



### Inside Story

- What are expert systems and how do they work?
- What advantages can expert systems provide?
- How can expert systems benefit developing regions?
- What is involved in the development of an expert system?
- What are the challenges?
- Conclusion
- Additional Reading

APDIP e-Notes present an analytical overview of specific issues related to information and communication technologies for sustainable human development in the Asia-Pacific region. APDIP e-Notes are developed by the United Nations Development Programme's Asia-Pacific Development Information Programme (UNDP-APDIP) based at the UNDP Regional Centre in Bangkok, Thailand. For more information, visit <http://www.apdip.net> or contact [info@apdip.net](mailto:info@apdip.net)

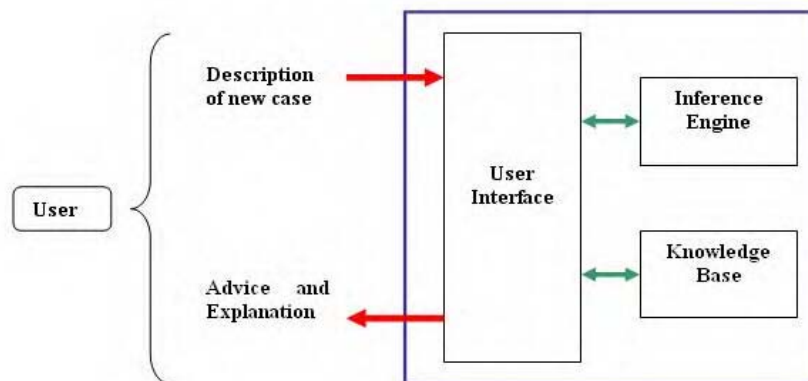
## Summary

As information communication technologies (ICTs) become increasingly sophisticated and refined, the potential returns from utilizing them in areas such as education and business is immense. Expert systems represent an opportunity to assist users lacking expertise in a specific area to carry out complex tasks, promote efficient governance and enable sustainable decision-making in developing regions. The ability of expert systems to guide and educate means they can also be used for knowledge building and tackling the low level of information technology literacy that have a direct negative impact on socio-economic advancement in developing regions.

This APDIP e-Note provides a summary of what expert systems are and how they operate; the opportunities they can provide as a driver for socio-economic development; and how they can benefit developing countries through capacity building and local empowerment.

### What are expert systems and how do they work?

Expert systems, also known as knowledge-based applications, are part of the general category of computer applications known as artificial intelligence. They are usually single-purpose programs filled with detailed information that enables them to guide users through a series of simple yes/no or textual questions, and provide answers about specialized fields. Expert systems consist of a knowledge base that contains facts about a specific task and rules for applying the facts; and an inference engine that processes knowledge encoded in the knowledge base to respond to a user's request for advice. The system reaches conclusions by using inference, a reasoning process, to make decisions similar to a human expert by relying on logic, belief, rules of thumb and experience within a given domain contained in the knowledge base.<sup>1</sup>



The knowledge used in an expert system is acquired from various sources such as expert opinions, legislation, reports, databases, policy papers, case studies, empirical data, textbooks and manuals. Although lacking the 'common sense' and human characteristics of intuition and empathy, they can contain great detail and sophistication to cover most circumstances and allow for manual intervention in instances when they are not appropriate.

### What advantages can expert systems provide?

Users can now choose from dozens of commercial software packages with easy-to-use interfaces making them ever more accessible, and they are in everyday use by organizations assisting with decision-making both internally and in the public domain. Such is their utility, they have been employed to enhance productivity across most

<sup>1</sup> Principles of Information Systems, Boyd & Fraser (1996) p 379 (ch 11).

sectors of government and business, for example, making financial forecasts and scheduling routes for delivery vehicles.

The potential to guide users to undertake complex activities and make well-informed decisions is most needed in countries where there is an acute shortage of experts and highly-skilled workers. Despite the difficulty and time required to gather the data and for the construction of rules for the knowledge base the advantages that expert systems can provide to developing countries are overwhelming. Expert systems:

- provide rapid and informed decision-making
- enable users to perform complex procedures
- reduce time taken to perform complex calculations
- combine collective knowledge of many experts
- organize information and preserve knowledge
- disseminate valuable and scarce expertise
- maintain continuity and accuracy of decisions
- provide transparency through audit trails
- avoid training or acquiring human expertise
- avoid problems associated with human errors
- have low overhead once initial set-up costs is outlaid
- can easily reproduce solution with extensive benefit

### How can expert systems benefit developing regions?

Expert systems provide an opportunity for developing nations to enhance and extend the value of information and knowledge in wider society

#### Knowledge Management

Expert systems are now widely used across the public sector in many countries providing transparency and improved productivity in public administration (e.g. the Treasury Department in Australia, Home Office in the UK). This represents an important use of expert systems as recognized in a recent report on Internet governance that highlighted an overwhelming concern amongst respondents across the Asia-Pacific region over a lack of availability of government information online.<sup>2</sup>

Expert systems also provide a system for capturing and preserving traditional forms of knowledge. The creation of the **Siddha Medical Knowledge System**, used for treating chronic illness, involved the transition of a valuable library of knowledge hidden in the form of Tamil poetries, to an electronic library.<sup>3</sup> The Siddha medical knowledge system demonstrates how technology can be used to facilitate the capture and organization of traditional knowledge.

<sup>2</sup> Internet Governance Priorities and Practices: Indonesia, compiled by Dieter Zinnbauer for the Open Regional Dialogue on Internet Governance, UNDP-APDIP, 2005.

[http://igov.apdip.net/resources/Indonesia\\_Report.pdf](http://igov.apdip.net/resources/Indonesia_Report.pdf)

<sup>3</sup><http://www.icml9.org/program/track7/activity.php?lang=pt&id=2>

Expert systems are of particular value in areas in which developing countries are less advanced, such as medicine and environmental science:

#### Medicine and Health Services

In the absence of expertise in the field of medicine, an expert system can assist in knowledge transfer and in making effective diagnosis and treatment.

**Mycin** was one of the first expert systems ever built and is an example of medical diagnostic decision aid used to help doctors diagnose infectious diseases (bacterium and meningitis) prevalent in developing regions.<sup>4</sup> It provides advice for the type of antibiotics and the recommended dosage, based on the analysis of the primary and secondary symptoms of the disease.

**Isabel** is another expert system in use which provides diagnostic advice on areas such as toxicology, oncology, bio-terrorism, and causative drugs.<sup>5</sup>

#### Environmental Management

Sustainable development frequently relies upon human expertise (resources managers and environmental planners) which can be captured in expert systems. Expert systems are a core component in the implementation of decision support systems that assist with the transition to a sustainable society through well-informed decisions. The United Nations Industrial Development Organization (UNIDO) recognizes in the Millennium Development Goals the important role that expert systems can provide in response to environmental issues, and the need to develop and disseminate expert systems to assist enterprises in developing countries with environmental assessments.<sup>6</sup>

Expert systems can assist with sustainable decision-making in land development and in the promotion of cleaner production methods. In the **Land Development Village** (Thailand) project an expert system was integrated with a geographical information system to assist with decision-making. It was involved in cost estimation and land evaluation concerning issues such as soil erosion and water conservation.<sup>7</sup> It is an example of how expert systems can be used in parallel with other technologies to help integrate the principles of environmental management into country policies and programmes.

The **Landfill Restoration Plan Advisor** (Malaysia) was designed for use in the planning of sanitary landfill restoration. Expertise was acquired from a combination of sources, including textbooks, manuals and interviews with selected domain experts.<sup>8</sup> Such a system

<sup>4</sup><http://www.computing.surrey.ac.uk/research/ai/PROFILE/mycin.htm>

<sup>5</sup><http://www.isabelhealthcare.com>

<sup>6</sup> UNIDO, Service Module 8 Environmental Management, see <http://www.unido.org/doc/5073>

<sup>7</sup> Kanjana, Sutasak, Ard, GIS and Expert Systems Integration for Land Development Village, Thailand, Paper: 755.

<http://gis.esri.com>

<sup>8</sup> Basri, "An Expert System for Planning Landfill Restoration", Water Science and Technology, Vol 37 No 8 pp 211–217 IWA Publishing 1998.

encourages local empowerment in developing countries as it assists them to responsibly manage their own social and economic development.

### Agricultural and Natural Resource Management

The application of expert systems for resource management provides a method by which developing countries can build capacity for themselves based upon their natural resources. **Prospector** is a consultation system designed to assist geologists working in mineral exploration with finding ore deposits from geological information.<sup>9</sup>

The agricultural industry encounters a range of problems which it must manage including the cost of pesticides and pest resistance, crop systems, yield losses, soil erosion, and market price fluctuations. Normally, these economic barriers require farmers to become expert managers of all aspects of their farming operations. **AGREX** is an expert system used by the farming community in Kerala, India, to provide timely agricultural advice. It assists with the use of fertilizer, crop protection, irrigation scheduling, diagnosis of crop diseases, and harvesting of fruits and vegetables.<sup>10</sup>

### What is involved in the development of an expert system?

An expert system is created by 'knowledge engineers' who analyze how human experts make decisions and translate this into terms that a computer can understand, using **facts** and **if-then rules**. This involves understanding what the experts know, through observation, workshops and scoping of the processes and business rules used to form the knowledge base. This process of codifying an expert's knowledge into components for representing logic flows is time consuming and complex. Particularly since a good knowledge base can hold the combined knowledge of many experts and forms a complex reasoning structure to interact with the inference engine. Comprehensive analysis of the logic built into the system must be undertaken by evaluating test data through a combination of manual and automated testing.

The time and cost of developing an expert system is dependant upon how wide-ranging the subject matter is and the complexity of the rules. A small project, such as an infrastructure charge calculator can take a matter of months for a small team of 3-4 people, consisting of a mixture of domain experts, software engineers, business analysts and knowledge engineers. Whereas, a system for processing a comprehensive range of immigration claims or a complex medical system can take several years to develop.

### What are the challenges?

For a cost-effective IT solution, the design process and system requirements must be well thought out and

<sup>9</sup><http://www.computing.surrey.ac.uk/AI/PROFILE/prospector.html>

<sup>10</sup> Manage Cyberary - Expert Systems in Agriculture, J. Panduranga Rao. <http://www.manage.gov.in/managelib/faculty/PanduRanga.htm>

have regard to wider development and policy issues. Consideration must be given to the relatively high cost of deployment compared to alternative solutions, and how the system will work with existing and planned infrastructure. Poorly programmed software and systems that are not adequately maintained can make dangerous and costly mistakes. Therefore, infrastructure and ongoing maintenance are essential, including reprogramming to acquire and adapt to new knowledge.

The technical expertise needed to develop an expert system places an emphasis upon access to technology and highly-skilled IT workers which may have to be outsourced from high cost regions. Although today's expert systems deal with narrow domains of knowledge, for them to perform competently over a broad range of tasks they will require larger knowledge bases, requiring additional programming and more sophisticated technology. With technological advancement there is the potential loss of employment opportunities caused by redundancy to automation of tasks. This is of particular concern to developing economies that have large poorly educated populations and depend upon high domestic employment rates.

Due to the range of models of decision-making and their appropriateness in sustainable development it is necessary to tailor specialized solutions to developing regions. Access to and training to use expert systems is essential, particularly in remote locations where they can be of most assistance. Expert systems must also be developed in local languages to assist the development of local expertise which in turn will enhance productivity and promote self-empowerment.

Another concern in using expert systems is the moral and legal dimensions - if it gives the wrong diagnosis, who do you sue? Although **Mycin** outperformed members of the Stanford medical school in tests, its use was hampered because of ethical and legal issues related to the use of computers in medicine.<sup>11</sup>

### Conclusion

Expert systems provide a support mechanism for socio-economic development and facilitate participation in society by enabling access to information in government, in the economy, and in the development process. The requirements involved in developing expert systems remain prohibitive to many developing nations, with few possessing the finances or technological expertise required. Therefore, financial and political commitment from governments, the private sector and NGOs is needed to increase the presence of affordable expert system solutions designed specifically for use by developing countries and which promote sustainable decision-making.

~ Glen Harris, Legal Analyst

<sup>11</sup> It was never used in practice due to the ethical and legal issues with using computers in the field of medicine. Mycin: A Quick Case Study. [http://www.cee.hw.ac.uk/~alison/ai3notes/section2\\_5\\_5.html](http://www.cee.hw.ac.uk/~alison/ai3notes/section2_5_5.html)

## **Additional Reading**

Buchanan & Shortliffe (1985) Rule-Based Expert Systems: The MYCIN Experiments, Addison-Wesley

Holsapple, C & Whinston, A (2006) Decision Support Systems: A Knowledge-Based Approach, Thomson Learning Custom Publishing

Liebowitz, J (2006) Expert Systems with Applications, An International Journal, Elsevier Ltd

Rapanotti, L (2005) Expert Systems - The Journal of Knowledge Engineering, Blackwell Publishing

Turban (1995) Decision support and expert systems: management support systems, Prentice Hall