UNIVERSITI PUTRA MALAYSIA

APPLICATION OF THE FUZZY APPROACH TO AGRICULTURAL PRODUCTION PLANNING IN THE ATRAK WATERSHED IRAN

SEYED AHMAD MOHADDES HOSSEINI.

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APPLICATION OF THE FUZZY APPROACH TO AGRICULTURAL PRODUCTION PLANNING IN THE ATRAK WATERSHED, IRAN

By

SEYED AHMAD MOHADDES HOSSEINI

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirement for the Degree of Doctor Philosophy

December 2005

Dedication

To: My wife and my daughter Seyedeh Zahra who are sharing in this study, My son Seyed MH who was born in Malaysia

And my martyr friends.

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Doctor Philosophy

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Chairman: Professor Mohd Ghazali Mohayidin, PhD

Faculty: Agriculture

The Atrak watershed is located in the northeast of Iran, where agricultural production is the main activity of the area. The government of Iran has adopted a sustainable agricultural development strategy for all watersheds in the country including the Atrak watershed. The government's goal is to embark on a sustainable agricultural development that not only provides the production of agricultural commodities and employment but also protects the environment from degradation. The rationale of adopting this strategy is that the watersheds of Iran, including the Atrak watershed, are facing many environmental problems especially severe soil erosion. The main purpose of this study is to define a framework for sustainable agricultural production planning for these watersheds particularly for Atrak watershed.

Watersheds are large-scale regions where agricultural production planning is usually associated with multiple objectives including economic, social and environmental targets. Uncertainty plays an important role in all agricultural planning because some factors are not fully controllable and some input data or parameters such as demand, resources, costs and objective functions are imprecise. This study develops and applies fuzzy multi-objective mathematical programming models to the Atrak watershed agricultural development plan. The models include three objectives, namely, profit maximization, employment maximization and erosion minimization, and they are subject to 89 constraints.

The models focus on sustainable agricultural production planning in order to determine the optimal cropping patterns in short-term and intermediate-term planning of the Atrak watershed. Results of the models show that the most important crops in the optimal plans in short and mid term are wheat, orchards (grape and other orchards) and alfalfa. Compared to current crop pattern, the results show that if the optimal plan was implemented, the optimal value of profit and employment would have increased respectively by 16.12 and 0.53 percent and erosion decreased by 19.88 percent. These figures may not show significant changes to the existing crop pattern, however it would improve farmers' income, and at the same time, achieve more sustainable agricultural development. The Atrak Watershed consists of eight zones. In this study, cropping patterns for all the zones are also determined.

The model is also applied to several scenarios, i.e. looking at different tradeoffs among different but conflicting objectives (using different weights). The result shows a high profit is achievable while pursuing erosion control and higher employment, whereas there are trade-offs between economic, environmental and social targets. In addition, the result also shows that if the decision maker insists on higher employment level, profit level will fall and the erosion will increase. Therefore, the decision maker should not expect more employment from agricultural sector of Atrak watershed. Where equal weights are given to the various objectives, the result shows that social goal (employment) and environmental goal (erosion) were more attainable over economic goal (profit) in the Atrak Watershed.

The study also compares the results from the fuzzy model with a non-fuzzy model. In the case of non-fuzzy model, goal programming (GP) formulation is used because GP is capable of handling multiple objectives and it is recognized as a useful tool for agricultural planning. This comparison indicates that the fuzzy linear multi-objectives model is

superior to the non-fuzzy linear techniques such as linear and goal programming models.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia memenuhi keperluan untuk ijazah Doktor Falasfah

APLIKASI PENDEKATAN FUZZY DI DALAM PERANCANGAN PENGELUARAN PERTANIAN DI LEGEH ATRAK, IRAN

Oleh

SEYED AHMAD MOHADDES HOSSEINI

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Legeh Atrak terletak di timur laut Iran dan pengeluaran pertanian adalah aktiviti utama di sini. Kerajaan Iran mempunyai strategi pembangunan pertanian lestari di kesemua legeh di negara ini, termasuklah di Atrak. Tujuan utama strategi kerajaan Iran adalah untuk memulakan pembangunan pertanian yang lestari yang bukan hanya mengeluarkan komoditi pertanian dan menyediakan peluang pekerjaan kepada rakyatnya, tetapi juga melindungi persekitaran semulajadi daripada kemusnahan. Strategi kerajaan Iran ini yang digunakan di legeh-legeh, termasuklah di Atrak, adalah kerana kawasan ini mengalami kesan hakisan tanah yang teruk. Tujuan utama kajian ini adalah untuk membangunkan kerangka untuk perancangan

pengeluaran pertanian yang lestari untuk legeh-leheh, terutamanya di Atrak.

Legeh adalah kawasan luas di mana perancangan pengeluaran pertanian selalunya mempunyai pelbagai objektif termasuklah objektif dari segi ekonomi, sosial dan alam sekitar. Ketidakpastian memainkan peranan yang amat penting di dalam perancangan pertanian kerana sesetengah faktor pengeluaran pertanian tidak boleh dikawal sepenuhnya dan sesetengah input atau parameter seperti permintaan, sumber-sumber, kos dan fungsi objektif adalah tidak tepat. Kajian ini membangunkan dan mengaplikasikan model program matematik fuzzy pelbagai objektif ke atas perancangan pembangunan pertanian di legeh Atrak. Model ini merangkumi tiga objektif iaitu memaksimakan untung, memaksimakan guna tenagakerja dan meminimumkan hakisan, dan kesemua ini adalah tertakluk kepada 89 kekangan.

Model ini memfokuskan ke arah perancangan pengeluaran pertanian untuk menentukan corak tanaman yang optimal dalam jangka masa pendek dan perancangan legeh Atrak dalam jangkamasa sederhana. Keputusan kajian menunjukkan bahawa tanaman yang paling penting yang disarankan di dalam perancangan optimal dalam jangka masa pendek dan sederhana adalah gandum, tanaman dusun (anggur dan lain-lain) dan alfalfa. Dibandingkan dengan corak tanaman sedia ada, keputusan kajian menunjukkan bahawa, sekiranya pelan optimal ini dilaksanakan, nilai keuntungan optimum dan guna tenagakerja akan masing-masing meningkat sebanyak 16.12 dan 0.53 peratus dan hakisan tanah akan turun sebanyak 19.88 peratus. Angka ini mungkin tidak menunjukkan perubahan yang ketara kepada corak tanaman yang sedia ada, tetapi ia boleh meningkatkan pendapatan petani, dan mencapai pembangunan pertanian lestari. Legeh Atrak mempunyai lapan zon, dan kajian ini menentukan corak tanaman untuk kesemua zon.

Model ini juga diaplikasikan kepada beberapa senario iaitu melihat kepada keseimbangan yang berbeza di antara objektif yang berbeza dan bercanggah (menggunakan wajaran yang berbeza). Keputusan kajian menunjukkan bahawa keuntungan yang tinggi mampu untuk dicapai semasa cuba untuk mengawal hakisan dan meningkatkan guna tenagakerja, dan terdapat kompromi di antara objektif ekonomi, sosial dan alam sekitar. Di samping itu, kajian turut mendapati bahawa sekiranya pembuat keputusan ingin meningkatkan tahap gunatenaga kerja, keuntungan akan menurun dan kesan hakisan akan meningkat. Oleh yang demikian, pembuat keputusan tidak seharusnya mengharapkan peningkatan guna tenagakerja di legeh Atrak. Apabila objektif berbeza diberikan wajaran yang sama, keputusan menunjukkan bahawa objektif sosial (guna tenagakerja) dan objektif alam sekitar (kesan hakisan) adalah lebih mampu untuk dicapai berbanding objektif ekonomi (keuntungan) di legeh Atrak.

Kajian ini turut membandingkan keputusan dari model fuzzy dengan keputusan dari model bukan fuzzy. Di dalam model bukan fuzzy, sistem program objektif (GP) telah digunakan kerana sistem GP ini boleh digunakan untuk pelbagai objektif dan ianya dikenali sebagai alat yang berguna dalam perancangan pertanian. Perbandingan ini menunjukkan bahawa model linear fuzzy pelbagai objektif hanya lebih bagus sedikit daripada teknik-teknik linear bukan fuzzy yang lain seperti model linear dan model sistem program objektif.

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I certify that an Examination Committee met on 16th December 2005 to conduct the final examination of Seyed Ahmad Mohaddes Hosseini on his Doctor of Philosophy thesis entitled "Application of the Fuzzy Approach to Agricultural Production Planning in the Atrak Watershed, Iran" in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulation 1981. The Committee recommends that the candidate be awarded the relevant degree. Members of the Examination Committee are as follows:

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This thesis submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of Doctor of Philosophy. The members of the Supervisory Committee are as follows:

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DECLARATION

I hereby declare that this thesis is based on my original work except for quotations and citations, which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at UPM or other institutions.

SEYED AHMAD MOHADDES HOSSEINI

Date: 21/Feb/2006

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