

## Sustainable Agriculture, Food Security and the Role of Agricultural Research and Technology Transfer in Yemen

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Received: 28/05/2018

Accepted: 10/01/2019

### Abstract

This study aimed to explore the current situation of food security and investigate the role of farm research and technology transfer in Yemen with special focus on effect of the present war and armed conflict. The study is primarily based upon the secondary data and the information available in the relevant literature. The systematic review leads to conclude that previously developed strategies of the agriculture sector and food security are no longer valid, viable and sufficient to address the emerging issues; without giving the adequate consideration to the newly emerged pressing realities and developments, it would not be possible to set the new directions to ensure food security. The analysis of agricultural sector, degrading natural resources, depleting aquifers, political un-rest, civil war call for the sound sustainable farming systems to feed the hungry and achieve food security backed by vibrant National Extension Service (NES) in the country.

**Keywords:** Sustainable Agriculture, Food Security, Poverty, Yemen, Qat, Water resources, War Impact.

### Introduction:

The Republic of Yemen sustains an estimated total population of about 25.3 million. With an increase about 3.2% a year, its population is likely to reach 34.1 million in 2025. Most of the population (60% of the total) resides in the mountainous areas of the country (Ministry of Planning and International Cooperation "MoPIC", 2014). About 75% of the population lives in rural area and depends on agricultural activities (mainly crop cultivation and livestock husbandry) (Ministry of Agriculture and Irrigation "MAI", 2013). However, the cultivated area is decreasing due to many factors like: use of traditional farming practices, poor management of land and other resources, low yield of crops, scarcity of water, limited use and high price of agricultural inputs and migration of labor force. All these factors lead to the expansion of poverty and malnutrition (MAI, 2013). On the other hand, the population increase and diversification of their economic activities lead to put more pressure on the already stressed and dwindling natural resources. As a result, an exacerbating competition for resource occurs causing social and political instability.

Not long ago, agriculture sector used to be a very vibrant and viable economic sector. However, it was not able to strengthen the farming community economically nor able to feed the population sufficiently. According to the available official data produced in the report of MoPIC (2013), the agriculture sector still absorbs 24% of total labor force approximately. Yemeni farmers have been familiar with agricultural activities since ancient times and successfully developed a number of appropriate farming techniques. For example, one can notice the large number of terraces, old dams and irrigation channels

prevailing throughout the country. Such practices and facilities not only help them in their survival, but also strengthen economy and realize sustainable use of the limited natural resources.

Out of the total geographical area, which is about 46.6 million hectares, only 3.7% brought under cultivation. Nonetheless, this cultivated area varies from one year to another depending on the variable rate of annual rainfall (MoPIC, 2013).

In 2013, the total area was 1.6 m.ha. cereals and legumes occupied 60%. The rainfed agriculture covers roughly 66% of the total cultivated land mass. While about 27% area of the total cultivated land is mainly irrigated from groundwater sources (MoPIC, 2013) and to a less extend (about 7% of agricultural land) on other sources like Gails (water streams), dams and reservoirs. However, the total arable land could reach approximately 2.5 m.ha rarely if it generously rains, which happens only once every 10- 15 years.

It should be noted that the overall production of cereal crops covers less than 20% of the local needs for consumption. This implies that Yemen resorts to compensate for the remaining portion (about 80%) from the world market to provide its population with their needs of food grains especially wheat (local production is about 8%) and rice which is not produced at all in the country (Almussali, 2008; Mai, 2012; International food security Phase Classification "IPC", 2017; and Food and Agriculture Organization "FAO", 2018).

The socio-political conflict, climate changes such as floods and land degradation in addition to the armed war erupted in the country after 2015 onwards certainly have deeply affected not only farm production but also the livelihood of Yemeni population. The country's average production of cereals in general and particularly of wheat and sorghum dropped at about 37% each as compared to the average of about 5 years ago as stated in a recent report (FAO, 2017). Sorghum crop, particularly in Yemeni rural area, is the most common crop for staple food and a basic component of main meals and food consumption pattern.

Similarly, there are estimations that about 40% of farm families suffered a decreasing rate of grain production compared to previous years prior to disruption of conflict and war (Relief web, 2017). Little below half of the farm families was forced to sell some of their animals in order to meet other family requirements like medication and other food commodities. This is despite the fact that the rate of precipitation was higher in the months of 2016 providing thus an opportunity of better feed and water for animals as explained in the same study (Relief web, 2017).

However, there was no much change in the production of horticultural products in 2016. But, the security situation, transport difficulties, the stoppage of some public services like electricity and the price hike of fuel, among other factors, all have resulted in low farmers share of the marketing (FAO, 2017).

On basis of findings reviewed above, it is important to identify the factors that threaten agriculture and in turn food security in Yemen. It also seems important to examine the role of agricultural research and extension in achieving food security in Yemen in the light of persistent changes indicated by mentioned above studies. The irrational increasingly growing depletion of natural resources under war conditions and the spread of poverty and famine alongside with the speedy population growth all effect sustainability of agricultural activities and growth of agricultural sector as well. Focusing on market-oriented agricultural production without clear overall development perspectives that conforms with desired direction and based on optimal management of available resources will not lead to preservation

and sustainability of resources. The present study is an endeavor in this direction particularly in light of war consequences on all aspects of Yemeni life including agriculture, which need to be understood for suitable future orientation.

### **Objectives:**

The study is guided by the following main objectives: 1) clarifying the state of agricultural sector and food security in Yemen; 2) to identify the impact of the present conflict, 3) to investigate the role of agricultural research and technology transfer toward realizing sustainable agricultural activities and achieving food security. It aims also to 4) develop some recommendations to improve the working of agricultural research and technology transfer toward realizing sustainable agricultural activities and achieving food security.

### **Methodology:**

- This descriptive study is based on the compilation of secondary data and review of available and relevant documents and studies on agricultural production, food security, farm research technology dissemination, and impact of war on present situation.
- The information gathered from different sources was reviewed and analyzed to make adequate investigation on basis of study objectives. Data was analyzed using excel program while simple statistics were also used like frequencies and percentages for same purpose. Graphic presentation was used to simplify important findings and comparisons.
- Researchers have also used their own knowledge of local reality, work experience and field personal observation of the relevant information relating to study objectives too in various areas visited.

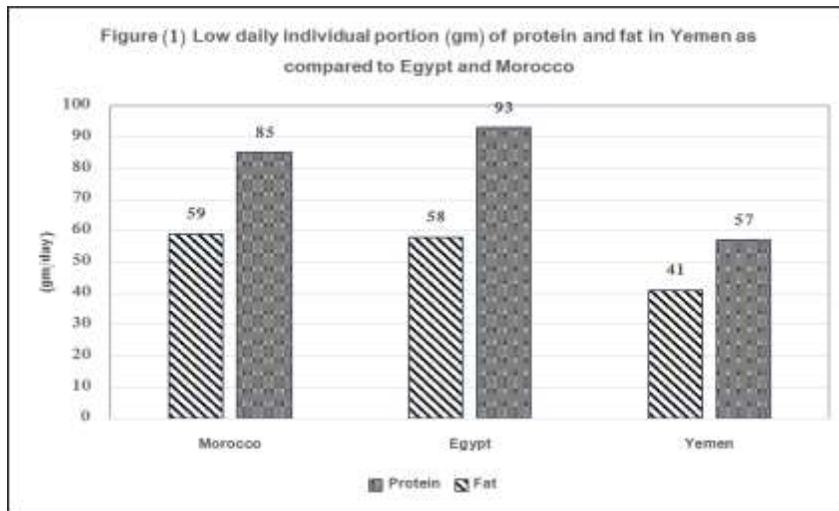
### **Results and Discussion:**

#### **1-Poverty and malnutrition:**

Most of the food items (about 90%) of the total food consumption in Yemen are imported. Though the lives of people are affected by the internal and external changes in addition to the climate change, yet poverty is expanding in all parts of the country. During the last few years, it increased dramatically. In 2012, the average percentage of poverty in Yemen was 46% of the total population, and about 10.5 person of them could not get enough food, most of them living in rural area (MAI, 2013b). This ratio varies from one governorate to another. About 60% of the children and young population are suffering from malnutrition (Relief web, 2017).

In 2012, Yemeni family spent about 45% of its income for food and 10% for transport and communications (MoPIC, 2012). These figures have doubled or even more because of the present war, economic impediments as well as the declining purchasing power of local currency.

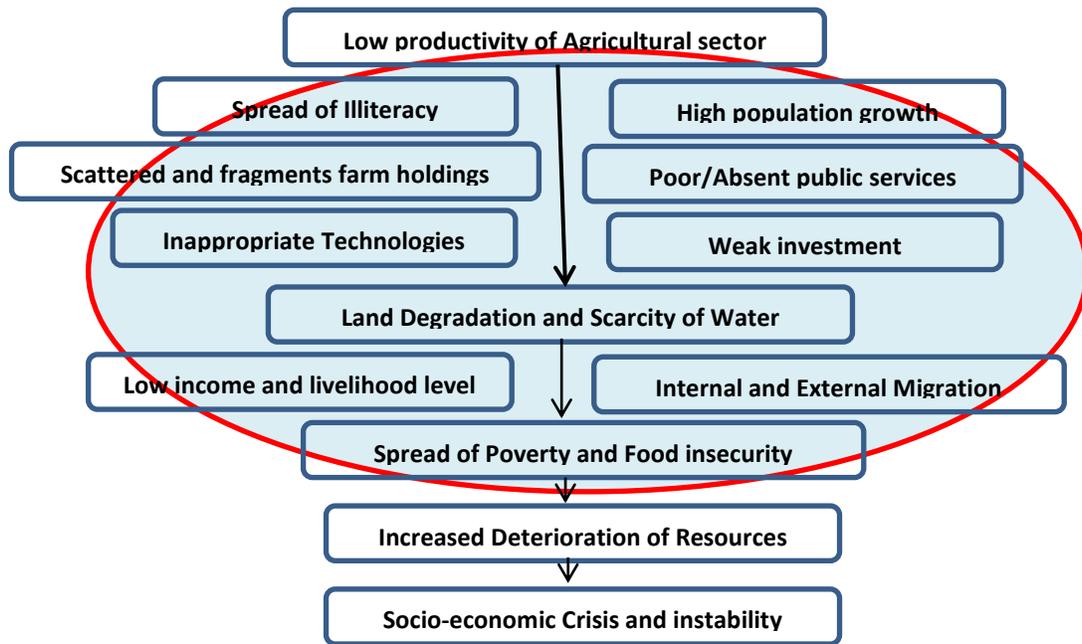
Yemen humanitarian response plan (2017) shows that about 3.3 million children and pregnant or nursing women are acutely malnourished, including 462,000 children under 5 years suffering from severe acute malnutrition. This represents an increase of about 57% since late 2015 (WFP, 2017). Yemeni citizen consumes less calories, protein and fat than the countries in the Middle East and North Africa (MENA) region. A Yemeni gets only 2020 calories/day, while the Egyptian individual consumes 3350 c/p/d and the Moroccan 3070 calories/person/day. Similarly, Yemeni individual gets lower protein and fat (FAO, 2007) as compared to other countries (Figure 1).



Source: Prepared by authors based on data from (FAO, 2007).

The current situation of the escalated spread of poverty and food insecurity in both rural and urban regions of Yemen is not purely a direct result of the current conflict. In fact, it stems from a chain of complex and interrelated factors and aggravated by the latest war and excessive use of limited resources. As shown in the figure (2), the low productivity of the agricultural sector and the high annual growth rate of the population (about 3%) are some of foremost factors lead to low income and livelihood. This is associated with high illiteracy level, especially among women, and high rate of school dropouts especially among females, who are entering into labor market with limited employment opportunities.

**Figure (2) Important Factors Affecting Poverty and Food Insecurity in Yemen**



Source: Prepared by authors

On the other hand, Yemeni farmers mainly use traditional farming practices with limited application of improved and modern agricultural technologies. The climate change, draught and fluctuating rainfall, scarcity of water interwoven with continuous destruction of terraces and deteriorating of the limited natural resources, all are calamities that stand in the face of bare-handed poor farmers and household. The low land productivity with the other allied factors forced many Yemenis to migrate to urban centers and abroad to search for other alternatives for livelihood.

It should be also noted that the country suffers low level of investment in various economic sectors including agriculture. This reality happens alongside with total absence, and at best, poor public services in both rural and urban centers. All residents compete for the limited resources and services, and pressurize on the environment leading to further lower and lower resources and poorer productivity and management. This high negative competition and disordered atmosphere is not only an optimally conducive to the widening poverty and food insecurity, but also to sharp decline in social peace and eventually to the eruption of societal conflict at all levels.

This black scene is drastically darkened by the local and external armed confrontations leaving people between death, hunger, displacement, cholera and other epidemics and totally in ruthless conditions.

### **2-Climate change:**

Like many other countries, Yemen is affected by the occurrence of climate change. The inter-governmental panel on climate change (IPCC) 4<sup>th</sup> assessment report, mentioned that Yemen is expected to warm up by 3-4 C° by the year 2080 (Environment Protection Authority EPA, 2013). The rate of rainfall is obviously less and its distribution is expected to be unstable, possibly with greater incidence of high intensity. The overall quantity and distribution over time and location will change the size of lowering production because of availability of soil water especially under rainfed farming system, affecting food risks, land degradation and water available for different uses. Crops will also be affected by the variation of temperature alongside with the beginning of the farming season. Additionally, draught results in production lowering, so that crops might be affected by some insects and pests. The weeds will bring about similar effect especially under low input farming and contribute to farther low production again. The farm production of poor Yemeni farmer with small land holding is characterized with low productivity per unit area for all crops. This actually happens in view of farmer's reliance on limited seasonal rainfall ranging between 50mm in coastal and desert areas to about 600mm in some mountainous highlands areas (Muharam and Alwan, 2015) and the minimal use of fertilizer (7-11 kg/ha) that is being the lowest average in the world (FAO, 2002-2015). Additionally, farmer's use of farm mechanization and pesticides is generally low except in few cases like protected farming and Qat growing where higher quantities of pesticides are used.

### **3-Political uncertainty and economic disruption**

Since early 2011, Yemen is passing through a period of political uncertainty and economic disruption that has significantly worsened the already serious food insecurity situation. The unstable conditions led to a vast economic crisis as reflected in a sharp reduction of the total contribution of agriculture production (ranging between 21-13%, with an average of 16%) due to several reasons such as the weak input supply and disordered marketing chain. Therefore, the rural areas are most affected by such a situation and its resulting conditions with drastic increase of the level of food insecurity. In line with this, a survey conducted in 2013 revealed that the high rate of malnutrition inflicting Yemeni children with (43%) of them were suffering from underweight (MAI, 1013b).

In this connection, the government adopted an agriculture and food security strategy in early 2011 aiming at lowering the level of food insecurity at about one third by 2015, to raise the level of food secure segment of the population to 90% by 2020, and to diminish rate of child malnourishment at 1% per annum (Mai, 2012).

The overall goals of the strategy were: to increase growth, sustainability, and equity by raising agricultural output; to increase rural incomes, particularly for the poor, and to improve food security and nutritional status by improving availability and access to adequate nutritious food and nutrition advice (Mai, 2012). However, these objectives are not realized due to eruption of socio-political conflict, armed confrontations and the protracted war.

In May 2016, FAO mentioned that 14.4 million Yemenis are food insecure, about 7.6 million are suffering from hunger, 82% (21.2 million) are in need of food assistance and 2.8 million people have been displaced. All these factors have negatively affected the level of livelihoods and lives of most of Yemeni people, pushing them into the hardships manifested in displacement, poverty, public services deterioration, suspension of salaries, high prices of food items and the like.

The situation has caused enormous pressures on the natural resources mainly vegetation, as people are forced to use woody vegetation as fuel for cooking; such un-lawful harvesting of wood leads to soil erosion.

On the other hand, the high prices of farm inputs pushed farmers to pay more care to qat growing and expansion due to its high market demand and rewarding revenues. Although, this direction exhausts natural resources needed for better development efforts, it is clearly in line with the interest of political authorities holding power in their attempts to involve people in qat consumption and numbness to forget their daily problems and whole dilemma of the country.

#### **4-War and social conflict:**

##### **4-1-War and social conflict and threat to sustainable agriculture:**

War and armed conflict prevent farmers from doing their daily routine work. The war forces farmers to leave their homes and lands and resort to other places with their families. If farmer were able to cultivate their lands, they may stop doing some important operation due to the lack of security and risk of not getting their money/cost back. The issue of social protection has become of crucial importance for farmers and others in urban areas who fled their partially or completely destructed homes. Other farmers may or may not be able to sell their surplus production at whatever prices. Others have reduced number of animals due to the need for cash money or difficulty of feed provision in view of price hike of farm inputs. These and many other similar cases and situations are not conducive to sustainable nor subsistence farming at all.

##### **4-2-Conflict and food security:**

Over the past two years (2016-2017), 13.1 million of population have been internally displaced due to ongoing conflict. In addition, about 17 million Yemenis (60% of population) are food insecure, and 6.8 million are severely food insecure. Food famine has possibly impacted millions of people, mostly women and children.

The situation is getting worse from day to day with the fighting continues to erupt here and there in different parts of the country. Therefore, the available wheat stock could hardly meet local consumption needs for three months. This was aggravated by the deteriorating exchange rate of local

currency (YR), the crisis relating to the central bank malfunctioning and the fighting around the Hodaidah port that impedes considerable amount of import (FAO, 2017).

According to Relief web (2017), about two thirds of Yemeni households are suffering from food insecurity with an increase of about 25% compared to 2014. According to this report, about 43% of those persons suffering of food insecurity are in need for emergency food assistance (Relief web, 2017). FAO (2017) mentions that about 75 percent of households confirmed that the current economic situation is worse compared to the pre-crisis period.

On the other hand, the relief web (2017) stated that the total number of acutely malnourished children in Yemen remained at over 2 million. The report mentioned four Yemeni provinces (Hudiedah, Hadramout, Taiz and Abyan) in which the malnutrition rates have exceeded the "critical" threshold. According to same report, in other seven provinces (Aden, Lahj, Al-Mahwit, Shabwah, Hajjah, Al-Jawf and Al-Dhale'a), this rate exceeds the "serious" threshold (relief web, 2017).

In this regard, it should be mentioned that the private sector was afflicted with great loss and market disorder forcing many of the traders, manufacturers and investors to reduce their operations and fire large number of employees. The situation is worsened by the fact that the government was unable to regularly make the salary payment for its employees too. Additionally, there was a serious halt of some services such as electricity and other services and energy sources. Moreover, prices of most locally produced (like wheat, millet and sorghum) as well as imported commodities and other related market services witnessed a considerable increase that ranged between 25-70% following the conflict and unrest eruption. All these complexities made the cost of living higher (40%) and harder for a vast sector of the population compared to the pre conflict era (MoPIC, 2017). Large regional price difference persists within the country due to variation of distance from ports, transport charges and the prevailing security situation in each zone.

#### **4-3-Food for internally displaced persons (IDPs):**

The number of internally displaced persons (IDPs) has exceeded 2 million in January 2017 and are mostly now residing in Hajjah, Sana'a city, Taiz and Amran. Those IDPs are putting immense pressure on the already limited resources available to such host communities (FAO, 2017) and are, thus, creating a higher competitive atmosphere leading to varied types of additional socio-economic conflicts and pressure on limited available resources (Unfortunately, there is no official precise statistical data are available beyond 2015 on most variables under consideration in this study. Issuance of agricultural and other national yearly statistics books has stopped due to conflict and war consequences).

As mentioned earlier in this paper, the different government services are handicapped and irregular. For instance, electricity is totally absent in some provinces. The situation of water and sanitation is poor in many of the provinces and the people are left to a limited and infrequent access to such important service. The lack of clean water is apparently the major spur to the eruption and spread of cholera at the end of 2016 and expanded during the past few months of 2017. Against this blights and worsening situation, the public health services and facilities are either closed down, severely hindered and/or ineffectively functioning, leaving various vulnerable segments (mainly women, elderly and children) of the society as mentioned by FAO (2017), under miserable conditions.

#### **4-4-Prices of agricultural crops:**

The average prices of agricultural food products have increased at different rates during the past two years (2016-2017) ranging from 25% (for rice), and reaching its peak of about 70% (for barley)

compared to 2014 prices for same items. The same applies to other products like sorghum, wheat, maize and similar food grains as confirmed in FAO report (2017).

Latest available information indicate that prices even got higher for wheat at about (33%), and rice at about (85%) as compared to pre-crisis prices of same commodities. Similarly, prices of locally produced products have increased by 57% for sorghum and 43% for millet (MoPIC, 2017). The situation has even worsened in 2018 due to collapse of local Yemeni Rial against foreign currencies (700-800 YR = 1 USD).

#### **4-5-Water issues:**

##### **4.5.1. Depletion of limited water resources:**

Development of agriculture sector and realization of food security both are highly depending on scarce and stressed water resources in Yemen. Rains are the prime source of water received in two major seasons; the first one is from March to May and the other is from July to September. The rainfall varies from season to season and from one area to another. Ground water resources are the secondary and is irrationally extracted and used. Therefore, the water resource in Yemen is in constant depletion due to the high population growth rate and inefficient water use like the widespread and commonly used traditional irrigation system.

##### **4.5.2. Water, sustainable agriculture and food security:**

Muharam and Alwan (2015) stated that total annual rainfall in Yemen averaged 58 MCM but is seasonally scattered and subject to evaporation due to high temperature and consecutive draught periods. Therefore, the rainfall quantity estimated is only minimally utilized. This could be rightly inferred by looking at the rainfall water quantity collected in dams and ponds networks constructed during the past few decades (1275 water structures that accommodate only 93 MCM of water). Similarly, Ward (2014) reports that Yemen receives an average annual rainfall of approximately 37 billion m<sup>3</sup> (BCM), most of which evaporates in situ shortly after rainstorms. The remaining amount goes to surface runoff, which is estimated to be about 1 BCM, or percolates into the ground to recharge to local aquifers is estimated to be 1.5 BCM. Hence, the total annual renewable water resources are 2.5 BCM, while the annual abstraction is estimated at 3.4 BCM. This means that 0.9 BCM of groundwater is depleted every year, lowering the water tables up to 6 meters per year in some aquifers (JICA, 2007). With a capita rate of water less than 120 m<sup>3</sup> a year, Yemen suffers an acute shortage of water (Hellegers et. al., 2008). Furthermore, due to the high population growth, and the irrationally over-use of water for irrigation, the country witnesses a sharp decrease of water availability and sources. The per capita share of renewable water in Yemen is expected to further decline to about 72 m<sup>3</sup>/cap/year by the year 2025 (Al-Hamdi, 2000).

In this connection, agriculture is the largest water consuming sector in Yemen, followed by the municipal and industrial sectors with shares of 93.1%, 4.6% and 2.3%, respectively (Al-Hamdi, 2000) and (Kuster, 2011). While Hellegers *et al.*, (2008) believe that the agriculture sector is currently consuming about 88% followed by urban use (10%) and the industrial use (2%). These figures are expected to change to 79%, 18% and 3% respectively by 2025 (Hellegers *et al.*, 2008).

In this regard, it should be mention that the water shares per capita (person) is 135 m<sup>3</sup>/person/ year. The situation will be more serious in the coming years. The availability of water per capita will be the lowest in the world (55 m<sup>3</sup> per capita per annum in 2031 (Al-Eshlah *et al.*, 2011) due to the increasing population growth, expanding of qat cultivation and other economic activities.

Therefore, the most important challenge that faces the Yemeni agriculture sector is the water scarcity with climate change. Many farmers are overusing water for crops irrigation, with limited use of modern irrigation system so as to save water and produce more crops. The use of traditional irrigation practices and the irrational water use are hindering agricultural growth. These factors also are limiting realization of better advancement of the sector and minimizing its contribution to development sustainability and food security.

Cereals crops occupied most of the agricultural land in both rainfed and irrigated agro-farming systems. In the irrigated areas, most of the groundwater goes to cereal crops (about 27%) and qat (23%). While fodders get only 13.4% of groundwater (International Food Policy Research Institute "IFPRI", 2010). This picture depicts the future endangered situation confronting cereal crop and animal production that forms the pillars of sustainable agriculture and food security in the country.

#### **4-6-Agriculture and food security:**

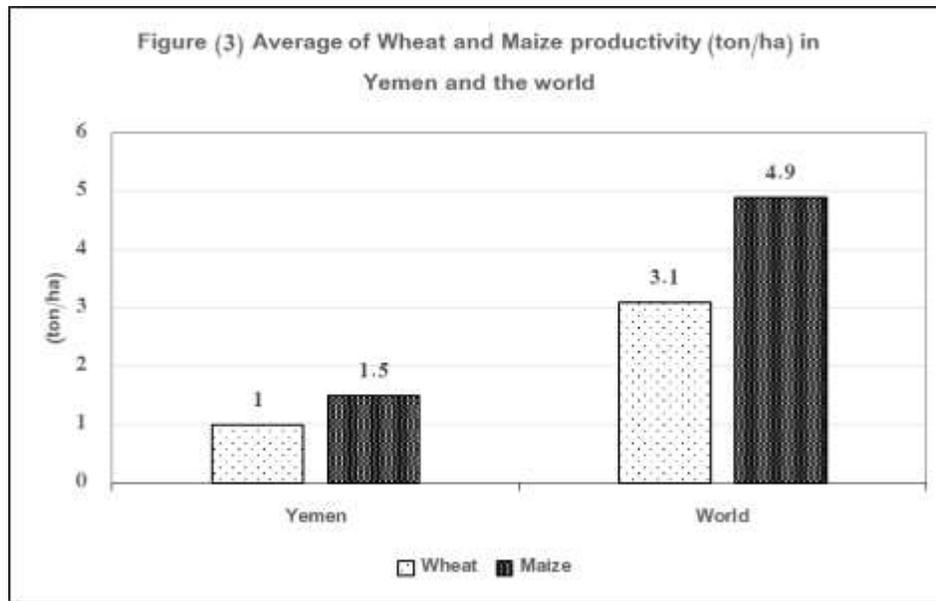
Agriculture and food security are strongly associated with each other as Yemeni people relies on agriculture, for their food items and other products. Farming is actually the main source of living for more than 70% of the population are mainly living in rural areas. However, with the changes in consumption pattern, the country can't depend on its agriculture sector to feed its growing number of people any more despite the fact that Yemen has become self-sufficient in increasing number of fruit and vegetable crops. Nonetheless, the agricultural sector continues to contribute to the national gross domestic product a certain share of about 13% by 2011 (MoPIC, 2013).

During the past few decades there were many changes whether in crop patterns of fruits, vegetable and qat, or the change from rain-fed system to irrigated system, and from subsistence agriculture to market-oriented agriculture. The cultivated land mainly under grapes and coffee expands annually at an average of 3% and 5% respectively; and for all fruits and vegetable crops at 5% annually during the period of 1970-2012 (Muharram, 2014).

Most farms are extremely small and households' farm incomes are typically very low. Therefore, the yield of most cultivated crops in Yemen are low compared with the yield of same crops in the neighboring countries from one side and the global average yield from other side. The average yield for wheat and maize in Yemen is much lower than that of the world as shown in figure (3). Similarly, the average yield of coffee per hectare in Yemen is only 0.53 t/ha (Muharram, 2009), while in Vietnam is about 2 t/ha (Antony, 2007).

There are many reasons behind the low productivity in Yemen most important ones are: scarcity of water, lack of inputs or high price mainly fertilizer, marketing problems and so. Despite, the declining size of area under cereal crops to about 63%, the production had increased by 20%. The same trend is also noticeable in fruit and vegetable crops where the production scored an increase of 7 and 4 times respectively during the past 3 decades (Muharram, 2010).

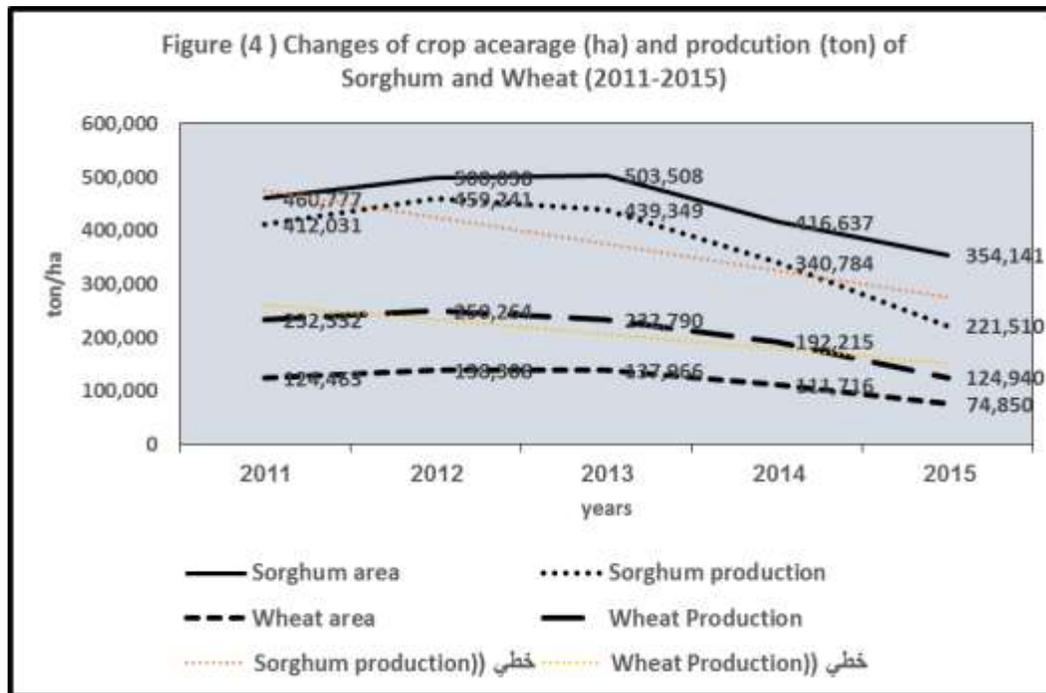
Although, the shares per capita of fruits during the period of 1994-2013 had increased from 32 kg/person/year to 44 kg/person/year, the per capita shares of eggs and meat had declined from 23 to 7 eggs/ person/year and from 5 kg of meat to 4 kg/person/year (MoPIC, 1995-2013).



Prepared by researchers based on data from (FAOSTAT, 2012)

In spite of the facts delineated above, it should be noted that the agricultural sector has shown a growth potential of about 5% per year during the period 2005 -2010. Some of the crops like grain, coffee and honey, have shown large increases. Similarly, it should be stated that almost all Yemeni farmers practice livestock production including the poor farmers, landless households and women especially in the rainfed areas for additional income. Therefore, livestock is another potential area of growth and value added contributing not only to household income, but also to the nutritional position and food security (MAI, 2013b) of Yemeni household.

However, the acreage and production of some crop, like sorghum and wheat, have tangibly decreased in latest years with the escalation of conflict and eruption of war apparently due to varied originated disruptions (figure 4).



Source: Prepared by authors based on data from the yearly agricultural statistics books (MAI, 2010-2016)

#### 4-7-Qat – the greatest challenge to sustainable agriculture and food security:

Qat (*Catha edulis*, family Celastrineae) is the greatest threat to sustainable agriculture and strongest barrier preventing realization of food security. It grows very well on altitudes of 600 – 3000 meters above the sea level. This mild stimulant and evergreen plant are the cause of economic, health and social problems in the Yemeni society. Most of Yemeni people chowing qat daily. It accounts for around 6% of gross domestic product "GDP", 10% of consumption, and one-third of GDP contributed by the agriculture sector. It provides employment for one in every seven Yemeni workers, making it the second largest source of employment in the country. It also depletes water resources and occupies larger segments of the good fertile agricultural lands. Qat consumption is one of the key causes of poverty in Yemen swallowing about 10% of the household budget, far exceeding household expenses allotted for basic foods, medicines and other necessities (Gatter, 2012).

Area occupied by qat has increased about 21 times from 1970 to 2012. Its cultivation has increased about 3 times under irrigated-system areas (Muharram, 2004; MAI, 2013; & Muharram, 2014). It must be noted that expanding area under qat is a negative indicator for poor agricultural development in the country as it occupies considerable portion of fertile land, consumes much water and of no export value.

Furthermore, the World Health Organization "WHO" considers qat as a narcotic crop (WHO, 1964). Many countries in the world prevent it from entry into their markets with the latest British government decree banning qat effective June 2014 (www.bbc.com). The agricultural area occupied by qat in the highlands is rapidly growing. It has encroached and occupied the land that used to be under cereals, fruits and vegetables consuming huge volumes of water as it can be produced in all seasons. However, the main factor responsible for increasing qat cultivation is its high economic returns it brings as compared to the other crops, fruits and vegetables.

#### **4-8-Agricultural research, technology transfer and food security:**

The productivity of different crops is stagnant and the water availability is declining. The priorities are to boost productivity whilst conserving water. Agriculture is confronted with a number of problems such as the limited natural resource, land and water, spread of traditional practices, limited infrastructures, small land tenure, limited human resources development, and lack of capital among others socio-economic issues (Muharram and Alsharjabi, 2008).

Most of the arable land depends on rain which is limited and irregular. Yemeni population growth is one of the highest rates in the world. Such varied difficulties pose a real dilemma for government to seriously consider the steadily increasing food needs and the change of the food habit from sorghum and millet to wheat and rice. Internal and external changes like globalization and institutional and economic restructuring had affected the agricultural sector from one side and on the farm research and extension organizations from other side.

#### **4-9-The role of Agricultural Research and Extension Authority (AREA):**

AREA addresses the issues of the agricultural sector (both plants and animals) through planning, implementing and evaluating scientific and applied research and studies via various research programs and activities so as to provide solutions that would ensure higher quality and quantity production, productivity, better income and living conditions for producers under all country's agro-ecological zones. AREA has under its umbrella 8 regional research stations and 5 national and specialized research centers prevails in different parts of the country AREA research plan, implementation and evaluation are based on the mandated responsibilities by the national agricultural Research Strategy developed in 1997. These main background document, in addition to directions delineated by government for socio-economic and institutional reform policies, and the emerging national, regional and world surrounding, all serve as bases in developing Mid-Term plans that goes in parallel with the 1<sup>st</sup> (2001-2005, 2<sup>nd</sup> (2006-2010) and 3<sup>rd</sup> (2011 – 2016) national five-years plans started in 2001 and beyond up to present time.

The research work of AREA conducted essentially in the main 2 farming systems (rainfed and irrigated) focuses on six themes, namely; Genetic improvement, management practices, resources management, livestock, food and post-harvest, and socio-economics.

#### **The major directions of the research agenda in AREA are:**

- Increase production of agricultural crops in quality and quantity with emphasis on market demands in every production system.
- Improve crop management with the aim of sustainable use of inputs.
- Realize a rational and efficient use of land and water as well as flora for optimal use of resources and environment protection.
- Improve animal production in the context of integrated system of animal, plant and range.
- Reduce post-harvest losses and improve techniques of food marketing, handling and storage.
- Review marketing systems and suggest alternatives for improvement of marketing procedures.

AREA human resource has steadily grown to about 1400 persons of which about 27% are researchers (AREA, 2013). Among AREA technical research staff, only 31 are females. AREA researchers with PhD. degrees were only 27 in the early 1990s (Alwan & Alsharjabi, 2012). Despite the fact that the

total number of research staff has almost doubled during the past two decades, this disparity was never settled till the present. Additionally, the increase in research staff is still low in proportion to total country's population, agricultural land, number of farmers and/or land holdings keeping in view the regional and world standards. With respect to financial resources, AREA used to rely heavily on annual public fund (about 82%), foreign loans and grants (10-18%) for about 3 decades following the foundation of farm research in the country (Alsharjabi and Vogelzang, 2010).

#### **Contributions of Farm Research and Technology Transfer:**

AREA continues to produce and disseminate farm technologies such as new varieties of main crops and relating crops agro-techniques so as to solve some of the problems facing the farming communities and to enhance farm productivity in different agri-ecological zones of the country. In this respect, it should be emphasized that AREA releases new farm (plant and livestock) technologies every 2-3 years after completion of technology verification trials on farmers' fields. More than 150 new high yielding, salt-tolerant and pest resistance varieties for different crops (for wheat, sorghum, maize, millet, barley among others) were released in the past 10-15 years for the benefit of farmers under different environments and farming systems. Only some of these varieties are reproduced by the general incorporation of seeds multiplication (GISM), and made available to farmers. These varieties and farm technology packages, if widely disseminate and applied by respective users, they are expected to increase crops' yield and contribute to the status of food security of the Yemeni people.

Additionally, AREA has developed and released during the same period a number of other improved high-yielding varieties for other crops like onion (Bafutiem), legume crops (like lentils, cowpea and beans), and mango crop. All these varieties are of proven desired marketing qualities and up to the farmer's preference. In terms of post-harvest technologies, AREA was also able develop a number of recommended measures and practices to improve grain storage, food processing, and crops' losses reduction techniques.

Similarly, the livestock research programs of AREA resulted in some new genetically improved breeds of Sheep and goats, enhanced feed mixtures of valuable nutritional value and some other animal production and health management practices.

With regards to sustainable natural resources management and utilization, AREA advanced a number of improved techniques and practices concerning soil and water, vegetative cover, farming systems and relating socio-economic aspects.

However, the General Extension Directorate which is located at the headquarters of the Ministry of Agriculture and Irrigation (MAI), starting in 2004, and in the Agriculture Office at the regional level are working together in disseminating information and knowledge to farmers. The responsibilities of the directorate are to supervise extension and provide training sessions for extension workers, plan extension activities at the national level, and disseminate information and knowledge through mass media and simplification and publication of applied research outputs at national level.

Furthermore, the field extension activities at the provincial level come under responsibilities of Agriculture Offices and Authorities which are considered as the branches of the MAI at the provincial level. Each office is a representative of the MAI within a geographical area of the respective province. The Agriculture Offices have the main responsibility to disseminate technology and information (produced by the AREA) to the farmers at the village level through the 250 Extensions Village Centers (VEC) distributed across the country. Each VEC is operated by 2-3 extension workers who are

responsible for direct and indirect contact with farmers for the transfer of technology and information related to the farming and agriculture. AREA and the National Extension Service (NES) contribute to the dissemination and transfer of modern and improved farm technologies to various groups of users including farmers and other rural producers.

This is done through different means such as on-farm trials, demonstration fields, farmers field schools (FFS), seed banks maintained by the farmers, on-farm research, training, farm exhibitions and the media. Socio-economic studies conducted during the past on the farm technology generated and transferred to the farmers at their farms clearly indicate the presence of some economic impacts in terms of net return that varied between 8-330% as shown in Table (1).

**Table 1. Examples of the impact of farmer's application of selected improved farm technologies recommended at the field level**

Agro-ecological zones	Theme	Technology (ies)	Economic impact
The highlands	Improved Varieties	Tajareb variety, Sorghum	160% net return
		Bohouth variety, Wheat	74% net return
		Jeezah-3 variety, beans	126% net return
		Bricoz Variety, Lentil	100-330% net return
		PS variety, Phrison, peas	145% net return
	Plant Protection	Faba beans store pest control using date palm oil	286% (% of marginal return)
Coastal areas	Improved varieties	Zabid Compound variety, Millet	77% net return
		Kod-94 variety, Sesame	200% net return
	Plant protection	Weeds control, Onion	8-20% extra yield
		White mildew control, Sesame	72% extra yield
	Water management	Irrigation scheduling, Cotton	65% water saving 67% cost saving
Eastern Plateau, Hadhraout	Improved variety	Hadhraout variety, Wheat	21% extra yield 17% extra net return
		Bafutaim variety, Onion	113% extra yield
	Plant protection	Pesticides, Weeds control, Onion	76% extra yield

Source: Alsharjabi and Taha, (2000).

The results of available studies indicate that due to the farm research and technology transfer efforts, an increase of about 62% in wheat yield/hectare was realized as compared to the same yield area of the years 69-1971. Some studies stated that the yield of wheat increased by 157% in 1995 as compared to the year 1981 (Muharram et al., 2005).

It is also well known that Yemen used to import many cereal, vegetable and fruit crops. But, due to contribution of research and technology transfer of improved varieties and agro-techniques of such crops, the country now is self-sufficient in most of these crops like potato, onion, tomato, and pepper among others.

Yemen prior to 2015 is also used to export surplus of such crops and other fruit crops such as mango, papaya and banana to outside markets. It should be noted that technologies of farm research are

characterized by a tangible considerable increase of yield, resistance to pests, salinity and other stresses such as draught. Table (2) shows data relating to maximum production realized by improved varieties of some crops under the research farm conditions.

**Table 2. Yield of crops' improved varieties under conditions of experimental farm**

No.	Crop(s)/ varieties	Yield (ton/ha)
<b>I</b>	<b>Wheat</b>	
1	Bohouth -15	5
2	Bohouth-14	5
3	Emran-2	4
4	Emran-4	4
5	Bohouth-13	7
6	Serwah	5.2
7	Hadhramout	4.5
8	Seiyun	4
<b>II</b>	<b>Barley</b>	
1	Bohouth-2002	3.8
2	Ashmoor	2.0
<b>III</b>	<b>Onion</b>	
1	Improved Bafutaim	70
<b>IV</b>	<b>Millet</b>	
1	Kod	3
<b>V</b>	<b>Mango</b>	
1	Surdud	40

Source: Khalil M. Alsharjabi (2013). Agricultural Science and Technology Indicators: Background paper. AREA, Dhamar, Yemen. pp. 10

#### **The role of research and technology transfer toward sustainable agricultural and food security:**

According to the research and extension review that was carried out in 2008-2009, the research and extension activities had shift from commodity research to on farm research, from irrigated crop production to rainfed system and from cash crops and big farms to strategic crops (grains, coffee and livestock) and small farmers. For that research and extension services considered to change their way of work and the methodology started to implement their activities on farm, with farmer participation not only in the implementation but also in the planning of interventions. Jointly with farmers occurred the selection of the suitable seeds, varieties and technology packages.

Yemen has also framed regulations to preserve the genetic material of healthy varieties and their seeds, maintenance in order to rehabilitate of dwindling agriculture. Resultantly, the number of farmers are benefiting from the research activities carried at the government research farms an increased use of the improve varieties their spreading on large area. Therefore, the average yield of wheat per hectare in wadi Hadramout has increased by 56% and onion about 89% compared with traditional farmer way of cultivation, in Tehamah region.

Similarly, the average yield for maize increased about 67.4%, tomato 62% and the onion 73% in Raimah area as revealed in the Table (3). The millets yield was increased about 50% and beans 81%; in central high lands the peas (basilica) yield increased by 54% that in turn resulted an increase of about 40% in the number of livestock in Tehama region as revealed in Table (3).

**Table 3. Average yield increases of some crops in selected Yemeni areas by adopting improved technology package compared to traditional farmers' way of cultivation (%)**

Commodities	Regions			
	% of increase yield			
	Tehamah	Hadramout	Central highlands	Raimah
Wheat	-	56	40	32
Barley	-	-	-	40
Maize	67.4	-	40	50
Millet	87	-	-	50
Sorghum	34	-	-	24
Onion	73	89	-	-
Tomato	62	-	-	-
Peas	-	20	54	81
Cotton	49	-	-	-
Livestock				40

Source: AREA annual reports 2008-2009

In this connection, El-Solh (2017) stated that there is a possibility to enhance Food Security in Arab countries including Yemen on realizing the agricultural potential by bridging the yield gap in wheat is an example. In an average of six seasons (2010/2011-2015/2016), wheat productivity yield gap was increased up to 124% under irrigated conditions in Sudan, up to 96% under supplemental irrigation in Yemen and up to 84% under rainfed conditions in Syria (El Solh, 2017).

#### **Strategies for improvement:**

To improve the performance of agricultural sector and alleviate poverty, the MAI has prepared the general guidelines in NASS in 2013 mainly represented in: achieving higher yield and food security through fostering productivity of both crop and livestock, and optimal use of water resources under both rainfed and irrigated farming systems. It also advocated the approach of combating rural poverty and poor nutrition and enhancing participation of beneficiaries especially women.

Earlier, the Government of Yemen had also launched the Poverty Reduction Strategy (PRS) (2003-2005), with the aim of reducing poverty percentage by about 13.1% during 2003-2005, and reduced to 35.9% in 2005, with economic growth of around 4.7%.

The National Food Security Strategy (NFSS) was also developed in coordination between the government and the International Food Policy Research Institute (IFPRI). This important document aims to reduce food insecurity by one-third in 2015, make 90% of the population food secure by 2020, and reduce child malnutrition by at least one percent per year. In order to reach these goals, the NFSS sets out a 7-Point Action Plan one of which "is to improve food security and risk management". In fact, the agricultural sector sustained a share of GDP of about 5.1% during the five years plan (2011-2015).

### **Impact of Conflict and Steps Forwards:**

The ongoing armed conflict spurs most of food security emergency in the afflicted country- Yemen. It pushed the originally poor and unstable country towards a devastating socio-economic, political and institutional chaos and breakdown.

Presently in the war situation, the agriculture sector and the food security are the hard hit, as most of Yemenis are food insecure and suffering from malnutrition. They do not have clean potable water to drink and live in poor health care, forcing a large number of people to displace.

In response to this alarming and deteriorating situation, there is a need to assist people in getting food, clean water, health care and the most importantly ensure their security. There is also a need to motivate people to return to the agricultural activities with proper assistance such as providing seeds, seedlings, agricultural inputs and making suitable marketing channels available for their production. However, more considerations are to be given to children education and health care.

There is an urgent need to maintain and re-operate institutions and different organizations mainly the security institutions, return of displaced people, rebuild houses and public buildings and infrastructures. Most important things for the time being include providing public security, food, clean water and health care. When the war stops, Yemeni people are expected also to face spread of epidemic diseases, food insecurity and unstable state.

### **The major constrains and Challenges:**

Agricultural sector faces several constraints during the present unrest and even during the peace achieving food security remained a big challenge. Most important constraints are as follows:

- Low productivity results low incomes, pushing farmers into poverty;
- Poor investment in agriculture sector;
- Depletion of natural resources especially water;
- High prices and unavailability of essential agricultural inputs;
- Weak modern technology generation and technology transfer;
- Poor marketing network and services;
- Poor working of institutions and their weak infrastructure

These difficulties have been exacerbated in recent years because of the current state of war started in first quarter of 2015, with series of following additional obstacles and problems:

- Farmers have abandoned the agricultural activities partially or completely in different areas mainly in armed clashes areas;
- Exporting of agricultural products has been almost declined;
- Destruction of the agricultural infrastructure including livestock and poultry farms, agricultural offices, roads, bridges and marketing centers. According to the MAI report, the initial losses to agriculture infrastructure due to the civil conflict and war are estimated to be US \$ 2.3billion.
- Increasing cost of production mainly due to big hikes in fuel and transport charges;
- Weak purchasing power and the potential of consumers;
- Outbreak of pests and diseases;
- The armed conflicts and absence of security in many places in the country;
- Disappearance and/or weakening of various public services such as electricity, banking, water supply etc.

- Reliance on nature as a source of food, fuel, herbal medicines and for other uses affecting thus biodiversity and genetic resources.

### **Conclusions:**

Yemen is one of the poorest countries in the world. It faces great challenges like increasing population growth and deterioration of originally limited natural resources. This effect livelihood and food security of Yemeni citizens. The problem exacerbates with increasing number of the poor, widespread of acute poverty, food insecurity, lowering nutrition level and citizens suffering from war and socio-political conflict afflicting the country.

Fragile population segments in the country (women, children and elderly) especially of poor and marginalized families representing majority of residents, bear alone most consequences resulting from such calamities. Spread of hunger, diseases and epidemics and children mortalities is a clear indicator of the huge disaster distressing Yemeni society.

Due to unrest and war disruptions, numerous socio-economic and political realities have triggered thus affecting use of natural resources, agricultural production, farming system, marketing and export directly and indirectly.

Therefore, there is a serious need for rigorous intervention and sincere efforts to be made by the government, humanitarian organizations, donor agencies and the developed states to overcome the complexities of the catastrophic situation.

### **Recommendations:**

Based on literature reviewed, data analyzed and researchers own observations of daily life the following recommendations could be pointed out:

- Agricultural sector is the prime sector, supporting employment and the livelihoods to the large segments of the society. Although it requires major improvements measures and strategies to make it productive and elevate productivity by introducing high value crops, paying more attention to the wise use water resources to enhance water use efficiency, in addition to establishing the stronger links between research and extension organizations for the efficient flow of information and effective transfer of technologies to the farmers.
- In order to realizing greater benefits, it is important to learn lessons from the past previous experiences.
- The country needs to design, introduce and launch the farmer friendly policies to offset the negative effects of previously launched policies that supported the imports of agricultural commodities and removed the subsidies on fuel while creating hardships for the farmers;
- More attention is also needed to greenhouse crop production; poultry farming animal health; and honey production.
- In Yemen, traditional agriculture is being practiced on mountain terraces since centuries. Maintaining and the rehabilitation of agriculture on these neglected and devastating terraces would help producing more in the country. This intervention will also lead to using more manpower and its traditional way of agricultural activities, with introduction of suitable and high yielding crops.
- More emphasis needs to be placed on crops carrying the potential to offer higher comparative advantages like high value crops.
- Establish seeds banks and offering small grants to the producers will ensure higher yields.

- Keeping in view water deficit, the depleting water resources in the country it is important to introduce the concepts of rationalizing water use. Further it is important to introduce more efficient and water-saving irrigation systems that could enhance and elevate water-use efficiency (WUE) and produce more with less drops of water.
- Providing some white or low-interest loans the small farmers and poor rural dwellers.
- Qat is the strongest competitor of the significant beneficial agriculture crops and the most valuable input - water. Its cultivation must be checked and eliminated. Agricultural extension should create awareness and launch training programs for the farmers, members of the civil society, young and women to discourage its production and consumption. Educational programs are needed at all levels at all the educational institutions to create awareness and make the nation adopt healthy life styles.
- Government should undertake right policies and strategies that deal with qat as a socio-economic and health blight and work towards limiting qat growing and chowing. Similarly, it should adapt and implement legislations to minimize irrational use of irrigation water for qat growing and expansion.

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## الزراعة المستدامة والأمن الغذائي ودور البحوث ونشر التقانة الزراعية في اليمن

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تاريخ القبول: 2019/01/10

تاريخ الاستلام: 2018/05/28

### الملخص

هدفت المقالة إلى استكشاف الوضع الحالي للأمن الغذائي ودراسة دور البحوث ونقل التقانات الزراعية في اليمن مع التركيز على أثر الحرب والصراع المسلح في الوقت الراهن. اعتمدت الدراسة بصورة رئيسة على البيانات الثانوية والمعلومات المتاحة في المراجع والأدبيات وثيقة الصلة. أظهرت المراجعة المنهجية للدراسة أن استراتيجيات القطاع الزراعي والأمن الغذائي التي تم تطويرها سابقاً لم تعد صالحة أو عملية وكافية لمواجهة المشكلات المستجدة، وهناك حاجة ملحة إلى الأخذ بالحسبان التطورات والمتغيرات الجديدة على أرض الواقع، وبدونها لن يكون ممكناً وضع اتجاهات جديدة تضمن تحقيق الأمن الغذائي. إن تحليل القطاع الزراعي، وتدهور الموارد الطبيعية واستنزاف الأحواض المائية، وعدم الاستقرار السياسي، وآثار الحرب والصراع، تقتضي وجود نظم زراعية مستدامة ملائمة لتأمين الغذاء للجوعى وتحقيق الأمن الغذائي، معززة بخدمات فعالة لجهاز وطني للإرشاد الزراعي في البلاد.

**الكلمات المفتاحية:** الزراعة المستدامة، الأمن الغذائي، الفقر، القات، الموارد المائية، آثار الحرب، اليمن.