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Education: Ground Water Protection and Management Strategy In Developing Countries

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ABSTRACT: With increasing populations and scarce resources, developing countries typically have competing demands for infrastructure investment. Access to safe drinking water is usually a political priority. Rural water supply is typically groundwater based and locally managed. Once wells are installed, aquifer protection strategies and control of water-use to achieve sustainability should become critically important considerations, especially in semi-arid countries such as South Africa. Investment in equipment and engineering is often not adequately matched by investment in local protection and sustainability education. If aquifers are exploited in excess of natural recharge or become contaminated, there is real risk of hydrologic, economic and social crisis. Citizen and community education is an effective link between the science of the hydrologic system and the political decision-making process needed for effective and equable water policy. A program of simple low-cost (but on-going) ground water awareness and education strategies should always be a budgeted ingredient of developing-country water schemes.

1 INTRODUCTION

1.1 *Population*

Two thousand years ago, the world's total human population was less than 3% of the present total. Currently world population is increasing by approximately 150 people per minute and now exceeds 6 billion. Although overall rates of growth have slowed, absolute numbers are increasing by 80 million people per year. By 2025 more than 3.3 billion people will live in 50 countries facing water stress or scarcity (Gardner-Outlaw & Engelman, 1997). Eighty percent of all disease in the world can be traced to drinking and washing with unsafe water supplies. Satisfying basic water needs is a priority for governments of most developing countries.

1.2 *Limitations to Growth*

Fresh water is finite although renewable. For centuries water has been diverted or transported from where it occurs to where it is needed. Even with the low per capita water use of 20-40 litres that is considered to be a minimum for drinking and sanitation, lack of freshwater is a factor in limiting community health, economic progress, and food production. Increased pumping and diversion of water is causing damage to ecosystems (Falkenmark & Widstrand, 1992, Davis & Day, 1997). Globally, 80 million hectares of farmland have been degraded by a combination of salinization and waterlogging (Hinrichsen, Robey and Upadhyay, 1998) but world food production will require a two to threefold increase per hectare to meet 2025 projected minimum food requirements (Board on Sustainable Development, 2000).

1.3 *Sustainable Development*

As countries become more crowded, consuming and connected there are increasing demands for land, energy, materials, goods and services - especially water supply. Because water is a renewable resource, supply development should be based on the concept of achieving sustainability. Publications such as Gore's *Earth in the Balance* (1992) and Gleick's *Water in Crisis*, (1993), have helped promote scientific and political awareness of the interdependence of society and the environment. Providing water is a prerequisite to reducing poverty. The challenge is to meet growing needs from finite resources while maintaining and restoring the planet's fragile life support system. Recently, the debate over sustainability has moved from a scientific exercise to political reality because of stress between human population and natural resources. The resource management principle is changing from, how much water is needed and where do we get it? to how much is there and how can it best be used?

2 RURAL GROUND WATER SUPPLY

2.1 *Management Issues In Rural Areas*

There are inherent problems in implementing local policies to ensure safe sustainable water supply. In many developing countries, management authority is often fragmented and poorly defined, with water supply provision and community health under different agencies. Financial assistance, availability of technical expertise and allocation of personnel are often centrally rather than locally administered. Under-pricing of water and lack of payment-collection capacity can constrain the ability of communities to manage and maintain water systems. Insufficient local and decision-maker understanding of hydrologic "cause and effect" with regard to over-pumping and contamination risks can further compound the difficulties of successfully implementing sustainable water projects. Information and education can help close the awareness gap.

2.2 *"Benign" And "Wicked" Problems*

Some thirty years ago in a discussion of planning theory, Rittel & Webber outlined two types of planning problems. "Benign problems" are those with a clear and logical definition with a specific disciplinary variable. "Wicked problems" have multiple definitions and objects and multiple and conflicting criteria for defining solutions (Rittel & Webber, 1973). Virtually all local ground water development and management issues are by definition "wicked" even although some individual components, for example defining aquifer boundaries or estimating local population growth, may be "benign." Ground water is simply that part of the hydrologic system that occurs in a geologic environment but there is not a simple scientific and engineering formula that can be used for water supply decisions. Science may be neutral but scientists are not necessarily neutral (Walker & Mairs, 1999). Best professional judgement is a starting point for ground water development and protection decisions but there can soon be a "wicked problem" disconnect between scientists, policy makers and the public because technical, academic and engineering professionals may not be adequately integrated into the political process. Agency authority can fill the gap with regulations but regulations should follow policy; policy should not be formed by regulation. Acceptance by the regulated that there is a rational need for regulations is an important prerequisite to making rules workable. Education needs to be a key element of regulation in order to achieve cooperation and compliance.

2.3 *Rural Water Supply in South Africa*

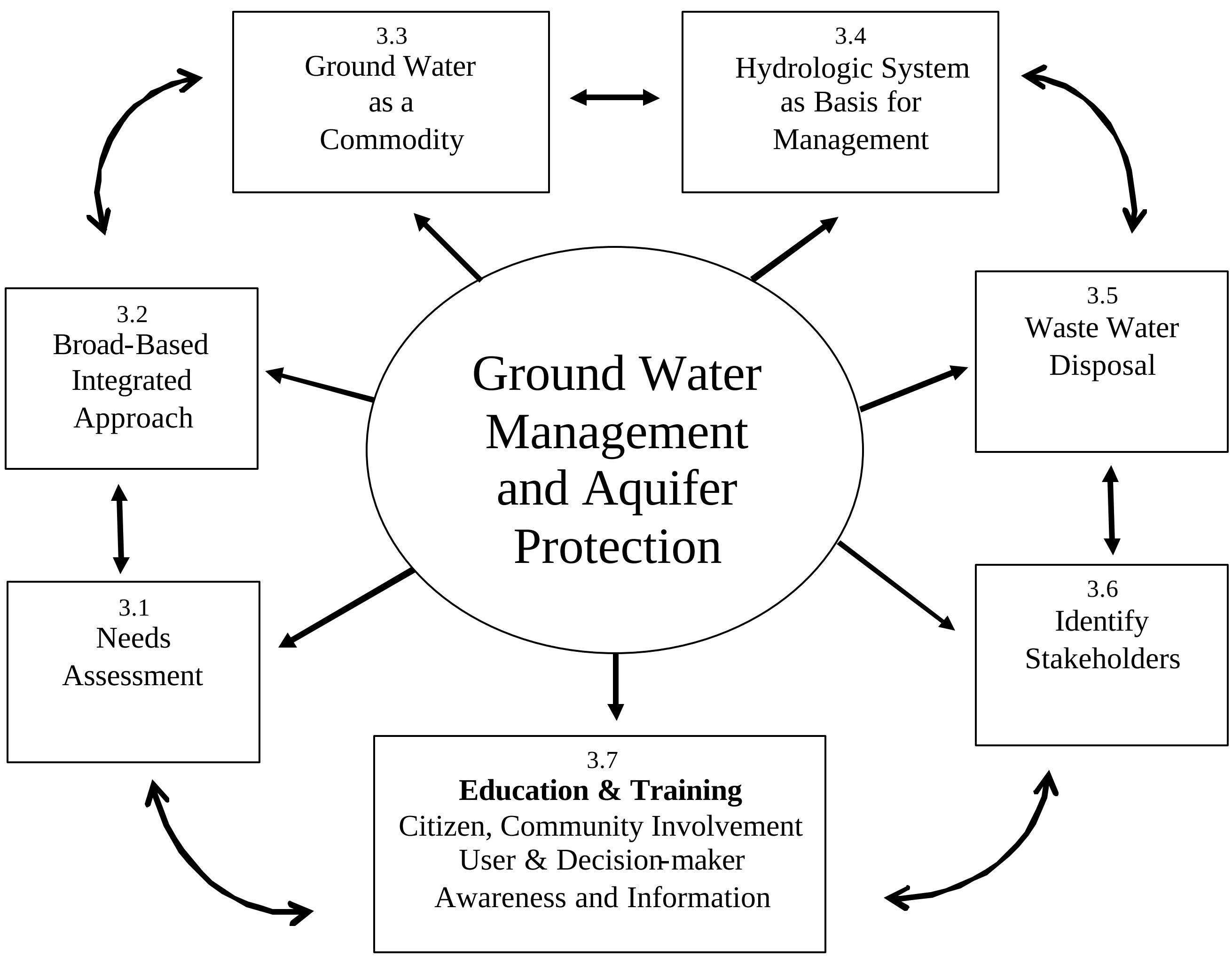
Provision of adequate water supplies to rural areas is a top government priority in South Africa (African National Congress, 1994). The national Water Act specifies that government, as the public trustee of the nation's water resources, must act in the public trust to ensure that water is protected, used, developed, conserved, managed and controlled in a sustainable and equable manner, for the benefit of all persons. It is estimated that 12 million South Africans have no access to safe potable water and that 23 million people have no proper sanitation facilities. South Africa's ground water is of great importance as a supply source for rural areas and there is often no feasible supply alternative.

By 2030, South Africa will reach the limits of its economically usable land-based freshwater resources (Basson et. al. 1997).

South Africa receives 470mm average annual rainfall compared to a world average of 857mm. If South Africa has a national water availability per capita index of (1.0), using figures of total renewable water and population, then by comparison; Botswana is (8.0), Mexico (3.0), Israel (0.37), USA (7.6) and Canada (80.0). This derived index is dimensionless and is calculated from data reported by Gleick (1998). It serves to demonstrate that management strategies will become increasingly important in water deficient areas. Engineering solutions can move water, but cannot economically create additional sources, although South Africa may have some limited supply options from water reclamation. South Africa currently reclaims about 3% of its wastewater compared with Israel's 84% reclamation of wastewater, (Grobicki & Cohen, 1999). However wastewater reuse is unlikely to provide solutions to drinking water supply provision in rural areas.

South Africa has boldly created the concept of a national water reserve. This is a defined quantity of water resources needed to satisfy basic human needs (human needs reserve) and protect aquatic ecosystems (ecological reserve). The concept incorporates recognition that the hydrologic system is integrated. The reserve amount for specific areas must be quantified and specify both amount and quality. Rural water provision schemes must therefore satisfy needs for community health, economic growth and ecological integrity. There is a great educational challenge to help communities and decision-makers understand the "reserve" concept, especially when long term ecological needs have to be balanced against immediate economic and social requirements.

Figure 1 Essential Components Of Ground Water Management And Aquifer Protection



3 CRITERIA FOR GROUNDWATER MANAGEMENT AND AQUIFER PROTECTION

If it is agreed that basic "cause and effect" content for hydrological education is critical for the implementation and maintenance of rural water schemes, then all aspects of decision-making criteria should be reviewed for their educational component. Education is a process not a result and is applicable at all stages of water project implementation. Awareness, information, public relations and outreach are popular buzzwords often used indiscriminately under a broad umbrella of education. They are all important! In order to complement rural management and protection initiatives, what happens under the umbrella is more important than the semantics of what it is called. Figure1. shows links among criteria that are likely to be appropriate for decision making for local ground water based supply systems in developing countries. Sections, 3.1 to 3.7, summarize some of the principal criteria to be considered as components of planning, carrying out and maintaining ground water management and aquifer protection projects.

3.1 *Undertake a Comprehensive Needs Assessment*

- assess social/economic/ecological costs and benefits from the improved water supply infrastructure
- assess the needs for parallel investment in health care and hygiene education
- use appropriate predictive models of economic growth and water need
- use long term time-frame for cost benefit calculations

When a water scheme is proposed, the need should be objectively assessed. This component is particularly important if projects are to be prioritized for investment. Pet water projects are popular with politicians world wide. Investment should be prioritized to the needy not the noisy (Stone, 1997). Water is likely to be just part of a community's needs, and the supply investment may be best packaged with other infrastructure investment.

3.2 *Take a Broad-based Approach*

- integrate hydrologic, economic and social planning and consider all potential resource users
- involve water resources specialists as well as water engineers
- establish cooperative government/ agency/ private sector authority over resources
- consider all complimentary supply strategies such as conservation and conjunctive use

It is important to integrate hydrologic information, economic forecasting and social planning into resource management decisions. Current and potential uses and users should be incorporated into the process. The whole concept of resource management requires an objective assessment of all potential beneficial users in addition to current users. A hurdle in decision-making is to overcome "turf wars" among overlapping jurisdictions. Establishing joint agency authority within a framework of collective consultation can help ensure that energies are devoted to solutions rather than power struggles.

3.3 *Consider Groundwater a Commodity*

- calculate all the financial costs of providing water and protecting resources
- factor-in ability of the community to pay and the value of government subsidies or user tax breaks
- price water realistically to ensure revenue for system maintenance and resource protection
- ensure that management capacity and cost recovery procedures are workable

A common approach to water management issues is to regard water as a commodity. The value of the commodity is then viewed in the light of its overall economic contribution to the local, regional and national economy. What is the value of water if used for some other purpose? Who is profiting from the current use of water? Is the water being paid for at current market value? Are there hidden government subsidies or tax breaks that are skewing water costs? Water schemes have failed in many countries around the world because insufficient budget was set aside for upkeep and repair.

3.4 *Use the Hydrogeologic System as a Basis for Management*

- adhere to the water supply sustainability paradigm
- use watersheds and/or specific aquifers as basis for assessment & management
- verify past hydrologic data and ensure integrity of current data sets
- review similar geologic/climatic areas-include hydrologic and regulatory strategies for drought

The "Dublin Principles" established by the International Conference on Water and the Environment in January 1992 recognized that water resources are finite and vulnerable and that sustainability should be a management objective. Sustainable water use supports the ability of human society to endure and flourish into the indefinite future without undermining the integrity of the hydrological cycle of the ecological systems that depend on it (Gleick et al., 1995).

Groundwater may be defined simply as that part of the hydrologic system that occurs in a geologic environment. It is a fundamental prerequisite of groundwater management that decisions are based on a understanding of the local hydrologic conditions. Implementation of the South African reserve concept fits into the recommendation of defining the whole hydrologic system of which a water project may be part.

Hydrologic science is dependent on good quality data. Researchers need to verify past hydrologic data and ensure integrity of current data sets. Few groundwater problems are totally unique and there is benefit for centralizing records and reports so that each project does not have to re-invent the wheel in assembling hydrologic information.

3.5 *Assessment of Industry, Agriculture, Waste Water Treatment and Disposal Impacts*

- consider full range of potential environmental impacts from increased water use
- assess impacts of solid waste and waste water disposal practices on water quality
- recognize that recycling programs are complimentary to aquifer protection strategies
- appreciate that strategies to ensure sustainable agriculture are likely to assist water conservation efforts

Increasing water supply availability will lead to increased water use. Anticipating wastewater disposal needs is therefore critical because of increased risks of aquifer contamination and other health related consequences. Education is especially relevant in areas where individual behavior can have an impact. Teaching environmentally friendly and socially desirable waste disposal habits can compliment water infrastructure improvements. Piped waste water disposal and hand collected fresh water is likely to be a more effective solution to health concerns than piped water with no investment in waste disposal or treatment. Nearby industrial and agricultural enterprises should be brought into both the assessment and the community education process.

3.6 *Identify All Stakeholders and Involve the Public*

- identify a role for the public in decisions and develop the water use "stakeholder" concept
- provide "cause & effect" education to empower citizens to meaningfully participate
- include area residents as well as those directly involved in the "Local Water Economy"
- assign responsibility for citizen awareness and decision-maker education programs

In public education the messenger can be as least as important as the message. One of the most important aspects of water resources decisions is to ensure that those affected by them have an opportunity to participate. The earlier on in the process that citizens are involved the more likely they are to cooperate. Ideally the whole community should be involved in decision-making that balances the risks, costs and benefits of water development policy. Most policy makers want to have the support of the people they serve. Public participation can be a positive factor. Policies with public support are more likely to work! However, in order for citizens to be meaningfully involved in the process, they must have an informed awareness of the issues.

The concept of "stakeholders" is based on the notion that many different groups may have an interest in being involved with policy decisions. There needs to be a forum for stakeholders to voice opinions, and to support or challenge the scientific and economic basis for water policy. There may be suspicion if one agency or entity dominates leadership in education forums or meetings. Meetings should be seen to be collaborative not proscriptive.

3.7 *Provide for Ongoing Education and Training*

- set aside a proportion of initial project funding for local education and training
- make routine reporting and data collection a condition for the resource use permit
- by means of user taxes or levies provide sustainable funding for annual education
- include water topics (health, economics, environmental) as part of school programs
- provide clinics/ agricultural advisors/ teachers with "water-training" opportunities

The preparation of a comprehensive citizen awareness and decision-maker education program can serve as a positive ingredient of establishing water policy. There is every reason to inform the public about the scientific, technical and economic aspects of water problems so that citizens can be involved in helping to formulate policy options. Politicians are elected to make decisions and decide policy. Elected representatives are expected to act responsibly, consult appropriate experts, invite full public participation, avoid any conflict of interest and take a standpoint in a context longer than an electoral cycle. Public opinion should be a potent and positive influence on political will.

From a practical point of view, educated water users and water-wise communities will help create and maintain the political will for water infrastructure investment. A vital element is to securing the means of raising revenue to ensure adequate system management. Resource sustainability has to be paralleled by management capacity sustainability.

4 EDUCATION STRATEGIES

There is not one single formula for successful education for citizens, communities and decision-makers. Education is a process and the needs are ongoing and are likely to change over time. Almost any (information awareness, public relations, outreach) initiative can incrementally add to overall understanding of the importance of water management and protection. However communities need to be thoughtful about what and when education programs/initiatives are implemented. Choosing the best teachable moment can enhance the effectiveness of the message. Targeting education information by "rifle-shot" may be more effective than making a lot of education noise by a "shot-gun" approach.

The general need for education as a component of water projects is reported in water resources literature, for example, Prehoda, & Tyburczy, (1999), Hinrichsen, et.al. (1998) and papers in Gleick, (1993). In case-specific reports, education is often cited as an essential or needed element, for example as reported in recent papers from Trigg (2000) Guatemala, McFarland (2000) Kenya, Nevondo & Clote, (1999) and Jagels et.al. (1999) South Africa, and Khosrowpanah & Heitz, (1997) Micronesia. Much of the literature points out that distribution and storage of water can be as important for health as is the integrity of the original source. Home storage protocols represent an example of a supply improvement than can readily be addressed by education. Resource protection and management aspects may require a more carefully crafted education approach.

There is an extensive range of educational experiences that can be used or modified to suit local circumstances. The 960 page proceedings from a recent American Water Resources Association water education conference (Warwick, 1997) and the summary of a 1994 US Environmental Protection Agency conference (USEPA, 1995) are a good starting point for ideas on education. There is a lot more to education than printing information flyers, and education programs can benefit from professional input. Just as experts are needed to advise on technical aspects of water science and engineering, so too should community education experts be consulted to help choose among the huge arsenal of potential techniques. Workshops, water festivals, site visits, development of school curriculum materials, interactive simulation programs, teacher training, posters, pamphlets, etc. are a few examples of the potential educational tools that can be used to compliment rural water projects. In all cases, the objective of a proposed education initiative needs to be established in order to prepare the best strategy. Knowing the destination is a great help when planning a journey!

The rising tide of community education about ground water management and protection requirements should also effectively raise the boats of public health, quality of life, economic well being and environmental sustainability.

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