Rainwater management: Past, present and future

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INTRODUCTION

Rainwater management is not a new phenomenon. For example, rainwater harvesting has been practised in several Middle Eastern countries, as well as in many other arid and semi-arid regions of China, India, Pakistan and several other countries for some 3,000 years. For a long time, rainwater harvesting received little or no attention from decision-makers and water professionals in most parts of the world. Yet, the practice has continued, and even accelerated, in numerous developing countries, primarily in the rural areas.

Towards the last two decades of the twentieth century, as the population of developing countries continued to increase significantly, urbanisation processes accelerated, and human activities expanded exponentially. Water was increasingly considered to be a scarce resource in most countries of the developing world. Concurrently, there was a concerted attempt by the world community to re-orient development activities so that they were focused very specifically to alleviate poverty, reduce hunger and improve the overall quality of life of the people. These developments contributed eventually to the universal acceptance of the Millennium Development Goals (MDGs), whose fulfilment has now been accepted as one of the most important components of the global development agenda until the year 2015. Many of these MDGs are directly related to water, and several others have indirect or tertiary implications for water development and management practices and processes.

While much has been said and written about the water crisis in recent years, the real crisis stems not from an absolute scarcity of water but from inadequate water management process and practices. Nearly all countries of the world have enough sources of water if these are managed efficiently and equitably. However, the efforts needed to manage the available water resources efficiently may vary from one country to another, and even from one part of a country to another because of different climatic, physical, social, economic and environmental conditions, as well as due to varying levels of available technical and management capacities, institutional performances and political considerations. Within this overall water resources planning framework, rainwater management should receive appropriate attention, which it does not, at present.

Furthermore, the time has come to move beyond rainwater harvesting and consider rainwater management in its totality. Rainwater management includes not only traditional rainwater harvesting that has been practiced for centuries, but also storage of rainwater for use in terms of disaster management, local flood and accelerated research and development activities to improve existing knowledge-base and enhance implementation potentials.

ECONOMIC PERFORMANCE DEPENDS ON RAINFALL

In spite of tremendous advances, countries as diverse as Brazil, China, Ghana, India and Morocco have continued to depend upon adequate rainfall to ensure good economic performances since prehistoric times. This dependence on rainfall will very likely continue in the foreseeable future for most developing countries.

In India, the world´s second fastest growing economy after China, nearly 60% of its population still depend upon farming-related activities to sustain themselves, and agriculture currently accounts for nearly a quarter of the country's GDP. Good and timely rainfall bolsters farm incomes, thus fuelling demands for consumer goods, industrial products and farm machinery. This, in turn, propels national economic growth rates to higher levels. Accordingly, for major developing countries like India or China, historically there have been direct interrelationships between rainfall, economic development and quality of life of their people. Famines occurred, with invaluable human sufferings, when rainfall failed over a period of years.

Historically, economic crises have often been triggered by extended periods of low rainfalls. Prolonged droughts have meant that the country's farmers were forced to leave their rural roots and migrate to urban centres searching for any type of employment opportunities to sustain their families. They mostly did not return to the rural areas after their dislocation, even when the droughts were over, contributing to a "lose-lose" situation for the country as a whole, in terms of increasing urban congestion and depopulation of rural areas. This is a common phenomenon for numerous developing countries, which again indicates the importance of timely and adequate rainfall to sustain such nations and their people. Proper rainwater management is thus a continuing requirement to assure the welfare of most developing nations.

RAINWATER MANAGEMENT IS DIFFERENT IN TROPICAL AND TEMPERATE CLIMATES

It should be noted that water management is far more difficult and complex in the developing countries, most of which are located in tropical and sub-tropical climates, compared to the developed countries of the temperate climate. This is because of the extreme seasonality of the distribution of annual rainfalls in developing countries, as well as their higher intra- and inter-annual variations.

If the annual average rainfalls are compared between three cities, two in developing countries (Sokoto on the Southern border of the Sahel in Nigeria and Delhi, India) and London, England, they are somewhat similar: 57cm, 71cm and 67cm respectively. However, if their distributions over the year are considered, the patterns are totally different. For example, in London, a temperate zone city, can be characterized by a low but reasonably uniform monthly rainfall rate over the year, varying from a high of 61 mm in October to a minimum of 35 mm in April. Because of this regular rainfall, moisture retained in the soil is reasonably uniform over the entire year.

However, the rainfall pattern is very different for Sokoto. Nearly 36% of annual average rainfall occurs only during the month of August. Over 92% of average rainfall occurs within the four-month period of June-September. There is no rainfall between the five months of November to March, and very little in April and October. Not surprisingly, Sokoto has significantly lower rainfall retention rate in the soil throughout the year, compared to London. Thus, not only do water management strategies for areas like London and Sokoto have to be different, even though their annual average rainfalls are somewhat similar, but even irrigation practices for crops.

Sokoto cannot manage water without proper storage of rainwater during the wet months, which can then be released and used as required over the year during the dry months. In contrast, climatic regimes in many European locations like London, with their more uniform and reliable precipitation and high soil moisture retention rates, the need for irrigation water is significantly lower.

Even the monthly rainfall figures may often give a misleading comparison. For example, the average number of rainy days in New Delhi in a year is about 40. During the rainy days, rainfall does not occur uniformly over a period of 24 hours. It has been estimated that Delhi receives most of its annual rainfall in less than 80 hours, though these hours are not necessarily consecutive, but within the short monsoon seasons.

Similarly, if the rainiest town of India, Cherrapunji, is considered, it receives most of its annual rainfall of 10,820mm during the southwest monsoon, between June and August. This intense rainfall occurs in about 120 hours. Because this immense quantity of water cannot be properly stored, Cherrapunji, in spite of its very substantial annual rainfall, has been facing a water problem during the dry months of the year.

The above analysis indicates that water scarcity in most developing countries and the resulting human sufferings are not necessarily due to inadequate rates of annual average precipitation, but primarily because of the difficulties associated with the storing of intensely seasonal rainfall over a short period for subsequent uses. Depending upon soil types and conditions, precipitation patterns and other associated factors, only about 20% of rainfall percolates in the soil, which can later be used for productive purposes. This is also the reason why, Cherrapunji, which is one of the wettest urban areas of the world that receives over 160 times the annual average precipitation of London, has a water scarcity problem during the dry months.

Overall, India as a country receives its annual rainfall in less than 100 hours. Because of this skewed pattern of distribution of rainfall, water management strategies for India have to be different from countries with temperate climates like U.K., Germany and The Netherlands, where the rainfall is significantly more regular and predictable.

The critical management issue is how to store such immense quantities of rainfall over short periods so that they can be used over the entire year. Since the fluctuations in annual rainfalls are also high in such countries, the incidences of floods and droughts are more frequent than in the temperate zone countries. Thus, for countries of the developing world in the tropical and sub-tropical regions, cost-effective, socially-acceptable and environmentally-sound solutions are needed to store high precipitations over a comparatively short period.

The technical complexities of water management that the developing countries of the tropics and semi-tropics face are significantly more than the developed countries of the temperate zones.The best techniques for water management in these two sets of countries cannot be identical. Such simple but fundamental differences have generally been ignored in the current global debate on water management practices.

Because of such climatic differences, developing countries must consider all alternatives available for storing water during the periods of intense rainfall so that these can be made available whenever needed to satisfy human and ecosystems needs. The alternatives available to smoothen out these wide inter- and intra-annual fluctuations in rainfall may include dams (small, medium and large), groundwater recharge and storage, and rainwater harvesting. The solutions are invariably site-specific, and may even have a time dimension.

THE CURRENT WATER MANAGEMENT DEBATE HAS BECOME DOGMATIC

The sad part of the current debate on infrastructure for water management is that it has become increasingly more dogmatic and emotional. Many times it appears to be a debate between the deaf. The alternatives are not either/or, as the current debate will make us believe, but rather what alternatives will work best, where, and under what conditions.

Depending on the prevailing conditions of the location under consideration, the most efficient alternative may be the construction of a large, medium or small dam, or rainwater harvesting, or a mixture of these two, and/or other solutions. There is simply no one dogmatic solution that would fit all climatic, physical, social, economic and environmental conditions, for all countries of the world, and for all periods in the history. Anyone who claims that "one size fits all," is simply wrong.

In the real world of water resources management, small may not always be beautiful: it could even be ugly. Equally, big could be sometimes magnificent, but on other occasions it could be a major disaster. Each alternative must be judged on its own merit and within the overall contextual framework through which it has to be applied. Solutions must be tailor-made for specific conditions. Dogmatic solutions, irrespective of whether big or small, are simply not universally applicable. Thus, the current "solution-in-search-of-a-problem" approach, which many individuals, groups or institutions are advocating, is unlikely to succeed.

The storage of rainwater is not an "either or" alternative between construction of large infrastructures or use of small-scale rainwater harvesting techniques. For example, middle to large-scale urban centres cannot be provided with reliable supply of water through rainwater harvesting for domestic, commercial and industrial purposes on a long-term basis. Rainwater harvesting can be a supplementary effort, but it cannot be an exclusive solution under such conditions. Neither can countries like India, China, Morocco or Brazil produce enough food to feed their citizens by exclusive reliance on rainwater harvesting. Furthermore, rainwater harvesting will not produce energy. Properly constructed and managed large dams are essential to ensure that enough water is stored to meet their water and energy needs. In addition, such structures can attenuate flood levels by storing excess water which can then be used during lean periods.

Rainwater harvesting of course can play a useful role even under these conditions. However, its role under these conditions often may be primarily complementary.

In contrast, for a large part of the rural populations, the best alternatives should be considered to ensure that rainfall during the wet seasons could be cost-effectively stored for use during the dry spells. Small-scale developments are often essential to meet their water requirements for domestic, livestock and agricultural needs. Under these conditions, rainwater harvesting must play an important role since large scale infrastructural development may not be technically feasible, economically efficient or socially acceptable. Accordingly, water management solutions must be based on exclusive consideration of prevailing local needs and conditions. A priori solutions, based on dogmatic and ideological beliefs, may often lead to inefficient, inadequate and unsustainable results.

RAINWATER HARVESTING

As noted earlier, rainwater harvesting has been practiced successfully in many parts of the world for at least some 3,000 years. Because of the importance of rainfall to ensure human welfare, many societies all over the world have rain gods and river gods. Prayers are regularly offered to such gods to assure timely and adequate quantity of rainfall.

At present, numerous examples exist in different parts of the world where rainwater harvesting structures are being used productively. As the population pressures in rural areas have increased, numerous rural communities, often with the direct assistance of non-governmental organisations (NGOs), have constructed rainwater harvesting systems in many developing countries. These systems are based on a variety of recharge and storage techniques, and conservation of surface run-off through direct or indirect groundwater recharge. The general technical principles used for the design of these systems are very similar. However, the techniques used in specific areas could be somewhat different, depending upon topographical and soil conditions, social and economic situations, climatic regimes and cultural conditions.

Irrespective of where these techniques for rainwater harvesting are used, they have many common indicators, among which are the following:

- Structures are small and thus can be constructed very quickly;
- Costs of construction are invariably low;
- They can often be adapted to suit the prevailing local conditions better, compared to large infrastructures;
- Community members often actively participate in their planning, construction and maintenance decisions and actions;
- Rural people generally contribute voluntarily with their labour for the construction of these structures;
- Benefits can start accruing very quickly, often immediately after the first rainy season;
- Quality of water, especially when groundwater recharge is involved, is mostly better than what was available earlier;
- They can serve only a limited number of households; and
- Sometimes it may not be easy to ensure their proper maintenance, as a result of which many such structures may become unusable after certain number of years.

In recent years, use of rainwater harvesting and conservation of surface runoff has proliferated in rural areas of many countries, where they were not used, or not used extensively earlier. For example, Sahelian Solution Foundation (SASOL), which was founded in 1990, has successfully promoted construction of sand dams in a cascade in the river beds of seasonal rivers in Kitui District of Kenya. Typically, they have been constructed at 0.5 to 1.0 km intervals on the sandy river beds. The average construction cost of these sand dams, which require around 60 m^3 of sand, has been around US$7500. They serve about 50 households in terms of domestic and livestock water needs, as well as water for small-scale irrigation. As of 2004, SASOL has helped in the construction of over 350 sand dams in this region.

The impacts of SASOL-assisted sand dams on the people of the Kitui District have yet to be properly evaluated. However, anecdotal evidences indicate that these structures have brought considerable benefit to around 200,000 households. Average time spent on water collection journey, primarily by women and children, have been cut from nearly 5 hours per day to about one hour per day, which is a significant saving. They seemed to have had noticeable positive impacts on animal husbandry, which appear to have contributed to improvements in household incomes and nutrition levels. Small-scale agricultural development activities seemed to have been an added benefit.

However, like most other similar structures in many other parts of the world, no serious independent and objective assessments of their impacts on the local population have yet been carried out. Since they are a new development, no definitive comments can be made on their long-term sustainability, even though there is no reason as to why they should not have an economic life of around 50 years or more. Prima facie, they appear to have improved the prevailing water availability conditions of arid and poor areas, and also seem to have noticeably improved the socio-economic conditions of the affected households, and have had certain positive effects on the environment. It is essential that objective ex-post economic, social and environmental impacts assessment of these structures be carried out so that definitive conclusions can be drawn on their usefulness and their possible replicability elsewhere could be considered.

CONSTRAINTS TO RAINWATER HARVESTING

If rainwater harvesting is an important and useful solution, as its many proponents have claimed, why it has not received a much wider acceptance in terms of its extensive application in the developing world? There are many reasons:

Environmental anti-dam movement – A large number of proponents of rainwater harvesting in recent years have been the activist environmental NGOs who have vociferously opposed the construction of large dams. In addition, they have claimed that rainwater harvesting will resolve the water scarcity conditions of the developing world. Such claims, of course, cannot be justified. Regrettably, the proponents have unnecessarily and improperly structured the debate between dams *versus* rainwater harvesting. In reality, the discussion should focus on dams *and* rainwater harvesting, depending upon the local conditions.

No objective individual can realistically accept the proposition that large dams are not necessary in the developing world, and rainwater harvesting can replace them. For example, in countries like Brazil, China, India or Turkey, if they are to maintain their current rates of economic growth, electricity generation needs to be increased at 6-12% per year for many decades to come. With oil import bills increasing steadily because these countries have to rely upon imported oil, more and more attention will have to be paid to national hydropower generation for energy security. Hydropower cannot be generated by rainwater harvesting, nor can large urban centres be supplied with water on a reliable, long-term basis. Irrigation will be required to assure the food supply of a burgeoning population at an appropriate nutritional level. All these needs will necessitate the construction of large infrastructure.

A casualty of this unnecessary debate, has been rainwater harvesting, which the activists groups have championed as the only universal solution for the future. Because of this unfortunate situation, the baby (rainwater harvesting) has been basically thrown out with the bath-water (irrelevant debate). Thus, there has been a delayed and somewhat reluctant acceptance of the need for rainwater harvesting, even under appropriate conditions. Thus, the activists have played a critical negative role in the overall acceptance of rainwater harvesting as an important component of water management. There are some positive signs that this situations may be changing.

Objective evaluations of the impacts of rainwater harvesting – Objective evaluations of the socio-economic impacts of different types of rainwater harvesting, and their long-term sustainability are needed from different regions of the world. At present, only some limited definitive assessments are available. The overall general perception is that the evaluations of their impacts by their activist proponents cannot be trusted. These assessments need to be carried out by objective and knowledgeable persons to gain wider acceptance.

Furthermore, objective, honest and comprehensive evaluations are also needed to determine:

- What techniques of rainwater harvesting have worked, why and where, and under what conditions;
- What techniques have failed, why and where, and under what conditions;
- Identification of good practices which can be replicated in other areas with similar conditions (a corollary is that because of absence of such knowledge, the syndrome of reinventing the wheel is widely prevalent at present in this area); and
- Further additional work is needed in order to determine how best the good practices can be upscaled.

Rainwater harvesting specialists have still not joined the mainstream water profession - Surprisingly, even at present, the rainwater harvesting specialists have not become an integral part of the mainstream water profession. Nor have they carved out a niche for their work in water management as a whole. For example, very few universities anywhere in the world devote much time in teaching rainwater harvesting as an essential component of water-related courses. If it is at all discussed, the coverage is shallow and superficial, giving students the impression that it is not an important and serious policy alternative.

Similarly, major international water conferences seldom cover the topic of rainwater harvesting. For example, the Stockholm Water Symposium, which is considered to be the most important annual water event in the world, has not had a single workshop on rainwater harvesting in its entire 15 years´ of history.

Thus, if rainwater harvesting is to take its proper place in national water policies and water management practices, the proponents of rainwater harvesting must make a determined effort to put this alternative in the national and international water agendas. There are no signs that it is happening at present.

RAINWATER MANAGEMENT NOT JUST RAINWATER HARVESTING

While rainwater harvesting has been practiced for centuries, the time has now come to consider rainwater management in its totality, rather than considering rainwater harvesting alone. Sadly, in spite of great potential for rainwater management to improve human welfare in the developing world and in many developed countries, research and development activities to improve the existing practices have been very limited.

In recent years, the importance of rainwater storage for disaster management has received increasing attention, especially in countries like Japan. Loss of water supply during disasters could lead to severe public health problems, and some times to catastrophic losses due to fires which could have been avoided if an alternative source of water was available. For example, during the Hanshin earthquake of 1995, water supply services were lost in virtually the entire urbanised area of Kobe as a result of some 2,000 fractures in the pipelines. The fire department had to control about 110 fires almost immediately after the earthquake. This was not possible because water was not available due to ruptures in the pipelines. Fire damages were extensive. Water supply in the Kobe area was very seriously impaired. Service could be restored to half of the residents in about 10 days. However, even after one month, some 20 percent of the Kobe residents still had no access to water supply.

Storage of rainwater at different sites could have provided an alternative source of water, both for domestic use and for fire-fighting, and could have substantially reduced human sufferings and property damages due to the fires at Kobe. Thus, rainwater storages for managing the aftermaths of disasters must receive increasing attention, especially in urban centres which are located in earthquake-prone zones. Following the Hanshin earthquake, many Japanese cities have accelerated their programme on rainwater storage for mitigating the impacts of future disasters.

Rainwater storage is also being increasingly considered to reduce localised flooding. For example, the University of Osaka will complete the construction of an underground floodwater storage tank in 2005. This huge tank, 100m in diameter and 50m deep, will be used for floodwater retention and management. Naturally, management processes, for rainwater for flood control will be very different compared with its storage for disaster mitigation.

CONCLUSIONS

Based on anecdotal evidences available, it can be reasonably assumed that rainwater management can be practiced on a much wider scale than now. For rainwater management to become a mainstream water management alternative, it is essential that objective and impartial assessments are carried out for the impacts (both positive and negative) of the existing schemes, and the nature and extent of their beneficiaries are identified. The long-term sustainability of such schemes also needs to be assessed.

It is necessary to evaluate the effectiveness of different methods of capturing and storing rainwater that can not only provide water for human consumption during the lean seasons, but also for use by livestock and to increase the agricultural productivity of the land in rural areas. Use of rainwater for mitigating the impacts of disasters and controlling floods need accelerated attention. A determined attempt must be made by the professionals engaged in rainwater management to identify and disseminate the best practices that can be currently observed in different parts of the world. Research should be encouraged on how to improve further the existing best management practices so that beneficial impacts of rainwater management can be maximised, and their cost-effectiveness and social acceptance can be increased. Only after these steps are taken, rainwater management is likely to be accepted as a mainstream and important water management alternative in the foreseeable future. ***AW***

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