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Land degradation Drought and Desertification

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I. INTRODUCTION

Jordan is a relatively small country with a population just over 5 million. However, the agricultural land area is even much smaller (table 1).

Table 1: General data on the country

Population (year 2000)	5.039 million
Surface area (km^2)	89287.1 Km^2
G.N.P / Capita (year 2000)	$7142.24
Agricultural surface area (ha)	684,000 ha
Added value of agriculture (year 2000)	$160.44

Jordan is a country that receives annually an average of 8.4 billion cubic meters of precipitation. However, about 90% of the country is arid receiving less than 200mm of annual rainfall. The dominance of arid conditions and the irregular rainfall distribution are the main limiting factors affecting agricultural production in general. Rainfall occurs mainly in the winter season with heavy rainfall during January and February. The rainy season normally starts in October and ends in mid May. The average annual rainfall decreases from west to east and from north to south reaching less than 50mm in the Southeast corner of the Kingdom. It ranges between 400-600 mm in the Western Hills. To the east of these hills, the altitude falls off rapidly, and so is rainfall. In the Jordan Valley, the average annual rainfall is 150-250 mm. In the eastern region, the country slopes gradually and merges with the Syrian Desert and rainfall declines to less than 100 mm, and its occurs mainly due to weather disturbances. The average rainfall over Jordan's agro-climatic zones, the respective land areas in km^2, the percentage of total area, the weighted average rainfall depth, and the average volumes of rainfall in MCM/yr for each zone are as follows:

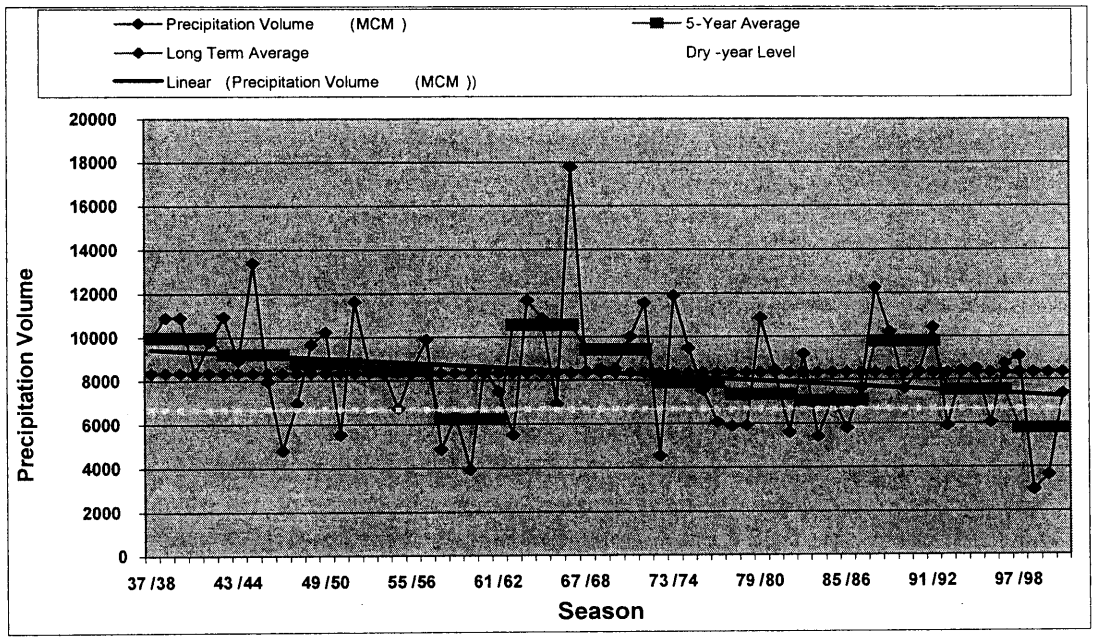
Table 2: Rainfall Depth and Distribution over Jordan's Zones

Area	Rainfall (mm)	Area (km^2)	Total %	Average Weighted Rainfall (mm/yr)	Rainfall Volume (MCM)
Desert	<100	633849	71.5	53.05	3414
Arid	100-200	19914	22.3	147.00	2947
Marginal	200-300	1965	2.2	250.24	513
Semi Arid	300-500	2947	3.3	393.22	1160
Humid	*>500*	625	0.7	650.00	390
Total		89,300	100%	93.60	8424

A. DROUGHT CHARACTERISTICS

The variability of precipitation volume over the country is relatively high. The trend in precipitation volume is that it is continuously decreasing with time over the period from 1937-38 until 2000-01 seasons. The frequency of drought over 10 years is 2.43. Moreover, the trend for drought is increasing. In the past 10 years, rainfall pattern is changing, where rainfall starts early in the season (November) and is followed by a

dry period extending between 20 to 30 days, to be followed by light rain during December and January. Heavy rain is occurring during the period from February till Early April. Average air temperatures during winter were higher than long term averages particularly during 2005-06 season.



The number of rainfall events during the season is also decreasing, with a noticeable increase in rain intensity and a decrease in storm duration. This phenomenon is negatively affecting the Agro-pastoral areas in Jordan, mainly areas cultivated to Barley. Over a period of 64 seasons, drought occurred in 14 seasons which means that the probability of a drought season was once every around 5 years. Severe droughts (rainfall between 35.6 to 45.2% of long term average) occurred during 1959-60, 1998-99, 1999-2000 seasons. The hardest period was from 1998 to 2000 with two consecutive severe drought seasons.

B. Drought Impact on Agro-Pastoral Systems

Drought impacts the agro-pastoral systems in different ways depending on the severity of drought. The impact could be either direct or indirect. Direct impact includes complete failure of barley fields, low dependence on natural range lands in supporting livestock feed requirements, increase the area covered by herders through more mobility, increased cost of providing extra feed to animals, sell of animals, and the death of animals.

Indirect impact includes mainly increased poverty and migration to urban areas.

II. NATIONAL STRATEGIES TO REDUCE THE EFFECTS OF DROUGHT IN JORDAN:

National strategies take into consideration full integration between socio-economic backgrounds, constraints like natural resource availability for some farming practices, and water harvesting technologies. Due to drought re-occurrences, the strategy dwells heavily on integrating water harvesting techniques with various farming systems to reduce the impact of low rainfall seasons. National strategies focus on:

- Range development through the introduction of new plant varieties.
- Rain-water harvesting is to be considered as a backbone strategy due to the high variability of rain (Increase rain-water harvesting storage capability through the construction of dams and reservoirs plus the rehabilitation of existing water harvesting facilities).
- Integration between production practices, utilizing water harvesting techniques, is to be carried in a way that will enhance animal husbandry farming (diversify production systems using watershed management approach and water harvesting).
- Protection of plant biodiversity and utilization and the establishment of range reserve areas (Carry in-situ and ex-situ conservation of plants).
- Development of animal feed resources through the improvement of its quality and the introduction of new feed resources.
- Poverty reduction to meet basic domestic consumption needs and the reduction of poverty-induced over-utilization of resources.
- Mobilization of the local population for sustainable management of their resources through existing mechanisms of community action.

LOCAL TECHNOLOGIES TO REDUCE DROUGHT RISK AND VULNERABILITY IN JORDAN:

- Drought early warning.
- Agro-ecological characterization.
- Water harvesting techniques.
- Soil conservation techniques.
- Introduction of new plant varieties and drought resistant fodder shrubs.
- Adjustment of animal number to meet forage availability.
- Job creation to improve the livelihoods of local communities.

III. DROUGHT AND LAND DEGRADATION IN THE ARAB REGION

The Arab region is characterized by low rainfall and high fluctuation of the precipitation. During the last century, this region experienced many episodes of drought whose frequency has increased during the last decades. This climatic phenomenon has affected negatively agriculture and livestock production and involved natural resources degradation. These problems have been associated with high population growth and hence they have been aggravated by the use of non adapted natural resources management. Among the populations that have suffered, the most, natural resources degradation are the pastoralists and agro-pastoralists. In fact, if natural pastures and rangelands provided enough feed for the small ruminants that predominated in the region until the beginning of the 20th century, these areas have decreased and their production has become today low and cannot any more meet the needs of the flocks that have increased significantly.

Since the indigenous approaches of coping with drought used in the past by pastoralists are not any more adapted, a high proportion of feed is provided by cultivated barley, crop residues and industrial by products and concentrates. Nevertheless, the situation is different from one country to another. Different systems, varying from nomadic to semi-nomadic rangeland to integrated crop/livestock systems exist in the region. For example, there is a reduction of livestock and people mobility and an increase of settlement and individual cropping and management of rangeland.

To help agro-pastoralists survive drought, many programs of subsidies and debt rescheduling have been launched by the governments. Unfortunately, these aids and supports have increased the dependency of herders on the State and encouraged the use of management techniques that enhance the agro-pastoral areas degradation.

A. Overview of the Situation of Drought and Pastoralism

West Asia and North Africa region is characterized by a low average annual rainfall (205 mm), and high fluctuation of precipitation. Hazell et al. (2001) stated that 74 % of arable land of these areas is located in semi-arid bioclimatic zones (200-400 mm). In these regions rain is unpredictable and drought has become more frequent and can occur at any time during the cropping and grazing periods of the plants.

During the last century, this region has experienced different episodes of drought with durations, intensities and timings varying from one country to another and hence inflicting different impacts. However, the last drought of 1999 affected most of the Arab countries with negative effects on agricultural production and natural resources. Hamadallah (2001)) stated that the 1999 drought caused in Syria an estimated loss of 40% of cereal grain production and a reduction in livestock production and in Jordan an expected productions of less than 1% of cereals and less than 40% of red meat and milk. In this last country, the small farmers and herders were the ones who were the most affected.

During the last two decades, Morocco experienced drought in the periods 1980-85 and 1990-95. Because of drought of 1999-2000, this country imported for 2001 year about 5 million tons of wheat. Tunisia suffered also drought during the same periods (1982-83 and 1993-95). In Mauritania, the two successive dry years involved crop failure and pastures production drastic reduction and hence resulted in high food and feed prices. For livestock production, Hazell et al. (2001) stated that in 1945 drought, 25% of cattle and 39% of sheep either died or were sold prematurely on a glutted market in Morocco. In Jordan, at least 70% of camel herd died due to the drought effect of the period 1958 and 1962. In the same country, around 30% of sheep flock died or was slaughtered prematurely in 1997 drought. The 1983-84 drought in Syria caused a slaughtering of 25% of national flock due to a shortage of feed (Oram and de Haan, 1995).

General models have shown that the Arab region might be the most affected by the global warming. In fact, temperature might increase by 1 to 1.5°C and rainfall might decrease by 20 mm.

In addition to low rainfall and high temperatures during a significant part of the year, the soils, especially in rangeland and pastures are usually shallow and have low water storage capacities. Moreover, water resources are becoming scarce and insufficient to meet the requirement of the rapidly increasing human and livestock populations. Only 8 of 23 West Asia and North Africa (WANA) countries have now more than 1000 m3 of available water per capita which is considered as the water stress threshold and some countries in the region are already at or even below the absolute or severe poverty level of 500 m3 of water per capita (Jordan, 160 m3 only). Prediction studies showed that by year 2025, most.

B. WANA countries might reach the severe water poverty level.

WANA rangeland and natural pastures areas that have less than 200 mm were, in 1950s, the main source of feed needs (70%) of small ruminants (Ngaido, 2002). These areas are experiencing now high degradation. In fact, the biodiversity is decreasing very rapidly due to the overgrazing caused by very high increasing of flock numbers, and non adapted animal and natural vegetation management. Moreover, rangeland and pastures are shrinking (10-25% of 1950s situation) because of the increasing transformation of these areas into cropped land and the introduction of intensive irrigation systems. Cropping of marginal lands

using non adapted techniques has enhanced soil degradation and desertification. In Tunisia, the contribution of rangelands to livestock diet has decreased from 65% to 10% (Nefzaoui, 2002). In Jordan, these ecosystems used to provide 70% of feed requirements for animal grazing; today, it has declined to 20-30% (Roussan, 2002).

C. CONCEPTS AND DEFINITIONS

Drought is a normal part of climate and occurs in virtually all regions of the world. Drought is the most complex; but the least understood of all natural hazards, affecting more people than any other natural catastrophe. Its impacts are spread over large areas and affect economic, social and environmental sectors; and all this makes its assessment and response difficult. Drought is a slow-onset natural hazard and its effects may continue for years after the termination of the event. It differs in terms of intensity, duration and spatial extent; consequently, it is often difficult to determine when it begins and when it is over and also to quantify the magnitude of its severity. For this reason, it is often referred to as a creeping phenomenon.

Drought has both natural and social components. Its negative effects are accentuated by human or social factors. In each region, its associated risk is a product of the exposition to the hazard and society vulnerability.

In general, drought can be defined as a prolonged period of insufficient precipitation, normally one or many seasons that causes water deficit in certain sectors of the economy of a country. This drought has to be considered taking into consideration:

1. Certain long term average conditions of final balance between the precipitation and evapotranspiration in a given region,
2. A temporal scale,
3. The efficiency of the precipitation.

Because drought has different impacts, definitions vary with the domain or sector considered. Consequently, there are different types of droughts:

Meteorological drought is characterized by a reduction, uneven distribution or even absence of rainfall in a given region during a period of time. It is usually defined for a given region and certain period by the measure of the deviation of cumulative precipitation from the normal of this same period calculated for at least 30 years.

Agricultural drought refers in general to situations where available soil moisture and water storage are not enough to meet crops and livestock needs in a given region. It is also defined for crops by the availability of soil water to support crop or forage growth.

Pastoral droughts could be defined as a lack of forage availability as a result of particular sequences of meteorological drought, in terms of length, seasonal timing and the intensity of the deficit.

Hydrological drought is defined for a certain period in a given region as the deviation of water supplies from some average condition (the normal) due to prolonged periods of precipitation deficits.

Socio-economic drought is the consequence of the impacts of all types of droughts described above. Its definition is based on supply and demand processes. So, the socio-economic drought refers to situations

where the supply of an economic good (water, energy..) cannot anymore meet the demand of this good and where the cause of this deficit is related to climate.

Drought Timing

Drought can strike at any time during the season, thus drought can be:

- Early season drought (Nov-Dec)
- Mid-season drought (Jan-Feb)
- Late-season drought (Mar-Apr

D. CAUSES OF DROUGHT

Although the causes of drought episodes are still not very well defined, several possible ones can be cited:

- Global cooling in the Northern Hemisphere as a cause for the prolonged drought of the Sahel Region;
- Global warming of the atmosphere was the basis for several suggestions as a cause for increase in the frequency of meteorological droughts;
- A reduction of the vegetative cover in arid and semi-arid areas, would lead to increased albedo (reflectivity of the Earth's surface);
- Variations in large-scale atmosphere circulation patterns at the locations of anticyclones or high-pressure systems which, if persistent for extended periods of time, could lead to weather extremes such as drought, floods, heat waves and cold snaps.

Climate Change

The fact of climatic change has been proved by the following:

☐ Global increase in atmospheric concentrations of greenhouse gasses
- CO2
- Methane (CH4)
- Nitrous oxide (N2O)

☐ Global warming

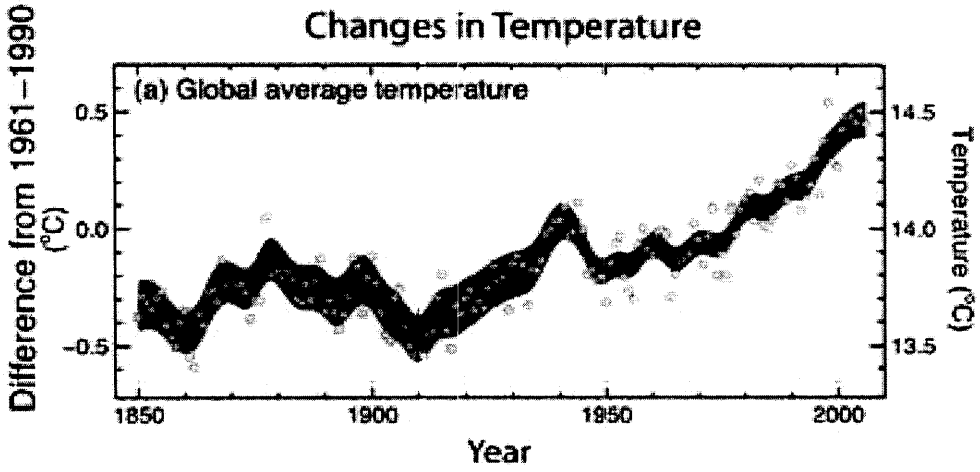
☐ The two increases are linked

1. CO2 is the most important green house gas.
2. Concentration has increased from 280 ppm in 1750 to 379 ppm in 2005.
3. Current CO2 concentration is more than the natural range over the last 600,000 years (180-300 ppm).
4. Growth rate appears to increase:
   - Over last 10 years (1.8 ppm/year).
   - Average growth rate 1960-2005 (1.4 ppm/yr).

Global warming trends are:

1. Spread: -0.6°C – 0.6°C
2. large fluctuations between individual years
3. Trends (Base year 1960)
   - Rise of 0.7°C over the last 100 years

- Steady warming 1880 – 1940 (0.7°C; 0.012°C/year)
- Mild cooling 1940-1965 (- 0.2°C; 0.008°C/year)
- Rapid warming 1965 – 1995 (0.4°C; 0.015°C/year)



E. DROUGHT MITIGATION AND RESPONSE

The strategies to be developed in a drought mitigation program require:

- Organization of institutional structures that allow higher efficiency of drought mitigation actions;
- Development of decision making tools including the ones that will trigger the contingency program and the ones that will allow the integration of the risk in the management of drought.

Drought mitigation actions are implemented during and in advance of drought to reduce the degree of risk to human life, property and productive capacity. The effect of drought is mitigated by two factors:

1. Modification of drought hazard through the use of suitable and drought resistant breeds and cultivars, the preparation of food security programs and the limitation of water wastage and losses
2. Diversification of crops and animals and the use of good farming practices.

In agriculture, Rossi (1997) classified drought mitigation measures in 3 categories:

1. Water supply-oriented measures (supply increase or deficit risk reduction),
2. Water demand-oriented measures in agriculture (less water consumption crops, evapotranspiration control, agronomic techniques for reducing water consumption), in municipal (rationing the use) and industrial (water recycling) sectors,
3. Impact reduction measures (drought early warning and monitoring, mitigation of economic effects through the voluntary insurance, the public aid to compensate loss of revenue, the tax reliefs or reduction or transfer of payment deadline).

Other response options during and following drought are summarized as follows:

- Provide information to affected farmers on financial and personal counselling;
- Assess available feed supply;
- Implement a water hauling program;
- Implement a feed/livestock freight assistance program;
- Recommend tax deferral;
- Implement drought disaster loan program.

A comprehensive drought management plan should have the following components:

1. Drought early warning,
2. Contingency planning,
3. Policies supporting drought resilience.

Drought early warning system requires data collection at local, regional and national levels on different biophysical (weather, natural vegetation, crop production and storage, animal production and health) and socio-economic indicators (movement of herds, livestock sales and prices, cereals and straw prices, immigration to cities, new jobs).

Because data collection is costly and time consuming the early warning system need to be evaluated to select the most important information needed for the determination of key early warning indices or indicators. The combination of seasonal weather forecast, the use of early warning indices adapted to different types of drought and the incorporation of the remote sensing to monitor natural vegetation and crops vegetation state can make this system more effective. Socio-economic data can be also used to complement and validate technical information. The involvement of agro-pastoralists in data collection and monitoring may reduce the cost and integrate the local knowledge which is usually valuable and improve the system.

Nevertheless, the institutional and organizational issues involved in information collection and dissemination needs to be improved to make the early warning system more effective. So, there is a need for the appointment of a multi-disciplinary task force that includes all decision makers and stakeholders at national, regional and local levels to better analyze and trigger actions at different scales.

Drought contingency planning is composed of drought mitigation, relief and rehabilitation measures (Barton et al. 2001). Nevertheless, the investment in drought early warning and mitigation will help to lessen the long term impact of this hazard on agro-pastoral households and hence reduce the need for costly food relief and rehabilitation which are short term and non sustainable measures.

The objective of drought mitigation is to minimize the impact of this natural hazard on production systems and livelihoods. Among the most important mitigation measures (Barton et al., 2001) are:

- Flock destocking. The best strategy to sustain production systems based on grazing is to adapt the number of animals to pasture resources availability. At the onset of drought, it is important to adopt the destocking of animals by encouraging the herders to get ready to face drought by selling animals early while the prices are still high to be able to purchase grains for food. This will help herders survive drought and reduce the pressure on pastures and use it more efficiently for feeding the minimum number of animals. The herders can be encouraged to do this if there is a guaranty of early stocking after drought through, for example, the creation of pastoral banks;

- Pasture feed and water storage preservation for drought periods. Pastoral and rangeland areas need to be always managed in a way that grazing is controlled so that some reserves or areas are protected and serves as a refuge only when there is feed and water shortage in the commonly used places. Under drought conditions, these reserves are open for grazing and watering. This can provide extra forage and reduce the pressure on commonly used pastures. Alternating grazing areas can also preserve natural resources;

- Forage supply under drought conditions. In many areas, rangelands have been transformed into agro-pastoral production systems through the introduction of farming in the system. Under these conditions, there is a need for a sound integration of crops and animal productions. Forage and cereals by-products (straw) can be stored during the wet year and used during drought years;

- Provision of credit or cash/food for work to prevent the collapse of the purchasing power of poor people;

- Maintenance of cereal availability. Agro-pastoral systems can help produce cereals during wet years. Part of the harvested grains can be stored and used during dry years;

- Provision of human and livestock health service;

- the establishment and strengthening of institutions for pastoralists to manage their own affairs as much as is feasible, to represent their concerns effectively to higher authorities and to manage conflicts between themselves, or between pastoralists and farmers;

- Promotion of new types of livestock insurance, particularly index-based systems which pay out on the basis of large-scale patterns of mortality that are beyond the control of individual livestock owners;

- Flexible taxation systems that do not tax pastoral populations during drought;

- Emergency animal purchase or the provision of subsidy to transport animals to market to enable herders to realize some cash for their animals before price collapse.

To recover from extended drought, rehabilitation and relief measures are sometimes needed to help the most affected members of the society. Among these measures are the restocking of flocks to help livestock producers reconstitute their herds and the distribution of seeds to guaranty the cropping of cereals and forages during the season following the dry year. To implement these programs, governments should launch a loan (credit) approach in the agro-pastoral systems. The aid from the government (relief) can be also an issue; but on a case-by-case basis to help only the agro-pastoralists that are really in need. Moreover, the cost of a generalized operation cannot be supported by the governments or donors.

The restocking has to be well thought to insure the adaptation of the number of animals to pasture and feed resources. Otherwise, the overgrazing and resources degradation will be increased.

Policies to promote drought resilience are necessary for the assistance of drought mitigation measures. Among the most important policies are the pastoral institution building, the support for pastoral marketing and infrastructure.

Some strategies of pasture and rangeland management developed in the past to cope with drought are not anymore adapted to nowadays context. In fact, there is now a tendency to more settlement of pastoralists, development of farming (agro-pastoralism), less migration possibilities of animals to search for water and feed resources. Moreover, these resources and rangelands have become insufficient because of human and animal populations increase and drought that has become more frequent. However, the indigenous knowledge and institutions developed for a long time cannot be ignored and have to be taken into consideration to readjust the strategies of livestock and pasture management in dry areas and make the coping measures more effective. As a matter of fact, pastoral associations should be based on traditional social organizations. These associations can help solve conflicts, be a link between governments and members, support mitigation programs and have capacity to lobby government proactively.