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# Fuzzy Logic Inference Proposal for Seaweed and Seagrass Modeling

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**Abstract**

Global warming and climate change impacts have influence on moss, seaweed and seagrass, but their numerical modeling has not been treated in open literature. Mostly linguistical data are available subjectively even after the literature review and in this paper fuzzy logic modeling principle is explained briefly so that in the future some researchers may apply this technique for objective scientific results. The most important parameters that should be taken into consideration in such a modeling are temperature, sea level rise, pH and carbon dioxide levels. Although there are several works in the literature that are based on statistical regression methodologies with rare numerical data, such equations do not provide the internal logical composition of the modeling. In this paper, the proposed fuzzy inference system (FIS) model opens ways to explore the logical bases of sea plant environment modeling even though numerical data is not available. It is recommended that in future studies FIS modeling should be used by collecting expert views from different sources to reach consensus for better prediction of sea plant environmental problems.

**Keywords:** Moss; Fuzzy; Inference; Seaweed; Seagrass; Modeling; Logic

## Introduction

In any climate change modeling lithospheric and oceanic effects on the atmospheric lower layer (troposphere) dynamic behavior integration composition is used for future climate predictions. The importance of oceans is due to its heat and carbon absorption characteristics and global warming temperature increments cause sea level rise because of glacier melt. All these dynamisms of oceans affect biological moss, seaweed and seagrass habitats [1-3]. General circulation models (GCMs) provide climate change scenario outputs until 2100 concerning temperature, precipitation and other hydro-meteorology variables, but unfortunately, it is not possible to see any effect on the sea habitat environment. Logically, sea and land plants are sensitive especially to temperature changes and precipitation amounts, although there are numerous studies of climate change impact of forests, agriculture mangrove lands, but it is not possible to allege similar studies for sea floor plants. This may be due to absence of numerical data, which is not easy to measure and collect sea plant variations under especially temperature, pH, carbon dioxide ($CO_2$) and solar energy. The only measurable variability is the salinity change temporally and spatially. Although there are many works for the classical simple modeling and interpretation aspects, more detailed modeling studies are not available mostly due to either absence of numerical data and not enough linguistical interpretations or both.

The main purpose of this paper is to provide a fuzzy logic approach possibility, because this modeling principle depends on expert linguistical data, which can be obtained from experts in this topic. The structural architecture of fuzzy inference system (FIS) is proposed for future moss, seaweed and seagrass modeling with suggestions of fuzzy logic rule base proposition form. The reader can find fundamentals of fuzzy logic modeling principles in books written by different authors [4-6].

## Sensitive Parameters for Seaweed and Seagrass

There are several sensitivity parameters that affect ocean habitat plants always under global warming and climate change circumstances or not. Among these are the following parameters that have primary importance.

**a) Temperature:** This parameter affects seed germination and growth. It is therefore necessary to have temperature measurements not only from the sea surface but at debts close to seaweed, moss and seagrass environment.

**b) Sea salinity:** It regulates sea plant distribution and causes nutrient imbalance especially when extreme intakes take place due to salinity fluctuations.

**c) Carbon dioxide ($CO_2$) concentration:** This gives way to increase photosynthesis and thus growth of seaweeds and seagrass clusters. This is the most important climate change effects on sea plant environment changes.

**d) Sea level rise:** This is another factor that is related to climate change and in this way the salinity of the oceans is bound to decrease, and the sea plants are subject to more pressure, which affect their harmonious lives.

**e) Tidal fluctuations:** This causes to light, pressure and photosynthesis fluctuations.

**f) Solar irradiation:** Its effects on sea plants are in the form of photosynthesis inhibition and metabolic activity increase.

Each one of these parameters play the role of inputs into any modeling system and the output is measured qualitatively as performance criterion.

## Fuzzy Inference System

This paper proposes the use of fuzzy logic modeling principle in the absence of available numerical data, and such a verbal modeling principles can be applied even numerically after the availability of data. Even though numerical data were available, the general structure of a fuzzy inference system (FIS) modeling has three major components, which are fuzzification, fuzzy logic rule base and defuzzification. In crisp (two-value, bivalent) logic, which is the basis of any mathematical equation needs numerical data for application. The elegancy of fuzzy logic modeling is that there is no need for numerical data for its construction, because the relationships between input variables and output are dependent on expert views, which are expressed in terms of fuzzy sets. In crisp logical approaches each parameter (input and output) is considered holistically as temperature, sea level rise, etc. However, in fuzzy logic each parameter is considered partially as "low", "medium" and "high" temperature groups and the distinction between the two logic is given in figure 1.

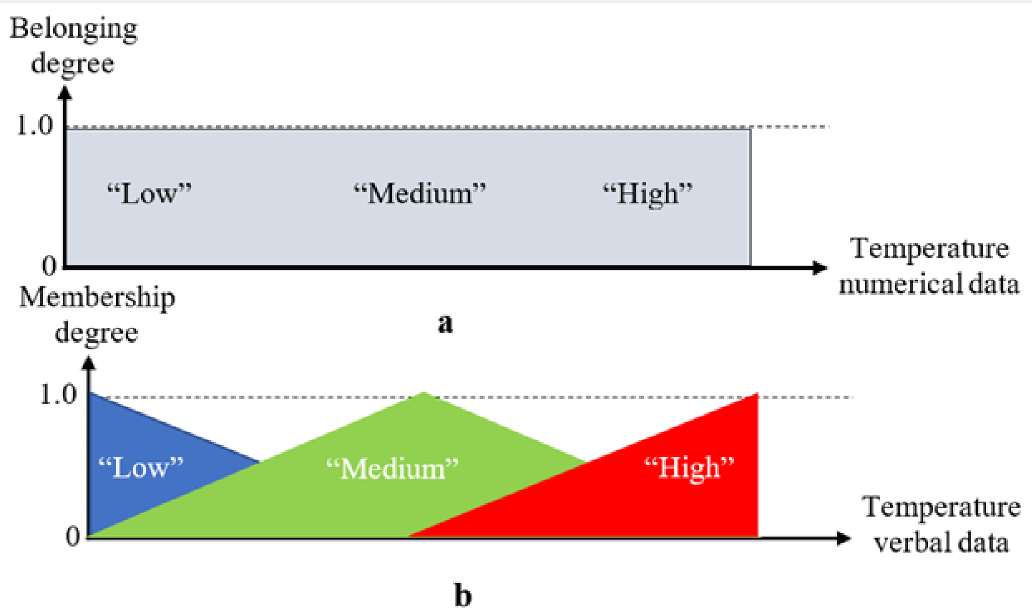


**Figure 1:** Temperature parameter a) Crisp logic, b) fuzzy logic.

It is clear from this figure that in fuzzy logic approach there are different membership degrees (MDs) between 0 and 1, inclusive, whereas in the crisp logic they are all equal to 1. Like figure 1 each effective factor is represented accordingly to the temperature fuzzy classification.

The general form of a FIS convenient for seaweed and alike plants' modeling is given in figure 2. In this figure input and output parameters are symbolized as temperature, T, salinity, S, carbon dioxide, C, sea level, L, tidal fluctuations, F, solar irradiation, I, and output efficiency, E. Instead of triangular fuzzy sets in figure


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1b, herein Gaussian fuzzy sets are proposed for input and output parameters. The most important expert view part of this model structure is FIS rule base. In figure 2 only one fuzzy rule is given in detail for example purpose, but there are many of such rules with combination of input fuzzy set combinations.

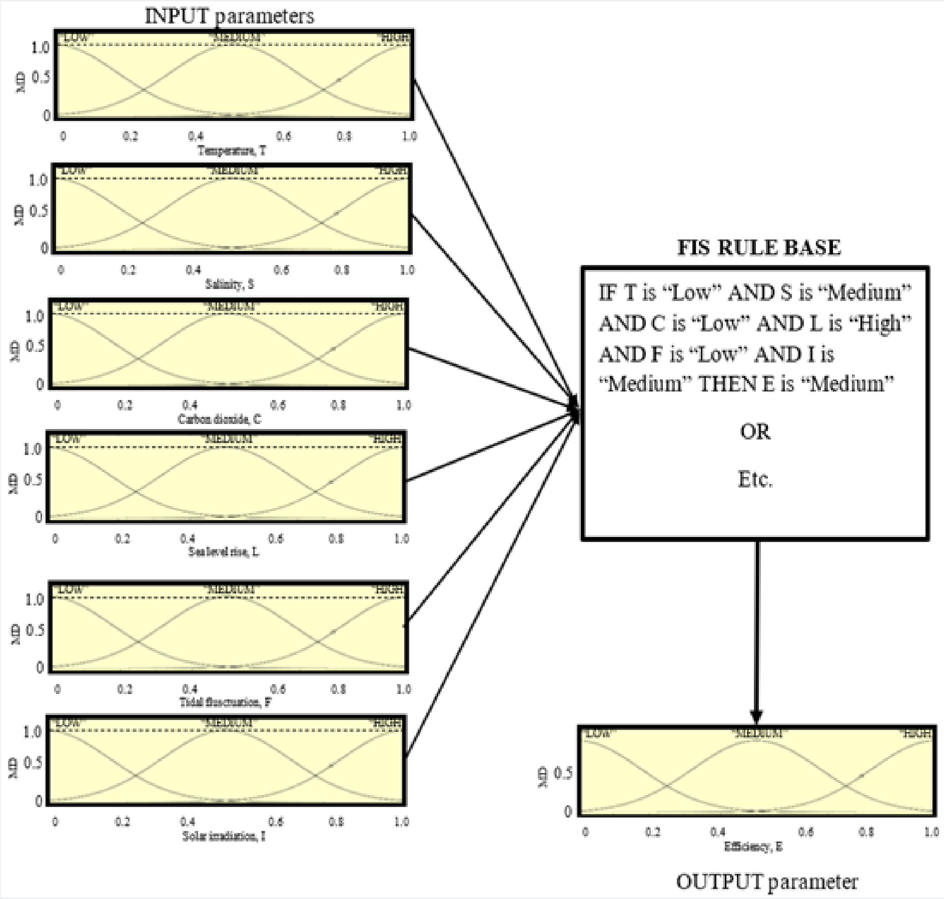


**Figure 2:** FIS structural parts for Seaweed environment modeling.

## Conclusion

In this paper the modeling structure of fuzzy inference system (FIS) is proposed for moss, seaweed and seagrass environment based on six input parameters as sea temperature, salinity, carbon dioxide, sea level rise, tidal fluctuations and solar irradiation and output parameter related to these is the efficiency response. The application of the proposed model in future studies will provide extensive rational horizontals for interpretation of sea plant environments in detail based on fuzzy logic and expert views combined through rule base. The proposed model can be used if numerical data becomes available, but even without such data the model can be developed and improved by consulting different experts on the topic.

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