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Comparative Study of Three Land Evaluation Systems in a North African region: case of Algeria

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Abstract

The present research consists of a comparative study of three land assessment systems Land Capability Classification (LCC), s STORIE and an assessment system adopted by the National Institute of Soils, Irrigation and Drainage (INSID) in applying them to two ecologically different regions, namely: the High Plains (Sidi Bel Abbes) and a steppe region (Djelfa).

According to the results obtained by the three systems, there is a similarity between the evaluation results of the three systems in comparison with the Sidi Bel Abbès region. The INSID rating system gave lower results compared to the other two systems, this is due to other soil properties that are only taken into consideration by INSID, such as the total lime content which is quite high for most cartographic units, the correlation between LCC – INSID is very highly significant $p<0.001$). Likewise, this relationship is significant between INSID - STORIE and highly significant ($p<0.05$) for LCC - STORIE. In order for the INSID system to be suitable for the contexts of Algeria and North Africa, some recommendations have been made. The reduction in the number of certain soil variables that are subject to evaluation, particularly those concerning interrelated properties. As is the case with pH and total limestone, if a soil has a high level of limestone it will have an impact on its pH at a certain limit.

The System adopted by INSID can be used for land valuation in the same study context, as long as the correlation is significant between INSID and LCC. However, the system adopted by INSID is improving, in order to make it more efficient.

Keywords : Land Evaluation, LCC, STORIE, INSID, Comparison, Algeria

1. Introduction

Land valuation involves estimating how it will respond to different types of use. However, it makes it possible to rationally decide on land use patterns, based on a multidisciplinary analysis, which gives an approximation of input requirements and expected production (FAO, 1988).

Furthermore, the need to make the best use of land has never been as pressing as today, in fact, the rapid population growth and urban expansion we are witnessing make agricultural land a rare resource.

However, land assessment for use type planning is carried out by different methods, in terms of the number and type of criteria taken into consideration (Oluwatosin and Ogunkunle, 1995). On the other hand, most systems that have been developed and used internationally do not take into account land characteristics specific to the local conditions of other regions outside of those where they were initially developed as noted by Dent and Young (1981). Therefore, the need to test the methods in these areas to determine their reliability (FAO, 1976; Oluwatosin and Ogunkunle, 1995), as their ability to predict land suitability in these areas remains uncertain (Adeyanju and Fasina, 2007). . As a result, in the arid and semi-arid environments of North Africa, limestone accumulations are frequently associated with those of gypsum and soluble salts. In many cases, the soils are salty, limestone and gypsum at the same time (Halitim, 1988; Hadj-Miloud et al., 2018; Hadj-Miloud, 2019; Hadj-Miloud, 2022a; ; Hadj-Miloud, 2023a; 2023b, Assami et al., 2024). It is therefore important to test several land evaluation systems, in order to adopt the most efficient system for the soils of North Africa.

Various approaches have been developed, such as that noted by FAO (1976) which defined a new approach to land valuation, called the land valuation framework. There is the approach of the United States Department of Agriculture (USDA, 1967) called: Landcapacity Classification (LCC), and also the evaluation system of R. Earl STORIE (1976).

The National Institute of Soils, Irrigation and Drainage (INSID) of Agérie has adopted a system for evaluating agricultural land which is inspired by the parametric method of R. Earl STORIE and the FAO guide. , it is in a way a hybrid approach. This system evaluates agricultural land based on the most common soil characteristics in Algeria in a particular way, and in the North African region in general. It should be noted that in North Africa little scientific work has focused on the evaluation of agricultural land. However, some works have

attempted to study the question of land valuation in the African environment such as Asadu et al., (1997) and Ukaegbu (2023).

The main goal of this work is to make a comparison between the system adopted by INSID and the two American systems, the STORIE index and the land capability classification of the U.S.D.A. By applying these three evaluation systems to two ecologically different regions, namely: High plateaux (Djelfa), High plains of Sidi Bel Abbès. This is for the purpose of improving the INSID system for the Algerian context.

2. Material and methods

Study description

Our work was carried out in two regions which present an ecological difference, namely: the region of Djelfa and Sidi Sidi Bel Abbès.

The Djelfa region occupies the central region of Algerian territory, located at an altitude of 1144 m (Fig 1). This part of the Algerian steppe is characterized by a Mediterranean-type climate, strongly marked by insufficient and irregular precipitation (less than 300 mm).

The region of Sidi Bel Abbès is located to the west of the capital, occupies a central position and extends over 15% of the territory of the northwest region of the country. However, the climate of this region is relatively dry throughout the region with rainfall less than 500mm (Fig 1).

Figure 1 : Geographic location of the study area

Methodology

The methodology adopted for carrying out this research is as follows:

Application of the three land evaluation systems, STORIE, LCC, INSID. Two regions were evaluated, namely: the high plateaux (Djelfa), high plains of Sidi Bel Abbès, which represent different pedological and climatic contexts. The analytical and descriptive data we used for the evaluation were provided to us by INSID. The assessment of the three regions was done manually, following an assessment guide for each system to assess the soils of each region. More than 200 soil profiles were evaluated using the three evaluation systems.

The soil characteristics taken into consideration for land evaluation by the INSID system are: texture (tx), depth (pr), stony load (%), Total limestone (ct) (%), Exchange capacity cationic (CEC) (cmol (+)/kg), Electrical conductivity (EC) (dS/m), pH, Structural stability index (Is),

The rating scale varies from 1 to 100, these constraints are classified as follows: 0 represents no constraint, 1 represents a mild constraint, 2 represents a moderate constraint, 3 represents a fairly severe constraint, 4 represents severe constraints and 5 represents a very severe constraint. Soil factors are rated according to their degree of constraint for agriculture (INSID, 2001).

the main indices obtained will be multiplied as follows:

$$Il = pr \times (cc/100) \times (tx/100) \times (Is/100) \times (ct/100) \times (CEC/100) \times (pH/100) \times (CE/100)$$

The USDA Land Capacity Classification (LCC) is one of several interpretive soil grouping systems developed specifically for agricultural purposes. This method is classified in the first group, namely constraint approach methods.

Furthermore, the properties or criteria applied by LCC for land evaluation are as follows:

1: Effective depth. (cm), Textures, Permeability (cm/h), Drainage class (state).

5: Available water retention capacity (cm of water/cm of soil), Slope (%), Erosion (state), EC (dS/m) and Alkalinity.

The system is made up of two main categories of soil grouping: suitability class and suitability subclass. In contrast, soil properties are first tested against the criteria for the best soil class. If all criteria are not met, the soil is downgraded to the lower class.

The types of constraints are represented by the subclasses: e, w, s and c are shown in Table 1.

e: Risk of erosion.

w: Excess water, drainage, flooding.

s: Depth texture, rooting constraints.

c: Climatic constraints.

Table 1. The digital conversion of each class of the LCC (LESA, 1997)

Classes	Notation/100
I	100
IIe	90
IIIs,w	80
IIIe	70
IIIs,w	60
IVe	50
IVs,w	40
V	30
VI	20
VII	10
VIII	1

The STORIE system is a method of weighting soils, called the STORIE index, based on soil characteristics that influence potential land use and productive capacities. Percentage values (%) are assigned to each soil property, including soil profile development and depth (factor A), slope (factor C), surface texture (factor B) and soil conditions. soil other than those of the three factors mentioned above (factor X). These factors relate to: drainage, nutritional status, erosion and alkalinity.

Furthermore, the most favorable conditions regarding each factor are rated at 100%. The values of each factor are multiplied. The result is between O and 100 will be the Storie land index. STORIE land index = A × (B/100) × (C/100) × (X/100) = [0- 100]. Thus, the STORIE evaluation index makes it possible to classify the soil into suitability grade, according to STORIE (1976) there are six grades : grade 1 (excellent), level 2 (good), level 3 (average), level 4 (poor), grade 5 (very poor) and grade 6 (non-agricultural soil).

Concerning the evaluation system adopted by INSID, its principle consists of a classification of soil properties according to their degree of constraint, a six-level scale is proposed (0.1, 2, 3, 4, 5) (INSID, 2001).

After obtaining the results, a comparison of the land indices obtained was carried out, during the evaluation of the two study regions. This comparison is based on 3 indices, namely: INSID evaluation indices, STORIE evaluation indices, LCC evaluation indices.

Finally, for the statistical analysis of the results, we adopted the 2×2 correlation method based on the value of the correlation coefficient "r", compared to those in the Pearson table. This approach allows us to appreciate the nature and intensity of the relationships existing between the three land valuation systems. The correlation method has been applied in numerous works which have been the subject of a comparison of land evaluation methods (Ukaegbu, 2023; Hadj-Miloud, 2022b).

3. Results and discussion

Results of the three land evaluation systems applied for the Sidi Bel Abbés region are illustrated in Figure 2.

The land evaluation results obtained by the three regarding the Sidi Bel Abbés region are illustrated in Figure 2.

Figure 2 shows that the INSID system performed lower than the other two rating systems. However, there is a similarity between the INSID and STORIE systems, this is due to the fact that both systems are based on the weighting of soil properties. Therefore, the INSID evaluation indices are between S3 and S4, that is to say the land is classified in the class of soils moderately to poorly suitable for agriculture. On the other hand, the LCC system gives evaluation results very close to LCC. Thus, most soils are classified in the good to moderately suitable class for agriculture. We conclude that the LCC and STORIE evaluation system gave practically similar results. However, the results obtained by the INSID system differ from those of LCC.

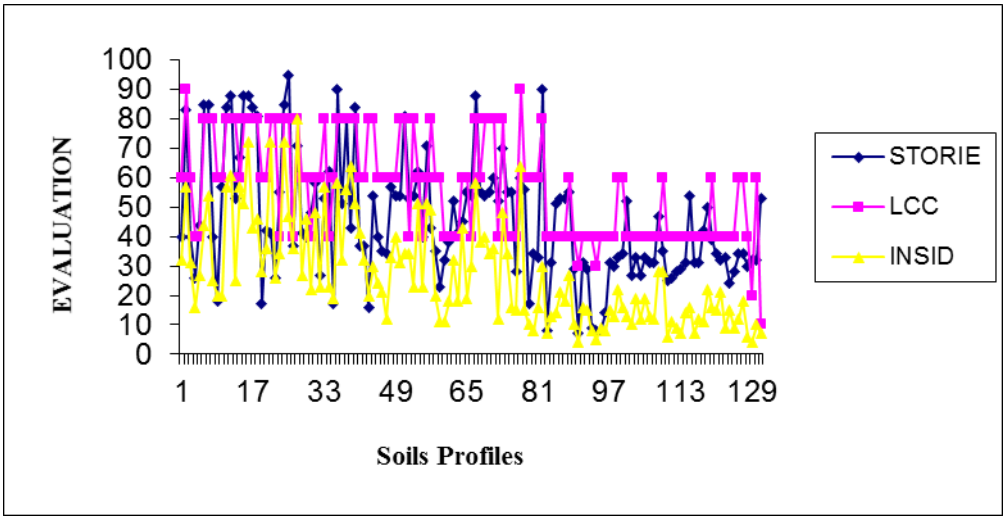

Figure 2 : Representation of the land indices of the three systems in question Sidi Bel Abbes region

Table 2 summarizes the correlation coefficients (r), for the three land valuation systems, in matrix form.

Table 2. Results of correlations between the three systems

	INSID	LCC	STORIE
INSID	-	0.72	0.74
LCC	0.72	-	0.59
STORIE	0.74	0.59	-

The correlation matrix (Table 2) clearly indicates that the correlation between INSID – LCC is very highly significant at the probability threshold P>0.001, (Figure 3) with r=0.72. The scatter plot closely approximates the regression line, which expresses the intensity between the INSID land valuation system and LCC (Hadj-Miloud et al., 2022).

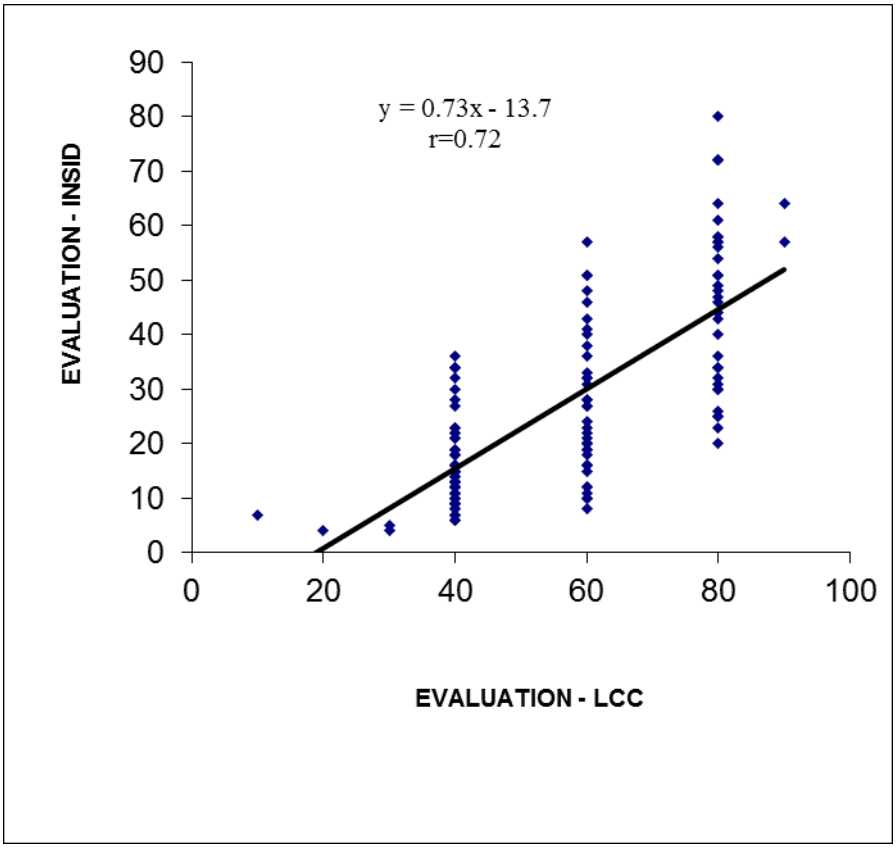

Figure 3 : Correlations between INSID and LCC

However, the correlation between INSID - STORIE is highly significant at the p<0.001 level, with r= 0.74. This result is well illustrated by Figure 3 which clearly shows the intensity of

the relationship between these two evaluation systems. Likewise, the scatter plot is relatively tight and the points are distributed on either side of the linear regression line. This result means that the two systems gave relatively close results.

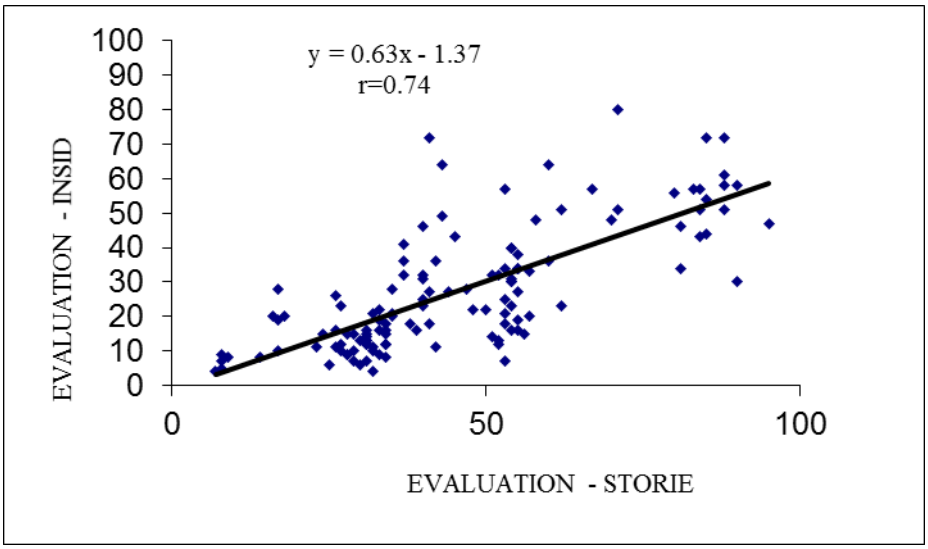

Figure 4 : Correlations between INSID and STORIE

Figure 5 reveals the existence of a significant correlation between the STORIE and LCC evaluation systems ($r=0.34$; $p<0.05$). Likewise, the scatter plot in Figure 5 is relatively spread out and is concentrated on either side of the linear regression line. However, the linear regression line illustrates an appreciable relationship between the two systems.

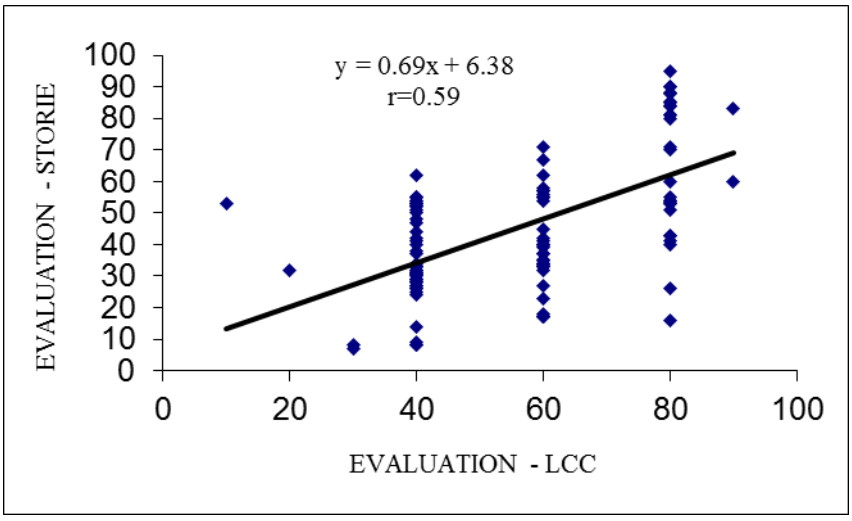

Figure 5. Correlations between STORIE and LCC

Results of the three land evaluation systems applied for the region of Djelfa Region

According to Figure 6, we observe à rapprochement of the evaluation results of the three systems. The results of the INSID rating system are lower compared to the other two rating

systems. However, the INSID and LCC evaluation systems gave relatively similar results for a number of map units. Likewise, the results of the INSID system are similar to the STORIE system for a reduced number of soil profiles.

Furthermore, the LCC evaluation system gave superior evaluation results compared to the other two systems, but there is a similarity between STORIE and LCC for some map units.

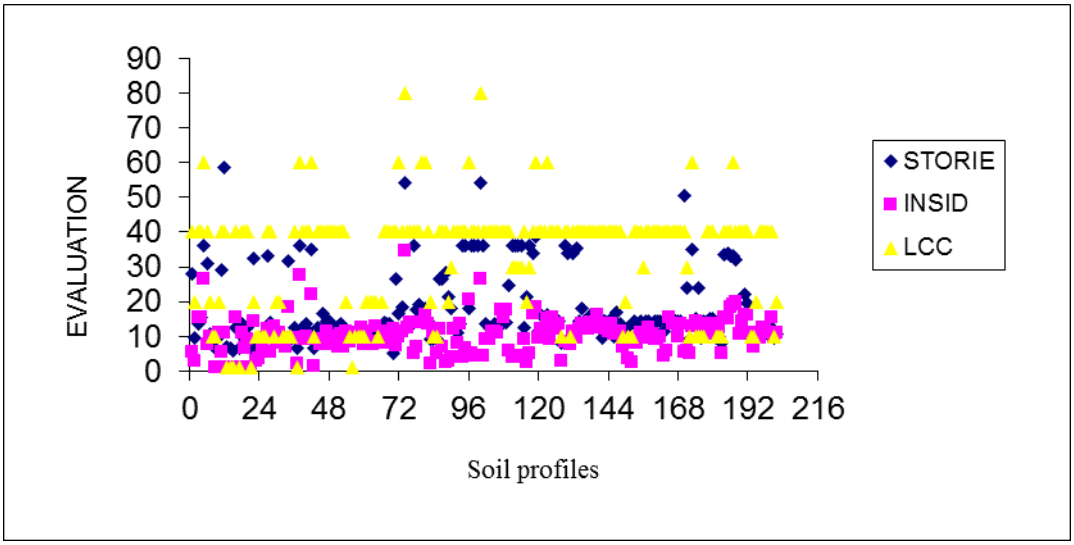

Figure 6 : Representations of the land indices of the three systems obtained for the Djelfa region

Table 3 reveals significant correlations between INSID-LCC ($r = 0.55$; $p<0.05$), the same for STORIE-LCC ($r = 0.5$; $p<0.05$) (Hadj Miloud, 2005). On the other hand, the correlation is not significant between INSID-STORIE LCC ($r = 0.28$; $p<0.05$).

Table 3. Results of correlations between the three evaluation systems

	INSID	LCC	STORIE
INSID	-	0.55	0.28
LCC	0.55	-	0.5
STORIE	0.28	0.5	-

The observation of Figure 7 indicates that the cloud of points is relatively dispersed, nevertheless the relationship remains significant between LCC-INSID ($r = 0.55$; $p<0.05$) and also significant for STORIE-LCC with regard to the correlation coefficients ($r = 0.5$; $p<0.05$). Therefore, there is a trend of increasing indices obtained by INSID with regard to LCC. It is the same for the two other systems LCC AND SRORIE.

Furthermore, in a previous study it was shown that the significant correlation between LCC and Fertility Capability Classification (FCC) shows that one or the other can be used on site (Ukaegbu, 2023). Likewise, the lack of correlation between evaluation systems is due to differences in the definitions of their criteria. LCC at the base is a qualitative classification and INSID is a classification based on quantitative values (soil rating), as indicated by Yousif et al. (2020) in à similar search. Therefore, the System adopted by INSID can be used for land evaluation in the same study context, to the extent that the correlation is significant between INSID and LCC at the levels of probability thresholds 0.05 and 0.01. Although the system in question requires some amendments, in order to make it more efficient.

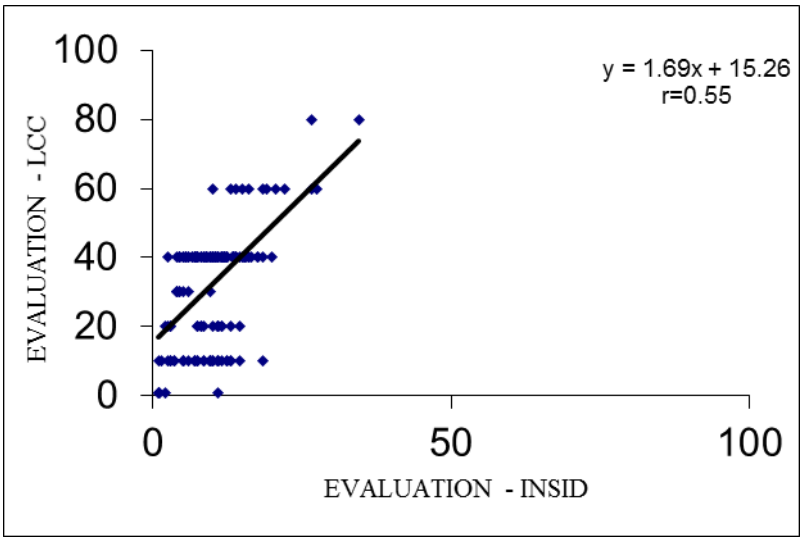

Figure 7 : Correlations between INSID and LCC

4. Discussion

According to the results obtained by the three systems, there is a similarity between the evaluation results of the three systems in comparison with the Sidi Bel Abbès region. The INSID rating system performed lower than the other two system; this is due to other soil properties which are only taken into consideration by the INSID, such as the total limestone rate which is quite high for most of the mapping units, the correlation between LCC – INSID is very highly significant and it is significant between INSID - STORIE and highly significant for LCC - STORIE.

The evaluation results obtained by the three systems are almost similar because the soils of the study region present a major constraint which is the texture and over the entire depth of the soil. These two soil properties are taken into consideration during the evaluation by the three systems. There are other constraints such as the lime content which is very high as well

as the CEC, due to the texture which is coarse. It should also be noted that the soils of the region are not very stable. For this reason, the INSID rating system performed slightly lower than the other two systems. The correlation is highly significant between INSID – LCC and LCC – STORIE and it is significant between STORIE – INSID.

The non-correlation of the land valuation index between the other systems could be the origin of the differences in the definitions of their different criteria. LCC is a qualitative method while INSID provides quantitative value for soil scoring (Yousif et al., 2020). In addition, only certain parameters were taken into consideration only for certain systems. The non-correlation between the evaluation systems notably showed the complementarity of STORIE with soil analyzes as indicated by Sanchez et al. (1982). It should be noted that the best complementary index to land evaluation is the land productivity index (Ukaegbu et al., 2012). While all three systems evaluate the soil in a general way without taking into consideration either the type of land use or its productivity.

Furthermore, Hadj-Miloud (2022b) showed that the CEC (cation exchange capacity) and the Is (structural stability index) which are rated with 60 or 80/100 cause a downgrading of the soil towards lower classes, this is accentuated by other constraints such as texture. The latter's assessment scale differs from the other two assessment systems, therefore there was an underestimate on the part of the INSID system. Regarding the STORIE and LCC systems, there is a notable difference between the results of the three evaluation systems. However, there is a certain similarity between the evaluation results of STORIE and those of the LCC,

In addition, the application of the INSID evaluation system revealed that INSID offers soil evaluation scales without specifying the analysis methods used. This for most soil properties, while knowledge of analysis methods is essential for the interpretation of the results. Likewise, for a possible evaluation like the present case, as an example for the evaluation of salinity, INSID proposes a scale without indicating the name of the analysis method, is in reality that of the paste saturated according to USSL standards (1954). In the present study, the “diluted extracts ratio 1/5” method was used. According to the latter the soil is considered salty from 1.4 dS/m while for the saturated paste method the soil is considered salty from 4 ds/m, hence the significant difference between the two methods. . In order for the system adopted by INSID to be effective for the North African regions, a certain number of suggestions have been made. These proposals are the name of the soil analysis methods for each evaluation scale retained for the evaluation of soil properties. Likewise, reduce the number of certain soil variables that are subject to evaluation, particularly those concerning interdependent properties. As in the case of pH and total limestone, if a soil has a high level of

limestone it will have an impact on its pH at a certain limit (Djili, 200), we will then have penalized the soil twice by a single property. There is also CEC and texture. Indeed, in Algeria the CEC depends mainly on clays, due to the poverty of the soil in organic matter. These parameters cause a considerable downgrading of land suitability classification.

Finally, the System adopted by INSID can be used for land valuation in the same study context, as long as the correlation is significant between INSID and LCC. However, the system adopted by INSID is improving, in order to make it more efficient.

5. Conclusion

A comparative study of the three land evaluation systems STORIE, LCC, INSID was carried out in two different regions Djelfa, Sidi Bel Abbès.

Concerning the region of Sidi Bel Abbès and Djelfa, a statistical analysis was carried out with the aim of carrying out a comparative study between the results obtained by the three evaluation systems in question. The evaluation results obtained by the three systems revealed the existence of a difference between LCC, STORIE, INSID. Furthermore, there is a connection between STORIE and INSID. On the other hand, INSID gives rise to lower evaluation results compared to the other two systems, but there is a closer connection with STORIE than with LCC when comparing the classes of the two systems, moreover the correlation is very highly significant between INSID and STORIE, we note on the other hand an absence of correlation between LCC and INSID.

Finally, the land evaluation system adopted by INSID requires improvements, so that it is adequate to the Algerian context, and to the African environment in general.

The final objective remains the increase in land productivity within the framework of precision agriculture.

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