

Modeling the Decisions of Segzi Plain Farmers Based on Cultivation Type Using the Multi-Variant Logistic Regression Model

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Extended Abstract

Introduction

Complex interactions between human decision-makers and their biophysical environment can be observed in land-use systems. These complexities are due to the differences between biophysical and socio-economic variables. To Model human decision-making, we need to know the interactions between landscape, community, and ecosystems. In reality, humans make decisions using a variety of strategies. We need to simplify the complex interaction between all individual agents and their environment by formulating an agent typology. In this paper, given the complexity of the decision-making in agent based models, the agricultural land use changes are simulated by the multi-variant logistic regression model to determine the socio-economic and environmental factors. The proportional random rules are used to implement the bounded rationality law for unique individual decision making. The particular environmental conditions of the region and the severity of the risk of desertification, the economic, social, and physical factors and the chemical parameters of soil were investigated with other environmental factors in the decision-making processes.

Methodology

Diverse data (including GIS and household data) were used to initialize the coupled human-landscape system and farmer household decision making simulations. GIS data is consisted of landscape agents (grid cell or patch) including Land use/cover (based on Landsat 8), soil Physico-chemical properties (EC, SAR, pH), texture, and moisture), institutional variables (i.e.

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ownership, village territory), and topography. Household data are socioeconomic attributes including labour force, educational status, income structure, and land properties. They were derived from an intensive household survey conducted in Segzi plain in Isfahan province (central Iran) during the spring 2013. The agent-based decision-making method has been presented by Le (2005). To determine decision-making approach, a mechanism of livelihood group dynamics was considered as follows. At first, Principal Component Analysis (PCA) was used to identify key factors differentiating household characteristics. These factors were then employed to classify the population into certain household groups using K-Means Cluster Analyses. The identified agent groups were interpreted and the types specified. Regression logistic multinomial model (M-logit) was employed for land-use choices modeling in each typological household agent group. The dependent variable of the model is land-use choice by farming households (P_{use}). The independent variables of the M-logit model include two groups of spatial variable and socioeconomic characteristics of farming households. Environmental features of lands were defined including P_{wet} (soil moisture), P_{slope} (derived from Digital Elevation Model), P_{elev} (elevation), P_{EC} (Electrical conductivity as salt factor), $P_{groundwater}$ (measuring the reduction of ground water), P_{PH} (PH), P_{SAR} (Sodium Absorption Ratio). Socioeconomic characteristics of farming households influencing farmers' decisions are including H_{age} (the age of the household head), H_{edu} (education of farmers), $H_{income/pers}$ (annual gross income per capita), $H_{holding/pers}$ (land holding per capita), $H_{cultivation/pers}$ (land cultivating per capita), H_{labor} (number of workers of the household), and H_{depend} (family members of the workers).

Results and Discussion

We reduced the dimensionality of 14 potential criteria by using PCA. The six principle components were extracted with total eigenvalues greater than 1.0, explaining 77.4 % of the total variance of original independent variables. The PC1 was strongly correlated to land variables: $H_{holding}= 0.911$, $H_{cultivation}= 0.925$. The principle components 2 (PC2), 3 (PC3), 4 (PC4), and 5 (PC5) were most weighted by percentage income from other off-farm activity factors ($H_{inothor}= 0.843$), household size ($H_{size}= 0.833$), percentage income from grain ($H_{inGrain}=0.773$), and percentage income from wheat ($H_{inWheat}= 0.898$), respectively.

The K-means run extracted three groups. The group I consists of households which are rich regarding both land resources and income. The group II includes households with average livelihood standard and the group III comprises the poorest households with the lowest amount of land and income. After the typological livelihood group determined, the variables affecting the decision-making were identified using the M-logit model. The effect coefficients were estimated with respect to the fallow land, i.e., the base case. The chi-square test shows that the empirical M-logit model is highly significant ($P<0.01$) to explain land-use choice by farmers of the group.

The M-Logit analysis of land use choices for household type I indicate that P_{slope} (-) and $H_{holding/pers}$ (-) inversely are effective variables for every land use option and have statistical significance at the 0.05, 0.1 level, respectively. A similar M-logit regression was also applied for the group II (figure.1). With regard to the choice of grain and wheat, effective factors were $H_{age}(+)$, $H_{labor}(-)$, $H_{depend}(+)$, $H_{cultivate_per}(+)$, $P_{SAR}(-)$, $P_{PH}(+)$ and $H_{edu=0}(-)$. The variables that significantly influence selection of other cultivations are $H_{labor}(-)$, $H_{depend}(+)$, $H_{cultivation_per}(+)$, $P_{EC}(-)$, $P_{Slope}(-)$ and $P_{groundwater}(-)$ For household type III, the results demonstrated that $P_{EC}(-)$, $P_{Slope}(+)$, $P_{wet}(+)$ were effective on each land use choice. In final, these coefficients are used to obtain the probability of selection for each land use according to the location of the plot in the process of implementing the model as follows:

$$P_i = \frac{\exp(\sum_K X_{ik} \beta_{ik} + \beta_{i0})}{\sum_j \exp(\sum_K X_{jk} \beta_{jk} + \beta_{j0})}$$

where β_{ik} is preference coefficients, X_{ik} dependent variables, and I is number of land use.

Conclusion

In this research, the preference coefficients for household decision-making are proposed by M-Logit model. These coefficients were applied to the process of implementing agent-based model at later stages. Multi-variant logistic regression model is useful to reduce challenges in modeling farmers decision and to simplify real world and it also indicates the effective factors and its rate that predict farmer decision using empirical data. All this suggests that the presented agent typology has been able to capture the diversity of land-use decisions and strategies in rural landscapes. Regarding the sensitive areas to desertification, as expected, soil chemical factors have a key role to determine type of culture. In general, recognition of the effects of soil physical and chemical factors in the decision, terms of regional strategy in Isfahan province, agricultural sustainability policy in this area and the attempts to avoid deserted villages can be applied for the planning and management of policies and programs in the future.

Keywords: agent based model, decision making, land use/cover, multi-variant logistic regression model.