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Potentials of Cropping Systems' Diversification in North-East Syria, for Enhanced Sustainability in Farming Systems

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Potential För Diversifierade Odlingssystem Och Förbättrad Hållbarhet Hos Jordbrukssystem I Nordöstra Syrien

Key words: North-East Syria, Al-Hassakeh, Agroecology, sustainability, Cropping systems‟ diversification, crops‟ rotation, intercropping, SAFA guidelines.

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Dedication:

To the one that taught me how important friends are.

To the one that I couldn’t be with at the last moments in this world

I dedicate my work

Nisreen ….dear sister

We all love you

R.I.P …..

Foreword:

By the time I was working for the extension department in Al-Hassakeh Syrian governorate, I was not familiar with the Ecology term. After I read about Agroecology on Studera.nu and SLU university websites, I became so interested in exploring the relationship‟s complexity of farm systems with their own surrounding, and I wanted to discover what Agroecology is about.

Being in the Agroecology programme for the past two years was a great step I made in the sense of developing the way of system‟s thinking, mentality and ethics of mine. It instantly made me realized that there was a missing link between the sustainability‟s pillars (environment, economy and society) in the advisory service back in Syria. Whilst before that, I was taught to focus mostly on increasing the "now yield" as it is the positive indicator for a prosper livelihood, with minor attention to the possible future impacts on environment and society, and even on future farm economy. Now, I hope I am able to plan an agricultural change on agroecological basis, with awareness of the ecosystem‟s matrix and its components‟ integration. Yet, the ability to properly recognize the promises and drawbacks of any change always needs to be shaped by the increased knowledge and application of the agroecology‟s principles.

The motivation behind this particular study is that the farmers in the area of Al-Hassakeh - as in many other areas in Syria - are in need of help. They are mostly dependent on agriculture for living, and when they lose their life means, they have to migrate seeking a better livelihood. But the case in the real life is not as bright as we think; in fact they get abused by labor market because of their need for jobs. There is no need for this to happen if the agricultural practices and resources were managed in a proper and scientific manner. I believe that system‟s agroecological analysis is the starting point to plan new sustainable systems that can provide them with what they need, and ensure the country‟s food and economic security. The appendix (A letter to farmer) shows a summary of how diversification could be adopted and how it will improve farmers‟ livelihood, in a brief and clear way as much as possible.

Sameer Fayez Younes, November 2012

Abstract:

The Syrian Arab Republic is a country which depends on agriculture as a second main sector in economy after oil industry, but the governmental strategies for the agricultural production diminished sustainability of the farming systems. Cropping systems‟ diversification is a practical application for enhancing sustainability through the collective benefits of the increased biodiversity in the agroecosystem, in order to view the potentials of such diversification it is required to evaluate the studied system properly to reveal its weakness and strength points. By collecting data from the internet, mainly the publications which are related to Al-Hassakeh governorate in the North-Eastern part of Syria, published by the international organizations like FAO (the Food and Agriculture Organization of the United Nations), ICARDA (International Center for Agricultural Research in the Dry Areas), and UNDP (United Nations Development Programme). The FAO Sustainability Assessment of Food and Agriculture Systems guidelines (SAFA) and the principles of Agroecology master‟s programme were used to analyze these data to assess the sustainability of the farming systems in Al-Hassakeh, and discuss the possibility of creating a diversified cropping system. It was found that farming systems in Al-Hassakeh have a multiple negative impact on the environmental and social aspects, but profitable yet not sufficient economic outcome. The area of Al-Hassakeh is promising in term of increasing its cropping systems sustainability due to variation of water availability and climate conditions that provide suitable cultivation environment for a variety of crops that can be used in cropping systems‟ diversification.

Key words: North-East Syria, Al-Hassakeh, Agroecology, sustainability, cropping systems‟ diversification, crops rotation, intercropping, SAFA guidelines.

Agroecological context:

There are many indications that the trends in food and agricultural production towards industrialization and globalization, are threatening humanity‟s future and natural world (Altieri & Nicholls, 2005). It is true that modern technologies in farming and food systems made it possible for the food production to grow rapidly, side by side with the population growth (Gliessman, 2007), but this change was convoyed with big and serious challenges. Food distribution inequity, issues in the nature of non-renewable resources and their limited supply, and the unfavorable effects of conventional agriculture (Gliessman, 2007) are important things to think of. All these challenges forced researchers in the field of agriculture to propose key modifications in the conventional practices in order to achieve more sustainability and making the agroecological systems more environmentally friendly, socially just and economically viable (Altieri & Nicholls, 2005).

Agroecology has a great global importance because "*it is the application of ecological concepts in the design and management of sustainable agroecosystems, and provides a framework to assess the complexity of agroecosystems*" (Altieri, 1995). Such application that not only considers the biotic and abiotic components of the agroecosystems, but also apply ecological knowledge to link environment, economy and society to each other in order to achieve a sustainable agroecosystem (Gliessman, 2007). The proposal of agricultural changes on agroecological basis increases the chances to create a complementary system, rather than a system analysis from one point of view like environmental or economic. For example, reducing the use of chemical fertilizers has many positive impacts on the environment and costs reduction; on the other hand it might cause a reduction in yield. It also affects fertilizers‟ industry and people who depend on it as owners or workers in this business. From agroecological point of view, it is more appropriate to promote the modification of fertilizers use with alternatives for fertilizers‟ producers like conversion to organic fertilizers production for instance. Another example could be bioenergy production which reduces the use of fossil fuel, but at the same time it increases land competition for food production, food security is a great concern for this matter.

The attempt in this study is to assess Al-Hassakeh‟s farming system from an Agroecological point of view with the use of The Sustainability Assessment of Food and Agriculture Systems (SAFA) guidelines (FAO, 2012a). These voluntary guidelines were developed by FAO - the *Food and Agriculture Organization of the United Nations* - in its conference on Sustainable Development (UNCSD) 2012, and meant to specify procedures, principles, and minimum requirements for production systems assessment. The guidelines set is characterised by environmental integrity, economical resilience, social well-being, and good governance, with methodological bases of relevance, simplicity, goal-orientation, and performance – orientation.

In this study, Al-Hassakeh governorate is the studying area, it is a part of the North-Eastern farming systems in Syria. This study is important because Syria is a developing country depends on agricultural production for its national economy, and the studying area is the largest agricultural production area in Syria. Moreover, there isn‟t enough studies focus on the use of agroecological assessment for enhanced sustainability at the farming systems in Syria, especially in the North-Eastern regions of the country. The outcome of this study is summarized in the only appendix in this study: A letter to the farmer, it contains a brief explanation of diversification principle and some methods of its application to increase sustainability in cropping systems in Syria.

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1. Introduction

1.1. Sustainable agriculture and diversification:

Food production in its primitive form was able to feed and fulfill four million people‟s basic needs since before the dawn of agriculture (Cohen, 1995), and modern agriculture is able to support six billion people (Tillman et al, 2002). In the last half-century, human utilization of the ecosystems on earth increased more than during the whole prior history of the planet (Steffen et al, 2004), also the agricultural research has been driven for a long time by the need of raising the yield, which has altered farming systems toward practicing monoculture. Water pollution, biodiversity losses and pathogens‟ increased tolerance against treatment became common consequences of this production system (Lichtfouse et al, 2011).

The ways we practice agriculture determine food production level, and the global environmental situation (Tillman et al, 2002). For instance, doubling the food production amount under the past practices, will add a triple amount of detrimental nitrogen and phosphorus to the ecosystem (Waggoner, 1995), and the use of conventional agriculture led to the depletion of agricultural resources, causing soil degradation, overuse of water and damaging hydrological systems, pollution of the environment, dependence on external inputs, and the loss of genetic diversity (Gliessman, 2007). Human activities have manipulated biogeochemical cycles on a global level, which changed the functioning of earth as an ecosystem (Chapin et al, 2011), and called for action to change these practices and activities in order to achieve a better agricultural resilience. For that, sustainable development was suggested as a framework of practices modification with considerations of the ecosystem‟s ability.

The World Commission on Environment and Development (WCED) uses the definition of sustainable development with emphasis on economic aspects (Becker, 1997), as the development that fulfills the needs of the present generation, without compromising the ability of future„s generations to meet their needs (Brundtland, 1987). It encompasses some fundamental concepts like:

- During sustainable development, the essential needs of vast number of human beings should be met properly (food, clothing, shelter, jobs…etc.). It must also support people‟s desire for an improved quality of life, equity, and all extending possibilities to satisfaction‟s opportunities.
- The fulfillment of needs is only sustainable when the consumption standards consider the long-term sustainability within the ecological capacity of the

systems. And as the consumption standards are socially and culturally determined (Brundtland, 1987), development should encourage the ethics in which a sustainable consumption change happens.

- Renewable resources (like forests, fish stocks) should be used with consideration of their regeneration ratio. For the non-renewable resources (fossil fuel for instance), the depletion should take into account the importance of the resource, and the possibility of creating alternatives to that resource.
- Meeting the needs partially depends on achieving full growth potentials, societies in this case have to increase productivity possibilities, at the same time, ensure equal opportunities for all. This process may cause a pressure on resources, especially in places where population growth is accompanied with poor distribution of resources, and they have to be given a special priority (UNCED, 1992).
- Human intervention during the steps of sustainable development should not endanger the natural resources. The accumulation of knowledge and reoriented technology‟s development could relieve the pressure on resources, and ensure equal access to the limited resources (Brundtland, 1987).

In general, the sustainable development could be present in a simple framework (Charles, 1994):

- Ecological sustainability: maintaining and enhancing the capacity and quality of relevant ecosystem, and the species in it.
- Socioeconomic sustainability: maintaining local and global viability, and fair distribution of beneficial returns. Enhancing social, cultural, and economic welfare of communities.
- Institutional sustainability: maintain a sufficient institutional structure for development (finance, administrative capabilities…etc.).

Nowadays, the world has to deal with difficult challenges, like the adaptation and alleviation of climate change, quick urbanization, amplified demand of natural resources, growing insecurity in food; water; and energy, increased natural disasters, and resolution of violent conflicts (Behnassi et al, 2011). The solutions should be undertaken urgently, simultaneously, and it should take in account sustainability principles in every step of the solution plan.

One of the main goals for all nations is to build a strong-growing and sustainable economy that improves the standards of living by generating jobs and wealth (Shediac et al, 2008). This goal has led to an increasing research in the field of sustainable business growth, and to the recognition of diversification as an important tool towards sustainable economy. Yet, its importance has been underestimated both in management strategies and international business literature (Wiersema and Bowen, 2008), the reasons for slow progress in diversification studies are that researchers prefer to publish their best work in a few number of prestigious journals, causing competition and tardy publishing rate, and because of the complex interaction between diversification studies and other scientific disciplines (Wang et al, 2011).

Diversification is an essential perspective to make decisions about business structures (Ansoff, 1957), and adapting a process of expanding the firm"s core activities (or production), to include other products markets (Berry, 1971; Andrews, 1980; Gluck, 1985). It reflects an alteration in business activities as a response to changing opportunities, created by new technologies, or market indications (Barghouti et al, 2004). The shift in business happens in two main patterns:

- Vertical diversification; when the firm works on improving and expanding the core product"s quality and its value chain.
- Horizontal diversification: when the firm adds new product (s) to the main product, and gets involved in other products" markets, which sometimes leads to a geographical diversification by opening up to new markets. (Barghouti et al, 2004; Ali, 2004).

For example, a dairy farm which has meat production as a core activity can diversify vertically by processing the cattle and the meat in different ways (having a slaughter house, packaging the produced meat). Or if it has an extra land, it can uses the land to grow crops for feeders which are related to the main product (concentric diversification), or to be sold as a separate product (conglomerate diversification) (Venohr, 2007).

The history of diversification has been discovered to be long before the approval of sustainability principles. (Chandler, 1990) reviewed the industrial history of some American companies between 1890s till early 1950s, and showed the dramatic change in their business structure from a one-line production to a multi-line or full-line system. First, the establishments started with a vertical integration, followed by three types of diversification, to end with a strategy of continuous product turnover. The latter change depends on the applied science to improve the product"s quality, and invest new technologies to enhance production methods. He found that with diversification, the entrepreneur"s horizons became “multi-functional and multi-industrial” (Chandler, 1990). And diversification proved to be a great power for decentralization of business. Rumelt (1986) also pointed out that by 1974 in America; 86 % out of 500 studied firms were operated as diversified businesses versus 14 % were as a single business.

Agricultural production as a business has many reasons to diversify. Globalization and economic reform during the 1990s that increased competitiveness in the world opened markets, especially after the creation of the World Trade Organization (Ali, 2004), fluctuation in inputs" prices especially energy and crises in food safety (Lahtinen, 2009). Moreover, the pressure on cereal production in the developing countries caused a decline in its profitability, due to low output prices over the past three decades (Barghouti, 2004). For instance, the growth of cereals production in the Arab region declined from 38 in 1983-1993 to 28 % in the period 1993-2003 (World Bank, 2012). Such emphasis on cereal production resulted in a declined growth rate for both GDP (from 4.7 to 3.9%) and agricultural value added (from 3.1 to 2.5) during the corresponding period (FAO, 2005a). For all these reasons, donors were motivated to find new investment opportunities in the agricultural sector in the developing countries (Hallam, 2009) through diversification, and consequently the Global Direct Investment (FDI) rose 3 percent in 2011 over 2010 (WIR, 2012).

Cropping systems" diversification is one pattern of diversification in agriculture; it is understood as shifting from one sole crop production, to cultivate other varieties or crops in the farm (Shome, 2009). It can be applied through different methods like crop"s rotation, intercropping, agroforestry, hedgerows and windbreakers. These methods vary depending on the heterogeneity in resources within the farm (Barghouti, 2004), the soil and water resources, the biological factors, the economic factors, the skills and management factors. They all contribute in the decision making for crops" diversification. The main benefit of crops" diversification in agriculture is strengthening sustainability growth within the system. By harvesting the advantages of diversified agroecosystem like the suppression of pests and diseases, mitigation and buffering of climate variability and increase production (Lin, 2011), creating different microenvironments in the field by growing different crops, distribute the demand of inputs like labor and machinery; diversify cash flow sources (Barghouti, 2004), increasing export and competitiveness in local and international markets, generating new jobs opportunities (Shome, 2009).
For a proper examination of the potentials for cropping systems" diversification in the North-Eastern farming systems in Syria, it is needed to analyse the system to gain a comprehensive image about its current situation. Then it is possible to work on finding suitable diversification potentials within the capacity of the existing ecosystem in the Syrian agriculture.

1.2. Syrian agricultural Background:

The Syrian Arab Republic or Syria (Figure 1) is a Middle Eastern country located on the east coast of the Mediterranean Sea, encircled by Turkey in the north, Iraq in the east, Jordan in the south, Lebanon and Palestine in the west (MSEA, 2003). The population is 24.5 million of which 21.3 million actually living inside the country borders (CBS1, 2011; CBS3, 2011). The total area is 18.5 million hectares, about 6.04 million hectares are arable land which represents 32% of total area, but only 5.6 million hectares are invested in agriculture (MAAR1, 2010). Syria is divided into 14 governorates (administrative regions), 61 districts and almost 6309 villages. There are about 700 thousand agricultural holdings all over the country (MEDSTAT II, 2009).

The climate in Syria is Mediterranean, characterized by rainy winter and hot dry summer, with an existence of two short transitional seasons to separate between winter and summer (Jones, 2001).

For agricultural planning purposes, the Syrian Ministry of Agriculture and Agrarian Reform (MAAR) has divided Syria into five agro-ecological settlement zones characterized by rainfall amount per year and the temporal distribution of rainfall as following:

- First Zone: it covers almost 15% of the total area of Syria with average precipitation is greater than 350mm per year. This zone is divided into two sub-zones, zone 350-600 mm per year and another with rainfall greater 600 mm per year.
- Second Zone: covers 13% of the area, rainfall average between 250-350 mm per year, and the rainfall is adequate in two out of three seasons.
- Third Zone: covers 7% of the total country‟s area, annual precipitation greater than 250 mm per year, during more than half of the seasons.
- Fourth Zone: covers 10% of the total area, and annual rainfall between 200-250 mm per year in more than half of the seasons.
- Fifth Zone: it covers 55% of Syrian total area, the annual rainfall average less than 200 mm per year in more than half of the seasons (Jones, 2001).

Agriculture is the second major economic sector after the oil industry. Besides the basic agricultural production, the bulk of exports and manufacturing are based on agriculture and agro-processing activities, and a huge proportion of trade, commerce, and services are likewise depending on agriculture. It was the largest productive sector in 1999 accounted for 7.3 % of GDP (Sarris, 2001).

Agricultural development targeted three main objectives; insuring food security, generate new jobs‟ opportunities and close the gaps of regional disparities in the country (CEDARE, 2009). To achieve these goals, the Syrian government has adopted the five-year plans since the 60s, and used it as a basis to structure its domestic economy and target orientation. Despite the fact that 98 % of the national agriculture production exists within the private sector in a small family-based holdings (Westlake, 2001), the government heavily intervened in planning, pricing, processing and marketing of seven major crops, called *strategic crops* which are: wheat, barley, cotton, lentil, chickpeas and tobacco. The farmers are issued with a license to grow specific crops according to the government‟s five-year plan design, and they are legally obliged to comply with the license, in turn, they get to obtain subsidies, inputs and services (Westlake, 2001).

The cultivation area in Syria is part of the *Fertile Crescent*, it extends from Al-Jazira plain and the Euphrates river basin in the North-East, through northern part then to the south along the coastal plains (TID, 2011) as shown in (Figure 1). The strategic crops are distributed over different regions of the cultivation area according to the suitability of climate conditions for each crop. They occupy 75% of the cultivation area, consuming 89% of the irrigation water and contribute to 60% of value added in agriculture (IFAD, 2009).

The outcome of this development strategy for agriculture has been: 1- the adoption of self-sufficiency strategy for main food commodities. 2- Major role played by the state in production and trade for major commodities and inputs. 3- Almost complete monopoly of foreign trade by the state. 4- The establishment of many facilities by the public sector, for food and agro-processing activity (Sarris, 2001).

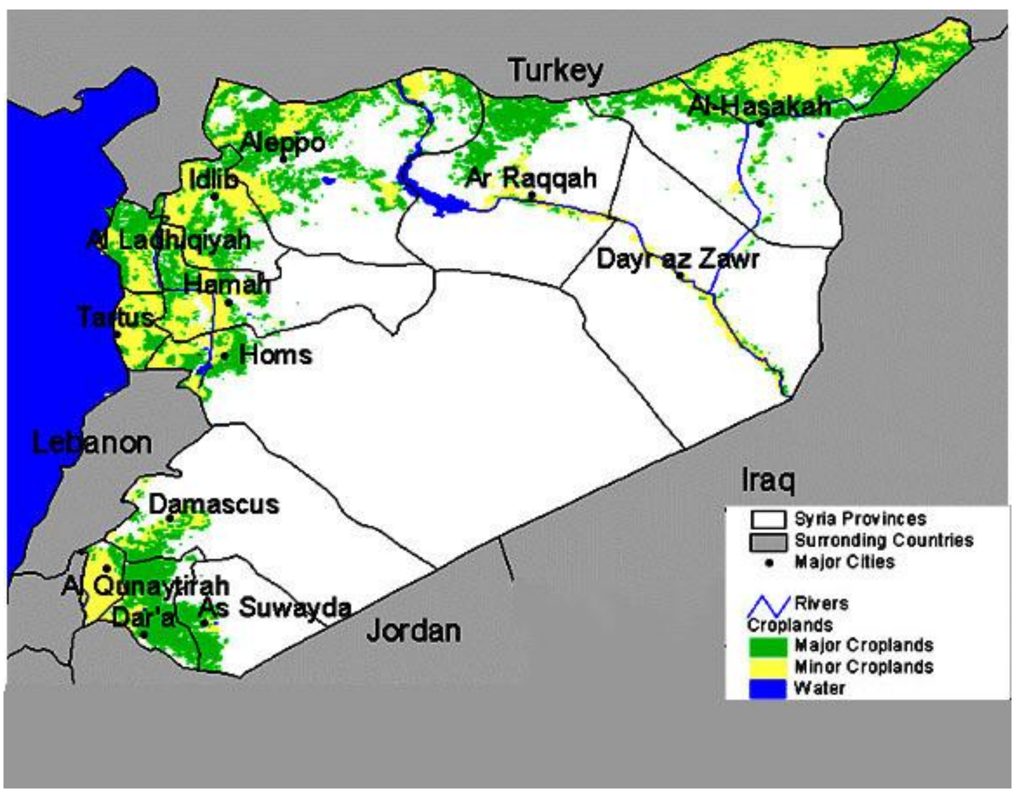

Figure 1: Cultivation area in Syria including major and minor croplands for wheat and barley. (Source: FAS, 2002).

Environmental analysis showed many problems that the government should pay attention to, like the loss and the contamination of groundwater resources, land degradation in different forms, air pollution and the loss of biodiversity and natural resources (MSEA, 2003).

1.3. Aim of the study:

This study aims to:

- Assess the agricultural practices in the cropping system (s) in North-Eastern Syria from sustainability point of view using SAFA guideline.
- Propose suggestion to modify practices or cropping system (s) if needed.

1.4. Research questions:

1- Are the farming systems in North – East part of Syria (Al-Hassakeh) sustainable according to SAFA guideline?

2- How will crop diversification affect sustainability for the farmers in North-Eastern part of Syria?

2. Materials and methods:

2.1. Studying area:

Al-Hassakeh governorate (Hasakeh or Hasakah in some references) is situated in the North-Eastern plateau of Syria (Figure 2). It has 1.6 million inhabitants according to the civil affairs records, representing 6.5 % of total population in Syria (CBS1, 2011). The total area of this governorate is 2.3 million hectares of which 1.5 million hectares are arable and 1.2 million are actually cultivated (CBS2, 2011). 22.7 % of the total arable land is irrigated, 54.5 % is rain-fed and 22.6 % is fallow (MAAR1, 2010). The rest 32.3 % is non-cultivated land of which 11 % as public infrastructure and 2.7 % for lakes and swamps, 67.9 % pastures, 12.3 % forests and 5.3 % rocky and sandy land (MAAR1, 2010; CBS2, 2011). In 2009 the cultivated land was distributed over the agro-climatic zones as shown in (table 1):

Table 1: land area by agro-climatic zones in Al-Hassakeh governorate (1000 ha), (adopted from Cafiero et al, 2009).

Al-Hassakeh	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Total
Irrigated	162	167	44	32	33	437
Rain-fed	311	220	109	205	1	846
Fallow	18	58	11	90	12	190
Total cultivated land	491	445	164	327	47	1473
uncultivated	83	47	94	186	451	860
Total area	573	492	258	512	498	2333

The Euphrates River and its tributaries (Al-Khabour and Al-Balekh) run across the plateau, providing a valuable source of water for agriculture and human settlement (TID, 2011). The area between Tigris and Euphrates rivers is called Al-Jazerah, which is mostly occupied by Al-Hassakeh governorate. Al-Jazerah is divided geologically into three regions; the upper Jazerah, the lower Jazerah and the Euphrates Valley (Jones, 2001).

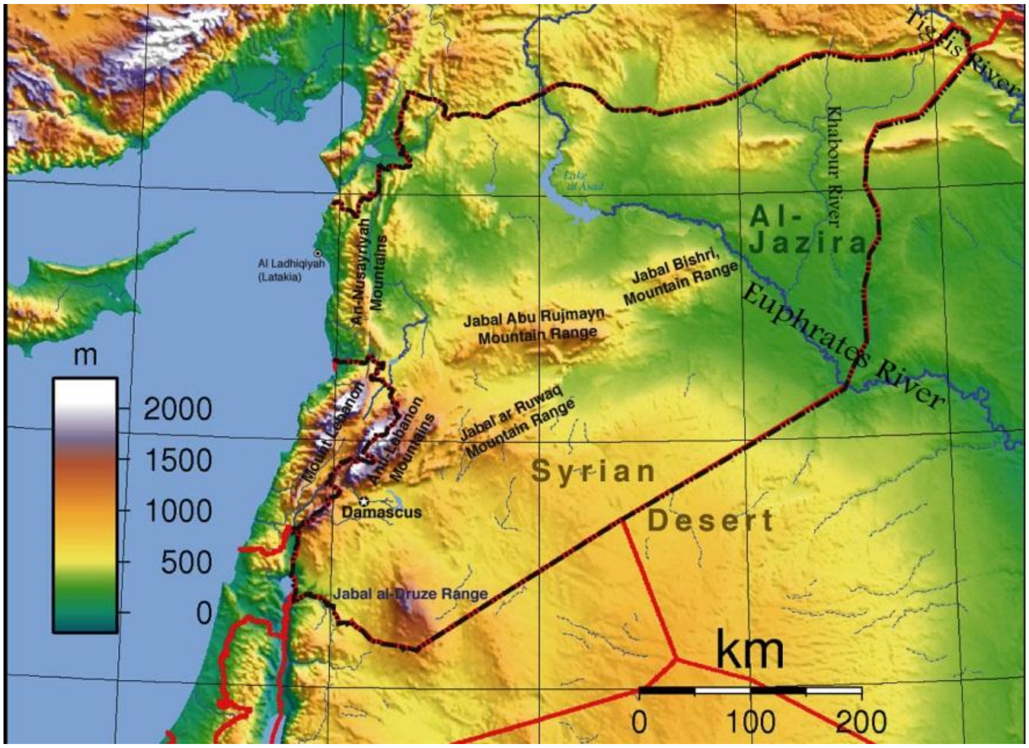

Figure 2: Topography of Syria, source: (Nationsonline, 2013)

Figure 3 : Syrian Arab Republic shows neighboring countries, governorates division, and the Euphrates River and its attributes. Source: (Encyclopedia Britannica, Inc. 2009).

Administratively, the governorate of Al-Hassakeh is separated into five districts from north to south; Al-Malikiyah, Al-Qamishli, Ras Al-Ayn (or Ras Al-Ain), Al-Hassakeh city, and Al-Shaddadi. The regions differ in climate conditions as they extend over many settlement‟s agro-ecological zones, especially in precipitation ratio. While it was up to 354 mm per year in Al-Malikiyah in far north of Al-Hassakeh, it dropped to 118 mm per year in Markada in the south in 2011 season (MAAR, 2012).
Al Jazerah and Euphrates region is characterized by its semi-arid Mediterranean climate, which can be classified as a desert-like Mediterranean climate. In general, the summer season is dry and hot with lack of rainfall for almost six months and a maximum temperature of 43 Celsius degrees (Galli et al, 2010), whereas the winter season is rainy and cold with a minimum temperature of 2 degrees Celsius. In comparison with other regions in Syria, Al Jazeera and Euphrates region is the richest in natural resources, and particularly water (MSEA, 2003), and this plateau of grassland is an important agricultural region, especially for cereal crops production (TID, 2011).

2.2. Method of farming system's assessment:

The SAFA guidelines (FAO, 2012a) will be used to evaluate the agricultural practices and the sustainability of the farming system (s) in the studied area.

2.2.1. Aims, principles, dimensions and categories:

The SAFA guidelines are a holistic assessment of the sustainability performance in a firm or any part of the food production chain, it aims to support an effective sustainability management towards environmental friendly, socially fair, and economically feasible development. The goals should be achieved through development, diffusion and continuous improvement of generic and science - oriented methodologies.
The principles of SAFA guidelines comply with the Bellagio STAMP – Sustainability Assessment and Measurement Principles- which are a set of interrelated principles that were published in 1996 for the first time and updated in 2009 by a group of international experts in Bellagio-Italy. The principles according to (Pinter et al, 2012) are:

1- Guiding vision: the assessment process towards sustainable development is guided by a goal of delivering well-being within the capacity of the biosphere to be sustained for future generations.
2- Essential considerations: the assessment considers the principal social, economic, and environmental components of the system and its interactions. It also considers

the suitability of governance mechanisms, the dynamics and complexity of current and intended changes, the impacts and risks across boundaries, the implications of decision making and its trade-offs and synergies.

3- Adequate scope: the assessment adopts an appropriate time horizon to capture the effect of short and long term change, and consider the geographical range of the change.
4- Framework and indicators: the assessment is based on a conceptual framework shows main domains that indicators should cover, the most recent and reliable data, projections, models…etc. to predict trends and establish scenarios.
5- Transparency: the assessment ensures that the results are accessible by the public, explains the choices; disclose data sources, methods, and potentials of interest"s conflicts.
6- Effective communications: to attract audience, the assessment process uses a clear simple language, presentations, and data elaborations.
7- Broad participation: to strengthen legitimacy and relevance, assessment should reflect public views in a proper way, and early engagement with the assessment users.
8- Continuity and capacity: the progress of assessment requires repeated measurements, responsiveness to change, investment in development, and continuous learning and improvement.

Dimensions and categories of the SAFA guidelines are shown in table 2:

Table 2: Dimensions and categories of SAFA guidelines

Environmental integrity	Economic resilience	Social wellbeing	Good governance
Energy	Strategic management	Human rights	Participation
Climate	Operating profits	Equity	Accountability
Air	Vulnerability	Occupational health and safety	Rule of law
Water	Local economy	Capacity building	Fairness
Soil	Decent livelihood	Food and nutrition security	Evaluation
Material cycles		Product quality	
Wastes			
Biodiversity			
Animals			

The reflection of these categories in the SAFA guidelines is driven by the degree of relevance to different operations. For example soil is not relevant in fisheries assessment.

2.3. Data collection:

Obtaining current and up-to-date information in any academic studies for the Euphrates region (Turkey, Syria, and Iraq) remains difficult. This is due to the local political conditions and policies which restrain access to fieldwork data (Beaumont, 1996). Therefore, it was not possible to cover all the dimensions and the indicators of SAFA guidelines, it is rather as much as possible of the recent available and relevant data was used in this study, and collected from the internet. Data was collected mainly from the Syrian ministries and administrative websites like the Ministry of Agriculture and Agrarian Reform in Syria (MAAR), the Central Bureau of Statistics (CBS), Central Bank of Syria, and International Center for Agricultural Research in the Dry Areas (ICARDA). International websites like FAO, FAOSTAT, World Bank. The use of SLU‟s library search engine is a great help especially with link to reliable international databases, Google search engine is another tool used to ease the process of finding articles.

3. Results & Discussion:

3.1. Current agricultural practices in Al-Hassakeh:

Crops in Al-Hassakeh governorate vary due to the differences in its areas (climate, water, soil…etc.), in general table 3 shows the cultivated crops:

Table 3: Cultivated crops in Al-Hassakeh showing season, area, accumulated production and yield in 2010, (compiled from MAAR2, 2010).

crop	Irrigated			Rain fed			Totals		
	Area 1000 ha	Production 1000 ton	Yield ton/ha	Area 1000 ha	Production 1000 ton	Yield ton/ha	Area 1000 ha	Production 1000 ton	Yield ton/ha
Winter crops									
Wheat	261	758	3	391	346	0.8	652	1104	1.6
Soft wheat	206	575	2.7	320	251	0.7	526	826	1.5
Durum wheat	55	183	3.3	70	95	1.3	125	278	2.2
Barley	30	42	1.3	418	75	0.1	448	117	0.2
Lentil	4	5	1.2	38	18	0.4	42	23	0.5
Chickpeas	-	-	-	0.5	0.5	1	0.5	0.5	1
Dry broad beans	0.05	0.08	1.5	0.04	0.004	0.1	0.09	0.08	0.9
Dry flowering Vetch	0.06	0.1	1.8	1	0.3	0.3	1.06	0.4	0.3
Cumin	-	-	-	6	3	0.5	6	3	0.5
Black cumin	-	-	-	0.02	0.06	2.7	0.02	0.06	2.7
Grazing vetch	0.08	0.8	10	-	-	-	0.08	0.8	10
Grazing barley	-	-	-	4	19	5	4	19	5
Grazing clover	0.05	0.5	10	-	-	-	0.05	0.5	10
Broad beans	0.2	0.6	3	-	-	-	0.2	0.6	3
Cabbages	0.01	0.03	3	-	-	-	0.01	0.03	3
Cauliflower	0.04	0.1	3	-	-	-	0.04	0.1	3
Leaf beet	0.06	0.2	4	-	-	-	0.06	0.2	4
Green onion	0.6	2	3	-	-	-	0.6	2	3
Lettuce	0.03	0.2	5	-	-	-	0.03	0.2	5
Other vegetables	0.2	1	6.9	3	2	0.7	3.2	3	1

Summer crops									
Cotton	53	154	2.9	-	-	-	53	154	2.9
Maize	0.2	0.9	4	-	-	-	0.2	0.9	4
Sunflower	0.1	0.3	2	-	-	-	0.1	0.3	2
Tomato	0.1	18	14	-	-	-	0.1	18	14
Watermelon	4	38	9	-	-	-	4	38	9
Melon	0.6	6	9.8	-	-	-	0.6	6	9.8
Potato	0.1	0.5	5	-	-	-	0.1	0.5	5
Spring potato	0.09	0.5	5	-	-	-	0.09	0.5	5
Haricot beans	0.04	0.4	10	-	-	-	0.04	0.4	10
Pumpkin	0.003	0.06	20	-	-	-	0.003	0.06	20
Eggplant	0.4	8	20	-	-	-	0.4	8	20
Cucumber	0.9	18	19	-	-	-	0.9	18	19
Garlic	0.05	0.2	2.9	-	-	-	0.05	0.2	2.9
Okra	0.07	0.7	10	-	-	-	0.07	0.7	10
Squash	0.2	4	20	-	-	-	0.2	4	20
Dry onion	0.9	13	15	-	-	-	0.9	13	15
Green pepper	0.3	3	10	-	-	-	0.3	3	10

Traditional agriculture in the Al-Khabour basin basically built on fall-sown cereals that are ripen in late spring, and an intensive summer cash crop when irrigation is possible (Hole, 2007a). In Al-Hassakeh, farms have a cropping pattern consists of 70 % winter wheat and 30 % of cotton as summer cash crop in most cases (Ortega & Sagardoy, 2001). Maize and barley could be found in the area between Al-Hassakeh and Al-Rakka (Corradi, 2006), they represent 66 % and 39 % respectively of the national production (Sadiddin, 2009).

In 2005 a percentages of 62.4 and 63.3 in zones 1 and 2 respectively in Al-Hassakeh were dedicated for wheat cultivation, covering around 35 % of total agricultural land in the governorate to provide 55.1 % of total wheat production in Syria (Cafiero et al, 2009).

Cotton is cultivated over 2.27 % of the total area. The climatic conditions are not preferable for its cultivation in this area, because of the relative low rainfall, and high evaporation. This issue was solved by converting the whole cotton cultivation area to an irrigated area (Chapagain et al, 2005) and most of it is located in the Northern regions of Al-Hassakeh. The emphasis on cotton importance appeared after it became one of the major sources of foreign currency, and Al-Hassakeh became a specialized in its production where it produces over than 40 % nationally (Cafiero et al, 2009).

Farmers tend to grow as much as possible, and utilize all growing seasons. They apply some kind of rotation as an economic measure rather than for conservation reasons

(Corradi, 2006). The rotation of wheat-cotton is the most common cropping form (Cafiero et al, 2009), and few farmers adopt fallow period in their rotation, this is mostly because of water shortage. But it is progressively disappearing due to land use pressure to the benefit of monoculture (Ryan, 2002).

The native fertility of the Mediterranean region is insufficient to continuously support economic yields of modern crops. This is because the calcareous soils lack sufficient nitrogen and phosphorous. „N is virtually always needed for non-legume crops, so economic yields are impossible without fertilization‟ (Ryan, 2004).
The consumption of fertilizers is the most in Al-Hassakeh and Aleppo governorates; they consume about 50 % of the total fertilizers‟ consumption in Syria (Parthasarathy, 2000). Estimates in 2010 shows that the consumption in Al-Hassakeh accounted for 43.9 % of total fertilizers consumption in Syria, it was 67.7 Mt of all fertilizer‟s types of which 48.2 of N fertilizers and 19.4 of P fertilizers (MAAR1, 2010)

The amount of recommended fertilizers differs according to water availability and application and the crop variety requirements, in 2003, the government recommended the following applications of fertilizers for some crops:

Table 4: Recommendation for fertilizers rates by crop and agro-zone, source (FAO, 2003).

Crop	Type	Zone	N fertilizers (Kg/ha)	P fertilizers (Kg/ha)
Wheat	Irrigated		150	100
Rain fed wheat	local	1 – 2 - 3	80- 60- 30	60- 60- 30
Rain fed wheat	HYV*	1 - 2	100- 80	80- 60
Barley	Rain fed	1 – 2 - 3	50- 40- 20	40- 40- 20
Cotton	Irrigated		200	150
Maize	Irrigated		120	80
Potatoes	Autumn cultivation		150	120
Potatoes	Summer cultivation		120	120

HYV*: high yield varieties.

In general, farmers in Syria use fertilizers without the consultation of local extension assistants, and many of them have used fertilizers for 15-20 years with little knowledge about the recommended amounts or types that they have to use and they only rely on their own and inherited experience (FAO, 2003). It was found that farmers use a wide range of fertilizers‟ strategies for rain-fed crops especially those related to Nitrogen use, as for phosphate they use P_2O_2 once simultaneously with planting.

Farmers are provided by seeds, fertilizers, machinery, fuel and loans at subsidized prices by the government in Syria, the government also plans the production levels of strategic crops annually, and guarantees prices of wheat and cotton for farmers (Hole, 2007a).

3.2. Environmental aspects:

3.2.1. Water:

The main sources of water in the North-Eastern part of Syria are the Euphrates River (runs for 680 Km in Syria) and its attributes Al-Balikh and Al-Khabour (Figure 3). The great springs of Ras El-Ain in the upper Khabour Valley, and Ain El-Aros used to provide a significant flow of 40 and 6 m^3 per second respectively, but the flow had decreased and became very small due to overexploitation (Ortega & Sagardoy, 2001). Other springs like Al Kebrit springs that support Al Khabour River in the area also had a decline in flow from 50 m^3 per second to almost 0 m^3 in the last few years (Galli et al, 2010). Lake Al-khatounieh is another water source for irrigation in Al- Hassakeh and Tigris Rivers also runs in the far North-East corner on the boarders with Iraq for 44 km.

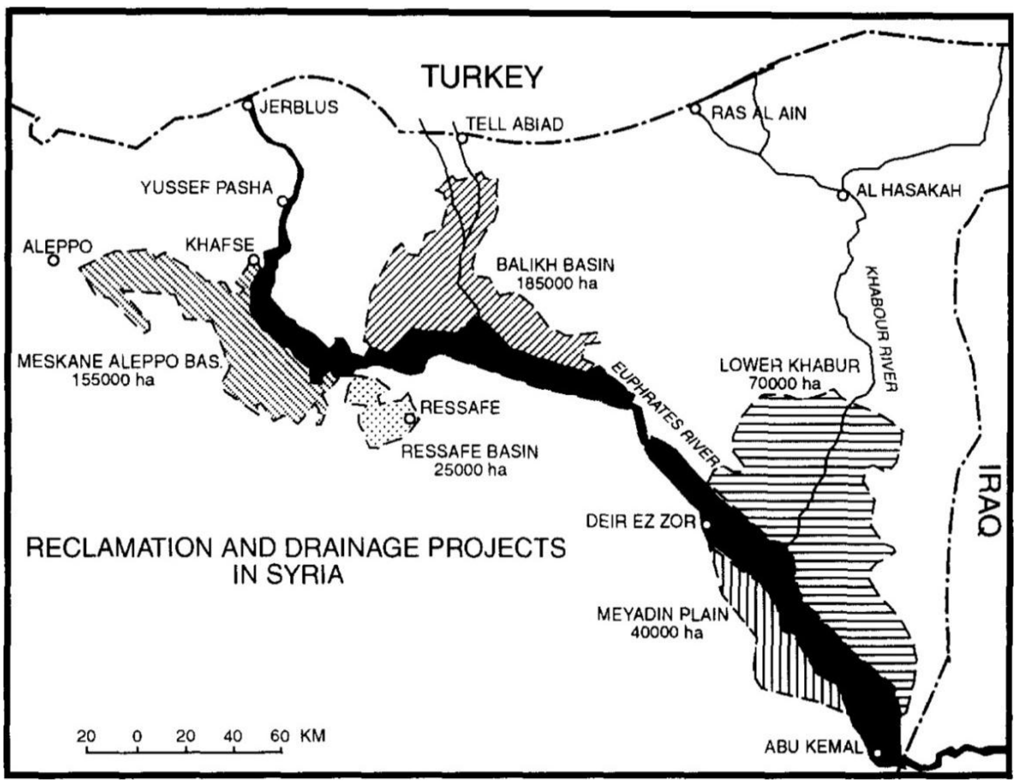

Figure 4: Rivers and attributes in North-East Syria, showing irrigation projects. Source (Beaumont, 1996)

The Euphrates is accounted for more than 80 % of the total water supply in Syria (FRD, 2005) and its valley has the largest irrigated area in Syria (Ilaiwi, 2001), in Figure 4 it is illustrated that agricultural use represents 86 % of total basin"s water use, whereas domestic and industrial purposes use represent 9.4 and 3.8 % respectively. A sum of 16 % is lost for evaporation annually (Cafiero et al, 2009).

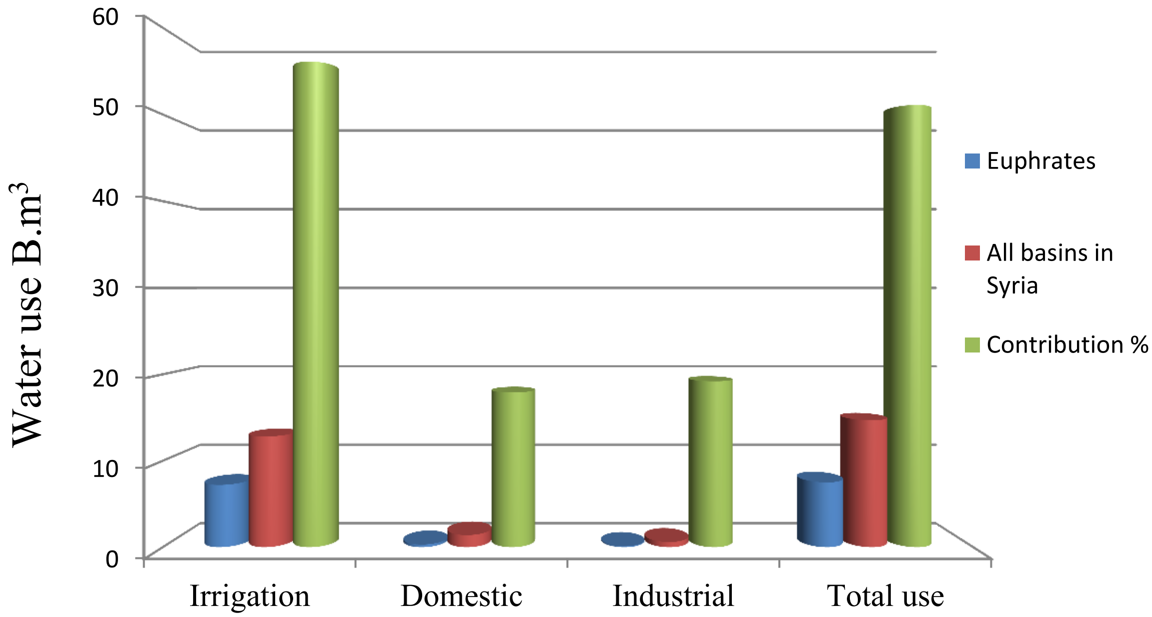

Figure 5: **Use an availability of water in Euphrates basin, compiled from (Salman & Mualla, 2003).**

Al- Khabour river is a tributary of the Euphrates River, it is fed by springs which continuously provided a base flow of 40 m^3 per second in 1980, declined to 14 m^3 per second in1998, then in 2003 the flow dropped to become only 7.38 m^3 per second (FAO, 2005b), the most recent estimates in 2007 showed that the average annual flow of the river became 5.9 m^3 per second (MAAR, 2007). The annual average of water resources renewal in the Al-Khabour basin in the period 1992 to 2003 was approximately 2447 million m^3, whilst the total water consumption was about 4233 million m^3. An estimate of 97 % of this amount was for irrigation and the rest were for domestic and industrial use (FAO, 2005b).

In 2001, the Euphrates and Tigris rivers had a positive balance of 732 million m^3 per year in total, adversely Al-Khabour has a sever deficit of -3105 million m^3, causing an overall negative water balance of (-3104) million m^3 per year on the national level as illustrated in Figure 5. The reasons could be the increased demand on water from Al-Khabour for irrigation accompanied with vibrant annual rainfall average and the occurrence of dry years, and the mismanagement of water use in the flowing springs" area.

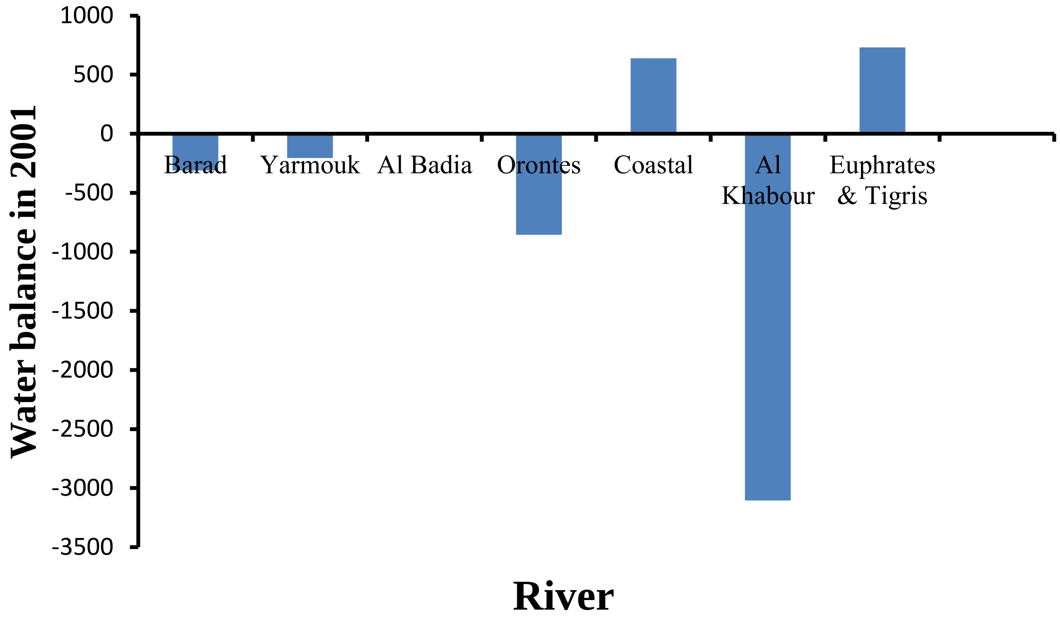

Figure 6: Balance in Syrians water basins, compiled from (Ortega & Sagardoy, 2001)

Groundwater and wells are accounted for 37 % of the total water resources in Syria and it is prevailed in the governorate of Al- Hassakeh. In the year 2001 Al-Hassakeh had 44 % of the total irrigated land using wells (Ortega & Sagardoy, 2001). The utilization of wells is governed by obtaining a license to drill and extract groundwater, this license needs to be renewed every ten years. The problem is that a large share of wells in Al-Hassakeh is illegal (Jones, 2001), for some reason farmers don"t comply with that law and dig illegal wells. In 2002 Al-Hassakeh had 29098 wells, 18747 wells of them are legal and 10351 which is about 35 % of total wells are illegal (Salman & Mualla, 2003).

The irrigated land in Syria estimated to be 27.9 % of the total cultivated area (CBS2, 2011), and the size of the irrigated holding differs between governorates. The largest irrigated holdings are found in the North-East region (Al-Hassakeh and Al-Rakka) as shown in Figure 6.

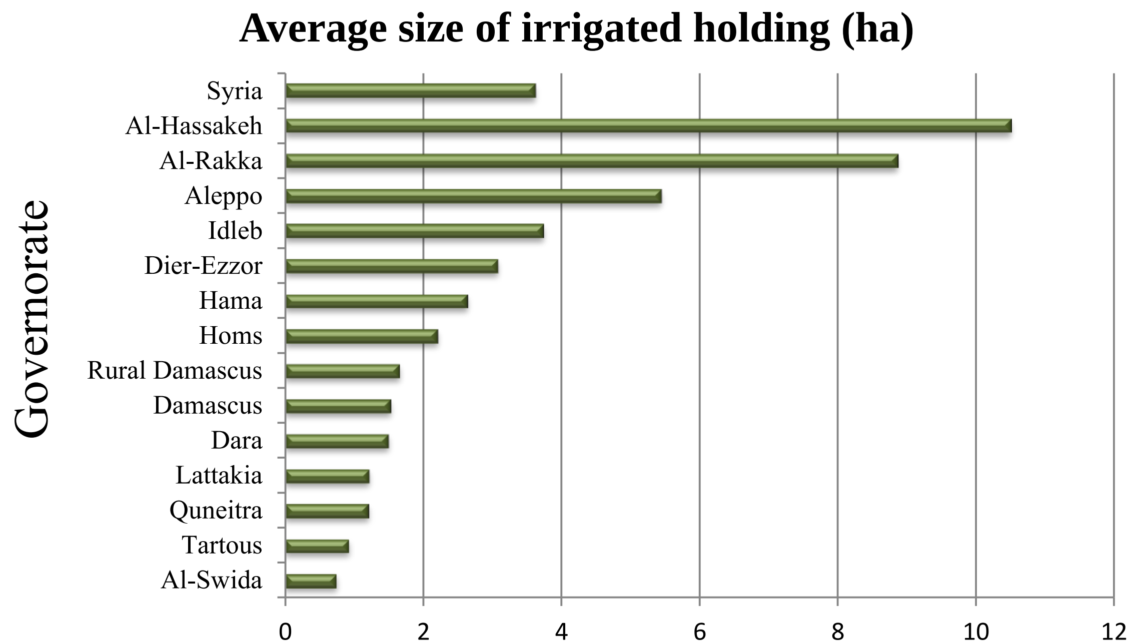

Figure 7: **Average irrigated holdings by governorate (ha), (Modified from: Ortega & Sagardoy, 2001).**

Irrigation methods vary in Al-Hassakeh according to many factors like water availability, irrigation system establishment and running cost, available fuel, soil properties and investment size (land and capita). Traditional flooding irrigation system is used in 97.5 % of the irrigated and mostly for cereals, furrow irrigation for vegetables, and basin irrigation for trees are the common irrigation practices. The improved irrigation technologies like sprinklers is used in 2.1 % of the land over 30 thousand hectares in Al-Hassakeh, Aleppo and Homs governorates together (IFAD, 2001), and 0.34 of them use drip irrigation (Sadiddin, 2009). The government built many networks for irrigation especially along the Euphrates and Al-Khabour rivers, consequently, farms tend to become specialized in irrigated wheat, cotton, and red-lentil in that area to improve productivity (Giuliani, 2007). The reasons for this variation might be adequate rainfall quantity and suitable quality of used water for irrigation.

The excessive extraction of ground water can cause a change in the soil profile texture, the unstable portions of land has a high risk of collapsing. The creation of hollow caves in the deep soil profile jeopardizes the infrastructure stability. In some sites, such unsustainable water management practiced and caused land collapse (Galli et al, 2010).

Figure 8: **collapse site in Ras Al-Ain-Al-Hassakeh governorate, (Galli et al, 2010).**

(Yigezu et al, 2011) conducted a survey study on the use of wells‟ water from different regions in Al-Hassakeh, by interviewing 78 sample farmers out of an original 182 sample farms. The results show that the amount of irrigation water and its relative salinity are the main causes of soil salinity as illustrated in table 5:

Table 5: **The effects of water salinity and quantity on yield and soil salinity, (source: Yigezu et al, 2011).**

Location	Water salinity (EC) Ds/m	Yield ton/ha	Applied water quantity 1000m^3/ ha									
			Crops season calendar 1997/1998					Crops season calendar 1998/1999				
Am-Hajar	2.6	4.35	2.8	3.4	4	4.6	5.1	8.3	9.9	12	13	15
Hassakeh	3.8	4.07	13	15.5	18	21	23	13	16	18	21	24
Bab Al-Faraj	4.4	3.35	9.9	11.9	14	16	18	14	17	20	23	26
Salmaseh	5.3	2.64	16	18751	22	25	28	19	23	27	31	34
Tel-Brak	7	3.14	15	18.4	22	25	28	16	20	23	26	29

There is also a water pollution problem due to the excessive use of chemical fertilizers and pesticides in Al-Hassakeh, with an absence of measurements or legislation to control leaching amounts of surpluses to the groundwater. The supported prices of strategic crops and energy inputs (fossil fuel in particular) were strong incentives for farmer to overexploit groundwater for irrigation (Salman & Mualla, 2003). In this case, the tremendous pressure on this water resource over the years is encouraged by the governmental policies.

Since 1986 the International Center for Agricultural Research in the Dry Areas (ICARDA) with cooperation with Syrian Ministry of Agriculture and Agrarian Reform (MAAR) started a project to promote Improved Supplemental Irrigation (ISI) (Figure. 8) and transfer it to the spring wheat‟s farmers in Al-Hassakeh among other areas with focus on the irrigation schedule (Salkini & Ansell, 1992). The Syrian government recently assembled legislations and standards for adopting modern irrigation systems like drip, sprinklers, undersurface irrigation. These methods mainly conserve water resources, they also fit to the climate conditions, agricultural holding‟s size, and farmer‟s skills in many Syrian areas (MunlaHasan, 2007).

Figure 9: methods of improved supplementary irrigation (ISI). Compiled from: (Owies & Hachum, 2012)

The irrigation history in Yigezu study - that was described earlier- in Al-Hassakeh governorate for the 78 farmers in table 6 shows that there is an increased pressure on water resources in Al-Hassakeh due to the expansion of irrigated areas, it is noticed that between 1980 and 2009 rain fed wheat disappeared to be replaced by irrigated wheat. Also it shows that there is an increased usage of Improved Supplementary Irrigation (ISI) method versus the traditional irrigation methods. However, traditional irrigation methods still the prevailing, where ISI represents 22.3 % of all irrigated land (Yigezu et al, 2011), which are low water use sufficiency methods.

Results show that Al-Hassakeh has a variation in water availability; while the upper Al-Khabour Valley has abundance in water because of high precipitation and the existence of spring"s area in Ras Al-Ain, the middle and lower parts suffer scarcity of water due to low precipitation ratio, and the overexploitation of groundwater in the spring"s area. The excavation of illegal wells increased the pressure on water resources in the area causing them to decline, and water table of Al-Khabour River has been lowered which consequently was the main reason for it to run dry every summer annually since 1999 in the lower Khabour River. This phenomenon has not been seen in the history of the area (Zaitchik et al, 2002) and it caused an internal migration of some families seeking a better life conditions either in urban or in surrounding rural areas. Moreover, the establishment of state canals in the area affected the settlement patterns, and led to a change in the demographic distribution in Al-Hassakeh. This strategy was observed over a long humanity"s history (Scott, 1999).

Table 6: Results summary of a survey from Al-Hassakeh shows irrigation History for 78 sample farmers, (Adopted from: Yigezu et al, 2011).

	Year						
	1980	1985	1990	1995	2000	2005	2009
Total size of the 78 households (1000 ha)	3	3	3	3	3	3	3
1- Total **wheat area** (1000 ha)	1.4	2.2	2.5	2.5	2.5	2.5	2.5
- rain fed wheat area (1000 ha)	0.8	0.2	0	0	0	0	0
- ISI irrigated wheat area (1000 ha)	0	0	0.2	0.2	0.5	0.6	0.7
- Traditionally irrigated wheat area (1000 ha)	0.6	2	2.3	2.3	2	1.9	1.8
2- Total area of **other crops** (1000 ha)	0.8	0.5	0.5	0.5	0.5	0.5	0.5
- Area under others rain fed crops (1000 ha)	0.7	0.2	0	0	0	0	0
- Area under other traditionally irrigated crops (1000 ha)	0.1	0.3	0.5	0.5	0.5	0.5	0.5
- Area under other crops irrigated with ISI (ha)	0	0	0	0	0	0	0
3- Fallow (1000 ha)	0.8	0.3	0	0	0	0	0
Used water by the 78 households (Mm^3)	2.7	6.8	11.7	11.6	11.1	10.9	10.8
- Water used in wheat fields (Mm^3)	1.5	2.6	6.1	6.1	5.6	5.4	5.3
- Water used in cotton fields (Mm3)	1.2	4.3	5.7	5.6	5.5	5.4	5.5
- Water used in traditional irrigation (Mm3)	2.7	6.8	11.5	11.4	10.3	9.9	9.7
- Water used in ISI (Mm3)	0	0	0.3	0.3	0.8	0.9	1.1

3.2.2. Soil:

Syrian soils are classified into 5 types according to the USDA soil‟s taxonomy. The Desert and gypsum soils represent 51% of the total area of the country, and they are widely spread over the North-Eastern, Eastern and South-Eastern parts of Syria (NAPC, 2003). Entisols also cover 16.9% of the country‟s land, and they are the predominant type of soils in the Euphrates valley (Jones, 2001). The Entisols in Al-Hassakeh are characterized by a slow profile development; consist of different parental materials, commonly found with Aridisols and they have a wide range of productivity potentials (PSS, 2012). In general, Al-Hassakeh soils extend over different agro-climate zones vary mainly in rainfall ratio and temperature, which in turn creates a variation of physical weathering factors that affect parental material transformation and produce diverse types of soils (Gliessman, 2007) in the Euphrates Valley and Al-Hassakeh governorate. The soils are insufficiently developed and sometimes shallow, lies over a substrate of gypsum, exposed to salinization in the middle and lower Al- Khabour Valley (USAID, 1982) due to desert-like climate. In contrast, the upper valley has wetter, deeper, well-drained soils, where its fertility could be preserved by a fallow cycle (Hole, 2007b).

Soils suffer several types of degradation like water and wind erosion, salinization(table 7) and chemical pollution, due to that there is a shortage in suitable quality of agricultural land, especially for small holdings (Kaisi & Al- Zoughbi, 2007).

Table 7: showing share, type and level of severity land affected by degradation in Syria. Source: (Jones, 2001; Sarris, 2001)

Degradation type	Level of degradation (10^3ha)			Total area (10^3ha)	percentage
	Slight	Moderate	Severe		
Water erosion	902	127	29	1058	5.7
Wind erosion	1210	380	30	1620	8.7
Sand accumulation	11	267	130	408	2.2
Salinization	15	20	90	125	0.6
Total	2138	794	279	3211	17.3

The north-east and south of the Euphrates River are the most affected areas by wind erosion, and the transported sand particles reduced the grazing area between al Balikh River and Al-Rakka (Jones, 2001). It was estimated that 12 tons per hectare per year of soil are lost because of wind erosion in al Badia region, and 570 thousand tons from national soil per day are aggregated (jones, 2001), and the migratory sands affected 0.2 ha of the irrigated land in Euphrates Valley (MSEA, 2003). The degradation of soil was mostly caused by the deep tillage that removed the native vegetation exposing the soil to water and wind erosion. It seems that The mechanization in the barley„s rain fed cultivation areas started wind erosion since the 1950s. Moreover, it destroyed the soil"s contents of organic matter which affected soil structure and properties (Ilaiwi et al, 1992).

The largest areas affected by salinization also exist in the Euphrates and Al- Khabour valleys (Westlake, 2001). Since the 1940s, salinization started to appear in the valley mainly due to the misuse of irrigation with an absence of proper drainage systems (Ilaiwi, 2001). By the 1980s, salinity in the area - expressed as electrical conductivity EC- exceeded 8 ds/m for 50% of the soil"s samples taken from Lower Euphrates Valley, and 16 ds/m for more than 30% of the samples (Abd Al-Kareem et al, 1994). It was estimated that 3 – 5 thousand hectares of the irrigated land became unusable for cultivation every year due to salinization (THF, 1994). The reason is that in the arid hot areas like Al-Hassakeh, the excessive use of water for irrigation, with the deficiency of adequate drainage systems resulted in a surpluses of unabsorbed water by the plants, water ultimately evaporate leaving its high contents of salts on the surface, gradually causing salinity of soils (Yigezu et al, 2011).

Nationally, irrigated wheat areas increased in the period 1987 till 1998 from 229 thousand hectares to 690 thousand hectares, most of it in Al-Hassakeh. The expansion in area was because of the expansion of land size supplied with water, and the use of marginal land (Westlake, 2001). The rangeland accommodates valuable biodiversity of animals" and wild plants" species and the investment of this land for agriculture caused the diminishing of biodiversity. Consequently more and more losses of ecosystem services had occurred.

Soil deprivation caused an exclusion of productive soils after they became non-arable, and an inclusion of low quality rangeland as a compensation for land loss. This exclusion caused a loss of potential economic profits from productive land and replaced it with low productivity soils, and lands also lost their value in the real estate"s market. Moreover, extra expenditures are imposed on the government"s budget for preservation measures like soil amendment and green cover restoration by reforestation and afforestation.

Socially, farmers who lost their land for degradation, lost with it the means of obtaining livelihood as agriculture is their main activity, so they had to leave their areas looking for alternative sources of income and survival. The degradation also hindered the state ability to improve transportation network due to soil instability, which limited mobility ability for communities.

3.2.3. Climate

On the national level, agriculture in Syria is ranked as the second contributor to GHG emissions after energy production sector; it contributed to 18 % of the total GHG emissions in 1994 with 6 % from energy use. The amount of gas emissions increased from 9.5 Tera grams (Tg) per year in 1994 to 14 Tg per year in 2005, representing 17 % of the total emissions, 8 % of it derived from energy use for agriculture (Meslmani, 2010). The main gases emitted were N_2O and CH_4, The N_2O emitted amount increased from 7.2 Tg of CO_2 equivalents in 1994 to 10.5 Tg in 2005. As for the CH_4 the amount increased from 2.2 Tg to 3.5 Tg of CO_2. The sources of GHG emission in agriculture are shown in Figure 8, it shows that the principal sources for N_2O are soil fertilizers and animal‟s wastes, and for CH_4 is the enteric fermentation (Meslmani, 2010)

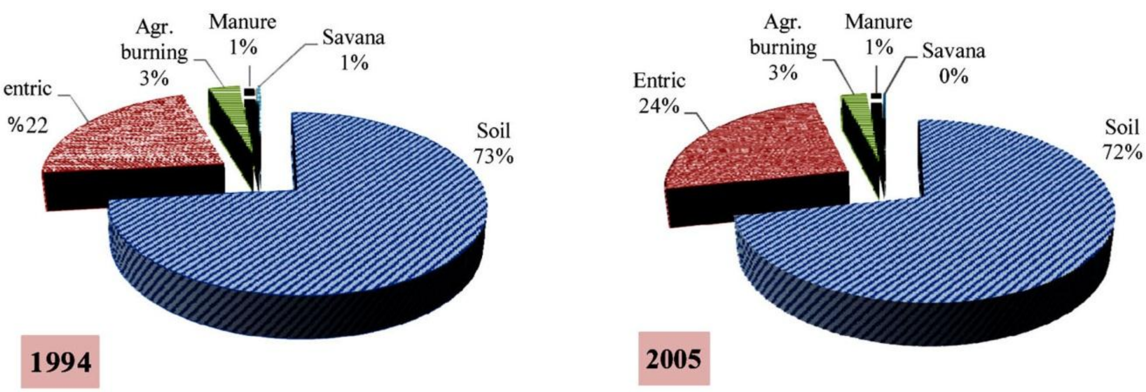

Figure 10: Sources of GHG emissions in Syrian agriculture, source (Meslmani, 2010)

There are no available data on governorates or regional level in Syria, but it sounds fair to say that Al-Hassakeh governorate is a large contributor to GHG derived from agricultural activities. This is because it is the largest agricultural area and a big consumer of energy and chemical inputs (fertilizers, pesticides, insecticides) for irrigation and crops production.

Al-Hassakeh climate is characterized by a variant climate between years, and steep rainfall gradient (Figure 9). The inter-annual precipitation variability is more than 100 % (Hole, 2003).

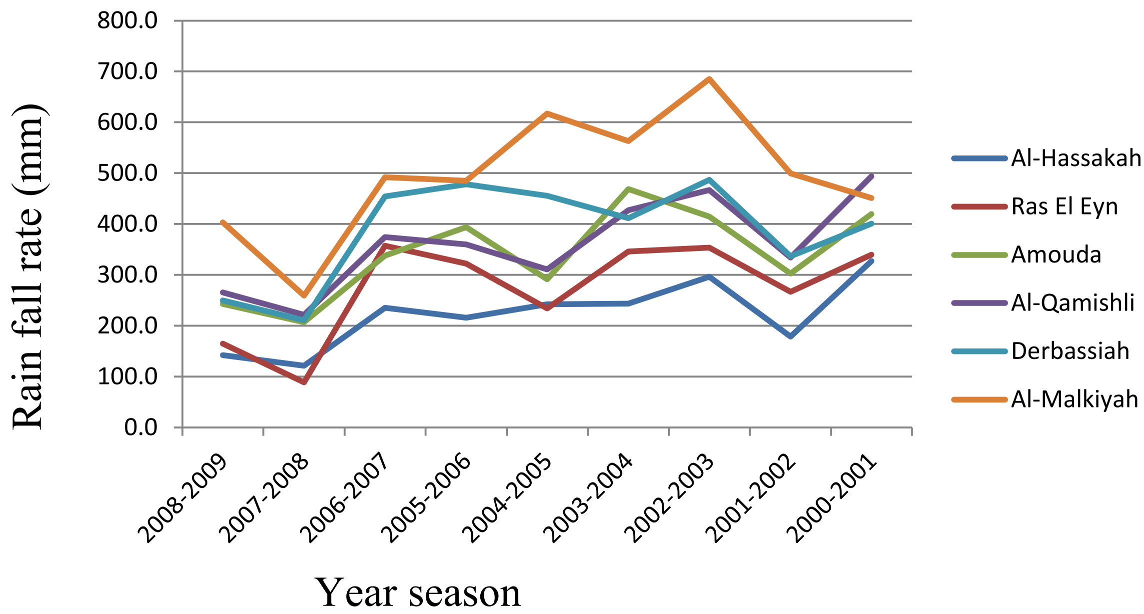

Figure 11 : Annual precipitation averages between 2001 to 2009. (Compiled from: MAAR, 2010).

Precipitation also varies regionally. The northern regions of Al-Khabour basin receive sufficient rainfall, whereas to the south in the middle and lower parts of it rainfall gradually decreases (Menze & Ur, 2012).

In 2007-2008 a severe drought occurred in Syria and the most affected areas were in the eastern part (Al-Hassakeh, Dier Ezzor, and Rakka). It was the worst in four decades where they suffered a reduced and short rainfall by 66%, 60% and 45% respectively below the annual average. The loss in rain fed crops production was about 50% in these areas (UNOCHA, 2010).

3.2.4. Energy

Fossil fuel and electricity are the main sources of energy inputs; they are basically used to operate irrigation pumps which were first used in the area in the early 1950s (Hole, 2003). About 75 % of existing wells use diesel for operating, and the remaining 25 % use electricity (Ortega & Sagardoy, 2003). In 2003 the agricultural sector demand represented 5 % of the total energy demand (MES, 2005). Diesel also is used to run machineries and for products transportation where farmers sometimes have to transport their wheat almost 800 Km to the mills in the capital.

Chemical inputs like (fertilizers, pesticides and herbicides) are indirect energy consumers; they considerably contribute to increase the energy consumption. For instance, producing 1 metric of anhydrous ammonia requires 1 – 1.2 thousands m^3 of natural gas (Gellings and Parmenter, 2004), moreover, packaging, transporting, and applying add more energy consumption as shown in table 8:

Table 8: The Global energy requirements in fertilizers industry by type and production process, compiled from (Gellings and Parmenter, 2004).

Process	Required energy (MJ/Kg)		
	Nitrogen	Phosphate	Potash
Produce	29.8	3.3	2.7
Package	1.1	1.1	0.7
Transport	1.9	2.4	1.9
Apply	0.6	0.6	0.4
Totals	33.6	7.5	5.9

In Syria, many establishments use diesel and electricity for chemical and synthetic fertilizers‟ production. Sulaiman Kanaan is a production manager at a small fertilizers‟ production establishment called the Arabic Establishment for Agricultural Development. He said that they use diesel for two main purposes in their factory, the first one is the fertilizers‟ drying machine which consumes 200 liters of diesel for a production capacity of 5 tons/hour. The second purpose is for the backup electricity generator which consumes 20 liters/hour. They also use an amount of 7000 Kw/month of electricity for a production capacity of 3-4 tons of different fertilizers (personal communication, 2012).

3.2.5. Biodiversity

Practicing monoculture causes a manipulation in the biological habitat through selective process of desired crops for production, and diminishes agro-biodiversity to be dependent on a limit number of grown plants. Modern crops breeding also tend to optimize crops genetic performance to be more efficient in highly altered agricultural environments, and the production of high yield hybrid led to uniformity in planted fields (Gliessman, 2007). The loss of agro-biodiversity leads to great losses in ecosystem services like water and air purification, pollination, biological control potentials…etc.

The land between the Al- Khabour Rivers and Iraqi borders is categorized as clay lowland with no drainage and salt marshes; it is characterized by having poor natural vegetation originally (Jones, 2001). Species like dwarf shrubs of *Artemisia herba-alba*, oak trees, and ash trees are found in the Al- Khabour plain are (Figure 10). The vegetation in general has been degraded and overgrazed due to human and climatic pressure (Zohary, 1973). Consequently, there was a decline in boreal pollination during the last millennium to reach 19-43 % (Zohary, 1973).

Figure 12 : Oak tree, Ash tree, Artemisia herba-alba. Source (tree-pictures.com).

The government continuously tried to restore the natural trees vegetation through reforestation and afforestation (Table 9) increasingly between 1993 and 2000 (Jones, 2001).

Table 9: Total reforested and deforested areas in Al-Hassakeh governorate, (Source: Jones, 2001).

Year	Reforested and afforested total area
1993	2600
1994	2880
1995	3000
1996	3305
1997	100
1998	3020
1999	3075
2000	2045

3.3. Economic aspects:

3.3.1. Strategic management

Agriculture in Syria is a dominant economic sector, it contributes to 32 % of the GDP, employing 31 % of the workforces and 50 % of manufacturing forces are depending on it for employment (FAO, 2005b). Most production comes from the Al-Hassakeh, Al-Rakka, Aleppo, Hama and Idlib (SPC & UNDP, 2009).

Despite the reduction of governmental intervention in agricultural planning, it still intensive enough to control production decision making and marketing. For example, for wheat production the government decides a target amount of production according to the five-year plan, then issues the farmers with licenses determine how much they have to produce and the share of land use for this purpose (Westlake, 2001). The marketing of wheat is dominated by General Establishment for Cereals processing and Trade (GECPT) which is governmental enterprise. It takes 70 % of the total wheat production (IFAD, 2009) and pays a subsidized price above the international wheat prices. The collected wheat is processed by the General Company for Mills (GCM) to produce flour which is then distributed for private and governmental bakeries for making standard and high quality bread. The standard flour and bread are heavily subsidized; estimates show that in the year 2000 standard bread cost 10.5 Syrian pounds per kilo, but the official price was 8.5 Syrian pounds per kilo for the publics (SPC & UNDP, 2009). A similar strategy applies for all other strategic crops with differences in establishments associated with the crop type and purpose of production.

Cotton is also bought by Cotton Marketing Organization (CMO) which is a state owned establishment; it is responsible for buying and ginning of cotton seeds, and the only exporter of cotton‟s fiber (Westlake, 2003). The produced fiber and seeds are used by both private and governmental mills to produce textile and cotton seeds oil under the supervision of the Ministry of Industry (Westlake, 2001).

3.3.2. Operating profits

Production costs in Al-Hassakeh changed due to the fluctuation in the inputs‟ prices like energy (diesel and electricity), labor and fertilizers. A look to the history of crops‟ production costs shows this vibration in numbers, for example in 2001 irrigated maize costs for services (tillage, weeding, fertilization…etc.) were 21 thousand SP/ha, decreased to an average of 18 thousand SP/ha between 2004-2006 then raised to around 30 thousand SP/ha until 2009. Table 10 shows the average production costs of the crops that are bought by the governmental establishments, for lentil and barley, the government did not set prices for 2010 but the prices of 2009 were used as the costs where almost the same in both years.

Table 10: costs and prices of main cultivated crops in Al-Hassakeh governorate in 2005-2010, source (MAAR3, 2010)

Crop	soft wheat		Hard wheat		Cotton	Barley	Red lentil
	Irrigated	Rain fed	Irrigated	Rain fed	Irrigated	Rain fed	Rain fed
Crop‟s services 1000 SP/ha	23.3	6.96	23.3	6.93	78.4	5.19	15.8
Inputs 1000 SP/ha	24.9	5.56	24.9	5.56	58.7	2.04	10.3
Total costs 1000 SP/ha	61.6	15.9	61.6	15.8	166	9.1	32.9
Average yield ton/ha	3.83	0.89	3.79	1.14	3.9	0.48	0.83
Total cost SP/kg	16	17.8	16.2	13.8	42	18.7	37.7
State price* SP/Kg	19.5		20.5		42	16	23

*prices are subsidized.

Profits are the sum of total revenues minus the total production costs (FAO, 2012a) and from table 10 we see that farmers are actually making profits according to the SAFA standard. Theses profits are obtained only by prices‟ support by the state‟s subsidies for wheat and cotton, where the USA price for soft wheat was 8.42 SP/Kg (FAO, 2012b) at exchange rate 45.39 for US$ according to the Central Bank of Syria. In contrast barley and lentil causing losses for the farmers, while for the same period lentil average producer price in Europe was 50.2 SP/Kg (FAOSTAT, 2012a).

A study to analyze the cost and outcome of subsidies for wheat and cotton was made by FAO in 2001 (Table 11). It shows that on the national level, wheat subsidies caused a loss of 3.24 % of the GDP in 1999, and cotton subsidies caused a loss of 0.79 % of the GDP at the same year.

Table 11: costs and benefits of governmental subsidies in 1999, adopted from (SPC & UNDP, 2009).

Crop	Billion Syrian Pounds	percentage of the GDP
Wheat		
GCM loss	26.2	3.24
Subsidy for farmers	10.8	1.33
Subsidy for consumers	1.98	0.24
Cotton		
CMO* losses	6.42	0.79
Subsidy for farmers	9.88	1.22
Implicit tax on domestic industry	2.30	0.28

* CMO: Cotton Marketing Organization in Syria.

The subsidies of strategic crops production chain (which are dominant crops in Al-Hassakeh) cause an approximate loss of 3-4 % of the GDP, it is a considerable pressure imposed on the government budget (Westlake, 2001; IFAD, 2009; SPC & UNDP, 2009).

Fertilizers prices (Table 12) are set by the government, the prices didn‟t change that much before 2003, but the exchange currency value did (FAO, 2003).

Table 12: Types of fertilizers and governmental paid prices in the period 1995 to 1999, modified (FAO, 2003).

Fertilizer type	Government price (SP / kg)
Potassium sulphate (K_2O 50%)	12.1
Triple superphosphate (P_2O_5 46%)	8.3
Urea (N 46%)	7.7
Ammonium nitrate 33.5% (Nitric N 16.9%- Ammoniac N 16.6%)	6.0
Calcium ammonium nitrate 26% (Ammonium 13% - Nitrate azote 13%)	5.4

The prices of fertilizers in the free market are controlled by offer and demand, where in the good rainy years the prices increase due to the high demand and vice versa in the low rain years (FAO, 2003). In 2009, the liberalization of fertilizers prices caused a significant increase in the production costs due to the increment of their prices (Maldonado, 2010). This made it difficult for the farmers to gain sufficient profits without state subsidies on fertilizers expenditures.

The balance between strategic crops outcome and land use is negative, where the contribution of strategic crops to the value creation is lower than the land use for producing them, although they still account for more than 50 % of total value of all crops (SPC & UNDP, 2009).

3.3.3. Vulnerability

Farm‟s income is entirely dependent on the cash flow from crop‟s production in most farms in Al-Hassakeh, which is determined by production quantity. Whilst this makes the income highly unstable (Westlake, 2001), the market disturbance has less effect on income stability because the crops are sold to the government anyway as a guaranteed buyer. If the government stops paying at official prices, farmers would make losses on all strategic crops even in an average production year (Westlake, 2001).

Production amount is affected by external inputs that are used in the process; in table10 we can see a noticeable difference in productivity between irrigated and rain fed cultivation without any difference in prices. The high dependency on diesel as main energy source for irrigation and machinery also puts the farm business in risk of instable income.

3.3.4. Local economy

Farm holdings ownership in Syria can be divided into many intersected categories; farmers can be land owners or non-land owners. They can practice farming as main profession or a part-time farmers (Fiorillo, 2003). The share of farm owners whose main profession is in agriculture varies by region, and it is significantly higher in rural area like Al-Hassakeh (NAPC, 2003). For these reasons, labor is mostly depending on family members which is generally the dominant form of labor over Syria (Sarris, 2001), and seasonal workers sometimes are needed for cotton picking.

Work force in Al-Hassakeh decreased from 314 thousand persons in 2010 (CBS1, 2012) to 268 thousand persons in 2011 (CBS2, 2012). It is not clear whether this happened due to labor force migration internally or externally, or due to the internal conflict in Syria during this assessment. Despite this situation, the direct and indirect agricultural workers in 2010 (before the conflict) were 79 thousand persons representing 25.2 of the total work force in the governorate. By dividing the number of persons on the cultivated area, we find that each 15 hectares have 1 person as a labor force. This indicates to a shortage in workers" fulfillment for the actual need, may be it is compensated by seasonal workers from other governorates or a system of cooperative neighbors work.

Women work in crops" service and animals" nursing if they exist in the farm; women"s labor is the most form of labor provided in the rural labor market, and if it is hired by farmers, it is usually cheaper than male labor.

Table 3 shows that there aren"t much vegetable production in Al-Hassakeh, which indicates that the local market cannot offer enough supply for the population and there is always a need to import from other cities where they have surpluses or external import to the country.

3.3.5. Decent livelihood

A report by UNDP about poverty reduction in 2004 showed that the North-Eastern rural region of Syrian has the largest poverty existence, depth and severity, mainly in Al-Hassakeh, Dier Ezzor, and Al-Rakka (Keyzer et al, 2006). Approximately 11.4 % of the population are poor, 58.1 % of them are found in the North-Eastern region (El-Laithy & Abu-Ismail, 2005), and this area has the highest level of inequity for the poor (FAO, 2005b). In the years 2003-2004, poverty decreased slightly in whole Syria, where the GDP per capita rose from 3.085 to become 3.541 Syrian pounds per month, signifying a growth of 1.9 % (El-Laithy & Abu-Ismail, 2005). But this alleviation didn"t mean a progress in poverty alleviation for the North-Eastern region, because regionally it was not equally distributed, where the middle and southern regions in Syria had expenditures of 4.023 and 4.110 Syrian Pounds per month of the GDP per capita respectively, the Northeastern region had only 3.487 Syrian Pounds per month (El-Laithy & Abu-Ismail, 2005).

Rain-fed cultivation is dependent solely on annual precipitation ratio and temporal rainfall distribution; the results show a great variation in precipitation over years which confirm the theory that Rain-fed cultivation is risky (Hole, 2003). In the years of drought, production and income reduction caused an elevation of poverty occurrence, and worsening livelihood standards for many families in the North-East of Syria in general, and Al-Hassakeh in particular.

The subsidized and relatively low prices of the energy sources in 2003 did not motivate farmers to use them efficiently (Wehrheim, 2003); the farmers consequently overused fossil fuel for irrigation purposes, which raised production costs for unnecessary energy consumption. The extra expenditures could be saved as profits by rationalizing diesel usage. Another savings are made by unpaid family labor, most of the workers are related to the farmer.

3.4. Social aspects:

3.4.1. Equity

The educational status of farm holders is very low, where it was found that more than 83 % of the holders have a lower education than elementary school, about 44 % of them are completely illiterates (Sarris & Corsi, 2003). The lowest level of education is found in the governorates of Aleppo, Al-Hassakeh, Al-Rakka, and Dier-Ezzor (NAPC, 2003). According to a governmental report in 2009, the school enrolment during the drought in 2006 till 2009 decreased 80 %, 19 schools were closed, a total of 7,380 children dropped out of school in Al-Hassakeh (UNOCHA, 2010). A recent census carried out by the CBS –Central Bureau of Statistics in Syria - for Al-Hassakeh province showed an increase of illiteracy between the years 2004-2011 from 26.9 % to 31.5 %, most of it was among females (41 %, and the highest percentage was in Ras Al-Ein 42.1 % (CBS4, 2011).

Women in the rural areas in Syria have an important role in poverty reduction and farm activities, they are responsible for lots of crops service practices like weeding, planting, harvesting, also they take care of livestock nurture. At the same time they are housewives, preparing food, raising children, and in some areas in Al-Hassakeh they collect firewood. However, despite this important contribution of livelihood, the rural women in most cases don‟t have access to capital assets and production resources or any control whatsoever over them due to the traditional dominance of gender that creates a considerable gap between men and women especially in education. Moreover, despite the fact that 10.9 % out of 238 thousand families in Al-Hassakeh are headed by women (CBS4, 2011), the national plans and development strategies had not yet recognized women‟s role in economy (Soubh, 2006).

From the adoption of ISI, construction of drainage infrastructure is the most important management practice to control salinity. However, no drainage structures are built in the whole Al-Hassakeh governorate, implying that education and experience are not helping in providing the minimum knowledge required to mitigate salinity problems through proper drainage (Yigezu et al, 2011). This indicates that there is an urgent need of high advisory services in the area to improve farmer‟s awareness of the surrounding ecosystem. There is also need for educational status enhancement to improve equity among farmers, and reduce gender differences to properly include women‟s role and contribution to local farm economy and decision making.

3.4.2. Food and nutrition security

In 2010 The Primary Health Care center (PHC) in Al-Hassakeh, Dier Ezzor, and Al-Rakka provided data showing a considerable increase in nutrition related illness during the period 2006-2009 (UNOCHA, 2010). The continuous drought over these years reduced their livelihood quality and their ability to deal with the shortage in food and income. A total of 65 thousand families left their villages, 35 thousand of them were from Al-Hassakeh province, and 55.1 % of the migrated families were from the far north areas (CBS4, 2011). The internal migration didn‟t save them from the harsh situation, but on the contrary they lost their social bonds and they were exploited under the labor market‟s prices (UNOCHA, 2010).

Although the country has attained self-sufficiency for wheat, mismanagement of groundwater improvement caused the drying up of wells for many rural areas, and increasing water scarcity due to population growth and urbanization became a major challenge (Bruggeman et al, 2005). The absence of flow in the river has effectively destroyed the livelihood of hundreds of farmers who had drawn irrigation water directly from the river, from its headwaters to its mouth at the Euphrates (Hole, 2007b).

3.5. Good governance:

Land reform and international political conditions since the 1960s onwards were the main factors that formed the agricultural schemes and strategies in Syria, especially alliances dominated during the cold war (Sarris, 2001). In the 1980s the government limited land ownership to 200 hectares, but this didn‟t stop farmers from trespassing on rangeland and use for crop‟s production (Jones, 2001). In 1981 season 3700 farmers encroached 620 thousand hectares, and between the years 1983 and 1984 the area was 720 thousand hectares (Masri, 1991).

It was noticed also that there is a limited governmental response to groundwater depletion in the basin of Al-Khabour (FAO, 2005b).

3.6. SAFA System assessment:

Environmentally, "To protect the integrity of Earth‟s ecosystems, a precondition for human existence, the use of natural resources and the environmental impacts of activities must be managed such that negative environmental impacts are minimized" (FAO, 2012a). Overall, the environmental integrity of the North-Eastern farm systems in Syria is endangered by human activities through agricultural practices and policies. The results show an overuse and mismanagement of resources in all studied environmental dimensions of water, soil, energy and biodiversity.

Economically, "To be considered economically sustainable, the company has to take precautions that ensure the maintenance of these capabilities in situations of economic, social and environmental turbulence" (FAO, 2012a). The results in case of Al-Hassakeh show a profitable economic activity, but it is not sufficient to provide a decent livelihood to the farmers. In 2004 the average farm holding in Al-Hassakeh was 18 hectares with a cropping pattern of 70% wheat cultivation with average yield of 2109 Kg/ha and crop‟s profits of 1.65 SP/Kg, and 30% cotton cultivation with average yield of 4665 Kg/ha and crop profits of 5 SP/Kg (MAAR, 2004). Calculations show that the total income is 174 thousands SP/Year, whereas the expenditures for the same year were 263 thousands SP/Year for the rural families in the governorate (CBS, 2004). This indicates that the agricultural production can only cover 66 % of the monetary needs of the families. Moreover, the system economically is under a great risk due to dependency on external inputs and limited market to the government as a sole buyer of major quantity of the production and minor dependency on free marketing.

Socially, "The satisfaction of human needs and aspirations is the major objective of development, and sustainable development requires meeting the basic needs of all and extending to all the opportunity to satisfy their aspirations for a better life" (FAO, 2012a). In 2003, agricultural wages for farm labor was 75 Syrian Pounds per day; it is lower than labor market price which was 100 Syrian Pounds (NAPC, 2003), these wages are significantly low and cannot ensure the minimum daily needs for individuals. Education also is an important extending opportunity for satisfaction and aspiration; the results show that Al-Hassakeh is underestimated for this matter.

3.7. Benefits and barriers of a diversified cropping system in Al-Hassakeh:

The case of Al-Hassakeh‟s farming systems propose many issues due to high dependency on agrochemical inputs and non-renewable energy resources, all governed by mismanagement of farm systems. By depending on external inputs, modern agriculture is productive, although it has lots of concerns about long-term sustainability have to be considered (Altieri, 1999). But, as all agroecosystems are continuously changing due to biological, cultural, socioeconomic and environmental factors (Altieri, 1998), it is possible to create a diversified farming system that mimics nature and enhance sustainability in the agroecosystem (Altieri & Nicholls, 2005). Through increasing biodiversity by cropping systems‟ diversification, the farming system becomes environmentally balanced, has a mediated soil fertility; able to biologically control pests and diseases and has a stable yield (Gliessman, 2001). Methods of cropping systems‟ diversification vary due to many factors like market support and demand, field biology and topography, available equipment and labor (Mohler & Johnson, 2009). Crops‟ rotation, intercropping, crops mixtures, agroforestry and hedgerows are methods of cropping systems‟ diversification that increase the genetic diversity and share the common benefits of environmental pressure resistance, less genetic vulnerability and rare catastrophic outbreaks of pests and diseases (Gliessman, 2007) stabilize yield, provide diversified diet, and magnify returns under low technologies and limited resources levels (Altieri, 2007).

In Syria, the General Commission for Scientific Agricultural Research proposed a list of certified crops (table 13); some of them are suitable for Al- Hassakeh governorate and could be the basis for a diversified cropping system over its agroecological zones besides the plants that are already grown in the area (see table 3).

Table 13: Certified crops' varieties in Syria and their suitable agro-ecological zone, yield and year of approval, modified from (GCSAR, 2012).

Species	Variety	Agro-ecological zone (AEZ)	Expected yield Ton/ha	Approval year
Barley	Furat 3	3rd AEZ (Hassakeh, Hama, Deraa)	1.8	2000
	Furat 4	2nd AEZ (Aleppo, Idleb, Hama, Deraa, Hassakeh)	3.1	2000
	Furat 7	3rd AEZ (Hassakeh, Aleppo)	1.7	2002
Bread wheat (soft)	Bohous 4	1st AEZ - Irrigated	3.9 - 8	1987
	1991	2nd AEZ	2.5	1991
	Cham 10	Irrigated (Hama, Aleppo, Raqqa, Deir Ezzor, Hassakeh)	8	2004
	Douma 2	2nd AEZ (Deraa, Idleb, Aleppo, Raqqa, Hassakeh)	2.2	2004
Chickpea	Ghab3	2nd AEZ	1.4	1991
	Ghab3	1st AEZ	2.2	1991
	Ghab5	1st & 2nd AEZs	2.1	2002
Cotton	Aleppo 90	Hassakeh	5.1	1977
	Rasafeh	Defined on after 2009 tests	4.6	2007
Durum wheat	ACSAD 65	1st AEZ	3.1	1985
	Bohous 5	Irrigated	7.3	1987
	Cham 3	2nd AEZ	1.9	1987
	Bohous 7	1st AEZ (Deraa, Homs, Hama, Hassakeh)	4.8	2000
	Douma 1	2nd AEZ (Hama, Idleb, Raqqa, Hassakeh)	1.7	2002
	Bohous 11	1st AEZ (Deraa, Tartous, Ghab/Hama, Idleb, Hassakeh)	4.6	2004
	Bohous 9	Irrigated (Idleb, Aleppo, Raqqa, Deir Ezzor, Hassakeh)	6.8	2004
Faba bean	Hama 1	Irrigated	3.8	1991
Lentil	Idleb 1	1st AEZ	1	1987
	Idleb 2	2nd AEZ	1.1	2000
	Idleb 3	1st AEZ - 2nd AEZ	1.5 – 1	2002
	Idleb4	1st AEZ - 2nd AEZ	1.6 – 1	2002
Maize	Ghouta 3	Irrigated	5.4	1989
	Bassel 2	Irrigated - Intensified	12	2000
	Sweet Faihaʿa	All AEZs	17	2002
Sorghum	Izraʿa 3	2nd AEZ	2.1	2002
	Izraʿa 7	Irrigated	5	2002

The northern regions of Al-Hassakeh receives approximately 500 mm of rainfall annually, whereas in the south of it the precipitation drops to 250 mm per year and a temperature of 18 Celsius degrees (Kaniewski et al, 2012), and in some years rainfall was even less than 100 mm per year (Hole, 2003). The fluctuation of rainfall makes cultivation a risky process, where it is possible to practice dry-farming (rain fed) in the north regions, the south fringes suffer a fail cropping season every 3-4 years (Menze & Ur, 2012). On the other hand, this range of rainfall ratio accompanied with temperature variation provide different margins climatic conditions for plants‟ cultivation, which makes it possible to grow a wide range of species to be used in cropping systems‟ diversification in the area. Water abundance in north regions of Al-Hassakeh (Al-Malikiyah, Al-Qamishli and Ras Al-Ayn) enables farmers to grow lots of plants in the farm. For example, tomato, eggplant, soybeans, watermelon, maize and sesame could be an alternative summer crops for cotton. As for wheat alternatives, lentil, chickpeas, peanut, cumin and spring potato are possibilities with a long-term benefits stressed by many experiments (Ryan et al, 2008a; Sadiddin, 2009).

Table 14: Syrian imports and exports of some agricultural commodities in 2010, (Compiled from FAOSTAT, 2012b)

Item	Exports 1000 ton	Imports 1000 ton
forage Products	1.6	0
Fodder & Feeding stuff	263.5	505.4
Soybeans	0.5	540.7
Dry beans	0.1	9.5
Dry Peas	0.2	0.5
Pulses	0.2	0.6
Lentils*	42.1	0.9
Beans, green	5.7	1.9
Leguminous vegetables	5.6	2.5
Pistachios	5	5.7
Total pulses	43.1	19.4
Garlic	1.8	3.2
Jute	0.03	0.3
Watermelons	211	7.8
Cinnamon	0	1
Sunflower seed	4.4	19.4
Potatoes	112.1	25.4
Cucumbers and gherkins	22.5	26
Eggplants	23.9	33.7
Sesame seed	0.06	52
Tomatoes	407.6	80.5
Maize	0.3	1918.5
Barley*	0	113
Wheat*	31.001	1045.3
Total cereals	31.7	3496.5

* Strategic crops in Syria.

Syria is rated as the fourth largest consumer of lentil in the world on a rate of 3.7 Kg/capita/Year (USAID, 2011), the needs of other food legumes can be fulfilled by expanding their cultivation areas in Al-Hassakeh and include them into the diversification scheme. Legumes are not only important for their high protein food value, but also they provide oil, fiber, fodder, supply nitrogen and carbon for the agroecosystem (Jensen et al, 2012). Table 14 shows that there is a need to grow some important legumes to fulfill the Syrian national market needs, instead of depending on importing the shortages. Pulses like soybeans, beans and peas are of a great benefit both for agricultural production from environmental point of view, and as food and fodder in the farm which reduces animal production costs. As for imports of cereals especially wheat and barley, the average imports were 243 thousand tons for the period 2004-2008 (FAOSTAT, 2012b) but it significantly increased in 2009-2010 due to the prevalence of drought condition during those seasons, and the yellow rust infestation (Maldonado, 2011). A study by (Grad & Karkout, 2008) on demand analysis of vegetables (green peas, green broad beans, green haricot beans, cucumber, eggplant, lettuce, cabbages, leaf beat) showed a negative growth of -0.9 for vegetables during the period 1982-2005 versus positive annual growth ratio in cereals & legumes (wheat, barley, maize, rice, lentil, chickpeas) and fruits of 2.5 and 1.7 respectively. Vegetables availability had a declined trend versus increased population for the same period to become (- 4.6 %) availability per capita. This suggests a need to expand these crops‟‟ cultivation in order to meet the increasing demand, and reduce their prices elevation which was the highest in comparison to other studied food groups (Grad & Karkout, 2008).

Crops‟‟ rotation helps breaking pests and diseases‟‟ life cycles (Karlen et al, 1994) and helps in the conservation of stored moisture which can be used by the following crop in the field (Ryan et al, 2008b). Rotation also plays a major role in enhancing soil fertility especially when legumes which are very important to include in crops‟‟ rotation (Olesen et al, 1999) for their known effect on elevating soil nitrogen contents. It was proved by (Jensen et al, 2012) that including legumes in the rotation scheme can save between 12-34 % of annually energy use average, which can result a mitigation of GHG emissions impact on climate, and save considerable amount of inputs‟‟ cost in the case of Al-Hassakeh. The new crops promoted in the rotation can change people‟‟s diet towards more diversified diet, legumes like chickpeas, lentil and beans can be alternative protein sources. This is important especially when farmers in the area of Al-Hassakeh cannot afford buying meat for enough needed protein for nutrition. Another benefit of rotation is increasing jobs opportunities where the farmers need extra expertise for the new crops included in the rotation regarding growing skills, crop‟‟s services, gathering and harvesting and marketing. On the long-run, (Ryan et al, 2010) stressed that lentil and forage legumes also can be a great alternative for fallow in the rotation, as in his experiment they increased wheat yield by 23 % of grains and 40 % of straw. Some farmers in Al-Hassakeh replaced fallow with the cultivation of watermelon as a summer crop, by that they could recover soil fertility. They had a positive result for wheat that was grown afterwards in the field (Corradi, 2006); such practice could be transferred to be applied by other farmers.

In 2009-2010 seasons, some positive vegetation increment noticed in Al-Hassakeh. The possible explanation is the use of drought tolerant varieties (USDA, 2009). Intercropping is a cultivation of two or more crops or varieties at the same land simultaneously (Hauggaard- Nielsen et al, 2009); through this method it is possible to get use of different available varieties of the same crop or crops‟‟ mixture of plants that can tolerate drought or other harsh conditions. It can save farm economy and utilize the benefits of increased biodiversity in the agro-ecosystem. The intercropping of grain legumes and cereal provide positive advantages on the yield level and stability comparing to their monoculture (Kundsen et al, 2004; Jensen, 1996), and the quality is affected by intercropping, in some experiments on wheat- peas, wheat-faba beans intercrops, the concentrations of nitrogen and sulphur were increased in the cereal grains regardless the location or the cultivation design (Gooding et al, 2007). The application of mixed crops and intercropping have many benefits on the ecological level, but in the case of Al-Hassakeh the differences in varieties characteristics may affect product quality due to the measuring standards of the government. Crops evaluation depends on the homogeneity of grain yield, and the ratio of starch and protein especially for cereals which can differ by variety.

The government initiatives for reforestation and afforestation are a necessity in Al-Hassakeh to restore natural biodiversity; these activities take place in limited reservoirs established by the government. A diversification potential reveals itself within this initiative as the government can include farm land boarders in the restoration plan by planting productive plants (crops or trees) as hedgerows in the fields. This kind of diversification has great benefits of providing habitat for wildlife and valuable control insects, source of wood, organic matter and pollinators (Altieri & Roge, 2010). The benefit of such diversity is not only having plants as possible extra income source, but also helps solving a major wind erosion problem that the area of Al-Hassakeh faces.

It seems that the potentials for cropping systems‟ diversification in Al-Hassakeh governorate can be increased by solving the water management problem. The adoption of new and improved irrigation techniques that guarantee water reservation and adequate renewable ratio for water resources, proved to be applicable without much difference in yield and farm income. For instance, bread wheat (*Triticum aestivum*) experiment by (Oweis et al, 1998) in a multi-years irrigation levels of 33 %, 67 %, and 100 % showed that a deficit of irrigation actually can save water with minor or even no losses in yield comparing to full irrigation level, and the yield of minimum irrigation level of 33 % was as much as a double of rain-fed yield. Another study by (Galli et al, 2010) in an experiment of 22 trial fields on an area of 12 hectares, showed that using improved irrigation systems like sprinklers and improved surface irrigation (ISI) did not decreased the income, but on the contrary, the use of ISI increased the yield by 11 % for wheat and 9.6 % for cotton, and the use of sprinklers the yield increased by an average of 13.6 %. Moreover, the use of new irrigation systems decreased the amount of irrigation water by 35 and 36 % for wheat and cotton respectively using ISI, and 59 % using sprinklers for irrigated wheat. Consequently, costs of fuel for operating irrigation system and labor were considerable saved expenditures. However, there are many evidences for extendable water resources which can solve water scarcity issue (Hole, 2003), there is a need of rationalizing water use methods and introduce more water saving techniques, after solving their barriers to be applied. For instance, using sprinklers is not suitable in some regions of the area due to high salts‟ concentration in the irrigation water, which cause lots of troubles in such irrigation system (Galli et al, 2010). In this case, a need to reduce water salinity is a priority by reducing and closely monitoring chemicals‟ use in the area.

Another limiting factor for diversification is the governmental intervention which controls decision making about what and how much to grow in the farm. The strategic crops are occupying a vast share of farm land, and they are the main purpose of the agricultural production. Even though, if the government wants to maintain the strategic crops, there is a possible cropping systems‟ diversification on the national level and inter-governorates level. Instead of making each governorate specialized in limited number of strategic crops, it is possible to create a rotation scheme of strategic crops cultivation over the country, for example, in 2010 soft wheat production from was 1.77 Mt of which 46.5 % and a yield of 1.5 ton/ha was gained from Al-Hassakeh governorate, and the second wheat source was Aleppo in the north with a production of 20.4 % and a yield of 1.5 ton/ha (MAAR2, 2010). From table 13, the average yield for bread wheat (soft wheat) from non-irrigated varieties (Cham4, Bohous4, 1991, Cham6, Douma 2) is 3.2 ton/ha, so theoretically, to produce the same total amount under this average yield, it will need an area of 543 thousand hectares. The share of each governorate will be 38.7 thousand hectares to achieve the planned goal. If the same measure was taken for other strategic crops, each governorate will contain a variety of crops to produce. In the governorate level, diversification methods could be undertaken to increase the benefits. Eventually we will get a mosaic structure of diversified cropping systems. The proper application of such strategy requires the involvement of many stakeholders like the ministries of agriculture, economy and trade, local affairs, and the farmers.

3.8. Exemplar for diversified cropping system:

When a farmer in Al-Hassakeh wants to diversify the cropping system in his farm, he has to choose crops that fit for climate, required inputs (irrigation, labor, machinery…etc.) and soil. He also has to research the needs of the local market before planning the diversification scheme. Marketing might not be a problem when it comes to strategic crops as the buyer is already guaranteed, but when he thinks of including crops other than strategic ones, creating sales channels is a very important issue. For that, farmers may feel insecure about rapid change in their farming practice, so it is safe to start diversification within the strategic crops criteria. Starting with a transition from monoculture of these crops to a cultivation of multiple strategic crops in the field, and then on the long run including other crops in the rotation or any other cropping systems‟ diversification method. In the appendix “A letter to the farmer” you can see some examples of cropping system‟s diversification methods that can be used in efforts of motivating farmers to adopt diversification.
Here, it is possible to present an example based on what have been said earlier in this paper. A field of 12 hectares divided into four equal plots, each of 3 hectares. The cultivated crops are hard (Durum) wheat and lentil as winter crops, cotton and one non-strategic crop like maize as summer crops. The choice of maize was made because it has an increasing demand in the local market especially for poultry production (Maldonado, 2011), with obvious production shortage shown in table 14.

Table 15: Economic information of the selected rotational crops.

		Wheat	Lentil	Cotton	Maize
Yield Kg/ha[1]		2614	590	2740	3510
[1]Local price SP/Kg		20.5	23	42	17
[2]Global price SP/ha		50	56	42	14
[1]Average cost SP/Kg		15	37	42	14
Profits	At local prices	5.5	-14	0	3
	At global prices	35	19	0	0

[1] Source: MAAR3, 2010, calculated as an average of wheat production.

[2] Source: FAOSTAT, 2012a, modified from SLC/ton.

The net income of such field from all cultivated crops per year will be 49941 SP/Year on at the local prices, but it is 308100 SP/Year at the global prices. The average expenditures for the rural family in Al-Hassakeh estimated to be about 263 thousands Syrian pounds per year (CBC, 2004) which can be covered if they sold their crops at the global prices.

Otherwise it is the government responsibility to modify its pricing standards to meet or at least come closer to the global prices. This of course needs further economic studies to identify the possibilities to assign suitable price for each crop.
(Christiansen et al, 2010) had a 6 years rotation that was conducted by ICARDA center. They had wheat in rotation with lentil, forage vetch, pasture medic, fallow and water melon, and they compared it with barley rotation for 2 more years. Cereals produce the highest yield of grain and straw at the sequence of vetch- lentil- medic after fallow and watermelon. The highest yields were: medic in dry matter, lentil in seeds, and barley produced more in term of grains but not straw (Christiansen et al, 2010). This example has the possibility of being applied in north and south fringes of Al-Hassakeh, considering the differences in rain fall ratio where in the south barley is more suitable to be cultivated. The economic analysis of this study proved that grain yield increment was the major factor in improving farm income (Peterson et al, 2002). The environmental benefits are mostly because of food and fodder legumes in the trial model (Ryan et al, 2008c) as explained in the previous section of this paper.
Many other trials and experiments in rotation showed positive results but still, the economic viability is a major constraint (Christiansen et al, 2000). This is majorly due to the government‟s pricing strategy, like the case of lentil which causes monetary losses for the farmers, also cotton - as shown earlier - does not make profits (see tables 11 and 15). Although farmers make significant extra profits for their savings or future business expansion through marketing liberalization, but it must be carefully studied to be presumed as the solution of the economic constraints. This liberalization caused increment in prices when it was applied for fertilizers in 2009 due to subsidization cut off, and resulted in a companion rise in inputs costs with slight change for producer‟s prices. Same thing can happen if subsidies were also cut off other agricultural inputs.

Finally, due to logistical limitations and the complexity of Mediterranean cropping systems, no long-term rotation can properly adopt solutions for all obstacles that hinder diversification in cropping systems (Christiansen et al, 2010).

4. Conclusions

The North-Eastern farming systems in Syria are not sustainable on the long run. Although they are economically viable to some extent, but they have multi-environmental and social negative impacts. Most of the impacts are human induced through irresponsible agricultural practices (water resources misuse, excessive chemicals use, and poor management overall), all encouraged by the government planning and subsidies system.

Al-Hassakeh governorate appears to be a promising area for cropping systems‟ diversification. Along with climatic variation, it has a wide range of soil types and water resources that can provide sufficient support for agricultural development. Farmers can profit of the collective economic, environmental and social benefits of diversification in their cropping systems if they were managed and utilized properly. However, designing a proper cropping systems‟ diversification in Al-Hassakeh requires more on-farm studies to gain more data about the current situation of the farm and farmers, with involvement of other stakeholders and modified governmental marketing strategies.

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Appendix:

A letter to the farmer:

Dear farmers of Al-Hassakeh:

First of all you have to know that your farm is a very important component of the Syrian agricultural future, and sustaining it for next generations is not only god‟s and scientists‟ responsibility. You are a major driver of the whole sustainability process through the way you practice agriculture and make decisions about your farm production. When you think of the farm as a living entity not just a money maker, you will realize the complex interaction between it and the surrounding ecosystem, and you will know that a small change within your farm will have an impact extends beyond the boundaries of the farm to affect the whole country.

Also, you should take in your account, the preservation and protection of your farm resources on many levels (environmentally and socio-economically), to guarantee its continuum ability to support you in the present, and your siblings in the future. This can be done through practicing a sustainable agriculture which aims generally to conserve the biodiversity rather than exploiting it, reduce natural resources degradation (water, soil, fuel…) and diminish pollution and pollutants use.

Of the methods to practice sustainable agriculture, we can present what so called *Diversification*. Diversifying your production in the simplest meaning is producing a variety of commodities within the capacity of your farm, and avoid depending on one product for survival.

There are many ways for you to apply diversification in the farm. Besides growing crops, you can nurse some animals like ruminants (sheep, cows, goats) or poultry (Chickens, turkeys) or a combination of all. Another way is to process your products on farm, for instance if you produce wheat, you can process it to produce bulgur which is

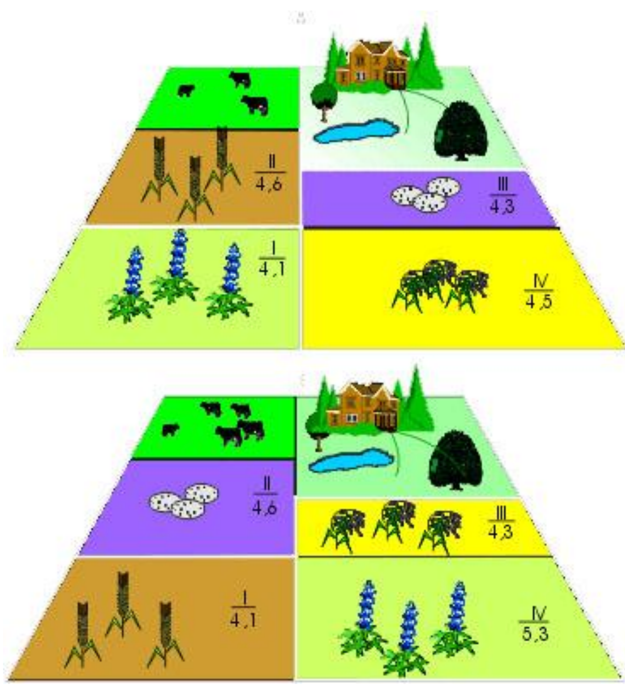

Figure1: Diversified farm, source: (farmgateblog.se).

a popular food in the rural and urban areas of Al-Hassakeh, or if you produce some legumes (beans, peas) you can process them to be ready for direct use (boiling, freezing, canning…etc.).

On the crops production level, there are also a plenty of methods to apply cropping systems‟ diversification, each one of them depends on your skills and available requirements to grow these crops, especially water. Even if you don‟t have enough experience in growing other crops, extension services department is there for you to provide what is needed for the success of your agriculture, and you have the right to use these services. You, with their help can find the suitable crops‟ combination for your farm.

Relatively, hedgerows seem to be a simple method for cropping systems‟ diversification, by growing plants at your own house and around the field you can gain lots of benefits. For instance, it is possible to grow walnut trees, olive trees, some shrubs of edible plants. Such hedgerows can accommodate beneficial insects that helps in pollinating your main crop, and they work as biological control against some diseases and other harmful insects, they can also work as wind breakers to mitigate the effect of sand storms on your crops, they might also have a market value where you can sell the fruits and increase the farm income, they have an ornamental value and provide shade in the summer time.

Crops rotation is very useful method to preserve soil properties and save water (Ryan et al, 2008) and fertilizers use, energy use (Jensen et al, 2012), pests and disease protection (Karlen et al, 1994).

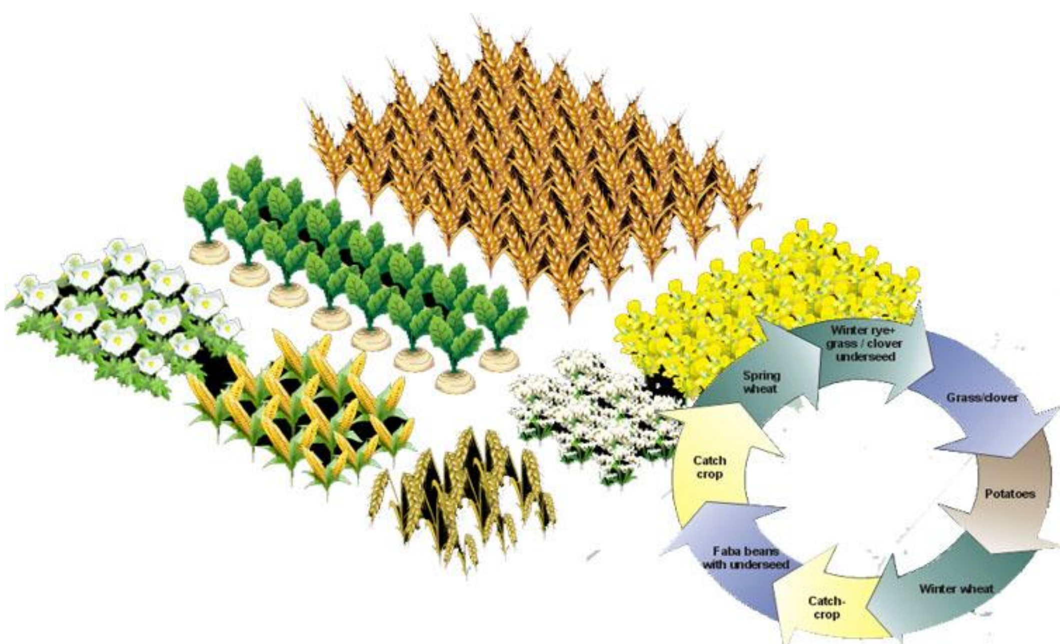

Figure 2: Crops‟ rotation scheme example.

Intercropping and crops mixtures are a method of growing two or more crops simultaneously at the same field and season. Plants In this case support each other in many ways like shading to reduce transpiration, water extraction through different roots‟ depth, increase nutrient contents (Jensen, 1996) in the soil which will save some fertilization cost.

By adopting diversification, you can harvest a plenty of benefits for you and for the ecosystem. For example, when you grow more than one crop at the same season, you will be able to sell to different markets and avoid buyer‟s monopoly. If one of the crops failed economically, the others can provide compensation for the income and reduce the loss.

Figure3: Intercropping maize and soybeans in South Africa. Source: (Walker et al, 2011).

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