.000
	b (Using modern irrigation ↓ water consumption)	.000	.000		.000	.000	.000	.000	.000	.000	.000	.000	.000
	b (Using modern irrigation ↓ water salinity)	.000	.000	.000		.000	.000	.000	.000	.003	.000	.000	.005
	b (Using modern irrigation ↓ soil erosion)	.000	.000	.000	.000		.000	.000	.000	.000	.000	.000	.000
	b (Using modern irrigation ↓ labour requirement)	.000	.000	.000	.000	.000		.000	.000	.001	.000	.000	.004
	e (↑ yields is important for my household)	.000	.000	.000	.000	.000	.000		.000	.000	.000	.000	.000
	e (↑ farm income is important for my household)	.000	.000	.000	.000	.000	.000	.000		.000	.000	.000	.000
	e (↓ water consumption is important for my farm and household)	.002	.001	.000	.003	.000	.001	.000	.000		.000	.000	.000
	e (↓ water salinity is important for my farm)	.000	.000	.000	.000	.000	.000	.000	.000	.000		.000	.000
	e (↓ soil erosion is important for my farm)	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000		.000
	e (↓ labour requirement is important for my farm)	.000	.000	.000	.005	.000	.004	.000	.000	.000	.000	.000	

Kaiser Meyer Olkin (KMO) and Bartlett's Test

KMO measures the strength of relationship among the variables. It measures the adequacy of sampling which should be greater than 0.5 to analyse the factors favourable to continue.

The KMO statistic varies between 0 and 1. A value of 0 indicates that the sum of partial correlations is large relative to the sum of correlations, indicating diffusion in the pattern of correlations. A value close to 1 indicates that patterns of correlations are relatively compact and so factor analysis should yield distinct and reliable factors. Bartlett's test measures the null hypothesis that the correlation matrix is an identity matrix (matrix in which all of the diagonal elements are 1) and all off diagonal elements (term explained above) are close to 0, if it is significant or not (to reject the null hypothesis).

Table A 7.13 below clarifies KMO statistics and Bartlett's Test. This table indicates that .848 of variance in the variables are sufficiently correlated.

Table A4.16. KMO and Bartlett's Test

Sig. < 0.05

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.848
Bartlett's Test of Sphericity	Approx. Chi-Square	650.658
	df	66
	Sig.	0.000

Bartlett's test indicates that factor analysis less than .05

KMO of 0.848 indicates that the variables are sufficiently correlated

Communalities

This clarifies how much of the variance (value should be > 0.5) to be considered for further analysis. Table A 7.13 of communalities below indicate that over 61 % of each variable's variance is explained by the factors. 81.6 % of the variance in reducing soil erosion is important for my farm, while 61.6 % of the variance in using modern irrigation reduced the consumption of water.

Table A 7.13 The communalities of modern irrigation dataset

Min value

Max value

Communalities

	Initial	Extraction
Using modern irrigation increases yields	1.00	0.701
Using modern irrigation increases my farm income	1.00	0.799
Using modern irrigation reduces water consumption	1.00	0.616
Using modern irrigation reduces water salinity	1.00	0.660
Using modern irrigation reduces soil erosion	1.00	0.684
Using modern irrigation reduces labour requirement	1.00	0.479
Increased yields is important for my household	1.00	0.787
Increased farm income is important for my household	1.00	0.812
Reduced water consumption is important for my farm and household	1.00	0.702
Reduced water salinity is important for my farm	1.00	0.744
Reduced soil erosion is important for my farm	1.00	0.816
Reduced labour requirement is important for my farm	1.00	0.654

Total variance explained

Table A 7.14 below illustrates components (factors), initial Eigenvalues, Extraction sums of Squared Loadings and Rotation Sums of squared Loadings. In this table for analysis and interpretation purpose only concerned with Extracted Sums of Squared Loadings. The first factor accounts for 59.228 % of the variance, the second factor accounts 11.227 %. All the remaining factors are not significant. These two factors indicate that the underlying effects are related with the use of modern irrigation system, but there is still scope for many of unexplained variation.

Table A 7.14 The total variance explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings[a]
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total
1	7.107	59.228	59.228	7.107	59.228	59.228	7.107
2	1.347	11.227	70.455	1.347	11.227	70.455	1.347
3	.833	6.941	77.396				
4	.586	4.885	82.281				
5	.492	4.102	86.383				
6	.407	3.392	89.776				
7	.340	2.834	92.609				
8	.304	2.530	95.140				
9	.215	1.790	96.930				
10	.198	1.652	98.582				
11	.103	.860	99.442				
12	.067	.558	100.000				

Overall, 2 factors are extracted explaining 70.455 % of the total variables

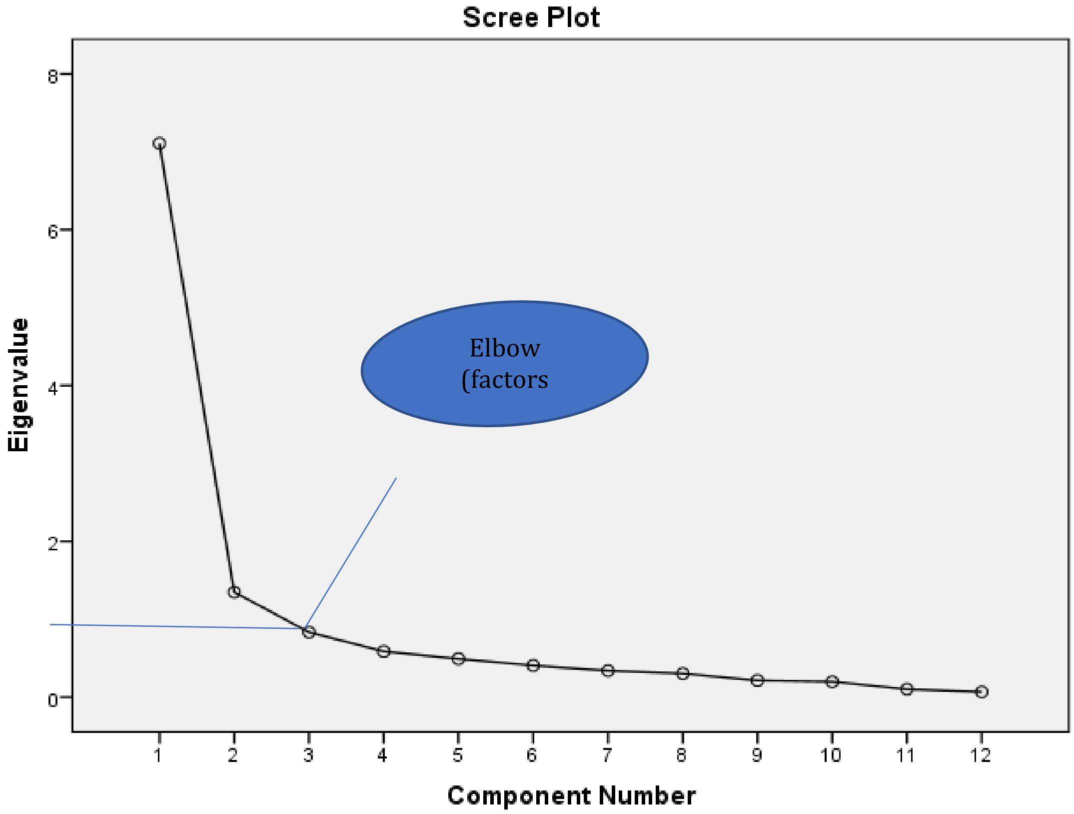
Extraction Method: Principal Component Analysis.

When components are correlated, sums of squared loadings cannot be added to obtain a total variance.

Scree plot

The scree plot is a graph of the Eigenvalues against all the factors. The graph is useful for determining how many factors should be retained in an analysis (The point of interest is where the curve starts to flatten), which must be greater than 1. Figure A 7.2 shows how many components should be retained in an analysis.

Figure A 7.2. Scree plot of modern irrigation system



Component matrix

The higher the absolute value of the loading, the more the factor contributes to the variable. Table A 7.15 clarifies the values in each factor.

Factor1:is related with using of modern irrigation and the important with some variables (descending order)

Table A 7.15. Component Matrix.

Component Matrix

	Component	
	1	2
Using modern irrigation increases yields	0.878	
Using modern irrigation increases my farm income	0.861	
Using modern irrigation reduces water consumption	0.843	
Using modern irrigation reduces water salinity	0.842	
Using modern irrigation reduces soil erosion	0.812	
Using modern irrigation reduces labour requirement	0.764	
Increased yields is important for my household	0.746	
Increased farm income is important for my household	0.732	
Reduced water consumption is important for my farm and household	0.691	
Reduced water salinity is important for my farm	0.685	
Reduced soil erosion is important for my farm	0.674	
Reduced labour requirement is important for my farm	0.662	

Factor 2: all variables are < .5

Rotated component matrix

Rotation makes the interpretation of the analysis easier. Looking at the table 8 below, are first 6 variables are substantially loaded on factor 1, while variables 7 to 12 are substantially loaded on factor 2. These factors can be used as variables for further analysis, and explained relatively large amounts of variance (Table A 7.16).

The first group interprets the farmer's belief about the significant or the beneficial of use of modern irrigation system has a role in increasing the productivity of farm and household's income. Reducing each of water consumption, salinity and soil erosion, as well as, the requirement of labour in farming. The second factor illustrates outcome how important of these variables to farm and household to increase the productivity and income. Moreover, maintain the main resources such as water, salinization and soil erosion.

Table A 7.16. Rotated factor Matrix

Rotated component matrix

	Component	
	1	2
Using modern irrigation increases yields	.826	
Using modern irrigation increases my farm income	.802	
Using modern irrigation reduces water consumption	.797	
Using modern irrigation reduces water salinity	.791	
Using modern irrigation reduces soil erosion	.779	
Using modern irrigation reduces labour requirement	.733	
Increased yields is important for my household		.834
Increased farm income is important for my household		.799
Reduced water consumption is important for my farm and household		.793
Reduced water salinity is important for my farm		.786
Reduced soil erosion is important for my farm		.661
Reduced labour requirement is important for my farm		.584

Component Correlation Matrix

Table A 7.17 below demonstrates if any correlate between factors. This table shows clear that there is no correlation between factors.

Not sig.
P_value > 0.05

Table A 7.17. Component Correlation Matrix

Component Correlation Matrix

Component	1	2
1	.717	.697
2	-.697	.717

Component plot in Rotated space

Figure A 7.3 clarifies the distribution of two groups of component in component plot in rotated space.

Figure A 7.3. Component plot in rotated space