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Water Conflict Resolution in Multiple User Scenarios in Mahakanadarawa Scheme in Sri Lanka

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Abstract—*Sri Lanka is an agriculture based developing country and currently Anuradhapura district provides the large contribution to the national economy through food production. The Mahakanadarawa irrigation scheme situated in east side of the A9 road, nearly 20km from the heart of the Anuradhapura city. This scheme has 126 Sqmls catchment and 36250 Ac ft. capacity. This scheme is the back born of the livelihood of around 5237 farmer families. The main income of these people is agriculture. Most of the farmers usually do paddy cultivation. Out of 6100 Acres the full extent cultivated in maha season and nearly 1500 acres cultivated in yala season. The cultivation of yala season reduces due to water shortage. The inflow of Mahakandarawa based on seasonal rain and inflow from Eruwewa .The Eruwewa Mahakandarawa feeder canal is not properly working due to poor maintenance and partially completed construction. This leads miss calculation on the estimation of the inflow from the Eruwewa clearly. The government and scholars identified some kidney disease spread areas far downstream of Mahakanadarawa scheme. Rambewa, Medawachchiya, Kebithigollawa etc. The major reason for this problem identified as the drinking water quality. The ground water of this area is highly polluted with the heavy material. Therefore the importance of the treated surface water become necessary. The government also announced to give the first priority to Drinking water. There is water shortage in Yala season in every year. The demand of drinking water makes another dimension to water sharing between the multiple users and emerging as bigger social problem. To address this problem a study incorporating, the agriculture pattern, and water balance of irrigation scheme and attitudes of people towards water management and reduce of the water wastage in this scheme is going on. This article spells out the importance, initial groundwork, the methodology of this curtail needy research study on socio engineering intervention of a social problem.*

Index Terms— Anuradhapura, *National economy, Mahakanadarawa irrigation scheme, Drinking water, Paddy cultivation, Socio engineering, Multiple user.*

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1 Introduction

UNLIKE others, "... Resolution of conflicting goals is a unique human function, imperfect and irrational as it may be. No optimization method - indeed, no model - can tell any decision-maker how to evaluate the degree to which various individual (or common group) desires should be fulfilled or compromised." Jon Liebman (1976)

Throughout most of the industrialized world, water reservoir systems are largely developed; relatively little new reservoir development can be expected. The climatic change, increase of population and changing of life pattern increase the water demand in several sectors.

Anuradhapura is one of the ancient city in Sri Lanka as well as famous for the ancient irrigation system. There is 12 major tanks in Anuradhapura, only 4 major tanks are utilized for the drinking water. Those are Kalawewa, Thissawewa, Nuwarawewa and Thuruwila. The new project planned in Mahakanadarawa (Fig 1), Wahalkada, Mahawilachchiya and Huruluwewa.

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The problems in these major schemes are

- The average crop intensity is 1.2
- Water shortage in yala season
- High water requirement for the crops
- Poor water management due to canal system
- Medwachchiya, Padaviya and Wilachchiya region are identified as Kidney Disease region

The government planned to build water treatment plant in Mahakanadarawa to give drinking water to Rambewa, Medawachchiya regions. As a result, people are facing problem in seasonal cultivation and drinking water.

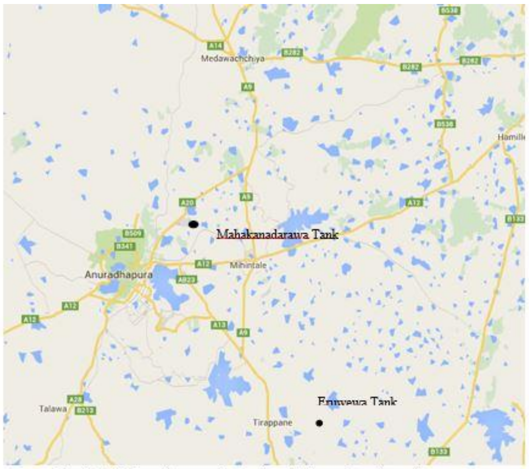

Fig.1 Mahkanadarawa Irrigation Scheme in Anurathapura

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2 Statement of Research Problem

There is water shortage in Yala season in every year. The demand of drinking water makes it the bigger problem. There is the relationship among the multiple water users for the agriculture needs, drinking water and water inflow.

To address this problem proposed study will give a scientific justification and will give new thoughts about the agriculture pattern, water balance of tank and expected attitude change of people for water management and reduce of the water wastage in this scheme.

3 Objectives of the Research

Main objective of this study is to

- Identify the Agriculture land use pattern in Mahakanadarawa Scheme
- Identify the water demand for different agriculture crops related to soil type
- Identify the water demand for drinking water
- Conducting a socio economic study to identify the present livelihood of the people and paddy, OFC cultivation
- Identify the water management techniques for agriculture
- Identify the inflow pattern and find out the solutions for increase the inflow
- Identify the methods to reduce the water wastage in Drinking water
- Implement the ACT to minimize the water conflict between Agriculture and Drinking Water

Based on this study a strategy will be introduced about the use this in other Major reservoirs in Anuradhapura for the Water Conflict Resolution among the multiple water users.

4 Review of Literature

4.1 The Water Economics Project (WEP)

Fishelson's statement and the considerations just given provided the impetus for what is now named the "Water Economics Project" or "WEP", a project of Israeli, Jordanian, Palestinian, Dutch, and American experts that has been working in various forms since 1992 with Franklin Fisher as the Chair.

The WEP began under the auspices of the now-defunct Institute for Economic and Social Policy in the Middle East (ISEPME) at Harvard's John F. Kennedy School (Leonard Hausman, Director). Until 1996, it was a purely private enterprise, and, by the end of 1995 had produced the first version of the WEP model described below.

In the Autumn of 1995, however, Hausman and Fisher met with Nabil Sha'ath, then the Palestinian Minister of Planning and International Cooperation (MOPIC). Minister Sha'ath informed them of the so-called "Dutch Initiative". At the second Middle East Economic Summit in Amman, Jordan, the Dutch government had stated their readiness to facilitate joint projects among Israel, Jordan, and Palestine, particularly projects involving regional infrastructure. Egypt had then expressed an interest and was added to the group (but took no active part in the water project). This initiative was to be governed by the planning ministers (or equivalent) of the regional parties, under the chairmanship of Jan Pronk of The Netherlands, the Dutch Minister for Development Cooperation within the Foreign Ministry.

The three regional ministers involved (omitting Egypt) were: Yossi Beilin of Israel; Rima Khalaf of Jordan, and Nabil Sha'ath himself. Sha'ath was firmly of the opinion that the WEP would be ideal for adoption by this committee. And so it proved, the project being so adopted in January, 1996 and fully starting work (after considerable negotiations) in July, 1997. ISEPME ceased to exist in 1998 and was replaced in the management of the project by Delft Hydraulics.

Not surprisingly, the attitude of the various governments towards the WEP has tended to depend on the non-water relationships among them. At present, there still remains interest (particularly on the part of the Palestinians) in continuation, at least for domestic purposes. The Lebanese government has also expressed interest in having a model created for it. The work is ongoing.

4.2 Goals of the Water Economics Project

The WEP has produced a tool for the analysis of water systems and associated problems. In doing so, its goals are as follows:

1. To create models for the analysis of domestic water systems. These models can be used by planners to evaluate different water policies, to perform cost-benefit analyses of proposed infrastructure taking system-wide effects and opportunity costs into account, and generally for the optimal management of water systems.

2. To facilitate international negotiations in water. This has several aspects:

    - The use of the Project's models separates the problems of water ownership and water usage. In so doing, it enables the user to value water ownership in money terms (after imposing his or her own social values and policies). This enables water negotiations to be conducted with water seen as something that can, in principle, be traded. Further, since the Project shows that water values are not, in fact, very high (partly because of the availability of seawater desalination), the water problem can be made a manageable one.

    - By using the Project's tools to investigate the wa-

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ter economy of the user's own country, the user can evaluate the effect of different water ownership settlements. (By making assumptions as to the data, policies, and forecasts of other parties, the user can also gain information as to the effects on them.) This should assist in preparing negotiating positions if the ultimate agreement is to be of the standard water-ownership-division type with no further cooperation.

- Perhaps most important of all, the Project shows clearly that cooperation in water will benefit all parties. Such cooperation in the form of an agreement to trade water at model prices can lead to very large gains to all participants (sellers as well as buyers) and is a superior solution to the standard water-quantity-division agreement. Our results show that there are very large benefits to both Israel and Palestine from such an arrangement. The gains are far larger than the value of ownership of more or less of the disputed water is likely to be.

- Beyond the economic gains of such an arrangement are the gains from a flexible, cooperative water agreement in which allocations change for everyone's benefit as situations change. Such an agreement can turn water from a source of stress into a source of cooperation.

In summary, the WEP hopes to promote "outside-the-box" thinking about water problems and thus to remove them as an obstacle to peace negotiations.

4.3 Why Actual Free Water Markets Will Not Work

Returning to Fishelson’s example, as already mentioned, the result of the calculation of the really important insight is that one should think about water by analyzing water values and not just water quantities. This should not come as a surprise. After all, economics is the study of how scarce resources are or should be allocated to various uses. Water is a scarce resource, and its importance to human life does not make its allocation too important to be studied in the same way.

In the case of most scarce resources, free markets can be used to secure efficient allocations. This does not always work, however; the important results about the efficiency of free markets require the following conditions:

1. The markets involved must be competitive consisting only of very many, very small buyers and sellers.

2. All social benefits and costs associated with the resource must coincide with private benefits and costs, respectively, so that they will be taken into account in the profit-and-loss calculus of market participants.

4.4 The WAS Tool

The tool is called WAS for "Water Allocation System". At present, it is a single year, annual model, although the conditions of the year can be varied and different situations evaluated.

The country or region to be studied is divided into districts. Within each district, demand curves for water are defined for household, industrial, and agricultural use of water. Extraction from each water source is limited to the annual renewable amount. Allowance is made for treatment and reuse of wastewater and for inter-district conveyance. This procedure is followed using actual data for a recent year and projections for future years.

Environmental issues are handled in several ways. Water extraction is restricted to annual renewable amounts; an effluent charge can be imposed; the use of treated wastewater can be restricted; and water can be set aside for environmental (or other) purposes. Other environmental restrictions can also be introduced.

The WAS tool permits experimentation with different assumptions as to future infrastructure. For example, the user can install wastewater treatment plants, expand or install conveyance systems, and create seawater desalination plants.

Finally, the user specifies policies toward water. Such policies can include: specifying particular price structures for particular users; reserving water for certain uses; imposing ecological or environmental restrictions, and so forth.

Given the choices made by the user, the model allocates the available water so as to maximize total net benefits from water. These are defined as the total amount that consumers are willing to pay for the amount of water provided less the cost of providing it.

4.5 Shadow Values and Scarcity Rents

It is an important theorem that, under very general conditions, when an objective function is maximized under constraints, the solution also generates a set of non-negative numbers, usually called “shadow prices”, but here called “shadow values” to emphasize that these are not necessarily the prices to be charged to water users). Such shadow values (which are the LaGrange multipliers corresponding to the various constraints) have the property that they show the amount by which the value of the thing being maximized would increase if the corresponding constraints were to be relaxed a little.

In the case of the WAS model, the shadow value associated with a particular constraint shows the extent by which the net benefits from water would increase if that constraint were loosened by one unit. For example, where a pipeline is limited in capacity, the associated shadow value shows the amount by which benefits would increase per unit of pipeline capacity if that capacity were slightly increased. This is the amount that

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those benefiting would just be willing to pay for more capacity.

4.6 Infrastructure Analysis

WAS provides a powerful tool for the analysis of the costs and benefits of various infrastructure projects. For example, if one runs the model without assuming the existence of seawater desalination facilities, then the shadow values in coastal districts provide a cost target that seawater desalination must meet to be economically viable. Alternatively, by running the model with and without a proposed conveyance line, one can find the increase in annual benefits that the line in question would bring.

Taking the present discounted value of such increases gives the net benefits that should be compared with the capital cost of plant construction. Note that such calculations take into account the system-wide effects that result from the projected infrastructure. Some examples of WAS-generated results for Israel, Palestine, and Jordan. These are results for each of the parties separately assuming them only to have access to the water they had in late 2004.

4.7 Conflict Resolution: Negotiations

The monetization of water disputes may be of some assistance in resolving them. Consider bilateral negotiations between two countries, A and B. Each of the two countries can use its WAS tool to investigate the consequences to it (and, if data permit, to the other) of each proposed water allocation. This should help in deciding on what terms to settle, possibly trading off water for other, non-water concessions. Indeed, if, at a particular proposed allocation, A would value additional water more highly than B, then both countries could benefit by having A get more water and B getting other things which it values more. (Note that this does not mean that the richer country gets more water. That only happens if it is to the poorer country's benefit to agree.)

Of course, the positions of the parties will be expressed in terms of ownership rights and international law, often using different principles to justify their respective claims. The use of the methods here described in no way limits such positions. Indeed, the point is not that the model can be used to help decide how allocations of property rights should be made. Rather the point is that water can be traded off for non-water concessions, with the trade-offs measured by WAS.

In addition to monetizing water disputes, WAS can facilitate water negotiations by permitting each party, using its own WAS model, to evaluate the effects on it of different proposed water arrangements. As we now exemplify, this can show that the trade-offs just discussed need not be large.

The water resource that is the subject of conflict is sometimes simply surface water, but it is often an interconnected system of flowing ground water and surface water.

The water body itself is frequently a jurisdictional boundary line that separates water users. Conflict arises when a water supply is not sufficient to satisfy the unrestricted use of all who share it. The conflict usually centers on a disagreement among people of multiple jurisdictions about use rates and whether those rates are sustainable. Frequently, one party of the dispute denies the uncomfortable reality of no sustainable use out of ignorance of water resource science. Occasionally, a high use rate is chosen out of a desire to achieve a private economic advantage that harms another party and/or the sustainability of a shared water resource. Often, the conflict involves the quality of the resource when contaminants, such as per chlorate (Houge 2003), are introduced to a water supply and overtax the water treatment capacity of those obligated to deliver water that is pure and potable.

Water resource institutions have emphasized technical and procedural aspects of the water governance process, with little attention being given to issues of conflict resolution and local stakeholder representation. As a result, the organizational structures and specific functions of water governance have tended to reflect blueprint planning approaches, often with very limited regard for the real-world dynamics with regard to which they were being implemented.

Recent years have seen the advent of more carefully reflected approaches, recognizing to a greater extent the need to accommodate stakeholder interests and address conflicts (Giordiano and Wolf 2003, GCI 2003). However, even in these efforts there often remains a notion that the way of preventing or overcoming such conflicts is simply a matter of creating 'better plans', that is, plans that are rational from a hydrological, economic and narrow organizational perspective, and thus assumed to be acceptable to all parties

If we are to take water conflicts seriously, we need to recognize them for what they basically are. Different interests held by different stakeholder groups within a highly political context. Water is the multi-purpose resource, applied in all areas of life and production by stakeholders at all levels, and as such it is almost by definition a contested resource.

A conflict perspective of this sort has important implications for the way development interventions approach water governance institutions and their associated functions.

- First, it suggests that substantial attention be given to issues of governance, representation and the development of political space for negotiation between stakeholders. These are enduring features of water governance issues: conflicts can be prevented and resolved to some extent, but new tensions are bound to appear as societies change and new needs and stakeholder groups develop.

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- Secondly, it implies giving attention to institutional processes, not just to static organizational arrangements. While specific outputs such as water management plans are crucial, they are unable to address different interests and tensions if they are not developed through careful processes of planning and negotiation between stakeholders.

- Finally, and importantly, it involves an approach that not only addresses conflict *resolution* mechanisms, but also works to address conflicts before they become deadlocked. Institutionally this entails a focus on ensuring stakeholder involvement in the water resources management process *as a whole*, not just in conflict situations.

Hence the Stakeholder participation and conflict resolution mechanisms are thus needed throughout the full water governance process. The governance dimensions of three key features in current approaches to water management, namely Integrated Water Resources Management, Stakeholder Participation and Conflict Resolution. Lastly, we seek to outline how conflict resolution and stakeholder involvement relates to specific water management functions.

Main water governance functions

- Overall policy development (priorities and principles for water management)
- Water resource policy/regulatory framework (water ownership, access and management obligations; monitoring; institutional framework)
- Domestic water supply policy/regulatory framework (standards, coverage, price policy for water provision; monitoring; institutional framework)
- Hydrological and environmental water resource assessments (water availability and environmental needs)
- Allocation of water rights (permanent or temporal withdrawal and discharge rights; monitoring)
- Inter-level ('transboundary') coordination and negotiation (deal with interdependencies between levels/units for water allocation)
- Intra-level coordination and negotiation (deal with competing claims from multiples users and for multiple uses)
- Independent appeal and dispute resolution (provide investigation and arbitration in cases of dissatisfaction with negotiated settlements)
- Independent knowledge production (assess state of the water and social, economic and environmental impacts)

Monetization of water disputes, however, is neither the only nor, perhaps, the most powerful way in which the use of WAS can promote agreement. Indeed, WAS can assist in guiding water cooperation in such a way that all parties gain.
The simple allocation of water quantities after which each party then uses what it "owns" is not an optimal design for a water agreement. Suppose that property rights issues have been resolved. Since the question of water ownership and the question of water usage are analytically independent, it will generally not be the case that it is optimal for each party simply to use its own water.

5 Methodology

The research method of this study can be categorized as below

- **Identify the Agriculture land use pattern in Mahakanadarawa Scheme**

  Satellite and GIS image will be use for find out the Land use pattern for agriculture in Mahakanadarawa Scheme. Use the past data from irrigation department to find out the seasonal harvesting pattern according climate variations.

- **Identify the water demand for different agriculture crops related to soil type**

  Soil sample collection locations will be identified in the Different part in agriculture land. Identify suitable cash crops to cultivate according to soil type. Find out annual water demand for the seasonal cultivation for identified cash crops.

- **Identify the water demand for drinking water**

  Identify the areas to fulfill the drinking water extract from Mahakanadarawa Scheme. Find out water According to population pattern of this area and water demand per head. Identify the variation of Annual seasonal drinking water demand pattern. Find out the increase of future water demand according to increase of population.

- **Conducting a socio economic study to identify the present livelihood of the people and paddy, OFC cultivation**

  Questioner will be issued to the find the socio economic standard of the people in farmer families and around. It will cover the personal information, educational standers, occupation, income from agriculture and income source, family type and size, interest of OFC cultivation, accessibility to drinking water, awareness on water quality and water pollution.

Hence we can identify farm families' economic problems, interest of OFC cultivation and interest to solve the drinking water problem

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Identify the water management techniques for agriculture

Water demand for paddy cultivation is very high in dry zone due to infiltration, evaporation, canal loss etc. Most of the canals are earthen canal therefore more than 40% water losses due to canal system. So find out the solution for reduce the water losses.
Find out the length of canals according to canal type. Find out water flow in start of the canal and water flow at the end of canal using current meter. Identify the time to take to fulfill the water requirement of the field in each field canal. Find out the relationship of water loss according to downstream length from the sluice and canal type. In this scheme 25.3 miles of Main canal and 29 miles of D canals
Introduce alternatives to reduce the losses like as introduce half round pipes to Field Canal, proper operating system, alternative methods like parachute methods and improvements of self canal maintaining of farmers.

Identify the inflow pattern and find out the solutions for increase the inflow

Using past rain fall data find out the annual inflow of the reservoir and do the water balance study using available inflow and water requirement of agriculture and water demand. The government planned for release some amount of water after completion of Morgahakanda project or NCP canal project.
Tabulate the results of water balance study and find out the extra inflow requirement from feeder canal. According to water demand finds out the weekly requirement or monthly requirement to fulfill the seasonal variation of water demand.

Identify the methods to reduce the water wastage in Drinking water

Questioner will be issued It will cover the personal information, educational standers, occupation, income ,people who are willing to use drinking water , water usage pattern etc.
Find out the wastage pattern in other areas those areas use treated water from NWS&DB and identify the sectors to contribute the wastage. To minimize this introduce the new water usage pattern in our areas.

- Treated water only for drinking
- Increase the unit price after some extent
- Awareness program to reduce water wastage

Implement the ACT to minimize the water conflict between Agriculture and Drinking Water

Identify the problems between the water demand sectors and implement the solution for water conflict. For this identify the head of the people to lead, organization, private sectors, stake holders and governmental parties who can effect by the problems and interest to solve this.
For the long term results the best solution want to be ACT. So the ultimate water conflict solutions derive as an ACT in national or interprovincial.

6 Data Analysis and Findings

6.1 Data collection

The following data will be collected for this research

- Satellite image and Agriculture pattern of Mahakanadarawa scheme
- Soil type the Agriculture areas
- Scheme data , farmer family data of Mahakanadarawa Scheme
- Population of Drinking water need areas
- Rainfall for Mahakanadarawa basin
- Water losses for each type of canal in different season
- Water losses of Reservoir
- Water Demand for drinking purpose and seasonal variations

6.2 Analysis

It could be noted that the water demand analysis will be carried out for Agriculture and Drinking water demands. Data collected seasonally will be correlated with water balance study. All these data will be first analyzed for consistency and put in to a suitable model to get the good correlation.

Formulate a model to represent the entire district; this model will be used for various studies related to water conflict resolution between Agriculture and Drinking water.

7 Conclusions and Benefits of the Research

This study will facilitate to understand the conflicts in multiple water users, particularly between Agriculture sector and Drinking water sector. Through this study importance of the water management will be understood and low water demand cash crops to be introduce to farmers.

We can educate the users of water resource to understand the wastage pattern of drinking water. By understanding this the water users can identified the value of water and how can we prioritize the basic needs in conflict. Finally we can make understanding of people regarding value of water and make governmental acts to the conflict resolution.

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