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Good Practices in Agricultural Water Management
Case Studies from Farmers Worldwide

Submitted by:

International Federation of Agricultural Producers (IFAP)

BACKGROUND PAPER NO. 3

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FORWORD

Water is a critical resource for farmers. Securing water access is crucial to poverty alleviation in rural areas because it underpins food security for all. "Farmers and water go together. Without water there is no agriculture and therefore no food security", is the key message of IFAP member organisations.

Over the past years and especially, since the World Summit on Sustainable Development, water has rightly been ranked high on the international agenda.

Since the beginning of the two year cycle on the three cluster themes of "water, sanitation and human settlements", IFAP actions were essential in ensuring that agriculture and the role of farmers was included as a priority for the review year during CSD 12 as well as for the implementation year for CSD 13, which focused on identification of constraints, obstacles, successes and lessons learned on the three cluster themes. Farmers were able to present their concerns about water issues with the support of farmers' real experiences, to ministers during CSD12. However, there is still a lot to be done. Farmers do not need more summits and targets; we know what needs doing. Rather, there is urgency to implement and monitor progress more effectively. CSD 13 offers the farmers the opportunity to do so.

The following case studies are meant to clearly outline the pivotal role of farmers in achieving the Millennium Development Goals and the goals and targets as contained in the Johannesburg Plan of Implementation, with a view to generating political commitment for secure access to water for farmers and participatory processes to manage this resource.

The different case studies presented give practical information on how farmers are undertaking their responsibilities with respect to this precious resource. They show their willingness to behave in a responsible way when dealing with water resources. They also provide means of achieving the expected changes, for example, the need for community-based, demand-driven management schemes involvement of women farmers in water management, as well as building innovative partnerships. These case studies and best practices, pertaining to the management of water resources, from IFAP member organisations in developed and developing countries, are actually an illustration of IFAP proposed policy options and priorities for action, presented during the Intergovernmental Preparatory meeting to CSD 13. These policy options will also serve for discussion during CSD 13. (See http://www.ifap.org/issues/Policy%20Statement%20on%20Water_Eng.pdf and major groups' priorities for action: http://www.un.org/esa/sustdev/csd/csd13/docs.htm).

It is important to build on the priorities for action, to serve as a solid basis to enhance farmers' work. There is a need to pursue this work on water by urging ministers and other decision makers, to give a human face to water issues; that is to say to recognise the key role played by farmers in conserving the environment whilst achieving food security.

Overall, farmers' real needs, such as capacity building should be advocated at the international level, reflected in the related outcome documents and followed by concrete project implementation.

We urge all relevant national and international authorities to ensure that IFAP recommendations are included in concrete action plans at the country-level. As the IFAP President stated "Let's get down to action with the support of public authorities, and transmit to future generations of farmers adequate systems for a more efficient use of water."

(Signed)

Nora Ourabah Haddad,

Head of IFAP activities on Natural Resources

Good Practices in Agricultural Water Management

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I. The Combat Against Desertification and the Conservation of Water: The Zai System of Water Harvesting in Mali

Desertification in the Sahel

For the countries of the Sahel region of Africa, a transitional zone between the Sahara desert and the wetter lands of Southern Africa, severe drought conditions have been a harsh reality. In fact the encroachment of the Sahara desert has been a concern for many years. Historically desertification in the Sahel has been attributed to a lack of rainfall and unsuitable agricultural practices. To combat desertification and to practice water conservation in a stressed water environment, farmers in Mali are employing a traditional system of water harvesting called Zai. This water harvesting system is highly effective in mitigating the effects of desertification and it meets the criteria for three types of conservation practices – soil conservation, water conservation, and erosion protection.

Agriculture in Mali

Located in Western Africa with a land area of 1,204,000 km^2, Mali is one of the poorest countries in the world, and a large majority of Mali's population is without adequate food, water and shelter. Characterized by hot, dry weather with variable rainfall in June, July and August, approximately 65% of Mali is desert and semi-desert. Only 2% of the land is arable; however, 80% of the labour force is engaged in farming, livestock breeding, fishing and forestry. Agricultural and economic activity is mainly confined to the southern region of the country where the Niger River provides a source for irrigation. Cotton, millet, rice, corn, vegetables and peanuts are grown in 780 km^2 of irrigated land.

The Zai System in Mali

Practiced mainly in Mali, Burkina Faso and Niger, where it is known as *tassa*, Zai is a traditional technique for conserving water and rehabilitating degraded land. The Zai system is a series of man made pits, or holes, dug on abandoned, or unused, land. The purpose of creating the holes is to capture runoff precipitation, because the land is typically less permeable to water. The zai pits are filled with organic matter so that moisture can be trapped and stored more easily. The pits are then planted with annual crops such as millet or sorghum.

The zai pits extend the favourable conditions for soil infiltration after runoff events, and they are beneficial during storms, when there is too much water. The compost and organic matter in the pits absorb excess water and act a form of storage for the planted crops. A disadvantage of the system is that they may become water logged during extremely wet years.

Zai pits are dug approximately 80 cm apart to a depth of 5 to 15 cm and with a diameter of 15 to 50 cm. No special equipment or knowledge is needed to adopt the technology and the cost of implementation is mainly calculated according to the farmer's opportunity cost of time. The maintenance of the pits does require the farmer to invest additional time in watching over, deepening and refilling the pits. However, the economic return to the farmers' investment is 100%, because the land brought under production is abandoned or unused land.

The Experience of Mali Farmers

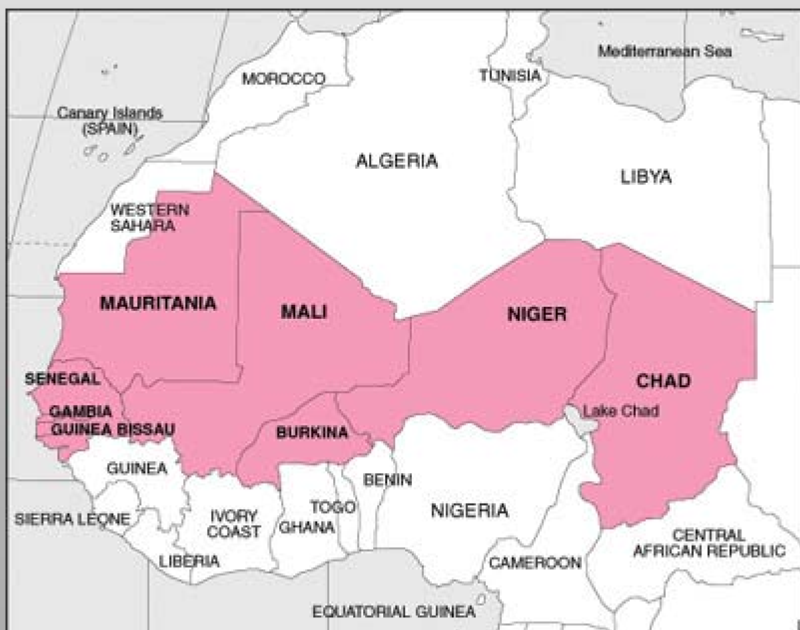
The success of zai planting pits has been documented all over the Sahel region. In 1989-1990, a project implemented by the Djenné Agricultural systems project (SAD) showed that agricultural yields increased by over 1000 kg/ha as compared to traditionally ploughed control plots. Approximately 1600 farmers from 17 villages participated in this project. The zai system is often practiced in combination with contour stone bunds and the planting of trees.

PDRT/GTZ, Tahoua

Desertification in the Sahel

For many years, agricultural mismanagement was believed to be the main cause of desertification in the Sahel, a region that extends over Burkina Faso, Chad, Gambia, Guinea Bissau, Mali, Mauritania, Niger, and Senegal. The three main agricultural activities that were believed to be the cause were overgrazing by livestock, slash and burn agriculture and the process of separating perennial crops from annual crops. Recent studies have found that the desertification of the region may be a natural phenomenon, and global processes such as climate change and changes in oceanic circulation may be some of the contributing factors.

Despite the debate over what are the causes of desertification in the Sahel, the remedy appears to be the improvement of soil and water conservation in the region. Thousands of hectares of degraded land have been revitalized over the past few years, and a return to traditional methods and practices has been the main cause of this success. Some of these methods include contour stone bunds, compost pits, mulching, re-generation of vegetation and zai or tassa pits.



II. Foggara: Traditional Irrigation in Algeria

Water Scarcity in Algeria

Persistent water scarcity is a harsh reality in Algeria. With an estimated 500 m^3 of water per capita in 2000, Algeria experiences water scarcity, an annual level of renewable freshwater that falls below 1000 m^3 of water per capita. In order to attain a level of adequate food security, 15 billion to 20 billion m^3 of water is needed annually, with 70% of this quantity reserved for agriculture. In reality, only 5 billion m^3 of water is mobilized each year and as result, there are significant conflicts over water use in Algeria.

Sustainable Agriculture

Sustainable development of agriculture became a priority in Algeria in 2000. The Plan National de Développement Agricole (PNDA) is a policy that advocates the sustainable, integrated development of rural areas by fostering the conservation and rational management of natural resources such as soil and water. This plan involves the participation and cooperation of government and farm groups in fighting rural poverty and reinforcing food security. The PNDA targets issues in desertification and water management, and some of the incentives introduced for farmers in water management are:

- Government participation in reconverting irrigation systems and water management
- The transfer of responsibility for drainage operations and localized irrigation systems such as drip irrigation to the Government in hopes of saving and conserving water

Water Management in Agriculture

All agriculture in Algeria involves irrigation. In Northern Algeria, the introduction of drip irrigation on industrial tomato farms raised the average yield of tomatoes from 13 tons to 19 tons. Although the increase in yield is a desired result, the introduction of modern agriculture, which advocates monoculture and irrigation using high volume pumps, may have adverse consequences on underground water sources. Consequently, underground water resources are overexploited in the north.

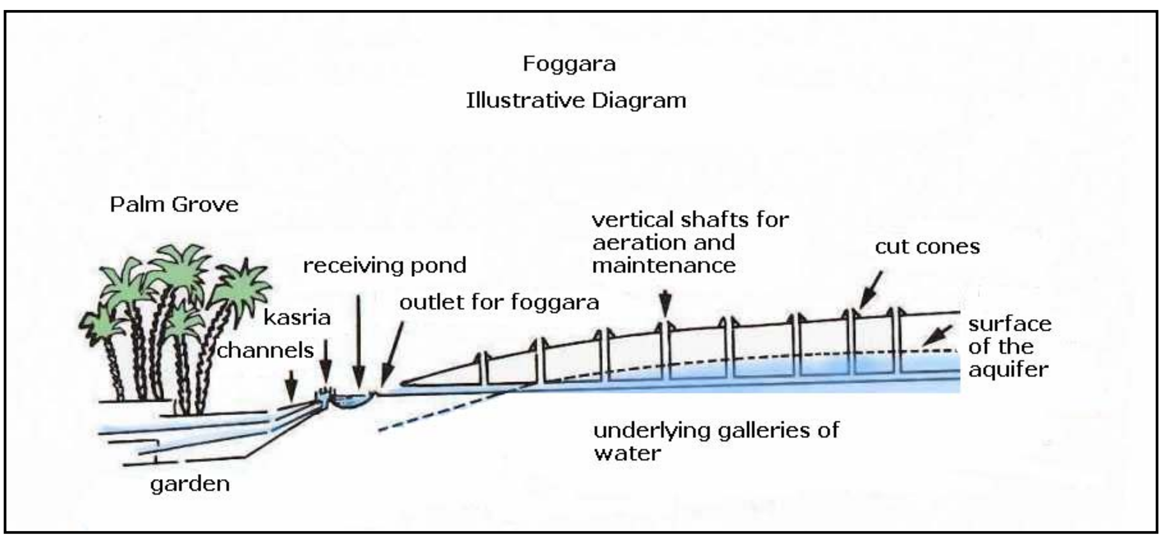
A traditional form of irrigation called foggara, whose origins can be traced back 3000 to 4000 years, is an alternative to modern irrigation. Foggara is used in Southern Algeria on conventional farms and serves as a source of water for several oases in the Ouled Saïd, a human-made wetland that covers an area of 25,400 hectares in southwest Algeria.

Foggara

Foggara is the French translation of the Arabic word "qanat" or the Pashto world "karez". Foggara was first practiced in Iran and brought to North Africa during the second expansion of Islam. The foggara system is a complex network of vertical shafts dug into a sloping plateau overlooking an oasis. These vertical shafts or wells are connected by an underlying channel, which has a gradient flatter than that of the ground. Water is drawn from an aquifer within the plateau by the force of gravity and directed through the channel to the surface for agricultural or domestic use.

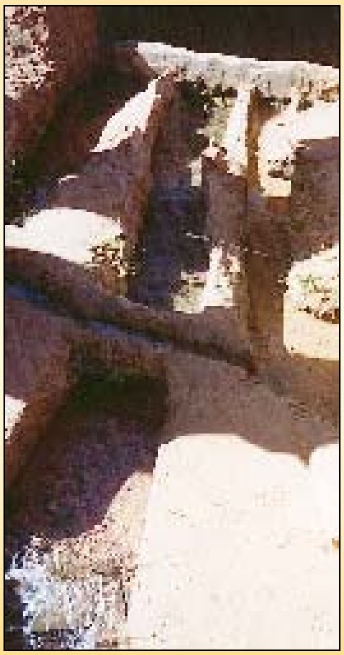
There are three significant benefits of the foggara system of water delivery. These benefits include:

- Water loss through seepage and evaporation are reduced because a majority of the channel is underground
- There is no need for pumps as the system is fed entirely by gravity



Michel Janvois: http://zoumine.free.fr/tt/sahara/donnees_geo_clim_bota/foggara.jpg

Foggara and Algerian Farmers



In the desert, land alone is not considered real capital, as its value is intrinsically tied to water rights. The ownership of water can be acquired through the investment of labour or money in the construction of a foggara. Partnership agreements between the owners of un-irrigated land and the owners of water quotas determine the share of water received by each recipient within the partnership and are based on the size or level of investment contribution. For regions of Algeria where this type of socio-economic arrangement still persists in conventional agriculture, the operators of foggaras have set up professional associations.

In one region of Southern Algeria, a partnership called "association-sharing" exists between owners of un-irrigated land and owners of water quotas for the production of palm dates. In this type of agreement, the owner of the un-irrigated land transfers half of the property rights to his land to the owner of the water quota. After approximately seven years when the palm trees first bear fruit, the "association-sharing" ends. At this time, the landowner assumes permanent ownership of the water on his land. Both individuals benefit from this type of partnership as each claims half the ownership of a palm grove that would not exist without foggara irrigation.

III. United Kingdom: Applying Water Audits to Agricultural Operations

Water resources are essential for farming and in the United Kingdom, agriculture and horticulture uses less than 2% of abstracted water. Increasing the efficiency of water use in farm operations makes economic sense, and ensures that the resource is protected for future generations.

What is an Agricultural Water Audit?

An agricultural water audit is a detailed analysis and account of water use in an agricultural operation. A complete water audit includes both an outdoor and indoor component, and must describe where, how, and why water is being used in a farming or livestock operation. It should also include how water use can be reduced without compromising crop quality and yield, or animal welfare.

An agricultural water audit should be simple, yet effective. The process should highlight the practical steps that the farmer or grower can take to create an immediate impact on a farm's water management. The loss of soil, nutrients, and other farms inputs as diffused pollution is reduced when water use is analyzed and accounted for.

Water Wise Campaign in the United Kingdom

The National Farmers Union (NFU) in the United Kingdom launched its Water Wise Campaign in November, 2000 to promote efficient water use on the farm, and to demonstrate and discuss best irrigation practices. In the summer of 2001, the NFU conducted a survey among all its members to document water use on farm operations and found that farmers were taking the initiative to increase the efficiency of water management on their farms. The Water Wise campaign is an effort taken by the NFU to encourage the agricultural industry to improve water use efficiency ahead of impending European and National legislation. A guide called "Water Wise on the Farm, A simple guide to implementing a water management plan", developed by the Environment Agency and LEAF (Linking Environment and Farming) organization and supported by the NFU, was launched in November, 2002.

Conducting a Simple Water Audit

The "Water Wise on the Farm" document outlines five simple steps for carrying out a water audit and developing a water management plan. These five steps are presented below:

1. Identify how much water you are using and its cost
2. Water use inventory
3. Calculate how much water you are using
4. Identify and compare water efficiency activities to reduce water use
5. Create, implement and review your Water Wise Action Plan

Step 1: Identify how much water you are using and its costs

An identification of all sources of water on the farm is the first step to conducting a water audit. Water for farm use can be supplied by a water company or abstracted from natural sources such as rivers, streams, canals, springs, boreholes, and ponds. It is also important to include the use of re-used water such as plating cooling water or rain harvested water. The goal of identifying, recording and calculating the cost of water use from all sources is to document water use patterns, so that seasonal fluctuations can be better understood, and any major changes will be monitored and accounted for.

Step 2: Water use inventory

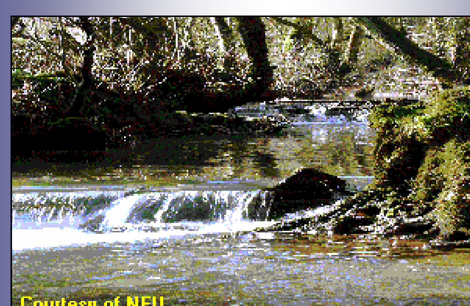
An inventory of water use documents the allocation of water to various activities on the farm. This exercise requires the farmer to identify all water

Summary of Water Wise Survey Conducted by the NFU

The results of the Water Wise Survey demonstrated that farmers are very conscious of water management and are pursuing measures to reduce waste and improve water efficiency.

Some important results of the Water Wise Survey:

- 2/3 of respondents said they are more efficient with their water use today (2001) than they were five years ago
- More than ½ of the respondents made plans to increase further their water efficiency over the next five years
- Nearly 40% either collect rainwater or recycle water for use on the farm
- Nearly 70% have invested in reservoirs or storage tanks in order to store water for use later in the year
- 50% of respondents use scheduling techniques in irrigation to make sure they are using water at exactly the right time of day to avoid waste
- 80% of respondents regularly test soil moisture levels in order to ensure delivery of appropriate levels during irrigation
- More than two thirds of those who irrigate store water for use later in the year



consuming activities, the amount of water used and the type of water used. A water map can be used to illustrate the inventory visually.

Step 3: Calculate how much water you are using

In this step, the efficiency of water use is calculated by comparing the amount of expected water use and the amount of actual water use. When the amount of actual water use is more than 10% greater than the expected use, then it is an indication that water is being used inefficiently on the farm. The calculation of actual and expected water use can be done with special forms included with the "Water Wise on the farm" guide.

Step 4: Identify and compare water efficiency activities to reduce water use

If the amount of water used is greater than the amount of expected water use, then it is necessary to adopt water efficiency activities. Choosing the most cost-effective activity can be difficult, and it is important to calculate and compare the costs of each activity to choose the most appropriate technology.

The calculation of payback periods takes into account the initial capital cost of the technology divided by the annual savings less the annual maintenance costs. This process allows the farmer to gauge how long it will take an investment to payback his initial capital cost in water efficiency benefits.

$$\text{Payback Period} = \frac{\text{Capital Cost}}{\text{Annual Savings} - \text{Annual Mainenance Costs}}$$

Step 5: Create, implement, and review your Water Wise Action Plan

After choosing an appropriate water efficiency activity, a Water Wise Action Plan must be created and implemented. The action plan should include the following: (1) how you plan to save water, (2) targets for water savings, (3) targets for financial savings, and (4) who is responsible for each action. When implementing the plan, the following issues must be addressed: (1) staff, family, and conductor awareness of the need to save water, (2) timing of improvements, (3) routine maintenance of checks, and (4) monitoring and reviewing progress. It is very important that a review be conducted after a plan has been implemented. The ideal time for a review is approximately a year after the implementation of the plan.

IV. Water Users' Associations in Tunisia

Water Resources in Tunisia

Situated south of the Mediterranean, Tunisia is a country with semi-arid to arid climatic conditions. Water management in Tunisia is a challenge because of irregularities in rainfall, and dry periods may last for several weeks during a season or over consecutive seasons. Average annual precipitation in the country is 37 billion m3 and ranges from 11-90 billion m3. Rainfall received in the North is highly variable from the rainfall received in the South, and often a transfer of water resources is needed from the North to the South. Evapotranspiration is high, and significant water deficits usually occur from May to October.

Water Management in Tunisia

Over the past 30 to 35 years, Tunisia has been actively evaluating and mobilizing water resources in the country. The progressive management of water has been a central component of Tunisia's socio-economic development strategy, and investments in the water sector have made up 40-65% of the Ministry of Agriculture's budget. In Tunisia's tenth economic plan, drafted in 2002, the mobilization of water resources was reiterated. This process of water mobilization will include the implementation of a comprehensive system of large and small dams and a water supply network that allows connections between surface and groundwater reservoirs within and between basins to supply inland regional water saving techniques and subsidizing irrigation equipment.

An interesting approach that the Tunisian government has adopted is the management transfer of irrigation and drinking water schemes to Water Users Associations. The involvement of water users in the management of the resource has been very important in changing the social concept of water, and redefining its value in economic terms. Increased awareness of the scarcity of water and the need for its rational use has been a success of this policy.

Agriculture and Water

Agriculture occupies 28% of the total land area of the country; however, it consumes approximately 80% of the water resources. Although agriculture is traditionally and predominately rainfed; irrigated agriculture has grown from 1.6% to 7% over the period between 1997-2001. Inappropriate and poorly applied surface irrigation techniques have resulted in significant water losses, and over the past few years, the government has made considerable efforts to improve the efficiency of irrigation by introducing water saving techniques and subsidizing irrigation equipment.

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Irrigation in Tunisia

Irrigation in Tunisia differs from most regions in the world, because the water used is high in salt concentration, approximately 4-6 times higher than standard irrigation practices. The use of brackish, low quality water has been extensively developed in the country. The most common type of irrigation practice is gravity irrigation, which accounts for 75% of all systems. Sprinkler (20%) and drip irrigation (5%) systems are not as prevalent.

Water Users' Associations (WUAs)

Water Users' Associations (WUAs) have a long history in Tunisia, and they were first created during the early 1900's. These organizations were charged with solving water management problems and ensuring efficient water distribution. In 1987, the mandate of WUAs was redefined to include the implementation, operation, and maintenance of irrigation-drainage or potable water supply infrastructures. WUAs are financially autonomous and managed by a governing council that includes a president, a treasurer and elected members. In Tunisia, WUAs are responsible for more than half of the public irrigation schemes in the country.

In 2001, water access and distribution in rural areas was increased by 90% through the efforts of WUA's and the Société Nationale d'Exploitation et de Distribution des Eaux (SONEDE), a government agency. There are 2470 WUAs operating in Tunisia—63% are responsible for providing drinking water, 34% are responsible for irrigation and 3% are responsible for both. By improving the access of water resources to the poor, poverty alleviation has been a benefit of the policy.

The government's policy of transferring water services to WUA's has been highly successful, because of the introduction the Fonds National de Solidarté (FNS). This government program was created in 1992 and its aim was to provide infrastructure to rural areas. The skills of WUAs in the financial and technical management of water services were reinforced by this program. The FNS is funded through voluntary contributions by public and private enterprises, international development agencies, private individuals, and the National Government.

V. Water Quality in New Zealand

Characterized by pristine lakes, clear streams and mountain sourced rivers, New Zealand is a country blessed with adequate water supplies for consumptive and productive purposes. In order to preserve the "clean green image" of the country, water management issues in New Zealand are mainly concerned with maintaining a high level of water quality. For the production of safe and sustainable food and fiber, agriculture in New Zealand demands good quality water for irrigation and livestock operations; however, certain agricultural practices also result in adverse effects on water quality.

Approximately 77% of abstracted water in New Zealand is used for irrigated agriculture that occurs in almost all regions of the country. Along with irrigation, the intensification of land use has been moving towards dairy farming, particularly in the east coast of the South Island. This intensification of dairy operations has particular effects on the water quality of groundwater, spring fed streams and lakes. Possible off-site contamination issues associated with irrigated agriculture and intensive livestock operations include soil erosion, soil salinity, the management of fertilizers and pesticides, livestock access to streams, and the safe disposal of biological effluent.

Water Management

At the National level, "Water Quality Guidelines" have been prepared as part of New Zealand's National Agenda for Sustainable Water Management. This set of guidelines was developed in collaboration with the Australian government as part of their National Water Quality Management Strategy. These guidelines are not enforced or applied directly to the management of water resources, and instead, they are used as a set of tools to assist regional and state governments in assessing and managing water quality. The management of water resources in New Zealand is the primary responsibility of the regional councils, and thus, the development of specific water quality guidelines and objectives are region specific. The responsibilities of the central and local governments in regards to water management are set out in the Resource Management Act, 1991.

Water Quality Guideline

A water quality guideline is defined as a recommended numerical concentration level (e.g. of a contaminant) or a descriptive statement (e.g. visual appearance of a water body) that will support and maintain the quality of water for a particular use. Water quality guidelines provide the chemical and physical parameters of water and sediment.

Guidelines should be modified and tailored for local conditions. This process involves the consideration of costs and benefits to a community. In some cases, the community might decide to allow a longer period of time to achieve certain water quality objectives or it may decide to accept a lower quality of water.

A Water Objective

A water quality objective is a numerical concentration level or descriptive statement used by managers to measure and report on the performance of water quality. Water quality objectives are negotiated by stakeholders or set by local authorities. These objectives become the indicators or measures of success in meeting water quality goals. Water quality objectives are usually based on scientific information; however, they may be modified by other inputs such as social, cultural, economic, or political constraints.

Good Practices in Dairy Operations

Minimizing the impacts of dairy farming on New Zealand's pristine water resources is a priority of the central and local government as well as the country's dairy farmers. The Ministry of Agriculture and Forestry and the Ministry for the Environment has been working in collaboration with Environment Waikato, a representative of all the regional councils, and Fonterra, a multinational dairy company owned cooperatively by 13,000 New Zealand dairy farmers, to create an Action Plan for water management in dairy farming. This Action Plan builds on the existing initiatives already put in place by the industry and local governments. Some of the priorities of the Action Plan include:

- Fencing streams and rivers
- Providing stock crossings at critical points
- Fencing significant wetlands
- Appropriate disposal of dairy shed effluent
- Managing nutrients applied on the farm

Other practices that farmers may employ include:

- Maintaining vegetation along streams to filter out sediment and other contaminants
- Better management of effluent ponds
- Reducing the grazing pressure on slopes that are erosion prone

Cattle Production in the Waikato Region

In the Waikato Region of New Zealand, a good example of sustainable dairy farming can be found on the Vincent family beef farm. Approximately 286 hectares, 70% of the farm area is used for beef production and dairy grazing, while the remaining 30% is used for forestry, native bush or retired riparian areas. The operators of the farm have spent $4,000 directly on pest management and an opportunity cost of conservation that is valued at $13,000.

VI. Water Boards in the Netherlands

Unlike most countries, the Netherlands has an abundance of water resources. A large proportion of the country is artificial, and an intricate network of dunes, dams, dykes, locks, pumping stations, flood barriers, canals and ditches makes the land habitable. Without these physical manipulations of the landscape, more than fifty percent of the country would be inundated with water during storms and floods. The Netherlands is an example of water engineering expertise, but more importantly, it serves as a model for local and regional water management and governance.

Water Management and Agriculture

In Europe, the Netherlands is known for its outstanding performance in agriculture, and it is home to some of Europe's most productive soil. The Dutch's strong agricultural position is attributed to the ability to manage water and reclaim flooded lands, which are rich in fertile clay soils. Farmers and landowners have created a system of water engineering works that allow excess water to be drained away and retained for later use during dry periods. In the Netherlands, flooding is the primary concern in agriculture and horticulture. Farmers must protect themselves from water on three fronts: (1) sea waters, (2) rising river waters, and (3) rainfall.

Despite the existence of these water management systems, agriculture and horticulture is still vulnerable to water damage. Rising sea levels and sinking land in the Netherlands is causing ground in low-lying areas to become brackish, resulting in drainage problems. For high yielding salt sensitive agricultural and horticultural crops, these drainage problems may have serious consequences. Cooperation between farmers and the national government and local and regional Water Boards is essential to addressing some of the problems in Dutch agriculture.

What is a Water Board?

A water board is an administrative organization that is responsible for water management in a specific region or locality. In most instances, water boards are instruments of government and may fall under the authority of a provincial or municipal government. Some water boards are independent, and they have their own areas of authority in which they may draw up regulations and levy taxes.

Water Boards

In the Netherlands, Water Boards or "Waterschaps" have been in existence since the Middle-Ages, and they are the oldest form of democratic institution. Water Board members were elected from among the community, and farmers and landowners worked together to carry out the management tasks of the board. In 1850, there were over 3,500 waters boards in the Netherlands, but since then, many of these boards have been consolidated to approximately 45 entities by 2002.

What does a Water Board Do?

Water boards in the Netherlands are responsible for controlling the flow of water, as well as managing the quantity and quality of water. By maintaining dunes, dykes, and canals, water boards control the flow of water in a region. Water quantity is maintained by managing the amount of water and ensuring that it is kept at a certain level; while, water quality is managed by combating water pollution and improving the quality of surface water. Water boards are also responsible for the management of inland waterways and roads.

It is important to note that Water Boards must balance the conflicting interests of water management. Careful consultation of the Water Board with multiple stakeholders often results in activities that include aspects of land use planning, agriculture, nature conservation and environmental protection, and recreation. Water Boards also try to implement the sustainable management of the water chain.

Water chain: the production of and distribution of drinking water, the collection and transportation of wastewater via the sewers and the purification of sewage water

Water Boards and the Involvement of Farmers

Water Boards trace their origins to the initiatives of farmers and landowners who worked together to build to polders, low-lying land reclaimed from the sea and surrounded by dykes, in the 14^{th} century. These farmers were actively involved in managing the supply and drainage of water. Because of the importance of water management to agriculture, farmers have always been actively involved in Water Boards.

Recent environmental concerns about biodiversity have changed the focus of Water Boards, because, historically, farm interests have dominated water management concerns. In the last few years, the interests of Water Boards have broadened to include environmental and non-agricultural issues. Nowadays, the emphasis of management is on the multi-functionality of water uses.

Structure of Water Boards

In the Netherlands, the structure of the water board is outlined in the Water Authorities Act. This legislation lays down the general rules for the composition of the Governing Body, which includes a general council, an executive council and a chairman. The governing body is made up of representatives from various interest groups such as land and property owners as well as household and industrial polluters. The level of representation is determined by the size of the financial contribution that each interest group makes to the water board. Each interest group elects its own representatives; while, the representatives from resident groups such as household polluters are appointed by the municipal executive and the representatives for industrial polluters are chosen by the Chamber of Commerce.

Information and Communication

Public accountability of the Water Board is assured by the release of information on current and planned water policy. Residents of an area have the right to respond to any policy proposals, and the public is encouraged to participate. Increasing public awareness about Water Board activities increases the appreciation of public for the work that is being done, as well as encourages individuals to be more careful in their use of water.

The Association of Water Boards in the Netherlands also works closely with public authorities and bodies all around the world. This cooperation with foreign organizations allows other countries to gain from the experience and knowledge of the Netherlands Water Board system. The Association also sends Water Board experts on external missions of water management and dyke maintenance.

VII. Austria: Water Protection and Agriculture

Ninety-nine per cent of Austrian drinking water is groundwater or source water. Due to the fact that the owners of land are also owners of the groundwater underneath, farmers have a vested interest to protect their water.

The protection of groundwater in Austria is achieved through both regulatory and voluntary measures. Regulatory measures include conservation area regulations, limitations on the amount of fertilizer, application time limitations etc. Voluntary measures are either environmental programs that are part of the rural development programme or contracts between farmers and water supply companies.

Frequently, the relationship between water supply companies and those farmers, who must tolerate regulatory production restrictions to protect water sources, is burdened by tension and sometimes even outright confrontation.

The example below shows that local partnerships between farmers and water supply companies can be successful and are well accepted by the water rights authorities as a non-bureaucratic way to achieve a common goal: the protection of our drinking water resources.

Example "Zirking" (Upper Austria)

In this instance, farmers from Zirking and the water supply company "Fernwasservorsorgung Mühlviertel" demonstrate the fact that both sides can benefit from alternative means, specifically through a well-understood partnership with contractual regulations. Through a strike vote, the farmers here clearly rejected the planned mandatory regulatory measures and voted in favour of the water protection model presented by the agricultural chamber.

A Redevelopment Area First of All

The four wells of the water supply company "Fernwasservorsorgung Mühlviertel" in Zirking are the second largest well system in upper Austria. This association supplies drinking water to 33 regional townships, more than half of which is drawn from the well in Zirking. Since some of the wells in the area do not supply the best quality water, and nitrogen levels can only be regulated through the blending of water, Zirking was named the first redevelopment area in 1996 according to the Austrian water law by the water rights authorities. Under the leadership of the agricultural chambers, the affected farmers organized themselves and established a democratically-elected working committee, which developed, internally, into a decision-making forum and, externally, as the legitimate opposition to the public authorities and contact body. Furthermore, this committee made an important impact on the amendments to the Austrian water law concerning the existing groundwater redevelopment terms.

According to the new legal situation, the water rights authorities conceived of the idea to enact drastic production restrictions for farmers through a conservation area regulation. The draft would have entailed an intensification of agricultural requirements which met with strong opposition from farmers. Additionally, in order to prevent this regulation, the agricultural chamber was finally able to settle the outstanding compensation measures, which the farmers held for excessive and difficult to implement.

Project Water Pollution Control as an Alternative Concept

The counter-proposal from the agricultural sector reshaped the model to a non-bureaucratic water pollution control concept tailored to practical requirements, while simultaneously abandoning the prospective regulations. The water rights authorities acceded and gave the green light to the pilot project under the precondition that the water pollution control resolution proves just as effective as the planned regulation in guaranteeing protection targets in the package of measures and level of participation.

Agreement with the Authorities and the Water Supply Company

After numerous negotiations, agreement was reached with the water supply company on the financial compensation and implementation of the package of measures. The water rights authorities agreed to that proposal.

The package of measures builds upon the activities of the Austrian environmental programme (part of the rural development programme) and ensures compensation is in place for additional water pollution control services.

Proposed measures are *i.e.*:

- Intensifying winter crop coverage (from 70 per cent up to 100 per cent of crop land)
- Reducing the cultivation of row crops (corn, beets, potatoes)

The degree to which individual farmers engage any of these measures remains their decision. A well-stratified, attractive system of premiums stimulates a high level of participation. In the first year, 86 per cent of the eligible farmers had already signed onto contracts, signalling great start-up success.

Successful Negotiations through Partnership

The negotiations about the conditions of the water protection project between the water rights authorities and the partnership of agriculture and the water supply company, demonstrate considerable important success:

- The area that would have been affected in the original plan was ultimately reduced in size by almost half.
- The excessive terms about the use of herbicides, which had solely a precautionary nature and would have accounted to a near application ban, could be eliminated through negotiation.
- The difficulty to realize regulatory conditions gave way to a more intelligent model with a catalogue of measures built upon the Austrian environmental programme.

The farmers of Zirking are certain this pilot project will prove that voluntary participation in the water pollution control project, and the simultaneous responsibility that grows from it, is the best way to attain successful protection of groundwater.

VIII. Finland: Water Management in Rural Areas

The Restoration of Wells

In Finland local authorities have an obligation to supply water to people in small towns and cities, however in the country side the farmer is responsible for his own water supply. Finish geology is particularly endowed with an environment that fosters small ground pockets that are fairly near the surface of the ground. This advantageous circumstance allows the landowner to dig a well and have access to water directly. As a result there is a proliferation of wells in Finland but many of the wells in the countryside are old and their structure has deteriorated through time.

The most common problem that affects the structure of the wells is when surface water leaks into the well and deteriorates the quality of the water in the well itself. Since these wells represent the most important water supply for farmers the government has put forward a financing initiative for structural upgrading of the wells in the countryside. The Finish government, through the ministry of agriculture, has provided a guide on how to restore the wells, and in addition has supplied an aid package of 30% of the reparation cost. A specified guideline has been provided by the government requiring strict adherence in order to be eligible for the financial aid itself. As a result farmers can utilize the benefits of modern technology to enhance the structural integrity of their traditional wells. Thereby farmers can restore or rebuild wells in order that a farm can meet their drinking and household needs, while adhering to strict quality standards.

Farmers' Self Reliance

The farmers ability to utilize modern technological upgrading of a traditional water management tool greatly enables them to manage this resource. Since in the rural areas farmers are themselves responsible for their own water supply, well reconstruction allows farmers to maintain control over the quality that they extract. This in turn bestows farmers with the ability to pursue water sensitive agricultural activities like dairy farming, without compromising neither quality nor control over their water supply. Therefore a self-controlled and maintained water source is of an enormous benefit to Finish farmers, both to their agricultural pursuits and the satisfaction of self reliance.

Water Cooperatives and the Price of Water

The example of Finland can also be used to illustrate the ability of farmers to organize in order to maintain low prices on water. In rural Finland there are about one thousand water cooperatives and about 400 small limited water companies. A majority of these water associations service very small towns and villages that on average are less than 200 inhabitants. Among these associations are cooperatives, which are servicing less than 100 inhabitants. These associations have grown in significance as the most important source of water supply in rural Finland.

The cost and investment of running a small scale water cooperative is very small. All cooperatives are licensed by the government, and are allotted a limit as to the amount of water they are allowed to extract per day. The Finish government also provides the cooperatives with financial programs for further investment. In addition members may opt out to participate with the labour to decrease costs for any of the projects that require reconstruction. The cooperative also has its own well and distribution network, and it has complete control over the prices. As a result the cooperatives can offer water at favourable prices to their members because the price of water is not influenced by the fluctuations of the market.

Water cooperatives also have the benefits of a network of other participating associations. The cross-organisational aspect allows for a far greater level of manoeuvrability and adaptability in various situations. If, for example, the water quality in one region is not good enough, as a result of extenuating natural circumstances, the cooperative may buy water from a neighbour cooperative or community owned water network. This form of inter-cooperative assistance allows for these associations and their members to benefit from mutual aid that is low in price and dependable. The cooperatives are vital component of the Finish rural sector and a great example of how mutual organisation, cooperation and activism work in unison to achieve inexpensive access to water.

IX. India: Use and Management of Water in India

In India the water resources are quite abundant, as it possesses 4% of the world's fresh water resources. Peninsular India's rich water sources include large rivers, lakes, reservoirs and massive ground water resources. Nonetheless for great number of people access to safe drinking water remains a challenge. In addition, a rise in growth of population over the past years has contributed to massive denudation and degradation of vegetative cover. The continuous problems being faced include silted surface water bodies, fallen water tables and disproportionate water resource endowment.

Water Scenario: World/India	
Flow in world's rivers per annum	41,000 cu.km.
Of which, water economically used	9,000 cu.km.
World's water resources in lakes and reservoirs	3,000 cu.km.
No. of international rivers	More than 200
Proportion of people in developing countries not having access to safe drinking water	25%
Per capita availability of fresh water World India	 7,400 cu.m 2,200 cu.m
Average annual flow of all river systems in India	1,869 billion cu.m
Annual precipitation of rainwater in India Of which, seasonal precipitation	4,000 billion cu.m 3,000 billion cu.m
Water now utilizable Ground water potential Total	690 billion cu.m 431 billion cu.m 1121 billion cu.m

The ecological impacts on the different regions are also quite varied and India gets anywhere from 100mm rainfall in the western desert to 11,000 mm in the northeastern region. The amount of water dispersion is further influenced by the effects of monsoons, evoking cyclical floods and droughts. As a result there are wide disparities in agricultural production and productivity in the different regions. Irrigation also posses one the biggest challenge since it accounts for 84% of the total water use, and therefore continues to be a focal issue of water resources development. Furthermore, only 28% of the land under crops is irrigated (46 million against 165 million hectares).

Industrialization, commercialisation, urbanization and introduction of fertilizer-pesticide-based agricultural technologies have polluted the water eco-systems as well as ground water. Above all else, wastage of water is also a considerable problem. Thus the deficiencies are mounting and can be largely attributed to excessive loss of irrigation water, due to seepage; inequitable distribution of water between head and tail reaches of rivers; inequitable distribution of water between the rich and the poor; poor extension services and limited involvement of the most affected poor populations.

The country has significantly overcome both the drought-famine and the rain-flood cycles. Nevertheless even marginal improvement of efficiency of water use would result in colossal savings of water. The criticality of water conservation could be realized, if the enormity of lack of access to drinking water is taken into account. As of 2000, there were 26,000 habitations not covered by drinking water supply arrangements. About 213,000 habitations were partially covered. Habitations with quality problem in water supply were 217,000.[1]

Water Quality

It has been estimated that three-fourths of surface water resources are polluted and 80% of pollution is caused by sewage alone. The level of contaminants such as fluoride, arsenic and chemical pollutants (mainly pesticides and insecticides) is on the rise. It has been found that fluoride contamination is widespread in 15 states, affecting 150 districts; eight districts of West Bengal have excess arsenic in their water. Other quality related problems are caused by biological contamination – for example, percolating effluents of tanneries reaching water table.

It is estimated that, worldwide approximately 250 million new cases of water borne diseases occur with over 10 million deaths each year. The majority of the cases occur in developing countries. In India, 1.5 million children under 5 years of age die every year on account of water-related diseases. The estimated man days lost due to water and sanitation diseases is 200 million.

Traditional Technologies

Historical evidence reveals that advanced water harvesting systems had been in use since centuries. India is generally divided into 15 ecological regions. The various regions have had their own area-specific systems. In hilly and mountainous regions, natural springs are harvested, as well as rainwater from rooftops. Thus the spring and rainwater that is collected is then carried over long distances with the help of bamboo pipes. In arid and semi-arid regions, ground water is harvested by constructing wells, such as open cut wells and step wells, which are achieved by tapping ground water aquifers. Rainwater is also harvested from rooftops, taken through artificially created catchments and drained into artificial wells called *kunds*.

Rainwater Harvesting

Rainwater harvesting is a convenient way to collect water particularly when either surface water or ground water sources are not available, or are not easily accessible. It

[1] Government of India, Planning Commission, Mid Term Appraisal of Ninth Five-Year Plan (1997-2002).

has been estimated that 85% of the drinking water supplied to rural India owes its source to ground water. Technology development in drilling and pumping methods has resulted in massive exploitation of ground water. Area under ground water irrigation has increased from 6.5 million hectares to 40 million hectares since 1950-51. Excessive draft of ground water has not been compensated adequately by recharge of the subterranean aquifers that store water. In seven of the country's areas, ground water depletion has exceeded 85%. Water table has lowered highly significantly as already stated. Over exploitation of groundwater has also caused problems of salinity intrusion from the sea in coastal areas. Catchments for rainwater harvesting could be rooftops, compounds, rocky surfaces, hill slopes or artificially prepared impervious surfaces.

Rooftop Harvesting

Rainwater harvested in rooftops is collected in storage containers via a channel on the roof periphery and a down pipe (Graphics in Appendix 1). Rooftops could be covered with tiles, iron sheets or fibreglass sheets as the circumstances may warrant. Amount of harvested water collected in rainwater harvesting projects depends on:

- frequency and intensity of rainfall
- catchments characteristics
- water demand and pace
- extent of runoff

Size of storages for rainwater collection is determined with reference to number of consumers, consumption per day, length of dry season and evaporation loss during dry period. Storage of harvested rainwater is done in tanks, lined pits, small dams etc, where they tend to get filled to capacity during rainfall. Collection of water thus ends with the rainy season, where the fixed volume of water is kept until the next rainy season.

Under the Comprehensive Water Management Programme in Chennai, several concurrent measures have come to be taken for water conservation – mandatory groundwater recharging through rooftop rainwater harvesting, equitable distribution of water and plugging of leakages.

Spill Water Recycling

Spill water from community water outlets usually stagnates around the sources, more often hand pump sites. It has been found that total spill over at a hand pump site used by 50-60 families works out to about 3000 litres a day. Spill water recycling technology has been successfully demonstrated by the *Gandhigram* Rural Institute in Tamil Nadu state, with the support of the Department of Science and Technology. [2] For spill water recycling, a prefabricated water recycling unit is set up to facilitate partial purification of water. The spill water is passed through a filter chamber by gravitational force. The silt

[2] Government of India, Department of Science and Technology, Science and Technology for Women, Some Experiences in Occupational Health and Water Management.

and mud in the water is held between graded granite chips during movement through a filter chamber. The water flows through an inspection chamber, which helps to monitor purification. The chamber facilitates further purification by sedimentation. The partially purified water is collected in a collection tank. It has been found that 49% of the solid deposits and 85% of the bacterial count of the spill water is reduced. The recycled water is, of course, unfit for direct internal or external use by human beings, but it is of immense value for agro-based activities.

Sectional View of Spill Water Cycling Unit

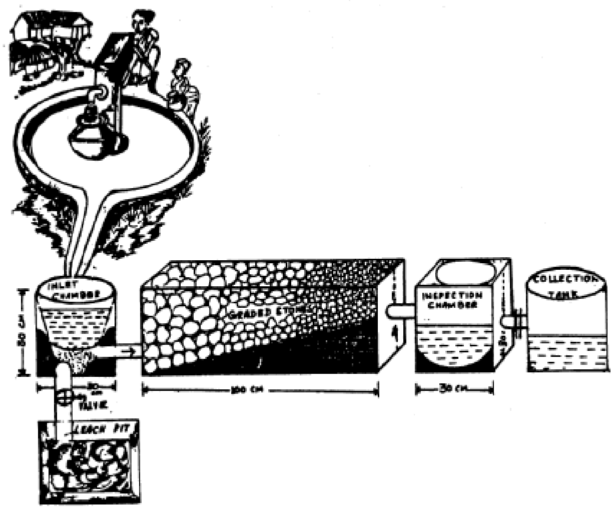


Fig. 1. Sectional view of spill water recycling unit

Government Sponsored Land and Water Management Techniques

In order to harness and efficiently utilize some of India's water and land resources the Indian government has put forward a number of initiatives. Some examples of key strategies that have been adopted to address the water management issues are the following:

- Command Area Development
- Dry land farming
- Multiple cropping
- Flood control measure

Command Area Development involves the development of irrigated areas along with on –farm development. The form of development would include development of field channels and field drains; land levelling and shaping; reclamation of waterlogged areas; development of ground water irrigation, along with other projects.

Dry land farming is a process that encourages rain fed and seasonal fallows in irrigated areas for production for short duration crops like sesamum, lentils etc. When this technique was undertaken in seasonal fallows or irrigated lands, this provided for rotational cropping.

In the process of multiple cropping, different crops were raised in the same land simultaneously, enhancing the aggregate cropped area - for example raising of tuber crops, fruits and vegetables, spices (pepper, ginger, turmeric etc.) amidst coconut plantations. For flood control, measures like flood forecasting, flood plain management through zoning, construction and maintenance of embankments were undertaken.

Women and Water

In water management sophisticated technical inputs have come to be applied extensively. This has shifted control of water management from the informal domain into the formal domain of bureaucratic decision-making structures. While the creation of such structures distances women from decision-making in the prevailing socio-cultural milieu, it has been increasingly recognized that water resource management in a community becomes successful with greater awareness of women and their full involvement in the management processes.

Training of Women in Fluoride Removal

A number of cost effective methods for removing fluoride from drinking water have been explored; particularly women have been trained in this field. In one of the projects, the method adopted is the use of medicinal plant materials like clove, pomegranate, gooseberry, nutmeg, dried ginger, *sathavari* (a kind of asparagus), *kozhinjil, karinochi, and ramacham*. The first four have an efficiency of 66-82%, the last two have 26-34%, and the others around 40%. These materials are dried and powdered for use as filtering media. The alternative chemical used for fluoride removal is alumina, which has 72% efficiency. The system used for filtration comprises of two PVC tubes of 11 cm in diameter and 27cm in height. They are placed one over the other and packed with the filtering media. A wire mesh is fitted at the bottom of the tube, and water filters through it.

Installation of Water Pumps and their Maintenance Management by Women

Women in rural India spend a great deal of time walking to conventional sources of water like rivers, wells, ponds, lakes etc, to basically meet their household needs. Introduction of tube wells and hand pumps (Mark II Pumps) brought water nearer to habitations. This brought about a significant improvement in their quality of life. There have been many instances of women agitating against location of the hand pumps on the roadside (for the convenience of the officials, in charge of maintenance) or at places convenient to the authorities of local institutional bodies. Nor do they feel pleased with location of these facilities being too close to their homes because they perceive the control of their in-laws as an impediment to socializing with other women. For women, often, water collection points are spots where they can socialize with their neighbours. They prefer locations ‘slightly removed’ to enjoy their liberty and space for themselves. Availability of water nearby, not only saves them from walking long distances, but also, it saves them time to pursue economic activities. In addition the availability of water bestow women more often the luxury of ‘leisure’ they would not have had otherwise. It is also a matter of record that water supply has become a matter of priority in governance at the level of local bodies, especially after mandatory reservation of membership and presidency in local bodies for women has been introduced.

Wherever training has been given to women in repair and maintenance of hand pumps, ownership of these facilities has improved. They have also felt empowered because they are called “water mechanics” and given tool kits for use. They then have the ability to move within a convenient radius to ensure that the installations work all the time (as long as ground water is available).

Appendix 1

Rainwater Harvesting Models

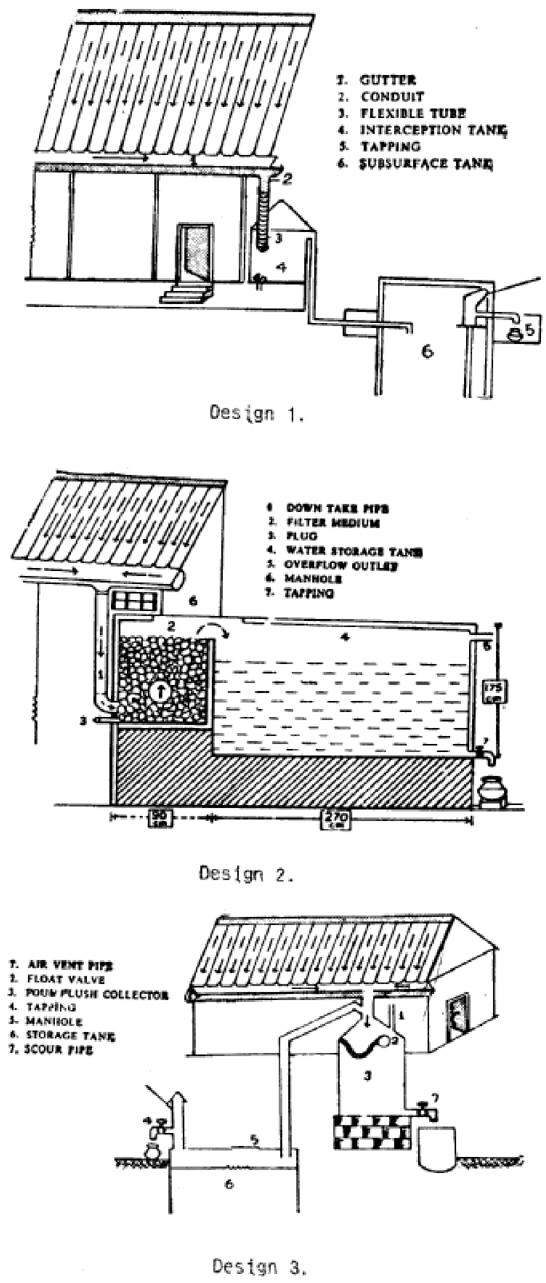


Fig. 2. Rain water harvesting models

X. Japan: The Flood Preventative Function of Paddy Fields and Rice Cultivation

In Japan a traditional agricultural practice has been proven to be a vital factor in both flood prevention and ground water replenishment. Rice cultivation practices have been determined to have an important role in upholding a gentle balance in a climate that is prone to typhoons and heavy rains.

The Role of Plough Pan

Paddy fields have a flood preventative function by catching and storing rainwater and then having the ability to discharge the water at a later period. Plough pan plays a very important part in supporting the flood prevention role.

Plough pan is a compacted layer of soil that builds up below the soil surface as a result of ploughing or cultivation activities. The plough pan lets less water through than the soil above or below it. It is important for rice farming because appropriate soil penetration should be held at a constant level and because the durability of the ground is necessary to support the weight of the farming machinery during ploughing.

Rice Roots and their Role

Permeation into the ground is promoted through underground root holes (deep-seated pore spaces) that are formed when the rice roots of the previous year decompose. Needless to say, this formation, which is a biochemical process, cannot occur without rice farming. The effect helps to raise the groundwater level when ploughing and irrigating fields, supporting the principal outcome of groundwater recharge by rainfall. Thereby, overflows from ridges subsequently are decreased and flooding is prevented.

Underground root holes of other plants may permeate underground water as well. However, depths and extents of roots and amounts of transpiration vary, therefore conducting proper water management is very difficult.

It has taken over one thousand years for the technical system for rice production to be established to fit the environment in each region. Considerable efforts will be required if the new technical system using other plants may be applied to incorporate the flood preventative function.

Monitoring the Fields

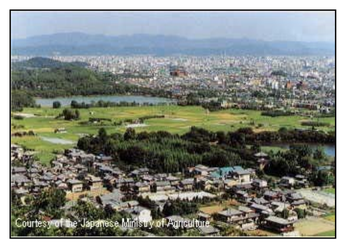
In order for the plough pan to be formed and its function retained, maintenance through various agricultural activities is necessary. Among the activities currently carried out in wet rice cultivation is ploughing and irrigating the fields. This process helps to restrain the occurrence of fissures on the field surface, by filling up the small cracks in the subsurface with soil and grains of earth. In addition, since rice production involves the daily control of irrigation water, this daily monitoring greatly aids the process of finding fissures on the field surface and subsurface of the soil.

Subsequently the process of monitoring and properly maintaining the rice paddy fields, greatly decrease the amounts of fissures, which prevents the occurrence of landslides during periods of intensive rain and typhoons. Studies have shown that abandoned farms that are not continuously monitored are three times as prone to landslides and other natural disasters.

It has been demonstrated that after intensive rain periods, if discharge from paddy fields can be limited, the probability of flood occurrence can be reduced, especially in flatlands in downstream regions. And it has been proven that discharge can be controlled by rice cultivation in paddy fields in hilly and mountainous areas. Thus illustrating that rice cultivation serves to be one of the most useful approaches in flood prevention.

The Flood Preventive Features of Rice Fields

The flood preventative phenomenon can be explained by observing the characteristics of the process of rice cultivation itself. In this process a system is formed where rainwater is stored in the whole basin using paddy fields and irrigation canals where drainage is controlled. This is realized through repeated use of irrigation canals within each area, which is particular to the process of rice cultivation.



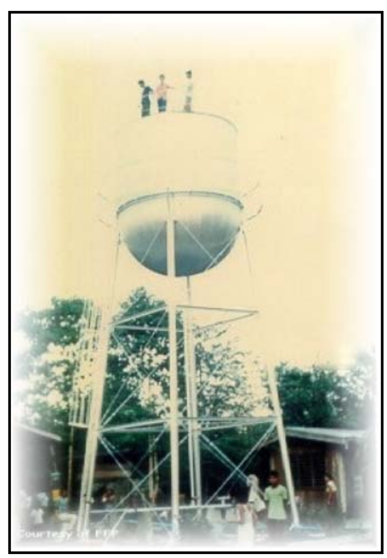
It has been demonstrated that paddy fields in low flatlands that are in marshy conditions have lower permeability when cultivation is abandoned. An increase of surface water that cannot permeate is a contributing factor to consequent overflowing and flood damage. Therefore without proper water control for paddy fields the probability of soil erosion and landslide occurrence is higher even in terraced paddy fields.

Rice cultivation has also been linked to being a vital contributor to the replenishment of groundwater. The Ministry of Agriculture, Forestry and Fisheries (MAFF, 2000) and the MAFF (2001) revealed that irrigation water in paddy fields permeates into the ground and fosters the replenishment of groundwater. It has been established that the groundwater levels respond to the mode of rice growing and the amount of water used. Studies have shown that as more and more paddy fields were converted, the groundwater level dropped.

XI. Philippines: Liton Potable Water System Project

The Liton Free Farmers Cooperative is situated in the village of Kayaga, in the town of Kabacan in North Cotabato province, in southern Philippines. It was formed more than 25 years ago by residents of the rice-farming village who saw the need to work together in order to address their economic problems. Because of the political situation in their region, the village residents eventually agreed to relocate their houses to a common settlement area, thereby creating the first cooperative settlement of the FFF/FFFCI. The cooperative has since expanded its activities from a humble consumer store to grains marketing, trucking, milling, farm machineries, and related projects. The settlement in turn has grown to accommodate up to 500 farm-households.

In 1989, the cooperative's officials approached the FFF/FFFCI National Office for possible assistance in setting up a potable water system for their settlement. They identified the lack of potable water sources and the community's dependence on polluted rainwater (and/or unhealthy shallow wells) as the main cause of many illnesses. The community relied on these sources for their drinking, washing, bathing and other household requirements. As a result the contaminated sources were the primary cause for the deteriorating health of their members and rising incidence of skin and intestinal diseases, particularly dysentery and amoebiasis among the young children in the community. The situation was further compounded by the pollution of nearby water tables due to the intensive contamination by chemical fertilizer and pesticides on the rice farms surrounding the community. In addition, the lack of a drainage system created stagnant water ponds, which were used by disease-bearing mosquitoes as breeding areas.



The proposal was to set up a 10,000-gallon capacity water pump and tank and a web of water distribution pipes that would provide clear and potable water to the 223 farm-households and about 1,300 individuals who were residing in the settlement at that time.

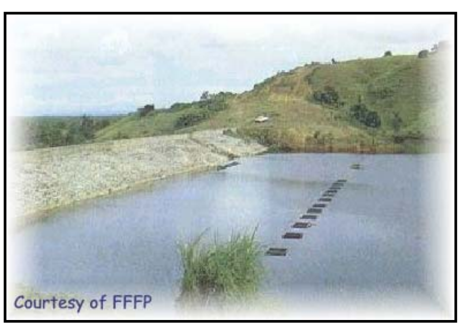
The FFF/FFFCI National Office fortunately was able to locate a donor who volunteered to provide a grant for the construction of the water tank and part of the distribution system. The Liton cooperative in turn agreed to shoulder the costs to complete the distribution system, while their members agreed to shoulder expenses for in-house pipes, fittings, and related items. Construction of the potable water system started in September 1989 and was completed around March 1990.

The village-based water system was the first of its type and scale in the province, given that most water systems are usually located in town and city centres. The most tangible and immediate impact of the project was the improvement in the sanitation and hygiene in the community and the corresponding improvement in the health and general welfare of the residents. This has had various spill-over effects, such as lower expenses for medication and hospitalisation, and the improved mental and physical health of young children.

Additionally, beneficiaries noted that the time they previously spent to haul potable water from remote areas was now being devoted to more housework and other constructive activities. The project also reinforced the unity and cooperation of the members of the cooperative, which was necessary not only for the continued success of their business projects, but also for the maintenance of their water system.

Although water systems can be set up anywhere, it is clear from the experience of the Liton cooperative that the existence of a strong organization of project beneficiaries, through a rice farmers' cooperative in this case, is critical in ensuring the efficient installation and sustained maintenance of the system. The cooperative's officials actually did almost all of the work, from contacting and negotiating with the water installation company, supervising the construction of the system, and securing the necessary water permits and laboratory clearances. The farmer-members in turn contributed their labour in helping construct the water system and setting up the pipe distribution network in the village.

The FFF/FFFCI national office's role was merely to link the cooperative to a donor. Still, it was also a critical role since the cooperative probably would not have been able to set up the Php1 million system (around $50,000 at that time) by itself. The national federation was also able to assist the cooperative in securing a water permit from the National Water Resources Board (NWRB), based in Manila.



The water system experience also shows that the existence of a farmers' organization can reap benefits beyond mere economic or business projects, or traditional social advocacy activities. The unity and cooperation of members of the cooperative served as the groundwork on which other services could be provided to the members. Aside from the water system for example, the cooperative has actually arranged for a consolidated electrical connection with the local electric company, so that the settlement is billed as one account, and the cooperative takes care of collecting fees from individual households. The cooperative settlement also maintains its own security force, which is accredited by the local authorities, given that peace and order continues to be threatened by insurgents operating near the area.

The experience of the Liton cooperative also highlights the need for a clear water rights policy. Although the cooperative settlement is 4 kilometers away from the town center, it had to secure a waiver from the town's water utility agency, which apparently had acquired prior rights and franchises over water tables in the area. Fortunately, the water agency agreed. However, as local communities expand, conflicts over water rights may arise; even communities surrounding the Liton settlement may eventually set up their own water systems and encroach on the water source of the cooperative. Rules on water rights have to be clearly laid out and explained, so as to avoid confusion and unnecessary conflicts in the future. Technically for example, even individual households setting up deep wells whether for irrigation or potable water have to secure permits from the NWRB and waivers from existing franchisees.

There is a clear economic, aside from social, rationale for investing in basic utilities, such as potable water systems, in rural areas. If life in the rural areas becomes unbearable due to the lack of such facilities, it will be difficult to stop the rural residents from migrating to town centres and cities to survive, and that will only result in congestion, urban squatting, health and sanitation problems, and stress on water and other utilities. Similar problems will crop up if governments neglect rural roads, irrigation facilities, and other basic infrastructure which will leave rural residents no choice but to look for jobs and other means of survival in urban areas. Therefore, the long-term solution for problems now besetting urban communities is to make life bearable and productive for the rural masses. In turn, sustainable development can be achieved only if the rural population, most of whom derive their livelihood from agriculture, are able to survive and grow with their families out of the fruits of their labour and their farms.

XII. Farmers' Participation in a Campaign to Enhance Water Quality: A Swedish Example

In 1999 the Swedish Parliament adopted 15 environmental quality goals, which would aid in ensuring agricultural sustainability, while promoting a clean environment.

Since many of the goals directly concern agricultural production and sustainability the government has taken on a participatory approach, by involving input and discussion from farmers. The objective of these goals is to reduce climate impact, and to promote clean air along with the promotion of natural acidification; promotion of zero eutrophication; good quality ground water maintenance; promotion of a non-toxic environment; thriving wetland protection, and many other beneficial effects. All these aims are obvious common denominators and examples of goals that farmers also want to strive for. Pesticide and nutrients leakages from arable land to water and air affect the quality of water and environment; as well as nutrient loss is also a waste of money for the farmers. Thereby a natural response from farmers is to strive to reduce losses of nitrate and phosphorous from farmland, reduce ammonia emissions from manure, and to avoid spreading pesticides into surface and groundwater

The participatory approach to environmental protection has been widely advocated by farmers themselves. In fact, the farmers have for a long time supported the idea that participatory methods, cooperation, involvement and voluntary approaches would achieve better results in the long run. The government has recognised the importance of public participation and bottom-up involvement, and as a result has approached environmental conservation by including farmers.

As a good example of this new approach an informal agreement has been made between the farmers' organisations and the authorities concerning spreading of slurry in autumn. This is a key issue for reducing nutrient leakage, particularly in the Swedish climatic conditions. The joint effort is to reduce the spreading of slurry in autumn before sowing winter cereals. The agreement is to allow for a systematic effort to minimize this spreading with the help of education, information and on-farm advisory. If this approach is successful the necessity for legislation, to achieve decreases, is no longer required. As a result the development of environmentally friendly cultivation methods, such as the protection of water, is not legislation driven, but farmer initiative driven. With this approach legislation becomes the last option, if all other methods fail.

Swedish Farmers' Participation in the Project "Focus on Nutrients"

Focus on Nutrients is the largest single undertaking in Sweden to reduce losses of nutrients to air and water from agriculture (livestock and crop production). Focus on Nutrients is a joint venture between the Swedish Board of Agriculture, the County Administration Boards, the Federation of Swedish Farmers and a number of companies in the farming business.

The project takes the form of a campaign officially launched in 2001 to provide training and advice and its name reflects the projects aim of encompassing the entire flow of nutrients on the farm; the campaign is intended to continue for the next five years.

The ultimate objective of this campaign is to increase nutrient management efficiency on the farms through raising awareness and knowledge sharing. Individual farm visits are organised by farm advisers, as well as on going study-circles are maintained, placing the farmer at the core of this campaign.

The Focus on Nutrients, on surface or groundwater catchments for the protection of drinking water, had been a widely welcomed initiative. A small catchment is a natural common denominator for cooperation and for protection of water. In these areas farmers will be offered advice both as individuals and as members of a catchment group. Therefore a method where individual on-farm advice is combined with catchment-group advice is being developed. The belief is that this combination gives a better result compared to only individual advice or only group advice. The knowledge and experience of a group of farmers is far greater than compared to the experience of each individual.

It is too early to evaluate the project and its effects on water quality. The expectation on the outcome of the campaign is high, both among the farming sector and authorities. A good sign is the high interest among farmers with around 4000 participants and so far 44 percent of the arable land in the southern part of Sweden.

An important factor for success has proven to be the great number of organisations involved. About 40 different farm advice bureaus with 200 advisors are involved in part time or full time, to give environmental advice on the farms that are participating in the project.

The most important method used is "farm-gate nutrient balances". The method of nutrient balances has been used successfully in a previous Swedish project where farmers have calculated yearly nutrient balances for seven years. The results indicate that there is a great potential for improvements and the largest progress is achieved when a farmer calculates the nutrient balance for the first time.

What is a Catchment?

A catchment is a structure, such as a basin or reservoir, used for collecting or draining water, especially rainwater. Rainwater harvesting using ground or land surface catchments areas is an effective way of collecting rainwater. It involves improving runoff capacity of the land surface through various techniques including collection of runoff with drainpipes and storage of collected water. In contrast to rooftop catchment techniques, ground catchment techniques enable the collection of water from a larger surface area. By maintaining the flows of small creeks and streams in small storage reservoirs (on surface or underground) created by low cost (e.g., earthen) dams, this technology can meet water demands during dry periods.

Swedish Success Story on Catchment Pesticide Management

In a pilot study in a small catchment in the south of Sweden farmers managed to cut down on findings of pesticide residues by 90% during a ten year period. The work was carried out in close cooperation with a scientist and a farm advisor. All farmers were interviewed on what procedures they used when spraying. In addition yearly meetings on how to improve management on pesticides were also held. The information led to an improvement of handling procedures such as filling and cleaning. Furthermore weed on the farmyard was regulated mechanically instead of chemically and a safety distance to stream and wells when spraying was kept. After ten years the concentration of pesticides had decreased by 90% in the small stream e.g. surface water. The yields were not affected by the improved handling procedures and the measures were cheap and therefore there were no economic loss to the farm.

Farmers Water Quality Management Groups

In certain places in Sweden farmers have started a cooperation to improve water quality in the local water environment. These groups usually consist of 10-30 farmers and gather around their local stream discharging from their farmland. The motive for this voluntarily work is to use a bottom-up approach to improve water quality and to have a proactive means that would be ahead of the authorities. An important part of the work is to increase knowledge and awareness on cultivation methods that are important to water quality. Evening courses are common as well as study trips to other farmers, or on-field experiments where measures to reduce nutrient leaching are tested.

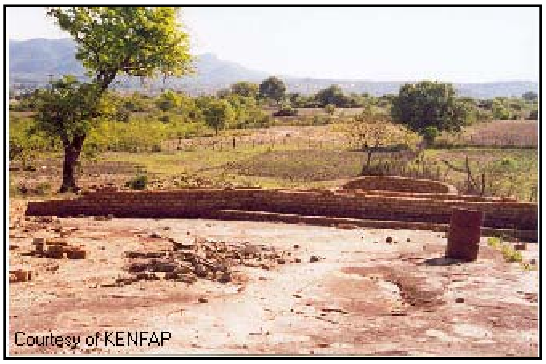
Major Outcomes of Participatory Methods

These projects show that it is possible to engage farmers in environmental work with voluntary and participatory methods, particularly if it is a mutually advantageous situation for both the farmers and the government. If the *Focus on Nutrients* campaign will be as successful as we predict it to be, then the farmers will have proved that they can manage environmental recovery and improvement with informal agreements and without the need for legislation. Although at times there is a need for clarifications in rules and regulations to support farmers' efforts, where then direct contacts and discussions between farmers, farmers’ organisations and authorities will be guided by legislation. Nevertheless farmers’ participation and their strong commitment towards environmental improvement speaks volumes.

In the case of measures to reduce nutrient leakages it is easy to illustrate a mutually beneficial situation. In this example the nutrients remains in the soil supporting the crop and as a result less amount of nutrients are needed for the farmers which reduces the production cost and also the effects on the water.

The successful pilot-project on pesticide management strengthens the farmers and the farmers' reputation as professionals. It gives more political and social credits to the farmers as a group than direct economical profit to individual farmers. But that is also an important gain, which in the long run increases the credibility for the green industry.

The outcome of getting the farmers involved through training and participation is perhaps not the quickest way of gaining environmental improvements but in the long run it's the only way to sustainable development. Hopefully these projects will also help to illustrate farmers' serious commitment towards sustainable development and environmental preservation.



XIII. Drip Irrigation: A Technique for Poverty Alleviation in Kenya

Poverty in Kenya

Almost half of Kenya is living below the poverty line, and the struggle for food and shelter is most prevalent in the arid and semi-arid interior regions of the country. For a typical smallholder farmer in Kenya, subsistence has been the main goal of farming. Unfavourable climatic conditions have resulted in periodic droughts and floods that have crippled the local economies, and poorly developed infrastructure and social amenities continue to isolate the rural poor. As agriculture is the mainstay of the Kenyan economy, poverty alleviation can only be accomplished through productivity gains in agriculture. In a stressed water system like Kenya, an increase in agricultural productivity requires proper and efficient water management.

> *"A stressed water system is defined as a system that cannot adequately meet the demands of households, communities, and nations. The factors that contribute to water stress are population growth, irrigation, livestock watering, droughts, deforestation, poor land management and pollution from human activities."*

Water Resources in Kenya

Water resources in Kenya are unevenly distributed, and most annual precipitation escapes through evapotranspiration or infiltrates the grounds. The remaining precipitation drains into various lakes and the Indian Ocean. There are five drainage basins in Kenya: Lake Victoria, Rift Valley, Athi River, Tana River and Ewaso Ng'iro. The Tana and Athi are the only two large rivers that cross the dry areas of Kenya. Therefore water sources vary, and can range from shallow wells, boreholes to seasonal streams.

These water resources are vital sources, which are able to supply the water intensive crop requirements. Increasing efficiency of water use is important for maximizing return from vegetable and fruit production. Water can also be collected from surface run-off and stored in low-cost tanks underground to be used for irrigation purposes. The most effective way of saving water is to minimize non-productive water losses such as evaporation from soil, runoff and use by weeds. The population of Kenya is estimated at 28.8 million and it is growing at a rate of 2.1%. With a rapidly increasing population, water availability per capita decreases, while the conflicting demands for water use increase.

Kenya and Irrigation

Agriculture in Kenya is predominantly rain-fed and is concentrated in the narrow middle 33% of the country, which is categorized as high to medium potential for agricultural purposes. The remaining parts of the country, which constitute 67% of the land area are arid and semi-arid, and are categorized as low potential for agricultural purposes. It can be then estimated that approximately 20% of Kenya's land area is arable. Irrigated agriculture is under-exploited, and only 13% of the country's irrigation potential is being utilized. Irrigation has been a priority for the Kenyan government for many years, and the National Irrigation Board (NIB) was instituted in 1966. Despite this history of irrigation management, little progress has been made in increasing the hectares of land under irrigation. Some of the problems that have plagued the NIB include: lack of participation of farmers, competition from cheap imports, high running costs of schemes, and inadequate funding from the state.

For many smallholder farmers, the high cost of irrigation equipment makes them reluctant to adopt the technology. In the past few years, the introduction of a simple, cost effective drip irrigation system has made it possible for many farmers to irrigate their fields or kitchen gardens. This system is easily assembled and can be adapted for individual farm conditions.

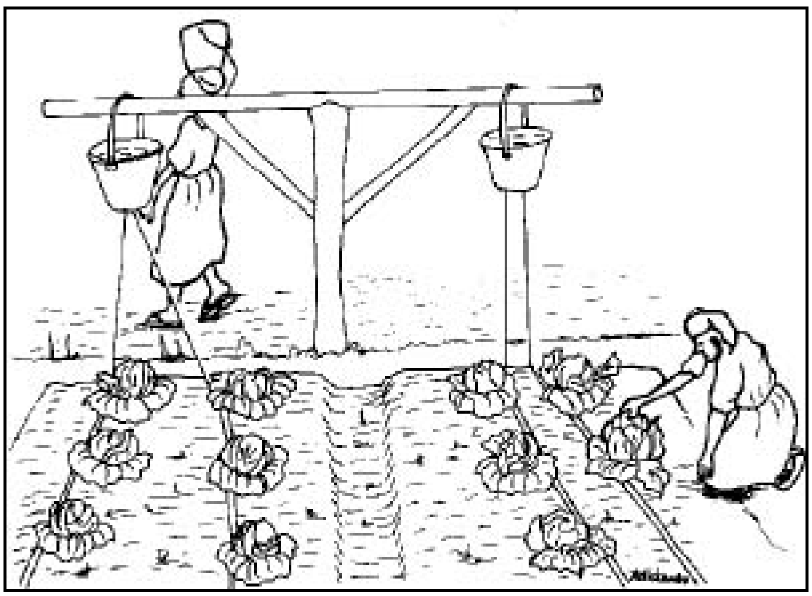
Drip Irrigation

A drip irrigation system consists of a network of porous or perforated piping that is installed on the surface or below ground. This plastic piping is usually laid alongside the rows of planted of crops, and water is directly applied to the root zones of the crops in a slow and controlled manner to reduce evaporation loss.

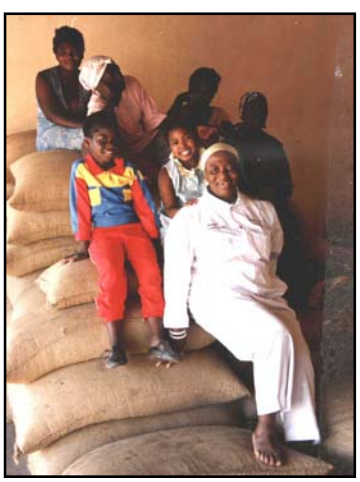
The use of this technique reduces water use by 40 to 60%, while the increase in yield can be as high as 84%. Advances in drip irrigation technology have made it more cost effective and accessible to smallholder farmers. In 1996, the Kenyan Agricultural

Research Institute (KARI) introduced bucket drip irrigation kits developed by Chapin Watermatics. A typical bucket drip irrigation kit costs 19 US dollars and includes a 20 liter bucket or a 200 liter drum, drip tape, filters, rubber washers, male and female adapters, two supple tubes, bard fittings and a screen filter.

The buckets are mounted on a stand, one meter off the ground with drip lines connected at the bottom. Water is poured into the buckets and released under pressures of 0.5 to 2 m water head. This system is considered a low-head drip system, while a standard drip system operates under pressures of 10-15 m water head. For dry areas where water has to be carried for long distances, this system is ideal as it requires less water and it allows every drop to be used efficiently. Drip irrigation technology is an ideal way to produce high value crops as it reduces water use, labour and increases crop uniformity and yields compared to traditional ways of irrigating crops.



An illustration of a Bucket drip irrigation system documented in the Sustainable Agriculture Extension Manual, produced by the International Institute of Rural Reconstruction.



Drip Irrigation and Women

Women in Kenya make significant contributions to agricultural production, resource management and the marketing of agricultural produce. Yet, they are generally sidelined in skills development programmes and denied access to assets and credit.

Proper management of water through drip irrigation supports women's capacity to meet household needs in terms of food and income. Approximately 70-80% of drip irrigation users are women who use the system to maintain kitchen gardens. Without the technology, many women choose not to plant vegetables in their gardens during the dry season, as it requires extensive watering. The introduction of drip irrigation enables many families to have vegetables in their diets all year round. Therefore there is a regular supply of food, thus evening out periods of shortage. And in some cases, the sale of surplus vegetables can be an additional source of income. This also encourages more successful crop yield and raises the income-earning potential of local water sources, thereby enhancing neighbourly cooperation. Therefore drip irrigation has the potential of being a powerful tool in alleviating poverty and providing food security to thousands of people in Kenya.

XIV. South Africa: Inter-Basin Transfers of Water

South Africa lies in a semi-arid region of the world and its water is an essential and scarce resource, which is poorly distributed in terms of growing socio-economic requirements. As the population grows and the economy develops, the water that is available has to be shared between a wide range of users while their impact on its quality increases.

A Scarce and Limiting Resource

The options for water management are limited by the topography of the country and by weather patterns, which are beyond human control. Droughts and floods are common and may strike anywhere unexpectedly. Rainfall, and to a greater extent runoff, is spread very unevenly across the country, not only geographically but also from season to season. On average over the longer term, most of the runoff is generated in the eastern part of the country. The greater part of the interior and the western portion of the country is arid or semi-arid. Sixty-five per cent of the country receives less than 500 mm of rain annually, which is commonly for successful dry land farming. Twenty-one per cent of the country receives less than 200 mm. In this context, South Africa is vulnerable to the impact of potential climate change.

Water use in South Africa

Recent estimates indicate that total water use in 1996 amounted to around 20 000 million cubic metres per year – about 38 % of total available water, but more than half of the economically exploitable water. In 2030 total water use could amount to 55% and 80% respectively of total available water and economically exploitable water. Although reliable figures are not available, the best estimates available suggest that the proportion of water used for domestic, commercial and industrial purposes is approaching that used by agriculture.

Thus, while South Africa currently falls into the category of “periodic or regular water stress”, it will face “chronic water scarcity” by 2025 if current population growth trends continue and would move towards “absolute scarcity” in the foreseeable future. Already, South Africa is actually worse off in terms of this indicator than some countries, such as Namibia and Iraq, which are traditionally regarded as arid lands.

Water Resource Management Responses

The traditional response to resource pressure is to take measures to increase supply. Thus total storage capacity in major reservoirs was increased from only 4 400 million cubic metres in 1956 to the present 29 500 million cubic metres.

South Africa is however reaching the limits of what can be achieved to make water available to everyone by traditional methods. The water needs of the nation will not be met sustainably unless managerial and technological innovation are brought to bear on all facets of water management. Further augmentation of water supplies is already being achieved or at least investigated from sources such as effluent re-use and rainfall stimulation by cloud seeding.

Other less conventional sources could include importation of water from better-watered neighbours to the north, desalination of seawater and even harvesting icebergs from Antarctica. Water from such sources could very well be more expensive than from existing sources, and some are technically untried. The current low growth of the economy puts many of the options out of financial reach although it also reduces need for them by slowing the growth of demand. It is however recognised that the application of most of the “novel” options lies some way in the future, and in the meantime energies must be devoted to making the best use of the currently available resources. It is in this context that inter basin transfers must be reviewed.

Inter-Basin Transfers of Water

Most of the major centres of economic and social development of South Africa are located in areas where water is not naturally found in abundance. Accordingly, an extensive system of inter-basin water transfer schemes has been developed, by which water may be conveyed from areas of relative abundance to areas of need where water is relatively scarce.

The existing schemes have a combined transfer capacity equal to a little less than 8% of the total available surface water in South Africa. Economic activity in all nine provinces is already supported to some extent by water imported from elsewhere. The central Gauteng province, upon which South Africa’s economy is centered, is the most dependent. With few exceptions, IBTs have international connotations, in as much as they either take water out of an international river, or add water to one.

It is however important to note that, beyond the mere ability to augment average supplies to water short regions, IBTs provide diversity of supply which increases the reliability and resilience of supply systems. In an environment of substantial variation, the contribution to risk reduction of such diversity may be as important as the quantum of water transferred.

What is an Inter-Basin Transfer?

Inter-basin transfer is the diversion, or movement of water from a basin-of-origin (i.e. river basin) and the transportation of such water to another receiving river basin for storage or utilization for a beneficial use.

The National Water Policy and National Water Act of 1998

The election of a democratic national government in 1994 transformed the political environment. The new Constitution demanded a change in approaches to the management of natural resources and a thorough-going review of the public service was initiated. The National Water Policy for South Africa, and the National Water Act which derives from it, have as their fundamental objectives the achievement of

- sustainable use of water;
- equity of access to water and to benefits from its use;
- mutual cooperation with neighbouring states to optimise benefits for all.

This has been translated into a core objective for water managers, namely,

"to manage the quantity, quality and reliability of the nation's water resources to achieve optimum, long-term, environmentally sustainable social and economic benefit for society from their use."

Inter-Basin Transfers in the Context of the National Water Policy

In line with best international practice, the policy and legislation provide for all new infrastructural development to be subject to environmental impact assessment in terms of the principles of Integrated Environmental Management. New development will also be expected to be consistent with regional catchment management strategies, which must provide for water conservation and demand management measures.

In respect of Inter Basin Transfers, the National Water Policy goes further and specifies that:

"Inter-basin transfers will have to meet special planning requirements and implementation procedures, which must involve agencies from both donor and recipient catchments. Catchments to which water will be transferred will have to show that the water currently available in that catchment is being optimally used and that reasonable measures to conserve water are in force."

Impact of New Policy Approaches on IBTs

The following are three examples of IBT projects which are currently in advanced stages of planning:

Thukela-Mhlatuze in Northern KwaZulu-Natal

This transfer scheme is intended to ensure that water supplies to the industrial growth point at Richards Bay are adequate and that water supply does not become a constraint to industrial development. A major tunnel project had been proposed for this purpose. In terms of new policy, the funding of such a project had to be based on user charges. Since the growth parameters and water demands could not be accurately predicted, it proved to be impossible to find funding for a single major transfer scheme. Instead, a series of smaller augmentation and transfer schemes are being planned, including schemes to share infrastructure with other users along the route. Imposition of the simple “user pays” policy has thus had the impact of delaying capital expenditure without, to date, any impact on water users.

Mooi-Mgeni in the KwaZulu-Natal Midlands

This scheme is designed to augment the water supply to the Durban - Pietermaritzburg conurbation. This is both the fastest growing urban area in the country and, as the country's principal port, the focus of industrial development aimed at integrating South Africa into the global economy. Despite the growth pressures, new water services approach adopted by the local government have see demand for bulk water reduced by 3% while the number of new consumers supplied has increased by 5%. The measures adopted have included both aggressive reduction of unaccounted for water as well as restructured tariffs to discourage excessive use. The result has again been to enable the planned start of the project to be delayed for perhaps six years. This particularly important since it allows available funds for infrastructure investment to be focused on priority areas for service expansion.

Berg River-Cape Metropolitan Area in the Western Cape

This scheme is intended to transfer water from the north flowing Berg River to the South flowing Riviersonderend system to augment supplies to the Cape Town metropolitan region. As with Durban, the Cape Town region is enjoying relatively rapid growth in tourism as well as intensive agriculture and this has been accompanied by rapid population growth. The regional water supply is derived from a complex system of impoundments and the Skuifraam dam and associated transfer works has been identified as the most cost effective scheme to provide for Cape Town's next augmentation.

The Western Cape environment has many special characteristics, including a unique biological kingdom and areas of outstanding natural beauty. In addition, agriculture in the region is booming as a result of the opening up of international markets post-1994. In these circumstances, any water resource development will be highly contested and this has been the case with Skuifraam.

A lengthy process of consultation has been undertaken during which many concerns were raised in relation to the efficiency of water use in the urban areas. As a result, no decision to proceed with the construction of the scheme had been made by 17 April 1999. The municipal authorities had instead been requested to undertake certain measures to manage demand and ensure efficient water use in their system. Subject to successful introduction of these measures and confirmation of the demand projections, it is likely that the project will proceed in the near future.

XV. Nicaragua: The Programa Campesino a Campesino (PCaC): A Program to Conserve Soil and Water

Assessment of Soil Deterioration

Over the past two decades, logging operations, the expansion of agricultural land and the indiscriminate use of chemicals products such as pesticides, herbicides and fertilizers have seriously deteriorated and disturbed natural resources. Desertification has led primarily to significant soil erosion.

Tailor-made solutions for farmers in response to this situation, in 1987 the National Union of Farmers and Ranchers (UNAG) implemented the Programa Campesino a Campesino (PCaC), an innovative program that offers small farmers various sustainable, economically viable technologies. The practices proposed focus on local resources and conditions. In particular, the program seeks to:

- encourage active participation by rural communities and the transfer of know-how;
- propose simple, inexpensive, effective practices.

The techniques allow for the reuse of biological matter by limiting reliance on chemical inputs and other energy-intensive technologies.

This approach makes it possible to reduce long-term production costs, although the projects are initially labour intensive.

Soil Conservation and Water Management

In addition to carrying out small-scale pilot projects, the PCaC supports initiatives and projects aimed at:

- using mulch and inedible stems;
- introducing plant residues and using biological fertilizers;
- reforesting and planting hedges;
- encouraging alternative cattle feed (plants and shrubs from the region);
- selecting animal species and plant varieties fully adapted to local conditions;
- diversifying plant varieties and encouraging the use of legumes and cover crops.

Soil Conservation: Strategies to Increase Fertility and Curb Erosion

Recourse to mulching and the construction of dikes, hedges and barriers are among the methods used to conserve water, control erosion and increase organic matter and biodiversity in the soil. The growing of cover crops such as legumes is also being encouraged. Drought-resistant legumes play a dual role: they enhance soil fertility and provide additional food for human beings and animals. Thirteen varieties of legumes and cover crops are grown throughout the country to protect soil, conserve moisture and regenerate nutrients. Moreover, the agro-forestry approach has aroused special interest among farmers. Over 300 of them have planted cacao trees, coffee trees and pepper plants around the Bosawas reserve. All of these simple practices are contributing to conserving natural resources and thus engendering increased production.

Water Management

Here are two examples of simple techniques that rely on available materials to ensure efficient water management.

Cisterns are installed in dry areas in the country in order to collect rainwater running off the roofs of farmers' houses. Ponds are dug in the ground and channel the water to storage ponds. Water collects in the cisterns and when it reaches a certain level, it starts an appropriately adjusted pump. The pumped water can be drawn by gravity to different sites. It is reused for domestic purposes or to supply irrigation systems.

A drip irrigation system that uses bamboo, pails, cans and other recipients makes it possible to continuously water part of a field or a garden. The systems directly irrigate the base of the plants and thus give better results.

A Successful Experiment in the Masaya Region

The PCaC was introduced at the Cooperativa Gaspar Garci Laviana five years ago. The following positive results have been achieved:

- crop rotation
- plant residues are incorporated into the soil
- natural barriers are used to combat erosion
- reforestation and cover crops
- spreading of manure

- a 90% decrease in the use of chemical fertilizers
- an increase in annual crops from 4 to 14
- an increase in perennial and semi-perennial crops from 3 to 19

In Masaya, 22 families are experimenting with the principle of the accelerated reproduction and multiplication of tubers such as cassava. This technique ensures the production within a short time of healthy, contamination-free plants. Given its potential, the technique has spread to other regions of the country.

Beyond natural resources, rural communities participation

The PCaC has made it possible to raise awareness among small farmers of enhanced management of their natural resources. Farmers have become aware of their potential and their ability to manage sustainable projects. Moreover, under the impetus of the PCaC, a number of new organizations and programs have been established, which has strengthened the role of farmers in enhancing their living conditions.