WATER CONSERVATION IN ARID AND SEMI-ARID REGIONS

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Summary

Water resources in arid and semi-arid areas are very scarce due to the low rainfall and high evaporation. This complicates the supply of water for domestic, industrial and agricultural uses.

Water managers in arid areas must therefore have a very clear understanding of the constraints and opportunities of the available water resource base. This will facilitate the development of an appropriate institutional framework to address the challenge of water management. Another prerequisite is that proper policy, laws and regulations should be in place to guide the water manager.

Water is required for developments in all sectors of the economy and therefore it is of critical importance that proper inter-sectoral coordination is achieved to utilize the available water resources to the best advantage.

In order to optimize the efficient use of the available water sources, a water conservation strategy is called for. This strategy should be based upon appropriate water policies, legislation and regulations. Water users should be educated to understand what water scarcity means and what they can do to conserve water. Water awareness and public participation are the cornerstones of a water conservation strategy.

Effective water demand management is another major component of a successful water conservation strategy. The main elements of such a strategy are of a legal, social, financial, economical, technical and participatory nature, but the total integration of all methods is the key to success.

Some of the most important measures to practice water conservation in arid areas are the conjunctive use of surface and groundwater, the re-use of effluent, artificial aquifer recharge, and the utilization of sand storage dams to reduce evaporation. The recovery of the full supply cost of water from the consumers and the application of punitive water tariffs are also very successful in reducing water demand. The desalination of brackish water and seawater finds an application where such waters are available for treatment.

The need for arid countries to gain access to perennial rivers that are, internationally shared water sources calls for cooperation with all the involved watercourse States to facilitate joint planning of water supply schemes.

The environment in arid areas is very susceptible to degradation and water resources must be protected against pollution or unsustainable use. Due attention should therefore be given to reduce the impacts of water utilization on the environment and how access could be obtained to internationally shared perennial water resources to augment scarce water sources.

1. Introduction

The activities related to efficient water conservation management in arid and semi arid regions are mainly determined by the nature of the prevailing hydroclimate. The mean annual precipitation is characterized by relatively low, erratic and unreliable rainfall events that are extremely unevenly spatially distributed over the landscape and vary considerably in duration. Because of these conditions, the location, magnitude and accessibility of the relatively scarce water resources pose a number of interesting challenges for water suppliers and water users alike.

Other factors that compound water conservation are the industrial and socioeconomic development potential in certain areas that must be served with water supply infrastructure, but are remotely located from sustainable water sources. Population growth, urbanization and the potential for an improvement in the standard of living of people in especially the developing countries, cause an increase in the demand on already scarce water resources. The concentration of the population in rural or urban areas with better economic potential (urbanization for example) impact adversely upon the available financial resources to establish new water supply infrastructure. The need for an improvement in food production and the creation of job opportunities through industrial or mining development, require more water that has to be supplied from already scarce water resources. This situation calls for clever resource management to reduce excessive demands, and to stretch the quantity of water available to meet the reasonable demand of all potential consumer groups.
In this regard, it should also be mentioned that the pollution of water sources in arid areas is a much more serious, irreversible and unacceptable threat than in areas with higher rainfall where the dilution and flushing of polluted water resources is perhaps possible. The conservation of water resources in arid areas should therefore be based on the best management practices, including the optimal use of all the institutional, technical, economic, environmental and social opportunities available to water managers.

2. Understanding an Arid Water Resource Base

In arid countries there is always a distinct rainy season, followed by a dry period for the rest of the year. The precipitation, which is the result of convective rainstorms in the summer period, is scarce and normally of short duration, but can sometimes be very intense. These downpours in a short space of time cause high stormwater runoff, often resulting in disastrous flood events.

Runoff in the normally dry ephemeral streambeds or "rivers" occurs as a direct response to rainfall events and runoff event is usually referred to as a "flood."

Another phenomenon, which compounds the availability of surface waters, is evaporation. The high evaporation rates experienced in arid regions are caused by high temperatures, and the low humidity of the air mass over the land. The potential annual evaporation is therefore much more than the average annual precipitation and the loss of the accumulated runoff in water bodies is significant, because the rate of evaporation from open water surfaces is so high. The mean annual rainfall may be as much as one hundred times less than the potential mean annual evaporation. This water deficiency is the cause of aridity and in areas where the rainfall is the lowest, the evaporation is usually the highest.

Because of this, the watercourses in arid areas are normally dry, but may flow during the rainy season only if, and when it rains enough. Countries like Botswana and Namibia have no perennial water resources at all, except for some access to perennial water flowing in the border rivers originating in the neighboring countries. This implies that the future augmentation of the internal water resources within the interior of those countries from these shared resources may become a cause of conflict if mechanisms for cooperation and joint planning is not established at an early stage.

The rainfall received in arid areas also shows large deviations from the expected mean annual rainfall. This compounds the planning, design and construction process in water infrastructure development, as well as the subsequent management of the water schemes. The deviation in mean annual rainfall is expressed as a percentage of the mean annual rainfall and is called the variability of the rainfall. This is a measure for evaluating the reliability that the expected mean annual rainfall will actually occur during a rainy season and has a great influence on the statistical analysis of runoff, maximum probable runoff evens and dam spillway design. This variability may range between less than 20% in the higher rainfall areas to more than 80% in the lower rainfall areas in arid countries.

Due to the erratic nature of the rainfall and the variability of the rainfall, the calculation of the mean annual rainfall in arid regions should be treated with caution, because it is not really a true reflection of the rainfall that can actually be expected to precipitate. The annual rainfall over a period of time is usually made up of a large number of years with low, below "average" rainfall and only a few years with very high, above "average" rainfall. In most years the actual annual rainfall will therefore be less than the expected mean annual rainfall as calculated and the total volume of water produced will be less than expected from the average rainfall over the period of time observed. If the few

years of high rainfall is ignored or reduced, an adjusted average can be calculated and is called the "median." This is a better reflection of what might be expected because in higher rainfall areas, the annual precipitation may be more or less the same each year and therefore the mean will be more representative. The mean and the median will also be nearly the same.

Another important hydrological phenomenon relating to runoff in arid regions is the so-called "antecedent factor". During the dry season, the vegetation cover is gradually reduced by stock and wildlife grazing. If there are successive poor rainy seasons and overgrazing takes place, the vegetation cover can disappear completely. When the first good rains precipitate after such a period of drought and overgrazing, good runoff is achieved immediately after the rains started. The vegetation also starts to recover very quickly, but has the capacity to contain or reduce runoff. It then often happens that if heavier rains fall later during the same rainy season, or even better average showers during the next rainy season, the runoff generated may be less than the previous events with less rainfall because of the improved vegetation cover.

It is well known that the silt loads in the runoff of ephemeral rivers are high due to the generally sparse vegetation cover in arid areas. The silt loads in the runoff immediately after periods of drought is much higher due to the lack of vegetation and much less when the vegetation has recovered after a number of better rainy seasons.

It is also interesting to note what happens to the water that is precipitated in arid areas. In Namibia, which has a mean average annual rainfall of 250 mm, it is estimated that only 2% of the rainfall is available as runoff and about 1% eventually becomes available as groundwater. Almost 83% of the rainfall evaporates shortly after precipitation and the balance of 14% infiltrates the parched soil where it is utilized by the natural vegetation. This portion of the rainfall is of critical importance to sustain stock farming, dryland crop cultivation and the preservation of biodiversity.

The economy in arid countries is extremely susceptible to the variations in the hydroclimate and in an attempt to manage the effects of scarce rainfall on the activities of man, it is not only important to predict what might be expected, but also to understand the prevailing conditions. The occurrence of droughts in Namibia can be classified into two main groups. These are referred to as a hydrological drought and an agricultural drought. A rainfall drought occurs when the total precipitation during the rainy season is very much less than the expected long term mean or median annual precipitation.

The hydrological drought can be subdivided into a rainfall drought and a runoff drought. The occurrence of a hydrological drought is critical in arid areas, but it is often not well understood that low rainfall is the norm in arid areas and that a drought is actually something worse than the normally dry conditions.

A runoff drought can occur when too little (or no rainfall) precipitates or it can occur when the average rainfall (or better) falls in the catchments, but the intensity of the rains are so low that no runoff events occur. No surface runoff can therefore be accumulated in the water supply dams. The same happens when the vegetation has started to recover

significantly after initial light rains at the beginning of the rainy season and by the time the heavy showers start to fall, the established vegetation cover reduces the runoff considerably.

The agricultural drought refers to the condition of the vegetation available for grazing and the failure of rainfed crop cultivation due to low rainfall during a rainy season. An agricultural drought can be subdivided into a grazing drought and a crop drought. A grazing drought occurs when the grass did not grow, or responded well to the rainfall. This can happen if there was a hydrological drought (little rainfall) or where average rainfall or better occurred, but the rain fell too early or too late to be of value during the optimal growing season.

A rainfed crop drought occurs when there is no rain or when the rains fall at the wrong time during the rainy season. This rainfall may even be higher then the expected average, but if a farmer starts planting after the first rains of the rainy season had fallen, and the follow-up rains stay away, then the crop fails. It may also happen that the first significant rains fall so late in the planting season that it is not possible to plant and harvest a crop in the remaining time. This is due to the fact that arid countries may have less than 4 months with more than 50 mm of rainfall. The length of the rainy season is therefore critical for crop production. The rainfall frequency is also important for crop production because most arid countries have between 20 to 60 days per year when rainfall actually occurs.

The prediction of crop yield is seriously affected by these erratic climatic conditions and has a major influence on staple food production under rainfed conditions. Even if good rains fall at the beginning of the rainy season, it is too early to predict if there will be a good rainy season and adequate crop yields or not. The best approach for farmers is perhaps to use their experience and institution. It is better to prepare the land and to plant, instead of waiting to see what will actually happen. However, a government cannot take such a risk and has a responsibility to make contingency plans to ensure that a secure supply of staple food will be available in case of a crop failure, even long before the onset of a rainy season. The same applies to the availability of fodder. If the rains fall before or after the growing season of the natural vegetation, it may result in severe grazing shortages in the period up to the next rainy season. It is clear that the erratic rainfall has a great effect on the productivity and economy of farming activities, both in the subsistence and commercial farming sector.

A fortunate aspect about arid climates, is that it is virtually impossible to predict the outcome of a rainy season and whenever someone has reason to believe that the worst scenario should be expected, there is always a good chance that the actual rainfall may prove the prophet totally wrong. The only way to predict the behavior of a rainy season in an arid area is to wait until the end of a rainy season and then to confirm what has happened.

3. Institutional Framework

3.1 Introduction

Competent management of water resources in arid areas is critical, but this cannot happen if adequate institutional arrangements are not in place. An appropriate institutional framework and resource capacity (human and financial) are vital components to achieve the objectives of a water conservation strategy. In arid and semi-arid countries like Namibia, Botswana and South Africa, water management is directed by adequately structured, competent Departments of Water Affairs. The common functions of these Departments of Water Affairs should deal with the overall management of water resources in the country to ensure that the water resource base is properly investigated to determine its potential and that water is utilized in a sustainable way. Other important functions are to protect water resources from pollution and allocate water to the consumers in such a way that maximum economic and social benefits can be achieved for the nation as a whole.

3.2 Water Legislation

The administration of water affairs is based on a number of pillars. These are for example, the constitution of the country, water law, water regulations promulgated in terms of the water law, and a water supply and sanitation policy. The Government may from time to time wish to implement various other measures to achieve the most efficient water resource management strategy for the country under drought conditions.

The adoption of water, sanitation and environmental policies, as well as the promulgation of appropriate legislation is facilitated by adequate provisions in the constitution of a country. For example, Article 95 of the Constitution of the Republic of Namibia deals with the maintenance of the welfare of the people. According to subarticle 95 (l) the Government must adopt policies for the maintenance of ecosystems, essential ecological processes and the biological diversity of the country, as well as the utilization of living natural resources on a sustainable basis for the benefit of all Namibians, both present and future.

Similarly, Article 100 of the said Constitution deals with the sovereign ownership of natural resources. According to this Article, the land, water and natural resources of the country shall belong to the State, if they are not otherwise lawfully owned. This enables the Government to exert control over the allocation of scarce water resources to competing demands.

Any water legislation developed for an arid country should at least make provision for the establishment of a dedicated Ministry or Department of Water Affairs and a representative advisory body to advise the Minister of Water Affairs on water matters. Legislation should provide for the proclamation of subterranean water control areas and the regulation of water abstraction in those areas. The water law should also facilitate control over the construction of dams, the apportionment of water, the judicious utilization of water resources and the equitable allocation of those sources on a priority basis to the different consumers. The granting of licenses or permits for the abstraction and use of surface runoff in public streams or groundwater in subterranean water control areas must also be regulated.

Water legislation should be administrated on behalf of government by a competent body such as the Department of Water Affairs. Water legislation should also give the Minister responsible for water affairs, the power to take all steps he may consider necessary for the investigation, development, control and utilization of water resources, as well as giving effect to the provisions in a water Act. The ownership of water is an important issue when it comes to the authority to control the use of water in arid areas and taking the responsibility to protect and conserve water resources. The Water Act in Namibia makes a distinction between public and private water. Public water is water normally found in a public stream, whether the water is visible or not (groundwater in an ephemeral watercourse), and the use of the water is regulated by the Act. Private water is water that occurs naturally on the land and may be used exclusively for any purpose by the owner of the land on which the water occurs. There is therefore no right of property in public water or private water. The distinction between public and private water in the Act is therefore not meant to determine who owns the water, but to define who has the right to use the water and how it can be used.

Surplus water is defined in the Act as all public water which is not normal flow, for example flood water. In arid areas like Namibia, there are no perennial streams with normal surface flow, and runoff is seen as floods, which may occur from time to time in those dry rivers. This surplus water is available for further beneficial use, but cannot be utilized unless it is impounded. However, the construction of dams in public streams and the storage capacity of those dams must be authorized in terms of regulations promulgated in terms of the water act to protect the environmental and the rights of downstream, riparian users. This will ensure that an adequate balance of the runoff is available for further downstream use.The water act allows for the use of water by people who are not owners of land or riparian land. The Minister can supply water from a State Water Scheme to any person for any use on any land and the same applies to private individuals, local authorities or any other legal person granted the right to supply public water to any consumer.

A water act should have provisions aimed at controlling the purification and disposal of effluents, as well as preventing the pollution of freshwater or marine waters from sources of effluent located on land. In arid areas the disposal of any effluent into ephemeral water sources should be prohibited, unless regulated by a permit with conditions that prescribe the purification of the wastewater in such a way that the effluent is of an acceptable quality.

A Minister is responsible for water affairs, should also be empowered to call for the construction of water works that he may deem necessary or desirable for the purpose of conserving or supplying water. He must also be able to drain land, to store water or to prevent the wastage of water or to control the abstraction of water from any surface or underground water source.The Minister must also be empowered to make regulations in connection with the development and management of water works. These may make provision to pay subsidies on water works constructed, the levy tariffs and charges for water supplied, and the periodical revision of those tariffs. The Minister must also be enabled to authorize any person to enter upon private land for the purpose of investigating the feasibility of any water work, or to monitor and inspect water supply schemes.

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Biographical Sketch

Mr. Piet Heyns has been directly involved in integrated water resource management and the development of water supply infrastructure in Namibia and Southern Africa for more than 28 years (24

years in Namibia). After school he did voluntary military training in the South African Air Force and then studied at the University of Stellenbosch in the Republic of South Africa where he graduated as a civil engineer with water engineering as his major field of study. In 1973 he joined the Department of Water Affairs in South Africa, but relocated in 1977 to the Department of Water Affairs in Namibia. He is presently the Director: Resource Management in the Department of Water Affairs in the Ministry of Agriculture, Water and Rural Development in Namibia

He is charged with the responsibility to ensure the investigation and assessment of the potential of the surface and underground water resources in Namibia, as well as the strategic planning of water supply infrastructure development. He also directs water research, environmental matters related to water and the administration of the water legislation in the country.

He is a member of a number of professional institutions, namely the Namibia Engineering Council, the Engineering Professions Association of Namibia and the South African Institute of Civil Engineers. He is also a member of various national and international bodies on water and related matters. At present he is a Commissioner in all the Water Commissions between Namibia and its neighbouring States, namely Angola (Cunene and Okavango rivers), Botswana (Okavango River) and South Africa (Orange River). He is the chairperson of the Okavango Basin Steering Committee, as well as a member of the Committee for Bilateral Agreements on the Cunene River and the Planning Committee on the Lower Orange River. He also serves as a member of the Water Resources Technical Committee of the Southern African Development Community and the Steering Committee of the Southern African Global Water Partnership

He traveled extensively in Africa, Europe, the United States of America, the Middle East, Central Asia and the Far East in connection with water resources management, attended conferences and presented about 30 technical papers. He published articles in many journals and papers.

Mr Heyns is married to Annalize and they have 3 children, Riza (22), Pieter (20) and Lucinda (17). His interests are history, technology, environment and medicine while his hobbies are philately and airplanes. He likes to do sea or freshwater fishing and plays social tennis.