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## Factors Affecting Agricultural Sustainability—A Case Study of Hail Region, Kingdom of Saudi Arabia

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### Abstract

Availability of data on agricultural activities and production are essential for an appropriate socio-economic planning and sustainability. This study was conducted using a questionnaire that was randomly distributed to farmers to identify some features of the agricultural activities in Hail region and to serve as baseline data on agricultural practices. The questionnaire was divided into main topics including socio-economic status of farms, farm area, main crops, production systems, agricultural practices, financial support, and use of wind breaks, water conservation, animal husbandry and marketing. Some of the results showed that date palms and alfalfa fodder were found to be the main grown crops in addition to citrus, grapes, vegetables, wheat and Rye. In most cases, all these crops were cultivated in open fields, compared to only 18% grown in green houses. About half of the farmers adopted the monoculture system and only 44.9% of them applied the crop rotation. More than 70% of farmers raise animals and the most commonly reared animal are sheep (53.6%) followed by goats (23%), camels (18%) and poultry (4.5%). The study revealed that Hail region is an important agricultural area in KSA and some agricultural practices need to be revised and directed towards sustainability through extension programmes.

**Keywords:** Agriculture, sustainability, crop rotation, multiple cropping, animal productions, Hail region, Kingdom of Saudi Arabia

### Introduction

The depletion of natural resources has become a major issue in many parts around the world, particularly the parts which are known as drylands. Drylands, including hyper-arid, arid, and semi-arid and dry lands, can be defined as a land with low amounts of water in soil (Walton,

1969; Laity, 2008). More than 40% of the global terrestrial area is drylands with 2 billion people use it for grazing and cropping (Stroosnijder *et al.*, 2012). Ecosystem services in drylands including the production of crops, forage and wood, however, are limited by water supply. As a result, crop production in drylands seems to be low resulting in the reduction of the food security, although it depends on other factors such as socio-economics and political factors (Stroosnijder *et al.*, 2012).

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The Kingdom of Saudi Arabia (KSA) lies within the arid zone, with the desert covering an area of about 2250,000 sq. km (Allaby, 2008; Laity, 2008). The hot, harsh weather and limited water supply of KSA, resulted in the climate not being suitable for agriculture leading to 2% only of the land is being cultivated (Al-Zahrani, 2009).

However, in the 80's, the Saudi government has started to upgrade the country's agricultural sector to a development priority in order to reduce dependency on imported food, as well as a means of diversifying the economy income in addition to its strong reliance on the oil and gas sector (Al-Subaiee *et al.*, 2005).

The Kingdom of Saudi Arabia has experienced rapid and successful agricultural development since the mid-1980s (Al-Zahrani, 2009). As a result of this development, Saudi Arabia has succeeded in achieving self-sufficiency in some crops and animal commodities, such as wheat, eggs, dates, milk, and some fruits and vegetables (Al-Subaiee *et al.*, 2005).

Wheat, for instance, was extensively cultivated in KSA in order to guarantee self-sufficient levels of food production, and was exported to many countries, including China in 1984 (Al-Zahrani, 2009).

However, shortage of water, lack of experienced technical personnel, soil and water salinity, and the rising cost of desalination, marketing problems, and low prices for products; pests and diseases are constraints facing the agriculture sector in KSA (Al-Zeir, 2009).

This, in turn, led the Saudi government to review all agricultural policies and apply the sustainable agriculture programmes for conserving the natural resources (Al-Subaiee *et al.*, 2005).

In this case, Saudi government has established a new plan on the cultivation of crops that require high water consumption resources (Al-Subaiee *et al.*, 2005). The new policy, for example, has been made for discouraging farmers to grow less wheat and to promote the idea of diversification of crops in order to protect water resources and accomplish their sustainability resources (Al-Zahrani, 2009).

In addition, extension agents have been trained and introduced in KSA, who had a positive effect toward sustainable agriculture, and farming practices and concepts (Al-Subaiee *et al.*, 2005).

In general trend, sustainable agriculture indicates an agricultural system adopted in a particular area in which crop and animal production do not decline over time and are reasonably stable over normal fluctuations of weather (Edeoghon *et al.*, 2008). Sustainable agriculture also refers to the agricultural practices that guarantee human needs for food and fibers, and at the same time protect natural resources and the quality of the environment (Edeoghon *et al.*, 2008).

Some of these agricultural practices can be summarized as: multiple cropping, cover cropping, crop rotation, integrated pest management, alley cropping, organic manure application, improved plants varieties, green manure, minimum tillage system and mulching (Edeoghon *et al.*, 2008).

Availability of reliable data on agricultural activities and practices is of paramount importance for development planning and a sustainable agriculture in KSA. This paper provides the detailed account on the practises and activities associated with the agricultural sector in Hail region of KSA.

The purpose of this paper is to set baseline data about agricultural farms including area, main crops, production systems, cultural practices, financial support, wind breaks use, animal rising, and agricultural residues disposal. In addition to that, this paper aims to investigate the agricultural practices practiced by farmers in the region and to determine the main problems facing them.

## Methodology

The study was conducted in Hail region, which is located in the north-western of the Kingdom of Saudi Arabia (27° 31' 0" N, 41° 41' 0" E) (Figure 1). Hail region is considered as an agricultural and pastoral area characterized by rich water resources and fertile soil, even though

the climate in this region is an arid and extra arid (Al-Turki and Al-Olayan, 2003).



**Figure1: Location of the study area**

This has resulted in agricultural development based on agricultural products such as grains, dates, vegetables, forage crops, and fruit production.

In the recent history, large percentage of the KSA's wheat production came from Hail Province, as the area to the North East of Hail, 60 km to 100 km away, predominantly consists of irrigated gardens (Al-Zahrani, 2009).

Nowadays, different crops and fruit trees are cultivated in Hail, including barley, corn, vine trees, date palms, citrus, and other economical crops.

Hail region is divided into three provinces. The structured questionnaire was distributed to 210 randomly-selected farms, 70 from each of the three provinces, in the spring of 2012. However, 207 copies were filled correctly and thus were the ones used in the analysis.

The questionnaire was divided into main topics including the socio-economic status of farms, general information about the farms (area, main crops, production systems, cultural practices, financial support, and use of wind breaks, water

conservation, animal rising, and agricultural residues disposal). The data were then analyzed using the statistical package SPSS® 14.0 for Windows. Results were presented in tables and graphs.

**Results and discussion**

**Socio-economic characteristics of farmers**

The results showed that all farm managers are males (Table 1). This finding is mainly attributed to the structure of the Saudi society, in which women in rural areas are responsible only for household duties, and are not involved in practicing agricultural operations with men, although sometimes Saudi women were involved in rearing of small numbers of animal in their homes, particularly goats, sheep and poultry (Al-Mana, 1982; Al-Saad, 1982; Al-Dehailan, 2007).

The results showed that only 12.1% of farm managers are not Saudi (Table 1). This could be due to the appreciation of Saudis to the value of agriculture and agriculture-related practices, oath socially and economically (Wu and Sardo, 2010).

**Table 1: Some socio-economic parameters of the surveyed farmers**

Parameter		No. of farmers	%
Sex	Male	207	100
	Female	0	0
Nationality	Saudi	199	96.1
	Foreigner	8	3.9
Age (years)	20-30	23	11.1
	31-40	66	31.9
	41-50	65	31.4
	>50	53	25.6
	Marital Status	Married	182
	Single	25	12.1
Education Level	Illiterate	34	16.3
	primary	37	17.9
	Elementary	24	11.6
	Secondary	56	27.1
	University	56	27.1
Experience (years)	0-10	77	37.2
	11-20	71	34.3
	21-30	38	18.4
	31-40	14	6.8
	41-50	7	3.3

The majority of farmers (74.1%) were within the active productive age (20-50 years) (Table 1). This makes the farmers more able to accommodate and adopt new approaches in agriculture. In terms of their educational level, only 16.5% of the farmers were illiterate and only 18.1% of them have had primary education (Table 1). The majority of the farmers (65.4%) have had elementary, secondary or university education.

Thus, more educated farmers are expected to understand and adopt new agricultural techniques and successfully adopt innovations and programmes better than illiterate or less educated farmers (Weir, 1999; Khisa and Heinemann, 2004; Asadulla and Rahman, 2005; Oladeebo and Masuku, 2013).

Moreover, the managerial abilities of farmers are greatly influenced by their level of education, age, experience, number of contact with extension agents, in addition to their personal traits and ability (Kalaitzandonakes and Dunn, 1995).

Eighty-eight point three per cent of the farmers in this study are married (Table 1). This is expected to make these farmers more “stable” in their personal lives, which could make the farmer more dedicated to his farm, which is the main source of income for him and his family.

More than half of the farmers (62.4%) have long experience in agriculture (more than 10 years of experience), with the majority (87.9%) of farm workers being non-Saudi (Table 1). Of the non-Saudi workers, the Indians were dominant, as in 67 farms, all the workers were Indians.

While in another 58 farms, workers were Indians mixed with other nationalities that included Egyptians, Bangladeshi, Sudanese and Pakistani. There were workers from other countries such as Ethiopia, Nepal and Yemen, but in very few numbers. The lack of Saudi workers could be attributed to the lack of incentives to work as farmers, and thus we recommend the introduction of particular incentives to encourage Saudis to work in the farms.

#### **Farm areas**

Farm areas ranged between 0.5 – 600 hectares with 54.95% of the farms having an average area of less than 20 hectares.

#### **Main crops**

Date palms and alfalfa are the main crops grown in the study area in the two forms, pure stands or in combination with other crops (multi-cropping) (Figure 2). As pure stands, dates and alfalfa represented 48.3% and 20.7%, and in multi-crops 26.4% and 21.8%, respectively (Figure 2).

Fruits such as citrus and grapes occupied minor importance as pure stands (1.7% and 3.4%, respectively) in those farms (Figure 2).

However, in multi-cropping systems, the frequency increased to approximately 10% for

both fruits (Figure 2). Farmers also grew vegetables, wheat and Rye.

The selection of cultivated crops seems to be according to the farmer's choice and is governed by experience, the market's demand and the available facilities for production.

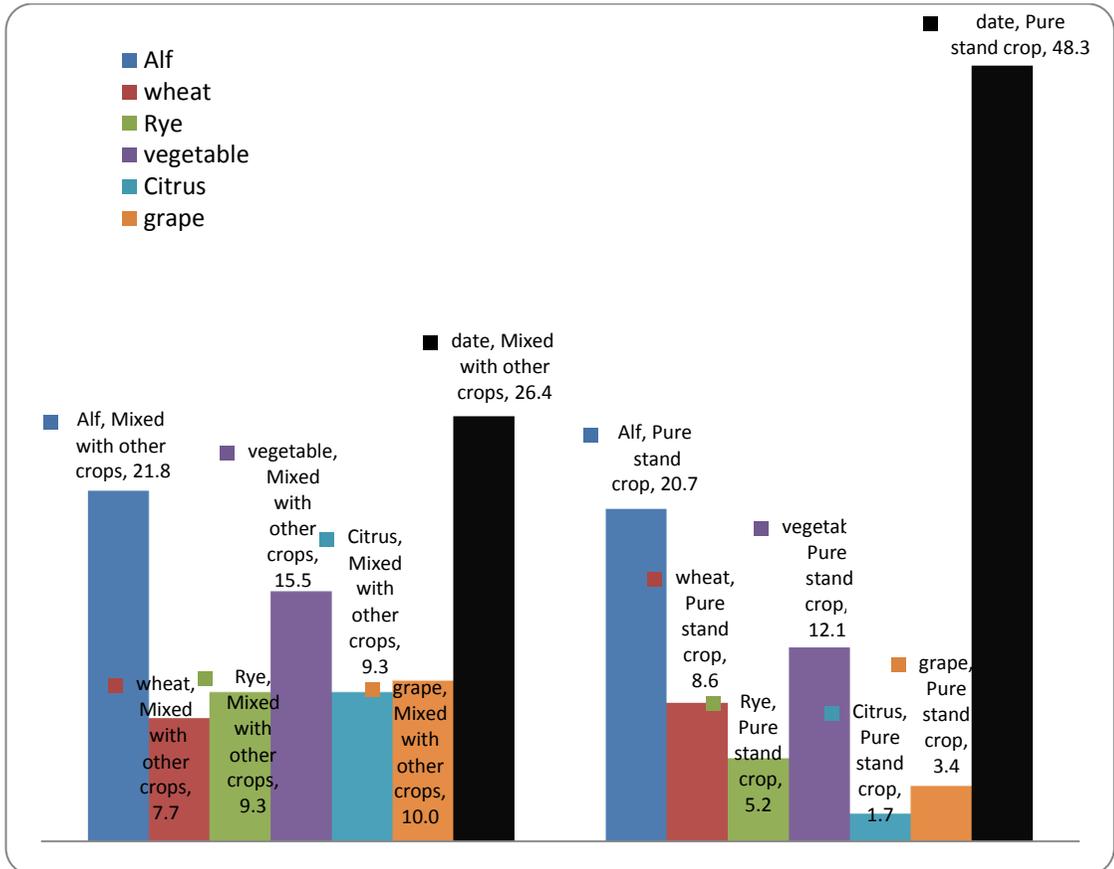


Figure 2: Percentage of main crops grown by the surveyed farmers as pure or mixed stands

Farmers may be used multiple-cropping for protect their crops against insect and daises pests as a cultural control (Altieri, 1991). This regime is a form of polyculture and can take the form of double-cropping, in which a second crop is planted after the first has been harvested, or relay cropping, in which the second crop is started amidst the first crop before it has been harvested.

It is clear from the results of the questionnaire that farmers are not familiar with green house

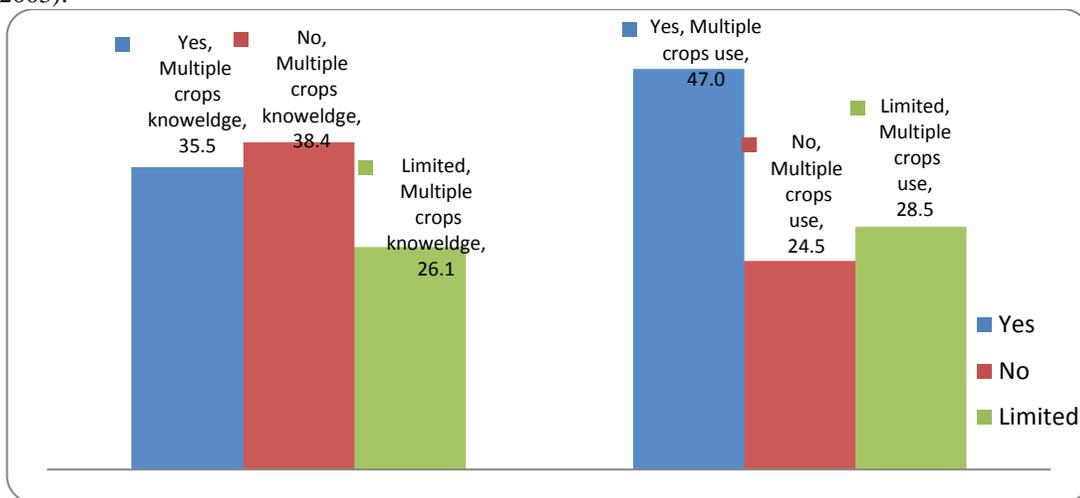
systems. Only 18% of the farmers reported that they use green houses. Green houses are used mainly for vegetable crops or crops of high value due to its high initial cost.

Due to its advantage in saving irrigation water and good control of the environment, farmers should be encouraged to use green houses. Greenhouses are usually adopted by farmers to have greater control over the growing environment of their crops.

Main factors that could be controlled within a greenhouse setup include levels of light and shade, temperature, amount of irrigation, fertilizers use, and atmospheric humidity. Generally, it is shown that greenhouses could be used to counteract the shortcomings expected in the growing qualities of a certain area of land, and thus they could improve the quality of food production in agricultural areas (Mao *et al.*, 2003).

**Multiple cropping**

Crop diversification was not commonly adopted inside green houses. Only 10% of farmers grew more than one crop in their green houses and as shown above, only a small percentage of the farmers use green houses. About 37% of the farmers grew different crops in their farms, outside greenhouses (Figure 3).



**Figure 3: Multiple cropping use and knowledge about its importance among the surveyed farmers**

About half of the farmers grew mono culture system in their fields. Diversification of crops helps farmers to sustain their production and save them from fluctuations in prices, as agro-ecosystem managements that involve multiple cropping are generally characterized by a stable and constant productivity in the long term (Gliessman and Amador, 1979; Gliessman *et al.*, 1981). Moreover, using multi-cropping helps to reduce the incidence of crop failure as a result of insect’s pest’s attacks and diseases (Liebman, 1987; Krupinsky *et al.*, 2002; Kumar and Nair, 2004).

Also, diversification of crops restores soil nutrients and fertility, due to the increased microbial activity in the soil, the reduction of water evaporation from soil surfaces, in addition to the reduction of soil surface erosion (Blanco-Canqui and Lal, 2010). About 60% of the farmers have knowledge about the importance of multiple crops (Figure 3).

This knowledge ranges from comprehensive to limited one. Moreover, 75% of the farmers expressed their willingness and ability to adopt the package of multiple crops. The adoption of polyculture management systems reduces the amount of agricultural waste as well as reducing fossil fuel consumption (Parrish and Fike, 2005; Tilman *et al.*, 2006; Groom *et al.*, 2008).

**Crop rotation**

About 55.1% of farmers do not practice crop rotation, but 44.9% of them grow crops in rotation. Out of all interviewed farmers, only 43.4% had previous knowledge about the importance of crop rotation as an agricultural system of production. On the other hand, 36% of them did not know about crop rotation and 20.6% had limited knowledge.

Moreover, only 43.6% of the farmers who did not practice crop rotation had the ability to practice it, while 28.2% did not have that ability and 28.2% had only limited ability to practice

crop rotation in their farms. Crop rotation confers various benefits to agricultural soil.

The use of green manure in sequence with cereals and other crops is a traditional factor of crop rotation to replenish nitrogen in the soil (Kurtz *et al.*, 1984; Bationo and Ntare, 2000). Moreover, crop rotation prevents the outbreak of pathogens and pests in addition to that it can improve the quality of soil structure and fertility by alternating deep-rooted and shallow-rooted plants (Campbell and Zentner, 1993; Portz and Nonnecke, 2011). Crop rotation can also lead to an increase in production costs as the total yield is increased significantly (Von Fragstein *et al.*, 2006).

Moreover, overall financial risks are more widely distributed over more diverse production of crops and/or livestock. Crop rotation requires additional planning and management skills, increasing the complexity of farming (Zollinger, 1998; Ambrosano *et al.*, 2010) and that is why extension programmes should be set and implemented in the area.

#### **Financial support (subsidies)**

A small portion (31.7%) of the farmers gets annual allowances from the government. Date palms receive the largest part of the allowances (80%), followed by vegetables (9.2%).

#### **Windbreaks**

In desert and desertified areas, windbreaks play a great role in protecting the soil from wind erosion and the crops from wind hazards. From the results of the questionnaire, it was found that more than 50% of farmers established windbreaks around their farms. Moreover, about 80% had previous knowledge about their importance. Sixty four point three percent of the farmers expressed their capability to establish windbreaks while 21.4% had no capability and 14.3% had only limited capability.

This necessitates that the portion of farmers who do not use windbreaks (40%) need to be informed about the importance of windbreaks and encouraged to establish them. Windbreaks should be established to protect the whole area. Protection of one farm is not enough if the neighbouring farms are not protected.

Windbreaks protect crops, livestock, wildlife or people from wind's harmful consequences. Crop net yields can be increased by 10 to 20% in fields with windbreaks (USDA, 2012). Livestock experience improved weight gains resulting in lower feed costs. Cooling costs for the farmstead can also be reduced. In addition, income producing plants such as fruit trees, nut trees and woody florals can be incorporated into a windbreak without reducing the beneficial functions (Mukhopadhyay, 2009; USDA, 2012).

#### **Animal production**

More than 70% of the farmers practiced mixed farming (animals rearing and crops cultivation). The most commonly reared animals are sheep (53.6%) followed by goats (23%) and camels (18%). Poultry production was practiced only by 4.5% of the farmers.

Animals offer a range of services to farmers, with the most important benefits mentioned by farmers being: source of income (46%), meat (8.8%) and manure (23%). About 75% of the farmers mentioned that they have good idea about the importance of farm manure as source of nutrients for agricultural soil. Other benefits such as weed control, source of milk, and as hoppy, were also mentioned by the farmers.

This reflects the awareness of farmers of the importance of maintaining a good source of nutrients to the soil, whereas feeding the soil to feed people. Programmes of composting animal and plant residues should be set and adopted to ensure provision of highly safe nutritive fertilizers to the soil, which in turn will also improve the soil physical properties (Morel and Guillemain, 2004).

#### **Use of fertilizers**

Only 12.3% of the farms did not apply fertilizers to their crops neither organic nor chemical. The rest of farms (87.7%) use one or more types of fertilizers. Out of all the farms that use fertilizers, 44.2% use only chemical fertilizers, 37.4% use only organic fertilizers and 18.4% use both types of fertilizers. This makes the farms that apply organic fertilizers alone or with chemical fertilizers more than half of the farms (55.8%).

Two major types of chemical fertilizers are commonly used, urea and foliar. Among the farms that use chemical fertilizers, 73.2% use urea only and 15.2% use both urea and foliar.

Chemical fertilizers are not only becoming more expensive but their availability at the right time and right quantity is a common problem. Bio-fertilizers are generally utilized to improve the fertility of soils as they include biological wastes and beneficial microbes.

They have several advantages such as being easy to be prepared by farmers with low technology and locally available raw materials and they are environmentally friendly and conserve the environment (Soumare *et al.*, 2003; Naureen *et al.*, 2005; Jilani *et al.*, 2007).

### **Fruits stabilizers**

Farmers are not familiar with fruit stabilizers since only 20% of them use them. Some chemicals have been extensively commercialized for some fruits as a postharvest application to control ripening (Sisler and Serek, 2003).

Potential benefits of fruit stabilizers, such as delaying maturation, expanding the harvest window, and slowing postharvest ripening rates, have been shown in some fruits (Villalobos-Acun *et al.*, 2010). They also play an important role in fruit abscission and might also produce a beneficial impact on postharvest fruit quality, delaying ripening for long-distance transport, and slowing the appearance of physiological disorders in storage.

### **Pests, diseases and pesticides use**

According to the results of the questionnaire, 33.9% of the farmers complained only from insect pests, 24.6% complained from weeds and 7.7% complained from worms. Moreover, 17.5% of farmers suffer from both insect and worm pests, 3.3% suffer from insects and worms and 12.6% suffer from insects, worms and weeds.

The results showed that most of the farmers do not differentiate between the pests and the diseases caused by these pests, or other causes of diseases. Most of their answers to the question on which diseases crops suffer from

were answered by mentioning insects or worms and in some cases they mentioned the names of these insects and worms.

Only few of the farmers (12.4%) pointed to the problem of fungal and bacterial diseases, which appear on alfalfa, dates and some vegetables.

A large percentage of the farmers (77.1%) used one or more types of chemical pesticides. Out of these farmers, 67.3% of them buy the pesticides from the local market, 14.2% get them from the Ministry of Agriculture and the rest (18.5%) buy part of their needs from the local market and get the other part from the Ministry of Agriculture.

Since insects are the main source of trouble to farmers, 57.1% of the farmers use insecticides, followed by 27.3% that use both insecticides and herbicides and 10.6% use only herbicides.

The high percentage of insecticide use is due to the fact that 60.1% of the farmers had no knowledge about how to control insects without insecticides, even farmers who have some knowledge about insect control without insecticide (39.9%), 63% of them answered that they do not have ability to control insect pests without insecticide.

It is clear that insects and weeds are the main problems affecting agricultural production in the study area.

Moreover, the farmers are not aware about integrated pest management (IPM) techniques. Therefore, there is need for introduction of IPM such as natural predators and cultural practices and cultivars resistance to pest and disease (Chandler *et al.*, 2011).

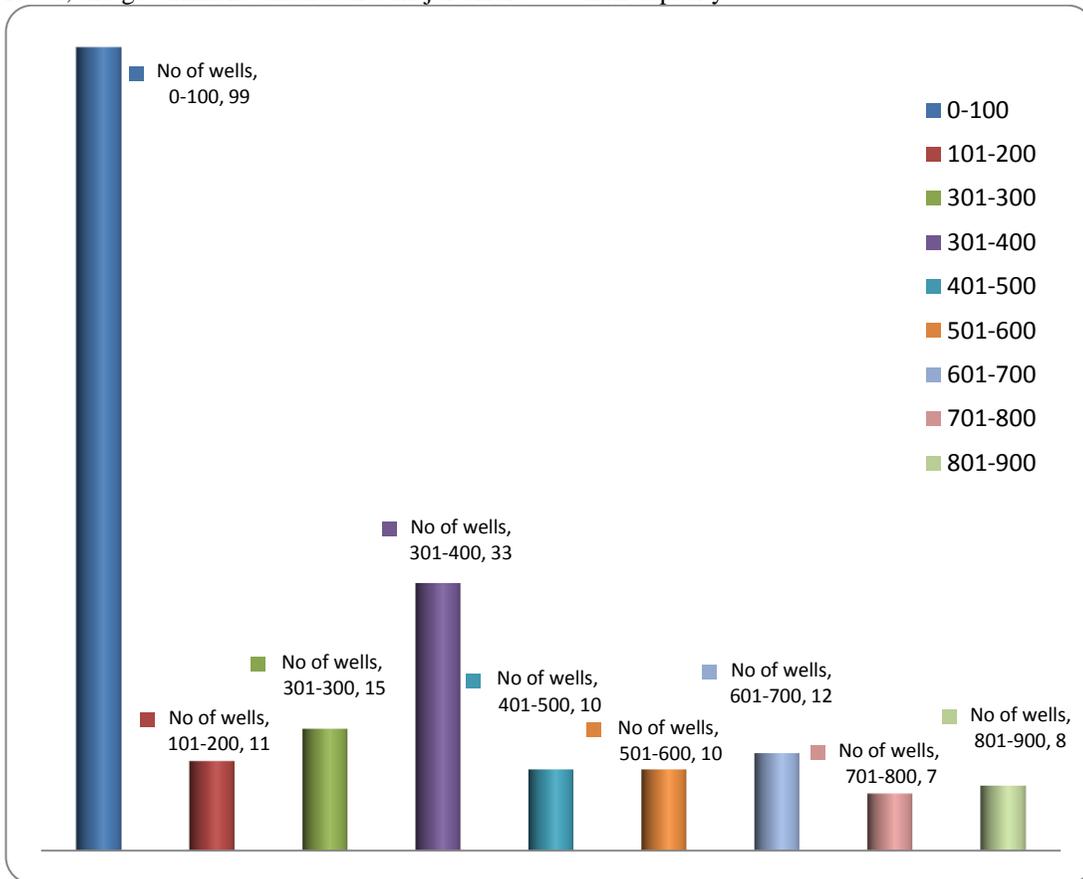
The increases in productivity of crops through management of pests could be achieved without increasing, and possibly by decreasing the amount of fertilizer and water used to grow them (Cook *et al.*, 1995; Rost *et al.*, 2009; Ghorbani *et al.*, 2010; Ratnadass *et al.*, 2012).

### **Irrigation and water conservation**

All farms are irrigated by artesian wells. The depth of artesian wells ranged between 10-900 meters, with the highest percentage within less than 100 meters in depth (Figure 4). Aquifers

are a major source of water in KSA. In the 1970s, the government undertook a major effort

to locate and map such aquifers and estimate their capacity.



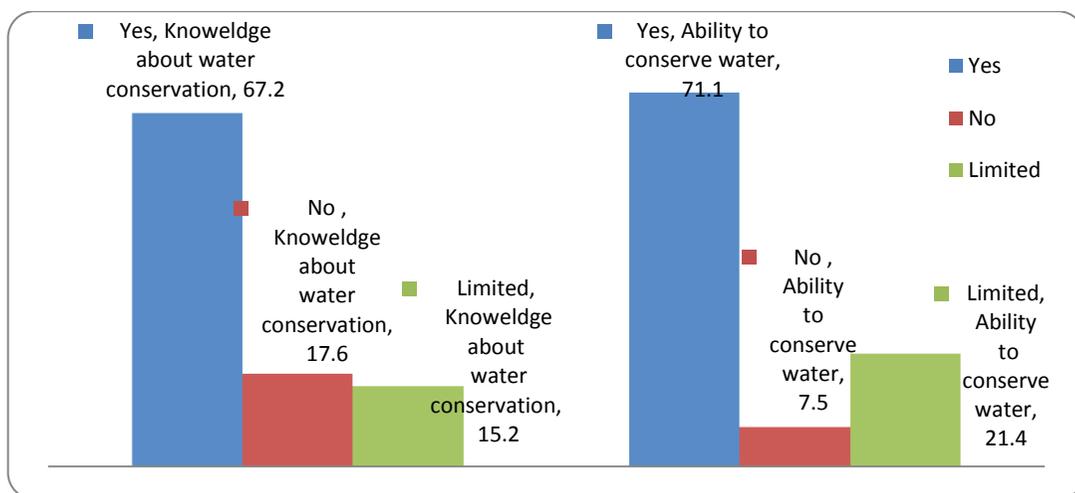
**Figure 4: Range of artesian wells depth (in meters) in the study area**

As a result, it was able to drill tens of thousands of deep tube wells in the most promising areas for both urban and agricultural use (Al-Zahrani, 2009). In order to meet the rising water needs, evaluation of water quality is important for allocation to various uses (Al-Hasawi and Hussein, 2012).

The wells’ pipes diameter in the study area ranged between 1-30 inches with 73.2% of them in the range of 1-10” and only 2% with diameter greater than 20”. According to the farmers, 18% of them considered irrigation water they use as “salty” and 78.6% considered it as either “fresh” or “medium salty”. Out of all the studied farms, 5% had no water tanks while 76% of them had 1

or 2 water tanks. The rest of the farms had 3-10 water tanks depending on the farm area. Farms in the study area apply different methods of irrigation. The methods most extensively used are sprinklers (36.9%), pipes network (19.2%) and drip irrigation (15.3%). Combinations of more than one method of irrigation are also practiced.

A high percentage of the farmers know about water conservation methods (Figure 5). 71.1% are willing to apply these methods properly. This entails that extension programmes aiming at application of ideal water conservation methods should be set and practiced in the area.



**Figure 5: Knowledge about water conservation methods and the ability to apply those methods among the surveyed farmers**

It was found that irrigation programming was practiced only in 59.5% of the farms. Recent studies have made several recommendations for management strategies for efficient utilization of the available water resources in Saudi Arabia (Hussain *et al.*, 2010).

### Soil and soil properties

The description of the soil given by the farmers is descriptive identification and cannot give clear picture about the soil types. However, 86% farmers described their farms' soil as being clay. Soil analysis is not performed by 68.6% of the farmers.

On the other hand, 46.5% of the farmers have knowledge about the importance of performing soil analysis in which about 40% of the farmers analyze their farms soil every 2 years. However, 14% do soil analysis every 10 years. It is important to carry soil analysis at least every 5 years.

It is clear from the results of the questionnaire that soil salinity constitutes about 63% of the farms, according to the farmers' answers. However, only half of them consult a specialist. Due to irrigation with saline water, salinity is expected to develop gradually in the fields.

Therefore, for sustainable production suitable reclamation programmes should be considered, especially that soil resources are one of the main

critical components of sustainable agriculture (Maqsood *et al.*, 2013).

The farmers seem to have access only to engineering agriculturists since about 54.8% of the farmers consult an engineering agriculturist . Only 9.6% of the farmers report this problem to an institution or to the Ministry of Agriculture.

### Agricultural waste

According to the questionnaire results, the most important water pollutant is chemical fertilizers (39.1%), while in the soil, pesticides are the most frequent hazard (63.1%). Other sources of contamination include sewage water (21.7%) and pesticides (27%) in water. In the soil, petroleum (17%) and garbage (30%) were mentioned as sources of pollution.

The majority of the farmers (85%) remove waste materials by burning. Other methods like burying and ploughing in the field are not practiced by most farmers. There should be clear distinction between useful wastes, which can be recycled in the field, and soil pollutants. A great effort is needed in this area for how to treat the waste and pollutant for environmental safety.

### Marketing of agricultural products

The main market for selling farmer products (77.3%) is Hail area (local marketing). The second choice is selling farm products within KSA. Exporting farm product to outside KSA is not a choice for farmers. Dates, alfalfa and

vegetables are the easiest products for farmers to sell.

They attribute this to high demands and low cost of production. The number of farmers who answered that wheat and barley are easy to sell is less than ten. Although the farmers reported that vegetables are easy to sell, some of them (53 farmers) mentioned that they are marketed with difficulties.

The main mentioned reasons are competition with imported products, short storage ability and fluctuating demand. About 62% of the farmers market their products by themselves, and 90% of them prefer marketing centres for sorting and packing of their products before sale.

The farmers attributed the marketing problems to transportation, lack of demand and high costs. Fodder has high market, which may be due to the presence of animal production farms. Moreover, the farmers have limited access to the markets within or outside KSA, since most of the farmers sell their product in Hail area.

Therefore, improving transportation and post-harvest operations will be a good solution for marketing. There is also an urgent need to determine exact consumption and demands in the area, in order to control supply and price, so as to make agriculture profitable to the farmers.

### **Mechanization**

Mechanization in agriculture and land preparation procedures is utilized by 77.7% of the farmers. However, only 49% of the farmers harvest their products mechanically. The farmers are not aware about the agricultural mechanization techniques.

About 50% of the farmers harvest their products manually. There is a need to introduce others agriculture machine and train farmers about their use. Setting and execution of agricultural extension programmes are also very crucial.

### **Other Agriculture problems**

Most farmers (67.7%) who mentioned that they have other problems, stated that they required

support either through funds or extension programmes. Other problems included shortage in agricultural labour, marketing, high cost of production inputs, lack of machinery, harsh weather and shortage of irrigation water.

### **Conclusion and recommendations**

The study revealed that Hail region is an important agricultural area in the Kingdom of Saudi Arabia since there is a large number of farms recruiting a large number of personnel and producing agricultural products (of crop and animal source) for the local market and markets outside Hail area.

It is also clear from the study that some agricultural practices need to be revised and directed towards sustainability to ensure maximum utilization of resources with the least adverse effects on the environment and highest possible production for the welfare of the community.

It is recommended that extension programmes should be intensified and directed towards training the farmers about the best environmentally-sound agricultural practices, which will ensure least cost with highest production. Establishment of marketing institutions from within the farmers is of vital importance to ensure best marketing opportunities and highest revenues.

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