Decision Support System for Waste Water Management: A Review

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Abstract-- In recent years population is increasing so much. Also there is big problem of wastewater disposal. So it becomes more complex to find sustainable solution for wastewater management.It requires more processes and advanced monitoring and control systems. This paper describes the development and operation of a Decision Support System (DSS) for waste water disposal management. It uses the concepts such as components,community context. These are based on data structure ontology. Ontology make use of a common vocabulary, which allows different groups from different domain to understand and communicate with one another.This paper defines two software module Design generation module and decision aid module. Design generation module gives the no of different alternatives designs.It uses Constraint Logical Programming for desiging alternatives. Decision aid module allows users to easily select their preferred design(s) by comparing tradeoff between different alternatives generated in Design generation module for that purpose it uses value charts .Finally DSS will gives the best alternatives which will balance environmental, economic, and social goals.

Keywords— **Constraint-Logical Programming, decision support system (DSS),design,ValueCharts**

I. INTRODUCTION

Today world's water issues are increasing so much in coverage and intensity so that there is need to secure water. In recent years wastewater disposal is becoming more complex, because it requires more processes and advanced monitoring and control systems. The most of wastewater technologies in the industrialized world will require retrofitting and replacement in the near future [8]. For sustaining life water shoud be available in some acceptable quality and quantity. A sustainable waste water disposal technology protects human health and does not contribute to environmental degradation or depletion of resource base.such a disposal method must be technically feasible, economically viable and socially acceptable.[9].

The design of a water treatment train will depend on water quality, regulatory requirements, consumer/ environmental concerns, construction challenges, operational constraints, available treatment technologies, and economic feasibility [2]. Information technology plays important role in the planning, design, and operation of waste water disposal. Now a days decision support system (DSS) are used to solve such type of problems.

II. NEED FOR DSS

Decision support system (DSS) is a computer program application that analyzes data and presents it so that users can make decisions more easily. It is an "informational application" (to distinguish it from an "operational application" that collects the data in the course of normal business operation).Typical information that a decision support application might gather and present would be for ex:

- Comparative sales figures between one week and the next.
- Projected revenue figures based on new product sales assumptions.
- The consequences of different decision alternatives, given past experience in a context that is described.

A decision support system may present information graphically and may include an expert system or artificial intelligence (AI). Decision support system (DSS) for waste water management is designed to help community planners to identify solutions which is best in terms of environmental, economic, and social needs.[5]. There are so many decision Support system approaches and methods used in the analysis,interpretation, and solution of waste water disposal . DSS will generate so many alternative designs. It will also help for selection of best alternatives which satisfies of environmental, economic, and social needs of community.There are so many methods that can help developers of DSSs to select the approach that most suitable to the problem under consideration.

III LITERATURE SURVEY

In this section we will discuss what techniques were used in wastewater disposal from Dss.

A. A paper on "**Wastewater treatment improvement through an intelligent integrated supervisory system**" [1] focused on the development and implementation of new techniques for design of complex process,that are mainly related to wastewater treatment plants(WWTP). The experience obtained indicates that the best approach is a Supervisory System. It combines and integrates classical control of WWTP with the application of knowledge-based systems.It Mainly uses expert systems and case-based system from knowledge-based systems.It defines architecture of the supervisory system and the work carried out to develop and build the expert system, the casebased system and the simulation model for implementation in a

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real plant (the Granollers WWTP). Finally, some results of the field validation phase of the Supervisory System when dealing with real situations in the plant are described. Architecture developed uses three modules: data gathering, diagnosis module, and the decision support module.This paper present research for multidisciplinary approach to tackle complex problems, starting from a basic research and finishing to its implementation at an industrial scale, in order to contribute to the amelioration of our environment.[1]

B. A paper on**, "Decision support systems in water and wastewater treatment process selection and design" [2]** defines a systematic approach to developing decision support systems.It includes the analysis of the treatment problem(s), knowledge acquisition and representation, and the identification and evaluation of criteria controlling the selection of optimal treatment systems. This paper describes approaches and methods used in decision support systems developed to aid in the selection, sequencing of unit processes and design of drinking water, domestic wastewater, and industrial wastewater treatment systems.There is a need to develop integrated decision support systems that are generic, usable and consider a system analysis approach.It defines Artificial intelligence methods such as Expert systems (ES) are knowledge- based systems (KBS) Issue-based information systems (IBIS), Case-based reasoning (CBR), Neural networks (NN), Bayesian probability networks.For selecting an optimum (or near optimum) solution it uses multi-criteria decision analysis (MCDA). For each alternative MCDA calculates the weighted sum score.[2]

C. A paper on, "**ONTOWEDSS-Ontology Based Envirnmental Decision support System for the management of Waste water treatment plant** "[3] For management of waste water treatment plant the new technology used is ONTOWEDSS system i.e. ontology based environmental decision support system. Ontology is hierarchically structured set of terms and relation. It describes domain of waste water treatment. It provides more flexible management capability. ONTOWEDSS is implemented in LISP programming language, using Allegro CommonLISP software. The two most important approaches are used i.e. Rule based expert system and Case-based resoning.The problem with RBESs is that they are very complex and related to specific domain. It always need an expert human to be solved. In process of extracting the knowledge and experience from source it have some problems. They are not reliable to unexpected situations.They need special programmer for making changes in KB.

In Case Based reasoning, for solving current problem, problem solver reuses the solution from some past cases.Advantages of this approach is improved efficienct.The system becomes more competent in its evolution over time.Main problem is that it can not work properly if there is no available experience.For evaluating alternatives this paper uses GAM(Goal Achievement Matrix) is used. It is most simple and effective mean of displaying preference.[3]

D. A paper on, "**Integrating sustainability in municipal wastewater infrastructure decision-analysis using the analytic hierarchy"[4]**,for finding out the 'most sustainable' wastewater treatment system,they use policy documents, academic literature, and the AHP (a decision support tool: Analytic Hierarchy Process). The objectives hierarchy was made up of four criteria and 13 indicators. Five wastewater experts were asked to use pair-wise comparisons to score the indicators and criteria of the constructed objectives hierarchy and provide their opinions on the same. In addition, four low foot-print wastewater treatment alternatives were selected for review.Participant rank four alternatives according to their performance on the selected indicators. This ranking, in combination with the rankings of the indicators and criteria, previously made by the five experts, were used to indicate the preferred alternatives for each of the separate participants. Then, the overall prioritization of the alternatives was used to carry out a sensitivity analysis. Wastewater treatment selection showed that the most contentious indicators among those studied were Initial Costs and Long Term Costs, Effluent Quality and Aesthetics .[4]

E. A paper on **"A Decision Support System for the Design and Evaluation of Sustainable Wastewater Solutions"[5]** describes the development and operation of an Decision Support System (DSS) for waste water disposal management. It uses the concepts such as components,community context. These are based on data structure ontology. Ontology make use of a common vocabulary, which allows different groups from different domain to understand and communicate with one another.This paper defines two software module Design generation module and decision aid module. Design generation module gives the no of different alternatives designs.It uses Constraint Logical Programming for desiging alternatives. Decision aid module allows users to easily select their preferred design(s) by comparing tradeoff between different alternatives generated in Design generation module For that purpose it uses value charts .Finally DSS will gives the best alternatives which will balance environmental, economic, and social goals.[5]

1) Developing a Wastewater Disposal Decision Support System

Decision support systems (DSSs) is designed to allow input from different parties involved in the decision making process as planners navigate through complex problems.The main purpose is to develop DSS which will help communities effectively by giving the design space of sustainable wastewater solutions that is relevant for the particular context, and make it possible to identify solutions that balance environmental, economic, and social needs.i.e.to identifying "the most sustainable solution" means finding solutions that minimize negative effects, while maximizing benefits for local and global environments.

The main objective our DSS are as follows-
1. The system is built on an open platform with the use of ontology. i.e. for no of technical and nontechnical concepts it will use a common vocabulary.
2. The system is able to automatically generate alternative solutions.
3. The system has capacity to effectively communicate the tradeoffs between these alternatives and simultaneously allow users to check which alternative is assessed to be the best solution and why.

This system basically developed for planners and their consultants. It can be also used by public. Such system must be scalable, adaptable, and flexible to allow fair assessment of new ideas and technologies.

Our DSS accepts information from three separate groups:
1. Information about the physical components of a system that can be arranged to create a sustainable sewage management system. This information is provided by engineers, inventors, technology firms and so on.
2. Context specific information (regulatory, demographic, geographical, etc.) provided by, for example, planners (municipality, city, region, etc.).
3. Information on values, preferences, and predictions provided by various stakeholder representatives (e.g., elected officials, the public, special interest groups, NGOs).

2) Architecture of DSS

The architecture of our DSS, as shown in Fig. 1,It contains two main software modules and several data structures. Ontology is used developing data structures.The data structures consists of system components, the community context, user values, and the properties and relationships each of these have with each other. The first module is design generation module which can automatically generate a large number of alternative wastewater system designs. Next one is decision aid module which is interactive visualization system. It allows users to easily select their preferred design(s) by comparing tradeoffs between a different solutions generated by the design generation module.

Methedoogy Used-

a) Ontology

An ontology is a formal explicit specification of shared conceptualization.[3]

DSS for waste water disposal requires information from different parts of community with variety of people with diverse knowledge and expertise. Different group uses of different vocabularies and language constructs.So it requires efficient communication among these people. So they make use of a common vocabulary, which allows different groups from different domain to understand and communicate with one another. Computer-based ontologies are designed to specify the meaning of the vocabulary used in an information system [6]

b) Component

Component is defined as the pieces which are connected together to create a waste water management system. Pieces may include processes, technologies, components, modules, or combinations of these. Each component has a set of constraints or limitations, and required inputs and outputs. Input, output, and constraint values are stored on the database.And this database is build on ontology.Means they use common terms for the same concept.

An example component is presented in Fig. 3

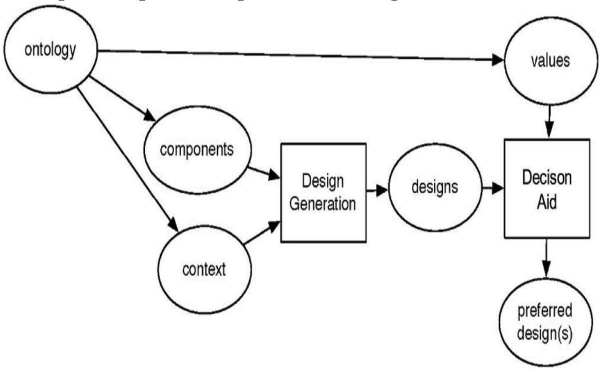

Fig.1.Architecture of DSS [5]

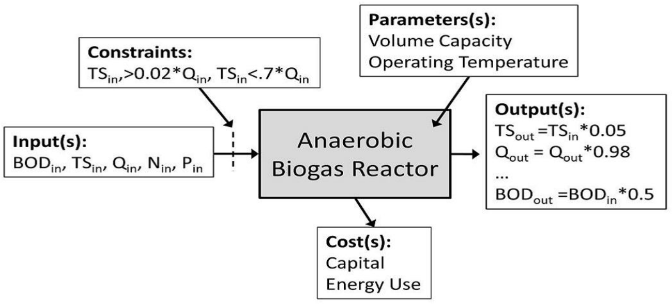

Fig. 2. Example of a component with the properties and constraints.[5]

c) Community Context

Community is nothing but an area for which we are going to build DSS. This area can be for example, a village or a city. So we will identify the best system for such a community .A community context provides constraints that the system must attempt to satisfy. These constraints may depend on a community's population, climate, and amount of land available, regulatory restrictions and so on. The constraints can be level of BOD (an indicator of effluent quality), capital available for construction and energy use. The structure of the community based on the community context ontology.

An example of a city community context is presented in Fig. 3

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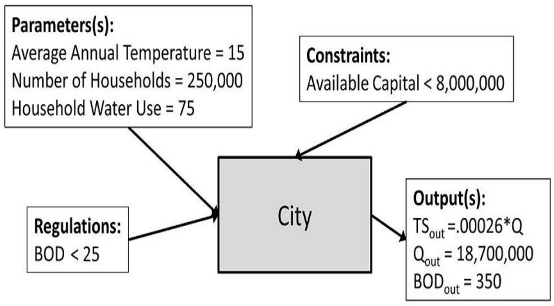

Fig. 3. Example of a community context with the associated properties [5]

3) Software module used in DSS Architecture

a) Design Generation Module-

This module will automatically generate a large number of alternative wastewater system designs.A design means it is a set of components which are arranged together. A design must be physically possible, should satisfy the constraints specified by the community context.

There are 3 types of designs:

Start - Initially, we consider the community as a component which has an output.

Partial – A partial design is a set of components in which components are connected together, but there some components which output is not yet connected to a component.

Complete- It is a design where all outputs of components are connected to other components.

So our DSS should generate a complete design.

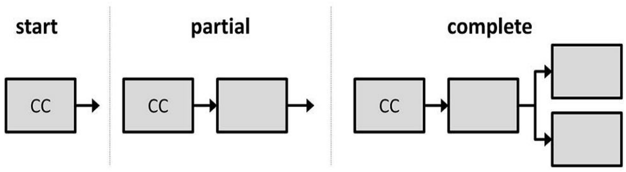

Fig. 4 Abstraction of starting, partial and completed designs. CC =community context, rectangle = component, and arrow =output[5]

We will convert a partial design to complete design by adding new component to it.So component addition is based on 2 conditions- if the input type matches the type of the available output and the constraints of the new and existing components of the design are all satisfied. As components are added, the DSS will calculate the costs (utility and community constraints) of completing that design. If the actual cost plus the heuristic value is less than the cutoff, then it extends the current partial design with additional components.

DSS will use Constraint Logic Programming (CLP) for getting automatic designs.

Constraint Logic Programming:

CLP is a merger of two declarative paradigms_ constraint solving and logic programming.It uses a rich and powerful language to model optimization problems. In this modelling based on variables, domains and constraints.Constraint Programming states constraints about the problem variables and finds solution satisfying all the constraints .C*onstraint* means relation among several unknowns.

2. Decision Aid module

It allows users to easily select their preferred design(s) by comparing tradeoffs between different solutions generated by the design generation module.For selecting design there are three phases:

1. Decision makers to simply rank the objectives in order of importance.
2. Assigns a score to each alternative, typically between zero and one, representing a range from the worst to best possible alternative.
3. A sensitivity analysis done in this phase. This analysis can help user to answer "what if" questions, such as "if we make a slight change in one or more aspects of the model, does it affect the optimal decision? Why?" There are so many tools available checking the sensitivity analysis like AHPTreemaps (TM), CommonGIS (CGIS).But ValueCharts is the most effective tool.

Value Charts:

Our adaptation of ValueCharts is a Multi-Criterion Decision Analysis (MCDA) tool which enables the assessment of various wastewater alternatives through the comparison of a variable number of criteria, their associated groupings and weight functions. The user can access ValueCharts by adjusting weights and functions of each criterion to assess the effects of these changing preferences on the evaluation of the alternatives. Finally, ValueCharts is based on simple visualization techniques, namely bar charts and staked bar charts; they do not require any expertise in information visu-alization and can be used by a wide range of users.

In fig:5 the objectives are arranged hierarchically, and are represented in the bottom left quadrant.Here the quality of a rural waste water system is decomposed at the first level of the hierarchy, into social, environmental, and economic criteria. The height of each block indicates the relative weight assigned to the corresponding objective and its percentage (in decimal value) of importance is also given. Then for each objective the corresponding value function is displayed. This function expresses the preference for each domain-value for that objective as a number in the [0,1] interval, with the most preferable domain-value mapped to 1, and the least preferable one to 0. For ex, if design is Acceptanced then it has value Yes i.e.1 otherwise it has value no i.e. 0.

Each alternative is represented with label (e.g., Design 3) and the amount of filled color relative to cell size depicts the alternative's value of the particular objective So, for ex Design 1 has the highest capital cost (lowest preferability), but it generates one of the lowest levels of BOD (high preference). In the upper right quadrant, all values are accumulated and presented as vertical stacked bars.It displays the aggregate score of each alternative. In this model, Design 4 is the best alternative the highest aggregate score.

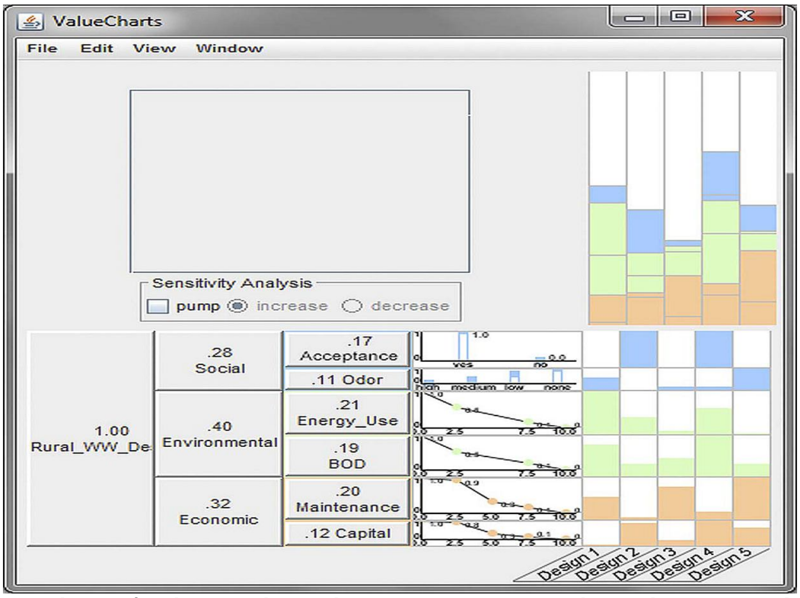

Fig. 5 . An example decision scenario showing five designs and six evaluation criteria representing the social, environmental, and economic values hypothetically identified by the user[5]

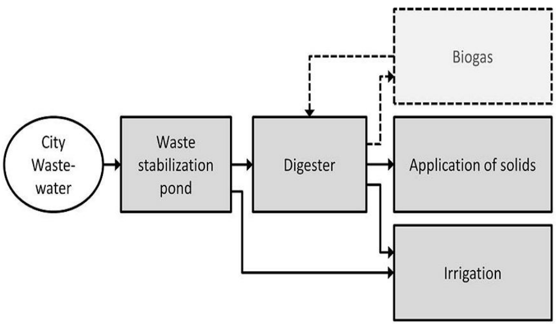

Fig. 6. Example solution for a large city (Q =18;700;000 L/d, TS =5;000 L/d, Capital = $8;000;000).[5]

We take an example for mid-size city (250,000 households) in an economically undeveloped country. In this particular scenario, we assumed that a household produces 75 L/d of wastewater (Q). Here, we assume that the wastewater from all households is piped into to a single location (a centralized system). Here, we calculate Q as 18,700,000 L/d, and TS of 5,000 L/d, the city budget is $8000000. We placed bound on the system, which restricted the number of component combinations to five (regardless of the cost). This was done in an effort to reduce the amount of time the system would take to process all

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possible combinations. Though the cost difference is little to none between the two options, the former would require the model to explore an unnecessarily large space of possible solutions. With a restriction of five possible components, the model found 190 alternatives. Increasing the number of components to six, resulted in 946 solutions; seven resulted in 17,818 alternatives; eight results in 142,186 alternatives. Of these solutions, most included combinations of a digester, stabilization pond, and some form of wetland. One example solution is shown in Fig6.

Waste stabilization ponds to separate the input product into two outputs. These outputs are commonly referred to as the effluent (primarily water) and the sludge. The sludge contains a large amount of the solids that can be converted to energy if managed appropriately. The output directed to irrigation is roughly 0.5 percent, whereas the output directed to the anaerobic biogas reactor (shown in dashed border) is 10 percent. Though the properties describing the outputs may be simplified, they are sufficient, in this case, to allow the model to infer which component can manage each of the various outputs. Suppose we add digester,then there are three outputs. One is irrigation, the other is a product which could be used for composting or other applications of solids and third one is digester. The production of biogas depends on the operating temperature, volume, and concentration of TS in the component. In Fig 6. We show how the biogas product could be reused directly by the digester (dotted line).

III. CONCLUSIONS

The decision support system given in this paper is intended to help planners integrate feedback from engineers, elected officials, and others, and facilitate exploration of possible wastewater solutions that meet their community's goals and best fit their values. It gives different alternatives designs and also informs users that how changing values influence their preferred design. this is a DSS that supports the planning and decision making process from a sustainability-oriented analysis approach.[5]

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