セイハン河下流灌漑プロジェクトの水資源制約と作付体系

Water Scarcity and Alternative Cropping Patterns in Lower Seyhan Irrigation Project: A Simulation Analysis

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1. Introduction

The purpose of this simulation analysis is to assess the water availability in 2070 and the possible cropping pattern and the farmer welfare in Lower Seyhan Irrigation Project (LSIP). We use expected value-variance (E-V) model which is used to analyze risk. By assuming future water scarcity in the LSIP, the simulation was run with i) current water use level, ii) 10% water reduction case, and iii) 20% water reduction case.

2. Water Use and Cropping Pattern in Lower Seyhan Irrigation Project

The Lower Seyhan Irrigation Project (hereafter LSIP) in Adana is initiated by the Turkish government as one of the important irrigation projects located in southern Turkey. During the 2002 cropping season, the largest area was planted by maize (56.57%), followed by citrus (13.51%), cotton (7.36%), vegetables (6.30%), melon (5.63%) and soybean (4.38%). In terms of production value, the highest value comes from citrus (38.90%), maize (33.43%), melon (9.86%), vegetables (6.24%), cotton (4.98%) and soybean (1.40%). Thus these major six crops covered 93.75% of total irrigated area and yielded 94.81% of total gross revenue of LSIP in 2002. Crops that yield highest gross revenue per decare are strawberry (2,417 YTL/da) and citrus (1,180 YTL/da) followed by fruit tree and vineyard.

3. Method and data

In order to estimate the optimal land resource allocated to various crops under different risky alternatives, expected value-variance (E-V) (or gross revenue) can be increased only at the expense of a larger variance of return (Harwood et al., 1999). Using this E-V model, it is possible to analyze optimal decision making under risky situations. The specification of expected value-variance (E-V) model is as follows:

$$\text{Max } Z = \sum_j \bar{c}_j X_j - \Phi \sum_j \sum_k s_{jk} X_j X_k \quad (1)$$

$$\text{s.t} \quad \sum_j p_j X_j \le b \quad (2)$$

$$\sum_j X_j = 1 \quad (3)$$

$$\text{and} \quad X_j \quad >= 0 \quad \text{for all } j,$$

where X_j is the proportion of land allotted to j^{th} crop, $\bar{c}_j$ is the mean gross revenue per decare for crop j, s_{jk} is the covariance of gross revenue between crop j and crop k, p_j is the water requirement per decare of j^{th} crop, and b is the maximum amount of water available per decare for irrigation and Φ is the risk aversion coefficient. Higher values of risk aversion coefficient indicate more risk aversion by decision makers. The solution of the model will give proportion of the area to be allocated to different crops to maximize gross revenue per decare under different risk aversion levels.

Eight major crops are chosen for the analysis. Those are maize, citrus, cotton, vegetables, melon, soybean, fruit and 2nd crop maize (II maize). The conveyance efficiency in LSIP and on-farm application efficiency under furrow irrigation are considered to be 0.8 and 0.6 respectively. Then it is assumed that the overall water use efficiency in LSIP is 0.48. This figure

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resulted in 683.52 million m^3 of water available for irrigation in whole LSIP. The total service area in 2002 was 1,168,830 decares. By dividing the actual amount of water available by the total service area in LSIP, the annual water availability of 585mm per decare for the base case was estimated.

4. Simulation results

The amount of irrigation water available for LSIP in 2070 is expected to decrease because of the decrease in precipitation by 5-10 mm in most of the months according to the pseudo-warming experiment by ICCAP[1]. Assuming that the availability of irrigation water in 2070 is going to decrease, the simulation of E-V model was run with i) current water use level (585 mm), ii) 10% water reduction case (526 mm), and iii) 20% water reduction case (468 mm).

Table 1. Land allocation in LSIP under base case (585 mm water availability)

RAP	0	0.0005	0.001	0.005	0.01
citrus	83.54	83.54	83.54	41.27	12.38
cotton					
vege					1.26
melon	16.46	16.46	16.46	58.73	76.58
fruit					9.78
gross revenue/da	2044.89	1945.55	1846.22	1243.47	974.68
shadprice	2.09	1.69	1.28		
idle				196.77	275.51

RAP: Risk Aversion Parameter

Table 1 shows the simulation result of base case. This table indicates the land allocation to various crops in LSIP with risk aversion parameter (RAP) between 0 and 0.01. In this base scenario, when farmers do not care any risk (when RAP=0), area under citrus and melon is 83.5% and 16.5% of the total irrigated land with average gross revenue of 2,045 YTL per decare. At the risk aversion level of 1%, area under citrus, vegetables, melon, and fruit is 12.4%, 1.3%, 76.6% and 9.8% respectively. This cropping pattern yielded average gross revenue of 975 YTL per decare in 2005 price. High risk aversion parameter yielded low gross revenue per decare. Under risk aversion level of 0.5% and 1%, water resources are under utilized resulting in redundant or idle water resources of 197 mm and 276 mm respectively. This means that in these cases, water is not the constraining factor in the model.

Similarly the 10% and 20% reduction of water availability resulted in lowering citrus production, which is water intensive, and increasing melon production, which is high value with relatively high income variability, between 0 and 0.1% risk aversion level.

5. Conclusions

Under the water constraint and variability of gross revenue, farmers are more likely to choose high value added crops such as citrus, melon, vegetables and fruit. There may be some factors that were not considered in the model which caused irrigation water in LSIP water not utilized fully. By making some adjustment for the water requirement, it may be possible to improve the model and simulation results.

6. References

DSI. (2002) Briefing of WUA and Year 2002 Management Activity Report, DSI VI Region, Adana.

DSI. (1997-2005) Yield Census Results for Areas Constructed, Operated and Reclaimed by DSI. DSI Operation & Maintenance Department, Ankara.

Nuran Özgenç, Faruk Cenap Erdoğan. (1988) DSI irrigated crop water consumption and irrigation water requirement.

Harwood, Joy, Richard Heifner, Keith Coble, Janet Perry, Agapi Somwaru. (1999) *Managing Risk in Farming: Concepts, Research, and Analysis*. Economic Research Service, U.S. Department of Agriculture. Agricultural Economic Report No.774.

[1] The Research Project on Impact of Climate Changes on Agricultural Production System in Arid Areas