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Phytoadaptation in Desert Soil Prediction Using Fuzzy Logic Modeling

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***Abstract*—**In terms of ecology forecast effects of desertification, the purpose of this study is to develop a predictive model of growth and adaptation of species in arid environment and bioclimatic conditions. The impact of climate change and the desertification phenomena is the result of combined effects in magnitude and frequency of these phenomena. Like the data involved in the phytopathogenic process and bacteria growth in arid soil occur in an uncertain environment because of their complexity, it becomes necessary to have a suitable methodology for the analysis of these variables. The basic principles of fuzzy logic those are perfectly suited to this process. As input variables, we consider the physical parameters, soil type, bacteria nature, and plant species concerned. The result output variable is the adaptability of the species expressed by the growth rate or extinction. As a conclusion, we prevent the possible strategies for adaptation, with or without shifting areas of plantation and nature adequate vegetation .

***Keywords*—**Climate changes, dry soil, Phytopathogenicity, Predictive model, Fuzzy logic.

I. INTRODUCTION

BOTH physical and biological processes are involved in the formation of lands resource. The loss of grassland in favor of the invasion of shrubs in semi-arid areas causes changes in the distribution of soil nutrients. Thus, the invasion of shrubs in semi-arid areas is associated with the development of islets according to the appearance of shrubs. Several microbial phenomena can be distinguished in desert environments: formation of biological soil crusts, colonization of plant roots by AM fungi, and the action of plant growth-promoting bacteria [1]. Nutrients and organic matter contribute to the stabilization process. The fine-textured soils become micro habitats for entire communities of organisms at all levels as islands of fertility resources [1]-[6]. Nitrogen fixation is a common event in most desert ecosystems. A robust assessment of the bacterial diversity of arid lands is a critical first step toward evaluating the potential contribution of soil bacteria from these regions to ecosystem biogeochemistry [7]. This is necessary to identify the diversity of the bacterial flora arid soils and to assess its ability to contribute to the biogeochemical cycle. The problem is that the arid ecosystems are highly heterogeneous distribution of resources, with greater concentrations of nutrients and microbial densities which focus much more vegetation than in bare soil. And all the parameters involved in the process are characterized by uncertainty and imprecision.

In order to analyze their effects on proliferation or extinction of plant species in arid areas, it is necessary to have an analysis tool that fits with these phenomena. In this study, we propose a tool based on artificial intelligence techniques such as fuzzy logic principles.

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II. MATERIALS AND METHODS

A. Soil

The soil plays an important role in determining the nature and quality of the vegetation. Different types of soil must be taken into consideration. Bedrock, limestone, sand...

The chemical composition of the soil is an essential element in plant growth as nutrients. The Characterization of elements important to bacterial nutrition in soil samples element ($\mu g.g^{-1}$) [TC^1, TOC^2, TN^3, P, S, Fe, Ca, Mg, K]. The physical characteristics of the ground can be represented by Elevation (m), temperature, wind speed ($m.s^{-1}$), pH, electrical conductivity ($mS.cm^{-1}$) and the concentration of Na expressed by ($mg.g^{-1}$).

B. Population of Micro-Organisms

In the preserved area, the number of cultivable bacteria can include *Rhizobium* sp. and *Streptomyces* sp. This bacterial abundance in resource islands suggests that plant–microbe interactions delay formation of badlands in the area [8]. The desert varnish (or colorization of rocks) is a product of microbial activity. The varnish is composed of micro-organisms that concentrate manganese from their surroundings to produce manganese-rich films that eventually form brown-to-black coatings. These microbes are cultivable and in the laboratory produce manganese rich bio films [9] in [1]. In general, we can summarize the bacterial flora in three levels: soil rich in plant growth promoting bacteria, soil bacteria through rate and poor soils in promoting bacteria growth.

C. Fuzzy Logic Inference

The fuzzy logic approaches, a sub-field of intelligent systems, are being widely used to solve a wide variety of problems in medical, biological and environmental applications. Fuzzy logic deals with reasoning on a higher level, using linguistic information acquired from domain experts. The above-mentioned capabilities make fuzzy logic a very powerful tool to solve many biological problems, where data may be complex or in an insufficient amount [10]. The fuzzy logic concept provides a natural way of dealing with problems where the source of imprecision is an absence of sharply defined criteria rather than the presence of random variables. The fuzzy approach considers cases where linguistic uncertainties play some role in the control mechanism of the phenomena concerned [11]. For example, there is not a straight-line relationship between the rate of plant growth and the chemical elements concentration.

In this study, we take to decision algorithms using the inference engine that makes inferences on a fuzzy rule system. For all the algorithms presented below there is a common rule form for rules that associate an observation vector.
a= (a(1), a(2), …. a(n)) with a diagnosis. Further, we assume the following general form of the k-th rule in the system (k = 1, 2, …K):

If a(1) is A_{1k} AND …AND a(n) is $A_{n,k}$ THAN b is B_k where Aik, are fuzzy sets (whose membership functions are designated by (μAi,k) that correspond to the nature of particular observations (for simplicity we assume the sets to be triangular fuzzy numbers) whereas k B is a discrete fuzzy set defined on the result set, with the B_k membership function. The particular decision algorithms to be used in plant effect have in common both the inference engine and the procedure for rule system derivation from the learning set. In the proto-formal deduction rule, the syllogism:

Q_1 A's are B's AND Q_2(A&B)'s are C's THAN Q_1Q_2A's are (B&C)'s.

III. Fuzzy Logic Modeling

A most studies interest exists for evaluating effect of physical and chemical parameters on plant growth. In our case, we can introduce the relationship between most parameters and rate of plant growth with vegetation type (Tables I, II).

TABLE I
Physical Parameters Effect on Bacteria Growth

Elevation (0-4000m)	pH (4-9)	EC (0.1-3 ms/cm)	Na (0.5-1.5 mg.g)	Veget. type	% Plant cover
Low	Acid	Low	Low	1	Low
Medium	Neutral	Medium	Medium	2	Medium
High	Basic	High	High	3	Dense

TABLE II
Chemical Elements Concentration Effect on Bacteria Growth

TOC (100-300) μg/g	TN	Other elements concentration	Vegetation type	% Plant cover
L	L	L	1	Low
M	M	M	2	Medium
H	H	H	3	Dense

A. Fuzzyfication of Inputs

The data for the inputs were classified into three linguistic categories: The input –Elevation- [Low, Medium, high]. In the same way, all other inputs are fuzzyfied. A value is assigned to each variable (the acidity, the electrical conductivity, the Na concentration, and the all TOC, TN, P, S, Fe, Ca, Mg, K) (Fig.1).

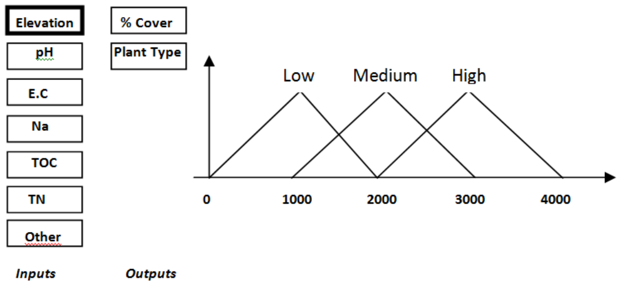

Fig. 1 Fuzzyfication of input variable "Elevation"

B. Fuzzyfication of Output

The data for the output (the % Plant cover and the Vegetation type) was classified into three linguistic categories: Plant cover Low, Medium and High and the other output variable "Vegetation type", we have chosen three type of arid vegetation -1-2-3 (Fig. 2).

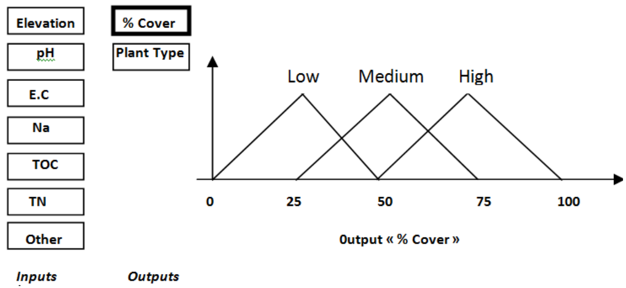

Fig. 2 Fuzzyfication of output variable "% Plant Cover"

C. Fuzzy Rules

The rules determined by the choice of the fuzzy membership function are defined for each input variable. In general form, each fuzzy rule is written as were A1 and A2 are the fuzzy sets that describe the nature of the inputs, such as young, adult, or old. The linguistic control rules of this system are given by [12]: **If** X_1 **IS** $X_1(1)$ and X_2 **IS** $X_2(2)$ and…Xn **IS** Xn(n) **Than** Y_1 is $Y_1(1)$

D. Defuzzifier

This system has tow outputs that describes the vegetation type and its degree of cover surface expressed by percentage of vegetation cover. In fact explains the contribution of each factor on bacteria growth in dry soil that induces directly effect on each plant species and degree of proliferation. The crisp value outputs are given by the defuzzyfication process after estimating its inputs values. In this system we used centre of average (C.O.A) method which has the mathematical expression that is: (ΣSi.Ri)/(Ri).

In the defuzzyfication, the exact expression is obtained with "centroïd" method according to validity degree. The outputs values according to the inputs values obtained from the designed fuzzy engine system.

IV. Results and Discussion

The factors effect on bacteria soil and the effect on vegetation system is based on fuzzy logic model. It is designed for measurement of different parameters. This system consists of seven inputs variables. The rule base of this system is used to determine the outputs parameters values: (low); (medium); or (high) for each species of plant, according to the seven inputs values. MATLAB-simulation is used by applying rules. Fig. 3 shows the MATLAB-rule viewer and simulation result.

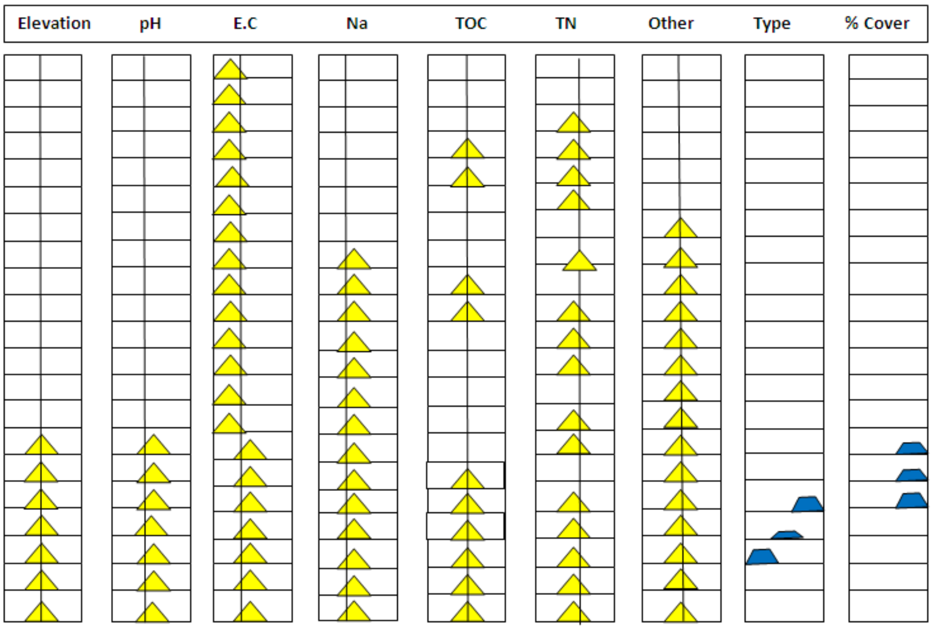

Fig. 3 Application Example: attribution random variable inputs and direct reading of the output variable

V. Conclusion

The artificial intelligent system using fuzzy logic method could extend our understanding of factors affects proliferation of bacteria soil and its impact on vegetation of arid or semi arid soil. The intelligent software created in this study could be used for prevention of arid soil the nature of vegetation and its degree of growth according the physical and chemical soil parameters. The goal of this study is to design and perform a pilot investigation which will provide preliminary data. Modern methods of computational intelligence such as fuzzy logic are used to achieve the highest accuracy of pattern recognition. The result of the fuzzy program so far, is a numeric and symbolic terms of plant variety and percentage of vegetation cover, using the fuzzy inputs data in the universe of discourse (Low, Medium or Hiegh). As the input parameters are characterized by uncertainty, we believe that this tool is very adequate. We emphasize that our fuzzy system is not meant to replace or substitute for an experienced physicians; on the contrary, we envisage that the fuzzy logic system should be viewed as a decision support in the most accurate.

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