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EXTENDED ABSTRACT

Optimal Allocation of Water and Land under Conditions of Uncertainty Using WFGP Model (Case Study: the City of Hamadan)

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Introduction

using mathematical programming models for determining appropriate cropping patterns has recently attracted a lot of attention. The agricultural sector is one of the most important and powerful economic sectors of the country. In the last ten years, its contribution to gross domestic product has been around 18% on average. The method of linear programming has been widely used in the fields of land allocation and determination of optimal cultivars since the 1960s. The purpose of linear programming is to maximize or minimize the objective function by considering a number of constraints and decision variables simultaneously. Fuzzy scheduling allows decision-makers to interfere with non-explicit data and data parameters in models. Compared to other models of math planning, it is more applicable and more flexible to be used in optimization problems and in determining the optimum crop cultivation patterns. Moreover, the results are more reliable (Rastegaripour and Sabouhi, 2009).

Mir Karimi et al. (2016) investigated the optimal cultivar pattern in the city of Amol using the ideal planning and taking into account the goals of reducing fertilizer use by seven percent. Their results showed a one-percent reduction in pesticides to protect the environment and a reduction of 93% of water use for the conservation of scarce water resources and sustainable agricultural development.

In this study, a fuzzy utopian planning model with three equal weight patterns, different weights, a decreasing weight and an incremental weight for ideals and water resource constraints are designed, taking into account environmental and economic objectives.

The main objective of this research is to optimize water and land resources in Hamadan province. First, we introduced a weighted fuzzy goal programming model (WFGP). Using this model, optimum cultivating model for farmers in Hamadan was determined, considering their income goals, environmental goals and sustainability of water resources of the region. Subsequently, the allocation between irrigation water inputs and land surface was calculated considering equal weights, different weights and different decreasing weights for the desired goals.

Methods and Materials

Objective function and model related to water and land allocation

The objective function of the problem involves minimizing the oscillation variables. If the oscillator variables are zero, the degree of the membership function is assigned a number. As a result, there is no fluctuation in the ideal (Kim and Wang, 1998). With this description, the ideal for optimal allocation of agricultural land is as follows:

$$Min: \sum_{i=1}^{2} w_i\theta_i^- + w_i\theta_i^+ \tag{13}$$

In the above relation, i=1, 2 and wt are weights corresponding to fuzzy ideals. The important thing here is that the total weights should be equal to one ($\sum_{i=1}^{2} w_i = 1$). (Sharma et al., 2007). The general form of planning model related to the optimal allocation of water and land is as follows:

$$Min: \sum_{i=1}^{2} w_i\theta_i^- + w_i\theta_i^+ \tag{14}$$

Subject to:

$$\sum_{s=1}^{S}\sum_{c=1}^{C} N_{cs}X_{cs} + \theta_1^- u_1^- \geq N \tag{15}$$

$$\sum_{s=1}^{S}\sum_{c=1}^{C} L_{cs}X_{cs} + \theta_1^- u_1^- \geq TL \tag{16}$$

$$\sum_{s=1}^{S}\sum_{c=1}^{C} F_{tc}X_{cs} - \theta_3^+ u_3^+ \leq F_t\,, \quad \forall T \tag{17}$$

$$\sum_{c=1}^{C} W_{cs}X_{cs} \leq W_s\,, \quad \forall S \tag{18}$$

$$\sum_{c=1}^{C} X_{cs} \leq L_s\,, \quad \forall S \tag{19}$$

$$0 \leq \theta_1^-, \theta_1^-, \theta_3^+ \leq 1, \quad \forall S \tag{20}$$

$$\sum_{i=1}^{2} w_i + \sum_{s=1}^{S} w_{2,s} = 1 \tag{21}$$

$$X_{cs} \geq 0 \tag{22}$$

Results and Discussion

As it is seen in Table (1), allocation lands vary in different patterns, but in all the three models proposed by Fuzzy Weight Planning, the highest level of land allocation is related to atmosphere and the lowest level is allocated to cucumber and potatoes.

Table 1- Allocation of land use planning fuzzy weight goal model in different patterns

The allocated cropping area in each pattern (in hectare)						
Variable	Season (c)	Product	Base year	The first pattern	The Second pattern	The third pattern
X11	Autumnal	Wheat	2467	891.51	898.45	902.65
X21	Autumnal	Barley	1840	3035.20	2063.60	3057.20
X31	Autumnal	Beetroot	560	0.0	0.0	0.0
X42	Spring	Garlic	668	848.94	858.10	831.98
X52	Spring	Cucumber	710	364.64	324.13	378.38
X62	Spring	Tomatoes	573	0.0	0.0	0.0
X72	Spring	Potato	765	2345.35	3421.56	3245.98
X82	Spring	Alfalfa	1270	1345.00	1871.12	1312.13
Total acreage of each pattern (ha)			8853	8830.64	9436.96	9728.32

Conclusion and Recommendations

Tomatoes and sugar beet are not recommended for cultivation in the region due to the greater need for fertilizer and labor inputs. For this reason, the allocation level of these two products is zero in the fuzzy idealized model of weighting model. Alfalfa has the highest level of crops due to high economic costs in the region. In order to maximize the potential profit, wheat is recommended for specific cultivating areas of 891.51 to 902.65 hectares and garlic with 838.98 to 8.848 ha for cultivation in the area. Results showed that creating flexibility in technical coefficients and using equal weights for fuzzy ideals will allocate the resources optimally and the total acreage of production will be reduced to 22 acres compared to cur conditions. However, as a result of using different weights (increasingly and decreasingly) for ideals, the total acreage of products increases as much as 25 and 875 acres. According to the results, planning and modeling from bottom-up were proposed in order to develop the agricultural sector. To accomplish this, it is necessary to begin makinf decisions from the urban level and continue up to the national level.

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