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Water Resources Management at Marab Hassan-NE Badia/Jordan

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Abstract: It is generally accepted that sustainable use and management of land resources will only be achieved by adopting a system of improved land, water and vegetation management. Given that watershed management is the implementation of management systems that ensure the preservation, conservation and sustainable use of all land resources. It is through this understanding that watersheds can be managed to protect the natural resources valued by local and national communities. This study aims to investigate the effect of water management on soil productivity at *Marab* Hassan/Jordan. It was found that the salinity in the initial soil samples (before treatment) were higher than the values for the final analyses reported in final soil samples (after treatment). Also, it was found that the average height of barley planted in the treated areas was 63 cm, while the average height of barley planted in the control area was 20 cm. This result is showing that the water management treatments were very successful in terms of retain water and store more moisture in the soil, so the barley grow in high rate compare to those have no treatments.

Key words: Barely, Jordan, land resources management, *Marab* Hassan, watershed management

INTRODUCTION

Ephemeral streams are common features of landscapes around the world, and are the predominant fluvial environment in arid zones (Shaw and Cooper, 2008). Degradation of semiarid and arid lands is a major concern and is usually described in terms of soil movement/erosion and changing plant communities (Ritchie *et al*., 2009). In most arid land systems, vegetation cover rarely exceeds 75% and bare soil is always a significant feature (Huxman *et al*., 2004). However, plant ecosystems in arid and semiarid climates show high complexity, since they depend on water availability to carry out their vital processes (Quevedo and Francés, 2008).

Badia comprises the majority of Jordan forming about 85% of the total area of Jordan. The vegetation is very poor mostly composed of fleshy plants, and sometimes non-existent, most of the plant cover is restricted to *Wadi* channels and outwash zones (local terms Wadi and Marab) where enough soil moisture is available to hold some vegetation (Al-Eisawi, 1996). Surface runoff in *Wadies* varies as much as the rainfall, flood waters remain several days or months before evaporating, depending on volume (Fariz and Hatough-Bouran, 1998).

Marab Hassan one of these largest *Marabs* in the Jordanian Badia that reflect areas where *Wadi* channels increase their width and water spreads across a wide area. Through the water movement sediments accumulate causing the flow velocity drops, (Shatnawi, 2002). A *Marab* is fed and drained by *Wadis*, i.e. it receives and delivers water, which is the major difference between it and the *Qa'a*. Normally water leaves the *Marab* in the shape of a well-defined channel, as illustrated by *Marab* Hassan and as has been earlier discussed.

Water movement in a system is affected by many physical, chemical, and biological components and processes. An understanding of these components and processes is an essential first step in the assessments of the condition of a watershed system and the impacts of management actions on a system (Lee *et al*., 2008). Watershed analysis enhances our ability to estimate direct, indirect, and cumulative effects of our management activities and guide the general type, location, and sequence of appropriate management activities within a watershed (Sadoddin *et al*., 2010). It is generally accepted that sustainable use and management of land resources will only be achieved by adopting a system of improved land, water and vegetation management. Given that watershed management is the implementation of

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management systems that ensure the preservation, conservation and sustainable use of all land resources. It is through this understanding that watersheds can be managed to protect the natural resources valued by local and national communities. This study aims to investigate the effect of land management on soil productivity at *Marab* Hassan/ Jordan. This aim was achieved by fulfilling the following objectives:

- Characterize rainfall- runoff measurements
- Measure soil moisture capacity and physical characteristics
- Establish earth treatments for flood distribution, minimizing soil erosion
- Water storage the in soil profile for development purposes
- Increase soil moisture yield in order to increase land productivity
- Maximize runoff beneficiation

The study was carried out between March, 2008 and June, 2009.

METHODOLOGY

Site description: *Marab Hassan* is located in the eastern Badia of Jordan (31º97′ N, 36º89′ E), North-western part of Safawi area (Fig. 1). It is consisted of hilly and rolling terrain. The *Marab* catchment's area is one of the largest catchments in the Northern Badia of Jordan with an area of about 360 km^2. The catchment's consists of three main *Wadis*; the largest one starts from the Syrian Jebal Al-Arab in the north and it is joined by the other two near the bottom of the catchment (Fig. 2). From the eastern side appears *Wadi* Hassan that starts from Jebal Al-Asfar. Then all the *Wadis* reach a mud flat (an area of accumulated sediments), locally known as "*Marab* Hassan". Downstream of the *Marab* one *Wadi* continues to the Azraq mud pan "*Qa'a* Al-Azraq" and encompasses an elevation gradient from 590.5 to 578 m

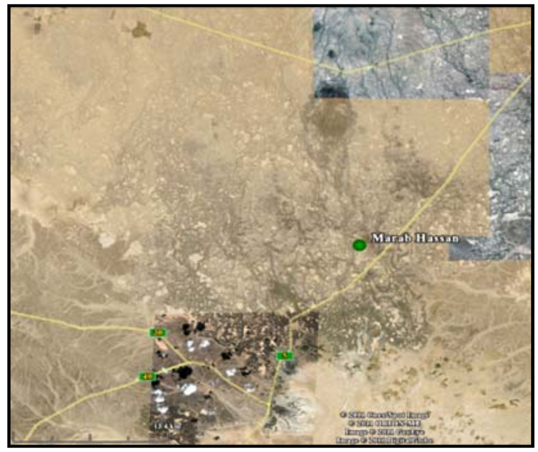

Fig. 1: *Marab* Hassan location

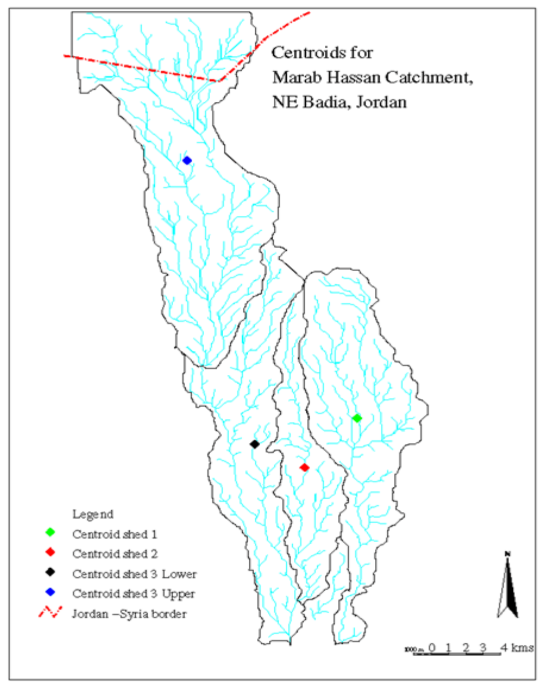

Fig. 2: *Marab* Hassan sub-catchments

The mean annual rainfall increases from 50 mm per year in the south to over 250 mm per year in the north near the Syrian border. The present day climate of the northeastern Badia is arid with 50 to 250 mm of rainfall per annum. The rainy season lasts from October through April, furthermore, it was estimated that 92% of the rainfall is lost to evaporation (Haddadin, 2001). Subsequently, Jordan has become highly dependent on these countries for its water needs. Most of the rain falls between November and March.

The average number of rainy days is 23 days and the average annual rainfall on the catchment is 194 mm, January is the coldest month in the year, where the average monthly temperature can fall to below zero degrees. The hottest months are July and August with an average temperature of 28ºC. The mean annual temperature is about 15ºC (Abu Ashour, 1998). The temperature gradually increases from January to July and starts to decrease from August to December. Summer temperatures rarely rise above 40ºC while winter temperatures seldom drop to 0ºC. The north-western part of the Badia area near the Syrian border is characterized by a marked variation in temperature, both in terms of its diurnal nature and annual change. This reinforces the fact that the area lies close to the transition from the Mediterranean conditions to a more continental climate further east, which is characterized by more extremes in both diurnal and annual terms. The average daily evaporation measured at Azraq North station is 11.5 mm.

The evaporation rate normally increases from January to July (4.2-19.2 mm/day), and starts to decrease from 17.4 mm/day in August to 4.3 mm/day in December (Shatnawi, 2002). There is a prolonged summer drought (June- September) where The maximum average monthly relative humidity is about 61% in December and January. Then it starts to decrease to reach 38% in May. The monthly average relative humidity ranges from 38 to 48% in summer and from 58 to 61% in winter. Annual estimates of productivity coincide with the water year, which starts in October the typical beginning of winter rains, and ends the following March.

The land is usually used as natural rangeland for grazing. The dominant natural vegetations in this region are mainly chenopod elements such as: Anabasis syriaca, Halothamnus acutifolius and other nonchenopods as: Gymnarrhena micrantha and Herinaria hirsute. In *Wadi* beds and runoff places other vegetation elements occur such as: Artemisia herba-alba, Astragalus spinosus, Achillea fragrantissima and Trigonella stellata.

RESULTS AND DISCUSSION

Hydrologic parameters: The *Wadis* that contribute to *Marab* Hassan catchment area are well defined, deep incised *Wadis* from the northeastern side and from the northwest. The catchment has been divided into three main sub-catchments as shown in Fig. 2. *Marab* Hassan has an area of 3.5 km^2. The volcanic eruptions of Tall Hassan to the eastern side of the *Marab*, as well as the existence of some faults and structural system have resulted in its formation. As shown in Fig. 2 the *Marab* has two inlets and two outlets, one major outlet and one minor to the right that discharges water in high flood seasons only. The flow pattern in the *Marab* takes two forms, sheet (overland flow) from the main *Wadi* in the west and a channel flow from the eastern *Wadi*. It has been used for barley cultivation for a long time.

Soil types at *Marab* hassan consist of Loam, clay loam and Silty clay loam as shown in Table 1 and Fig. 3. Rainfall data were taken from several rainfall gauge stations within and around *Marab* Hassan (Fig. 4).

Surface water management: The topographic data (0.5 m contour line) was used to construct a 3-D model of the *Marab* and the flow pattern and direction using GIS technique. The 3D Digital Elevation Model (DEM) of *Marab* Hassan catchment area is shown in the Fig. 5.Using the 3-D model of the area (Fig. 6) and the flow pattern of the surface runoff, 5 barriers or ridge across the study area with specific incline in order to absorb the stones (each is 600 long) were constructed (Fig. 7)

Table 1: Soil types at *Marab* Hassan area Shatnawi (2002)

Soil type	Sand (%)	Clay (%)	Silt (%)	Texture
NAT	42.88	21.76	35.36	Loam
SHA	21.12	32.64	46.24	Clay loam
UB	I21.12	32.64	46.24	Clay loam
ZUM	32.00	24.48	43.52	Loam
BIS	7.52	29.92	62.56	Silty clay loam
FAR	7.52	35.36	57.12	Silty clay loam

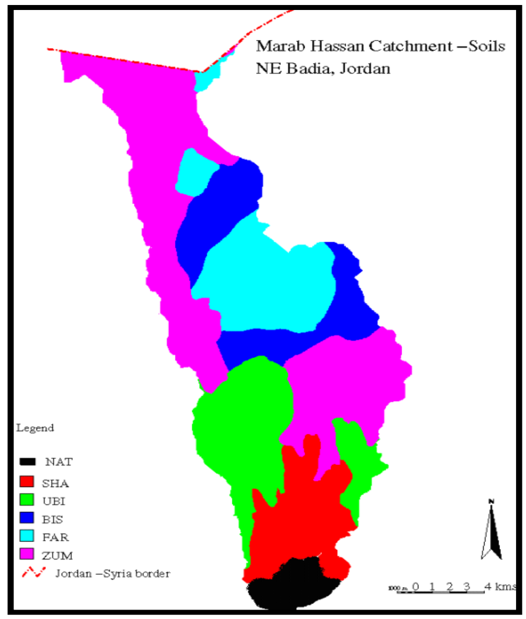

Fig. 3: *Marab* Hassan soil types

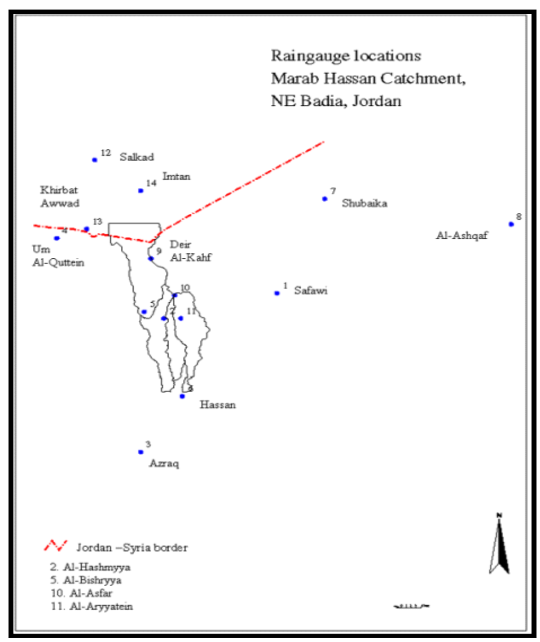

Fig. 4: The locations of the rainfall gauges within and around *Marab* Hassan

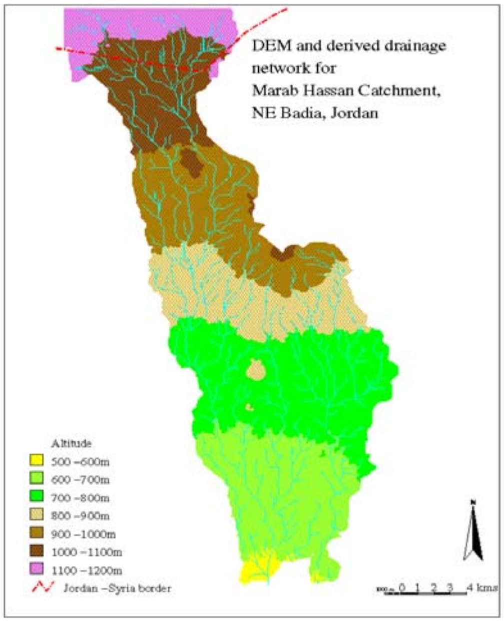

Fig. 5: Land altitude at *Marab* Hassan catchment area

momentum of water (flash floods) in the western part of the *Marab*. A small part of the *Marab* was left without any treatment for comparison purposes. The barrier locations were chosen such that they help in redistributing the surface runoff as sheet flow to help in giving water more time to percolate into soil and be available for vegetation.

Due to the topographical characteristics of the site it was possible to construct only one type of surface treatment which was the gabion. Gabions of various lengths were constructed to divert and distribute the runoff water on the land surface. The installation such surface intervention was to increase the water detention time which enhance the infiltration and soil moisture storage.

Water harvesting techniques seem to be very effective and the difference between the control area and the treated areas is very clear and significant. Since several flash floods occurred this year, some of the earth marks (Fig. 8 and 9) (stone ridges) were partially damaged and later had to be reconstructed.

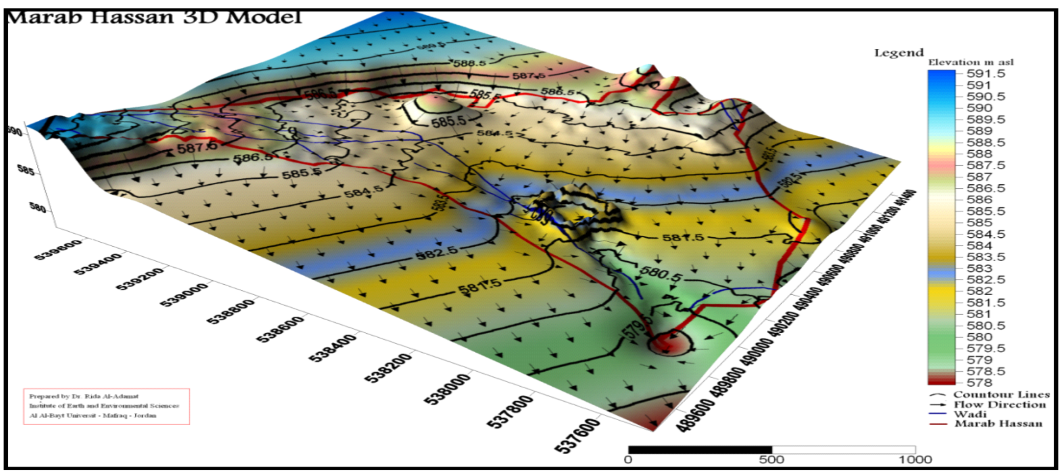

Fig. 6: 3D digital elevation model of *Marab* Hassan

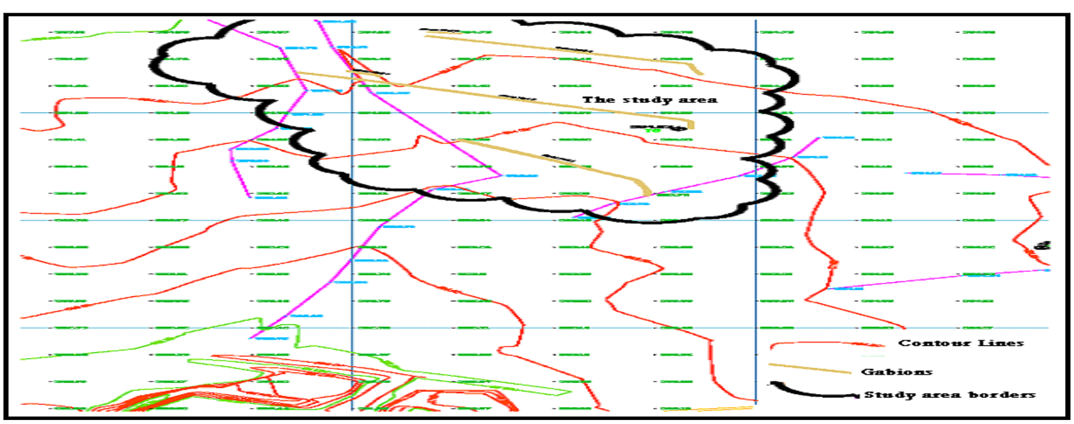

Fig. 7: Earth marks shown on the topographic map

Fig. 8: Photos of earth marks (Ridge stones)

Fig. 9: Photos of floods around the earth marks

The effect of land management on the soil: To asses the effect of various gabion on soil moisture and lengths, soil sampling sites were identified and soil moisture and relevant soil characteristics were measured. Soil samples were collected from 6 sites at two depths (0-15 and 15-30 cm), giving a total of 12 soil samples for analysis. Analyses were carried out at Jordan University of Science and Technology and are given in Table 2 and 3.

The soil analyses showed that the salinity of the soil dropped significantly due to the flooding and water harvesting technique used. The salinity found in the initial soil samples as expressed in EC (dS/m) were higher than

Table 2: Initial soil analysis

Code	Sample #	EC (dS/m)	N (%)µg/g K	$CaCO_3$ (%)
A	1A	0.48	0.04	77022
B	1B	0.45	0.02	81020
C	2A	0.52	0.02	60015
D	2B	0.30	0.02	6005
E	3A	0.50	0.04	7208
F	3B	0.37	0.02	86020
G	4A	0.72	0.11	92010
H	4B	0.56	0.08	9108
I	5A	0.47	0.07	89014
J	5B	0.40	0.04	8806
K	6A	0.44	0.06	87010
L	6B	0.34	0.06	9305

Table 3: Final soil analysis

Code	Sample #	EC (dS/m)	N (%)	µg/g K	$CaCO_3$ (%)
A	1A	0.009	0.0303	1453.736	18.267
B	1B	0.009	0.0235	1356.446	18.978
C	2A	0.008	0.0293	660.325	17.916
D	2B	0.008	0.0306	486.695	17.499
E	3A	0.008	0.0904	752.826	16.778
F	3B	0.008	0.0461	869.055	18.632
G	4A	0.008	0.0872	1507.151	17.340
H	4B	0.008	0.0646	1364.787	17.108
I	5A	0.008	0.0646	875.430	17.092
J	5B	0.008	0.0523	972.675	18.622
K	6A	0.008	0.0813	943.710	17.184
L	6B	0.008	0.0592	186.537	17.596

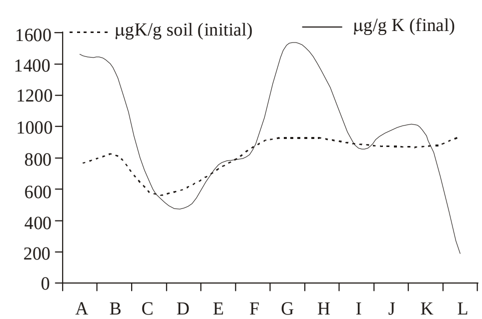

Fig. 10: K in the soil samples collected before the treatment (initial) and after the land treatment (Final)

the values for the final analyses reported in final soil samples. Another very important parameter should be mentioned and discussed is the values of extractable K, an essential nutrient for plant growth and cereal crops, like barley, have high requirement for this nutrient. The flood water brought with it K which is contained in the eroded top soil that arrives to the *Marab* (Fig. 10). Other soil parameters (Table 2 and 3) could be used to monitor changes in the *Marab* in the long range. They are not expected to change much in short time, as was the case of the duration of this study.

The effect of land management on Barley growing: The *Marab* was planted with Barley seeds during December 2008 to test and assess the effect of various water harvesting and land treatment techniques on vegetation cover. The results (Fig. 11) show that the water and land treatments significantly affected the height of the barley. It has been found that the average height of barley planted in the treated areas was 63 cm, while the average height of barley planted in the control area was 20 cm. This result is showing that the water treatments were very successful in terms of retain water and store more moisture in the soil, so the barley grow in high rate compare to those have no treatments. On other hand, it can be said that the barley seeds which were planted in the *Marab* was suitable to the area and very good species, it is the same species that the local people plant in their fields.

Fig. 11: Photos of Barley growth (treated and control areas)

In relation to the biomass production for the planted barley in the treated and the control areas was 2420 Kg/ha and 700 Kg/ha respectively. It can be seen that the water treatment significantly affect the biomass production, in other words the water treatment result in producing biomass three times more than the control area. This result is highly appreciated by the local community and they were asking for doing these techniques every year. The Barley production which was produced under the treatment areas is similar to the same production in the areas which receives more than 250 mm rainfall a year compare to the rainfall average in *Marab* Hassan 50-100 mm a year.

CONCLUSION

From the field visits, it was observed that soil movement and erosion have been tangibly reduced, where it has been noticed that no movement of soil, as happening usually in the Badia *Marabs* after flash floods, occurred.

Runoff water speed has been effectively harvested and reduced and utilized for the irrigating of plant and grass. Soil fertility is expected to be improved due to the high intensity of biomass; this will be measured and recorded at the end of the project.

It is expected that the landowner income will be improved, since the productivity of the *Marab* is very high and this will have direct and positive influence on the land owners. It is clear from the study that biomass productivity is very high and increased due to the interventions and good management (the earth marks).

The outcomes of this research will be used as a model for similar areas with similar conditions, and will be disseminated other land owners in the region. It is planned that *Marab* Hassan will be a national and regional incubator in the future in terms of hydrological system and water resources management.

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