ESTABLISHING WORLD WATER EXPERTISE SYSTEM BASED ON KNOWLEDGE BASE

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Introduction

Presently, huge amount of information is accumulated in each knowledge area related water resources use, particularly in irrigated farming. But this knowledge utilization is difficult because of its fragmentation, lack of systematization and coordination between various bases of knowledge.

In view of global processes taking place during last decade (Europe unification, impetuous development of information technologies, etc.), there is necessity for world knowledge concentration and management in order to ensure free access to them.

This theme topicality is proves by launched Sixth Frame EU Program in context of a purpose to build European society base on knowledge.

General objective

Main idea of proposed project is combination of scientific potentials of various countries of the world in water science through (1) creation of the world base of knowledge on thematic directions of water-related area with access from any point of the world; (2) creation on this base **the world expert system.**

Suggested world base of knowledge can consist of several thematic and regional databases (each with own peculiarities) unified, for instance, in Web Ring[1]. Intensive information exchange will permit to strengthen scientific research in water-related field of knowledge.

In our opinion, lack of knowledge expertise and coordination between functioning thematic and regional bases of knowledge like WCAinfoNET (FAO), WMO, IWMI is main disadvantage of these systems.

That's why the first stage of the world base of knowledge establishing will be coordination of existing bases of knowledge. Second stage will be unification of thematic and regional bases of knowledge in single information-searching mechanism (for instance, based on principle of Web-Portal or Web-Ring) of the world base of knowledge. Third stage is establishing the world expert system.

[1] Web Ring is presented by circular list uniting close thematic sites. Ring creation assists to unify resources and obtain maximum information within minimum time period. As in each site-ring participant there are references to other participant; sites, visitors coming in any site and obtaining organized list of sites with similar theme, can travel over all ring. Besides, ring significantly widens audience of participants because "neighbors" naturally share by their audience.
Visitors can travel through system of references over all ring sites. Along the ring you van move in any direction, come to preceding or next site, look through several next sites or display full list of sites-participants of Web-Ring.

Question arises: "Why expert systems should be developed? Maybe is better to refer to human experience as it was in the past?" Let us note only main advantages and positive properties of expert system (ES) use:

1) Constancy. Human competence weakens with time. Break in expert activity can seriously impact his professional skill.
2) Easy transmittance and reproduction. Knowledge transmission from one person to another is long and expensive way. Transmission of artificial information is simple process of program or file copying.
3) Sustainability and reproduction of results. Expert can take various decisions under the same circumstances due to emotional factors. Results of expert system are stable.
4) Cost. Highly qualified experts are very expensive. Expert system, on the contrary, relatively cheap. Though its development is expensive, they are cost-effective in operation.

By the way, it worthy note that ES development does not permit to refuse fully from experts. Although ES operates well, nevertheless in certain conditions human competence exceeds artificial one. But even in these cases ES allows to refuse from highly qualified expert maintaining expert of average level using ES to strengthen and expend his professional abilities.

What we wait from expert system?

AS it is known, main goal of any expert system is development of software allowing obtain results not worse in quality and efficiency compared with expert. ES is used to solve so called non-formalized tasks, which have following common features:

- Tasks can’t be set up in numerical form;
- Objectives can’t be expressed in terms of precisely defined target function;
- There is no algorithmic solution of the task;
- If algorithmic solution exists, it can’t be used because of lack of resources deficiency (time, memory).

Besides, non-formalized tasks possess fallacy, incompleteness, uncertainty and contradiction both of data and knowledge.

Expert system is software using expert knowledge for effective solution of non-formalized tasks in narrow subject area. Base of knowledge in subject area accumulated during ES establishing and functioning. Most important property of ES is knowledge accumulation and arrangement. (Fig. 1).

рис.1.

Fig.1: 1-ES major properties; 2-knowledge accumulation and organization; 3-high quality experience application; 4-availability of predictive possibilities; 5-institutional memory; 6-opportunuties for education and training.

Knowledge is evident and accessible that distinguishes ES from traditional programs and determines their main properties:

1) Using high quality experience representing mentality of most qualifies experts in water resources and environment that leads to creative, accurate and efficient solutions.
2) Availability of predictive opportunities when ES gives answers not only for specific situation but also shows how these answers change in new situation with detail explanation how this situation led to changes.
3) Providing such new quality as institutional memory at expense of base of knowledge, which is developed during interaction with specialists of organization and presents current policy of this group of people. This knowledge choice becomes a code of qualified opinions and permanently updated reference book of the best strategies and methods used by personnel. Leading specialists leave but their experience remains.
4) Possibilities of SE use for education and training of top level specialists providing new specialists with experience and strategies, which can serve for study of recommended policy and methods.

Who participates in ES establishing and operation?

Major participants are Es itself, experts, engineers, means of ES formation and users. Their main roles and relations are presented in fig.2.

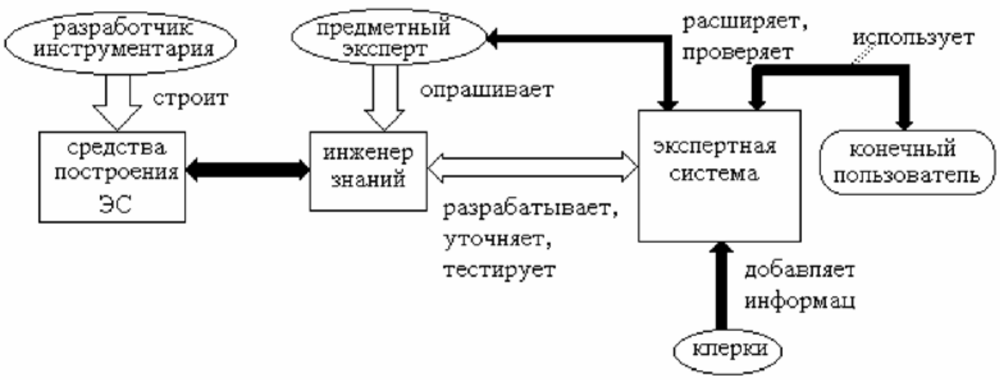

Рис.2. Взаимосвязи основных участников построения и эксплуатации экспертных систем

Fig.2. Interrelations between major participants of expert system establishing and operation:
1-tool developer; 2-subject expert; 3-builds, asks, expands, checks, uses; 4-ES establishing means; 5-knowledge engineer; 6-develops, specifies, tests; 7-expert system; 8-end user; 10-adds information; 11-clerks.

Reference:

Expert system is software using expert knowledge for effective tasks solution in subject area of interest. It is called system but not a program because it contains base of knowledge, problem solution program and supporting component. Latter helps user to interact with main program.

Expert is a person able to express his thoughts clearly and having good reputation as a highly qualified specialist in water and environment. Expert uses his methods in order to reach most effective solution and ES simulated his strategy.

Knowledge engineer is a person having knowledge in informatics and artificial intellect and knowing how to build ES. Engineer asks experts, arranges knowledge in ES and helps programmer in program preparation.

Mean of ES building is software used by engineer of knowledge and programmer for ES creation. This tool differs from ordinary programming languages because it provide suitable methods of complex high level notions presentation.

User is a person using ready ES. Term “user” is not simple. Usually it means end user.

From fig. 2is evident that user can be:
- *Tool author debugging ES creation means;*
- *Knowledge engineer specifying knowledge within ES;*
- *Expert adding new knowledge to system;*
- *Clerk entering current information to the system.*

It is important to distinguish tool, which is used for ES creation and ES itself. This tool includes language used for access to knowledge within the system, their presentation and supporting programs helping users to interact with ES component solving a problem.

Work plan for expert system in water and environment establishing

In technical aspect ES development technology includes 6 stages (Fig. 3): identification, conceptualization, formalization, implementation, test and experimental operation.

Let us consider in more details succession of actions necessary at each stage.

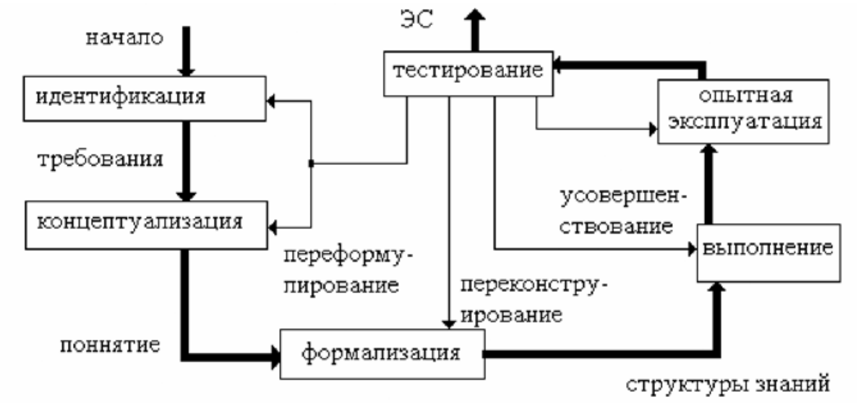

Рис.3.

Fig.3: 1-start; 2-identification; 3-requirements; 4-conceptualization; 5-notion; 6-ES; 7-test; 8-experimental operation; 8- perfection; 9-implementation; 10-knowledge structure; 11- reconstruction; 12-formalization.

1) Identification:
- identification of tasks subject to solution and goals of development,
- definition of experts and user type.

2) Conceptualization:
- substantial analysis of subject area,
- distinguishing main notions and their interrelations,
- definition of methods for tasks solution.

3) Formalization:
- selecting software for ES development,
- definition of knowledge types presentation,
- formalizing main notions.

4) Implementation (most important and labor consuming).

- Expert fills up base of knowledge including:

- Knowledge "abstraction" from expert,
- Knowledge arrangement ensuring effective ES operation,
- Knowledge presentation understandable for ES.

Process of knowledge possession is performed by engineer based on expert activity.

5) During test expert and engineer using dialogue and explanatory means check ES competence. Test is continued until expert decides that system reaches required level of competence.

6) During experimental operation ES suitability for end users is checked. Based on test results ES significant modernization is possible.

Process of ES creation is not divided into strict successive stages because during development there may be return to preceding stages and revision of some solutions.

Stating situation before given problem solution

Activity in this direction is oriented to adequate contribution to problem solution and single information space organization. It requires big totality of tasks – providing meta-data abstraction and structuring, input support in structured type, integration of information from various sources (depositaries), etc.

If to input request «knowledge base water» in searching machine Yahoo (www.yahoo.com) 1 540 000 references will be received. If to suppose that all references come directly from server with base of knowledge, anyway we deal with multitude of bases.

Let us consider only some of them:

1) Established by water specialists of North, Central and South America and Europe Water Web Consortium (www.waterweb.org) contains huge amount of references to "water" resource of internet unified in Web-Ring that is big database.

2) Functioning knowledge base WCA infoNET (www.wca-infonet.org) is managed by FAO through IPTRID program. Undoubtedly, existing IPTRID infrastructure is unique in framework of international community and connects states-participants in different disciplines in irrigation and drainage field all over the world.

AS it was mentioned before, IPTRID network weakened our attention to information dissemination among IPTRID members including the Aral sea basin. At XVII ICID Congress (July 21-28, 2002, Montreal, Canada) IPTRID representatives concentrated on necessity of further involvement of the Aral sea basin countries in information system WCA-InfoNET established within IPTRID. Main attention should be paid to search of «bottle necks» within zonal and regional program of irrigation and drainage their solution. It is clear that IPTRID itself can't solve these tasks but it must be «conductor» and organizer of this network using and involving national committees, ICID technical groups, FAO base of knowledge and newly established "Dialogue" IWMI program.

3) В регионе Центральной Азии работу по сбору, систематизация и распространению информации по использованию земельных и водных ресурсов осуществляет Научно-информационный центр МКВК.

WE have made first step in base of knowledge "Utilization of land and water resources in the Aral sea basin" (www.icwc-aral.uz/cont_en/partner/copern/index.html) establishing. This base will help to solve many issues in water and land resources use as stress is made on reliable, scientifically grounded recommendations using long-term experience of Central-Asian specialists though its synthesis in knowledge base.

What is done:
a) detail development of several most topical branches of knowledge tree including systematized set of factors and consequences connected with main definitions: «Desertification and its monitoring», «Irrigation impact on various types of water».

b) Glossary has been prepared where all terms are explained in dictionary papers (another terms are supposed). Linguistic work includes linked fragments building by terms "binding". Under proper work, notion hierarchy appears in notion structures. Notion hierarchy is global scheme within conceptual analysis of knowledge structure in any subject area. Notion definitions are input in knowledge base as commonly accepted terms and explanations, which can serve as universal ones for all over the world.
c) Preparation of bibliographic index of books, papers and abstracts has been started in the following directions:
- global (including references to global scale works characterizing field of knowledge);
- regional dealing only with Central-Asian countries;
- local.

d) Information for knowledge base is collected from the projects implemented in the Aral sea basin:
- from 65 ongoing projects;
- from 216 pilot (completed) projects.

e) Description of past research projects and projects implemented under support of donors during last years.

But world's interest in getting knowledge is not limited by irrigation and drainage. Knowledge bases on all aspects of water use, IWRM, water conservation and hydropower are of high interest, etc.

Below example of knowledge base rubricator for land and water resources use in basin scale is presented (table 1):

Table 1

Database rubricator on land and water resources use within basin (preliminary composition)

1. Physical-geographical characteristics of region	2. Water resources	3. Water resources use
Landscape	Surface water	Rural water supply
Climate	Seas and lakes	Urban water supply
Temperature	Rivers. River systems.	Hydropower
Wind	Reservoirs. Dams.	Recreation
Humidity	Ground water	Agriculture
Precipitation	Hydrology	Irrigated agriculture
Evaporation	Surface run-off	Arable lands
	River flow	Pastures
	Soil water	Soils. Soil fertility. Soil fertility class.
	Waste water	Crops
	Return water	Water consumption
	Water quality	Crop rotation
	Water quality criteria	Crop yield
	Drinking water quality	
	Surface water quality	
	Ground water quality	

	Waste water quality Water quality control	
Irrigation Crop irrigation regime Irrigation methods Sprinkling Stationary sprinkler method Portable sprinkler method Surface irrigation Contour-furrow border irrigation Check flooding irrigation Furrow irrigation Irrigation by gravity On longitudinal scheme On crosscut scheme Irrigation over slightly sloped or horizontal flat surface Cross- blind furrow-irrigation Adverse irrigation Check flooding-furrow irrigation Irrigation over permanent irrigated plots Constant stream irrigation Alternate stream irrigation Surge flow irrigation Micro-irrigation Drip irrigation In-soil irrigation Water losses on the fields Soil water-salt regime Salinity control Leaching irrigation and irrigation leaching regimes	*Irrigation impact on different water types* - surface river flow reduction downstream irrigation river water quality deterioration discharge of pollutants and toxicants tugai reduction delta desertification water-borne diseases development (malaria, etc.) loss of bioproductivity change of biocenose, water fauna, and flora social losses and environmental damage loss of river navigation abilities - ground ground water table rising (or lowering) ground water salinity increase (or decrease) ground water head increase (decrease) contamination with nitrites, nitrates, and pesticides water logging and salinization ground water inflow increase into river - miscellaneous inland reservoirs' desiccation, their volume reduction desertification loss of fish productivity climate dryness intensification salt and dust transport from dried seabed ground water inflow increase social-environmental damage to sea-related sectors delta losses and degradation	*Irrigation systems* canals pipelines water lifting pumps and pumping stations dams modernization reconstruction systems' losses and efficiency irrigation systems' operation *Drainage* open horizontal drainage closed horizontal drainage vertical drainage combined drainage biodrainage drainage flow drainage flow utilization and location drainage systems' operation
4. Desertification and its monitoring		
Desertification preconditions water scarcity draught climate aridization forest cutting down overgrazing biological death draining lack salt accumulation man-caused damage aeolian transport reservoir water balance breaking loss of fertility	*Desertification types* salinization deforestation land degradation (incl. grasslands) desiccation of seabed and reservoirs *Desertification indicators* soil salinity degree change of trees density and species soil fertility class desiccation area	*Monitoring approaches* terrestrial soil samplings estimate mapping remote aero and satellite
5. Organizational-juridical issues of water resources management and financing		
Management organization	*Juridical issues*	*Financing* State financing from budget At the water users' expense Tariff establishment methods Water tariffs

Expert System introduction benefit

Expert System (ES) on water and environment conservation will help in planning and organization of researches as well as in dissemination of innovation decisions in water sector. On the one hand, population growth and limitation of water, land, and financial resources, on the other hand, compel water sector looking for more productive use of all these resources and cost reduction of water, land, labor, finances per unit of consumed product (water saving, power saving, and resources conservation in general).

Such ES promotes effective water use in agriculture providing extension of researches in efficient water use under its increasing deficit to enhance food production and agricultural production, reinforce food security, and facilitate poverty elimination as well as foster proper treatment to environment requirements.

Specific contribution of water and environment conservation ES

First of all, it represents high value for user-experts, because it is difficult to obtain finished problem solutions emerging during their activity process. There are following reasons of such difficulty:

1. Lack of time for searching and reading technical papers and journals to be sufficiently informed about present subject state, for example, water saving with regard to environmental requirements.
2. Lack of specific knowledge to work with complex technical texts and terminology as well as understand key moments of engineering solutions.
3. Even under available unlimited access to Internet user can't implement it entirely because of great flow of heterogeneous and semistructured information.

User, especially expert, needs in reliable and scientifically grounded solutions (recommendations) presenting well written and simple in application guidelines on emerging problems related to its direct activity as well as available in any world part.

As for researcher, ES use is an opportunity of proceeding his activity on interdisciplinary basis, quick acquaintance with neighboring fields of his activity to reach long-term goals as well as prove that data obtained by this researcher is actual and relevant.

Expert System should be flexible in opportunity to be modernized and with sufficiently studied, intuitively accessible interface intended not only for experts in the field of information technologies, but also for people not experienced in cobwebs of computer technologies and programming.

ES created on database will allow experts to analyze available situation and predict water resources use at regional and national level as well as carry out assessment of scenarios for water-land resources management, including economical aspects and environmental impact. Essentially database is synthesis of knowledge about available processes, their assessment approaches, interrelations between water-land resources and nature necessary for efficient use of these resources. Opportunity of evaluating alternative management scenarios will provide formulation of general "game rules" in potentially conflict water sector.

Necessary measures

To establish ES following should be done in accordance with recommended technology of knowledge base:
1. Review of researches and achievements in the region (country) by present moment;
2. Selection of acting normative documents used in design and operation of water-land resources;
3. Selection of available water use norms, water quality assessment, land reclamation state assessment, etc. as well as critical indicators;
4. Analysis of data from funds of research and design institutes, academic institutes, extracts of outputs related to processes in soils during irrigation, highly saline water use for irrigation, determination of zonal coefficients, water efficiency assessment, etc.
5. Description of empirical dependencies (incl. graphical), balance equations used in analysis and prediction of water-land resources use;

During database creation process obtained data analysis and assessment should be carried out on following aspects:

1. Selection, analysis, and systematization of existing design methods (including empirical equations) of water demand for irrigation, water supply, and power needs;
2. Selection, analysis, and systematization of different norms and standards used in design and operation of water-land resources;
3. Analysis and systematization of available experimental data on designs of coefficients, empirical, balance equations and different design parameters in them under assessing and predicting water-land resources including economical calculations while using them as well as graphical display of different interrelations (for example, crop yield dependence on water availability, water table evaporation dependence on its depth, crop yield and soil salinity, etc.);
4. Analysis and systematization of analytical and balance equations applied in analysis and prediction of water-land resources availability and use as well as associated natural and antropogenic processes;
5. Preparation on basis of all above recommendations' points on using specific methodic, equations, standards and so on, proceeding of analysis of their benefits and disadvantages.

Database is supposed to have three levels: global, regional, and national in order to take into account specific features of each level.
Database information is taken mainly from bibliographical sources, official normative documents and data, research institutes' reports on experiments and their generalization etc. Presently there is no similar base of knowledge in any country of Central Asia. There are only its small fragments in existing individual databases and models.

Thus, ES established on knowledge base of water-land resources is developed on basis of analysis and systematization of all available in the region normative-methodical documents, bibliographical generalization and similar data, with selection of indicators and methodic, which will be acceptable as in global aspect so for regions and specific countries, and its any zone. In this base of knowledge in the first time data important not only for Central-Asian countries, but also for rest regions will be integrated on problems related to desertification process, including its monitoring, irrigation impact on surface, ground water, and Aral Sea; rehabilitation of river systems and freshwater ecosystems, and water resources management; land use and production capacity; salinity and drainage; irrigation systems and management both on-farm and outside farm; agricultural crops and crop rotation.
ES established on base of knowledge will provide all users (scientists, experts, ecologists, politicians, and society as a whole) with necessary and easy available data to achieve efficient water-land use, including economical aspects and environmental impact.

Principles of creating Global Base of Knowledge and Global Expert System

Creation of global knowledge base (GBK) and expert system (GES) should be based on following principles:

- general data selection rules to be developed, kind of knowledge storage standard providing in further GES unification. This is especially critical in connection with adoption of intellectual property acts and data transformation to specific business branch in many countries;
- single search mechanism to be established to allow inherent searching for data in all regional databases and knowledge bases, at the same time transiting from general to individual and vice versa;
- systematic analysis of macro-economical trends worldwide and in regions related to water-land use dynamics including development predictions for water consumption, irrigation, and drainage to be carried out;
- continuously updated information to be available of level of reached advanced indicators of water-land resources use in different regions, including water efficiency at various water users and consumers, in particular over different production sectors;

- continuously updated information to be available of best practices directed on resultant water saving, efficient irrigated land use, price reduction for water use product while keeping water saving demands, operation and maintenance costs reduction for irrigation and water supply systems.

Conclusion

Establishing a single world knowledge base and on its base world expert system supposes to ensure maximum effective use of scientific potential and material resources of EU and other countries taking into account accumulated experience and developments on base of close interrelations of European and national scientific policies, knowledge and information exchange.

This will permit to concentrate scientific and technical resources of EU and third countries for solution of global issues like food security, environmental security (climate change, desertification, biodiversity and natural resources), health and diseases caused by social and ecological environment violation.

Let us note once more that main components of the world knowledge base (like any other base) should be:

- disseminating advanced experience, developments, methodology in water-related field (concrete examples of problem solution, description of pilot projects, etc.), distributed over branches of knowledge tree (over sub-rubrics): irrigation, drainage, hydrostructures, etc.;
- exchange of ideas and plans of scientific-technical activity;
- consultations and expert evaluation of the projects, etc. on-line;
- express-information about conferences, workshops, training, new industrial products, new technologies in sector though subscription and “news” sites;
- Capacity Building directed to management sustainability increase including legal, organizational and economic perfection;
- Information about donor programs, which can be used for sector development;
- Experience in transboundary water sources;
- Electronic library for thematic publications (multilingual);
- Remote training of water specialists.