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Study Project

Livestock-Water Interaction in Middle East Countries: A Case Study in Syria

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Table of Content

List of tables

List of figures

1. Introduction

Water is an important requirement for all forms of life. The availability of adequate water in terms of both quantity and quality is essential for human existence. People recognized the importance of water quite early. Civilization developed around water bodies that could support agriculture and transportation as well as provide drinking water. Water thus constitutes one of the important physical environments of man and it has a direct bearing on his health.

Water availability is a function of recharge efforts and extraction rates; therefore sustainable approach for protection and management of this crucial resource is vital. Available fresh water amounts to less than one half of one percent of all the water on earth, and it is renewable only by rainfall at a limited yearly rate of 40-50 000 km^3 per year. Meanwhile, global consumption of water is doubling every 20 years, more than twice the rate of human population growth. As a consequence, many parts of the world are facing an increasing water scarcity. Often drought is a common phenomenon and the effects are likely to increase in the future in both frequency and severity. Scarce water resources affect almost all sectors of a country's economy. But, farmers, herders and the rural population often suffer more than the rest. Therefore there is a high vulnerability to deteriorating water supply, especially if the economy relies heavily on agriculture.

Industrial use of water increases with country income, going from below 10% for low- and middle- income countries to more then 50% for high-income countries. Inversely, water for agricultural use decreases with country income. High-income countries use 30% of the water for agriculture and low- and middle- income countries use about 80%. In many developing nations, irrigation accounts for over 90% of water withdrawn from available sources for use. Even in some developed nations, such as Spain, Portugal or Greece, water used for irrigation exceeds 70% of total usage. (*Facts and trends –Water (Brochure). WBCSD, August 2005)*

Irrigation has been a key component of the green revolution that has enabled many developing countries to produce enough food to feed everyone. In the future, more water will be needed to produce more food for 3 billion more people. But increasing competition for water and inefficient irrigation practices could constrain future food production.

For the 2007-2008 study project of the department of animal production from the Humboldt University of Berlin, it has been decided to make an attempt to give an overview of the current situation and some future issues for the livestock sector in relation to this increased water scarcity. Therefore, the case of the country of Syria has been chosen as an example to illustrate the topic.

Syria has a large and rising livestock population comprising of cattle, buffaloes, goat, sheep, camel etc. Draught power for agriculture and dairy milk production are the two main purposes for rearing bovines while small ruminants are reared in a low input intensity manner taking advantage of the forest and common lands. Water is required for direct consumption by livestock as well as for supporting the production of biomass on which livestock thrives. Additionally, livestock contributes significantly to the household economy of the poor but they own no water sources for supporting their livestock. As such the water requirement of livestock has an important dimension of social equity. Due to increasing of population and changing consumer behaviour, livestock consumption and production are also increasing significantly

Moreover, livestock products are an important food group that has often been neglected in water development and management. Evidence suggests that there is a huge knowledge gap and much misinformation about livestock's use of and impact on water resources. About one-quarter of the world's total land area is used for grazing livestock, with large implications for water availability and quality. In addition, about one third of the global cereal production is used for livestock feed. *(2005. Addressing the impact of livestock on water availability and quality, LEAD, FAO)*

Preliminary analysis suggests that in water scarce regions water used for animal production may exceed water used to satisfy human dietary needs. In these regions the direct and indirect degradation of water available for other uses may well be an equally important issue: livestock contaminate water with pathogens that put human health at risk, changing land use and degrading soil structure significantly influence seasonal availability of "green" water, etc. *(2005. Addressing the impact of livestock on water availability and quality, LEAD, FAO)*

As in many other countries in the world, Syria does not have yet a fully integrated policy for the management of their water resources. The activities are also often fragmented between several institutions, with no or little coordination. Integrated water resource management includes a very wide range of actions related to all the concerned sectors (water, agriculture, etc.) and of different natures (technical, social, economic, policy- related, etc.). Additionally, the country is strongly exposed to serious challenges for water conservation, like low rainfall, dropping groundwater levels, water pollution... Moreover, the potential for development of new water resources is limited.

Since Syria was recognized as an independent republic in 1946, it has experienced many disputes and conflicts due to water issues. Water resources in the region are typically scarce by nature, and the situation is even made worse by the fact that most of them are transboundary. Mutual reliance on these resources has made water a catalyst for various conflicts. In parallel we also see internal conflicts developing, like the urban-rural conflict. Competition for water will continue to grow with growing population and increased needs for food, drinking water supply, industrial goods, recreational facilities, safe environment... This clearly demonstrates the necessity of a better understanding of all the elements of the situation the country is facing.

The project is a method of learning adopted by the department of Animal Breeding in the Tropics and Subtropics, at Humboldt University to make students participating in this course, learn and gain scientific knowledge relating to animal production and water- livestock interaction. In achieving this, an important component of real-life field project was initiated through team work and grouping. During this study project, students carried out field visits closely supervised by lecturers from the department. On the field, the students interacted with local farmers (actors), other students, researchers and other stake holders considering the target study aims.

2. Materials and methods

During this study project the following materials were put at the disposal of the students.

- Firstly, during the training of “Team Work Management” materials like: flip chart, cardboard papers of various colours, bold markers of various colours, handouts (printed) and a conference room for the training were provided by the host University.
- Secondly, during the preparation period of the course, prior to departure to Syria, supporting documents for literature review were provided by the by the department in the visiting University .
- Thirdly, at the field (Syria) breakfast, logistics and transportation were provided by Damascus University in collaboration with Humboldt University.

A participatory method of learning was used during the study project where students interact with the lecturers, identify problems and were guided by the lecturers to obtained possible solution. Students were given specific assignments to work in sub groups and presentations of their findings were done in plenary. During each day of class work, two students were chosen to coordinate activities (one chairing the session and the other taken down minutes to be circulated to others) in class.

During the field visit the same participatory method was used. On arrival at the University in Damascus, the study team were presented to the Dean of the Faculty and the objective of the study project was explained by Prof. Dr. Kijora heading the study project group team from Humboldt University. At all project sites visited, the team was introduced by the facilitator and the project leader explained to us the functioning of his project. Room was given for questions and answers. At the end of each project visited, a walk around the installation was done with guidance of the project leader which initiated more interaction between the students and the local staff of the project.

At the end of the field visit, presentation of the results (findings) was done in plenary at the Damascus University. Attendance during the presentation of results were students of the faculty, lecturers of Damascus University, Head of Department of Livestock, visiting lecturers, National and International Researchers attached to Damascus University, and Project coordinators of some of the projects we visited.

3. Importance of water as resource

Manjunatha Arahalli Venkataronappa

Water is lifeline input for all forms of life. All living organisms are predominantly made out of water. For instance, human beings about 60 percent, fish about 80 percent, plants between 80 and 90 percent. Water is necessary for all chemical reactions that occur in living cells and is the medium through which information is exchanged between cells. The sustainability of human development depends on the hydrological cycle, since water is essential for food production and all living ecosystems.

In general, three main sectors of freshwater use are differentiated: (i) The domestic sector - includes household, municipal uses, commercial establishments and public services, (ii) Industrial sector- includes water withdrawn for industry and (iii) The agricultural sector- includes water use for irrigation and livestock (World Water Council, 2007; Steinfeld *et al.*, 2006). In particular, livestock need water as all living beings for mere survival, growing feeds and fodders for the livestock and for cleaning. Some of these needs such as free grazing livestock that grazes on wastelands and forests are met from green water, while stored (blue) water has to be intentionally sidetracked to meet the other needs (Phansalkar, 2005). The subject matter of water needs of livestock sector is important in view of the importance of livestock to the national economy, food security and nutrition all around the world, in general and water scarce areas specifically.

With this background, this chapter primarily addresses the importancy of water as a resource at global and Middle East level in general and Syria in particular. The chapter is divided in three major parts. First part mainly focuses on global water use, depletion, projections and trends for future availability and use. Second part includes water use and depletion in Middle East. In this part some facts related to country specific cases are analyzed. Final part deals with water distribution and allocation at basin level in Syria, water use for different sectors and drinking water requirement is estimated for livestock and finally the chapter will end with addressing what technical solutions are followed and what additional solutions are needed to cope with the predicament of water scarcity, and which institutions are involved in management and protection of water. This will be followed by conclusion drawn from the reviewed literature.

3.1. Global water resources

The earth has 1400 million km^3 of water which can submerge earth 3 kilometers deep. Out of total water, 97.3 percent of earth's water is salt water. Only 2.7 percent of earth's water is fresh water available for different competing uses. Of this fresh water, 75.2 percent lies frozen in Polar Regions and so not available, 2.2 percent is available as surface water in lakes, rivers, atmosphere and moisture and 22.6 percent is available as groundwater(World Water Council, 2007; U.S. Geological Survey, 2006; Steinfeld *et al*, 2006). Therefore scope is higher for groundwater than surface water. This small amount of fresh water resources will support for sustaining development and maintaining food security, livelihood, industrial growth, and environmental sustainability (Turner *et al*, 2004 in Steinfeld *et al* , 2006).

At global level, fresh water resources are unevenly distributed as a result of a lack of proper water resources management, a number of countries are faced with ongoing reduction of water resources. For instance, more than 2.3 billion people in 21 countries live in water stressed basins and 1.7 billion live in basins under scarcity conditions with less than 1000 m^3 per person per year often called as water poverty basins (Rosegrant *et al*, 2002).

3.1.1. Sector wise water use and depletion

Table 1: Global water use and depletion by sector (Source World Water Council, 2007; Brown, 2002 & FAO-AQUASTAT, 2004 in Steinfeld et al, 2006)

Sector	Water Withdrawals	Water Consumption
Agriculture	66 %	93 %
Industry	20 %	4 %
Domestic use	10 %	3 %
Evaporation from reservoirs	4 %	

At present, agriculture is the largest consumer of water followed by industry and domestic use. Loss of water through evaporation is 4 percent which is also included in total water withdrawals. Out of the total agriculture water use, 93 percent is not put for reuse and is lost through evaporation, seepage and pollution of surface and groundwater aquifers. But most of the water used for industry and domestic use are reused because of recycling efforts. From the above discussion, it is clear that greater efforts should be made in agriculture sector towards avoiding loss of water. According to UNESCO, the figures change slightly, 69 percent of all water withdrawn for human use on an annual basis is soaked up by agriculture (the agricultural sector includes water for irrigation and livestock),industry accounts for 23 percent and domestic use (household, drinking water sanitation) accounts for about 8 percent. These international averages vary a great deal between regions. In Africa, for instance, agriculture consumes 88 percent of all water withdrawn for human use followed by domestic use (7 percent) and industry (5 percent).But on the contrary, in Europe, most water is used in industry (54 percent) followed by agriculture(33 percent) and domestic use (13 percent) (UNESCO, 2003; Anonymous, 2008).

Global water use in livestock

Livestock uses water for three main purposes :(i) Drinking and servicing, (ii) Product processing- slaughter, agro-food industry and tanneries and (iii) Feed Production (Steinfeld *et al*, 2006).Water use in livestock and its contribution to water depletion trends are high and mounting. An increasing amount of water is needed to meet the growing water requirements in livestock production process from feed production to product supply. Livestock meet their water requirements through drinking water, the water contained in feed stuff and metabolic water produced by oxidation of nutrients. Water is lost from the body through respiration, evaporation, defecation and urination. Water losses increase with high temperature and low humidity. Drinking water requirement of animals will increase with high temperatures. For instance, cattle (200 kgs) require 21.8 liters at 15^0C, 25 liters at 25^0C and 28.7 liters at 35^0C. Similar trend is applicable for goat sheep, camel, chicken and swine. Reduction of water intake results in lower meat, milk and egg production (Luke, 2003; National Research Council 1985,1987,1994,1998 & 2000; Ranjhan, 1998 in Steinfeld *et al*, 2006). Industrialized livestock production systems need service water for cleaning production units, wash animals, cooling the facilities, the animals and their products and waste disposal. In case of water servicing, pigs require lot of water when kept in flushing systems as compared with other animals (Hutson *et al* 2004; Hoekstra 2003 in Steinfeld *et al*, 2006). All these account to global water use for livestock drinking water requirement to 16.2 km^3 and service water requirements to 6.5 km^3 excluding water requirements for small ruminants.

At global level, livestock water use forms 8 percent of total use of fresh water which includes drinking, servicing, processing and irrigation of feed crops. The major portion of this water is used for irrigation of feed crops, representing 7 percent of the total global water use. The water used for product processing and servicing is insignificant at global level (less than 1 percent of global water), but it may of local importance in dry areas. Livestock have a significant influence on water quality through the release of nutrients, pathogens and other substances into waterways, mainly from intensive livestock operations. The contribution of livestock sector to water depletion is not easily quantifiable but there is strong evidence that the sector is a major driver (Steinfeld *et al*, 2006). From the above discussion it is clear that livestock need less water for drinking but need more water for other purposes. It contributes to water depletion in some way but it is not correct to attribute depletion only from livestock, since there are various sources which contribute to water depletion and pollution. Even most of the livestock pollution is non-point source in nature.

3.1.2. Water situation and projections

Considering global water situation, consumption of water is doubling-up every 20 years, more than twice the rate of human population growth. Pollution and over extraction in many parts of the world has hindered ability to meet the growing demand.

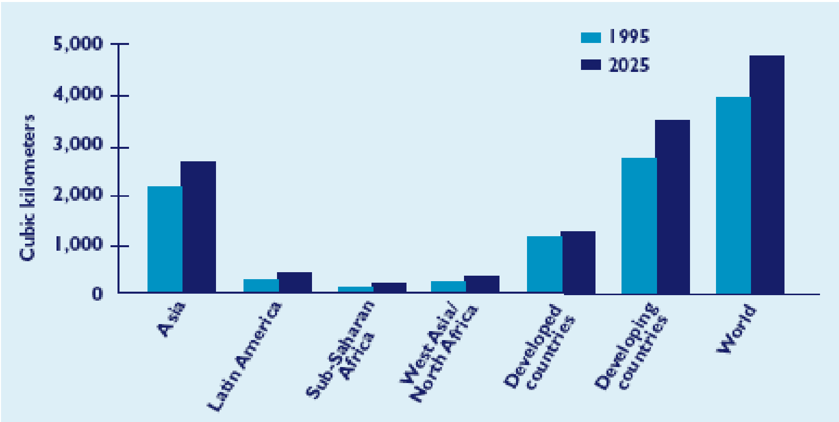

Figure 1: Global water uses by sector, 1995 and 2025 (Source Rosegrant et al, 2002)

During the last 70 years, the global population has tripled, but water withdrawals have increased over 6 times and water withdrawal is projected to increase by 22 percent in 2025. This increase will be driven mainly by domestic, industrial and livestock uses. Expected demand in livestock water use alone is more than 50 percent and non-agriculture purpose (62 percent) but irrigation water will increase only 4 percent (Rosegrant et al, 2002). This projected demand for water in livestock sector clearly reflects greater scope in coming years. As a consequence of the expected increase in water demand, Rosegrant et al, 2002 projected that by 2025, 64 percent of the world population live in water stressed basins (as against 38 percent today). Global water situation is not so alarming, but due to uneven distribution, some countries face water scarcity. For instance, the worst hit areas are in the Middle East, North Africa and in sub-Saharan Africa (Anonymous, 2008). This increasing water scarcity is likely to compromise food production, as water has to be diverted from agriculture to other uses (IWMI, 2000 in Steinfeld et al, 2006).

The above Figure 1 clearly show that, industrial water use will rise much quicker in developing countries (121 km^3) which is 7 km^3 greater than in the developed world which was contrary in 1995 situation. At global scale, the concentration of industrial water use will decrease worldwide, particularly in developing countries due to improvements in water saving technology and demand policy such as pricing, water markets, taxes etc. However, the absolute size of the increase in the world's industrial production will still lead to an increase in total industrial water demand (Rosegrant *et al*, 2002).

For livestock, direct water consumption is minute compared with other sectors. Although the fast increase of livestock production, predominantly in developing countries, means that livestock water demand is projected to increase 71 percent between 1995 and 2025. Livestock water use will rise much quicker in developing countries (from 22 to 45 km^3 – an increase more than double) than in developed countries (19 percent) which was contrary in 1995 situation (Rosegrant *et al* 2002).

3.2. Water situation in Middle East

The Middle East is primarily arid and semi-arid consisting of grasslands, rangelands and deserts. Water resources in the Middle East are scarce by nature, and most of them are shared by several countries. Water scarcity is increasing yearly due to persistent population growth, over-exploitation, and pollution of existing resources. In addition, scarce fresh water is becoming even more limited due to global warming which has further aggravated the water situation. Nile and the Euphrates are the major rivers for supporting water for irrigation. In addition several major acquifers (Figure 2) provide water to large portions of the Middle East (Anonymous, 2008; Khosh-Chashm, 2000). Middle East and North Africa (MENA) constitute the driest region in the world. Annually, it has only 355 billion cubic meters of renewable water resources, compared with 5379 billion cubic meters in North America, 4184 billion cubic meters in sub-Saharan Africa, and 9985 billon cubic meters in Asia. Currently, this region has 284 million people which form 5 percent of the world's population with access to only 1 percent of the world's fresh water (Fisher and Hossein, 2001).

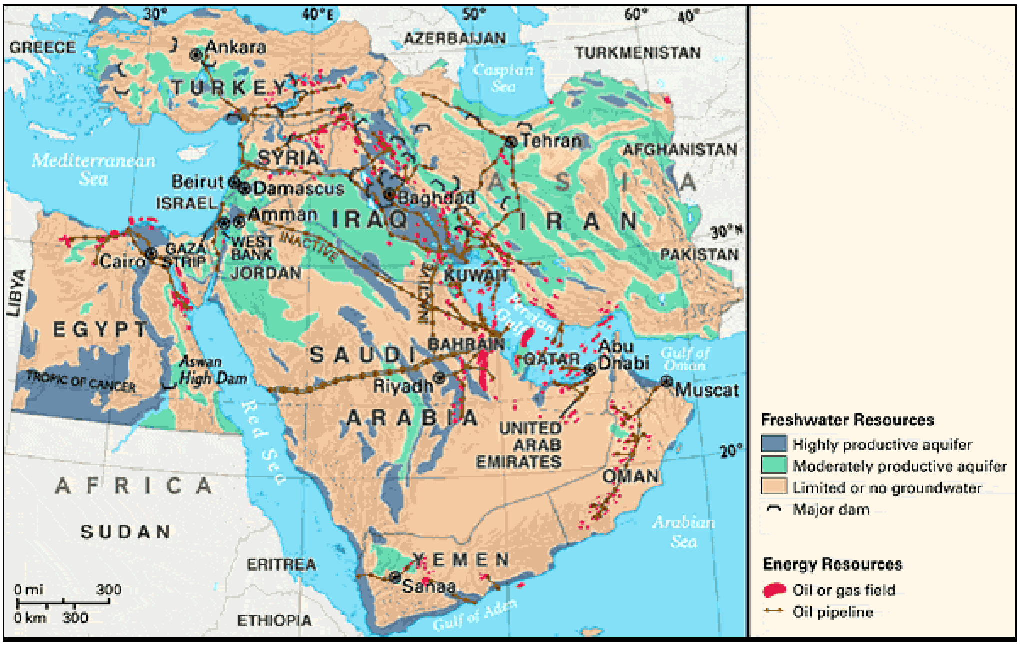

Figure 2: Fresh water resources in Middle East (Source: http://www.nationalgeographic.com/iraq/map_midEastNR.html)

For easy understanding, only few countries in Middle East were taken by the author to compare water situation across individual countries. Summarizing the Table 2, it is clear that population is increasing both at Middle East and individual country case where as per-capita annual fresh water is reducing at a faster rate. In case of renewable fresh water and per-capita annual fresh water, it is best in Egypt and Syria but worst in Jordan.

Table 2: Population growth and freshwater in Middle East (2002) (Source: Adapted from Farzaneh et al. in Reutsnir, 2008)

Countries	Population(millions)			Annual renewable freshwater (Km^3)	Per-capita annual fresh water(m^3)		
	1970	2001	2025		1970	2001	2025
Syria	6.3	17.1	27.1	46.1	7367	2700	1701
Egypt	35.3	69.8	96.2	86.8	2460	1243	903
Lebanon	2.5	4.3	5.4	4.8	1944	1120	896
Israel*	3	6.4	8.9	2.2	740	342	247
Jordan	1.6	5.2	8.7	0.9	555	174	103
Total	**48.7**	**102.8**	**146.3**	**140.8**	**13066**	**5579**	**3850**

* Israel includes the Palestinians who live in the West Bank and Gaza.

3.3. Water resources in Syria

Syria is a semi arid country with scarce water resources. The country receives average annual rainfall of 252 mm. Potential per-capita annual renewable water resources is 1420 m^3 which is better compared to most middle east countries exceeding the scarcity level of 1000 m^3(World Bank, 2007). The total annual water withdrawal was estimated at 15 billion m^3 of which agricultural use accounted for 87 percent which shows the significance of agriculture to the Syrian economy (FAO, 2003; Salman and Mualla, 2003). Most of these areas are supported by groundwater irrigation as compared with surface water. Groundwater is over-exploited in most of the hydrological basins due extraction of more water greater than the available recharge rates. This has caused water deficits which are now observed in most regions of Syria (see Table 3 and Table 4).

Agriculture is supported by 32 percent of the land area but livestock is supported in most areas of Syria (FAO, 2003). Livestock production is a vital component of the agricultural sector and national wealth, providing employment to about 20 percent of the workforce and is the main source of income and living for Bedouin herders (Bourn David, 2003). Livestock composition is influenced by numerous factors: rainfall pattern, prevalence of forests, availability of irrigation, advent of mechanization and development of remunerative markets for livestock products (Phansalkar, 2005). For instance, settlement zones 2, 3 and 4 are dominated by cattle while zone 5 dominated by sheep (See Figure 8 in chapter 4).

On supply side, country has dams and borewells to support irrigation, livestock, industrial and domestic uses. Supply side interventions have reached saturation stage. Hence, efforts should be made for demand side interventions such as pricing, taxing and regulating water use for efficient and sustainable management. For instance some efforts are made for treatment of domestic wastewater mainly in the towns of Damascus, Aleppo, Homs and Salamieh.This recycling need to be extended to agriculture sector since 93 percent of the total water use in agriculture is depleted and not used. All treated wastewater has to be reused (FAO, 2003; Steinfeld *et al*, 2006).

Comparing water resources of Syria with MENA, the following conclusions can be drawn; Agriculture contributes more to GDP of Syria followed by industry which is contrary in case of MENA (Table 3). In both cases, agriculture consumes more water as compared with other sectors and they are importers of virtual water. For instance, All MENA countries except Syria are net importers of water embedded in food, because they do not have sufficient rain or irrigation water to grow crops domestically (World Bank, 2007).

Table 3: Comparison of water resources in Syria and MENA (Source Adapted from World Bank, 2007)

Indicators	**Syria**	**MENA**	**Source**
Land area (million hectares)	18.5	948.9	FAO AQUASTAT
GNI per capita (current US$)	1,190	2,000	WDI database, 2004
Share of agriculture in GDP (percent)	24.4	13.6	WDI database, 2004
Share of industry in GDP (percent)	28.2	39.2	WDI database, 2004
Water withdrawals (‘000’ million. m^3,)			
Agricultural	18.9	188.3	FAO AQUASTAT, 2002
Domestic	0.7	17.5	
Industrial	0.4	7.9	
Total withdrawals	20.0	213.8	
Virtual water(‘000’ million. m^3, 2003)			
Virtual water imports in crops	4.4	57.8	Hoekstra & Hung ,2002
Virtual water imports in livestock	0.3	14.4	Chapagain &Hoekstra,2003
Water scarcity (percent)	75.3	-	Chapagain &Hoekstra,2003

3.3.1. Sector wise water use and depletion

The total estimated water use is about 15 billion m^3. The Euphrates (50 percent) and Orontes (20 percent) basins contribute major portion for water use. From the Table 4, it is clear that, water has been in deficit in most basins except in the Coastal, Orontes and the Euphrates basin. The situation will be aggravated further in basins surrounding large urban areas such as Damascus and Aleppo (Salman and Mualla, 2003).

As mentioned earlier, agriculture is the largest water consuming sector accounting for about 87 percent of water use followed by domestic (9 percent) and industrial (4 percent) water use respectively. On one hand urban water demand is increasing due to population growth and pressure on existing resources is mounting. On other hand existing resources are not used efficiently. This will aggravate further the situation of scarcity of water in agriculture.

Table 4: Water use in Syria (in million.m^3) (Source World Bank, 2001 in Salman and Mualla, 2003

Basin	Irrigation	Domestic	Industrial	Total Use	Renewable water resources	Deficit
Yarmouk	360	70	10	440	500	60
Aleppo	780	280	90	1150	500	-650
Orontes	2230	320	270	2820	3900	1080
Barada	920	390	40	1350	900	-450
Coastal	960	120	40	1120	3000	1880
Steppe	340	40	10	390	700	310
Euphrates	7160	250	110	7520	N.A	N.A
Total	12750	1390	570	14710	-	-
Share	87%	9%	4%	100%	-	-

Figure 3 shows renewable water resource and total water use. Water deficits experienced in Aleppo and Barada basins since total water use is higher than renewable water resources. While other basins are well within the limits of renewable water resources. This over use in Aleppo and Barada basins will worsen the water scarcity situation. Hence care should be taken for efficient and sustainable utilization of water resource through appropriate solutions. For instance water saving technologies such as drip and sprinkler use for irrigation.

In Syria, agriculture contributes about 32 percent to the GDP, and employs nearly 31 percent of the workforce directly and 50 percent indirectly in agriculture dependent manufacturing sectors. In 2000, the cultivated land area was estimated at 5.5 million ha (30 percent of the total country area). Out of total cultivated area, 20 percent of the cultivated land area (1.2 million hectares) was irrigated. The Euphrates and the Orontes basins reported for the major share (Table 4). The total irrigated area increased from 650,000 ha in 1985 to 1.3 million ha in 2002 (Somi *et al*, 2001 2002 in Salman and Mualla, 2003).

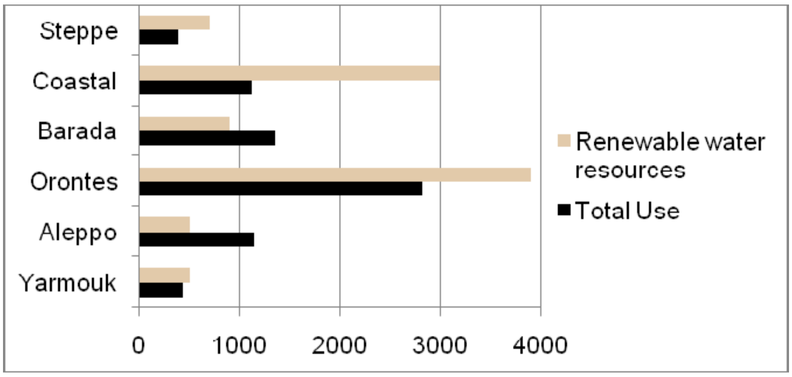

Figure 3: Renewable water resources and total water use in Syria (Source Adapted from World Bank, 2001 in Salman and Mualla, 2003)

This rapid growth of irrigated agriculture is mainly attributed to the government policy goal of realizing food self sufficiency and significant boost in groundwater irrigation. Groundwater (57 percent) forms the major irrigation source at present which was contrary situation in 1985 and 1990, where surface water (51 percent) forms the major irrigation source (Table 5). This sizeable portion of increase in groundwater use is attributed to area increase in wheat, cotton, and citrus and sugar beet, private control over well drilling and subsidized price from public irrigation systems which doesn't reflect the true value of the resource (Rodriguez, *et al*, 1999 in Salman and Mualla, 2003).

Table 5: Irrigated areas by source of irrigation in Syria (in 1000 hectares) (Source: Somi et al, 2002 in Salman and Mualla, 2003)

Year	Surface Water	Groundwater	Total Area
1985	334(51 %)	318(49%)	652
1990	351(51%)	342(49%)	693
1995	388(36%)	694(64%)	1082
2000	512(42%)	698(58%)	1210
2002	583(43%)	364(57%)	1347

From the Figure 4, it can be implied that both groundwater (bore wells and dug wells) and surface water (canals, dams and tanks) use is increasing at a tremendous phase but the rate of increase is higher in groundwater use. This increase in groundwater use is attributed to favorable government policies. Even the irrigated area has doubled over past two decades. This growth of groundwater irrigated agriculture has resulted in groundwater being overexploited in most basins of the country. Groundwater exploitation also affected some surface sources such as spring flows and causing seawater intrusion in land areas adjacent to the sea. Usually, surface water has been developed widely in most basins and a large share of the surface water is supplied by dams. Although there still remains some possible for further development of dams and expansion of storage volume, the cost for such management is considered extremely high. Except for the Euphrates (60-70 percent), most of the distribution systems of the irrigation schemes are with low conveyance efficiency that does not exceed 40-50 percent (Salman *et al*, 1999 in Salman and Mualla, 2003). Ministry of Irrigation has planned to convert old open surface distribution system into pipeline system and rehabilitate new lined canal systems to improve conveyance efficiency, access and reliability of water resources.

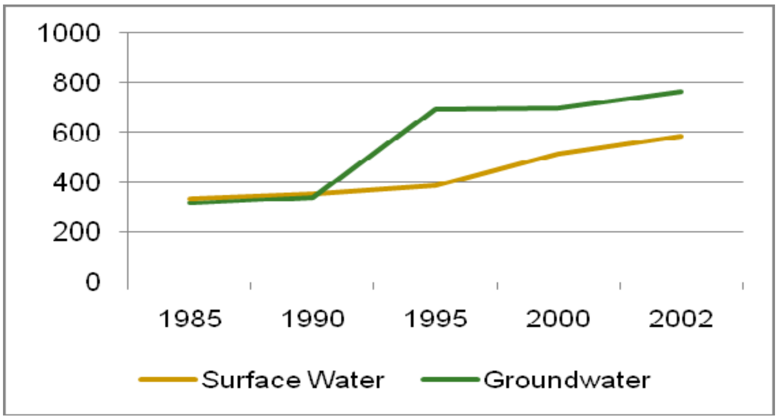

Figure 4: Irrigated areas by source of irrigation in Syria (Source Adapted from Salman and Mualla, 2003)

3.3.2. Water use in livestock

Direct drinking water needs are less as compared with water use for growing feed crops, cleaning and product processing. Table 6 shows that sheep dominates the livestock population followed by goat and cattle. While other animal's forms less proportion in total livestock composition. But water requirement is higher for buffalo, cattle and horse as compared with other animals. The water use in livestock varies from 4 to 80 litres per day depending on the kind of animal and temperatures. In Syria, estimated annual drinking water requirement range from 29.5 to 50.5 million meter cube which forms less than one percent of the total water use in Syria.

Table 6: Estimated drinking water requirement of livestock in Syria (in million. m^3) (Source Estimated from Bourn David, 2003; Legel, S.1990; Baudelaire, J.P. 1972; Greg Lardy, 1999)

Livestock	**Number**	**Water use/day in liters**		**Water use/yr in million.m^3**	
		Min	**Max**	**Min**	**Max**
Sheep	12361800	4	5	18.0	22.6
Cattle	836868	25	75	7.6	22.9
Goat	979325	4	5	1.4	1.8
Camel	13500	30	75	0.1	0.4
Buffalo	2477	70	80	0.1	0.1
Horse/equines	256417	23	30	2.2	2.8
Total	14450387	156	270	29.5	50.5

Note: Minimum and maximum water requirement for drinking is considered irrespective of growing period.

3.3.3. Effects of water scarcity in Syria

Water is essential for food security, livelihood, industrial growth, and environmental sustainability Water scarcity affects all social and economic sectors and threatens the sustainability of the natural resources base. For instance, groundwater is being overexploited and many basins have problem of water deficits. Groundwater exploitation also affected some surface sources such as spring flows and causing seawater intrusion in land areas adjacent to the sea causing salinity problems. This situation is attributed to droughts and wide climate variability, combined with high population growth and economic development. This has caused imbalances between availability and demand, the degradation of groundwater and surface water quality, intersectoral competition, and interregional and international conflicts. Some symptoms observed are environmental degradation, declining groundwater levels, and increasing problems of water allocation
(FAO, 2007; Salman *et al*, 1999 in Salman and Mualla, 2003)

3.3.4. Management options: Technical solutions for Syria

Water a shortage in Syria is mounting and has become severe concern for government as future demand of water will exceed available resources. Agriculture sector (85 percent) is the single largest consumer of water with less rate of reuse. Hence improving water use efficiency in this sector is crucial for coping with the predicament of water scarcity.

Box 2.1 Development of Efficient Irrigation Techniques and Extension in Syria (DETTEX Project)

To know about information on water related projects. A visit was made to one of most successful water related project located Kafar Hawar Village in Governorate of Rural Damascus on **18th February 2008**. The project was mainly funded by Japan International Co-operation (JICA) and operated through General Commission for Scientific Agriculture Research (GCSAR) and many other government departments of Syria. International Center for Agricultural Research in the Dry Areas (ICARDA) and The Arab Center for the Studies of Arid Zones and Dry Lands (ASCAD) are part of Advisor committee. The project mainly aimed at saving water through technological interventions such as drip and sprinkler irrigation through providing adequate training and extension activities to cope with the predicament of water scarcity.

A discussion was made with irrigation engineer of DETTEX project (Mr.Bassam A Husein) and progressive farmer cum trainer by our study group. In addition project site of drip irrigation for fruit crop was visited on the same day for getting more practical insights. Cost sharing of farmers and benefits of project are as follows:

(i) **Cost sharing mechanism:** 20% subsidy for legal groundwater users while non legal groundwater users have to form informal association and approach the government to get 10% subsidy for installation of drip and sprinkler irrigation for crops. However, free technical support will be provided for both groups.

(ii) **Benefits:** Both tangible and intangible. The project has strengthened the relationship among farmers in exchange of information. The project has succeede in – increasing cropping area under drip and sprinkler from 30 % in 2004 to greater than 90% in 2007 (Figure 5), changing cropping pattern towards less water intensive crops and creating awareness of water scarcity through installation of flow meter. All these benefits have improved the socio-economic status of farmers.

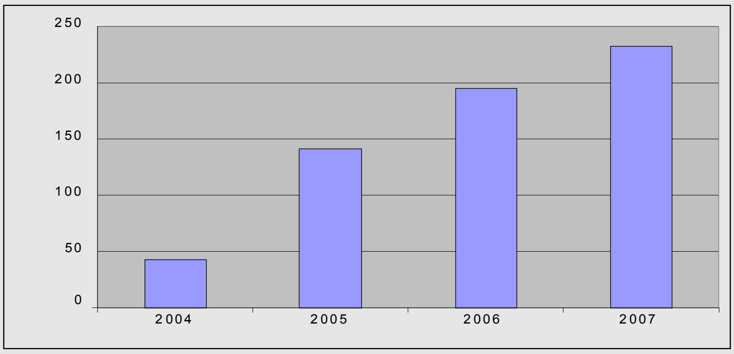

Figure 5: Area under micro-irrigation of DETTEX project (Source Adapted from information collected from Kafar Hawar project center)

The project has future plans for adoption of fertigation techniques and formation of water users associations.

In this regard Government has reacted favorably via incorporation of component of technical efficiency in its policy regulation (Consuelo and Sagardoy, 2001; World Water Council, 2007). Government is motivating farmers by providing subsidies for installation of water saving technologies such as drip and sprinkler irrigations. For instance, at present,

13 percent of the total irrigated area using modern irrigation technologies such as drip and

sprinkler irrigation (Salman, 2003; FAO, 2003).In addition waste water recycling, rainwater harvesting and water harvesting via watershed programs are important for better protection and protection of this crucial resource.

Box 2.2 Development of Water Harvesting structures in Deserts of Syria

The project was mainly operated by The Arab Center for the Studies of Arid Zone and Dry Lands (ASCAD) through collaboration with other institutions but the fund are from various national and international donor agencies. The main aim of the project to meet water requirement for Bedouins. There are around 150 water harvesting structure (Figure 6). One of the project sites was visited on **18t**
February 2008.

Figure 6: Water Harvesting structure in Deserts

Discussion was held with the officials of ASCAD to know about activities of the project. They explained projects activities as :(i) Identification of appropriate sites for development of water harvesting structures and (ii) Construction of water harvesting structures and (iii) Management of the same. The project has strengthened relationships via effective communication and increased livestock population especially sheep. All these have improved the socio-economic status of Bedouins.

3.3.5. Current institutions involved in water management in Syria

The following institutions play important role in management of water resources in Syria: Ministry of Irrigation: Overall responsibility of water resources management in the country. Some functions include (Salman , 2004)

- Incharge of irrigation, dams, planning, research, operation and maintenance and pollution control.
- The Directorate of Irrigation - water resources studies and surveys, water legislation and sharing international waters.

- Three other departments: the Euphrates Basin Development Authority, the Euphrates Basin Land Reclamation Authority and the General Company of Major Water Resources Studies.
- Seven basin directorates

There are 4 other organizations involved in the water sector in Syria (FAO, 2008):

- Ministry of Agriculture and Agrarian reforms(Directorate of Irrigation and Water Uses): Advisory role on farm water use & basic extension services to farmers
- Ministry of Housing and Public services(Directorate of Water Supply and Waste Water)
- State Planning Commission, Section(Irrigation and Agriculture Sector)
- State Environmental Affairs Commission, Section(Water Environment Safety Sector)

All these institutions are involved in management and protection of water.

Conclusion:

Water plays an important role for development worldwide in general and Middle East and Syria in particular due to their increasing dependence on agriculture and allied activities including livestock to meet the food needs of growing population. Water security for irrigation in agriculture is vital for strengthening food, nutrition, health and economic securities (Rosegrant, 1997). The availability of adequate water is a function of recharge efforts, extraction rates and use in agriculture, livestock and allied sectors. Symptoms of over extraction such as initial and premature well failure, cumulative well interference and decline in water table have been surfacing affecting agriculture and livestock specifically in Middle East. The situation is further aggravated by inefficient use of water. For instance, except for the Euphrates (60-70 percent), most of the distribution systems of the irrigation schemes are with low conveyance efficiency that does not exceed 40-50 percent (Salman *et al*, 1999 in Salman and Mualla, 2003). Accordingly there is a dire need to sustainable extraction and use of water considering both quality and quantity. In this regard, the institutional and techno-economic aspects play a crucial role. Government should encourage water use through appropriate policies. For instance, water saving technologies, pricing of water, recycling water in agriculture, participatory irrigation management and irrigation management transfers for protection and management of this crucial resource is the need of the day.

4. Livestock production systems and its water use issues

Minette Flora de Asis

4.1. Farming systems in the Middle East and North Africa

The livestock production system is a sub-system of the overall farming systems. It is thus important to define the patterns within the farming systems in order to understand fully the livestock production system. The Food and Agriculture Organization together with the World Bank defined major farming systems in six developing regions in the world based on a combination of criteria like natural resources, climate altitude, crops, livestock, irrigation development (Bourne 2003). One of the regions identified is the farming systems in the Middle East and North Africa. There are 8 farming systems within this region which includes: irrigated, highland mixed, rainfed mixed, dryland mixed, pastoral, sparse (arid), coastal artisanal fishing and urban based systems. In Figure 7, the coastal artisanal fishing and urban based systems are not plotted because the contribution to these systems is quite small as compared to the rest of the systems.

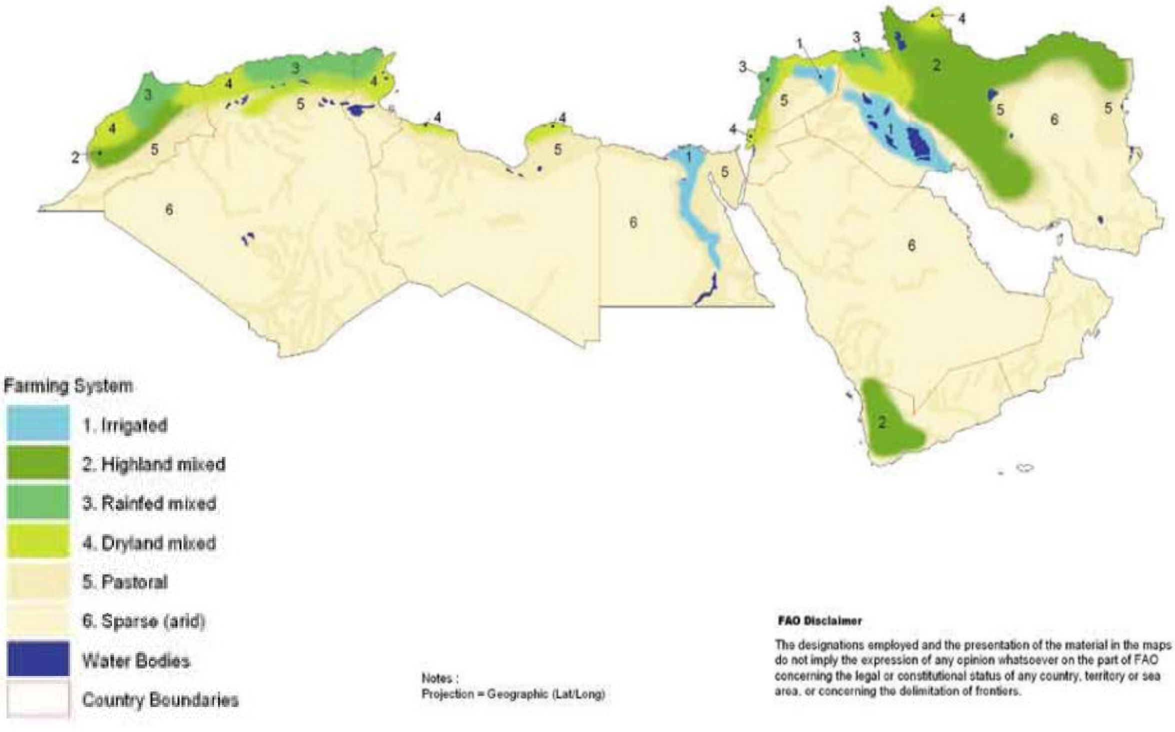

Figure 7: Major Farming Systems in the Middle East and North Africa (Source Dixon *et al.*, 2001)

Dixon *et al*, in the book Farming Systems and Poverty provided the characteristics of the region including the different systems which is summarized in the succeeding paragraphs. The region is comprised of 14 low and middle income countries which can be found from

Morocco in the west, to Iran in the east (see Figure 7). It contains a significant number of pastoralists who move from high altitude areas to wetter zones and steppes. Livestock, mainly sheep and goats, are an important characteristic of the system and provide linkages within the different systems, from extensive pastoralism to feedlots in peri-urban agriculture. 90 % of the total area of the region is classified as arid and semi-arid zones while the remaining 10 % are humid zones. The arid and semi-arid zones experiences low and variable rainfall while the humid areas are characterized by long dry summers and mild wet winters. The humid zones comprise basically 50 % of the agricultural production comprised of wheat, barley, legumes, olives, grapes, fruit and vegetables. Meanwhile, the 90% of the arid and semi arid areas is inhabited only by 30 % of the over-all inhabitants which are located in dispersed intensively irrigated areas, which is covering 2 % of the total area.

Specifically in the Middle East, it is said to have been the cradle of civilization. It laid the foundation of developing the irrigation systems for agricultural production. Irrigation practices used effective indigenous technologies to cope with the constraints of limited water supply. Cereals and leguminous crops originated in this region including the early domestication of sheep and goats.

The succeeding paragraphs highlights the characteristics of the eight farming systems and it can be summarized in the Table 7 below.

Table 7: Major Farming Systems in the Middle East and Africa (Source Dixon *et al*., 2001)

Farming Systems	Land Area (% of region)	Agric. Population (% of region)	Principal Livelihoods
Irrigated	2	17	Fruits, vegetables, cash crops
Highland Mixed	7	30	Cereals, legumes, sheep, off-farm work
Rainfed Mixed	2	18	Tree crops, cereals, legumes, off-farm work
Dryland Mixed	4	14	Cereals, sheep, off-farm work
Pastoral	23	9	Sheep, goats, barley, off-farm work
Sparse (Arid)	62	5	Camels, sheep, off-farm work
Coastal Artisanal Fishing	1	1	Fishing, off-farm work
Urban Based	<1	6	Horticulture, poultry, off-farm work

1) Irrigated Farming Systems. Irrigation has been an important component to aid agricultural production in the region using both large scale and small scale irrigation systems. The major sources of large-scale irrigation are coming from the Nile and the

Euphrates River. The Euphrates is the source of water of countries in Turkey, Syria and Iraq as is the Nile for Egypt and Central and Southeast Africa. In the old times, the *quanat* or *karez* is another kind of water management used to intensify and expand irrigated areas in arid and semi arid like the Middle East. It is a technology where water is tapped from the surface water; it is constructed in a way that water is pulled by gravity and efficiently delivers water in long distances without the need to pump.

Over the years, drilling and pumping technologies were constructed and sourced from groundwater aquifers which paved the way to the development of agricultural areas for high value crops, export crops, vegetables and fruits. At the moment water is not used efficiently due to inappropriate water pricing policies and centralized management. Moreover, other problems include excessive use of water in irrigation leading to rising groundwater tables, salinity and sodicity problems (Dixon *et al.*, 2001). Meanwhile, small- scale irrigated systems are also developed in small perennial streams, oases or boreholes
(Bourne 2003). The impact of this irrigation system in the environment is not as crucial as large-scale systems; instead they are an important water source for small-holder farmers producing cereals, fodder and vegetables. At the moment, there is already growing competition of water use evident between small-holder due to limited water supply.

2) Highland Mixed System. The system comprises about 7% of the total land area in Middle East and North Africa (as shown in Table 7). There are two sub-systems within this system. The first sub-system is dominated by rainfed cereal and legume cropping including the cultivation of tree crops, fruits, olive trees and coffee (i.e. Yemen).The second sub-system is based on livestock, for instance, Iran and Morocco farmers are raising sheep in communally managed lands. They are involved in transhumance system where there is seasonal migration of flocks. This kind of systems is still evident in some parts of Iran and Morocco.A serious concern within this system is the degradation of natural resources.

3) Rainfed Mixed System. This system can be found the areas of Morocco, Syria and Iran. Only 2 % of the area is rainfed but contributing to about 18 % of agricultural production of tree crops and vines including wheat, barley, chickpeas, lentils and fodder crops. Although the system depends on rainfall distribution, nowadays, some areas can be irrigated with the use of drilling and pumping technologies. Aside from the cattle which form a significant part of animal rearing, migratory sheep coming from steppe areas are existing within the system.

4) Dry Land Mixed System. This system receives an annual rainfall between 150-300 mm. Almost all of the countries with the region fall within this system. The rainfed areas cultivate barley and wheat but these areas can be vulnerable to drought. The livestock reared include cattle and small ruminant animals of which they strongly interact with the cropping and fodder system. For instance, barley can be grown as grain but at the same time it also serves as fodder for the livestock.

5) Pastoral System. The system consists of about 30 % of the total land area with mostly grazing sheep, cattle, goat and camel found in semi-arid steppe lands. Human settlements are mainly densely populated within the irrigated areas. Livestock production is supported by agriculture within the irrigated areas. Moreover, there is a strong linkage between this system to other systems because of the seasonal migration of herds in humid areas in the search for water, grass and crop residues, while in urban areas, animals are sold in feedlots. These systems are mostly controlled and financed by urban capitals. The Pastoral system can be found in all countries in the region.

6) Sparse (Arid) System. This system consists of 60 % of the total land area including some desert areas in Tunisia, Algeria, Morocco, Libya, Saudi Arabia and Iran. In these arid areas, there is also the production of dates, palm, fodder and some vegetables while the majority of the inhabitants are dominated by pastoralists of cattle, camels, sheep and goats. However, the boundary between pastoral grazing and sparse systems is indistinct depending on the climate where, in good seasons, it can be a grazing area for the herds of the pastoralists.

7) Coastal Artesanal. The system exists between countries lying along the Mediterranean Sea and the costal areas of the Atlantic Ocean. Aside from fish catch, supplementary income is based on animal production and cultivation of small scale crops.

8) Urban Based Farming System. The inhabitants under this system are mostly engaged in small scale horticulture (i.e. fruits and vegetables) and livestock production grown in feedlots. In this system, there is a strong linkage between the peri-urban and rural production systems.

4.2. Farming Systems in Syria

Land Use. Syria's land area is about 185,000 square kilometer. The land use of the area is characterized by 46 % pasture land, 29 % arable while the remaining are uncultivated and forest lands (FAO STAT 2004; Masri 2006). From the arable lands, only 25 % is irrigated (FAO STAT 2004) while the pasture lands are used for camels and sheep (Masri 2006). Meanwhile, Figure 8 shows a more graphical land use distribution in Syria. It is divided according to woodland/forest, permanent crops, arable land, irrigated farming, rough grazing/nomadic herding, wasteland including oasis. As can be seen, majority of the land area is attributed to rough grazing/nomadic herding.

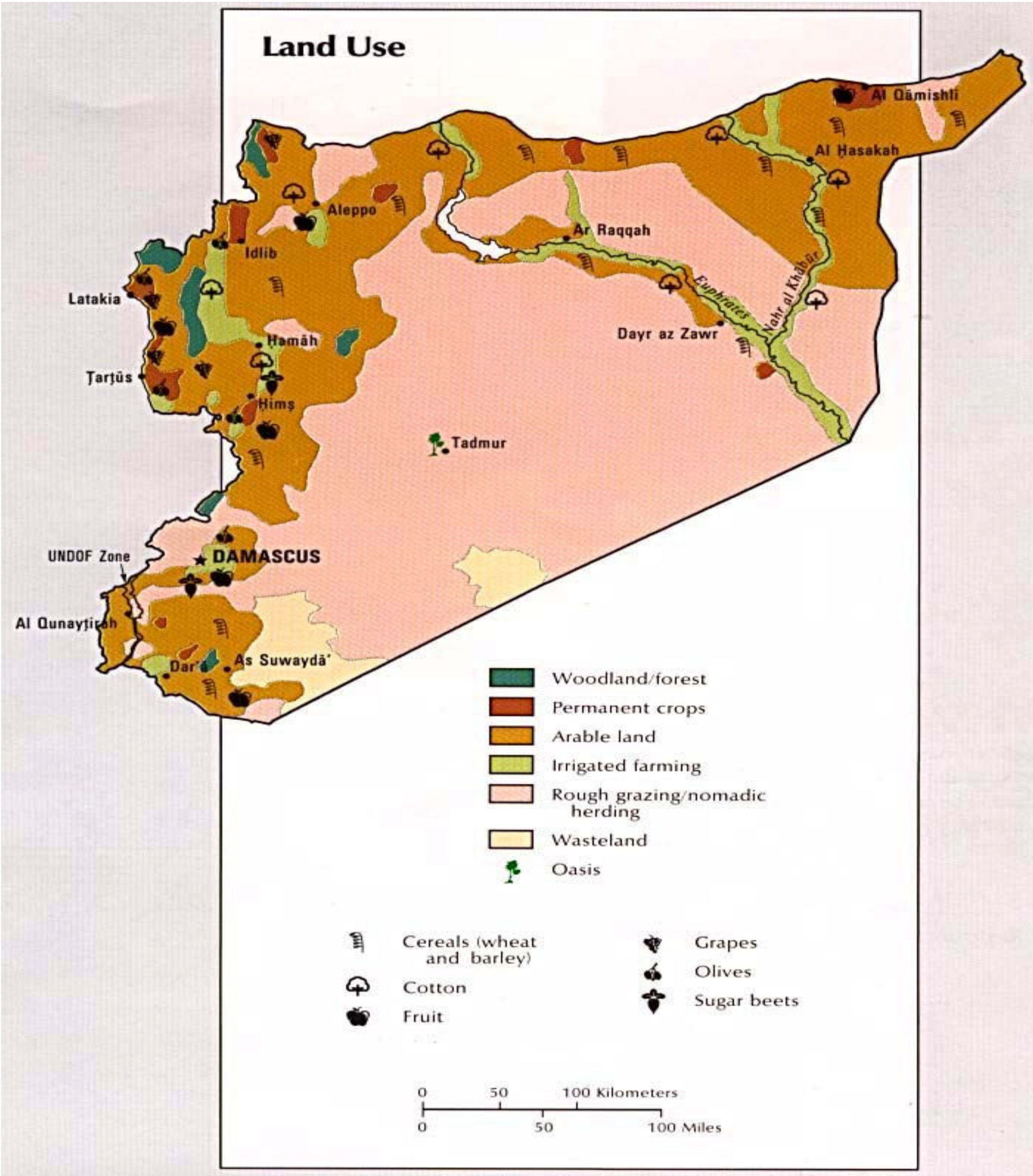

Figure 8: Graphical Land Use of Syria (Source Münchhausen, J., 2007)

Agro- Ecological Zones. From the Food and Agriculture Organization, Syria is divided into 5 agro-ecological zones (as shown in Figure 9) which are primarily based in the rainfall distribution of the area.

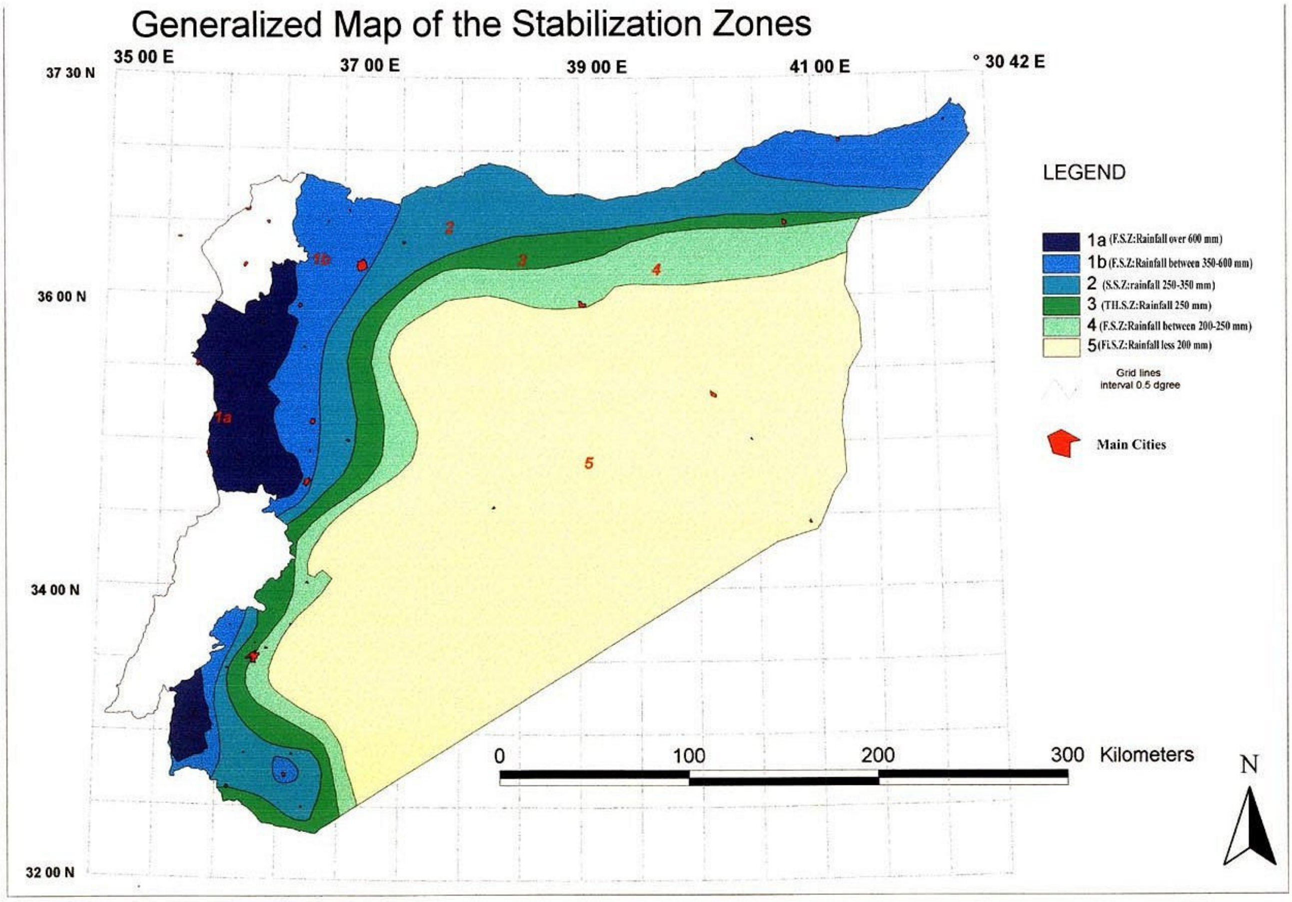

Figure 9: Agro-Ecological Zone of Syria (Source http://www.fao.org/ag/agl/swlwpnr/reports/y_nr/z_sy/symp131.htm)

Zone 1 has an annual rainfall of 350 mm. It is sub-divided into areas, 1a (see legend in Figure 9) experience annual rainfall of about 600 mm where crops are successfully grown while 1b (see legend) receives an annual rainfall between 350 to 600 mm. Zone 1 is about 14.6% of the total land area (Masri 2006). Crop percentage share is 50 % wheat, 30-40 % pulses, forage legumes and 10-20 % summer crops (Masri 2006).

The second zone (Zone 2) experiences a rainfall between 250-350 mm with wheat, barley and forage legumes as the main produce. The grain, straw & residues grown in this zone are used for feeding the animals (Swaid 1997). Zone 2 is about 13.3 % of the total land area.

Zone 3 has an area of 7.1 % of total surface area and experiences an annual rainfall of 250 mm. Barley is the main crop in this zone while there is a considerable amount of legumes cultivated (Masri 2006). Meanwhile, Zone 4 comprised of about 9.9 % of the total land area. The annual rainfall is between 200–250 mm. Like the Zone 3, barley is cultivated and fallow is practiced in case of capital shortage (Masri 2006).

Zone 5 attains only less than 200 mm of rainfall and only irrigated crops are cultivated in these areas (Swaid 1997). This zone is a desert and steppe area and comprise of 55.1 % of the land area (Masri 2006). It serves as the seasonal grazing resource of ruminant and nomadic animals based in the barley zones (Swaid 1997).

Irrigation Development. Among the 16 river bodies in Syria, the Euphrates is the largest with a length of 602 kilometers. The irrigated area which is 1,185,679 hectares can be found in all areas of the country tapped from available surface and ground water. The main crops in the irrigated areas are cotton, beet and wheat. In cities, they are planted with vegetables, fruits and legumes as forage for dairy cows (Masri 2006).

4.3. Livestock Production Systems in Syria and its water issues

Livestock production in Syria contributes 30 % of the over-all agricultural production (Cumins *et al*., 2003) employing about 20 % of the total labor force. It serves as the main source of income and livelihood for Bedouin herders (Bourne 2003). The country remains to be the largest exporter of sheep in the Middle East (Bourne 2003). Figure 10 shows the contribution of livestock in Syria where sheep dominates in terms of population.

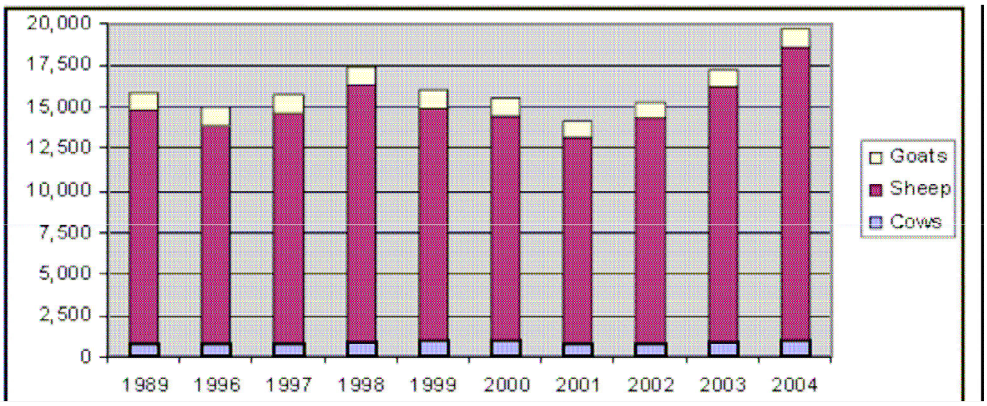

Figure 10: Number of Goats, Sheep and Cows in Syria, 1989-2004 (Thousands) (Source MAAR, Annual Agriculture Statistical Abstract (2004) of Münchhausen, 2007)

Box 3.1. Livestock population in Syria, 2006

Table 8: Livestock population in Syria (Source Al-Merestani, 2008)

LIVESTOCK	BREED	# HEAD	T0TAL
CATTLE	Shmee	3,575	
	Local	108,975	
	Friesian	99,172	
	Improved	909,717	
Sub-Total			1,121,439
SHEEP	Lactating	14,239,698	
	Non-lactating	7,140,332	
Sub-Total			21,380,030
GOATS	Shmee	33,329	
	Mountain Goat	1,386,516	
Sub-Total			1,419,845
CAMEL			26,712
BUFFALO			5,039
HORSES	Hors	13,974	
	Ass	112,541	
Sub-Total			126,515

The above table is the recent population data of livestock in Syria based on the presentation of Prof. Dr. M. Rabih Al-Marestani on the Livestock Production Systems in Syria. Al-Merestani is a professor in the Damascus University as well as a consultant for the Arab Center for the Studies of Arid Zones and Dry Lands (ACSAD).

From the table, it can be derived that 88.79 % of the total population of livestock in Syria is dominated by sheep, 5.9 % by goats (mostly mountain goat breed) and 4.66 % by cattle. There is also a significant number of horses (0.53 %), camels (0.11 %) and buffalo (0.02 %). The population of poultry is not included in this statistic table.

4.3.1. Sheep production

Sheep are the most important livestock in Syria. There are about 15.3 million sheep (FAO STAT 2005) and they are distributed in different areas in Syria. 70 % of the sheep population is found in Al Baida or Zone 5 (see Figure 11), 16 % in Dayr Az Zawr, 16 % Aleppo, 14 % Homs, 14 % Ar-Raqqah and 13 % Hama (Münchhausen 2007).

Figure 11: The 8.4 million hectare Al Baida Steppes (Source Münchhausen, J., 2007)

These local sheep are called Awassi breed (as shown in Figure 12 and 13) where it is best known for its meat and milk products and it has the ability to tolerate heat, drought, cold and long treks (Bourne 2003). Moreover, its fat tail provides a reserve of nutrients for periods of feed shortage (Masri 2006). As they are mostly located in Al Badia (Zone 5), they graze during the late autumn till late spring then migrate to irrigated and rainfed areas (Zone 2-4) for crop residues and then return again in Badia. Consequently, rain water within the autumn season in Al Badia becomes the drinking water of the sheep while when water supply is dried up at the end of the rainy season, the herds move back to rainfed areas where drinking water is available (Masri 2006). Drinking water of herds can be sourced in water harvesting dams or natural lakes, boreholes and wells. At the same time, sheep flocks are required to move out of the rainfed areas from mid February until after harvest of the crop, they are only allowed to graze weeds and young cereal crops in winter but must be removed later to prevent night grazing of crops by flock owners (Nordblom *et al*., 1995).

As to sheep ownership, 25% of the herders own less that 100 sheep, 30% own between 100-200 head, another 25% own 200-300 head while the remaining percentage owns above 300 heads (Razzouk 1998 of Masri 2006).

Box 3.2 Sheep Ownership (Al-Merestani, 2006)

According to Al-Merestani, sheep ownership can be classified as follows:

- Poor Households comprise of 60% holders who have small ruminant herds below 200 heads (typically up to 10 heads), which are often village based.
- Medium households typically own 200-500 heads making p about 30% of holders;
- Better-off households own above 500 heads but herds above 1,000 are exceptional.

Figure 12: Male Awassi (Ram)

Figure 13: Female Awassi (Ewe) & Young Kids (Lamb)

Box 3.3

From the excursion, the output of sheep is based on milk and meat products alone excluding wool production. Wool is not processed commercially because the production is very labour intensive and time-consuming while its market value is very low as compared to other wool producers in the world. Moreover, the awassi wool is not of good quality thus the production is mainly based on household use of sheep herders.
However, the milk produced by the sheep is not consumed fresh or it does not serve as a milk beverage for local consumers. In extensive systems, the fresh milk is sold to so called *cheese traders* who have the equipment to process the milk for cheese while in semi-intensive or intensive systems, milk is sold to government entities that process cheese and yoghurt or they are processed within the farm itself.

Sheep production has been the major source of income for Bedouin herders. The income is dependent on milk and meat derived from the sheep and also some wool production. Specifically, the output of sheep production is based primarily on live sheep for export and also meat and other milk products. Syria is one of the top sheep exporters in the world accounting about 5.7 % of the export value as well as the dominant exporter among the Arab countries with a share of about 24 % total exports (FAO STAT 2003). It supplies the Arabian Peninsula, Lebanon and Jordan with the Awassi lamb and fattened kids because prices in the mentioned countries are higher (Bourne 2003). Meanwhile the milk coming from sheep provides 30 % of the domestic milk demand (Cumins *et al*., 2003).

The Bedouin herders use traditional technical knowledge in the herding of sheep. But nowadays, trucks, GPS, radio and mobile phone are used extensively by herders. Specifically, about 80 % of the herders own machines (see Figure 14) like trucks, tractors or cars (Razzouk 1998 of Masri 2006) to easily transport their flocks in available grazing areas. Along with the trucks, supplementary feeds and water is also transported to keep the flocks in the pasture. Moreover, with the improvement of infrastructure like roads and transport vehicles, flocks spend more time in the cropping zones like the barley zones (Cumins *et al*., 2003). About 61 % of these Bedouin herders are nomadic pitching their tents (see Figure 15) near the grazing areas of their flocks (Razzouk 1998 of Masri 2006).

Figure 14: Bedouin herders with trucks (Source Münchhausen, J., 2007)

Figure 15: Bedouin herders in Tents (Source Münchhausen, J., 2007)

The main feed source of these animals are based on grazing rangeland pastures (e.g. wheat, barley, alfalfa, sugar beet, cottonseed, maize and other by-products of leguminous crops) but there is a shift now on more intensified supplementary feeding like early weaning and feedlotting of young sheep (Cumins *et al*., 2003). It has shifted to the traditional grazing of flocks and which changed radically the flock movements and feeding patterns in the rangeland.

Figure 16: Sheep Fattening on Feedlots in Syria (Source Münchhausen, J., 2007)

Figure 16 shows some sheep fattening on feedlots in Syria. Feed in this regard is sourced outside. Unlike monograstic animals, sheep require more intensive feeding because food supplements need more fibrous nutrients. Specifically, the feeding component for sheep fattening is shown in Figure 17. It can be noticed in this figure that barley is the most used supplementary feed among farmers. This production systems is very labor intensive (LEAD 2008). Purchase of lamb fattening on the available feedstuffs on the farm is very common and is encouraged by development programmes in Syria (De Wit *et al*., 1995). Such increase in demand happens during the time of muslim religious festivals where the meat price will be very high (De Wit *et al*., 1995). Sheep pass through the fattening cooperative before going back to the market to be sold for export or slaughtered. At the moment there are about 95 % cooperatives who undertake sheep fattening and are heavily subsidised by the government through short term loans for feeds and long term loans for warehouse construction (Masri 2006).

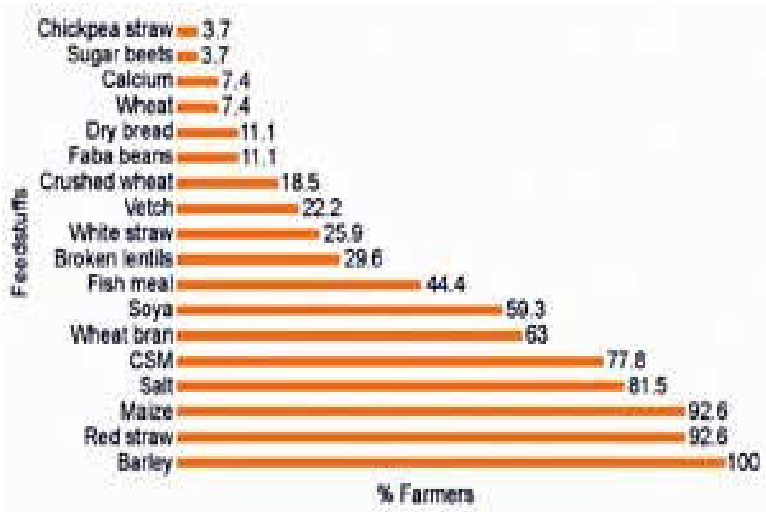

Figure 17: Percentage of Supplementary feeding for feedlotting used by Farmers (Source Münchhausen, J. 2000)

Box 3.4

In extensive systems, Bedouin herders use to move their flocks for grazing from east (Al Baida) to west (irrigated and rainfed areas) and vice versa.Usually, it takes them 2-3 weeks to move their flocks in a distance covering 300-400 kilometers. However, the trend within the last 5-10 years is moving towards the use of trucks to transport the flocks in available pasture resource. For semi-intensive systems, private sheep herders bring their flocks in cultivated areas immediately after harvest season for crop residue of wheat, barley, sugar beet, cotton and other by-products of leguminous crops. If private herders do not have cultivated lands, they normally rent out the grazing land with crop residues from farmers. Meanwhile, supplementary feeding of concentrates (e.g. hay from barley and wheat, cotton and olive cake) in the stubbles is practiced within semi-intensive systems.

From the excursion, intensive feed-lotting is not a very common practice in Syria as earlier expressed in the secondary data. There are few cases of feed-lotting near the urban areas. According to sources, all these fattened lambs were already sold last year (2007) and the government already banned or stopped to subsidize the cooperatives of feed-lotting.

It has been known also in the excursion that 95% of the sheeps can be found in the Al Badia (Zone 5) or the steppes (Al-Merestani, 2006) and they graze together with existing population of camels.

The government's role is to improve the breeding of the Awassi sheep as can be seen in the current efforts of the Damascus University Research Station. First is to increase the efficiency of the ewes (female sheep) like designing the line to improve the twining production (or twining rate) and to improve the breed of the ram (male sheep). At the moment, there is already 51% twining rate among the ewes. While improved rams are sold by the government farms to private herders. For milk yield efficiency, before 128 litres/lactation is only realized, however through improved efficiency, awe can generate 248 litres/lactation while uncorrected (fat content is not removed) can be 355 litres/lactation. The duration of lactation of the ewe is 160 days.

It is important to note in this system that there is a strong relationship between the wetlands and cropping systems for the feed of the flocks. However, one of the major constraints seen within this production is the diminishing rangeland resource brought about by mismanagement through inappropriate policies in the use of the rangeland. There is no way of expanding the area of the rangeland because of competition with areas for cash crops, leading to the lack of feed and fodder for the livestock. In effect, supplementary feeding becomes very expensive.

As to grazing in rangelands, pastoralists have access to communal pastures based on the agreement on the local right to use the resources. The hima is a communal property system developed by pastoralist in West Asia and North Africa (WANA) which governs the use of grazing land, areas to be used during drought and maintaining grazing land productivity. This system remained an important aspect in WANA, while in Syria there had been four major institutional changes done by the government to manage rangeland resources: (1) assertion of state ownership over rangeland, (2) settlement and transformation of herders into farmers, (3) formal reorganization of the Bedouin population into range improvement and sheep husbandry cooperatives and lastly (4) the development of rangeland reserves (Bourne 2003). Specifically in 1994, the government banned the cultivation in rangeland as well as enhancing livestock production through better conservation, improvement and management of rangeland resources. With the banning of cultivation in the range land, herding communities have to come up with new strategies for overcoming their production constraints and seek alternative feed resources (Bourne 2003).

In relation to water issues identified with mobile grazing of sheep is the conflict between cultivators crops against pastoralist due to damage of crops brought about by the animals and moreover, there are also some disputes with regard to the access to watering points (LEAD 2008).

The Table 9 below, is derived from the matrix of environmental risks of the LEAD Toolbox specifically discussing the water problems arising in mobile grazing and it lists all risks (-) and opportunities (+) in each resource base including the factors affecting it.

Table 9: Water Issues in Mobile Grazing System (Source LEAD, 2008)

Resource Base	Risks & Opportunities	Underlying Factors
Water Underground Reserve	(-) Increase of run-off, decrease of soil water reserve	Excessive grazing and browsing, animal trampling
Water Quality	(-) organic pollution	Animal waste and feces
	(+) access to good water for drinking	Drilling programmes for water supply

4.3.2. Goat production

Goats are can found in the steppe areas and in some irrigated-cropped areas. There are two main breed of goats, the (1) mountain goat which is the major breed and comprised about 86% of goat population is found in the west part of Syria (Bourne 2003). They are kept as grazing herds in the mountain ranges close to the forest areas (Masri 2006). They graze during the day and return to the village for enclosure at night where they are fed some concentrates (Masri 2006). The average herd size is 75-125 (Masri 2006). As shown in Figure 18, the (2) shami (Damascus) breed can be found in the Ghoota area of Damascus and they are raised usually for milk and used as a milk-improver breed for crossing with the mountain goat (Bourne 2003). It is also known as the "cow of the poor family" (Masri 2006). It is raised like dairy cattle. The main constraints in goat raising is the degradation of the rangelands because of the lack of property rights while the shami goat especially the new born goats should be allowed to be exported in neighboring countries (Masri 2006).

Figure 18: The Male Shami or Damascus Goat

4.3.3. Bovine production

The cattle industry is the main source of bovine production which are based on local and imported dairy breeds (Cumins *et al.*, 2003) having a population of 940,000 heads (FAO STAT 2005). They are mainly kept near the towns or urban areas and where water is available for forage production. The 70 % of these dairy cows are mainly stall-fed further fed with concentrates and crop residues due to the limited access for grazing lands (Cumins *et al.*, 2003). They are mostly intensive systems where feed is sourced outside the farm.

The Shami is the local breed while the Friesian Holstein is the imported high-yielding variety dairy breed. The Shami which was kept in the Damascus Oasis has decreased substantially in number due to the import of the Friesian cows which has higher milk production. The annual milk production goes from 1.4 to 4 tons (Masri 2006). Dairy cows are raised on the farm margin with average holding size of 1-3 cows per family (Masri

2006). The feeds are based on concentrates, vegetable residues, grazing barley in winter and grazing legumes in summer. Private commercial dairies are uncommon and the majority is state-owned. Farms of the government are undertaken by the General Organization of Dairy (Masri, 2006).

Box 3.5

The Shami goat or the Damascus goat is famous all over the world because of its colour and appearance while its production efficiency in terms of milk yield is very high. However, the shami goats are very sensitive where they have to be kept in shadow areas unlike mountain goats that are more resistant to extreme climatic conditions.
Mountain goats, contrary to the literature are only known for the meat products and not for the milk. They are mostly found in mountain or forest areas and not on the steppes because these goats cannot be integrated together with sheep and camels in the Al Badia.

The major constraints under this production include the lack of good quality ingredients for balanced feeding (Cumins *et al*., 2003), lack of free grazing and high cost of forage due to competition from fruit and vegetables for land and irrigation (Masri 2006).

There is also the local grazing breed called Golani (Akshi) located in the Golan Heights (Masri 2006). They are rather small in size, various colors and they have the ability to increase weight very fast. The average weight is 400-500 kg while the output form milk production is 550-650 kg/year (Masri 2006). The breed can survive on natural grazing and concentrates. The main constraint under the Golani breed is the lack of suitable genetic material (Cumins *et al*., 2003). While in general, the cattle industry in Syria faces serious problems of the over-all milk and meat productivity (Cumins *et al*., 2003).

Box 3.6

To improve the production efficiency of the dairy cattle industry, the University of Damascus Research Station is improving the breed of the dairy cattle through cross breed of the local Shami and the Friesian Holstein breed from Canada. The milk produced by the dairy cattle especially in state owned dairy farms are sold to cheese and yoghurt processors which are also owned by the government.
The dairy cattle industry has suffered 5 generations of low productivity. From the past, there was severe breed lost since the government of Syria had a law to prohibit the entry of imported semen. Thus, there was a very slow fertility rate and reproductive performance of the local shami breed. However, the government is promoting now the breeding program (e.g. artificial insemination) and slowly the dairy cattle sector is coping.

Figure 19: The Friesian Holstein Breed of Dairy Cattle in Syria

4.3.4. Poultry production

The system under poultry production is based on intensive production. These broiler and layer stocks are coming from imported grandparent stocks (Cumins *et al*., 2003). At present, the industry is dominated by 40 breeders who controls the whole poultry market (Cumins *et al*., 2003).

The major constraints identified in the industry include stability of feed supply and poor feed quality while there is also the growing competition of domestic feeds with the cattle and sheep (Cumins *et al*., 2003).

4.4. Critical issues in development

Crucial aspects in the overall livestock production systems in Syria is its integration with the over-all farming system as there is a strong interaction between crops produced and the fodder used for the animals. For instance, sheep are highly nomadic in nature. They graze in the steppes and rangelands when there is availability of water and forages while if resources are depleted they move in rainfed and irrigated areas in search of food and water.

Historically, there has been an evolution on government policies toward management, protection and sustaining the available rangeland resources because of serious concerns on rangeland degradation brought about by overgrazing. Herders like the Bedouin should come up with their own strategies to provide supplementary feeding for their flocks. This has put pressure and competition within the agricultural sector because of the demand for forages and other supplementary feeding for the animals and the demand for food also for the inhabitants. Moreover, the trend now is more on supplementary feeding of sheep on feedlots thus exacerbated the problem of forage availability. There is a competition between the uses of agricultural areas: will it be for cash crops or for livestock needs. The government kept subsidising barley through importation, which remains to be the main supplement of sheep especially in feedlots. However, this is not sustainable in the long run because of the instability of world prices which makes the cost of feeds very expensive.

The ICARDA acknowledges that there is incompatibility of the sheep production in the farming systems. They proposed some strategies for more viable sheep feeding. For instance, in one of the FAO projects, they encouraged farmers to grow legumes in irrigated areas rather than grazing forages. They said that lentils are more profitable than grazing forage due to the low productivity of the sheep. There was a low adoption rate of the strategy and perhaps it is worth to be revisited.

Box 3.7 Final Remarks based on the Excursion

The water source accompanying the livestock production system particularly the sheep production is based on the availability of water within the farming systems. From the excursion, the crop and fodder used for animal is strongly integrated within the livestock production system such as the use of crop residues in agro-ecological zone 2-3 as feed for the animals. However, attention should be given to the fifth zone or the Al Badia where 95 % of the sheep are concentrated during winter. As this zone (Zone 5) is purely government controlled, proper management of the grazing resource is needed to ensure sustainability of the pasture area. There are already existing policies and projects to manage the Al Badia in a more sustainable way but what is needed is to educate herders on the proper use of the pasture resource. The concept of free lunch should not to be inculcated in the minds of sheep keepers as their flocks graze freely within available pasture. Sheep keepers should have the responsibility to manage the grazing fields together with government current efforts like helping improve the Al Badia in terms of re-planting crops that require less water and at the same time it is nutritionally valuable for the sheep. Meanwhile, the problem for water use in Zones 2-3 is the unregulated use of waters as most of the sheep keeper have unlicensed wells for the use of drinking for animals as well as household consumption. This is completely unsustainable as groundwater water will be completely depleted if government does not do something about it.

It is perhaps proper for government to study crops to be cultivated which require less use of water, for instance barley and cotton is water consuming. Researches should deal more on crops that are water resistant but is nutritionally equal to the feed requirement of animals like the awassi.

It is also interesting to look into the improvement of the value adding products that can be derived from sheep and camel produce. For instance, as sheep cheese is highly demanded in Europe, it can be a good initiative to explore the possibility of producing cheese products that is suited for the European market. At the same time, as European market is now keen on biological or organic products, perhaps, camel milk and meat products can be a good entry point for camels are raised in ecological areas and its meat and milk products are known to be healthy because it is less in fat content.

4.5. Consumption of water by livestock

Christopher Achu

4.5.1. Introduction and importance of water consumption

Water is the most important nutrient for livestock but at times often underestimated by grazers and policy makers. Limitations on water intake depress animal performance quicker and more drastically than any other nutrient deficiency. Domesticated animals can live about sixty days without food but only seven days without water (Lardy and Stoltenow, 1999). Like most things, pastured livestock require water in sufficient quantities and quality for optimum health and growth. However, the intake varies in each production system with the availability of grazing lands and feed. Thus, in respective of production systems water plays a crucial role in enhancing production capacities. This section will address issues like the direct and indirect water consumption by livestock and show the typical daily water requirement for range livestock in Syria in particular.

4.5.2. Direct and indirect consumption of water by livestock

The problem of water is a growing worldwide phenomenon. At the same time, the distribution of water is highly uneven creating problems to man to bring water from one place to the other for consumption. Livestock consumed water direct or indirectly for their survival depending on the situation of the animal. The total quantity of water consumption (voluntary consumption) or water intake by livestock depends on several physiological and environmental factors:

- Size and type of animal
- Physiological state (pregnant, lactating, growing)
- Activity level - more active animals consume more water
- Type and amount of diet - animals fed on dry feed will require more voluntary water than those fed on silage or lush grass
- Weather conditions - water consumption increases as air temperature increases
- Water quality - more palatable water or greater total salt intake will result in increased water consumption
- Ease of access - animals will consume less water if they have to travel further to the source, or if access to the source is awkward and uncomfortable
- Type of feed

These requirements are met by water consumed from wells, ponds, fountains, etc., as well as moisture found in feedstuffs. Water in the body performs many functions. Water helps to: eliminate waste products of digestion and metabolism, regulate blood osmotic pressure, produce milk and saliva, transport nutrients, hormone and other chemical messages within the body, and aid in temperature regulation affected by evaporation of water from the skin and respiratory tract.

Box 3.8 Size, type and Physiological state of livestock

The University Research Station in Damascus was visited on the 18[the] February 2008 an during this visit discussion was held with the supervisor of the station and a visit round was conducted with the aid of the station supervisor and the study project team from Humboldt University. The infrastructures and livestock were visited and explanation on how they functions were given by the station supervisor. He said the main aim of the station is for research by the University. "Both students and lecturers carried research in this station for academic purpose he said".

Figure 20: Animal under lactation Source: Study Group Team

The dairy cattle section is composed of 40 cross breed of the Friesian Holstein calves imported from Canada with the local Shami breed. He explained that it is very difficult to know the actual amount of water consumed by the cattle but it depends on the size an physiological state of the animal. The bigger the animal the more the animal need more water for its functioning and activities. Cattle (Figure 20) under lactation consumed as double the amount of water as that which is under non lactation. Drinking water is an important tool for enhancing animal production, but the volume drunk is a small fraction of the total water used for feed production.

a) Direct water consumption

Water is consumed directly by livestock from the water source by drinking and services. These freshwater resources are unevenly distributed at the global level. The provision of adequate supplies of good quality drinking water for livestock is of major concern to farmers and graziers through out the world (Luke, 1987). Water use for drinking and servicing animals is the most obvious demand for water resources related to livestock production. For instance in Syria, direct water consumption forms less than 1% of the total fresh water consumption which similar to the global scenario of water used for livestock (Steinfeld *et al*., 2006). Water quality can affect both total water consumption and the general health of the livestock. Water is needed to raise livestock, be it cows, chickens, horses, or rabbits. Livestock water use is water associated with livestock watering, feedlots, dairy operations, and other on-farm needs. This includes water for raising cows, chickens, horses, rabbits, fish, and pets, and also water used in the production of meats, poultry, eggs, and milk.

In the past, livestock were turned out to summer pasture and allowed to walk through and drink from any slough, creek, river, or lake available to them. Today, allowing livestock direct access to surface water sources is a concern to livestock producers and to other water users. The practice is also a problem for livestock. Livestock producers want to provide a safe, reliable supply of good quality water for their livestock, and they want to increase their management to better utilize their pastures for livestock production. Many producers are using remote water systems and applying the latest technology available for extended livestock grazing and winter feeding of livestock away from the farmyard. Livestock producers, like other water users, want to do their part to protect both natural and constructed water sources from environmental damage and to address herd health problem (Agri-fact, 2008). There are many related problem related to livestock if allow to walk and drink water or have access to water directly from it source. These problems are related to environment to health hazard to the animal and human being. The environmental problems with direct watering are loss of riparian habitat and vegetation, damage to banks of streams and dugouts, rapid growth of weeds and algae, nutrient build up in both the source and downstream water bodies, deterioration in water quality etc. A number of herd health problems are related to direct watering: reduced rates of gain due to long distance movement, increase exposure to water-transmitted diseases, bacteria, viruses and cyst infections, leg injuries, stress etc.

Most ground and surface waters are satisfactory for livestock, where water quality is a problem, it is commonly excessive salinity. Cattle can tolerate poor water quality better than humans, but if concentrations of specific compounds found in water are high enough, cattle can be affected. Most factors affecting water quality are not fatal to cattle but dirty water is a host for disease organisms. Cattle may not show clinical signs of illness, but growth, lactation and reproduction may be affected, causing an economic loss to the producer (Braul *et al.*, 2001). Disease can spread rapidly if animals drink from the same trough, so sick animals should be isolated from the trough and the trough cleaned and disinfected. A good disinfectant is dilute bleach solution after the trough has been thoroughly cleaned. Sprinkling baking soda into the fountain periodically may reduce algae growth. Tip tanks are sometimes installed in larger dairy free stall barns to simplify cleaning.

Intensive livestock facilities use the greatest amount of "service water". For example, intensive piggeries can use 7 times the amount of drinking water consumed by the pigs just to flush the waste away (see Table 10 below). The following table gives you an idea of how much "service water" is used for different animals and shows the dramatic increase in "service water" consumption when animals are kept intensively compared to extensively.

Table 10: Service water (litres/animal/day) requirements for some different livestock type (Source http://www.animalsaustralia.org/features/water_animal_production.php#toc2)

Animal	Age group	Intensive	Extensive
Beef cattle	Young calves	2	0
	Adult	11	5
Dairy cattle	Calves	0	0
	Heifers	11	4
	Milking cows	22	5
Pigs	Piglet	5	0
	Adult	50	25
	Lactation	125	25

b) Indirect consumption

Not all water provided to livestock is by direct drinking others means of consumption are indirectly through feed (concentrate, pasture, etc.). Feeds that are high in moisture such as green chop, silage or pasture will provide part of the requirement, while feeds such as grain and hay offer very little moisture. The quality of the feed determines the amount of water consumed. Consumption of water and feed can be reduced when there is a lot of activity which diverts the animals' attention (Lardy and Stoltenow, 1999). Normally, low quality water in feed will reduced water and feed consumption.

Over the past twenty years, Syria has become self sufficient not only in food grains but in most livestock products as well. Feed contain salts and gases in solution and make the feed more palatable if not present in excess. However, while livestock is a major consumer of crop products as feed, the support to agriculture continues to favour the production of crops over livestock. There is, however, an interactive and complex relationship between agriculture and livestock and between the various livestock production systems, requiring a better balanced approach. The livestock sector, and dairy production in particular, competes directly with crops for land and water, while sheep rising occurs predominantly in areas where other forms of agricultural or livestock production are not viable. Cropping also encroaches on the margins of pastoral lands. As sheep numbers and production in Syria increase, competition intensifies with dairy, beef and poultry for the main feed resource: crop residues and concentrates.

In extensive grazing systems, the water contained in forages contributes significantly to meeting water requirements. In dry climates, the water content of forages decreases from 90 percent during the growing season to about 10 to 15 percent during the dry season (Pallas, 1986). Air dried feed, grains and concentrate usually distributed within industrialized production systems contain far less water. Metabolic water can provide up to

15 percent of water requirement. The type of animal (whether, sheep, cattle, etc…) will determine the amount of feed consumed. However, one kilogram of meat requires much water to produce – depending on how much feed is given to the animals versus animals that graze on rain fed pastures. However it is difficult to estimate the exact water consumption because livestock also feed on common lands (e.g. pasture land; extensive) whereas in intensive production system, water consumption can be estimated roughly. In addition, the quantity, quality and salt content of feed also affect the amount livestock drink or consumed water. Water intake is related to the intake of dry matter. The more moisture supplied in the feed, the lower the need for drinking water.

4.5.3. Typical daily water requirement for range livestock

Range Livestock are animals that feed on range land. Examples of animals are mainly sheep and cattle. These lands consist of grasses and harvested crops residues. There exist well documented literature in developed countries (see Table 11 and 12) related to water requirement for range livestock as to developing countries including Middle East and Syria.

Table 11: Approximate total daily water intake of beef cattle*

Animal description	**Intakes in litres for temperatures in Celsius (C)**					
	4.4°C	**10°C**	**14.4°C**	**21.1°C**	**26.6°C**	**32.2°C**
Feeders and replacements 2 - 6 months	20.1	22.0	25.0	29.5	33.7	48.1
Feeders and replacements 7 - 11 months	23.0	25.7	29.9	34.8	40.1	56.8
Feeders and replacements12 months and older	32.9	35.6	40.9	47.7	54.9	78.0
Bred heifers and dry cows	22.7	24.6	28.0	32.9	-	-
Lactating cows	43.1	47.7	54.9	64.0	67.8	61.3
Herd bulls	32.9	35.6	40.9	47.7	54.9	78.0

* Adapted from the Nutrient Requirement of Beef Cattle Update 2000, 7th revised edition. National Academy of Sciences National Research Council.

However effort had been made to estimate only direct water requirement for range livestock based on available livestock composition and different temperatures (see Table 11 & 12) in Syria. Temperature is the main factor affecting water consumption by livestock. It could be recognised that animal increase their intake of water as temperature rise at low humidity. Reduction of water intake results in lower meat, milk and egg production.

Table 12: Estimated Water Consumption in range livestock in Syria (Source Formulated from Steinfeld *et al.*, 2006 page 153 of 406)

			Water Consumption at different temperature					
			Per Day			**Per Year**		
Type of Animal	**Number**	**Body weight**	**15^0C**	**25^0C**	**35^0C**	**15^0C**	**25^0C**	**35^0C**
Sheep	21,380,030	36	186,01	275,80	451,12	68078,29	100943,67	165109,42
Cattle	1,121,439	200*	24,45	28,04	32,19	8947,74	10261,17	11779,82
		680*	49,46	82,09	114,72	18100,70	30044,70	41988,69
		680*	115,28	128,74	142,20	42193,92	47119,28	52044,64

200*: African pastoral system – lactating – 2 litres milk/day

680*: Large breed – dry cows – 279 days pregnancy

680*: Mid – lactation – 35 litres milk/day

The Middle East and North Africa (MENA) region is particularly vulnerable to climate change. It is one of the world's most water-scarce and dry regions; with a high dependency on climate-sensitive agriculture and a large share of its population and economic activity in flood-prone urban coastal zones. An increasing level of awareness is building among all stakeholders in the MENA region on the significance of climate change, reflecting both the global increase in awareness of the phenomenon, as well as mounting concerns in the region about increasingly frequent droughts and a looming water supply shortage. According to the latest World Bank (2008) assessment, the climate is predicted to become even hotter and drier in most of the MENA region. Higher temperatures and reduced precipitation will increase the occurrence of droughts. In Syria ACSAD (The Arab Centre for the Studies of Arid Zones and Dry lands) is create artificial lakes from rain captured at the bottom of the mountains or hills to make it available for livestock and the planted of trees to reduce the effect of the desert.

In this section of water consumption by livestock, it can be concluded that water is a very important nutrient for livestock survival though it is very scarce in supply in the Middle East and North Africa particular in Syria due to lack of efficient management practiced. Sheep and cattle are the dominant livestock and the cattle consuming the highest amount of water in the livestock production system in relation to their numbers as compare to sheep (see Table 12 above).

Box 3.9 Calculation of water consumption by livestock in Syria

The calculation was based on the figures in the table below. Sheep, Goat and Cattle are the dominant livestock in Syria with 88.8 %, 5.9 % and 4.7 %. But Sheep and Cattle were chosen for the calculation since Sheep is a small ruminant and has almost the same features and characteristics as Goat, and Cattle on the other hand is a large ruminant.
NB: Figures used in the calculation are obtained from the field during the visit.

Table 13: Livestock population in Syria

	Heads	Percentage
Cattle	1,121,439	4.7
Sheep	21,380,030	88.8
Goat	1,419,845	5.9
Camel	26,712	0.1
Buffalo	5,039	0.0
Horse	126,515	0.5
Total	**24,079,580**	**100.0**

Sheep Total number of Sheep =	21,3
Number of Sheep under Lactation =	9,62
Amount of water consumed by Lactating sheep (Litres/day) =	
Therefore total amount consumed by lactating sheep =	76,96
Number of Sheep not under Lactation =	11,75
Amount of water consumed by non Lactating sheep (Litres/day) =	
Therefore total amount consumed by non lactating sheep =	47,03
Total consumption by Sheep (million litres/day) =	124,00
Total consumption per Sheep (per sheep/litre/day) =	**5,**
Cattle	
Total number of cattle =	1,12
Number of cattle under Lactation =	0,560
Amount of water consumed by Lactating cattle (Litres/day) =	7
Therefore total amount consumed by lactating cattle =	39,23
Number of cattle not under Lactation =	0,560
Amount of water consumed by non Lactating cattle (Litres/day) =	3
Therefore total amount consumed by non lactating cattle =	16,81
Total consumption by cattle (million litres/day) =	56,0
Total consumption per cattle (per cattle/litre/day) =	**5**

The calculation shows that a sheep consumed 5.8 litres/per sheep/day against 50 litres/per cattle/day. From the above figure it could be concluded that sheep consumed almost times less water than cattle. Drinking water is an important tool for enhancing animal production, but the volume drunk is a small fraction of the total water used for feed production. Animals adapted to dry land conditions tend to drink less water as observed in Syria. This could be due to the following factors: size of the animal, physiological state, type and amount of diet, weather conditions, etc. Thus identifying the factors that affect domestic or livestock water demand and consumption is very important in management of available regional water resources in Syria.

5. Water pollution by livestock

Kennvidy Sa

In recent years there has been a great interest in the impact of livestock on the environment. One of the environmental issues is that livestock can be a source of anthropogenic emissions and water pollution. Wastewater can contain high concentrations of pathogenic or indicator bacteria, which can act as a potential reservoir for contamination of groundwater (Budisatria *et al*., 2005). Manure could be use as fertilizer which provides the major nutrients (N, P, K) compulsory for plant growth. Over dosage of manure applies on agriculture land can be associated with water pollution during leaching surface run off, surface flow and soil erosion (Brandjes *et al*., 1996). Moreover, Slurry and faeces of grazing animals can carry a variety of bacterial and protozoan pathogens, and groundwater can be contaminated with nitrates and nitrites (Budisatria *et al*., 2005). Through agriculture intensive, particularly fertilisation, livestock raising and plant protection does not only increase pollution of soil and surface water resources (Maticic, 1999) and thus a growing risk for heavy metal uptake by human and livestock (Moller *et al*., 2005). In addition, pollution arising from agricultural activities has increased mainly as a result of the intensification of food production systems. The demand for food production has been met by a combination of high yielding crop varieties and greater reliance on pesticides, fertilisers, and imported animal feedstuffs. Similarly, the total number of livestock: cattle, pigs, sheep and poultry increased. This has led to intensified farming practices where large numbers of animals are reared on relatively small areas, with the waste production. The intensification of livestock production with its associated increased demand for fodder has encouraged farmers to rely more heavily on chemical fertilisers and imported feeds, and very often the waste is considered as a disposal problem rather than a useful source of plant nutrients. Consequently, quantities of farmyard manure and slurry far in excess of crop requirements are frequently applied to soils, with storage and weather considerations often determining the timing and rates of application, rather than agronomic interests (Hooda *et al*., 2000). Moreover, livestock manure is a potential threat to the health of other animals and humans. Manure contains enteric and possible pathogenic bacteria, nitrogen and phosphorus that may pass, via water, to animals and humans. Animal wastes from diseased or disease-carrying livestock are capable of spreading a large number of diseases, to other animals or humans. Bacterial contamination of surface waters by runoff (Derek and Ronald, 1996).

In this part, we review major factors of water pollution concerns in livestock farming areas by livestock's waste, processing, feed and fodder production, and their impacts on human and animal health, aquatic environment, and soils.

5.1. Water’s pollution by livestock's waste

Most of the water used for livestock drinking and servicing returns to the environment in the form of manure and wastewater. Livestock excreta contain a considerable amount of nutrients (nitrogen, phosphorous, potassium), drug residues, heavy metals and pathogens. If these get into water or accumulate in the soil, they can pose serious threats to the environment (Figure 21). Different mechanisms can be involved in the contamination of freshwater resources by manure and waster. Water contamination can be direct through the loss via run off from farm buildings, losses from failure of storage facilities, deposition of faecal material into freshwater resources and deep percolation and transport through soil layers via drainage waters at farm level. It can also be indirect through non-point source pollution from surface runoff and overland flow from grazing areas and croplands (Steinfeld *et al*., 2006) (Figure 21 and 28).

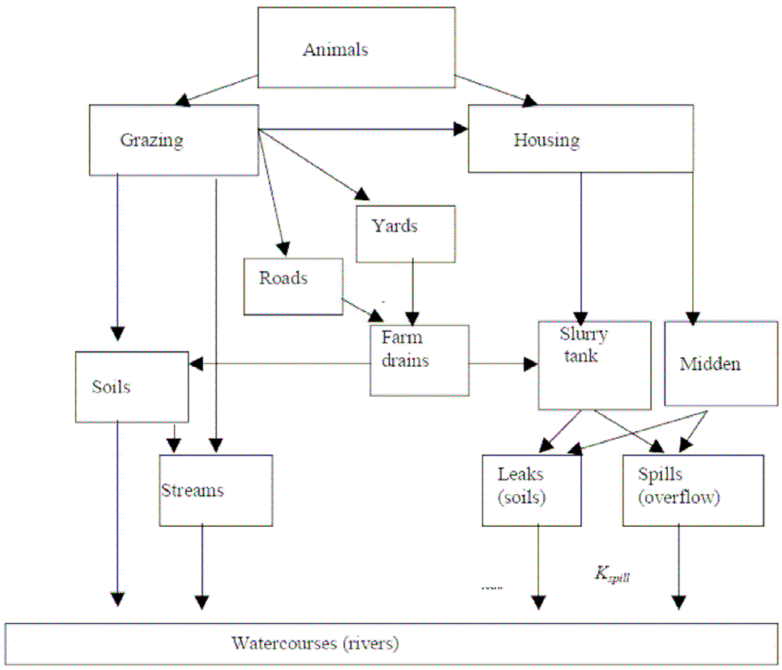

Figure 21: Waste production processes, pools and transfers in the farm budget pathogen model (Source Moller *et al*., 2004)

In some countries with intensive livestock systems, manure is discharged directly into the surface water, often after first having been treated in lagoons. Direct discharge into surface waste causes an-aerobiosis in the water, because the easily decomposable fraction of manure will start to decompose immediately using all dissolved oxygen and killing the water fauna and flora. In addition, run off manure into surface water cause the same problems as direct discharge. The most important sources of run off are locations where animals are concentrated such as feedlots, stables, bomas and kraals. The manure in these places if often drained and the liquid allowed to flow, directly or indirectly via the soil, into surface water (Brandjes *et al*, 1996).

Figure 22: Intensive sheep production, Syria

Figure 23: Wastrewater contains the manure and urine in the milking house

Box 4.1

In Albadia (Figure 25), the artificial lake storages the huge amount of water from the rainfall. Also, it is considered as the main surface water resource for extensive livestock production system, graze land agriculture, and human usage. However, nowadays, the direct consumption of water by the animal without control especially the sheep in the extensive system has not yet caused any particular damage to the water quality but it could possibly have some harmful effects in the future, such as the contamination of virus, bacteria, etc. Moreover, we found also the manure, the plastic material, the fertilizer bags surround the lake which could pollute the water in this lake in the future. Thus, to avoid these problems in the future, the cleaning activities should be done frequently.

Figure 24: Extensive sheep production system, Syria

Figure 25: Surface water in the artificial lake considers as the main water resource

5.1.1. Nutrient surpluses

Nutrient surpluses could be the main pollutant for water quality by livestock. Nutrient intake by animals can be extremely high. According to the Figure 28 amount of N and P intake by dairy cow is higher than amount of N and P intake by sow, growing pig, layer hen and broiler. Some of the nutrients ingested are sequestered in the animal, but most of it return to the environment and may represent a threat to water quality (Annex I). In case of a productive dairy cow, 129.6 kg of N total ingested (163.7 kg) and 16.7 kg of P total ingested (22.6 kg) is excreted every year (Figure 27). Moreover, at global level, livestock excreta were estimate to contain 135 millions tones of N and 58 millions tones of P in 2004. Cattle were the largest contributors for excretion of nutrients with 58 percents of N, pig accounted for 12 percent and poultry for 7 percent. The major contributors of nutrients are the crop systems that represent 70.5 percents of N and P excretion, follow by grazing systems with 22.5 percent of the annual N and P excretion. High concentrations of nutrients in water resources can lead to over-simulation of aquatic plant and algae growth leading to Eutrophication[1], undesirable water flavour and odour, excessive bacterial growth in distribution systems. They can protected micro-organisms from the effect of salinity and temperature, and may pose a public hazard.

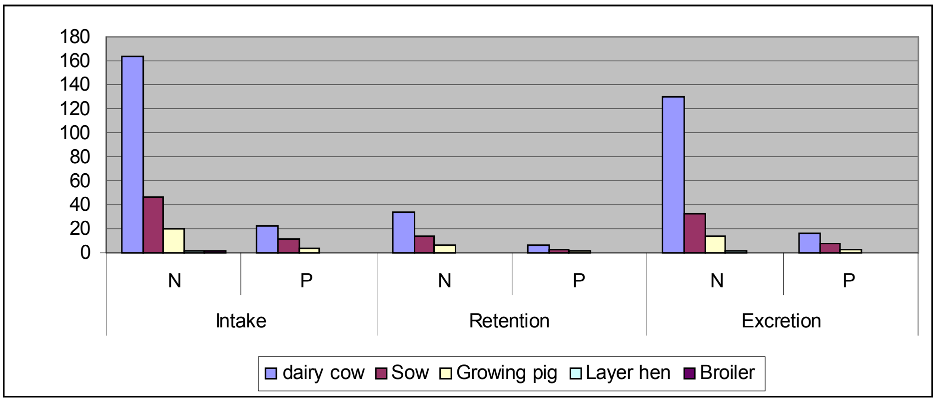

Figure 26: Nutrient intake and excretions by different animals in the highly productive situations (Source Steinfeld *et al*., 2006)

If the plant growth resulting from eutrophication is moderate, it may provide a food base for the aquatic community. If it is excessive, algal blooms and microbial activity may overuse dissolved oxygen resources, which can damage the proper functioning of ecosystems. These impacts occur both in freshwater and marine ecosystems, where algal blooms are reported to cause widespread problems by releasing toxins and cause anoxia

[1]Eutrophication is generally associated with the environmental impacts of excessively high levels of nutrients that lead to shifts in species composition and increased biological productivity, for example as algal bloom (Baumann, H et *al.,* 2004).

('dead zone'), with severe negative impacts on aquaculture and fisheries (Steinfeld *et al.*, 2006).

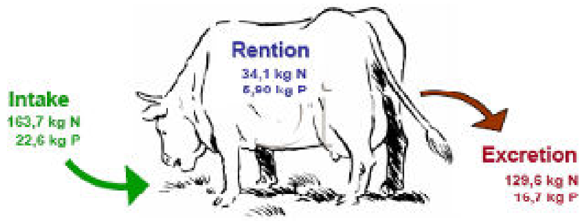

Figure 27: Nutrient (N, P) intake and excretions by a dairy cow per year (Source Steinfeld *et al.*, 2006)

5.1.2. Biological contamination

According to Budisatria *et al.* (2005), wastewater can contain high concentrations of pathogenic or indicator bacteria, which can act as a potential reservoir for contamination of ground water. Water resource contaminated by wastewater which was caused by livestock's manure had very high levels of faecal Coliform bacteria and total Coliform bacteria. Similarly to Steinfeld (2006), livestock excrete many zoonotic micro-organisms and multi-cellular parasites of relevance to human health. Pathogenic micro organic can be water-borne or food borne, especially if the food crops are watered with contaminated water. Several biological contaminants can survive for days and sometimes weeks in the faeces applied on land and may later contaminate water resources via run off. The most important water-borne bacterial and viral pathogens that are of primary importance to public health and veterinary public are: Campupylobacter *ssp.,* Escherichia Coli., Salmonella *ssp.,* Clostridium botulinum, Micosporidia *ssp.,* Fasciola *ssp.,* etc.

5.1.3. Drugs residues

Pharmaceuticals are used in large quantities in the livestock sector, mainly antimicrobials and hormones[2]. In developed countries, drug used for animal production represents a high share of total used. However, a substantial portion of the drugs used is not degraded in the animal's body and ends up in the environment. Drug residues including antibiotics and hormones have been identified in various aquatic environments including groundwater, surface water, and tap water. Additionally, antimicrobials and hormones are not the only drugs of concern. For example, high quantities of detergents and disinfectants are in dairy production. Detergents represent the biggest portion of chemicals used in dairy operations.

[2] Hormones are used to increase feed conversion efficiency, particularly in the beef and pig sector.

High levels of antiparasitics are also used in livestock production system (Steinfeld *et al*., 2006).

5.1.4. Heavy metals

Heavy metals are fed to livestock, at low concentrations, for health reasons or as growth promoters. Metals that are added to live stock rations my include copper, zinc, selenium, cobalt, arsenic, iron and manganese. For example, in the pig industry, copper (Cu) is used to enhance performance as it acts as antibacterial agent in gut. Other potential sources of heavy metals in the livestock diet include drinking water, some limestone and the corrosion of metal used in livestock housing. Animals can absorb only 5 to 15 percent of the heavy metals they ingest. Most of the heavy metals they ingest are, therefore, excreted and return to the environment. Water resources can also be contaminated when foot baths containing Cu and ZN used as hoof disinfectants for sheep and cattle. More to the point, the highest concentration of copper and zinc was found in pig manure also (Steinfeld *et al*., 2006).

5.2. Water pollution by feed and fodder production

Over the two last centuries, the increased pressure on agricultural land, associated with poor land management practices, has resulted in increased erosion rates and decreased soil fertility over wide areas. The increasing demand for food and feed production, combined with declining natural fertility of agriculture lands, lead to increase use of chemical and organic input (fertilizer and pesticides) to maintain high agricultural yields. This increase, in turn, contributed to the widespread pollution of freshwater resources. Most geographical areas the livestock sector should be considered as the major driver for the trend of increasing water pollution (Steinfeld *et al*., 2006). The major sources of livestock feed in Syria come from natural pastures and rangeland, cultivated green and conserved fodder, as well as crops and agro-processing by-products and residues. Grazing provides the most important source of fodder for ruminants. As the livestock population increases and production intensifies, an increasing proportion of the dietary requirements of ruminants are however met through supplementary feeding with cereals and by-products from crops and agro-processing. For example: Barley accounts for more than 85 percent of feed grown for livestock (Vercueil, 2003).

5.2.1. Fertilizer

Manure is applied to agricultural land chiefly because of its fertilizing value. Animal manure supplies all major nutrients (N, P, K, Ca, Mg, S,) necessary for plant growth, as well as micronutrients (trace elements), hence it acts as a mixed fertilizer. Manure application in a given year will influence not only crops grown that year, but also crops in subsequent years, because decomposition of the organic matter is not completed within one year. Therefore, the application of manure, thus, saves mineral fertilizers for various nutrients. This illustrates that nutrients from animal manure can be substituted for mineral fertilizers and which is far better for the environment.

A disadvantageous aspect of the uptake of components from manure by the crop is over dosage, which can lead to the absorption by plants of non-degradable components such as heavy metals (Cu, Zn) and organo-chlorines. These components can accumulate in the food chain and become a health hazard. In addition, the manure applied to crops including feed crops can be associated with water pollution. When the manure applied on agriculture land, Nitrogen and Phosphate reach watercourses during leaching surface runoff, surface flow and soil erosion. The main dangers of the application of manure are runoff of manure or manure components into surface water and leaching of nitrate (NO_3) and P into the ground water. Mineral N in manure is largely present as NH_3. If, upon application of the manure, it does not volatilize, it will be quickly nitrified, i.e. transformed through microbial action into NO_3. Also, N mineralized from the organic fraction of the manure, will readily be nitrified. As NO_3 is an anion that is not adsorbed by clay minerals or soil organic matter, it is easily leached in case of a precipitation surplus. This holds good for NO_3-N from manure, and for that originating from mineral fertilizers or from decomposed soil organic matter. If ground water concentrations of NO_3 become too high, it is unsuitable for drinking water. Under certain conditions, ground water can flow into surface water. In brackish and salt water in particular high NO_3 concentrations in surface water will lead to Eutrophication. Under certain conditions this may lead to excessive growth of algae, causing oxygen shortage and consequently the death of fish (Figure 28).

Phosphorus is not nearly as mobile in the soil as NO_3 and therefore much less susceptible to leaching. Nevertheless, leaching of P can occur under certain conditions. Many sandy soils have become "saturated" with phosphate (P_2O_5) after many years of heavy doses of manure. When saturated, the soil loses part of its capacity for P retention and leaching occurs. If P flows into the ground water and subsequently into surface water, the same problems as described above for NO_3 will occur. Note, P causes Eutrophication in freshwater bodies in particular. In developing countries, many assessments have shown the link between high fertilization rates, irrigation and groundwater pollution by nitrates (Brandjes *et al*., 1996).

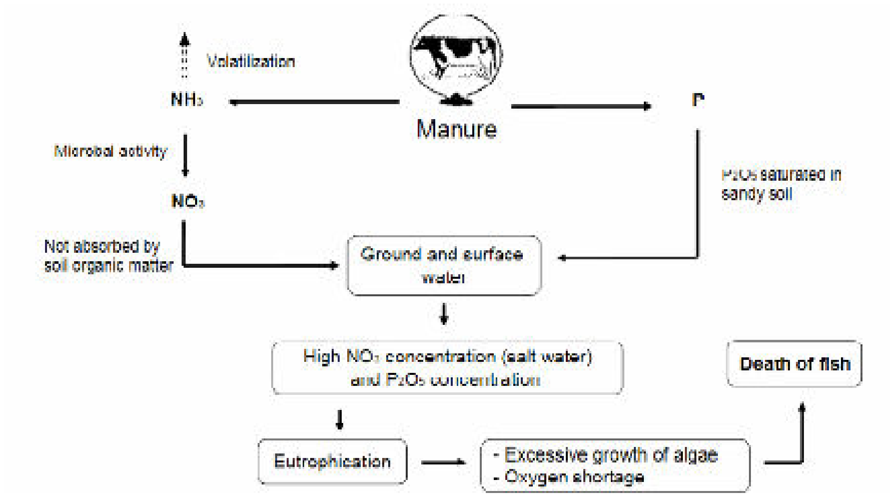

Figure 28: Surface and ground water pollution by livestock manure (N and P)

5.2.2. Pesticides

Modern agriculture relies on the use of pesticide to maintain high yields. Pesticide use has declined in many OECD countries but is still on the increase in most developing countries. Pesticides applied on agriculture land can contaminate the environment (soil, water and air) and affect non-target living organisms and micro-organism, thus damaging the proper functioning of ecosystems. They also constitute a risk to human health through residues in water and in food. The main form of loss of pesticides from treated crops is volatilization, but run off, drainage and leaching may led to indirect contamination of surface and ground waters. Surface water contamination may have eco-toxicological effects on aquatic flora and fauna and for human health if the water is used for public consumption (Steinfeld, 2006).

Box 4.2

In Syria, the agriculture and the livestock are considered to be the primary source of nitrate causing water pollution. Materials used in agriculture production such as fertilizers, pesticides, urine and fesses leading to problems of nutrient microbial contamination and sediment accumulation. Nitrate accumulation in the water bodies in Algota which located in the rural area by Damascus, as well as discharges from the soil and animals move into both surface and ground water systems at higher rates than would be. Moreover, the leached amount of Nitrate into the groundwater in Algota from the illustrated activities showed as below: 16 tons Nitrate per year from livestock, 9.4 tons Nitrate per year from the agriculture activity and 1,5 tons per year from the dumping site (landfill). Thus, the livestock activity is identified as the primary source for groundwater contamination with nitrate in Algota (Ibrahim, 2007).

Figure 29: The storage of manure in the agriculture field

Figure 30: Olive tree plantation

5.3. Wastewater from animal processing

Slaughterhouses, meat-processing plants, dairies and tanneries have high polluting potential locally. The two polluting mechanisms of concern are the direct discharge of wastewater into freshwater courses, and surface run off originating from processing areas. Wastewater usually contains a high levels of total organic toxic carbon (TOC) resulting in high biological oxygen demand (BOD), which leads to reduction of Oxygen level in water and suppression of many aquatic species. Polluting compounds also include N, P and chemicals from tanneries including toxic compounds such as chromium (Steinfeld, 2006).

5.3.1. Slaughterhouse

Slaughterhouses can be classified on the basic of their final products. A slaughter and packing house that processes meat productions, such as canned, smoked and cured meat, produces significantly more waste than a simple slaughterhouse that is only producing carcasses (Bos and Wit, 1996). Likewise, wastewater from the abattoir is contaminated with organic compounds including blood, fat, rumen contents and solid wastes such as intestines, hair and horn. Typically 100 kg of paunch manure and 6 kg of fat are produced as waste per tonne of product. The primary pollutant of concern is blood, which has high BOD (150,000 to 200,000 mg/litre). Indeed, if directly discharged into a water course, the wastewater originating from the processing of 1 tonnes of read meat contains 5 kg of BOD, which would need to be diluted into 200,000 litres of water in order to comply with EU standards (Steinfeld, 2006). In OECD[3] countries, where environmental concern has grown considerably, care is taken to use by products, blood and offal as much as possible and treat the waste water before disposal. In many countries blood is washed away, offal is wasted (washed or dumped) resulting in high water pollution levels (Bos and Wit, 1996).

[3] Organization for Economic Co-operation and Development

5.3.2. Tanneries

The tanning process is a potential source of high local pollution, as tanning operations may produce effluents contaminated with organic and chemical compounds. Pre tanning activities (including cleaning and conditioning hides and skins) produce the biggest share of the effluent load. Water is contaminated with dirt, manure, blood, chemical preservative and chemicals used to dissolve hairs and epidermis. Acid ammonium salts, enzymes, fungicides, bactericides and organic solvents are widely used to prepare the skins for the tanning process. Wastewater from tanneries, with its high concentrations of chromium and hydrogen sulphides, greatly affects local water quality and ecosystems, including fish and other aquatic life. According to WHO standards, the maximum allowed concentration of chromium for safe drinking water is 0.05 mg/l. In areas of high tannery activity the level of chromium in fresh water resources can far exceed this level. When mineral tannery waster is applied on agricultural land, soil productivity can adversely affected, and the chemical compounds used during the tanning process can each and contaminate groundwater resources (Steinfeld, 2006). In Syria, the untreated effluents of the tannery industrial estate at Zablatani east of Damascus have been directly discharged into the Barada River and hence have been used for irrigation. The highest Cr values with more than 1,800 mg Cr kg^{-1} soil were found near by outlets of the tanneries (Moller et al*l*., 2005).

We conclude that the impact of livestock on the water pollution remains as a major concern to the environment and agriculture area. Pollution and contamination to livestock farming system are mainly caused by livestock's waste, feed and fodder production and wastewater from the animal processing. The source of water contamination summarised below and the root cause are closely related. Water contamination by the livestock can only be controlled or minimised with proper planning and management among the farmers.

- Water used for livestock drinking and servicing returns to the environment in the form of manure and wastewater which contain high concentrations of pathogenic or indicator bacteria, drug residue, heavy metals and nutrients (nitrogen, phosphorous, potassium).
- Surface water and ground water contamination run off from farm buildings, losses from failure of storage facilities, deposition of faecal material into fresh water resources. In addition, the increasing demand for food and feed production in the livestock production system, combined with the declining natural fertilizer of agriculture, lead to increase used of chemical and organic input such as fertilizer, pesticide to maintain high agriculture yield. Over dosage of fertilizer (manure) applies on agriculture land can be associated with water pollution by N and P during leaching surface run off, surface flow and soil erosion.

- The discharge direct of the wastewater into the water resource from animal processing including the slaughterhouse and tanneries which hold a high levels of total organic toxic carbon, biological oxygen demand, chromium which leads to reduction of O_2 level in water and pollute the water source. Wastewater will affect to the soil productivity and it leached to contaminate groundwater. The impact of water pollution describe in the following point.

5.4. Impacts of water pollution

Nguyen Than Binh

Livestock production and related activities release a lot of wastes which are different from other sources and cause heavy environmental pollution. The characteristics of such pollutants includes: bad flavor and odor, rich nutrients, high level of organic matters, heavy metals, drug residues, pathogens, and agro-chemicals (Delgado *et al.*, 1999; Catelo, 2006; Starmer, 2007). In this section, the impacts of water pollution by livestock sectors on human and animal health; aquatic environment; and soils and agricultural activities are reviewed and talked about. As a case study, some examples of water pollution and cost of environmental degradation in Middle East with special reference to Syria, where water scarcity and water depletion become more and more serious are also given and discussed based on current literature reviews.

5.4.1. Impacts of water pollution on human and animal health

Livestock wastes generate **bad flavor and odor and toxic gases** such as ammonia, hydro sulfide, methane, etc. which may affect to humans and animals. A study showed that residents living downwind from confined animal feeding operation emitting hydrogen sulfide at fairly low levels were suffering from permanent nervous system impairment. Exposure to persistent, low levels of hydrogen sulfide can cause fatigue, short-term memory loss, headaches, and other symptoms (Starme, 2007). Many epidemiological studies show significantly higher incidences of chronic bronchitis, asthma, flu-like symptoms, skin irritation, and lower respiratory tract inflammation in both livestock raisers and households residing near to livestock farms than in others because of ammonia, toxins and dust (Catelo, 2006; Starme, 2007).

Nutrient loading in livestock wastes may bring about water pollution due to leaching, runoff, storage failure and so on, of which phosphorous tends to be more of a problem with surface water quality through eutrophication phenomenon, whereas nitrogen seems to be more of a threat to ground water quality by nitrate leaching through soil layers (Steinfeld *et al.*, 2006). ***Nitrate*** is considered as an acute contaminant which means a single exposure can affect a person health (Ibrahim, 2007). According to WHO guide value for nitrate

concentration in drinking water is 45 mg per liter. High nitrate concentrations in drinking water can cause methemoglobinemia (blue baby syndrome) and may contribute to developmental defects in fetuses or miscarriages in pregnant women. Nitrate toxicity may also cause stomach cancers (Cole *et al.*, 2000 in Starmer, 2007; Steinfeld *et al.*, 2006). High nitrate level of water has been reported worldwide and more serious with industrialized livestock production systems (Delgado *et al.*, 1999). In the United State, for example, Goodman (1999) showed that one-third of all wells in Maryland's chicken- producing areas have high concentrations of nitrate which exceed standards for drinking water (in Starmer, 2006). In Syria, water pollution by nitrate was also documented. Ibrahim
(2007) reported that "nitrate accumulation in the water bodies in Al-Gota (the rural area by Damascus) – as well as discharges from soil and animal move into both surface and groundwater systems at higher rates than would be". The author estimated around 32 tons per year of nitrate were leached in the groundwater at the study area, of which the livestock is considered as the primary source for groundwater contamination with nitrate (Figure 31).

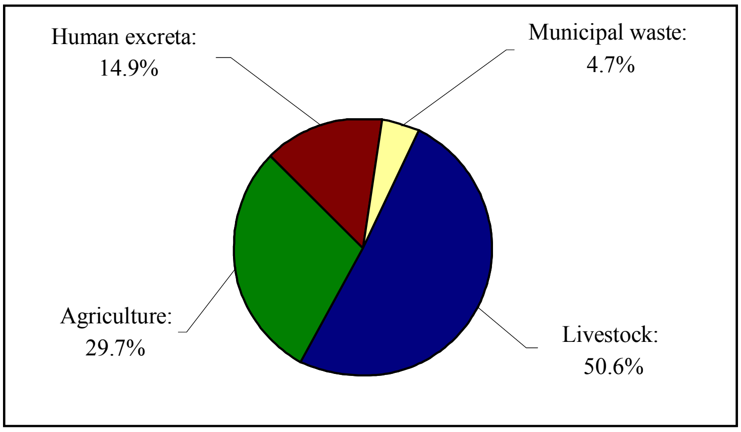

Figure 31: Share of groundwater pollution with nitrate by sectors in Al-Gota, Syria (Source Adapted from Ibrahim, 2007)

Phosphorous in water is not considered to be directly toxic to humans and animals, therefore, no drinking-water standards have been established for phosphorus (Steinfeld *et al.*, 2006). However, phosphorous generate development of phytoplankton, cause eutrophication, and damage aquatic environment that will be discussed more detail at sub-section 3.6.2. In areas with high livestock densities phosphorus levels may build up in soils and reach water courses through runoff. In grazing systems cattle treading on soils affect the infiltration rate and macroporocity, and causes loss of sediment and phosphorus via overland flow from pasture and cultivated soil (Steinfeld *et al.*., 2006).

Pathogens: Difference between livestock wastes and other agricultural wastes is biological contamination which puts a highly public health concern. Livestock excrete many pathogens such as bacteria, virus, protozoa, endoparasites, and unconventional agents which can be transmitted to humans so called zoonoses (Catelo, 2006; Steinfeld *et al.,* 2006). Raw manure can contain up to 100 million fecal coliform bacteria per gram (Cole *et al*., 2000 in Starmer, 2007). The most common and dangerous pathogens that influence the public health and veterinary public health include:

Bacteria: There are several bacteria pathogens shed in livestock manure which can cause diseases in humans, including the common food-born pathogens *Campylobacter, E. coli, Salmonella, Listeria, Staphylococcus,* and *Clostridium* (Delgado *et al*., 1999; Nicholson *et al*., 2004). *Campylobacter* is capable of causing gastrointestinal infection. At global scale, campylobacteriosis is responsible for 5 – 14% of all cases of diarrhoea (Institute for International Cooperation in Animal Biologics, Centre for Food Security and Public Health, 2005 in Steinfeld *et al.*, 2006). *Campylobacter* can be found in all common livestock manure as cattle, pig, poultry, sheep (Nicholson *et al*., 2004). *Escherichia coli O157-H7* is a human pathogen that can cause colitis and in some cases hemolytic uremia syndrome. Cattle have been implicated as a main source of *E. coli O157-H7* contamination in water-borne and food-borne (Delgado *et al*., 1999). *Salmonella* cause salmonelloses for humans and animals. Chickens are considered as a major reservoir of *Salmonella*. The *Salmonella dublin* is one of the more frequently isolated serotypes from cattle and a serious food-borne pathogen for humans. Surface water contaminated with bovine *Salmonella dublin* or foods rinsed in such water may serve as vehicles of human infections (Delgado *et al.*, 1999; Steinfeld *et al*., 2006). The bacteria can infect humans through consumption of infected livestock products (raw or undercooked) or through food chain at the primary food-production stage especially when manure is applied directly to ready-to-eat-crops (Nicholson *et al*., 2004; Catelo, 2006). The WHO reported that more than 3 million children under five years of age die each year because of diarrhoea, contaminated water and food-borne pathogens cause much of this diarrhoea especially in developing countries (in Delgado *et al*., 1999). However, most pathogen bacteria can be killed with common water treatment such as chlorine if water contamination is suspected (Benham *et al.*, 2001).

Viral diseases: Viruses are important factors for several diseases which can infect to humans and animals such as food and mouth diseases, avian encephalomyelitis, swine vesicular diseases, encephalomyocarditis, swine fever and so on (Steinfeld *et al*., 2006). For example, bird flu caused by virus H5N1 was killed 93 persons between 2003 and February 2006, mainly in Southeast Asia. But now it becomes worldwide discussion because of virus spreading (Catelo, 2006).

Protozoa: *Giardia lamblia* and *Cryptosporidium parvum* are two protozoa shed in animal manure of greatest concern. They can cause severe diarrhoea, nausea, fever, vomiting and fatigue in humans (Benham *et al.*, 2001). Both have become significant water-borne pathogens as they are indigenous infections in many animal species. Moreover, their oocysts are small enough to contaminate ground water and can not be easy to remove by common water treatment. In many cases, humans are infected via food or water which is contaminated with these pathogens. *Microsporidia* is intracellular spore-forming protozoa. In developing countries they represent an even greater public health hazard. The presence of human pathogenic *Microsporidia* in livestock or companion animals has been widely reported (Nicholson *et al.*, 2004; Steinfeld *et al.*, 2006).

Endoparasites: *Fasciola hepatica* and *Fasciola gigantica* are important parasitic infection of herbivores and a food-borne zoonosis. Endoparasites can be disseminated in manure and more dangerous for human because they may survive for long periods in the absence of an animal host (Steinfeld *et al.*, 2006; Benham *et al.*, 2001).

Fungi: Fungi are naturally found in livestock operation. Several species infect and cause diseases in humans ranging from dermatitis to invasive diseases of the lung that are sometimes fatal. In addition, some fungi produce toxic compounds called mycotoxins that can produce pneumonia or disrupt the function of kidney, liver, and spleen. Unlike bacteria, treatment for fungal infections is more difficult (Benham *et al.*, 2001).

Heavy metals are fed to livestock such as copper, zinc, selenium, cobalt, arsenic, iron and manganese at low concentrations for health reasons or as growth promoters. Animals can absorb only 5 to 15% of the metals they ingest. Most of the heavy metals, therefore, excreted and return to the environment. Besides, the heavy metals can come from other activities such as tanneries. They can affect indirectly animals and humans through food chains (Delgado *et al.*, 1999; Möller *et al.*, 2005; Steinfeld *et al.*, 2006).

Drug residues**:** Large amount of drugs, mainly antibiotics and hormones, are used for livestock operation. Antibiotics are given for therapeutic and/or prophylactic purposes whereas hormones are used to increase feed conversion efficiency (Catelo, 2006; Steinfeld *et al.*, 2006). A large portion of the drugs used is not absorbed by livestock but excrete to the environment and contaminate in water courses. Drug residues are harmful to health and become public discussion nowadays. The presence of antibiotics in animal food product can cause allergies. But more important, the use of antibiotics is increasing the concern about new strains of bacteria that may resist antibiotics and put human and livestock health at higher risk (Delgado *et al*., 1999; Starmer, 2007). Hormones are possible endocrine disruption in human and wildlife. They also increase incidence of breast and testicular cancers and alterations of male genital tracts among mammals (Miller, 2001; Soto *et al*., 2004 in Steinfeld *et al*., 2006). Hence, in developed countries as UK, US, EU, banned the use of certain antibiotics as growth promoters in the late 1990s (Catelo, 2006).

Generally, wastes from livestock production and related sectors are dangerous for human health and veterinary public health. They increase expenses of health cares, veterinary medicines, hygienic conditions and public water supplies due to pollution and diseases. For example, Figure 32 shows the water pollution cost of some countries in the Middle East and North Africa region. It is estimated from 0.6 to 1.2 % country GDP per year due to lack of access to water supply and sanitation (Sarraf, 2004).

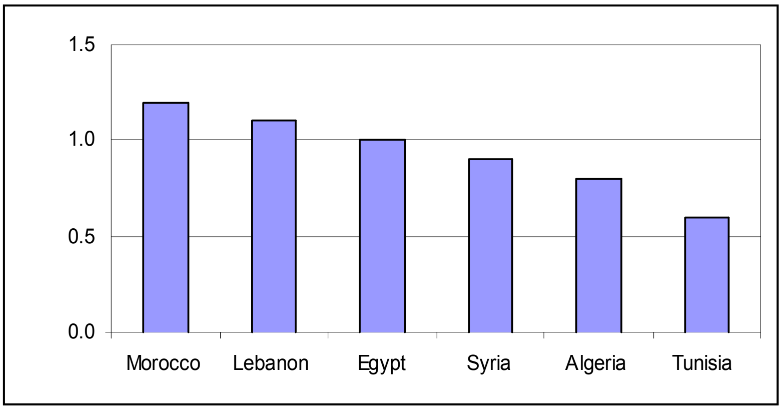

Figure 32: Annual damage costs from lack of access to water supply and sanitation (Source Sarraf, 2004).

In Syria, the annual damage cost of water pollution on human health, quality of life and water supplies were estimated around 0.88% of total Syrian GDP (or 8.1 billion Syrian Pounds per year). Of which the losses from diarrhoeal child mortality, diarrhoeal morbidity, treatment for and care of sick children were at 73%; the cost of pumping clean water to Damascus and Homs at 8% (because of local water pollution); and the incremental cost of groundwater pumping for agriculture at 19% (because of declining water tables). More than 1050 children under the age of five are died annually by diarrhoeal disease (due to lack of safe water, sanitation facilities and inadequate hygiene). It is calculated that the diarrhoeal deaths represent an annual loss of about 36,850 DALYs (disability adjusted life years). The same factors also lead to infectious diseases such as intestinal worm infections and non- fatal diarrhoea. The diseases cause discomfort to victims and impose the cost of treatment and time of caregivers. Taking all into account, such illnesses result in the loss of 19,000

DALYs annually (WB/METAP, 2004). However, it is difficult to know exactly how much pollution is related to livestock. Because the livestock sector has a complex impact as it represents an indirect and direct source of pollution (Steinfeld *et al.*, 2006). In Syria, the poultry population has been increasing almost doubled during the last decade especially intensive production system in urban areas which can consider as point source pollution. While the rangeland sheep (dominant animal in Syria) have been also grown and resulted in overgrazing and environmental degradation. With the rangeland systems, it is more difficult to manage the wastes because the livestock are always moving and shifting (Edwards-Jones, 2003; Vercueil, 2003).

5.4.2. Impacts of water pollution on aquatic environment

High concentrations of nutrients and organic matters from livestock production and related activities can lead to eutrophication, algal blooms, and excessive bacterial growth in aquatic environment. According to Steinfeld *et al.* (2006), the adverse effects of eutrophication include: generation of undesirable water flavour and odour; overuse of dissolved oxygen resources; shifts in habitant characteristics owing to change in the mix of aquatic plants; replacement of desirable fish by less desirable species, and the associated economic losses; production of toxins by certain algae; increased operating expenses of public water supplies; infilling and clogging of irrigation canals with aquatic weeds; loss of recreational use opportunities; and impediments to navigation due to dense weed growth.

In many cases such phenomena can harm to aquatic ecosystem so called “dead zones” because of toxins and anoxia. Starmer (2007) has given an example that Chesapeake Bay has become a “dead zone” due to excess phosphorus and nitrogen by poultry manure. In Syria, Yoshiro and Melhem (2000) reported that the Barada River receive approximately 12.5 tons of biological oxygen demand (BOD) per day from industrial wastewater, in addition, huge amount of domestic waste and agricultural wastewater are also discharged in the region without sufficient treatment. As a result, the Barada River has become completely dead in the recent years. A matter of course, it will cause negative impacts on human life, ecosystem and economic growth. Eutrophic surface water may cause blooms of cyanobacteria, which can kill livestock and pose a risk to humans (Steinfeld *et al*., 2006; Benham *et al.*, 2001). The phenomenon may occur not only in freshwater but also in marine water. The pollution of coastal areas and river basins in Middle East and North Africa region has been also reported in many countries such as Tunisia, Lebanon, Syria, Algeria, Morocco and Egypt. Marine ecosystems, as the coral reefs around Hurghada, Egypt, on the Red Sea, have suffered irreversible damage. The degradation costs in coastal zones are estimated annually between 0.1 and 0.7% of the country GDP (Sarraf, 2004). An example from Syria showed that pollution from port, municipal and industrial waste and sewage have been impacting the coastal areas in terms of fishing, tourism and ecosystem losses. Areas along the coasts of Lattakia and Tarous are polluted and tourism is impacted. The revenue losses from tourism sector are estimated to be 350 million Syrian Pounds per year (0.04% of Syrian GDP). In addition, coastal water pollution cause changing in fish species which can be lost about 225 million Syrian Pounds per year or at 0.02% of country GDP (WB/METAP, 2004).

The contamination of **hormones** in aquatic environment cause endocrine alterations and can lead to feminization or masculinization of fish. The uses of **agro-chemicals** such as pesticides, fungicides and so on for feed production and agriculture also remain in soils and water courses which can contribute to lose aquatic biodiversity and also can affect fauna,

flora, and humans (Steinfeld *et al.*, 2006; Estevez *et al.*, 2008).
However, an appropriated application of animal wastes stimulates phytoplankton and enriches natural food in fishponds. So, the inputs for fish can be reduced while the fish production increases. By this way, the integrated livestock – fish (or/and aquatic crops) farming systems give many positive impacts in terms of economic, environmental and natural resource management aspects (Prein, 2002; Lee, 2005; Nhan, 2007). Therefore, it could be the systems which need more studying and expanding as a strategy for reducing of aquatic environmental pollution.

5.4.3. Impacts of water pollution on soils and agricultural activities

The animal wastes have both negative and positive impacts on soils and related agricultural activities depend on how much manure and slurry are applied. In this sub-section, the problems from excess nutrients, problems from organic matters, soil pollution from heavy metals, the problems of soil salinity, and weed seed and pathogen dissemination on soils from livestock wastes will be discussed in detail.

The problems from excess nutrients: Introduction of nutrients such as nitrogen, phosphorus and potassium from manure for crops has been historical event. The integration of livestock and crop operation is still the main farming system for sustainable agriculture in Asia (Delgado *et al.*, 1999; Lee, 2005). However, there is an unbalanced nutrient composition of many livestock manure relative to plant requirements. Steinfeld *et al.*, (2006) reported that the application of manure on agricultural land has increased level of phosphorous in soils overtime due to difference from N/P ratio in manure and uptake by crops. Additionally, the development of industrialized livestock production systems has been causing more pressure on soil pollution by over-application of manure especially in urban and sub-urban areas. As a result, nutrients are accumulated in soils and exceeding the plant demands. Obviously, the situations have negative impacts on crop production and/or natural vegetation. Recent years, the livestock sectors in Syria have been increasing very fast in terms of population and productivity. For example, poultry industry has already intensified as industrialized countries. The intensification, of course, puts more pressure on water pollution and land degradation in the country (Edwards-Jones, 2003; Vercueil, 2003).

The problems from organic matters: Organic matter in manure can be a valuable environmental resource if managed properly, or an environmental pollutant if managed poorly. The use of organic wastes as fertilizers generally increases soil fertility and soil structure and improves crop yields. However, if large amounts of animal wastes are applied to soils, there are numbers of counter effects. The clogging of soil pores by organic matters may severely reduce the water infiltration rate and oxygen diffusion, and enlarge anaerobic zones. Under these conditions, many toxins are produced as acids, alcohols, hydro sulphide, methane, and so on. Besides, nutrient mineralization processes are also affected. Such toxins could not be assimilated by the plants but become harmful due to reduction of root respiration, root growth and root hair formation. Moreover, manure is also good environment for fungi development. Application of non-composted manure to crops can result in increased crop diseases (Delgado *et al*., 1999; Benham *et al.*, 2001).

Soil pollution from heavy metals: In small quantities, many heavy metals like iron, manganese, copper, zinc and molybdenum are essential to plants. But high concentration of heavy metals is one of the most severe threats to soil fertility and photosynthesis and can be harmful for humans and animals via food chain (Delgado *et al.*, 1999). Application of livestock wastes can enrich soils with common heavy metals such as cadmium, copper and zinc. Unlike copper and zinc, cadmium is not essential element for crop growth and is usually phytotoxic even at low concentration. High level of copper in the soil leads to poor root development and difficulties in uptake of nutrients, whereas zinc is supposed to be the least toxic of the main heavy metals found in livestock wastes. On the other hand, the accumulation of heavy metals can reduce the number and the variety of soil organisms that may affect the soil respiration, organic matter decomposition, nitrogen mineralization, nitrogen fixation, and degradation of pesticides (anonymous).

The problem of soil salinity: The soluble salts (Na^+, K^+, Ca^{2+}, Mg^{2+}, Cl^-, SO_4^{2-}) in animal manure, slurries, and other wastes can lead to salinity of water and soil. The addition of these wastes to soils could cause salinisation especially in semi-arid and arid areas due to rapid evapotranspiration and low annual rainfall. If the salinity occurs in soils, the physical, chemical and biological properties will be affected. Soil salinity and sodicity have become more serious in semi-arid and arid regions nowadays (Edwards-Jones G., 2003; Jalali *et al.*, 2008; Qureshi *et al.*, 2008). For example, soil salinity affect agricultural productivity and the supply of livestock fodder are documented in Middle East and North Africa areas (Sarraf, 2004). In Syria the yields of wheat and cotton can be reduced 15 – 40% because of soil salinity. An estimated 530,000 ha of irrigated land in the Euphrates basin (more than 40% total irrigated land in Syria) is affected by varying degrees of salinity and it can cost from 3.7 to 5.3 billion Syrian Pounds per year (WB/METAP, 2004).

Weed seed and pathogen dissemination from livestock manure: Application of livestock manure may influence the level of contamination and nature of weeds in agricultural land. Nutrient competition between weeds and crops can happen and lead to reduce crop production. The potential risk of weed dissemination could become more serious in rangeland livestock production systems. The germination capacity of weed seeds in livestock manure depends on animal species. It is decreasing in the order poultry, pig, horse and cattle (anonymous). The application of manure also increases the pathogen dissemination. More important than, pathogens can survive in the soils several months or years (Table 14) after manure spreading in cultivated land (Nicholson *et al.*, 2004).

Table 14: Pathogen survival times in soil (Source Nicholson *et al.*, 2004)

Pathogen	Reported survival time
Escherichia coli O157	Up to 6 months
Salmonella	Up to 3 years
Listeria	Up to 2 years
Campylobacter	Up to 20 days
Cryptosporidium	Up to 3 months

Although there are some problems and threats from animal wastes on soils and agricultural activities as mentioned; however, we should acknowledge that the application livestock wastes on cultivated land have many advantages in environmental and economic point of views. Firstly, rich nutrients from them reduce the need for purchased chemical inputs. Secondly, the organic matter contained in the manure improves soil structure, fertility and stability, reduces soil vulnerability to erosion, increases water retention and cation exchange capacity, and enhances microbial biomass. Thus, the use of manure as fertilizer should not be considered as a potential threat to pollution but more as a means to reduce it. In other words, manure should not just be thought of as a waste product but rather as a resource (Delgado *et al.*, 1999; Steinfeld *et al.*, 2006; Benham *et al.*, 2001).

5.5. Livestock waste management

In order to protect the environment especially water pollution by livestock sectors people have to be aware of waste management issues. Technical options are suggested as the best strategy that can be divided into five stages: production, collection, storage, process and utilization (Steinfeld *et al.*, 2006). Detail technical solutions for each stage will be discussed in this section.

5.5.1. Production stage

The production stage refers to the amount and characteristics of faeces and urine generated at the farm level (Steinfeld *et al.*, 2006). The technologies applied in this stage have to address two questions: (1) How can improve production while reduce environmental pollution by excreta? and (2) How can reduce the quantity of manure excreted per unit of feed and per unit of product? According to Steinfeld *et al.* (2006) the purposes can be achieved through:

- improving animal genetics in order to get better feed conversion ratio;

- improving feed crop genetics to have highly digestible feedstuff;
- meeting nutrient requirements without exceeding them;
- selecting feed ingredients with readily absorbable nutrients;
- supplementing diets with additives, enzymes, vitamins that improve phosphorous availability and guarantee an optimal amino acid supply at reduced crude protein level and retention;
- minimizing animal stress;
- other technological improvements include particle reduction, pelleting and expanding.

Those technologies somehow relate to livestock water productivity principles which will be continued to discuss in next chapter.

5.5.2. Collection stage

The collection stage refers to the initial capture and gathering of manure at the original point. There are three issues which can improve manure collection process: (1) better design of animal housing to reduce losses of manure and nutrients through runoff and prevent dilution process by rainfall; (2) redirect into manure storage if any runoff; and (3) better use of water in the animal house to reduce the volume of waste (Steinfeld *et al.*, 2006).

5.5.3. Storage stage

The storage stage refers to the temporary containment of manure. Improved manure storage aims to reduce and ultimately prevent leakage of nutrients and minerals from animal housing and manure storage into ground water and surface water. The manure storage facility must be a structure designed to store manure and effluent generated from livestock operation. Appropriate storage capacity is the most important thing to prevent losses through overflow, especially during the rainy season in tropical areas. The manager has to estimate the volume of wastes and consider the timing of production systems. For example, the removal of manure should accord with the nutrient requirements of crops (Steinfeld *et al.*, 2006; Benham *et al.*, 2001).

5.5.4. Process stage

Improved manure processing aims to reduce local manure surpluses and convert surplus manure in products of higher value and/or products that are easier to transport such as biogas, fertilizer, feed for cattle and fish. The technologies can include and combine physical, biological, and chemical treatments. Some options have already applied, for example, aerobic digestion; anaerobic digestion; flocculation; composting; drying of solid manure; lagooning systems; etc. (more detail in Steinfeld *et al.*, 2006).

5.5.5. Utilization stage

Utilization refers to recycling of reusable waste products, or the reintroduction of non-reusable waste products into the environment. Most of livestock excreta are used as fertilizer for agricultural land. Other can be used as feed for fish or worms, or fertilizer for aquatic crops, or energy production (Delgado *et al.*, 1999; Kumar and Sierp, 2003; Hughes and Wilkie, 2005). If the application of manure is right way, it will be good for the environment and the economy. Otherwise, soils and water courses are polluted and cause many threats for human life and the environment as discussed above (see section 3.6). Hence, the method, dose, timing, frequency, and spatial characteristics should be taken into account when manure is applied for agriculture or aquaculture (Prein, 2002; Steinfeld *et al.*, 2006).

Integrated farming systems as livestock – fish, livestock – crops, livestock – biogas, or livestock – agri-aquaculture – (biogas) have been practiced successfully in many countries, especially small scale farmers in Asia. An important characteristic of such systems is the recycling of nutrients between sub-systems to gain synergy effects. The systems have shown many benefits in terms of risk reduction, job creation, income generation and environmental protection (Prein, 2002; Nhan, 2007). Therefore, it is necessary to improve and encourage them as a way to increase utilization of livestock wastes.

Box 4.3 Livestock waste management practice in Syria

The information in this box was gathered during excursion time in Syria from 15th to 23rd February 2008. Livestock production in the country includes extensive system (mainly sheep) and semi-intensive or intensive system (sheep, cattle and poultry). It seems to be no pollution by extensive practice but become more and more problematic by semi-intensive and intensive production systems. Biogas digester has bee introduced in research stations to treat livestock waste, but not common practiced in individual farms due to lack of capital. At farm level, manure is applied for cultivated land. If the manure exceeds farm use it can be sold, approximately €2 for 6 cubic meters.

Pollution by intensive production

Biogas-a way to treat manure

5.6. Conclusions and recommendations

Water pollution is influenced by both human factors and non-human factors, for example, population density, production systems, climates, soil characteristics, technological uses, management knowledge, culture, infrastructure, political and institutional issues, and so on. Impacts of water pollution by livestock and related activities have been increasing threats for the human health, the livestock and wildlife, the aquatic ecosystems and the environment. However, the problems can be mitigated through improving technologies and enhancing management knowledge at both farm level and higher levels. At production level, the concepts of integrated nutrient management or whole-farm nutrient balance (Figure 33) could be an appropriate approach, especially, the countries where water becomes more scarcity and depletion and large of rangeland farms such as Middle East areas. But it is not easy to achieve the "balance"; hence, research and extension have to pay more attention on the issues. There are still rooms for improvements.

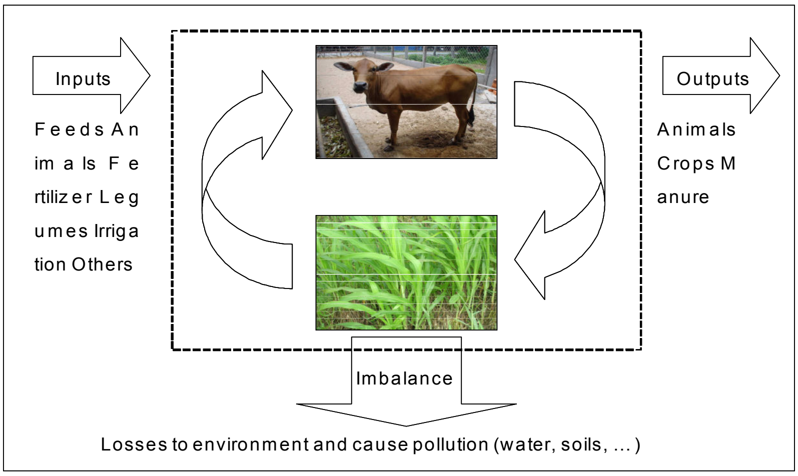

Figure 33: Whole – farm nutrient balance (Source Adapted from Benham *et al.*, 2001)

On the other hand, collection and appropriate treatment of domestic and industrial wastes are necessary to reduce the risks on the human life and the environment. At governmental levels, institutions that provide regulatory frameworks and environmental policies need to be more developed and reinforced. Building human resources that aim to enhance knowledge in management skills and technological aspects, a key to resolve environmental problems, should be facilitated by the governmental supports. As conclusion, with proper planning and allocating, "a problem can turn into a profit" (Ibrahim, 2007).

6. Livestock water productivity

An integrated approach to managing animal – water interactions

Roselien Vanderhasselt

Water and poverty are more and more extremely being linked in public debates over the world. This is partly due to the Millennium Development Goals (MDG's) in which access to safe drinking water is stated as an explicit part of the first MDG. This to eradicate extreme hunger and poverty (United Nations, 2000).

In the Middle East, poverty is much more widespread in rural areas than in urban areas. The biggest part of the poor households consists out of farmers or pastoralists who depend on agriculture as a primary food and livelihood source. Poverty is primarily conditioned by lack of access to the limited soil, access to limited water resources and by low productivity. The poverty is aggravated by highly unpredictable rainfall, relatively few crop and livestock options and continuing natural resource degradation (Dixon, J., *et al.*, 2001).

In the Middle East there exists the problem of water scarcity. The concept of virtual water was introduced in the early 1990s when studying the options of importing virtual water, as opposed to real water, as partial solution to the problems of water scarcity in the Middle East. Virtual water is defined as the volume of water required to produce a commodity or service. The idea aroused of using virtual water import (coming along with food imports) as a tool to release the pressure on the scarcely available water resources (Chapagain, A., K., Hoekstra, A., J., 2004).

The Virtual water content of some selected crops and livestock products for a number of selected countries are presented in Annex II.

Water productivity in agriculture.

Despite all the concerns about the technical inefficiency of water use in agriculture, water productivity increased by at least 100 percent between 1961 and 2001. Yield increase has been the major factor behind this growth. For many crops, this yield increase has occurred without increased water consumption and sometimes even with less water use, given the increase in the harvesting index. Examples of crops for which water consumption experienced little (if there was any) variation during these years are rice (mostly irrigated) and wheat (mostly rainfed). The recorded increases worldwide amount respectively to 100 and 160 percent (Kijne, J., W., 2003).

Water productivity and livestock.

Like humans, animals need water for drinking. Water is also needed to grow feeds for the animals. Following are some figures about the Nile Basin. More than 58 million tropical

livestock units (TLU)4, comprising cattle, sheep, goats, camels, horses, donkeys, pigs and poultry, occupy the Nile Basin. The production of livestock feed requires as much water as human food crops in the Nile River Basin. The feed production to maintain all these animals, requires about 26 km3 of water per year. However, in the past, water productivity concepts have been applied mainly to crop production. But as demand for milk and meat will likely double over the next 20 years, livestock production needs to be factored into future assessments of water use and productivity (Peden, D., 2005).
The general hypothesis is that better management of livestock-water interactions will contribute to increased efficiency and effectiveness of water-use for food production. Livestock products covers an important component of agricultural production, but have largely been ignored in water management for food security. Area-wide integration of livestock production in the context of holistic integrated river basin management, is required to encourage changes in agricultural practices, to better meet the needs of all users and to reduce conflict over water resources (Tadesse *et al*., 2006).

Some interaction between livestock and water can be listed. First of all, the body composition. 60 to 70 percent of the animal weight is water. The amount of drinking water is around 25 l/TLU/day, but little of it is depleted water. For a good livestock management, grazing close (< 250 m) to a source of drinking water is required. And a reasonable estimation of the water used for of maintenance feed production amounts to about 450 m^3/TLU/year (Astatke, A., et el., 2005; Tadesse *et al*., 2006), but this number is dependent on the climate. In general, it is said that livestock production requires more water per kg than plant production, but per kg of animal protein, water productivities are closer (Tadesse *et al*., 2006).
Livestock takes in water that is coming from three sources, namely drinking water, water contained in animal feed and metabolic water. The water that is contained in the consumed feeds is very variable from feed to feed, depending on the moisture content of the feed. This moisture content can range as low as 5 % in dry feeds to as high as 90 % in succulent feeds (Sirohi *et al*., 1997, cited by Astatke, A., et el., 2005). When the water content of the ingested feed is low, the water that is drunk is the major source of water intake. If the water content of the feed is high, some animals like e.g. camels do not need extra drinking water. For most people, the provision of drinking water is a major concern and the watering of animals has a high household labour cost. Daily water intake from drinking and water in feed will vary from about 20 up to about 50 l/TLU/d, depending on climate, species, breed and states of animal activity and physiology (e.g. growth, lactation) (Astatke, A., et el., 2005).

[4] 1 One TLU equals 250 kg of live animal weight.

6.1. The ruminant livestock production in Syria and there feed resources

In the previous chapters we could already read that in Syria, the dominant livestock production system is the ruminant production system. In Annex III the Syrian statistics for livestock numbers, meat and milk production, cattle and sheep imports and mutton and lamb and fresh milk imports can be found for the period 1995-2005 (Masri, A., 2006).

Cattle The most important livestock are the dairy cattle. They are most often kept near the towns where the dairy product prices are good and where water is available for forage production. In this systems (majority are state enterprises), the Friesian cow has almost replaced the local Shami breed which was kept in the Damascus oasis. The feed of the Friesian dairy cow consists mainly out of concentrates, vegetable residues, grazing barley in winter and alfalfa in summer. In the Golan heights, there is the use of a local breed, Golani. This breed survives on natural grazing and concentrates.

Goats The major breed that can be found in the goat production sector, is the local mountain goat. The goats are kept extensive as grazing herds in the mountain ranges close to forest areas. They graze during the day time and at night they are enclosed and fed concentrates. In a more intensive system another breed is used for milk production, the Shami goat. They are called the "cows of the poor family". They are raised in a similar way to dairy cattle.

Sheep The only local breed is a milk breed, the Awassi. This is a breed that is well adapted to harsh desert conditions. It has e.g. a fat tail which provides a reserve of nutrients for periods of feeds shortage. These sheep graze in the Badia from late autumn till late spring with supplements. After this they return to the rainfed and irrigated areas cleaning all crop residues (cereal, cotton, beet and summer vegetables). There also exists sheep fattening operations in Syria.

6.2. Concept of livestock and productivity

The concept of livestock water productivity.

Productivity is a ratio between a unit of output and a unit of input (Kijne, J., W., 2003). Livestock water productivity in agriculture is the ratio of the sum livestock products and services produced to the amount of water depleting in producing them. This helps to identify options for improving the livestock water productivity through integrated livestock and water management in an agricultural system (Tadesse *et al*., 2006). And both benefits as negative impacts related to livestock production have to be accounted for in the productivity equation. Because than this would imply that livestock related systems which lead to environmental degradation or that have other negative impacts, will have a lower water productivity (Sonder, K., *et al*., 2008).

The sources of water available for agriculture include rain, surface in-flow and ground water, as well as pathways of water loss or depletion (Tadesse *et al*., 2006).
For the assessment of livestock water productivity, quantitative indicators of animal outputs could be used such as for example kg of meat, milk or manure, or hectares of land that oxen plough, or indicators of economic and social benefits that people derive from animal keeping (Peden, D., 2005).
For water accounting: all the water entering and leaving the agricultural system should be included. The water accounting helps to identify the options which increase water productivity involving increased animal productions and services and decreased water depletion. This concept is applicable to fields, communities, watersheds and river basins. The challenge is to manage water, land and animals in ways that use available water to increase transpiration5 needed for production and environmental health and to decrease evaporation and harmful discharge (Peden, D., 2005).

There are different management practices which can be used for improving livestock water productivity (Peden, D., 2005).

- Feeding

Food crops are grown for sustenance and income. Efficient use for value-added animal production, of the crop residues and byproducts of those food crops, increases food production and incomes without significantly increasing the use of transpired water. Well-managed grazing makes efficient and productive use of rainfall on land unsuitable for crops.

- Grazing

Overgrazing compacts soils, reduces plant diversity and increases surface water run-off. Optimal grazing conserves soils and encourages infiltration of rainwater that helps to prevent down-slope flooding and sedimentation of reservoirs. In contrast to grazing livestock on the stubble that remains after harvesting, cut-and-carry feeding methods combined with conservation tillage reduces water run-off and soil erosion associated with annual crop production. Application of manure also increases the water-holding capacity of crop soils.

- Watering

Animals often contaminate many water resources, making them unfit for human consumption. Implementing simple measures such as construction of drinking troughs for livestock, prevents animal access to domestic water supplies and transmission of numerous costly water-borne diseases. Strategic development of ground water for livestock drinking can exploit underutilized pasturelands in large areas.

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[5] Transpiration is water depletion that enables crop, livestock and tree production and sustains biodiversity and ecosystems services.

- Feeds, genetics, veterinary care

Many poor African farmers lack good-quality feed, breeding stock or artificial insemination services, and veterinary care. Making these available to farmers and herders can greatly increase animal production, water productivity and returns on investments in agricultural water.

- Market chains

Many areas suitable for livestock production are located far from market centres. Herders from western Sudan, for example, make use of migration routes that extend up to 1000 km, that end near Khartoum. Crop residues, crop byproducts and irrigated fodder can be used to fatten animals after their long trek, making them more attractive to international and urban markets. Ensuring water and feed supplies in the market chain increases opportunities for remote pastoralists and others who walk animals to markets.

- Resolving conflict

Improving the integration of livestock and water management can calm down conflicts between herders and farmers.

6.3. Strategies for increasing livestock water productivity

There exist three basic strategies which help to increasing livestock water productivity directly. First of all improving feed sourcing. Secondly enhancing animal productivity and third is conserving water. But providing sufficient drinking water of adequate quality also improves livestock water productivity. However, this last one does not factor directly into the livestock water productivity equation because water that has been drunk remains inside the animal and thus within the production system, although subsequent evaporative depletion may follow (Peden, D., *et al.*, 2007).

For increasing the livestock water productivity, it is better not to focus on a single strategy. This may not be too effective. It is better to use a balanced, site-specific approach (including all four strategies) which will help to increase the benefits derived from the use of agricultural water for the production of animal products and services (Peden, D., *et al.*, 2007).

Livestock keeping often is an occupation of as well the children as the women and men. But children, women and men often receive different benefits from animal keeping and have different roles in managing livestock-water interactions. These considerations need to be taken into account in attempts to improve livestock water productivity. Livestock water productivity does not seek to maximize the number of livestock or the production of animal products and services. It rather opens opportunities to produce the same benefits with fewer animals and less demand for agricultural water (Peden, D., *et al.*, 2007).

6.3.1. Improving feed sourcing

Animal production depends on access to sufficient animal feed supplies which need to be of good quality (e.g. grains, crop residues and by-products, pasture, tree fodder and forage crops). Production of feeds is one of the world's largest users of agricultural water. The entry point for improving global livestock water productivity must be a strategic sourcing of animal feed. This is an issue that has largely been ignored during the past 50 years of research on livestock and water management. A wise selection of feed sources is potentially one of the most effective ways of improving global agricultural water productivity (Peden, D., *et al*., 2007).

The science-based knowledge of water use for feed remains contradictory and highly variable. The discussion here focuses on three main issues: the water productivity of feeds and forages, conversion of feeds to animal products and services, the distribution of feed resources (Peden, D., *et al*., 2007).

Global use of water for feed production.

Global evapotranspiration for producing feed to maintain cattle, sheep and goats may be about 536 billion cubic meters a year in developing countries. And if, taking into account the water for other livestock species and requirements beyond maintenance, the conclusion can be made that water used for global feed production ranges from 1 to 2 trillion cubic meters per year plus the water used in developed countries6 (Peden, D., *et al*., 2007).

6.3.1.1.Water productivity of feeds and forages

Peden, D., *et al.* (2007) state that evapotranspired water used to produce 1 kg of dry animal feed is highly variable, ranging from about 0.5 kg per cubic meter of water to about 8 kg. The amount of water depleted through evapotranspiration is influenced by many factors, including the vegetative leaf area index, animal preferences for specific fodder plants, root depth, rainfall, plant genetics and soil structure, moisture and chemistry.

Keller and Seckler (2000, cited by Peden, D., *et al.*, 2007) suggest that transpiration efficiency7 is relatively constant for in particular plant species and that the variability in crop water efficiency depends on site- and season-specific differences in the evaporation component of evapotranspiration. The opportunity exists to select water-efficient forage species and varieties. One of the most important and practical pathways for increasing feed

[6] These estimations remain quite imprecise and are lower than some other estimates.
[7] Transpiration efficiëncy is the dry matter production per unit of transpired water.

water productivity and thus livestock water productivity, will be reducing the evaporation component of evapotransiration (Peden, D., *et al*., 2007).

Crop residues and by-products present a unique opportunity for feed sourcing. Because efforts to improve crop water productivity have focused on grains and fruits that people consume. So any residues and by-products that can be used by animals, represent a potential feed source that requires no additional evapotranspiration. To the extent that animal production can take advantage of this feed source, huge gains in livestock water productivity are possible. Hence, the use of crop residues can boost farm income without the use of additional water (Peden, D., *et al*., 2007).

Although, theoretically, if livestock production were based solely on the use of crop residues and by-products, water for feed production would be nil. However, this extreme may not be economically and environmentally desirable if sufficient residues and manure are not left in or returned to the soil for maintaining soil productivity. Furthermore, crop residues tend to be relatively indigestible and to have lower nutritional quality. These limitations will have to be overcome if this method for feeding will be used. Options include making urea-treated silage from residues and providing high-quality supplemental feeds containing limited grains or leguminous forage crops. Studies are needed to find the tradeoffs associated with different options for using residues and by-products (Peden, D., *et al*., 2007).

6.3.1.2.Conversion of feeds to animal products and services

Improving livestock water productivity requires assessing the feed requirements of livestock and selecting feeds with high water productivity relatively to other uses of the water for agriculture. This in turn requires estimates of the feed energy and nutrient needs of animals for maintenance, growth, reproduction, lactation, work, thermoregulation and symbiotic micro-organisms and parasites of the digestive tract. The digestibility of feeds varies from 20 to 70 % and the indigestible component of a feed returns to the ecosystem under the form of manure. The question which rose with this manure is the following. Should the transpired water used to produce indigestible feed that ends up as manure is attributed to livestock production, when this manure contributes to the fertility replenishment of soil, household fuel and construction of materials for homes? The value of manure could be included among the benefits attributed to animal production, or the estimated water depleted for animal production could be reduced. Either way, recognizing the value of manure will lead to increased estimates of livestock water productivity where there is demand for manure. In cases where excess deposition of water damages the environments, this environmental cost should be included in estimating the net benefits associated with livestock production (Peden, D., *et al*., 2007).

Peden, D., *et al*., (2007) conclude in there study that water transpired for feed production will be about 50 times or more the amount of dinking water intake. Increasing livestock water productivity will depend strongly on increasing the amount of feed animals use for production, relative to the amounts used for maintenance.

6.3.1.3.Distribution of feed resources

In developing countries almost 50 million of agricultural land is used to produce livestock, but on the other hand, animal production is not optimally distributed within production systems to take advantage of many feed resources. Some areas are overgrazed; some have feed surpluses that remain unused. Rangelands and drier rainfed areas often lack drinking water for animals. Drinking water is very essential because without, livestock, especially cattle, cannot access available forages and crop residues. Feeds that have been produced but cannot be consumed constitute a major loss of potential benefits and productivity of agricultural water. Global, regional and national map inventories that quantify the gaps between feed production and animal demands for feed are needed. This knowledge can be used to identify possible options to enhance livestock water productivity by balancing animal stocking rates with sustainable feed supplies. Possible interventions may include bailing or transporting surplus feed to livestock or providing drinking water so that animals can remain near feed sources (Peden, D., *et al*., 2007).

6.3.2. Enhancing animal productivity

The water that is transpired to produce maintenance feed is a fixed input required for animal keeping, whether or not the animals are gaining weight, producing milk or working. For production, additional water is needed. A key livestock water productivity strategy requires increasing the productivity of each animal. This is the domain of the traditional animal science disciplines of nutrition, genetics, veterinary health, marketing and animal husbandry. Typically known interventions include: providing continuous access to quality drinking water; selecting and breeding animals for improved feed conversion efficiency and thus increased water productivity; providing veterinary health services as part of investments in irrigation development in dryland areas to reduce the risk of water-born animal and zoonotic diseases and to meet animal health safety standards for marketing animals and animal products; adding value to animal products (Peden, *et al*., 2007.

6.3.3. Conserving water resources

Heavily grazing has bad hydrological consequences. Livestock must be managed in such a way that it maintains a vegetative ground, because vegetation loss results in increased soil erosion, downslope sedimentation, reduced infiltration and less pasture production (Todd, S., W., Hoffman, M., T., 1999).

The grazing species composition and the stocking levels of grazing animals affect the species composition of the field's vegetation. High grazing pressure causes loss of palatable species which are suitable for animal production, but on the other hand, very low grazing pressure may encourage the invasion of woody vegetation. Either way, vegetation shifts can reduce the amount of useful vegetation and increase transpiration channelled through plant species that have little value for animals or other users (Peden, D., *et al*., 2007).

Livestock grazing and animal drinking interacts with each other. Animals, and especially cattle, concentrate and often overgraze near water sources and leaving thus more distant areas undergrazed. Apart from removing vegetation as feed, animals worsen runoff sedimentation by trampling and trekking on paths. Riparian areas, including streams, natural and artificially created pools and lakes, wetlands and irrigation infrastructure are all subjected to degradation by inappropriate managed livestock. Animals potentially affect water resources by causing chemical, physical and bacteriological changes in water: modifying habitats and associated vegetation and changing water flow patterns. Hence, overgrazing is a major threat to water resources (Peden, D., *et al*., 2007).

The water that is necessary for meat processing and rendering (slaughtering animals and fowls, curing, canning meat products, transforming inedible and discarded remains into useful by-products such as lards and oils) is variable, but this needed water is likely less than 2 % of the water needed for feed production (World bank, 1998). Further should be mentioned that effluents originated from meat processing are often sources of pollution, potentially degrading water resources and putting human health at risk (Peden, D., *et al*., 2007).

6.3.4. Providing sufficient drinking water

Drinking water is an important tool for improving animal production, but the volume drunk, is a small fraction of the total water used for feed production (Peden, D., *et al*., 2007).

Drinking water and water for feed.

About 450 m^3 of water is required annually to produce feed to maintain one TLU. Animals use even more when they are growing, working, stressed or lactating. Transpired water which is depleted for producing feed for animal maintenance and production can be 50 to 100 times more than the water that is used by animals for drinking. Although this relatively small amount of quality drinking water is essential for animal health and production, drinking water is not part of water productivity because the water that is consumed by an animal has not been depleted or lost from the agricultural system (Peden, D., 2005).

Livestock drinks about 20-50 litters per tropical livestock unit per day. But the drinking water volumes vary greatly by species and breed, ambient temperature, water quality, levels of feed and there water content, animal activity, pregnancy and lactation. Lactating cows, for example, require additional drinking water (Peden, D., *et al*., 2007).

Animals which are adapted to dryland conditions, tend to drink less and to have high urinary osmolar concentrations when they get dehydrated compared to those adapted to more temperate conditions. They often also have adaptations for eating and drinking to the dry climate. Domestication and breeding for productivity may have made livestock more dependent on drinking water and less able to withstand dry conditions (Peden, D., *et al*., 2007).

6.4. Application of livestock water productivity principles

Livestock-water interactions have been largely neglected, as well in water as in livestock research and planning. Except for irrigation and crop sciences, there are few examples of research and assessments that attempt to understand the total water needs of livestock and how animal production affects water resources. Consequently, opportunities to maximize investment returns in past investments in water and livestock development have been lost (Peden, D., *et al*., 2007).

How will managing livestock water productivity help?

Applying new knowledge about livestock water productivity through integrated livestock and water management will help to ensure more effective, equitable and sustainable use of water resources (Peden, D., 2005).

During the past 50 years, investments in agricultural water and livestock development often failed to achieve potential and sustainable returns. Evidence exists that suggests that the livestock water productivity approach can help to identify opportunities for integrating livestock and water development for the benefit of both. But of course there should be realized that these opportunities require intersect oral and interdisciplinary planning, development and management of water and livestock resources. Integration demands location-specific adjustments in institutional arrangements and integrated cost-benefit, enterprise budget and land-use analyses. The integration of pasture management and water use associations will be needed in communities. Integrated governance at and across various scales has great potential for increasing the productivity and sustainability of water and livestock production worldwide (Peden, D., *et al*., 2007).

6.4.1. The case of Syria

To sustain any type of agricultural development, optimization of the scarce water resources is of major strategic importance. At present, application inefficiencies of water resources at the farm result in water losses. Increasing the efficiency of water application is essential if production is to continue increasing (IFAD, jan. 2007).

Livestock activities are an essential part of the Syrian farming system and an important source of household income (IFAD, jan. 2007).

Improving feed sourcing.

In Syria, the bottleneck, on national level, in the development of the livestock sector is shortage of feed. Present production levels of animal feed cannot sustain the present livestock populations. This makes animals very susceptible to natural disasters, such as drought. As long as livestock herds continue to increase, this gap will continue to increase in the future. Sustainability of livestock activities depends on the integration of fodder crops into the settled farming systems to ensure higher level of feed production (IFAD, jan. 2007).

In every ruminant livestock production systems in Syria almost one of the constraints is always the degradation of grazing land that increases the dependency on costly supplementary feed (Masri, A., 2006).

Feed resources - The fodder situation.

Mainly due to population growth there has been an increased consumption of livestock products. Result is the denudation of natural grazing and limited grazing forage expansion because of cash crop competition. Under these conditions, the state took some measures to control and subsidize the barley grain (major supplementary feed) and also the mill by-products (wheat bran, cotton cakes, beet pulp, etc). The first measures were the supply to farmers of barley through the General Organization of Mills and Cereal (GOMC). Then the GOMC sells the feed to livestock owners through the General Organization of Feed (GOF) and stores the surplus for dry years. The second measure was the establishment of the Feed Revolving Fund (FRF) in 1964. This fund developed through World Food Programme (WFP) assistance to farmers and livestock herder projects. The FRF which is attached to the Ministry of Agriculture and Agrarian Reform (MAAR) has provided sheep fattening and sheep/range improvement cooperatives with short term loans for feed and long term loans for warehouse construction. The third measure was the establishment of the General Organization of Fodder (GOF) in 1974, attached to MAAR. GOF does the marketing and distribution of controlled feed (barley and mill by- products) to animal sections according to regulations (Masri, A., 2006).

Masri, A. (2006) states that if the government had distributed the feeds trough GOF and FRF to livestock cooperatives on a credit base directly after the harvest and not in the winter, the feed availability and stabilized prices would have been ensured for herders. In an FAO report by Mirreh *et al.* (2000, cited by Masri, A. (2006)) on the impact of subsidized state feed policy, it was indicated that such a policy will put pressure on the already degraded pasture through an increase of sheep numbers. They suggested that subsidies could be directed to other options such as subsidising only those cooperatives that have implemented a grazing management plan, and rehabilitation measures.

According to IFAD (jan. 2007), encouraging feed production in these areas will require a suitable incentive/price framework, appropriate input delivery mechanisms, as well as the development of appropriate marketing channels. Subsidies on livestock feed could however encourage unsustainable increases in livestock numbers. The gradual liberalization of animal feed imports, production and marketing may induce an increase of feed prices at the beginning, but it would also reduce subsidy payments, rationalize demand for animal feed, and stimulate forage production in the medium to long run (IFAD, jan. 2007).

In literature has also been found that some projects in Syria work around improving water productivity. Like this example in Western Syria. Wheat yields increased there from 2 to 5 metric tons per hectare with timely application of 100-200 millimetres of water and water productivity improved from 0,6 kg per cubic meter to 1,85 (Oweis and Hachum, 2003, cited by Steduto, P., *et al*. 2007)

In the dry and semi-arid Badia zones, the key to sustainable development is livestock production. A mixed livestock/farming system contributes to the household food security and to income generation. An increase on reliance of crop residues, fallow grazing and supplementary feeding occurred after a sharp drop in rangeland productivity. The International Fund for Agricultural Development (IFAD) has a project running to improve livestock productivity per animal unit through improved use of existing feed resources, but there is not yet information available (IFAD, july 2007).

Enhancing animal productivity.

A limited productivity per animal unit (among other things) is most often a characteristic of animals in the dry and semi-arid zones. But these local breeds, however, have adapted very well to the harsh ecosystems and the severe fluctuations in these zones. They have a big potential for improvement (IFAD, july 2007).

IFAD helps to improve the Syrian herds through, for instance, providing training and extension, technical packages developed by the Arab Centre for the Studies of Arid Zones and Dry Lands (ACSAD), including improved herd management, feeding and veterinary services. Or, IFAD is also involved in genetic improvement programmes of the Awassi sheep (IFAD, july 2007).

Providing sufficient drinking water.

Another free state services to livestock that may have caused pressure on the unmanaged ranges are the free drinking water and the free veterinary services (Masri, A., 2006).

Box 5.1 The situation of water livestock productivity found in Syria

During the time in Syria, we saw a several research centres. None of them was really working on feed resourcing. According to M. Amin, A., some are working on the improvement of feed or on the water productivity, like the example of wheat that I found on the internet.

There are many more researches done on the improvement of the animal productivity. For example on the improvement of the Awasi sheep. According to the law, it is possible to only work with this sheep breed for production in Syria. The visited research centre worked on improving the milk production, meat production and wool production, but now they work more on improving both meat and milk production.

In the research centre that we visited in Aleppo, they told us that they worked on improving pastures. But eventually it came out that it was more working on the grazing management. The feed stuff with which they worked was (mostly) originally plant species from that area, which are not such fantastic feeds, according to the nutritive value.

For drinking water, it is true that farmers don't have to pay for this. In the more dry areas, the government provided some natural lacks. Even there, pastoralist does not have to pay to take water from this basin.

For the use of animals which are more adapted to the dryland conditions (e.g. Camels) for production, this is not yet really practised in Syria. The amount of camels in Syria is not that high and the population in Syria is not so fond of this meat because it has a strong taste, which they don't like in there traditional dishes. It would be difficult to change the population's habits for changing the animal production systems more orientated to animals that are most adapted to the conditions of water scarcity.

On the other hand, the use of the Awasi sheep is also already good. This is a fat tailed animal which that his animal can also store energy under the form of fat in his tail. This energy it can apply whenever the need is there.

7. Management of water resources

7.1. Institutions around water

Elias Rebai

Syria is situated in one of the world's regions where water resources are rather scarce. This means not only that there is increasing pressure on the water resources due to sustained population growth, but it also makes the topic very sensitive to discuss, especially concerning the institutional issues. Water issues are of fundamental economic, social and political importance to Syria. This illustrates clearly the importance of a suitable institutional setting for the management of the water resources. Therefore, it will prove a critical issue for coping adequately with challenges of the future.

Most institutional analyses now emphasize the fundamental role of information, models and analyses in creating the shared understanding that is necessary to develop effective management strategies (IPTRID, 2004). This shared understanding applies to both the local level and the higher levels. It is thus essential to enable all the groups to reach agreement on the nature of the problems and the strategies to address them. According to IPTRID (2004), a common vision is the catalyst ensuring that all parties will actually devote human, social, financial and political capital to achieving what are often extremely difficult objectives.

Syria is presently at an important transition point in the recent history of its water management.
As previously mentioned, the agricultural sector is the largest water consumer in Syria. Groundwater use, especially for irrigation has increased dramatically over the last two decades. Sixty percent of the entire irrigated area in Syria is currently irrigated by groundwater; most is privately developed and operated. The groundwater balance is negative in all basins, except the Coastal and Steppe basins (IPTRID, 2004; IPTRID, 2003). As other common pools, groundwater is often overexploited. Without regulation, it may run into certain depletion that could be a source of serious economic, social and environmental consequences. Groundwater is probably the most prominent water management challenge for the country (IPTRID, 2003). Additionally, most surface water resources have been developed to their full extent. Given the difficulties to develop new water sources the focus will have to be laid on the efficient management of the existing sources. This transition needs the building of management institutions and capacities within the government and local user populations (IPTRID, 2004).

As mentioned, the focus was laid on the development of water resources, being the supply side. Demand management and the improvement of patterns of water use have received less attention. Irrigation schemes were also built and agricultural activities were greatly expanded to achieve self-sufficiency in essential food products and food security. This will show difficult to support because of the declining availability of water. Moreover, water demand at current prices is increasing rapidly. The important development of the irrigated agriculture was pushed by at least two institutional measures. First, the national government has been heavily engaged in the building of the infrastructure, for the most part sustained through the public budget. Second, agricultural policy has been based on subsidized prices paid to farmers in excess to market value, what has given further incentive to irrigate. The high level of self-sufficiency and the increase in the production of selective crops appear, however, to have come at the expense of unsustainable water use patterns (IPTRID, 2003).

However, the sensitive nature of the topic translates into limitations on the flow of information. Again, we have to stress the importance of accurate and up to date information to organize and optimize the overall efficiency of water use. Until now, the institutional framework for water management has been quite hierarchically organized and thus, mainly planned in a centralized way. It must be mentioned here that, in the past years, there has been an important attempt to reorganize and improve the institutional framework for water management. This has been translated in the creation of new institutional bodies and the development of the legal framework. But, apparently, it remains now too early to find substantial information to describe and evaluate the full extent and impact of the recent changes.

Next to the challenge of a more efficient use of its water resources to continue satisfying the needs of its fast growing population, water pollution is another issue that has reached alarming levels for both surface and groundwater and threatens their sustainability (Bazza & Najib, 2003). Many cities have expanded without sufficient planning and existing sewage systems do not reach these areas. Untreated sewage is being used in agricultural irrigation, creating health and environmental hazards in rural areas (METAP, 2001). Drainage from irrigated areas contaminates ground and surface water. In areas with heavy groundwater extraction, saltwater seeps into aquifers from the sea and saline groundwater (METAP, 2001). Therefore water quality control and wastewater treatment will also constitute critical issues for future Syrian water management.

7.1.1. Sector organization

7.1.1.1. Governmental institutions

The governmental institutional organization concerning the governance over the water structures is quite hierarchically organized, with the main decisions being taken in a centralized manner, overseen from Damascus.

At the top of the decision making bodies, we find the Supreme Agricultural Council, headed by the Prime Minister. It is composed of representatives from the major water related ministries, the leading Ba'ath political party and the head of the Farmers' Union. This council has parallel regional councils in each governorate, headed by the respective governors. The council is composed in order to represent the perspectives of the critical political and user stakeholder groups (IPTRID, 2004).

On a day-to-day basis, the key government organizations involved in water management are the Ministry of Irrigation and Ministry of Agriculture and Agrarian Reform (ETIC, 2006; IPTRID, 2004). In addition, the Ministry of Housing and Utilities is responsible for the water supply and sewerage sector (IPTRID, 2004). The Ministry of Local Administration and Environment is in charge of pollution monitoring and control (ETIC, 2006). Unfortunately, in the past each of these organizations tended to conduct operations and management separately. The level of feedback among the organizations seemed to be limited and the responsibility and accountability were blurred (IPTRID, 2004). However, recently, a National Water Resources Board was established in charge of all matters related to water in Syria (ETIC, 2006).

An overview of the many government organizations involved in water management in Syria, and their functions, is given in Table 15

The Ministry of Irrigation is the organization with the greatest direct responsibility for water resources related activities. According to IPTRID (2004), it is formally responsible for:

- policy formulation and research regarding water resources development including water quantity, quality and allocation among sectors
- issuing water permits both for surface and groundwater
- planning, construction and operation & maintenance of most of the hydraulic facilities, such as dams, canals and pumping stations
- hydrological and hydro-geological monitoring of river flow, dam storage volume, groundwater level, water abstraction, water quality indexing...

Table 15: An overview of the many different Syrian governmental institutions, and some of their functions linked to water management (adapted from METAP, 2001; IPTRID, 2004; ETIC, 2006)

Supreme Agricultural Council

- main decision making body
- represents perspectives of critical political & user stakeholders

Ministry of Irrigation	**Ministry of Agriculture and Agricultural Reform**	**Ministry of Environment**	**Ministry of Local Administration, Ministry of Housing and Utilities**
FUNCTION■: - policy, quality, allocation... - permits and licenses - enforcement and compliance for wastewater discharge - planning, construction, operation and maintenance of hydraulic facilities - hydrological & hydrogeological monitoring	FUNCTION■: - advice on cropping patterns - advice on on-farm water use - other extension services	FUNCTION■: - licenses for sewage discharge - control of water quality	FUNCTION■: - urban water supply - management of sewerage infrastructure
DEPARTMENT■: ↕ Directorates in each governorate ↕ Dams Department ↕ Directorate of Pollution Control ↕ Water Resources Department ↕ Water Research Center ↕ Establishment of Land Reclamation ↕ Water Resources Information Center ↕ General Company for Water Studies	DEPARTMENT■: ↕ Directorates in each governorate ↕ Farmers' Union ↕ Steppe directorate ↕ Directorate of Agricultural and Scientific Research (DASR) ↕ Department of Irrigation and Water Use (DIWU) ↕ Department of Extension	DEPARTMENT■: ↕ High Council for Environmental Safety ↕ General Commission for Environmental Affairs ↕ Scientific environmental Research Centre ↕ State Planning Commission	

The countries seven hydrological basins are managed on a decentralized basis by the Central Directorate and six General Directorates. In the vital Euphrates basin, the Establishment of Land Reclamation exists, which is responsible for land reclamation, irrigation and drainage. Additionally, the Ministry of Irrigation has a variety of specialized directorates, including the Directorate of Pollution Control, the Water Resources Department, the Dams Department, ... (IPTRID, 2004). Also, the Ministry of Irrigation has made a step forward in the direction of coordinating the information flow. In cooperation with the Japan International Cooperation, it has established a Water Resources Information Centre. The long-term objective of this centre is to achieve integrated and sustainable surface and groundwater management in Syria, both in terms of quality and quantity

(IPTRID, 2003).

The Ministry of Agriculture and Agricultural Reform (MAAR) also has directorates in all the basins. Its main role in water management is through the directorates and Farmers' Union's advisory measures on cropping patterns and on-farm water use. The ministry also provides basic extension and research services to farmers (IPTRID, 2004). However, according to the World Bank (2001), the control of the ministry over cropping patterns has been declining in the recent years.

Formal agricultural research began very late in Syria within some experimental farms close to Damascus, in the early 1940's. The creation of the first Agricultural Research institutions dates back to 1964 when the Directorate of Agricultural Scientific Research (DASR) was established by the MAAR as a new central unit responsible for almost all research activities (Al-Ahmad *et al.*, 1999). Since then several organizations involved in research around the water resources in Syria were founded.
Under the umbrella of the Ministry of Irrigation we find the Water Research Center and the General Company for Water Studies, established to carry out all investigations, studies and designs of irrigation and land reclamation (IPTRID, 2004). The Department of Irrigation and Water Use (DIWU) of the MAAR carries out nationwide research on crop water requirements, farm water management and irrigation methods and technologies (Al-Ahmad *et al.*, 1999; IPTRID, 2004). The department has a research station in each of the seven water basins which link the research program to the local water, soil, crops and climate conditions of the basin. Technology is transferred by the Department of Extension by the means of field days and seminars (IPTRID, 2004). Unfortunately, in the past there was little coordination between the researches carried out by the two ministries. However, Al-Ahmad *et al.* (1999), claim that still the DIWU has good relationships with the DASR and the Department of Soils. To a large extent, other physical resources (labs, library, transport) are insufficient, but efforts are being made to improve scientific and computer

equipment. Given the administrative status of DASR within MAAR, administrative procedures for mobilizing the financial resources are not flexible enough (Al-Ahmad *et al.*, 1999).

The Ministry of Environment has only been established in 1991 and is thus relatively young. Other major steps in environmental protection have been taken in the past decade, among others the establishment of the Higher Council for Environmental Safety, the General Commission for Environmental Affairs, the Scientific Environmental Research Center and at the local level eleven General Environment Directorates (NTCSD, 2001).

To cope with the environmental issues around water pollution and quality, the government has developed a National Environmental Action Plan. It includes the participation of the Ministry of Irrigation, the Ministry of Local Administration (issuing licenses for sewage discharge), the Drinking Water Directory of the Ministry of Housing and Utilities, the Sewage Disposal Directorate. The State Planning Commission of the Ministry for Environmental Affairs coordinates environmental monitoring and work plans among ministries (METAP, 2001). The Ministry of Irrigation is responsible for enforcing compliance with wastewater discharge regulations, though the ministry has been hampered by lack of funds (METAP, 2001).

7.1.1.2.Users institutions

The private sector gets involved in design or construction of irrigation and drainage systems only when the state owned companies are unable to do so due to heavy work (IPTRID, 2004). The Farmers' Union, present in different decision making bodies is an independent structure composed of village level, regional and national farmer committees or cooperatives and often provides representation for the farmers' perspectives (IPTRID, 2004). Farmers play a key role in planning and management of the agricultural sector. In Syria, this role is however only at a high level policy through the Farmers' Union representation and does not expand to scheme level since water user associations do not exist (IPTRID, 2003).

In the steppe, the majority of the people are tribally organized and dependent on a migratory pastoral or agro-pastoral economy where mobility and natural resource management are facilitated by extensive customary systems. After World War II, the new states generally perceived that the tribe and their mobility were divisive and unstable elements; they saw customary grazing practices as archaic, inefficient and environmentally exploitative. The tribe was seen as a political and environmental threat that if not eliminated would undermine the state and stifle economic growth (Rae *et al.*, 2001). The dominance of this paradigm had considerable influence on the direction and evolution of state institutions responsible for steppe management. Despite a lack of clear consensus on the best model for predicting the extent and causes of rangeland degradation, the Syrian government through the Steppe Directorate, aided by international research and development institutions, has undertaken several measures to bring about a change in rangeland management. Actions taken went from centralizing the governance and enforcement of rangeland management to introducing new technologies designed to enhance the quantity and quality of rangeland vegetation. Despite more than 50 years of technological efforts, however, technology uptake has lagged far behind expectations (Rae *et al.*, 2001).

Historically, conflicts have arisen between the old sheep herding tribes over water and pastures in the near steppe. The disputing tribes sought then an agreement through customary channels and under the auspice of the state (Rae *et al.*, 2001). The authorities assumed full responsibility for rangeland management, placing it with the Steppe Directorate from 1961. Nevertheless, customary institutions continued to exert authority over rangeland management and tribal control. Substantial cooperation to regulate control and access to steppe resources persisted among herders from different tribes, including a significant level of tribal corporate activity in protecting rights (Rae *et al.*, 2001). The *shaykhs'* (tribal leaders) intermediary roles were officially terminated in 1958, but two decades later little had changed in practice (Rae *et al.*, 2001). Indeed, customary institutions remain the principal mechanism regulating access to steppe resources on a day- to-day basis, while the state continues to implicitly recognize and endorse tribal customary rights and practices, with high officials and party cadres guaranteeing agreements and signing documents in the name of the state (Rae *et al.*, 2001).

This discussion demonstrates the value of the customary institutions supportive of herd mobility, reciprocal arrangements with respect to resource use, and inter-tribal conflict resolution mechanisms when it comes to rangeland management. Contrary to popular belief that they have broken down and disappeared, many customary institutions in Syria remain strong and continue to be influential in the property rights domain (Rae *et al.*, 2001).

7.1.1.3.Other actors

In 1960, the University of Aleppo established a Faculty of Agriculture, and the Ministry of Education created the High Institute of Agriculture at Damascus, which became in 1963 the Faculty of Agriculture, affiliated to the University of Damascus. Three other FA's were later created; one in Lattakia by the University of Tishreen (1971), one in Deir Ez-Zor

(1977) by the FA of Aleppo, and one in Homs (1994) (Al-Ahmad *et al.*, 1999). There are several universities where Hydraulic Irrigation and Environmental Engineering are taught (ETIC, 2006).

The faculties are semi-autonomous within their universities which are in turn affiliated to the Ministry of Education. But their main activity is just teaching. The ratio of students to academic staff is still rather high. Each faculty has one or two farms for demonstration, training and for production. Physical facilities are generally inadequate both in quantity and quality. The faculties have no financial autonomy; their budgets are provided by the universities in function of available means (Al-Ahmad *et al.*, 1999). Scientific coordination among the faculties and linkages with the national agricultural research and scientific institutes and extension services are moderate and informal. Often, there is too little time available for the academic staff to carry out research activities due to the heavy teaching loads and the "necessity", due to low salaries, to seek other sources of income. However the situation has been improving over the recent years (Al-Ahmad *et al.*, 1999).

According to Al-Ahmad *et al.* (1999) three international organizations are present in Syria and participating in Agricultural Research is worth mentioning:

- the International Centre for Agricultural Research in the Dry Areas (ICARDA) established in 1977 and supported by the Consultative Group on International Agricultural Research (CGIAR). This centre is, amongst other things, involved in the improvement of on-farm water-use efficiency and farming systems
- the Arab Centre for the Studies of Arid Zones and Dry Lands (ACSAD) created in 1971 by the Arab League. It's based on the same campus as the DASR and DIWU at Douma, Damascus. It has a division conducting research on water resources
- the Arab Institute for Forestry and Grazing, essentially involved in training of students

7.1.2. Institutional capacities

From a management point of view, the capacities of the Syrian ministries show certain limitations. It has already been mentioned a few times that there was a lack of coordination between the different organizations that posed problems for the optimization of the strategies. Also, there seems to be difficulties with the enforcement of the measures imposed through the various regulatory activities (IPTRID, 2004). There is a lack of skilled staff for the wide array of social, economic and technical issues necessary for water management instead of the development of water resources. IPTRID (2004) has identified some key areas in which capacity appears to be lacking:

- Data collection: due to limited staff and analytical facilities, weak groundwater monitoring system
- Data management and analysis: weak computer capabilities, need for new hydro-geological data
- Outreach and communication: limited capacity to communicate technical insights to local users, little participation of users for development of effective management systems
- Economic, legal and social analysis: lack of staff with necessary educational background and training
- Integrated water resources management: strong fragmentation of the water resources management functions between the different authorities, previous lack of focus on demand management

One of the most important issues faced when carrying out any study about water resources and use in Syria is the availability and reliability of data (IPTRID, 2003). Also, the strengthening of the data collection and analysis appears central to developing an accurate understanding of water management challenges and options (IPTRID, 2004). Another obstacle to the good functioning is the limited level of feedback amongst the organizations, and the accountability and responsibility amongst them are sometimes blurred. Data and information are often kept with each organization and coordination and data exchange are at a low level. Therefore it is essential to focus on this matter and strengthen collaboration and exchange between the different organizations (IPTRID, 2003).

To improve the data collection, the Water Resources Information Centre is building a water resources information system which comprises of hydrological and meteorological observation stations, a computer system and computer network linked to a monitoring program. According to IPTRID (2003) the system was already in place in Damascus and in the Barad/Awaj and Coastal basins. However, there is still the need to link it with other ministries than that of Irrigation and to exchange data with the others and not isolate.
It is equally important that these data can be analyzed and communicated so that they assist in creating the social and political foundations for management (IPTRID, 2004). A critical issue is the active involvement, understanding and support on the part of the water users. Understanding is also essential to building the political acceptance for the management decisions. A detailed understanding of the social, legal and economic factors influencing the viability of different management approaches and their effects on different user groups is vital. Furthermore, ministry officials have indicated that the building of political support for difficult management decisions is new for their organizations (IPTRID, 2004).

Field visits to public irrigation systems indicated that payment of operations & maintenance fees is very high (90-95%) and that services received are considered as satisfactory in general terms (Varela-Ortega & Sagardoy, 2001). This is a strong side for the financing of the agricultural infrastructure investments. However, the capital cost payments, made at local branches of the Central Bank, are funnelled into the National Debt Fund, which is autonomous within the Ministry of Finance. Also, there is no linkage between the collected operation and maintenance fees and the actual budget for the operation and maintenance activities. Farmers, therefore, do not perceive that the charges they pay are associated with the actual operation and maintenance activities being carried out (IPTRID, 2003).

The institutions needed for environmental management have to a large extent only been established quite recently and still lack the institutional capacity to function effectively. There are very little experiences of modern environmental practice available to the ministries and they suffer from the low salaries in the public sector, have therefore difficulties attracting and retaining qualified staff and somehow show scarcity of resources to function adequately (NTCDS, 2001). Most of the obstacles or weaknesses for effective implementation are caused by the lack of financial support and related policy and non availability of advanced technology, in addition to the lack of legislative or regulation supportive of sustainable development. The main lacking institutional factors are the insufficient planning and management, legislation and standards and the awareness of the environmental issues between decision makers and public (NTCDS, 2001).

There is another institution present in Syria with non negligible capacities for the raising of public awareness and education to guarantee the participation and involvement of the public in the water sector, which is the Islamic institution. It has been shown that campaigning for the environment within the Islamic faith is productive, and specifically that using the Islamic education system. Following Atallah *et al.* (1998), raising awareness using Islamic concepts of water conservation is feasible for the following reasons:

- Islam has a strong influence in the Eastern Mediterranean region
- Water conservation and protection are stressed in Islamic teachings
- Islamic communication channels are very effective in raising public awareness

Islam promotes behaviours that protect health and discourages habits that have a detrimental effect on it. In Islam, the relationship between humans and water is part of daily social existence, which is based on the Muslim belief that everything on earth worships the same God. Humans are responsible for the welfare and sustenance of the other citizens of this global environment. Water is the most precious and valuable resource of the physical environment for all living things (Atallah *et al.*, 1998). The link between life and water is even explicitly stated in several verses of the Holy Quran, for example, "We made from water everything"; "And Allah sends down the rain from the skies, and gives therewith life to the earth after its death". (Atallah *et al.*, 1998). Conservation is also a fixed concept in Islamic teachings; various texts of the Holy Quran give special attention to water conservation. According to the tradition of the Prophet of Islam, a Muslim is ordered to be economical with water even if he is taking water from a fast-flowing river (Atallah *et al.*, 1998).

In any society, one measure of good governance is the quality of the treatment of its poorest and most vulnerable members. And with respect to local water management, the condition of women, minorities, and the landless poor is a specific responsibility of institutional authority. These are the people who suffer the worst hardships of misgovernment — and whose lives are most improved by good water management. Perhaps not surprisingly, research in Egypt found that girls and young women were not only the most receptive to new information about household water but were also particularly effective as agents of change. Women play a central part in the provision, management and safeguarding of water (Brooks, 2002).

7.1.3. Legal framework

Water is defined by Syrian law as a "public good" that is not treated according to market forces. The right to use surface or groundwater is acquired through the issuance of water use licenses by the Ministry of Irrigation. The licenses specify the number of wells and their discharge. Presently, a very strong law banning the construction of new wells is in place, except in the coastal basin. It allows the repair of problematic wells but prohibits new wells. Also the depth of wells is being limited to 150m and a prohibition of water pollution exists (IPTRID, 2004). As mentioned before, the authorities are experiencing difficulties to fully enforce the legal measures. Although in most cases of non compliance the offenders are theoretically subject to fining. However, all existing wells are to be equipped with discharge meters. Maximum extraction level will be fixed for each well, depending on the location, irrigated land area and other factors. The Ministry of Irrigation is also in the process of regularizing all illegal wells. A committee is set up in each basin to study all applications and decide whether to grant the license or close the well (IPTRID, 2003).

Water use priorities have not been set in any official legislation yet. However, there is a widely accepted consensus among the ministries that drinking water has the top priority, followed by agricultural and industrial water. Disputes over water issues are currently resolved through the normal court system, often involving a committee containing representatives from the Ministry of Irrigation, local authorities and the Farmers' Union. Enforcement is, however, generally lacking. Part of this conflict may relate to perceptions instead of lacking government enforcement capacities. For example, farmers may have a different perception of the nature and origins of groundwater which differs from that of officials, which makes them not accepting the official views on the declining groundwater table.

A new water law has been drafted in 2005 with the objective to supersede and replace the large number of fragmented laws in place, in order to come to a comprehensive and unified water law that matches the development of irrigation and land reclamation projects. According to Hazeem (2007), some basic issues in this law are:

- Basic water need for humans life and health should be secured by this law
- Lack duty descriptions of high national committee
- Rules and responsibilities institutions are practiced with overlapping, duplication, and competition
- User participation shouldn’t be managed by the ministry
- Private sector participation is not allowed.

However, the law is still based on land and not water. The law confirms the established rights on public water but gives the government the authority to nullify them and requires compensation if this is done (IPTRID, 2003; IPTRID, 2004). It is remarked by IPTRID (2004) that the new law establishes a highly centralized system for regulating and managing water resources, including groundwater. It is reflected in the wide array of key management decisions that are being made at the ministerial level and in the absence of any detailed mention of either regional or local management organizations. It is also evident in the high degree of centralization for enforcement actions, e.g. the management decisions for well spacing the “haram” (zone of prohibition for wells) is allocated at the ministerial level. The law also includes an array of financial and additional sanctions if regulations are violated; but it contains no indication of how they would be implemented nor does it specify who would have the responsibility for enforcement (IPTRD, 2003; IPTRID, 2004).

7.1.4. Recommendations

The Syrian National Strategy for Sustainable Development (NTCSD, 2001) resumes well the actions to be taken to accomplish strategic objectives to prevent the misuse of water resources. Next to quite broad and general objectives as encouraging development or combating desertification it is advising to stop the over-exploitation of water resources in order to maintain sustainable use levels. This is achieved by focusing on the irrigation systems, non-conventional water resources and combating the deterioration of the water resources, all of this through integrated water resources management (NTCSD, 2001). More specifically stated strategies are:

- securitization of sufficient water
- protection from pollution
- encouragement of stakeholders participation in water management
- cost recovery of investment in water projects
- strengthening of water legislation
- establishment of regional mechanisms for conservation and rationalization of water resources
- cooperation between states in the management of shared waters

To improve institutional effectiveness, the following suggestions are recommended by the NTCDS (2001):

- decentralization of decision making process for enhancing community participation in the formulation, execution and evaluation of local development projects
- strengthening electronic information systems, networking and cooperation and coordinating among relevant organizations to enable all users to benefit from data at the local, national, regional and international levels

Close attention needs to be paid to the development of appropriate decision support systems and the key users of data. The lack of coordination between ministries as well as between institutions within ministries hinders to a great extent the implementation of strategies and programs. The establishment of co-ordination mechanisms between institutions, with clear mandates, responsibility and accountability, are very much needed and would be very beneficial. In addition the current level of investment and working means are below the needs (Bazza & Najib, 2003).

The movement towards more efficient irrigation systems started by the governmental organizations has to be pursued. For example, the Ministry of Irrigation's plan to convert the old open surface distribution system into pipelines and the rehabilitation of new lined canal systems has to continue to increase the conveyance efficiency. Also, the institutions will have to facilitate the options for the use of the considerable scope to increase the efficiency of the water use at field level by the introduction of advanced on-farm irrigation techniques and water management (IPTRID, 2003; Salman & Mualla, 2003). Additionally, the incentives towards farmers have to be seriously reconsidered, notably the subsidy policy on water and energy pricing (Salman & Mualla, 2003). Changes in agricultural policy and investment in improved production methods can potentially yield enormous benefits in soil and water conservation (NTCSD, 2001).

Groundwater is probably the single most important challenge facing Syria. As in many other developing countries, groundwater wells represent an “on-demand” source of irrigation in contrast to government surface irrigation schemes. Thus they provide a more reliable source of water to farmers. Legally, licenses are required to drill and use wells. Licenses specify the extent of water use and require renewal every ten years. However, poor enforcement has resulted in a large increase in the number of illegal wells in recent years (almost 50% of the total number of wells) that has contributed to the groundwater table declines in many areas, especially in Damascus countryside (IPTRID, 2003; Salman & Mualla, 2003). The lack of critical information such as the amount of renewable groundwater resources and the interaction between the surface and ground water systems has made the task of enforcement more difficult if not impossible. Thus, an urgent plan and action to rehabilitate and upgrade the hydrological monitoring network for groundwater resources and intensive monitoring need to be established (IPTRID, 2003; Salman & Mualla, 2003). This situation illustrates clearly the challenge posed by the registration and monitoring of the wells. It shows the need for a well organized structure for licensing and controlling the wells, like discharged quantity. The question remains of given the present situation such a monitoring by the Syrian authorities is realistic.

Recently, important achievements have been made in the sector of wastewater treatment. Starting with a project on the impact of treated effluents on crops, soil, health and the environment. Farmers and government officials are being trained in using treated sewage and agricultural drainage for irrigated agriculture (METAP, 2001). Other studies and projects are being carried out around Damascus to prepare a plan for the provision of wastewater treatment services. An integrated and coordinated approach to water quality management should be adopted. Here also, to give data credibility, one monitoring system with standard objectives should be implemented and data should be coordinated and shared (METAP, 2001). Water and sanitation plans at the basin level that include all institutions and communities should be initiated to solve water quality issues. The domestic sewage problem should be addressed immediately through the construction of new wastewater treatment facilities and the upgrading of existing ones (METAP, 2001). The organizations responsible for water quality should be enabled by the legislation to enforce pollution control measures and take legal action when necessary. Capacity building needs to take place at all levels to address water quality issues and find sustainable solutions (METAP, 2001).

An intensive training program should accompany the implementation of the modernization targets. Intensive and wide capacity building programs for staff at different levels and in different domains do necessary if Syria is to establish an accurate understand of water management and to make a strong foundation for the transition from a development to a management approach (IPTRID, 2003). Another aspect is the creation of awareness among farmers to the issue of water shortage through sensitization and indication of the potential benefit from improved technology and management tools (Bazza & Najib, 2003). Salman & Mualla (2003) also found that for its project research units working on the application of new on-farm irrigation techniques and crop water demands were in a good situation but their results never reached the farmers. So, the conclusion is that establishing communication channels between water agencies and farmers and bringing back the trust of farmers in the agencies is of utmost importance and must be accomplished through strengthening the capacity of extension services and transferring the results of research to farmers (IPTRID, 2003). Also, properly designed irrigation systems may easily prove to be poorly performing if they are operated in a wrong way (Bazza & Najib, 2003) According to Varela-Ortega & Sagardoy (2001), the training program should be addressed to the following recipients:

- Farmers
- Extension agents
- Professionals from the public and private sector to increase the design and implementation capacity.

The number of people to be trained in each category and the related costs will require the preparation of a detailed proposal and the following are only gross estimation by Varela-Ortega & Sagardoy (2001) for an initial period of 5 years.

- 50 000 farmers
- 500 extension agents
- 30-40 professionals from the public and private sector.

National capacity building is considered as a critical and important task for proper environmental management and sustainable development. Different measures have to be taken according to the NTCDS (2001). A strengthening of the framework for environmental management together with building a legislative framework for environmental management. Also a department for sustainable development should be established. Additionally, the role of NGO's and the private sector in environmental management should be expanded. The awareness of environmental sustainability issues should be raised, in part by increased investment in environmental education and training (NTCDS, 2001).

The Islamic education system offers several forms for delivering Islamic teachings. The mosque is the best forum for addressing the general public at all levels on matters covering all the issues of daily life. At a minimum, the Friday prayer represents a weekly opportunity to address the public. In Islam, everyone is responsible for education, therefore it provides a dynamic forum that is capable of reaching the entire Muslim population: in the house, street, school and mosque (Atallah *et al.*, 1998). Unfortunately these forms for reaching the public have not been used efficiently. Water conservation must involve all people and requires behavioural changes. It involves sacrifices and social and financial costs, which necessities the full cooperation an integration of efforts of all stakeholders. The Islamic concepts and tools have to be incorporated in the public awareness activities (Atallah *et al.*, 1998). Imams could play a key role in pubic awareness activities on water conservation. Imams should be properly trained and informed: as community leaders, they should never be excluded from water resources planning and management activities. Although their knowledge of water resources and conservation practices is usually insufficient for them to act as educators on the subject. Therefore, water specialists must train, educate and inform imams, not only about water shortages, water conservation practices and the need to involve the public but also about audiovisual tools and materials to help them reach the public (Atallah *et al.*, 1998).

Of course, one can ask if the Islamic institution is so important. The different moral and ethical issues mentioned are valid for many religions, not only Islam. Also, it has to be evaluated for the Syrian case whether religion can have a real influence on people's daily lives, and whether such an influence is desirable. It is possible that advertisement in newspapers or on television might present more perspectives currently towards the sensibilization of the population. Or maybe only financial incentives are seen as able to shift the users' preferences. This issue has certainly to be addressed in more detail.

In the steppe, the inherent flexibility of the customary institutions means they are usually better suited to the prevailing non-equilibrium environment of the Syrian rangelands when compared to the rigid statutory laws and inappropriate technologies imposed by the state. Imposition of technologies will not succeed unless tribal land tenure and institutions are taken into account. These institutions are the foundations of a sustainable system by reducing transaction costs and affording local legitimacy (Rae *et al.*, 2001). Past policies centralizing rangeland management were founded on misplaced assumptions about the physical dynamics of the steppe environment as well as the capacity of the herders to cooperate together and regulate their use of pastoral resources. Tribes no longer represent a political threat as they once did, but they do represent irreplaceable social capital. The task for the Syrian authorities is to respond to this opportunity and enter into a genuine partnership with the steppe users for the management and conservation of steppe resources (Rae *et al.*, 2001).

When considering the establishment of water user associations, it does not appear as an urgent need, but a greater participation in the decision making processes will be recommended. Such mechanism could consist in the establishment of Irrigation Committees in every irrigation system integrated by a mix of farmers representatives and government officials to decide in all operational and investment matters.(Varela-Ortega & Sagardoy, 2001). Experiences from other countries indicate that the establishment of water user associations among the owners of wells could provide an important inter-phase between the government and the farmers particularly when severe measures are needed to reduce water abstraction (Varela-Ortega & Sagardoy, 2001; Bazza & Najib, 2003).

Therefore, it would be advisable to establish water user associations by grouping wells located in the vicinity and discuss with them the implementation of the restrictive measures. This could be tried out in some specific areas and expanded if the results are considered positive by concerned parties. In many cooperatives the provision of water is treated like one more input and the general manager allocates the resource according to established rules. It could be a positive experience if all water affairs are handled by a special committee of farmers. This could be an initial step in moving towards a more independent management of the irrigation water in the cooperative (Varela-Ortega & Sagardoy, 2001). Although there may be no direct organized role of farmers in managing water at scheme level, it may be a significant opportunity to develop user-based approaches and to establish an institutional framework for farmers to participate more in water management (IPTRID, 2003).

Big engineering projects are also growing increasingly expensive. They can cause great harm to the environment and frequently incite a justifiable fear and resistance by indigenous peoples. Community based natural resource management must play a critical part with those larger approaches in solving scarcity problems. Local water management permits a democratizing decentralization of decision and accountability (Brooks, 2002). And it encourages the integration of traditional knowledge with innovative science to promote fair and efficient supply management. In these ways, water degradation and shortage can be transformed in sustainable sufficiency. Successful governance and research each demand an alert sense of a community's social, cultural and political structures, including most particularly its power structures. People need to be engaged in the decisions affecting their lives. Success means taking into account the precise details of local irrigation patterns, faring systems and available markets (Brooks, 2002).

Promising research results seldom translates effortlessly into acceptance by local farmers and households. Smaller and less complicated approaches are more likely to be adopted and put to lasting use than grand designs of integrated resource management. Research results that emerge only in academic journals scarcely qualify as true development research. Applying the discoveries of research is invariably a multiphase enterprise with many partners collaborating (Brooks, 2002). The private sector should also be encouraged to invest in the sectors parallel to irrigation such as the fabrication, import and marketing of repair parts, maintenance of irrigation equipment and other services (Bazza & Najib, 2003). Obviously, the farmers have to keep participating to the support of the operation and maintenance costs of irrigation water.

Box 6.1 Institutions around water

During the field visits, it became clear that the issue of water was taken quite seriously at all levels in the country. We could observe that the situation was already quite worry some in certain zones with dropping groundwater stocks. Especially the exploding urban population of Damascus will pose a real challenge in the future. The recent affluence of Iraqi refugees in the region has only deteriorated an already dramatic situation. All the water of the El Barada River is already being diverted at its source to supply the city in its needs, leading to the decay of the green belt around the city.

Also, the capacity of most the urban areas of the country to treat the sewage water and solid waste is too limited. This is a domain to which increased attention must be paid in the future if Syria is to implement an adequate integrated management of its water resources. The purification and re-use of water can offer a substantial increase in the efficiency of use for the available resource, potential presently left unexploited. Also, this would improve the health problems experienced due to irrigation with, and consumption of polluted water. Encouraging were the efforts to increase the efficiency of the Irrigation systems countrywide. It is widely accepted that, due to the important water use in agriculture combined with the low efficiency of the old irrigation systems, improvement of the irrigation network offered the most interesting prospects for reduction of the water consumption. We have visited such a project, Development of Efficient Irrigation Techniques and Extension in Syria (DETTEX project), of the General Commission for Scientific Agricultural Researches (GCSAR) of the Ministry of Agriculture and Agrarian Reform (MAAR). There, up to 95 % of the project area had already been converted to drip irrigation, with very promising results. In the visited extension unit in the village of Kafar Hawar, rural Damascus, there had also been an extensive effort of capacity building with the formation of specialised staff and farmers. It seemed exemplary for the improvement of the irrigation system in combination with a good linkage with the farmers. It would be immensely efficient if this approach could be pursued nationwide.

However, during the visit of the project, appeared also clearly the two main obstacles to the success of the Integrated Management of the water resources in Syria. First of all, it showed the overlap and lack of coordination of the efforts and different projects by the two main water related ministries, being the MAAR and the Ministry of Irrigation (MOI).

There seemed to be many projects for different purposes (irrigation technology, extension, water harvesting, less water intensive cropping patterns...) even inside the same ministry running in parallel ways. Another example of overlap is that for the provision of the necessary loans to improve their irrigation system, the farmers have to turn to the MOI, while the equipment is then provided by the MAAR. The second problem emerging during the field visit was the ambiguity around the licensing of existing illegal wells. From two different sources it was mentioned that since somewhere around 2006 it was in fact not possible anymore to acquire such licenses. However, later, it appeared that getting licenses should still be possible but that in fact the procedure for acquiring a license was too demanding for the farmers to be able to file adequate requests. Additionally, it is seem to be impossible to close most of the illegal wells for subsistence reasons. There are some attempts by the authorities to encourage farmers to constitute water users associations, but there is a problem to get the farmers together, their preference being to work alone. Also, although the authorities have strongly condemned the drilling of new wells, this would in practice still be taking place, but we could not confirm this personally. Anyhow, we have to stress here that as long as Syria has no better monitoring of the extraction of groundwater by all the wells on its territory, legal and illegal, it is impossible to define an adequate strategy to tackle the groundwater issue. A first step to good groundwater management is to have an understanding of the water flow.

Different important issues were discussed during the different interviews and presentations, amongst others the different policies existing towards crops with high water requirement, like cotton. It will have to be weighed against the economical importance of the different crops. It is not clear yet what the plans of the ministries in this area are. Also there was some discussion about the setting necessary to be able to proceed to correct and efficient water pricing. It was quite clear that from the farmers' side, there is not an immense demand for such regulating measures to encourage the efficient use of water. In conclusion, priorities and strategies will have to be defined basin by basin, leading to adapted patterns of water use and efficient coordination of the activities to be realised.

7.2. Water policies in Syria

Nondh Nuchmorn

Syria is one of the semi arid countries of the Middle East. Water problems in Syria are bringing a serious concern in its society since, from the forecast of water demand in the future, if the population growth in Syria continues its current rate (about 3%) and water use efficiency is still not increased; water demand could surpass the available water supplies and Syria will be soon classified as a country with *a severe water stress* (Mualla and Salman, 2002). This crisis requires the necessity of public authorities to find some strategies to improve water use efficiency in all sectors. This section of the paper, thus, aims at reviewing the current policies of Syrian government related to water and the evidenced impacts from their implication. The principles and framework of water policy will be stated at the beginning as a base of understanding the issues and a steering concept for benchmarking with the ongoing policies which will be analyzed in the last part.

7.2.1. Water policy: principle and framework

Water allocation: Market vs. Policy

In the economic viewpoint, 'water' could be considered as tradable economic goods which its market price (determined by demand and supply) is theoretically supposed to reflects its scarcity and willingness to pay of users. However, water market is not naturally well-functioned since many water sources are found as costless in marginal using due to the unclear ownership or no flexible price systems occurred. As a result, some environmental problems (i.e. water scarcity and pollution) could emerge and become the costs that the whole society has to bare together; namely, '**externalities**' or '**market failure**'.

Government intervention seems to be the key mechanism in resolving market failure. In any society; we can see at least one government authority functioning in water management. Their tasks are to set up 'policies' in water allocating which could direct water use into the way of social welfare's optimum. Nevertheless, not always the policies are perfectly implied, inversely; they could also increase the inefficiency of the market which called by Steinfeld *et al*. (2006) as **'policy failure'**. The causes of these failures could be from price and market distortion or misleading/insufficient information used in decision making etc. To effectively and efficiently approach the goals of society with minimized policy failure is the question for any policy making.

Analytical Framework for Water Policy

Considering 'water' as goods, the '***market framework***' could be proposed to help us visualize the situations of water allocation systematically, and also suggest appropriate policies or evaluation tools for assessing policy impacts. To illustrate the link between policy and water market clearly, the framework could be divided into two parts; (1) *policy arena* and (2) *market arena* (see Figure 34).

(1) *Policy Arena*

This part will explain the principles underlying policy formation. From the upper part of framework in Figure 34, policy is developed according to the **policy goals, objectives, approaches,** and **instruments**. In setting '*policy goals'*, state has to give the priority between 'efficiency' and 'equity' depending on its focus in development. Then, 'policy objectives', the more specific sub-goals, will be accordingly set. After that, the *'policy approaches'* determining characters of implementation will be chosen between; the *top- down approach* which monopolize the decision-making power by the federal authorities and the *bottom-up approach* which pays more attention in empowering local authorities in self-regulation of water resources.

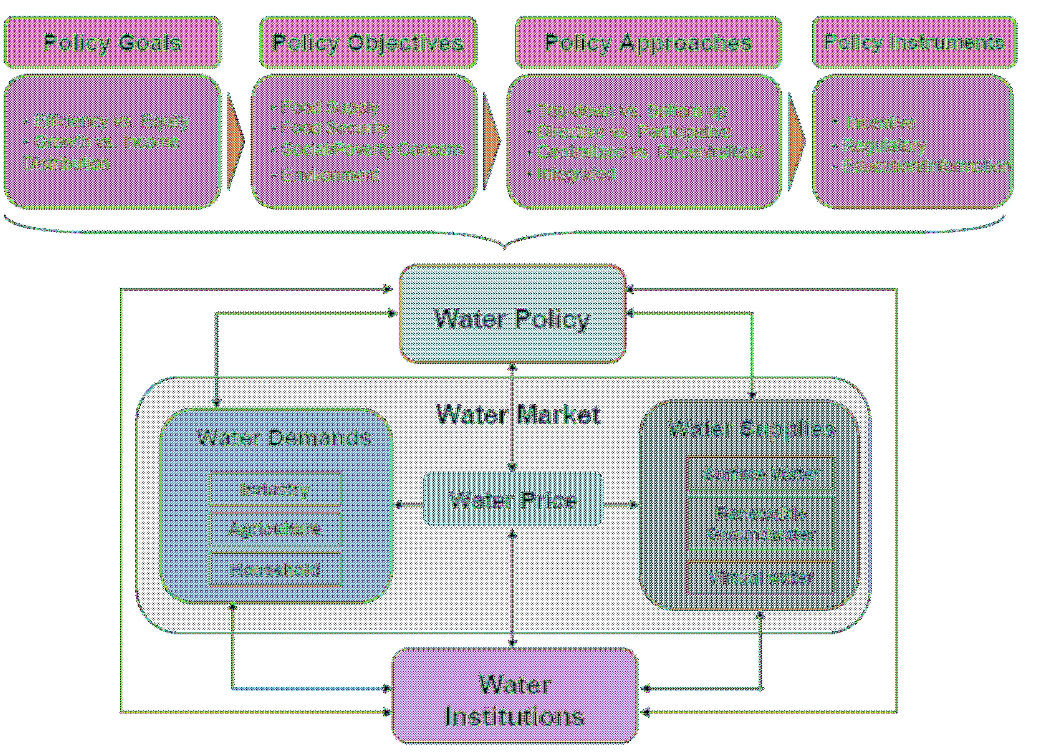

Figure 34: Analytical Framework of Water Market and Policy

'Policy instrument' is the practical actions of policy in influencing popular behaviours; particularly in 3 main categories; (1) **Incentive instrument**; include policies on pricing, subsidy and taxation, and supporting investment policy (2) **Regulatory instruments** such as prohibitions, ensuring minimum standards, zoning mechanisms (3) **Information and educational instrument;** aim to change the behaviour by adjusting attitudes such as campaigning, training, etc.

All the options selected which comprise to the policy must be carefully considered because they could be the criteria in resolving some water-related conflicts such as the decision to allocate water to urban and industrial sector or agricultural sector, the decision to enforce strict environmental regulations on export farms, etc.

The ***trade-offs*** between each option should be also recognized. For example, from Figure 35, the policy in developing livestock sector is the trade-off between 4 objectives; food safety, food supply, social, poverty concerns, and environments. Governments in low development countries tend to secure the people food security and export volume as first priority, the water as environments would be definitely put in the less significant factor to concern/ invest on.

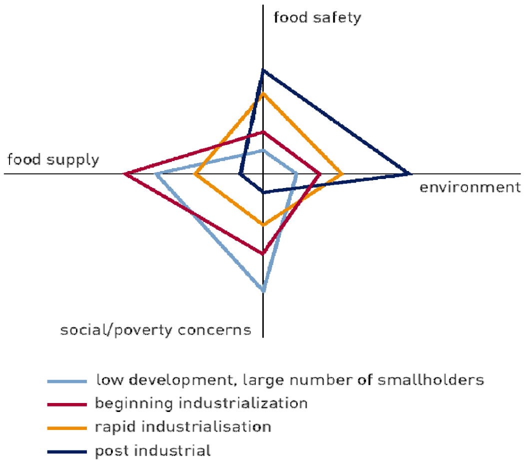

Figure 35: Trade-offs in Policy Objectives for Livestock Sector in differently developed countries (Source Steinfeld *et al.*, 2006)

(2) *Market Arena*

The lower part of framework in Figure 34 shows that all the policies being made could affect the water market in 4 main channels; water demand, water supply, water price, and water institutions. Some examples are shown in the Table 16;

Table 16: Examples of Water Policies in Different Channels

Demand-side policy	*Supply-side policy*	*Price policy*	*Institutional policy*
- Reduction of water consuming activities - Improving efficiency of water uses - Education on water conservation	- Controlling number of current water sources - Seeking for new sources - Water quality Treatment - Importing virtual water	- Water pricing - Measuring unit of water uses - Environmental charges - Subsidy of water	- Re-defining property rights - Policy reform - Decentralization - Legal reform - Improving administrative efficiency

To approach the goals, a single policy is not sufficient. A '**policy framework**' which contains a wide range of policies would be more proper in affecting the market in an integrated way. The next part focuses on the current policy framework in Syria.

7.2.2. Current water policies in Syria

In Syria, there have been many literatures mentioning about the efforts of government in tackling with both national and local water problems and indicating the importance of water resources on Syrian economy. From 1999 to 2001 is a period of water sector's reform which a considerable amount of legal regulations and decrees had been launched. The legal framework that affects irrigation water has been thoroughly modified and strict measures have been taken into action (Varela and Sagardoy, 2001). All of them are in response to specific *policy objectives* that are;

(1) Conservation of water resources

(2) Food security and food production targets

And (3) Settlement of nomad population

Each policy objective includes several policy strategies that are implemented by different policy measures which could be seen in the policy matrix in Table 17. These policies could be classified by its aspect of impacts on water market as:

a) Demand-side Policy

The agricultural sector in Syria consumes up to 85 % of all available hydraulic resources in the country (Varela and Sagardoy, 2001). However Syrian government pays very less attention in decreasing water demand and improvement of patterns of water. Instead, the need to ***increase water use efficiency*** in agriculture is at the center of the nation's water policy discussions. At present, water policies in Syria are designed to combine the expansion of irrigation and to attain a sustainable use of water by increasing technical efficiency and by reducing future consumption.

For ***surface water market***, one of the pillars of this policy is the adoption of ***modern irrigation technologies*** at farm level projects. With the objective of reducing water use, the government has decided that all irrigated areas will be equipped with modern irrigation techniques in 4 years with the investment of about 32 billion Syrian Pounds (600 million US$) (Salman and Mualla, 2003). Most of the new systems are of line canals from the headwork to the farm gate aiming to improve conveyance efficiency and minimize distribution losses through converting open irrigation canal systems to pressurized pipe systems and rehabilitate lined canal systems. The development of new irrigation in the public sector has been important increasing from 219,273 ha in 1993 ha to 396,518 in 2000 at a rate of 25,000 ha/year (MAAR, 2001 in Varela and Sagardoy, 2001).

To gain effective implementation, the government has some technical and financial measures to support farmers in changing irrigation system in their farms. Technically, some regional projects have been established as a part of extension unit to educate farmers in adopting and utilizing the uses of new modern system. Financially, because the cost of farmers to implement is considered high (estimated average cost for the conversion into a pipe system is about $ 3,600-4,000/ha), the Co-operative Bank provided loans to the farmers to purchase modern irrigation equipment at subsidized interest rates, with higher subsidies for cooperatives. However, the capacities of staff to operate and maintain are found low and the use of pressurized networks is still rather infrequent.

Table 17: Policy Matrix Related to Water in Syria (Source Varela and Sagardoy, 2001)

	POLICY STRATEGIES	MEASURES
CONSERVATION OF WATER RESOURCES	Sustainable use of groundwater aquifers	• Well drilling is banned in the cretassic layer. • Only public Ministries are allowed to drill wells for domestic water use.
		• Forbidding cultivation of summer crops in the steppe areas to preserve non-renewable groundwater reserves.
		• Obligation to license all unlicensed wells by July 1, 2001.
		• Well drilling licensing is banned. • Well deepening licenses are subject to the conditions of the irrigation department in the governorates. • Pumping system installation is not permitted unless renewable water is available.
		• Installation of flow meters in wells. • Grant irrigation license to farmers investing in the installation of flow meters.
	Cost recovery in public irrigation schemes	• O&M costs: Irrigation fee of SP3 500/ha for spring irrigation and SP600/ha for winter irrigation. • Capital costs: establish a land reclamation fee from SP2 000 – 7 000/ha.
	Irrigation rehabilitation and modernization	• Committee of Ministries should submit a national study for adoption of pressurized pipe irrigation systems.
		• Rehabilitation of public irrigation schemes within a specific schedule. • Supply to farmers with the required equipment and inputs. • Agricultural Credit Bank will finance modern irrigation networks and pumping sets.
		• Rehabilitation of the Al Manajeer irrigation projects in the Tigris and Al Khabour basins.
		• Already implemented projects should be rehabilitated to adapt to modern irrigation techniques.
	Adoption of modern irrigation technologies at farm level	• Committee of Ministries should submit studies for adopting modern irrigation techniques for strategic crops according to basins' capacity. • Allocate annual budgets and provide necessary loans. Perform quality control of equipment.
		• Conversion from traditional irrigation methods to modern irrigation techniques in four years. • Start conversion in public sector systems.
		• Financing of adoption of modern irrigation by the Agriculture Cooperative Bank. • Give priority for financing the projects located in the water-deficit basins. • Licenses will be granted to unlicensed wells provided that modern irrigation (sprinklers, drip) is installed.
FOOD SECURITY: MEET FOOD PRODUCTION TARGETS	Coordinate Agricultural Plan with irrigation water availability	• Establishment of crop rotations and cropping patterns of strategic crops according to the renewable water resources, dams and reservoirs allocated for irrigation.
	Development of new irrigation areas	• Allowing farmers in Raqqa Governorate to plant 1 400 ha with summer crops and 2 800 ha with winter crops. • All irrigation and land reclamation projects should consider the adoption of modern irrigation techniques.
SETTLEMENT OF NOMAD POPULATION	Development of new irrigation areas	• To ensure settlement of population in specific areas, it is permitted to cultivate pastoral shrubs and fodder barley not exceeding use of 1 500 million m^3/year for all uses. • Summer crops are forbidden to preserve non-renewable ground water reserves. • Promoting investment by wells in the steppe trying to preserve water and settlement of population

For ***groundwater market***, as well as surface water, not so many significant evidence of reducing water consumption is found. There is merely a control of demand in some arid zone which the cultivation of summer crops in the steppe areas are forbidden to preserve non-renewable groundwater reserves. Alongside, the government has decided to promote the installation of measuring devices in all existing wells and is requiring that all wells must be licensed by July 2001 to control groundwater use.

b) Supply-side Policy

The water resources of Syria are very limited compared to the needs of the country. The available resources amount to only 16,058 million m^3 per year whereas the total uses reach around 19,162 million m^3 per year (Varela and Sagardoy, 2001). Supply-side management is, thus, an important management option in Syrian water policy framework and has been given higher priority than controlling demand in the past.

For ***surface water market***, *supply-side management* mainly focuses on locating; developing and managing new water resources, aiming to augment the national water budget with new water. The most popular way to control surface flows is by building new dams and creating multi-purpose reservoirs (there are now around 160 dams in Syria with a total capacity of 14 billion m^3) (Salman and Mualla, 2003). However, over the years, most existing potential water resources have been already developed and utilized. The option to increase more supply by developing less accessible resources has very high costs and is considered not economically feasible. The emphasis is now shifted to only optimizing the utilization of those existed. To link with demand-side management, the technology in water-harvesting and irrigation schemes were also built.

Groundwater is another alternative source of water. Syria has important groundwater resources estimated at 5,395 million m^3 which represents 37% of the total water resources of the country. Groundwater wells provide a more reliable source of water to farmers and represent an "on-demand" source of irrigation in contrast to government surface irrigation schemes. The critical problem is, during the period 1990-1999, water tables have decreased enormously in many areas (drastically, in the Orontos basin and Damascus countryside). This has led to the serious policies restricting uses of groundwater supplies.

Legally, licenses are required to drill and use wells in Syria, specifying the extent of water use and require renewal every ten years. However, poor enforcement has resulted in a large increase in the number of illegal wells in recent years (almost 50% of the total number of wells) and this becomes a key factor contributing to the groundwater table declines. Recently, any drilling of new wells is prohibited by recent enacted legal decisions. This policy has not only enhanced the conservation of groundwater water, but in the other hand, has also blocked the opportunity of the current numbers of illegal wells to be legalized. The cause of this inefficient control is the lack of critical information such as the amount of renewable groundwater resources and the interaction between the surface and groundwater systems. The hydrological monitoring network for groundwater resources need to be widely established.

c) Water Pricing Policy

Pricing irrigation water is a generally-accepted instrument in correcting water market. Efficient pricing system of water market is supposed to reflect both 'the real costs of using water to real users' and 'their willingness to pay to water providers' and finally could lead to prevention of externalities and remedy of water scarcity. By principle, water pricing has two key roles (Johansson *et al*., 2002):

(1) An economic role of signalling the scarcity value and opportunity cost of water to guide allocation decisions both within and across water sub-sectors; and

(2) A financial role as the main mechanism for cost recovery.

These two functions comprise to the concept of '***full cost recovery***' theoretically including ***fixed costs*** (depreciation, interest payments on facility, permanent labour and administration, and some operations and maintenance (O&M)) and ***variable costs*** of water used per unit. Practically, two options of water pricing are found. First, price based on ***marginal cost*** which could maximize social welfare (the joint surplus of farmers and suppliers) in the short run. Charging water at this price makes the allocation of water economically efficient but government has to subsidy more costs because fixed costs remain being unpaid. Second, price based on ***average cost***, which, on the other hand, is adequate to cover fixed and variable costs of water supply, but push all the burdens to water users and could run the risk of driving the farmer out of business (Tsur *et al*., 2002 in Johansson *et al*., 2002). This trade-off must be carefully considered.

For the situation in Syria, in ***public irrigation systems***, operation and maintenance (O&M) costs of the irrigation and drainage networks are charged through a ***flat fee*** of SP 3500/ha for permanent irrigation and SP 600/ha for winter irrigation. These fees were determined not from volatile demand and supply but under a legal regulation established in 1999. These flat rates are quite low compared to the estimated actual O&M costs, which are found at 5,594 SP/ha for pump irrigation and 1,708 SP/ha for gravity irrigation. (Varela and Sagardoy, 2001) By this price, farmers bare less costs than actual O&M costs while government bare close to 90% of O&M cost which is considered very high for world standards. Meanwhile, in the groundwater system, there is no charge for water use at all. This could be seen that Syrian does not have adopt principle of pricing system (either marginal or average cost-based). And this makes farmers have no incentives to use water efficiently and to conserve water stock or quality.

Box 6.3

Water pricing seems to be very good and 'must-do' policy instrument in Syria. However, from discussion with farmers during the excursion Syria, making water price rises could bring up the sudden unacceptability and dissatisfaction of farmers and also create negative impacts to economy since the price of agricultural products would be increased. This reflects that water pricing policy could not be done lonely but needs any other kinds of subsidy for farmers and agricultural sector in the short-run. Time adjustment and participatory communication with farmers are also required

d) Institutional Policy

The policies towards water institutions will not be mentioned here in details since they have been already emphasized in the previous section (see chapter 6.1.2). The general findings are that water management in Syrian is rather centralized, being strictly controlled by the government. However, the coordination between the related authorities is still poor and scattered. The policies in developing stakeholder network, improving staff capacity, and more efficient information system are required.

7.2.3. Critical issues for current water policies in Syria: questions for sustainability

(1) Macro-level: Are Policies Reaching the Goals of Water Balances?

The current policy focus on modernization of irrigation system in Syria seems to have many benefits in improving water use efficiency. However, some studies showed that this is not a sufficient factor in water conservation. Varela and Sagardoy (2001) had assessed the effect of water development and water conservation policies at country level and at basins' level along the years 2000-2015 in 4 policy scenarios[8].

The results found are the present water policy (modernization policies combined with the expansion of irrigated areas) even though they could reach the projected goal of 420,000 ha for the 15 year period, the water balances tend to revert back to the low initial values in the long run (see annex IV, scenario 1). While the other scenario such as the policy which

[8] Scenario 1: Present policy: Combination of irrigation modernization (4 years) and irrigation expansion (15 years)
Scenario 2: Modernization policy: Modernization of existing irrigation schemes with no expansion of irrigation
Scenario 3: Long-term combined policy: Combination of irrigation modernization and irrigation expansion (15 years both processes)
Scenario 4: Differentiated policy: Modernization in critical basins and limited irrigation expansion in selected basins.

combining irrigation modernization and irrigation expansion still also results only in a moderate reduction of the deficit (see annex IV, scenario 3). The study indicated the explanations that the situation is some basins have quite large deficits (e.g. Al Khabour) meanwhile others have positive balances and this requires a *'differentiated policy'* to attain a national positive balance. The scenario yielding least disadvantages seems to be the policy which modernization concentrated in the high deficit basins whereas development of new areas will be permitted only in the basins that have positive balances (see annex IV), scenario 4). Although the expansion of the irrigated area in this scenario could reach only one forth of the projected objectives, the worthwhile trade-off is the more sustainable water balance, especially in the arider areas.

(2) Micro-level: Can Policies Effectively Induce Water Conservation in Farm Level?

While, in micro-level, the irrigation modernization policy directed to substitute traditional irrigation systems with new water-saving techniques, the study of Varela and Sagardoy (2001), indicated that this system does not ensure an efficient use of water. Some reasons are;

- *Fault technological appropriateness*: - The modern irrigation systems are better suited for holdings irrigated by *private wells* because they provide the more certain and continuous water flow which are available when necessary than the surface irrigation.
- *Lacks of effective irrigation networking*: - Most of the irrigation networks work in a rotation system and make water availability to the farm not compatible with the use of sprinkler and drip irrigation systems that require a frequent water supply.
- *Lacks of efficient pricing system*: - Most farmers are operating under an area-based administered water pricing system (for surface water use) and are not charged for the actual use of water. As a result, the policies have not affected much the demand for water since the irrigators still can use large volumes of water for the crop requirements without any penalty.
- *Inefficient institutional and managerial support:* - A study by IPTRID[9] on irrigation modernization of the Old Alyarmook Project has concluded that in spite of careful technical upgrade, the managerial and institutional upgrade have not been given attention (Salman, 2002). The parallel effort on strengthening the capacity of operation and maintenance staff is needed.

With these above reasons, the *irrigation modernization polices* in Syria seems ***not*** to be able to induce as much water savings as aimed in the policies.

[9] The International Programme for Technology and Development in Irrigation Drainage

Box 6.4

From the field observation, there are the efforts of Syrian government authority (Ministry of Irrigation) in promoting modernization irrigation techniques together with communication for water conservation. The working units are evidenced in a form of project (supported by JICA; Japanese International Cooperation Agency) as a part of each regional extension department. The key running staffs are the water engineers, so-called "water extensionists". The monitoring of modernized irrigation is done and the water amounts used are also measured by them. The main problem voiced from the project is the difficulty in controlling illegal wells. The project sustainability after the funding period from JICA is still being questioned.

(3) Virtual Water: A Rational Future Alternative?

Virtual water is water embedded in commodities. This concept termed by Professor Tony Allen of the University of London in 1995, focusing on "*the import of the high water consuming foods they need, particularly the staples which can be shipped easily and stored for long periods (i.e. grains, dried beans, food oil, fodder and even frozen meat and fish), from those countries with plenty of water from natural renewable sources and sufficient areas of arable land*" (Shuval, n.y.) which is considered a more economical strategy, not only for assuring an adequate supply of food but also resolving domestic water scarcity problem. In the case of most MENA (Middle East and North Africa) countries which are in the context of arid and semi-arid countries, food imports are found to have the logical and rational outcome based on comparative advantage (Hakimian, n.y.). The Figure 36 proofs that among MENA countries, Syria is one of those benefiting from the import of cereal compared to her limited endowment of water and labours.

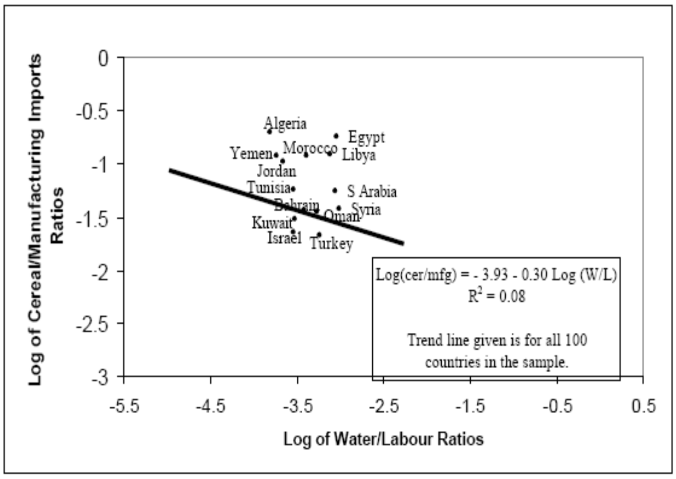

Figure 36: Imports Structure and Water Endowments (MENA, 1997) (Source: Hakimian (n.y.))

However, to promote the import of virtual water more strongly, the local production units will be affected unavoidably from less production. The welfares of farmers and agricultural sectors could be drastically lost. The factors like livelihoods and rural employment must be carefully taken into account.

Box 6.5

From the discussion during excursion, we found that nowadays Syria has already imported a large amount of inputs for livestock production; for examples; grains and fodder for feed. However, the current import is done by the purpose of insufficient domestic supply only, not strategically by adopting the concept of virtual water.

Conclusion and Remarks for Future Water Policies in Syria

The Government of Syria has launched an active policy in resolving her critical water scarcity problem. The main focus in the policy seems to be the modernization of irrigation techniques and expansion of irrigated areas, aiming at improving water-saving efficiency. However, there are evidences that the large amounts of invested budgets in this policy are not efficiently leads to the goal of balancing water deficits in the soon future, and also the rate of adopting modern technique is still concentrated only with some private farmers since the entire irrigation networks are not simultaneously developed. Looking back to the concept of water market in the first part, Syrian policies towards water saving efficiency market could be seen as unbalanced and inadequate options.

For policy recommendation,

- The policies towards other aspect of water market should be also paid more attention. For examples; water demand management, there is no obvious policy aiming at decreasing or limiting water demand for both livestock and feed farms.
- The water institution and infrastructure should be more invested together with irrigation technology.
- The policy of water pricing should be put as an important agenda to internalize the costs of water use/polluting to the users/polluters.
- The concept of bottom-up approach and integrated water resources management (IWRM) could be applied to local level, not only to improve the water market efficiency but also be a good means of poverty reduction and strengthen democratic culture in Syria.

7.3. Syria and water conflicts

Giacomo Mencari

"Access to safe water is a fundamental human need and, therefore, a basic human right."

Kofi Annan, Former United Nations Secretary-General.

7.3.1. General issues

The disputes over water between different populations, sovereign states, interest groups or individual consumers have a background as old as the human history. The relative imbalances in the distribution of natural water resources by different areas, the disparities in their qualities, the rapid increase of the population and the frequent misuse, they are all sufficient reasons to lead toward disputes and conflicts. Pressure on fresh water resources is more evident in those cases where competitors claim the exclusive right for using one source. In those cases where competitors are members of the same national entity, an internal conflict will rise on who has the priority to provisions. In those cases where the water source is shared by two or more countries, the dispute assumes an international profile under the subject of transboundary water.

Besides the term "transboundary water" is traditionally used into navigation context, it is becoming more widespread in order to indicate shared waters resources, utilized for economical or civil purposes, such as irrigation, drinking or energy sources. During the recent years, it is definitely replacing the terminology of "International watercourse" adopted in the 1997 United Nation Convention; the reason seem to be attributable to its broader means, which include either surface water flows then groundwater resources.
Both transboundary watercourses then aquifers extend hydrological interdependence across national frontiers, linking users in different countries within a shared system. The latter can be figured out by three different cases:

- Watercourses are shared by two different countries and they constitute the natural boundaries between the two states.
- Water that originates and run into a country, after which the flow cross one or more neighbourhoods borders before to end in the sea.
- Aquifer intersected by the boundary between two or more States.

Official data show that around 40% of the world's population live along more than 260 transboundary water systems; furthermore 145 nations worldwide are accounted to have some regions located within international river basin (BMZ, 2006). Every continent has the own examples, which are largely variable in terms of dimensions and socioeconomic interactions. In order to illustrate some relevant cases, in this paper the World Resources Institute Data Base has been adopted (WRI, 2005).

As outset the Nile River - the longest river in the world – is a case rather interesting: its watershed covers 10.3% of the total area of the African continent and it spreads over ten countries, influencing directly the livelihood of 150 million people. In Asia the Mekong River, one of the major water systems in the world, from its source on the Tibetan Plateau to his delta in South Vietnam, it runs across six different countries with more than 60 million of people that withdrawn form the river the own life support. In Latin America, the Amazon River watershed is shared by 7 countries and it occupies a surface of 6,144,727 km^2 where people live there are esteemed to account 25 million units. Finally the longest European river, the Danube, its basin covers 817,000 km^2 including 17 countries that represent the 8% of the area of the whole European continent.

Furthermore, amongst the most important transboundary water systems in the world, it is possible to mention several lakes. In these cases water reserves represent fundamental livelihood resources for million of people that live along the lake banks or in the relative basin shared by two o more States. One representative example is given by the Victoria Lake in Africa: it divides its watersides with three countries but its water basin includes six states, which population is strictly depending to the lake water resources for their livelihoods.

Although rivers and lakes are the most evident transboundary water systems, they are not the exclusive cases. As previous mentioned groundwater reserves are also included. Main feature of the aquifers is that they do not correspond to political borders, despite that, they supply almost 90% of the total fresh water useable in the world. This fact is the cause that, their resources utilization represents even more delicate and problematic matters. Transboundary water systems situation provides an ample opportunity for political tensions, especially on the light of the increasing pressure on the fresh water resources, which result to be even hotter topic in those areas already affected by social conflicts and political instability, such as Africa, Middle East and Southeast Asia.

At international level, water disputes are regulated by some multilateral agreements and numerous declarations and resolutions; nevertheless, a binding legislation framework universally accepted is still missing.

7.3.2. International legal framework

International Law concerning water issues has a rather short history. Still at the beginning of the twentieth century, the only international agreements about water issues were exclusively related with navigation. First step toward a transboundary water regulation, which intended water as resource, has been made in 1911 by the International Law Institute (ILI) that promulgated the *Madrid Declaration on International Regulations Regarding the*

Use of International Watercourses for Purposes other than Navigation, which has been followed by *the Resolution Concerning the Utilization of Non-Maritime Waters for Purposes other than Navigation* in 1961. Both documents had the exclusive role to formulate some guidelines where to build on the following texts regard the subject. Few years later in 1966, the International Law Association (ILA) formulated some basic rules for an equitable and reasonable utilization of sharing common waterways through *the Helsinki Rules on the Uses of the Waters of International Rivers*. This text tried basically to provide a conceptual basement further upgraded by some terminological clarifications.

Then in 1971, the International Law Commission of the UN started to organize the principles inspired on the on previous declarations and resolutions, with the purpose to set up an official regulation to submit to the International Community. Finally in 1997, the UN General Assembly adopted *the Convention on the Law of the Non-navigational Uses of International Watercourses*. The agreements has the goal to regulate the uses of the international watercourses for purposes different than navigation, through measures of protection, preservation and management related to the uses of watercourses and their waters (UN, 1997). Nevertheless until now, the Convention has not been ratified by sufficient states to enter into force (amongst them also Turkey). That is the reason because the agreement has not legally binding effects in the international community. Nevertheless it provides some principles that can be used as guidelines for specific cooperative endeavours in the area of transboundary water cooperation, although exclusively under the form of substantive provisions in every particular case.

The basic principles are resumed by the German Federal Ministry for Economic Cooperation and Development declaration paper as follow:

- Principle of equitable and reasonable utilization and participation (Article 5 of the UN Convention) means that all riparian states have a right to enjoy the benefits of the use of international water resources (BMZ, 2006).
- Obligation not to cause significant harm (Article 7 of the UN Convention) derives from the principle of restricted territorial sovereignty and stipulates that a state may only use an international watercourse in a way that causes no significant harm to another riparian state (BMZ, 2006).
- Principle of cooperation (Articles 8, 9, and 11 of the UN Convention) relates to the procedural dealings amongst the riparian states and essentially comprises two distinct obligations. On the one hand, it obliges the parties to exchange data on the condition of the water resource regularly. On the other, parties are obliged to provide prior notification of planned activities affecting the condition of the water resource (BMZ, 2006).

- Obligation to seek peaceful settlement of disputes is stipulated in the Charter of the United Nations (Article 33) and underlies Article 33 of the UN Convention. This article obliges disputing states to seek a solution by negotiation, enquiry, mediation, conciliation, arbitration, judicial settlement, or other peaceful means of their own choice (BMZ, 2006).

As the *UN Convention* does not have an implementation framework, the international water legislation is still a precarious field. The subject is related with the more general international legislation framework, and as general rule, international courts do not have compulsory or automatic jurisdiction to deal with international legal disputes. As consequence the global scenario is still formed by over 200 promulgations amongst agreements, resolution and declaration concerning use of international waters resources that have been signed at unilateral, bilateral and multilaterals statements. In addition the pronouncements of the International Court of Justice's in The Hague try to give a more universal acceptance to the controversies.

Nevertheless this is the only basement where in the future, further elaborations of more concrete guidelines are expected to be considered and applied by the international customary law regarding international disputes.

7.3.3. The case of Syria

Syria's water provision is strongly related with geopolitical situation of the entire region of the Middle East. Several disputes and also conflicts, which have reached sometimes violent statements, are the ordinary framework of the Syrian water provision policies. Several reasons are attributable to this fact:

The region's climate conditions characterize the area by water scarcity that makes it a required and contended element; the proof is given by the fact that since the 1970s the Middle East states have largely been unable to meet basic water needs for food production and others industrial use. In addition the main water courses and the groundwater basins in the area are largely shared throughout different countries creating an interconnected and interdependent system. It is estimated that 50 per cent of the population of the Middle East depend on the freshwater that is drawn from transboundary rivers and transboundary underground aquifers (Jobson, S., 2003).

However the most important reason of disputes over water seems to be attributable to the general political environment of the region. Historically the entire area has seen follow many different civilizations which have been often in contrast and in conflicts amongst them. Still nowadays, the Middle East situation is complicate: the political scenario is still characterized by many different impulses related with fundamentalisms, militarisms and authoritarisms. Together with the actual central focus that in the area is given to the oil, all these factors seem to be the main causes of multiple obstacles towards a development of mutual cooperation, in terms of natural resources uses.

Several studies date as first disputes over water issues in the area, to the Kingdom of Babylonia in the old Mesopotamia, between 1720 – 1684 BC. Furthermore, the Bible narrates of some disputes concerning water use in the region. Nevertheless the more detailed case of conflict over water resources seems to be dated to the Assyrian war again the Armenian in 720-705 BC, when the latter saw their irrigation system destroyed as act of subjugation (Gleick, D. P. H., 2006). Checking the Middle East history, the list reporting similar cases is long and likely compiled by defect. In order to get more detailed information regarding water conflicts in Syria, the foundation of the modern Arabic Republic State is probably the best reference. Since then, numerous disagreements went out because water issues; first with Israel, later with Turkey and Iraq. In spite that, reading betters the political relations between the involved countries, water really appears to be exclusively a pretext that hides more relevant contrasts and political divergences. The following list (Table 18) filled on the basis of the Water Conflict Chronology Report of the Pacific Institute for Studies in Development, Environment, and Security, illustrates the long sequences of water conflicts where Syria has been engaged since its independency. It is important to notice that it refers exclusively to those cases where some kind of violent conflict caused by water issues disagreements. Institutional verbal disputes are not mentioned.

Despite the strong relevance of the political environment, it is obvious that there are also some technical reasons for such frequency of water conflicts. Syria's unmistakable hydrological asset dependence with its neighbours is not a secondary element.

As the present report already illustrated in previous paragraphs, considerable part of the Syrian territory receives insufficient rainfall in order to form autonomous water reserves. On the light of this fact rivers that born outside the national borders cover vital role for the national water providing. Confirm this hypothesis the fact that, 6 rivers on a total of 16 that run in Syria have transboundary courses and two of them supply the bulk of the national water provision (Aquastat 2007).

Table 18: Chronology of international water conflicts where Syria has been involved. (SourceGleick, D. P. H. 2006)

Date	Parties Involved	Description
1720 – 1684 BC	Sumerians, Babylonians	The Tigris has been dammed for prevent the retreat of the rebels that declared the independence of Babylonia
720-705 BC	Assyria, Armenia	Assyrian destroys irrigation network and floods in Armenia.
1951	Israel, Jordan, Syria	Jordan makes public its plans to **irrigate the Jordan Valley by tapping the Yarmouk River**; **Israel responds by commencing drainage of the Huleh swamps** located in the demilitarized zone between Israel and Syria; border skirmishes ensue between Israel and Syria.
1953	Israel, Jordan, Syria	Israel begins construction of its National Water Carrier **to transfer water from the north of the Sea of Galilee out of the Jordan basin to the Negev Desert for irrigation**. Syrian military actions along the border and international disapproval lead Israel to move its intake to the Sea of Galilee
1962	Israel, Syria	Israel destroys irrigation ditches in the lower Tarfiq in the demilitarized zone. Syria complains.
1964	Israel, Syria	Headwaters of the Dan River on the Jordan River are bombed at Tell El-Qadi in a **dispute about sovereignty over the source of the Dan**
1965-1966	Israel, Syria	Fire is exchanged over “all-Arab” plan to divert the **Jordan River** headwaters (Hasbani and Banias) and presumably pre-empt Israeli National Water Carrier; Syria halts construction of its diversion in July 1966.
1967	Israel, Syria	Israel destroys the Arab diversion works on the Jordan River headwaters. During Arab-Israeli War Israel occupies Golan Heights, **with Banias tributary to the Jordan; Israel occupies West Bank.**
1974	Iraq, Syria	Iraq threatens to bomb the al-Thawra dam in Syria and massed troops along the border, alleging that the dam had reduced the flow of **Euphrates River** water to Iraq.
1975	Iraq, Syria	As upstream dams are filled during a low-flow year on the **Euphrates**, Iraqis claim that flow reaching its territory is “intolerable” and asks the Arab League to intervene.. In May Syria closes its airspace to Iraqi flights and both Syrian and Iraq reportedly transfer troops to their mutual border. Saudi Arabia successfully mediates the conflict.
1982	Israel, Lebanon, Syria	Israel cuts off the water supply of Beirut during siege.
1990	Iraq, Syria, Turkey	The flow of the **Euphrates** is interrupted for a month as Turkey finishes construction of the Ataturk Dam, part of the Grand Anatolia Project. Syria and Iraq protest that Turkey now has a weapon of war. In mid-1990 Turkish president Turgut Ozal threatens to restrict water flow to Syria to force it to withdraw support for Kurdish rebels operating in southern Turkey.

According with the FAO country profiles data base, the 6 international rivers that run in Syria are listed and described as follow:

1. Euphrates (Al Furat), the Syria's most important river for dimension and for water resource. It comes from Turkey and flows to Iraq.
2. Afrin River comes from Turkey, crosses Syria and flows back to Turkey;
3. Orontes (El-Ass) is placed in the western part of the country coming from Lebanon and flows into Turkey;
4. Yarmouk River is located in the south-western part of the country; its sources are shared between Syria and Jordan. Besides its rather short course, it follows an intricate route crossing several borders and reclaimed territories;
5. El-Kebir origins in Syria and it constitute the border with Lebanon before flowing to the sea.
6. Tigris forms the border between Syria and Turkey in the extreme north-eastern part of the country, but its importance as water resources for Syria is limited to the neighbouring area.

FAO official estimations show the relevant importance of the Euphrates River and its tributaries in terms of water supply in comparison with the others transboundary watercourses. Moreover because its long route, the Euphrates influences directly a vast part of the national territory, on the contrary of the others watercourses that have more local affect. Also the Tigris, which together with the Euphrates forms the most important watershed of the Middle East, it touches the Syrian territory only in a limited area in the north east bordering with Iraq; because that its real importance is limited to the local provinces which are directly in contact with the river banks. This is the reason because the Tigris's flow is accounted separately in the Table 19 below.

Table 19: Major rovers entering, bordering and leaving Syria (Source Aquastat 2007)

River	Inflow into Syria (km^3/year)			Outflow from Syria (km^3/year)		
	From	**natural***	**actual****	**from**	**natural**	**Actual**
Euphrates	Turkey	26,29	15,75	Iraq	30	9
Tribut. of Euphrates	Turkey	1,74	1,74			
Afrin	Turkey	0,19	0,19	Turkey	0,25	
Orontes,	Lebanon	0,51	0,43	Turkey	1,2	
Yarmouk				Jordan	0,4	0,2
Baniyas				Israel	0,125	
Sub-total		28,73	18,11		31,975	9,2
Bordering Tigris	50% of Tot	9	9			
Total	Inflow	37,73	27,11	Outflow	31,975	9,2

* Natural water flow

** Water flow establish by agreement

The following Figure 37 can be useful in order to better understand the effective importance of transboundary watercourses in Syrian, especially the vital role that the Euphrates has for the Syrian water provisions.

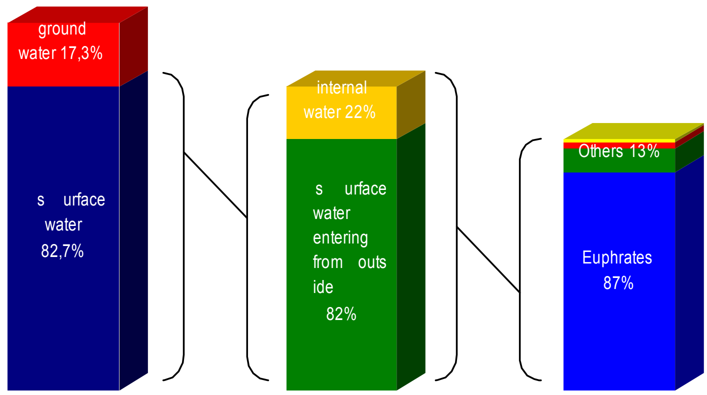

Figure 37: Water resources distribution in Syria (Source Aquastat 2007)

7.3.4. Conflicts at stake

Syria has been involved in several bitter conflicts over water scarcity as well as in some attempts to build cooperation between otherwise hostile neighbours. Several disputes have been resolved through a certain easy way: or because their concrete relevance for Syria's interests was scarce, such as the Tigris Basin, which covers a very limited portion of the national territory, or because the opposite interlocutor shared some common interests as happened with Lebanon.

Nowadays Syria's current issues over transboundary waters are focused prevalent on two basins. First the Euphrates watershed, where there is a long history of bilateral negotiations and agreements, more or less successful between all the states involved in the dispute. Second the Jordan River Basin, where the inclusion of Israel into the dispute makes it amply improbable peaceful conclusion in short time.

Figure 38: Disputes still ongoing or arranged with provisional agreements (red); Disputes definitely concluded (blue) (Source maps.com)

7.3.4.1. Jordan river basin

Despite its small size, the Jordan River is one of the most important watercourses in the Middle East; it is reason for intense international competitions as well as a cause of conflicts that go beyond the its real water supply importance. The Basin is shared by Israel, Jordan, the Occupied Palestinian Territories (West Bank and Gaza), and Lebanon. Syria is only interested for a limited area in the south west but, as it has some important headwaters of the Jordan River system, because that it takes part at the argument as an active actor and a crucial political protagonist as well.

Due to population growth and economic development, demand for water in the region is rising. Pressure on the natural resources is high, and Israel, Jordan and Palestine are already facing a situation where water consumption is close to or exceeding the renewable amount available.

The two most important rivers in the basin are the Jordan River and the Yarmouk River. The first is fed by three separate sources: the Dan, which alone constitutes half of the Jordan River water flow, the Hasbani and Banias that together supply the other half. The

Hasbani has its springs in Southern Lebanon, the Dan within Israel's internationally recognized borders, and the Banias originated from the Golan Heights, which belonged to Syria until 1967 and currently are under Israeli control (Libiszewski, S., 1995). The Yamouk River originates in Syrian territory, afterward it forms the present boundary between Syria and Jordan and later again, it forms the border between Jordan and Israel. It flows in the Jordan River 10 km below Lake Tiberias (Murakami, M., 1995). The geopolitical situation evidently is very complex, in spite of that, the Basin represents only very limited water resources for Syria which estimation talk about scarcely 1% of the total water demand (Aquastat, 2007). The issue is considerate an extremely important state affair because the dispute regards territorial sovereignty. Golan Heights in fact represents a fundamental territory for the Jordan River headwater and at the same time it is an important territorial reclamation for Syrian national integrity.

Also for Israel the water originated from that area has very little importance comparing with the total needs: nevertheless the control of that area has also a very important strategic role as it guarantees Israel's main water source, the Sea of Galilee. That is the reason because from the Israeli side, that issue is not considerate to be negotiable.
Intricate geopolitical situation, contrasting idealisms and political firmness make the context hard for finding a solution. Historical reports concerning a determined attempt to reach a multilateral agreement was made by US mediation between 1952 and 1955. The goal was to find a basin-wide arrangement to optimize the allocation of the river's waters for Jordan, Israel and Syria. However, the proposals were rejected by Arab governments, as acceptance would have implied recognition of Israel as a legitimate nation-state (Jobson, S., 2003).

In conclusion, in the Jordan River Basin water conflict appears to be more a small part of a more complex and intricate mix of revendications and mutual ideological contrasts.

7.3.4.2.Euphrates river basin

Euphrates River measures 2,700 km, of which 28 percent basin lies in Turkey, 17 percent in Syria, and 40 percent in Iraq. Euphrates has its springs in the highlands of Eastern Turkey, after that, it enters in Syrian territory where along its south eastern course is joined by two more tributaries, the Khabur and the Balikh, which both have the own sources in Turkey as well. According with the official data, Turkey in total contributes with 89% of the water potentially carried by the river; Syria contributes 11% with a consistent part coming from two tributaries coming also from Turkey. Iraq does not contribute to the Euphrates flow (Aquastat, 2007). Nevertheless, the consumption of the Euphrates water resources result to be inversely proportional to contributions: Syria and Iraq are indicate to use 21% and 44%, respectively, with Turkey only with 35% (Rickson, F. M. L. a. E. J., 1999).

As it has been illustrated in the previous paragraph, Euphrates River represents for Syria the most important water resource. Because that, it is also the most delicate mater of dispute, either in the upstream with Turkey then in downstream with Iraq.

Turkish approach from a position of strength, its plans for the South Eastern Anatolia Project (GAP), which plans aim to fully utilize the own share of the river resources are the proof. The goal is the construction of 22 dams and 19 hydroelectric power plants on the Euphrates and Tigris rivers and their tributaries, main goals are hydroelectric productions and enlargement of irrigated lands in the east part of the country.

Syrian (and Iraqis) clams are addressed to the entire GAP plans but in special way to the construction of the Ataturk Dam, the central piece of the entire project. The Euphrates downstream countries argue that the amount of water released by Turkey is inadequate and it will get worst for the future. In the other hand Turkey refuse the objections considering water as own private resources on par with oil as private national resource for the two contenders.

In the down extremity of the river, controversial between Syria and Iraq on water issues goes back to times when Turkey was not in the heat of the problems yet. Syria started Euphrates water utilization for irrigation purposes in the early 1960s, whereas Iraq - a political and military power at that time - complained a lot. The dispute for the water supply crashed down in 1975, when relations between Iraq and Syria threatened to turn violent. Syria closed its borders and airspace to Iraq and both countries concentrated military forces to the mutual borders. Situation was turned to peaceful statement through Arabia Saudi mediation.

Some signs of possible multilateral cooperation came up when Turkey and Iraq established the Joint Technical Committee for Regional Waters in 1980, afterwards joined by Syria in 1983. Under this committee the three states agreed to exchange data concerning the respective parts of watercourse. Progress, however, was short-lived. Situation deteriorated again in 1984, when Turkey reduced drastically the downstream flow so much that Syria's electricity production was affected by falling water levels in Lake Assad, the reservoir created by Syria's Euphrates Dam. Inevitably tensions between the two litigants rose again. Furthermore in 1986, the completion of the Turkish Kayakaya Dam once again left Syria with a shortfall of water (Rickson, F. M. L. a. E. J., 1999). So after presumed external pressures, Turkey accepted higher rates of water release for the downstream states. This fact is considerate to be the first step toward a beginning of a bilateral agreement concluded in 1987 with the signing of Protocol on Economic Cooperation. The agreement fixed some practical constrains in terms of mutual cooperation regarding several subjects as economical development, fight against terrorisms and natural resources uses. In particular this latter point fixed some standard parameters for the transboundary relation between the two countries in relation to the Euphrates River (see Annex V).

Nevertheless, also this time the agreement has been brook again, when In order to fill up Atatourk Dam, Turkey cut off the water flow for one month in 1990. Syria and Iraq complained again and Turkey responded according to the International Rules notifying Syria and Iraq about the cut off period. Because that Turkey allowed water flow with higher ratios to compensate for the whole interruption period.

7.3.5. Agreements and treaties concluded

The contrast has been solved by the sign of the *Joint Communiqué between Republic of Turkey* (GAP) and *the Arab Republic of Syria* (GOLD), which has been considered the main bilateral agreement between Syria and Turkey in terms of frontier water sharing. The *Communiqué* main goal was to regulate definitely the relations between the two countries in terms of all transboundary water flows relations, on the light also of 1990s facts. The *Communiqué* is characterized by more boarder spectrum action as it deals with all the watercourses shared by the two countries like the Euphrates as well as the Orontes, the Nahr El Kabir and the Tigris (UNEP 2002).

Orontes River issue was also included in the *Joint Communiqué between Republic of Turkey* (GAP) and *the Arab Republic of Syria* (GOLD), which has been the main bilateral agreement between Syria and Turkey to deal with frontier water sharing. The *Communiqué* main goal was to regulate definitely the relations between the two countries in terms of all transboundary water flows, relations also on the previous 1990s disputes on the Euphrates's flow interruption by Turkey.

Still in relation with the Euphrates River issue, in April 1990, Syria reached an agreement with Iraq as well. The treaty established a proportionally division of the waters released at the Turkish–Syrian border between the two countries, fixing the parameters respectively at 42 for Syria and 58% for Iraq (see Annex VI). The agreement has been defined as "provisional" because the noticeable Turkish absence.

Concerning the Jordan River Basin, Syria is still involved into a precarious situation. In 1955 Syria took part to the already mentioned attempt of negotiation carried on by the US mediation to find a peaceful agreement for the area. But as it is noted, results were not successful.

The only agreement stipulated by Syria in this area is dateable in 1953, when an agreement about the utilization of the Yarmuk waters has been signed with the Hashemite Kingdom of Jordan. The agreement was further revised in 1987.

In spite of the conflicted atmosphere that exists around Syrian borders concerning water issues, some further transboundary water relations have been promulgated through less tortuous negotiations. Syria has stipulated two agreements with Lebanon concerning the Orontes River and the Al Kabir River that have been signed respectively in 1994 and in 2002. In both cases the purpose is to realize an equitable division of the water resources between the two countries, moreover in Al Kabir River there is a common plan for water uses development through a common project of for building a join dam on the river main course.

In the dispute around the Euphrates Basin, several improvements have been reached. Situation is still far to be planed by a multilateral agreement, but at least a certain degree of cooperation seems to be accepted by the parts. Nevertheless, the recent Iraqis war, the Turkish aggression to the PKK nucleolus outside its national borders and increasing international suspects to a supposed Syrian support to terrorism, altogether contribute to aggravate the already delicate regional scenario creating uncertainty for the future. Different context in the Jordan River Basin: Palestine dispute seems to be unsolvable in spite of all the efforts spent by the international community. Besides water resources confirm to be not the main issue at stake, it remains one of the elements of the controversy. In the near future due to population growth and the consequent increase of pressure on the water resources, water importance in the conflict is expected to rise.

7.3.6. Internal conflicts

External conflicts are probably the most evident for the international community: disputes between countries and especially in this geographical area come to the fore of the international news. Nevertheless transboundary water resources are not the only issue at stake concerning water disputes. Also within the same country contrasts between two or more different interest groups happen. Probably literature is not as profuse as with the international issues, but problematic exist and they are not so easy resolvable.

As the present report has already argued, agriculture is the largest water-consuming sector in Syria adsorbing about 87% of total national water consumption (Aquastat, 2007). Due to strong population growth rate (about 3% per annum) and the little but noticeable industrial development, water supply and sanitation facilities have been enlarged to accommodate the expanding population. The phenomena caused rising water unbalance between cities and rural areas. The fact has been exacerbated in those basins encompassing large urban cities like Aleppo and Damascus, where increasing demand for drinking water and the priority given by the government to the urban consumers, caused internal conflict over water resources use between urban dwellers and farmers.

In Syria there is a dualistic approach towards water uses management: government's policies assign a top priority to drinking water, at the same time through production subsidies and prices support, it contributes to the increments in groundwater extraction for irrigation purposes.

The groundwater issue is very delicate one in Syria. The use of groundwater for irrigation has been expanding rapidly in Syria because water extraction from underground is cheaper than surface water. Permission to pumped water is free and it needs only little investments of money because farmers can get a financial support by the state through facilitate credits as well as preferential rates of interest to purchase fuel. A second factor explaining the increase in irrigation from groundwater is the large number of farmers with small farm holdings. Besides to dig well without permission is strictly forbidden in Syria, small farmers can do it by illegal way and to provide an easy water supply avoiding the complex procedures necessary to access to the high regulate surface water resources. In 1994, the total number of wells in the country was estimated at 122 276 of which 53 453 were not licensed (Aquastat, 2007).
Farmers relying strongly on groundwater resource started to find some problems since water scarcity caused a preferential access by the urban consumers as happened in the Damascus region.

Barada/Awaj basin, where the city of Damascus is located has no significant water sources, both surface and groundwater other than the Barada and Figeh Springs which supply drinking water to the inhabitants of the city. As most of water resources of the basin are being dedicated continuously to support Damascus increasing demand for drinking water, internal conflict over water has raised. Farmers, in Damascus countryside, who have been using groundwater for irrigating their lands for years, have protested the drying up of their wells caused by the massive groundwater extraction (M. Salman, 2003).

Situation seems to be still under control: nevertheless as pressure on the water resources seem to be unstoppable from both sides, rural and urban; effective water management improvements appear to be the only way to solve the situation that in the near future could be difficult to control.

Box 6.6 Institution

After several months of theoretical studies about water management and livestock in Syria, the field visit gave the possibility to the research team to get a more concrete idea about the real situation that characterizes the country.

From all data base regarding water resources we assumed that Syria is not at the moment a water scarce country; the various comparisons with other Middles East countries and Africans confirm the fact that lack of water is not a nowadays problem. Nevertheless demographic increments, spread pollution, incorrect managements and frequent conflicting relations with neighbors' countries concerning water resources, represent all together a reason for justifying the interest about water issues in the future prospective by researchers and institutions.

Amongst all the areas that we visited, the urban district of Damascus seems to run the most serious risks concerning water problems in the near future. In general the region is very dry, surface water resources are reduced at minimum level, pollution is heavy and city result to be overpopulated. At least concerning what we have seen, water pollution appears to be a sensitive problem.

Even if water issues seem to be already a concern for the research community, in general normal people seem to be rather uninterested about that. Through some interviews we understand that in Syria people do not see water as a non-renewable element but, it is rather seen as a right which not even the public state can interfere on its use and the distribution.

Probably this is the most interesting element that I got along the whole excursion; as we did not have the opportunity to visit the Euphrates River basin and any surface water systems, we focused many much more on the ground water use and its management. Because that, the most important assumption of the research team was that ground water utilization and the wells regulation are both evanescent concepts. Water extractions is not measured or regulate in any case, water as resource is not priced and who holds the right to use a well is authorized to get as much water as he desired.

The wells drilling concession is even more controversial problem. In Syria wells licenses are banned since 2001, moreover all the illegal wells realized until that date have been redeemed. The problem is that many rural communities need ground water for their livelihoods anyhow. Without groundwater resource they cannot water crops and herds, so life would be impossible. That is the reason because the phenomena of drilling new wells seems to be unstoppable and the state seems to be unable to control the situation.

Despite the very short time of the field quest, and the very limited opportunities to undertake a conversation with sensible people concerning conflicts, it has been possible to withdraw few ideas about the local situation.

Farmers basically are hardly favourable to develop a common action in terms of cooperation for resource management, especially water. In spite of that, through several interchanges of services or commodities, they seem (!!) to have reached a pacific or at least a no conflicting balance in the relation amongst the different interests at stake. For instead farmers and herders seem to be well integrated for land resource use; even the nomads herders in the deserts area have appeared to be in accordance with the institutions. Any evaluation of the issue has been explored concerning conflicts between urban and rural areas.

The same accordance situation is not possible to admit concerning external conflicts; in all cases that the topic regarding relation with the neighbours' countries came up, the topic has been presented as too hot issue and because that not really explained or in certain cases even declined.

As final conclusion I could observe that lack of serious and concrete regulation in terms of water management is the main topic. Whereas the lack of truly freedom for expression of opinion is suppose to be the main cause for lack of information about conflicts.

8. Conclusion

Water plays an important role for development worldwide, directly as the means of life existence and indirectly through many economic activities. Due to the increasing of population and inefficient uses of water supplies, water availability becomes the main problem in many countries, especially, in the arid and semi-arid areas like the Middle-East. Syria is one of the countries being scarce of water, in which have contributed to the country's limitation in development, environmental degradation and a series of internal and external conflicts. Livestock sector could be considered as the key main cause since it consumes both directly and indirectly large amount of water and disposing pollution degrading the water source as well. This situation calls the attention from macro and micro level in searching for some technical and policy alternative to approach the goal of more efficient, equitable, and sustainable use of water.

The vital findings of the study project, from both secondary data and field survey, could be concluded in 3 main groups as;

- ***Water Use in Irrigation and Management***
  - *Water scarcity is increasing*: Water has been in deficit in most basins except in the coastal basin and the Euphrates basin
  - Inefficient application of water resources at the farm results in water losses
  - *Technological option*: Drip irrigation has increased area and income levels and water harvesting has shown good cooperation between government and Bedouins
  - The rate of adopting modern technique is still concentrated only with some private farmers since the entire irrigation networks are not simultaneously developed.
  - The use of contaminated water with sulfate for irrigation is still a problem.

- ***Water Consumption and Pollution from Livestock Sector***
  - *Water balancing from appropriate integration of farming systems*: There is a strong interaction between crops produced and the fodder used for the animals i.e. sheep in Nomadic system are grazed in the steppes and rangelands only when there is availability of water and forages, while when

resources are depleted they move in rainfed and irrigated areas in search of food and water.

- Livestock-water interactions have been largely neglected, as well in water as in livestock research and planning.
- *Low focus on feed sourcing*: Present production levels of animal feed cannot sustain the present livestock populations. This makes animals very susceptible to natural disasters, such as drought.
- Low focus of research and extension on the issues of waste management from livestock

- ***Water Policy and Institution***
  - *No control over use and extraction of groundwater*: Well Licensing has poor enforcement and resulted in a large increase in the number of illegal wells in recent years and has contributed to the groundwater table declines in many areas
  - *Lack of inter-institutional coordination*: between ministries as well as between institutions within ministries hinders to a great extent the implementation of strategies and programs.
  - Large amounts of invested budgets in this policy are not efficiently leads to the goal of balancing water deficits in the soon future
  - No significant evidence of reducing water demand is found
  - Syrian does not have adopted principle of pricing system and this makes farmers have no incentives to use water efficiently and to conserve water stock or quality
  - There is a good sign of cooperation between states in the management of shared waters around the Euphrates Basin which several improvements have been reached by a multilateral agreement. While in the Jordan River Basin, political dispute with Palestine seems to be unsolvable and becomes a threat for water cooperation.

For recommendations to improve the situation of water-livestock interaction in Syria; these following ideas should be implemented in each sector;

- ***Irrigation Sector***

< **Surface water**

- o Modernized techniques (e.g. pipeline system) should be still promoted to improve water use efficiency, but not in the severe-arid area.
- o The water charge should be variable connected to the actual use
- o New potential water source should be developed (i.e. extending water harvesting structures)
- o Transboundary water sources should be better coordinated.

< **Groundwater**

- o The existing illegal wells should be legalized and controlled.
- o Effective control over extraction, use and drilling is necessary. The measurement apparatus for water use could be set up.
- o Recharge pits around bore wells should be created.
- o The price of water use should be charged.
- o The committee/ association should be formed for participatory management of wells.

- ***Livestock Sector***
    - o Herders like the Bedouin should come up with their own strategies to provide supplementary feeding for their flocks instead of passively following the government's rangeland protection scheme.
    - o Needs in improving feed sourcing and livestock productivity per animal unit through existing feed resources
    - o Subsidies on livestock feed should be reduced since it could effect water sustainability and pasture degradation by increases in extensive livestock numbers.
    - o Some strategies for alternative viable sheep feeding should be studied.
    - o Adopting 'virtual water' concepts by imports more feeds should be carefully considered. The goals of farmers' income security and country's water security have to be traded-off and compensated.
    - o For water pollution problem; improving technologies and enhancing management knowledge at both farm level and higher levels. The concepts of integrated nutrient management or whole-farm nutrient balance could also be an appropriate approach.

- ***Policy and Institution Sector***
    - Decentralization of decision making process for enhancing community participation in the formulation, execution and evaluation of local irrigation development projects
    - The establishment of co-ordination mechanisms between institutions, with clear mandates, responsibility and accountability, are very much needed.
    - The concept of bottom-up approach and integrated water resources management (IWRM) could be applied to local level to improve the water market efficiency
    - An intensive training program for staff at different levels and in different domains should accompany the implementation of the modernization targets together with the creation of awareness among farmers to the issue of water shortage through sensitization.
    - The establishment of water user associations among the owners of wells could provide an important inter-phase between the government and the farmers particularly when severe measures are needed to reduce water abstraction
    - The policy of water pricing should be put as an important agenda to internalize the costs of water use/polluting to the users/polluters.
    - Further cooperation between states in the management of shared waters must be continuously preceded.

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Annexes

Annex I

Nutrient intake and excretions by different animals (Steinfeld, 2006).

Animal	Intake *(kg/year)*		Retention *(kg/year)*		Excretion *(kg/year)*		Percentage of N excreted in mineral form[1]
	N	P	N	P	N	P	
dairy cow[2]	163,7	22,6	34,1	5,9	129,6	16,7	69
dairy cow [3]	39,1	6,7	3,2	0,6	35,8	6,1	50
Sow[2]	46	11	14	3	32	8	73
Sow[3]	18,3	5,4	3,2	0,7	15,1	4,7	64
Layer hen[2]	1,2	0,3	0,4	0	0,9	0,2	82
Layer hen[3]	0,6	0,2	0,1	0	0,5	0,1	70
Broiler[2]	1,1	0,2	0,5	0,1	0,6	0,1	83
Broiler[3]	0,4	0,1	0,1	0	0,3	0,1	60

[1]Assumed equivalent to urine N excretion. As mineral N is susceptible to volatilization, this percentage is often lower in manure applied on the land.

[2] Highly productive situations

[3]Less productive situations

Note: Owing to the variation intake and nutrient of the feeds, these values represent examples, not averages, for highly and less productive situation.

Annex II

Average virtual water content of some selected products for a number of selected countries (m3/ton).

	USA	China	India	Russia	Indonesia	Australia	Brazil	Japan	Mexico	Italy	Netherlands	World average*
Rice (paddy)	1275	1321	2850	2401	2150	1022	3082	1221	2182	1679		2291
Rice (husked)	1656	1716	3702	3118	2793	1327	4003	1586	2834	2180		2975
Rice (broken)	1903	1972	4254	3584	3209	1525	4600	1822	3257	2506		3419
Wheat	849	690	1654	2375		1588	1616	734	1066	2421	619	1334
Maize	489	801	1937	1397	1285	744	1180	1493	1744	530	408	909
Soybeans	1869	2617	4124	3933	2030	2106	1076	2326	3177	1506		1789
Sugarcane	103	117	159	164		141	155	120	171			175
Cotton seed	2535	1419	8264	4453		1887	2777		2127			3644
Cotton lint	5733	3210	18694	10072		4268	6281		4812			8242
Barley	702	848	1966	2359		1425	1373	697	2120	1822	718	1388
Sorghum	782	863	4053	2382		1081	1609		1212	582		2853
Coconuts		749	2255		2071		1590		1954			2545
Millet	2143	1863	3269	2892		1951		3100	4534			4596
Beef	13193	12560	16482	21028	14818	17112	16961	11019	37762	21167	11681	15497
Pork	3946	2211	4397	6947	3938	5909	4818	4962	6559	6377	3790	4856
Goat meat	3082	3994	5187	5290	4543	3839	4175	2560	10252	4180	2791	4043
Sheep meat	5977	5202	6692	7621	5956	6947	6267	3571	16878	7572	5298	6143
Chicken meat	2389	3652	7736	5763	5549	2914	3913	2977	5013	2198	2222	3918

Source: Chapagain, A., K., Hoekstra, A., J., 2004.

Annex III

Syrian statistics for livestock numbers, meat and milk production, cattle and sheep imports and mutton and lamb and fresh milk imports for the period 1995-2005.

Item	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Cattle nos. 0,000	775	810.2	856.8	932	977.9	984.4	836.9	866.7	937	940	1018
Sheep nos. 0,000	12.075	13.120	13.829	15.425	13.999	13.505	12.362	13.498	15.293	15.300	15,31
Goat nos. 0,000	1063	1082	1100	1101	1046	1050	979.3	931.9	1017	1018	1018
Camel nos, 0,000	6.7	7.1	7.5	8.9	13.3	13.4	12.2	12.5	15.2	15.0	15.0
Horses nos. 0,000	27	28.2	27.5	25.6	26.6	27.1	18.4	16.8	17.0	17.0	17.0
Beef & veal prod. (mt) 0,000	33.8	40	41.8	43.4	46.7	47.1	42.3	47.1	47.3	47.4	47.4
Mutton & lamb prod. (mt) 0,000	130.7	142.9	148.4	154.2	176.7	184.1	168.6	183.6	207	207	207.0
Goat meat prod. (mt) 0,000	5838	7375	5374	5888	5304	4633	4922	4977	5120	5120	5120
Milk prod. (mt) 0,000	888.8	934.4	1008.7	1118.8	1143.4	1156.4	1032.3	1173.5	1200.0	1250.0	1250.0
Sheep milk prod. (mt)('000)	453.8	498.7	523.8	581.9	445.9	445.6	482.8	535.9	604.2	604.2	604.2
Cattle imports (nos) (,000)	1738	5969	2000	313	97	0	9240	4905	49,075	23,2	n.r
Sheep imports (nos) (,000)	1087.5	1215	844	406	441	205	23.7	185.8	177.8	68.1	n.r
Mutton & lamb imports (mt)	5706	2159	366	1	1	1	1	0	0	0	n.r
Fresh milk imports (mt)	43	317	97	0	0	0	0	480*	84	8531	n.r

Source: FAO Database, 2006.
n.r. - no records
*In 2002 and 2003 total milk equivalent imports were 175,512 and 154,772 mt respectively

Annex IV

Scenario Analysis of Different Water Policy Options in Syria

Figure 2- Scenario 1: Current policy. Modernization (4years) and irrigation expansion (15 years)

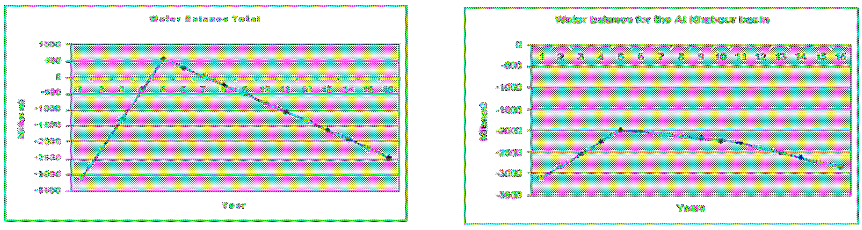


Figure 3: Scenario 2: Modernization policy with no irrigation expansion

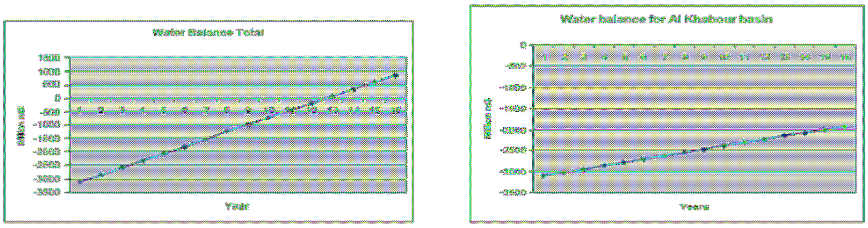


Figure 4: Scenario 3: Long term policy. Modernization and irrigation expansion (15 years)

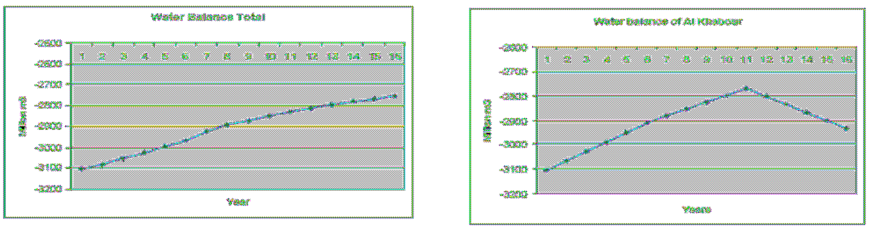
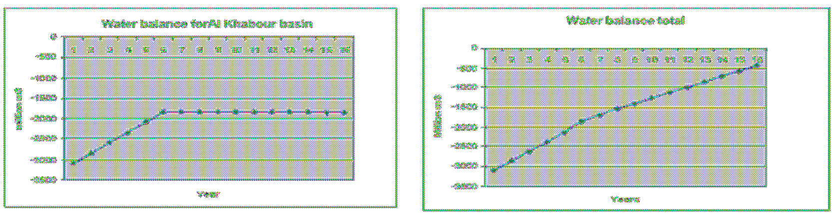


Figure 5- Scenario 4: Differentiated policy. Modernization in all basins, no expansion in critical basins



Source: Varela and Sagardoy (2002)

Annex V

No. 30069
SYRIAN ARAB REPUBLIC and TURKEY
Protocol on matters pertaining to economic cooperation.
Signed at Damascus on 17 July 1987
Water Issue, Point 6
During the filling up period of the Ataturk Dam reservoir and until the final allocation of the waters of Euphrates among the three riparian countries, the Turkish
Side undertakes to release a yearly average of more than 500 M3/Sec. five hundred cubic meters per second at the Turkish-Syrian borders and in cases where the monthly flow falls below the level of 500 M3/Sec, five hundred cubic meters per second, the Turkish Side agrees to make up the difference during the following month.

Annex VI

Law No. 14 of 1990
REPUBLIC of IRAQ and the SYRIAN ARAB REPUBLIC
Ratification of the Joint Minutes concerning the provisional division of the Euphrates waters between the Republic of Iraq and the Arab Republic of Syria signed in Baghdad on
11 Ramadan 1409 Hegira which falls on 17 March 1989.

Taking note of all these, the Two Parties Iraq and Syria waiting for reaching the trilateral agreement with Turkey agreed in the following:
1. The Iraq water share on the border region between Iraq and Syria is 58% as a fixed annual total percentage (water year) of the water of Euphrates River allowed to pass in Syria through the border with Turkey, and the Syrian share of water is the remainder quantity 42% of the water of Euphrates River allowed to pass through the border between Turkey and Syria.

Annex VII

Minutes of Session during Excursion in Syria (15^{th}-23^{rd} February, 2008)

List of participants:

1. Dr. Claudia Kijora
2. Yasser Amin
3. Christopher Achu
4. Elias Rebai
5. Giacomo Mencari
6. Kennvidy Sa
7. Manjunatha Arahalli Venkataronappa
8. Minette Flora de Asis
9. Nguyen Thanh Binh
10. Nondh Nuchmorn
11. Roselien VanderHasselt
12. Master's students of Damascus Agricultural University

I. Minutes on Sunday, 17th February 2008

Morning:
First, official reception by Prof. Hamzeh Belal, dean of the Faculty of Agriculture of Damascus University. During a short ceremony in his office, the dean welcomed the visiting group from Humboldt University in Syria and at the Faculty in particular. He wished for a happy cooperation that hopefully would continue in the future. This was followed by a brief introduction to the political situation of the country by the Professor of Plant Fysiology. We learned that Syria was a democracy, but that all parties made an agreement to support the leading Ba'ath party. Indeed, we learned that, due to the conflict situation with Israel about the occupation of the Golan Heights, there was a need for a strong and united leadership at the time in Syria.

Following the official welcoming, the visit proceeded with a presentation, by Prof. Dr. Bachar Ibrahim, head of the Department of Rural engineering, about the general national water situation and the relationship with livestock in particular. He held a presentation of some data issued from the Al Ghota region around Damascus, discussing the impact of organic manure on the water pollution, with special attention paid to the blue baby syndrome. Next to this, he mentionned that according to him it is not appropriate to speak of water scarcity in Syria. It's not a case of lack of water but rather bad use and management of the available resources and an inequal spread. Still, the overall non-renewable water resources of the country are being depleted at the rate of 3 billion m^3 every year. An attempt has been made to divert some water from the coastal basin, in surplus, to the Barada-Damascu basin where it is cruelly needed, but this solution seemed to be too costly.

The next presentation given was about the diverse Syrian livestock production, by Prof. Dr. M. Rabih Al-Merestani, from the Arab Center for Studies of Arid Zones and Dry Lands (ACSAD). Some topics discussed were amongst other the potential of camels for the future. At present there is however still no breeding programme, except for sport purposes. The milk and meat are of good quality and attractively priced, and certainly do offer some prospects for the future. However, the demand is still quite low but a change of preferences could occur. It was also mentionned as a product of organic agriculture. About the sheeps in the Al – Badia steppe we were told about some 140 state owned deepwells delivering free water to the flocks. The groundwater level in that basin is also not in deficit.

Afternoon:
Free time.

II. Minutes on Monday, 18th February 2008

The journey started at 9 am from the student dormitory. Planned activity of the day mainly includes two aspects**:**

- **First**, information about project on Development of Efficient Irrigation Techniques and Extension in Syria (DETTEX project) from unit located in the governorate of rural Damascus. This was followed by field visit to project implementation sites.
- **Second**, faculty farm of dairy cattle,sheep and goat belonged to Damascus Agricultural University are visited to collect information on current practices
  According to planned activity, First activity is mainly on water saving goal which include:

A. Visited office of project on Development of Efficient Irrigation Techniques and Extension in Syria. The office was located Kafar Hawar Village in Governorate of Rural Damascus.

In the morning, discussion was held with the coordinator of DETTEX project, farmer cum trainer and some other staff of the center. Firstly the session started by introducing our study group by Minette followed by general introduction of the project activities by the coordinator. The information from coordinator and practical insights of progressive farmer cum trainer are as follows -

- Target of the project: to save water in irrigation through providing adequate training and extension activities.
- Project coverage: Rural Damascus, Daraa and Hama Governorates with 20 irrigation engineers in each of the governorates
- Specific project activities: Adoption of sprinkler and drip irrigation in the rural Damascus. Project implementation involve three steps- irrigation field survey, design the irrigation net and preparation of extension materials-leaflets and brochures. They also provide 3-4 training programs per year. The project has Subject Matter Specialists (SMS) and water extensions to provide technical assistance.
- Cost sharing mechanism: 20% subsidy for legal groundwater users while non-legal groundwater users have to form informal association and approach the government to get 10% subsidy for installation of drip and sprinkler irrigation for crops. However, free technical support will be provided for both groups.
- Benefits: Both tangible and intangible. The project has strengthened the relationship among farmers in exchange of information. The project has succeeded in – increasing cropping area under drip and sprinkler from 30 % in 2004 to greater than 90% in 2007, changing cropping pattern towards less water intensive crops and creating awareness of water scarcity through installation of flow meter. All these benefits have improved the socio-economic status of farmers.
- Future plans of the project: Adoption of fertigation techniques and formation of water users associations
- Some of the above information is result of active participation from questioning on various activities of the DETTEX project from our study project group.

B. Visited project sites of DETTEX project near to Kafar Hawar Village center. Drip irrigation plot of 5 hectares was seen with 5 tube wells. The plot was with flow meters to record the water consumption of different crop in the individual cropping area. The average irrigated area per groundwater well is around one hectare. The coordinator and the accompanied staff were happy to say that project beneficiaries have increased the area and productivity due to adoption of modern irrigation technologies.

According to planned activity, Second activity is mainly to know current practices and activities of faculty farm of dairy cattle, sheep and goat in the research station of the Damascus Agricultural University

- The research station is about 75 hectares farm which was established in 1996. The feeds for all the dairy cattle, goats and the sheep are sourced outside the farm.
- The dairy cattle is composed of 40 cross breed of the Friesian Holstein calves imported from Canada with the local Shami breed. The feed are based on hay from legumes and barley including wheat bran. The milk produced by the dairy cattle in the research station is sold to the milk and yoghurt station processors owned by the government.

The stubbles have automatic watering for the dairy cattle. The station has a section for artificial insemination while there is also a mechanised milking system.

The mechanised milking system has the ability to detect if the milk is coming from sick cattle, automatically; the milk is excluded from the rest of the milk produce.

The station has 10 years of data recording where they calculate the milk produced per head and calculate the feed concentrate needed per each animal. However, the analysis is only concentrated on the fat content of the milk yield but not the protein content. From the total water consumed, about 6-30% is used for cleaning the stalls and the milking system.

- The cattle industry has suffered 5 generations of low productivity. From the past, there was severe breed lost since the government of Syria had a law to prohibit the entry of imported semen. Thus, there was a very slow fertility rate and reproductive performance of the local shami breed. However, the government is promoting now the breeding program (e.g. artificial insemination) and slowly the dairy sector is coping.
- There is only breed of sheep found in Syria which is the Awassi. As stated, the law prohibits the import of other breed. The milk and other milk products are processed as cheese. Traditionally, the milk produced is not eaten fresh by the local producers instead they are processed immediately into cheese products. The research station has 3 rams and the rest of the populations are ewes and lambs with identification. The objective of the research station is to improve the breed of the ram and eventually sell to private farms and to improve the efficiency of twinning rate of the ewes. Meanwhile, the station has also 5 shami goats.

The visit concluded with the announcement of plan for the next day of excursion that, driving along the five settlement zones to see the difference with respect to the irrigation and water uses, crop and livestock production systems and overnight stay in Aleppo

III. Minutes on Tuesday, 19th February 2008

We started the trip to Aleppo in the morning around 9:45 am.

Along the road to the natural water basin, we stopped at a place where a Bedouin was herdering his Awasi sheep. There was no interview with the Bedouin, but we had a first view of this extensive system.

Second stop was at the natural water basin in Qarah.

They look for a natural collection point in the area and then they improve this basin. Bedouins come to these natural lacks for providing drinking water to their animals. This is free of charge. There is a good cooperation between the government and the Bedouins we saw here.

Stop at the waterwheel in Hama city. This waterwheel is for pumping water from the river into the a canal.

Arrival at the research centre for improvement of the awasi sheep, where we will stay for the night. From there we drove to one of their cooperating farms which lays in the 4th ecological zone. This farmer has a semi-intensive system with Awasi sheep. Some Shami sheep are kept between them. This farmer bought the improved Awasi bucks from the centre and is now working with them. He seems to have a good business. At this farm we were also able to see how they herder their sheep. They work with a donkey, which they accustomed the leader sheep too. This leader sheep will than follow this donkey where ever he goes. And of course this donkey is controlled by the herder. In winter they stock the animals in the house, but when they go out for grazing, they do this on the land owned by the farmer or on rented land. The sheep are not allowed to graze on land that is not allowed for them. There are strong agreements between the farmers for this grazing. This farmer owns 50 ha which are cultivated with wheat and barley and then he also rents 70 ha extra. This farmer also uses an illegal well.

The research centre worked in the past on the improvement of the Awasi sheep for milk, meat and wool. But because the wool had no economical value and because they could not found genetically variance, the centre stopped with working on wool improvement of the Awasi sheep. Now they work on improving both meat and milk productivity. The building of the centre where we slept in are more for education purposes. In summer times, they educate the farmers.

IV. Minutes on Wednesday, 20th February 2008

Agenda:

1. **Visit the Research Station for Sheep Production in Salamien**
2. **Visit the EU-funded Al-Badia Agricultural Development Project in Aleppo**

1. Visit the Research Station for Sheep Production in Salamien

The visit started at 8.30. This research station is specialized on sheep production, covering the areas of 21 hectares. The station was found using both surface and groundwater from well. The ground water (650 meters deep) contains sulphate which can used only for agriculture purpose only. The main visit points were;

1) Biogas Station

The manures from the nearby farms are collected everyday. While some are used as fertilizer, some are used in biogas production. The residue of manure after biogas is also fertilizer. The procedure is; 1. Mix manure with water; 2. Transport by underground canals; and 3. Gases produced come up from pipe and be collected in the tank

The station can produce 50 litres of gas per week. This could support the gas needed in the university in specific amount. The production is only during winter/spring due to its effects to plants.

2) Milk and Reproductive Laboratory

Milk Lab; Analyzing the milk yield and quality (protein, lactose, fat …) and then analyze the problem

Reproductive Lab: The main task is to improve the breeding. First by colleting sperm for artificial and natural breeding, and experimenting about artificial insemination and embryo transfer. Now there is some frozen sperm/ semen imported from sheep in Germany; The lab is studying the technique to give only sperms to farmers.

Feed Lab: Now is attached with the reproductive lab but planned to be separated soon. The task is to analyze and improve the feed.

3) Milking Station

On-farm milking: The process starts with the sheep keepers shouting to gather sheep into the milking place. They arrange sheep in two lines. And then the sheep will be manually milked. The sheep manure is filtered before being tanked. The veterinary staff comes often to take milk sample to test the milk quality

In-house Milking: Milking with the equipment with more milk yield.

4) Milk Processing Station

Focus on cheese production only since the milk has very high fat contain (around 7%). First, milk is tested (milk that contained the antibiotic and chemical material for treatment will be thrown away), then put in the heater of 74 degree for pasteurization, used high pressure until the water content is gone, put salt and kept in vacuum for long keeping.

The visit finished around 9.15 with the short discussion with Dr. Ishmael, the director of the research centre station. The study project team did the thank you speech and handed him the souvenirs.

2. Visit the EU-funded Al-Badia Agricultural Development Project in Aleppo

The visit started at 13.10. The project director introduced that this project had started since 2001 and would last for 8 years. The objective is to improve the agriculture and develop the communities in rural area. The project was financed by EU, and also involved with Ministry of Agriculture, IFAD, Arabic Bank, and Syrian Government. The project followed the participatory approach. This project covered the working area of 3 million hectares (mainly in the zone 5) in 8 governorates in the Al Badia area, and worked directly with 16,000 farmers and indirect with 10 000 farmers.

The main activities were;

1) To improve sheep genetics (for better meat and milk quality)

- Develop livestock welfare, improve the breeding program of the sheep, twinning rates improvement
- Give number and weight each lamb after birth
- Control milk yield and give good feed grains, especially, during the last 2 years which rainfall is low and price of feed is increasing
- Provide vaccination to sheep who participate in the program

2) To improve grassland

- Growing the grass (commonly, 'artiplex') for the animal by direct seeding and transplanting
- Organize the 'grassing association':
    - teach the farmer to manage the grass (i.e. Open 1 line, distance between 2 lines, 4-6 meters gap between holes, density of plants = 400-500 plants/ha)
    - record the farmers' benefit from the project
    - Women were obliged to be, at least one, in each association, since they have more knowledge about collecting plants
- Avoid sheep keepers from getting sheep feed out of season (open twice a year; one in autumn, Oct-Nov, and the second time Feb-March)

3) To improve infrastructure in the Al Badia, wells, roads, havesting water in lakes

- Aleppo has 8 wells & water harvesting, with water amount of 15,000 m^3
- The project try to avoid cost from overuse of water from sheep keepers

The visit finished with the video presentation of the projects' activities.

V. Minutes on Thursday, 21st February 2008

The presentation started at 11:00pm. Present during the presentation were Lecturers and students of the Damascus University, National and International Researchers, Project coordinators in Syria and others.

In the introductory and welcome speeches, the Head of Department of Livestock of Damascus University welcome the Study Project Team from Humboldt University and those present for the interest for the study and concern for water related issue in Syria.

Next was Prof. Bachar Ibrahim, he explained the importance of such study and called for collaboration between the two Universities (Damascus University and Humboldt). He said such collaboration is very necessary to promote research activities amongst the two Universities. Prof. Claudia Kijora who was heading the Study Project Team thanks the participants present. She said this type of method of learning is a "normal kind practice in Humboldt University for several years by their department which is called the Study Project". She said the goal is to make the student learn and gain the scientific knowledge and also learn as a group working in team. This was immediately followed by the presentation. The first presenter started by introducing the members of the study project team and said the success and result of this work is a join effort of all members of the team which was closely supervised by Prof. Peters and Claudia Kijora.

At the end of the various presentations Prof. Claudia Kijora made the remark that the students are not familiar with the institutions of Syria and said their recommendation is based on student opinions.

Prof. Bachar Ibrahim thanks the students and Humboldt University for the initiative and re-echoed the promotion of further collaboration amongst the two Universities. He said the work done by the student for just a week is very interesting. He said there are lot of opportunities in the domain of water related issues in Syria and world over and that the student should go forward to prepare their Ph.D. thesis based on the recommendations presented which were very interesting. He concluded by saying they are welcome to finance Ph.D. thesis proposed by any of the students in this domain.

The Head of Department of Livestock thank the student for the marvellous result. He said in their University they do not consider livestock and environment as very important and that in the further they may focus in the teaching in this domain.

Next on the agenda were questions and answer:

A participant and researcher from the United State of America (USA) mention the important of recycle water reuses which was not properly handle. He said removing the sulphate from use water could be reused time and again. He also mentions the EU grant that the two Universities could take advantage and further research in this demanding sector.

Another participant questions the importance of the topic. He said for him the study project team should have considered topics like water and vegetation or crop production.

In responding to these questions the student said, this is just a study project and because of time constraint not every aspect on water could be handle at once might be subsequently the other issues mention by the participants could be taken into consideration.

For concluding remarks, Prof. Bachar Ibrahim gave thanks to the students for their result and sense of professionalism for working as a group.

The day ended with the Head of Department of Livestock introducing his faculty to the participants. He said the faculty consisted of 9 departments, 300 students with 80 M.Sc. (14 in Livestock Production) and 4 Ph.D. students.