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Salinity Development During Three Decades in the Oasis of Ktoua, South East Morocco

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## 1 Abstract

Water scarcity in the Draâ Valley, south Morocco, has led to an excessive increase in the use of groundwater for irrigation in the Draâ Oases, and consequently accelerated the natural soil salinisation process. Combined with water shortage, salinity had major negative impact on yield in the area. To assess the development of soil salinity three monitoring studies were conducted in one of the six Middle Draâ Oases “Ktoua” in 1968, 1981, and 1995. A total of 130 sites were sampled representing a study area of 7 341 ha. Results were originally presented as tables and manually interpolated maps. Data are presented here differently. Measured electrical conductivities were interpolated using Inverse Distance Weighting method. The resulting interpolated surface was classified into 5 classes: non-salinized, slightly salinized, moderately salinized, strongly salinized, and severely salinized representing: 0-4, 4-8, 8-16, 16-32, and >32 dS m<sup>-1</sup> respectively. Results for the period 1968-1995 showed a homogenous, however more saline, top and subsoils salinity in the oasis in 1995. Topsoils at the same year were moderately to strongly salinized, whereas subsoils were mostly strongly salinized. Preliminary results from soil survey in 2009 showed that salinity continues to increase. The increased salinity has led to reduced yields and land abandonment especially on the right hand side of the Draâ. Results will be integrated in oasis-scale modeling to test field management and agro-political scenarios to combat salinity and mitigate its effects.

## 2 Background and Objectives

Water scarcity in the Draâ Valley, South East Morocco, has led to an excessive increase in the use of groundwater with varying quality for irrigation in the Draâ Oases (IMPETUS 2003). Exponential increase in number of groundwater wells occurred since the construction of El Mansour Eddahbi dam in 1972. Consequently, the natural soil salinisation process has been accelerated. Also, groundwater table has fallen rapidly and its quality has been deteriorated (KLOSE AND RICHERT, 2006). Combined with water shortage, salinity had major negative impact on yield in the area and hence on livelihood of the inhabitants. Ktoua is the most severe example among the six Draâ Oases. In the current paper, the development of salinity is investigated. The current research aims at assessing the development of salinity in Ktoua Oasis from previous studies, and give hints about salinity current status.

## 3 Material and Methods

Three monitoring studies were conducted in Ktoua in 1968, 1981, and 1995 (ORMVAO 1996). A total of 130 sites were sampled representing a study area of 7 341 ha. Results were originally presented as tables and manually interpolated maps. Data are presented here differently. Measured saturated soil paste electrical conductivities (EC) were interpolated using Inverse Distance Weighting method. Interpolation was done following ROBINSON AND METTERNICHT (2006) recommendations to test performance and choose interpolation parameters.

The resulting interpolated surface was classified into 5 salinity classes:

<b>R1:</b> Non-Salinized	0-4	mS cm <sup>-1</sup> ,	<b>R2:</b> Slightly Salinized	4-8	mS cm <sup>-1</sup> ,
<b>R3:</b> Moderately Salinized	8-16	mS cm <sup>-1</sup> ,	<b>R4:</b> Strongly Salinized	16-32	mS cm <sup>-1</sup> , and
<b>R5:</b> Severely Salinized	>32	mS cm <sup>-1</sup>			

A recent soil sampling campaign was conducted in 2009 to update the soil salinity status. The later is mentioned here for comparison, as the heterogeneity of the surface and low number of sampling points did not allow for efficient interpolation. EC was measured in 1:5 diluted solution, then was used to estimate EC in the paste extract with a texture dependent regression equation.

## 4. Results and Discussion

### 4.1 Development of salinity between (1968-1995)

Results showed that salinity topsoils lie mostly (70%) within the slightly salinized category R2 (Figure 1.A), which means up to 25% yield reduction of a moderately salt tolerant crop like wheat. Subsoils (40-80 cm) are more saline than topsoils, and are generally slightly to moderately Salinized—in total 90% in the two classes—which means further reduction of yield (Figure 1.B).

Both topsoils and subsoils are developing towards more homogenous, however more saline, conditions till the late 90s (Figure 2. A and B).

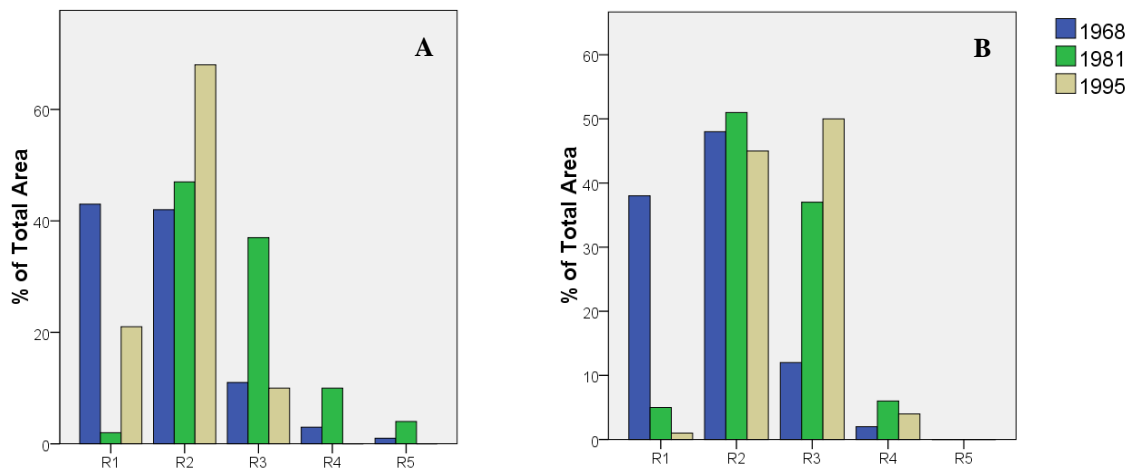


Figure 1. Changes in area percentage of salinity classes. (A, left hand side) shows topsoil (0-40 cm); (B, right hand side) shows subsoil (40-80 cm). Salinity classes are: R1 non-salinized (0-4 mS cm<sup>-1</sup>), R2 slightly salinized (4-8 mS cm<sup>-1</sup>), R3 moderately salinized (8-16 mS cm<sup>-1</sup>), R4 strongly salinized (16-32 mS cm<sup>-1</sup>), and R5 severely salinized (32< mS cm<sup>-1</sup>).

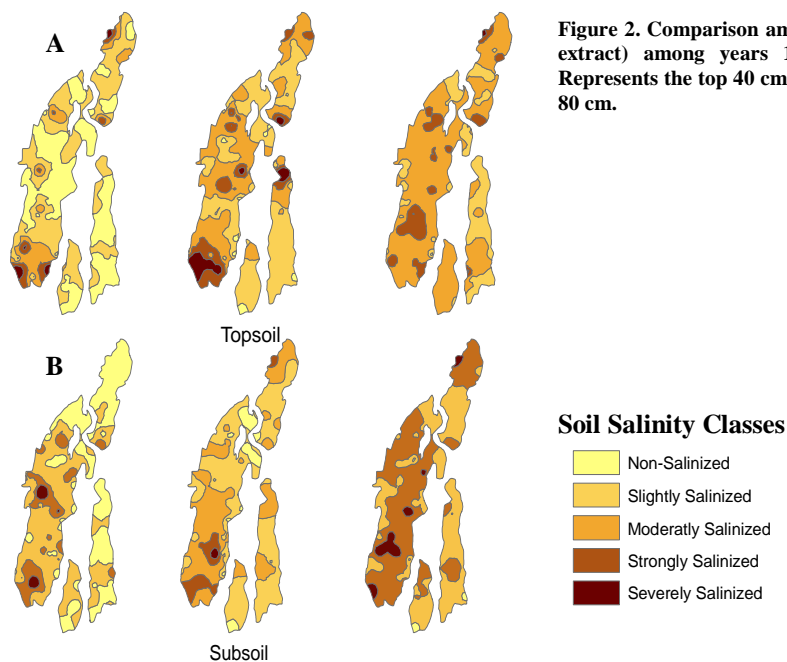


Figure 2. Comparison among Interpolated surfaces of soil salinity (soil paste extract) among years 1968, 1981, and 1995 (from left to right). (A) Represents the top 40 cm soil; (B) represents subsoil of depth between 40 and 80 cm.

## 4.2 Current status of salinity

Results from the recent soil survey showed that salinity is still increasing (Fig. 3). Salt crystals are visible at soil surface in many areas of the oasis. Consequently, farmers abandoned the most saline soils. With the current yield levels, farmers' income is not sufficient to support their families. Hence, a high percentage of young male family members have migrated to bigger cities. Migration led to even more land to be abandoned due to lack of labor.

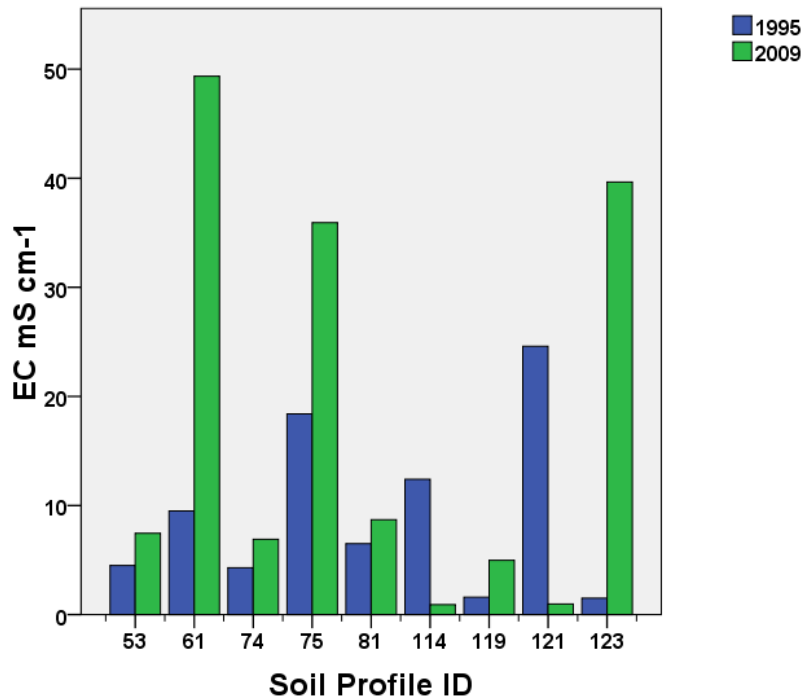


Figure 3. Comparison between 1995 and 2009 topsoil (0-40 cm) salinities of selected profiles (sets are significantly different at  $p=0.05$ )

Results from soil survey will be integrated in oasis-scale modeling to test field management and agropolitical scenarios to combat salinity and mitigate its effects.

## 5 Conclusions

Top and subsoils salinity had been increasing during 70s till 90s in Ktoua and appear to be still increasing threatening crop yields and food security. The combined effect of increasing salinity and water shortage—along with other factors—had lead to decreased agricultural yields and reduced income and hence forced youth migration from the area. Ktoua is an example of what is expected to occur in other oases of the Draâ in the near future

## 6 Acknowledgement

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