Expert Systems in Agriculture

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Knowledge engineering is a vast area of computer science. It may find endless possibilities of usage. Because concerning of all knowledgeable information, it would create a value for many industries. Since Türkiye earns much of its inter-country profit from agriculture, applying expert systems to agriculture in Türkiye would help to improve the production in agriculture and to improve profit. This paper seeks some well known solutions to help development of agriculture in Türkiye.

Situation of Agriculture in Türkiye [3]

Land distribution in Türkiye: 66,878,178 hectares of land
- %27,63 Forest
- %22,78 Field
- %21,86 Pasture (where animals may be grazing)
- %14,47 Land not suitable for cropping
- %5,60 Leaved for refreshing
- %3,87 Long life vegetables
- %2,91 Suitable for cropping but not used
- %0,88 Vegetables and flowers

<table>
<thead>
<tr>
<th>Size of holdings (decar)</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Turkey Holdings without land</td>
<td>4 068 432</td>
<td>234 510 993</td>
<td>50 211 258</td>
<td>11 320 373</td>
</tr>
<tr>
<td>Less than 5</td>
<td>101 610</td>
<td>-</td>
<td>2 254 821</td>
<td>298 219</td>
</tr>
<tr>
<td>5 - 9</td>
<td>251 686</td>
<td>667 059</td>
<td>1 425 192</td>
<td>331 418</td>
</tr>
<tr>
<td>10 - 19</td>
<td>381 287</td>
<td>2 511 091</td>
<td>1 728 784</td>
<td>623 156</td>
</tr>
<tr>
<td>20 - 49</td>
<td>752 156</td>
<td>10 042 501</td>
<td>4 607 482</td>
<td>1 512 624</td>
</tr>
<tr>
<td>50 - 99</td>
<td>1 274 609</td>
<td>38 668 961</td>
<td>12 224 649</td>
<td>3 454 268</td>
</tr>
<tr>
<td>100 - 199</td>
<td>713 149</td>
<td>46 750 693</td>
<td>11 298 427</td>
<td>2 481 379</td>
</tr>
<tr>
<td>200 - 499</td>
<td>383 323</td>
<td>49 216 633</td>
<td>8 037 755</td>
<td>1 516 356</td>
</tr>
<tr>
<td>500 - 999</td>
<td>173 774</td>
<td>46 487 432</td>
<td>5 835 880</td>
<td>845 793</td>
</tr>
<tr>
<td>1000 - 2499</td>
<td>24 201</td>
<td>14 982 493</td>
<td>1 444 934</td>
<td>153 421</td>
</tr>
<tr>
<td>2500 - 4999</td>
<td>10 266</td>
<td>13 856 621</td>
<td>1 043 675</td>
<td>56 756</td>
</tr>
<tr>
<td>5000+</td>
<td>1 930</td>
<td>6 538 082</td>
<td>177 869</td>
<td>32 097</td>
</tr>
<tr>
<td>5000+</td>
<td>441</td>
<td>4 789 427</td>
<td>131 790</td>
<td>14 886</td>
</tr>
</tbody>
</table>

Table 1: Number of agricultural holdings and livestock and the land operated by type and size of agricultural holdings.
Expert Systems in Agriculture

The problems in agriculture are often multidisciplinary and very complex because of affecting complex events. Expert systems approaches will succeed with this kind of problems. It has many methods for uncertainty and reasoning using whatever on the hand. ES in Agriculture will help farmers and animal breeders make their decisions more efficiently and timely.

Currently many people are forced to make decisions about agricultural activities without enough knowledge. Many of them have inadequate training about agriculture and needs to be managed. Some guidance is done by the Ministry of Agriculture and Forestry (Tarım ve Orman Bakanlığı) but they are not performed by using latest knowledge engineering methods or even using GIS.

Usage Areas of Expert Systems on Agriculture

Expert systems are used in a wide range of areas in agriculture. Its main usage areas are: [2]

1) Crop Management Advisors
2) Livestock Management Advisors
3) Planning Systems
4) Pest Management Systems
5) Diagnostic Systems
6) Conservation/Engineering Systems
7) Process control Systems
8) Marketing Advisory Systems

Crop Management Advisors
These kinds of systems help the farmers by giving decision support on the process of growing a certain type of crop. Example implementations are:

*GRAPES*: Deals with a specific crop. This system gives advice to grape growers in Pennsylvania.

*An ES to generate fertilizer recommendations*: This system deals with specific task “fertilization” in growing crops.

Livestock Management Advisors:
Similar to crop growing advisors, these systems gives integrated advices for animal breeders. Example implementation:

*Application of conditional causality in an integrated knowledge-based system for dairy farms.*

The system has health, production and financial modules. It gives decision support for daily farm management tasks.

Planning Systems:
Production planning systems with ES in agriculture, deals with identifying and suggesting projections, plans for future cropping activities. Example implementation is:
*CROPS: A whole-farm crop rotation planning system to implement sustainable agriculture.*
Main purpose of the system is to obtain sustainable and profitable cropping plans which meet given production needs and various constraints.

**Pest Management Systems**
These systems help farmers to deal with harmful creatures with optimal management solutions. Such a system is:
*POMI: An expert system for integrated pest management of apple orchards.*
The system helps the farmer first identifying the problem and then gives advice for taking actions.

**Diagnostic Systems**
Different from the pest management, diagnosis is concerned with any kind of disease in plants and crops. These tools are like the well-known MYCIN. It works the same way.
*An abductive reasoning expert system shell for plant disorder diagnosis:*
It is a domain-specific generic tool for diagnosing plant diseases.

**Conservation/Engineering Systems**
Problems dealing with engineering solutions to conservation problems. A typical example is:
*Development and validation of an expert system for soil erosion control planning in Prince Edward Island:* It is used for conserving soil by recommending the appropriate engineering solution to control soil erosion within typical cropping systems.

**Process Control Systems**
These systems monitors some sensors and takes corrective actions using some instruments.
*Determination of greenhouse climate set points by SERRISTE:* Its function is to maintain certain conditions in a glass house for winter production of tomatoes.

**Marketing Advisory Systems**
Gives advices to farmers on marketing different products.
*Cattle Marketing:*
Helps farmers to select different marketing alternatives for their cattle.
*GMA (Grain Marketing Advisor):*
It helps farmers select and analyze their marketing alternatives for their grain.

**Benefits of using ES in agriculture**

*Consistent mapping:* Output maps from an expert system is very consistent. It includes the combined information from all layers resulting the decision making hint. [5]
Rapid decision updates: Since the expertise is made through an automated process, re-executing this process gives new decisions immediately.

Reduced cost: After first development of the ES there will be no need for employing a lot of personnel to analyze the whole data again.

More focused agriculture scientists: Agriculture scientists are no more obligated to draw maps and calculate intersections. By the help of GIS and ES they can be more focused in their field.

Maintaining knowledge continuity: Most valuable agriculture data is collected during years of experience. When an expert is retired, a large portion of expertise is lost. If these expertise is collected in an ES it will continue to help making decisions.

Digital products: Since the evaluations are made on GIS layers and the result is another layer of decision making hints this new map is in digital format and ready to use.

Everybody is expert: Inadequate training for farmers and animal breeders results loss of profit. ES’s will help untrained people give better decisions.

An Example : Land Suitability Analysis For Agricultural Crops: A Fuzzy Multicriteria Decision Making Approach [1]

After stating the usage areas of ES’s, inspecting an appreciable usage of ES will give a better aspect of view. This system is a good start for establishing usage of ES in Agriculture.

Land use problems:
There is two types of questions in land use planning:

- Given a desired activity, which sites might be best for that activity? (Where to put something?)
- Given a site or sites, what kind of activity might be most suitable here? (What to put here?)

Accordingly, four main land use problems are identified:
- Site (Location) Selection: Given a set of specific land use types, rank the set of sites for that land use and order them based on priority.
- Location Allocation: Situation where the functional relationship between the attributes of a land and the goals of decision making is stated.
- Land use selection: Given a set of sites, find the land use types (LUTs) that suits best and order them based on the priority. It can also be called as Alternative Uses.
- Land use allocation: Given a set of sites, which land use is the best for that site. It addresses the surface of land that should be allocated to a specific land use.

Spatial Multi-Criteria Decision Making

Spatial multi-criteria decision-making (MCDM) is a process where geographical data is combined and transformed into a decision. Multi-criteria decision-making involves input data, the decision maker’s preferences and manipulation of both
information using specified decision rules. In spatial MCDM, the input data is geographical data. Spatial MCDM is more complex and difficult in contrast to conventional MCDM, as large numbers of factors need to be identified and considered, with high correlated relationships among the factors.

Schematic representation of the decision problem with spatial effect.

In each layer of geographical data, there is a attribute is defined. Suitability at a point is an evaluation of elements according to their importance.

**Framework of Land suitability decision making**

The purpose of this research is to investigate the study area to find the possible land use types. The parameters like present cropping-system, local food habit, major agricultural markets and facilities, processing industries in and around the area, population and economic status of the society and literacy are taken into account.

Relationship between the objectives and attributes has a hierarchical structure. At the highest level one can distinguish the objectives and at lower levels, the attributes can be decomposed. Evaluation is done using this hierarchical attribute tree. Each node has its value and weight. And each point in the map, has a set of this properties. Then the expert system decides the suitability of the land using the attributes values with fuzzy evaluation.
Hierarchical organisation of the criteria considered for the study.

Now a new problem arises that, what criteria is most important and what criteria least? To overcome with this problem a systematic approach is applied. Experts are asked to compare a criteria with another in relevance of importance. And some matrixes are formed to reveal the ordering and weights of importance for criteria.

<table>
<thead>
<tr>
<th>Chemical</th>
<th>pH</th>
<th>Fertility</th>
<th>OC</th>
<th>Weights</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>1</td>
<td>1/4</td>
<td>3</td>
<td>0.2176</td>
</tr>
<tr>
<td>Fertility</td>
<td>4</td>
<td>1</td>
<td>6</td>
<td>0.6910</td>
</tr>
<tr>
<td>OC</td>
<td>1/3</td>
<td>1/6</td>
<td>1</td>
<td>0.0914</td>
</tr>
</tbody>
</table>

Example matrix for ordering and weights

The suitability of the rice suitability is analyzed using fuzzy evaluation, with 60% uncertainty in the expert knowledge about deciding upon the crop suitability parameters and their requirements by the crop and the uncertainty for deciding according to their importance.
Conclusion

Although there are many uncertain effects in agriculture, expert systems enable planning and making decision using powerful methods like fuzzy logic, CBR, neural networks, machine learning [4], etc..

Expert systems have many applications in the agriculture industry. We have mentioned its usage types and gave an example to a common beneficial usage. Currently in Turkey, the data collected about agricultural activities is not adequate for using in these types of systems. But there are some studies for increasing location based data in the Ministry of Agriculture and Forestry. Using these data, ministry can manage the agricultural activities using expert systems.

References

4. ROBERT J. McQUEEN, Applying Machine Learning to Agricultural Data, Management Systems, University of Waikato, Hamilton, New Zealand