OPTIMIZING USE OF RAINFALL WATER IN EAST DESERT OF EGYPT

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Abstract

Most of the population increases will take place in Arab world countries that already suffer from water, food, and health problems. Increasingly, the various water uses (municipal, industrial, and agricultural) must be coordinated with, and integrated into, the overall water management of the region. Sustainability, public health, environmental protection, and economics are key factors. More storage of water and especially rainfall is necessary to save water in times of water surplus for use in times of water shortage.

The natural processes of rainfall interception by vegetation and natural depressions, together with soil infiltration and storage and groundwater recharge/discharge, largely determine the rate of water discharge relative to rainfall depth. It has been found that significant amount of rainfall and flash floods are available, while water gap exists in most Arab countries especially by 2025. Rainfall can be reliably harvested and used in many countries adding some millions m3/yr. to the Arab water resources. Detailed records of rainfall and flash floods are needed to better estimate the amount of water and to adopt appropriate water harvesting technology.

The objectives of this study are, first to analyze of existing water harvesting techniques, where there are many forms of traditional and modern rainfall harvesting techniques, second optimizing use of rainfall water.

RAINFALLS MANAGEMENT PRACTICES

Detention Basins

Detention basins provide one means of managing storm water. Detention basin can range from as simple a structure as the backwater effect behind a highway or road culvert, up to a large reservoir with sophisticated control devices. Detention is holding of runoff for a short time before releasing it to the natural watercourse. The terms "detention" and "retention" are often misused; retention is the holding of water in a storage facility for a considerable length of time, for aesthetic, agricultural, consumptive, or other uses. The water might never be discharged to a natural watercourse, but instead be consumed by plants, evaporation, or infiltration into the ground as ground water.

On-site detention of rainfall water is storage of runoff on or near the site where precipitation occurs. In some applications, the runoff may first be conducted short distances by collector sewers located on or adjacent to the site of the detention facility. The concept of detaining runoff and releasing it at a regulated rate is an important principle in storm water management. In areas having appreciable topographic relief, detention storage attenuates peak flow rates.

There are several considerations involved in the design of storm water detention facilities. These are: the selection of a design rainfall event, the volume of storage needed, the maximum permitted release rate, pollution control requirement, and design of the outlet works for releasing the detained water, Figure (1).

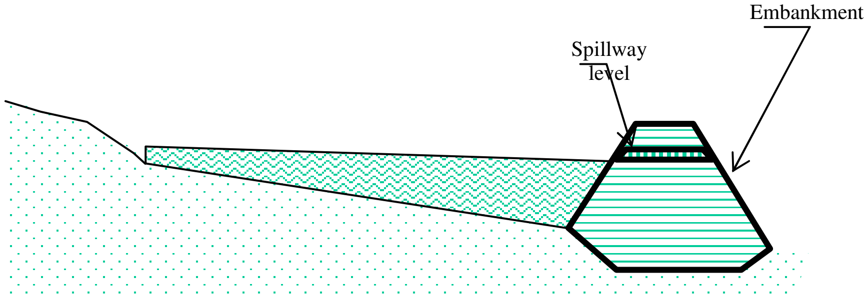

Fig. (1) Illustration for detention basins

Detention basins comprise an impoundment created by an embankment or excavation, and by restriction of their outlet flow capacity. Detention basins are also being adopted for water quality enhancement and as part of a wider pollution control treatment train. Attention is required in their design to ensure the safe spillage of excess flows, such that life and property are not at risk downstream, and to ensure the requirement of community safety. Also attention is required to the potential for flood impacts resulting from their backwater effects. Properly designed extended detention basins can achieve significant pollutant removals. The combined use of detention basins as flood and pollutant controls can yield economic benefits in terms of delay of costly hydraulic infrastructure enlargement downstream and the provision of alternative water pollution interception measures.

Retention Basins, Ponds & Wetlands

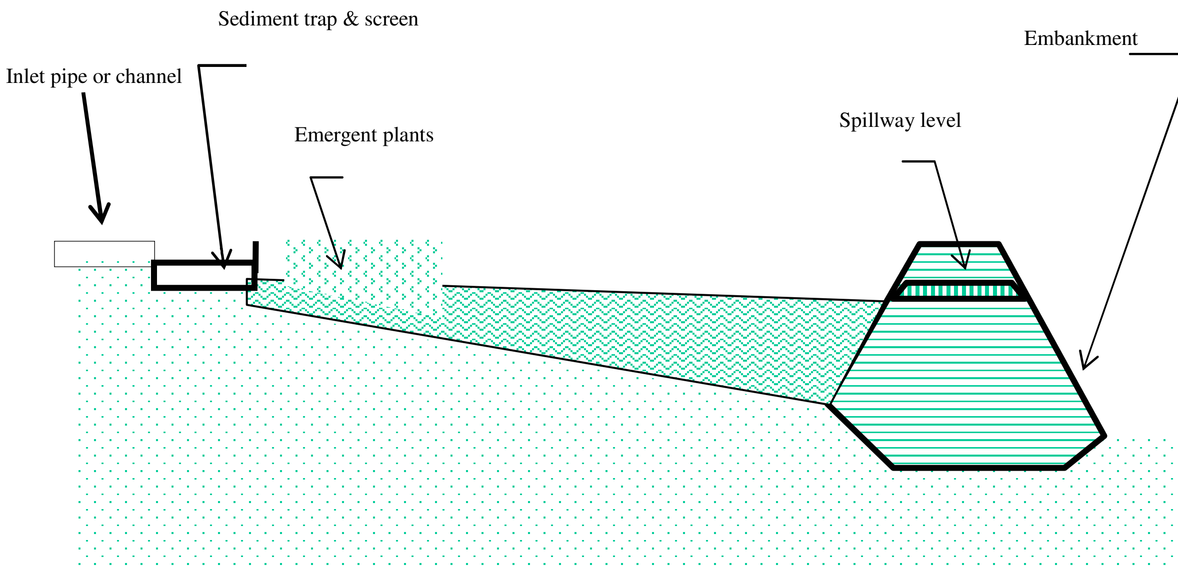

Fig. (2) The retention basins and wetlands practice

Retention ponds are small lakes with a permanent pool of water and some emergent vegetation, while wetlands are shallow basins with most of the surface covered by emergent vegetation. Sediment interception prior to discharge into ponds or wetlands is required in order to protect the emergent and submerged plants, hold off the need for costly dredging, and to protect the landscape quality, as shown in Figure (2).

The retention of water enables settling of suspended materials that are associated with and adsorbed by active sediments, and interception and take-up by emergent and submerged plants. There has been extensive application of this practice in many countries. The community perceived ponds and wetlands as valuable conservation and landscape features, attracting a diverse range of water birds and aquatic biota. Open space requirements and hydraulic backwater impacts should be taken into consideration when applying this technique.

Restoration of Natural Vegetated Channels

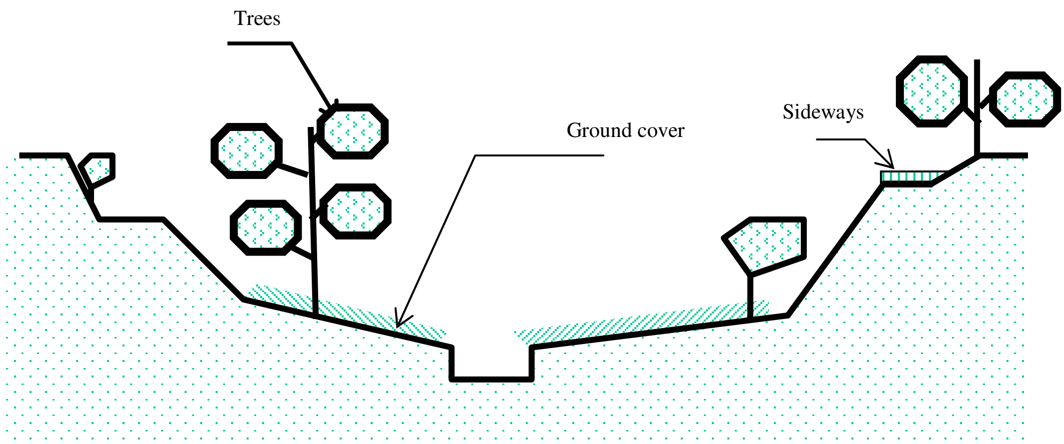

Fig. (3) Restoration of natural vegetated channel practice

The purpose is to restore natural stream channels and floodways within urban areas to secure economies, retard discharges, reduce peak flows, and enhance the interception of suspended solids and nutrients. Also to maximize use of rainfall water and open space and landscape values. Control is required over the rate of sediment deposition, to ensure the viability of grass and other ground covers, Figure (3). The application of this practice is gaining acceptance, in view of its enhancement of adjacent land values, more environmentally sympathetic treatment, and the open space values it affords. Unless the flow channel incorporates capacity for sediment transport, there will be a requirement to intercept stormwater sediment prior to discharge into the natural stream, in order to sustain channel grass cover. This practice represents a low cost solution as compared to concrete channels. It affords maximum benefit, enhanced land, open space and recreation values.

On-site programs of runoff management

The purpose of this practice is to decrease rainfall losses through urban areas by minimization of impervious areas, the direction of impervious area drainage to pervious areas, maintenance of vegetative cover and preparation of on-site retention of rainfall.

OPTIMIZING USE OF RAINFALL WATER

Introduction

Rainfall water, which is discharging into the River Nile through wadis in Upper Egypt during flash flood seasons, is one of the water resources D/S of Aswan High Dam. Although this amount of water is small compared with the River Nile discharges, it is considerable in case of heavy rain on the east and west wadis along the River Nile. In the last few years, the importance of the evaluation flash flood water increased, due to the increase of population density in the major urban areas of Egypt. This has been placing a serious stress on the quantity and quality of water. The estimated flash flood water which is discharging into the River Nile D/S of Aswan High Dam can be used to control the discharged water to the River Nile from the Aswan High Dam, in order to avoid wasting water, especially in the rain seasons [Amer, 1996].

DATA HANDLING AND ANALYSIS

Area of wadis discharging into the River Nile

It is known that the River Nile is divided into seven reaches down stream the Aswan High Dam according to the great barrages along the River Nile to control and manage the water. These barrages are, Old Aswan Dam (1902), Old and New Isna Barrage (1908, 1996), Assuit Barrage (1902), Delta Barrage (1861), Zefta Barrage (1903), Idfina Barrage (1951) and Fariskur Dam.

In the first-four reaches, the valleys of the eastern and western sides pour their water inside the River Nile. In the last reach downstream Delta Barrages, there is no water gained from flash floods water. The wadis, which pour in the first four reaches either from the east or west sides, together with their areas are defined from the topography maps. Table (1) shows list for the areas of east and west wadis along the River Nile.

It can be noticed from table (1) that the second reach has a biggest area of wadis (41,595 Km^2), which is about (51%) of the total area which pour in the River Nile. This is because a lot of wadis, are found in this reach in Qena Governorate. It is also clear from the literature that the biggest wadi, which discharges into the River Nile, is Qena wadi, which is found in the second reach, where its area amounts to 16300 km^2.

Table 1: Area of wadis discharging into the River Nile, [Amer, 1996]

River Nile Reaches	Length Km	East Wadis Km^2	West Wadis Km^2
Aswan _ Isna (I)	163	7247	3203
Isna _ Nag-Hammadi (II)	191	38640	2955
Nag-Hammadi_ Assuit (III)	185	10095	2082
Assuit_Delta Barrages (IV)	385	17199	248

In general wadi areas which lie in the eastern side of the River Nile are bigger than those lying in the western side of the River Nile. The importance of these characteristics will be noticed when the water discharge of each wadis be presented. The wadi area is considered one of the main factors affecting the discharged water from different wadis to the River Nile.

Rainfalls data

Table (2) shows the rain station data along the River Nile from the south of Aswan to the south of Giza, which were collected for 1994 and 1995 by the Meteorological Authority. These data showed that the maximum amounts of rain are observed through October, November, March, February and September and the minimum amounts of rain are observed through the other months.

It is well known that when the rain falls on wadi basin, this amount of rain is divided into water collected in pits and depressions, another part of this water evaporates, and another part is absorbed by the soil. The absorbed water depends on the soil kind, plant cover, and the land use and rain quantity. Finally, some of this water remains and gathers in the wadi basin and forms the flash flood phenomenon. Accordingly, this all water depth which has a value of less than 5mm can be neglected because it does not cause flash flood, but it is lost either through absorption or evaporation. According to that, there were no flash floods water in some of Upper Egypt governorates during the years 1994 and 1995, where the maximum recorded rain was 5mm.

Table 2: Maximum daily rainfall (mm) recorded by rain stations in Upper Egypt (1994-1995)

Station	Month				
	September	October	November	February	March
	mm	mm	mm	mm	mm
Aswan	0.30	5.00	-	0.40	-
Luxor	0.90	16.00	1.00	0.90	-
Qena	0.80	6.50	1.20	-	0.70
Sohag	-	2.60	14.00	-	1.50
Assuit	-	0.10	60.00	-	9.60
El-Minia	-	-	1.00	-	1.50
Beni-Suef	-	0.80	1.60	1.30	5.50
Helwan	-	0.10	13.30	2.60	1.90
El-Geza	-	0.30	14.20	2.40	-

Source: Meteorological Authority

Average surface flow coefficients for the River Nile wadis

The geological description of the River Nile valley and the area around it depends on the data, which are published in the spatial Atlas of the Arab Republic of Egypt, Sensation Center, Scientific Research and Technology and in the Geology of Egypt [Said, 1962]. A Summary of this description from South Aswan to Cairo in the North will be presented. Figure (4), illustrates the general location for the River Nile valley D/S the Aswan High Dam.

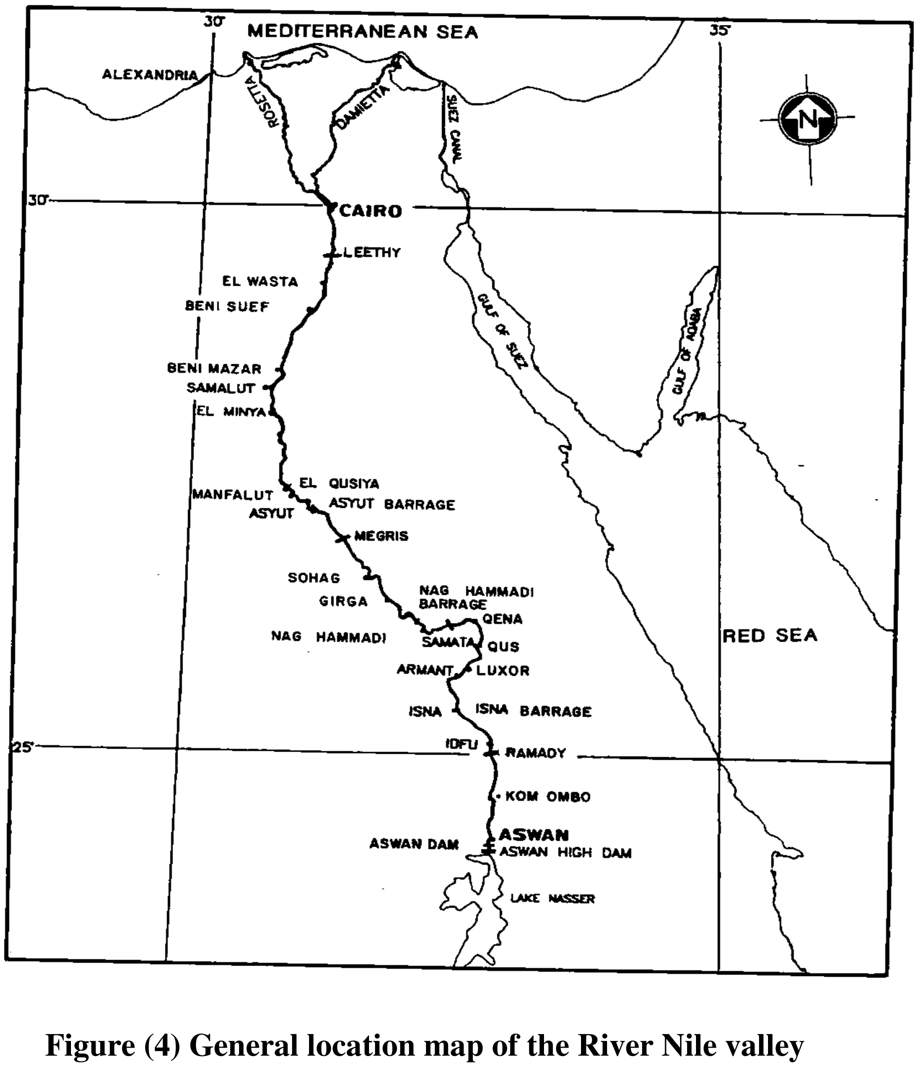

Figure (4) General location map of the River Nile valley

From the geological description of the River Nile valley and the area around it, the surface flow coefficient could be estimated. This coefficient has a big value in case of bedrock soil, and a low value in case of a very permeable soil. The surface runoff flow coefficient indicates the ratio between the surface runoff and the amount rainfall. It is very difficult to determine the value of this coefficient accurately, since this value depends on many factors such as rainfall intensity, rainfall duration, and the period between storms. The increase of rainfall intensity, quantity of rainfall, the rain distribution on the wadi basin and the short period between storms lead to increasing the surface flow coefficient. Also this coefficient depends on the type of wadi soil, and plant cover. The runoff coefficient increases when the soil is impermeable and the plant cover is small. Also, the coefficient increases if the density of the wadi drain-net increases (the density of the draining net, defined as the ratio between the total length of drain net and the whole wadi area). With reference to the surface flow coefficient of all wadis that were studied in Egypt in many different areas, the values of surface runoff coefficients were determined, Table (3). It should be known that these values are the average values of all wadis in each reach and not the real ones for each wadi separately.

Table 3: Average surface flow coefficients for the River Nile wadis [Amer, 1996]

The River Nile Reaches	The Surface Runoff Coefficient for Eastern Wadis	The Surface Runoff Coefficient for Western Wadis
First Reach	0.20	0.12
Second Reach	0.26	0.13
Third Reach	0.12	0.05
Fourth Reach	0.11	0.03

Calculate the annual quantity of flash floods water

The equation, which is used to calculate the amount of flash floods water, is the rational equation, which was selected to calculate the amount of flash floods water in this study because it is suitable and simple to be applied. This equation can be written as follows:

$$Q = 1000 * C * I * A$$

Amount of water = surface flow coefficient * depth of rain * surface area
where:

Q = water volume which the valley pours in the River Nile (m^3)
C = a coefficient which indicates the ratio between the flowing surface water and the amount of the fallen rainwater.
A = wadi basin area (km^2)
I = average of the rainfall intensity on the valley basin (mm) in one rainstorm.

Using tables (1) to (3), the quantity of flash floods water was computed for season (1994-1995) where, the quantity of flash flood water for each month and each reach computed separately. Also, the quantity of water from wadis in both sides east and west of the River Nile and the total water discharged into the River Nile D/S of Aswan High Dam in all reaches have been computed. It can be concluded that the values, which are not included in table (2) did not have any quantity of water. The amount of rainfall which, falls down on the River Nile valley during the months, August, December, January and from June through July was zero.

RESULTS AND DISCUSSIONS

The annual water discharges of rainfall into the River Nile during September, October, November 1994 were 9349732 m3, 129934641 m3, and 74945123 m3 respectively. And the annual water discharges of rainfall into the River Nile during February and March 1995 was about 6837693 m3 and 10588150 m3 respectively.

The maximum amount of the floodwater, which drains into the River Nile, was during October. This amount is estimated at 130 million m^3, and about 56% of the whole amount of the flood water drains into the River Nile D/S of Aswan High Dam, during the period of year (1994-1995). During November, an amount of 75 million m^3, which equal to 32% of the total rainwater, is drained into the River Nile. So, these months contribute about 88% of the total amount of flash flood water to the River Nile during that period, while the least contributing month is February which gives 6.85 million m^3, only about 3% of the total flood water.

The eastern River Nile wadis contributed more than the western River Nile wadis. This is because the areas of wadis in the east side are bigger than the areas of wadis in the west side. In addition, some wadis in the west side of the River Nile are close to the western desert, which lower the coefficient of surface flow runoff there. Also, the second reach Isna - Nag-Hammadi contributed the biggest amount of rainfall water, and the third reach Nag-Hammadi _ Assuit came in the second order, then the fourth reach Assuit _ El-Delta, and finally, the first reach from Aswan to Isna. The percentage of these reaches during the water year (August – July) (1994-1995) are 60.5%, 25.5%, 9.75%, and 3.95% respectively. So, we can conclude that the total quantity of rainfall water which fall in the first four reaches of the River Nile D/S of Aswan High Dam during the water year (August - July) (1994-1995) is about 232 million m^3.

CONCLUSIONS AND PROPOSED MANAGEMENT

This paper illustrates the most of related information about wadis, which drain into the River Nile down stream of Aswan High Dam, for the four reaches up to the Delta Barrages. These wadis were divided into wadis in both the east and west sides of the River Nile. Their total area, the average of surface flow coefficient in each reach, and the meteorological information of the weather stations in the studied areas has been presented. The average of the surface flow runoff coefficient of the wadis located in both sides of the River Nile depends on many factors, such as, surface geology, reports and previous studies. According to these data, the quantity of flash flood water, which drains into the River Nile D/S of Aswan High Dam, was calculated. Also the meteorological information has been analyzed, especially that related to the maximum amount of rain in one storm. The following main conclusions are drawn:

[I] The total quantity of flash flood water which discharges into the River Nile D/S of Aswan High Dam during a water year period (August – July, 1994-1995) was about 232 million m3.

[II] The wadis located east of the River Nile contributed flash flood water (221.50 million m^3) more than those located west of the River Nile (10.50 million m^3).

[III] The second reach (Isna _ Nag-Hammadi) is considered the most contributing reach of flash flood water to the River Nile (142 m m^3), followed by the third (56 m m^3) and fourth (23 m m^3) reaches, while the first reach is the least contributor (11 m m^3).

[IV] October (129.90 m m^3), November (74.95 m m^3), March (10.59 m m^3), September (9.35 m m^3) and February (6.84 m m^3), are the months of maximum flash floods water respectively.

PROPOSED MANAGEMENT

1. Storing flash flood water upstream the barrages to use it instead of flowing to the sea is recommended. This can be done by reducing the discharge during rainfall months D/S Aswan High Dam and by reducing water level U/S the barrages, especially Nag-Hammadi barrage, which is considered as the most contributing reach of flash flood water to the River Nile.

2. To save water, it is recommended to remove the obstacles from the wadis and drain the flash floods water through drainage canals to the River Nile.

3. Establishment of meteorological stations for measuring rainfall intensity in the valley basin and gauge-discharge stations to measure the water level and discharge in the main drains is recommended.

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