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Flash Floods Mitigation and Harvesting

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Abstract

Flash floods are dangerous and destructive weather disasters, mostly in arid and semiarid zones. They usually happened quickly in mountain areas exposed to heavy thunderstorms, but dam or levee break can also lead to flash floods. Flash floods frequently cause landslip which have damaging outcomes on constructions and highways, property, and may leads to deaths.

Water shortage in Egypt has certainly become a serious problem. Water uses in Egypt have exceeded accessible water resources because of fast population growth. Ethiopian Renaissance Dam also may lessen Egypt's quota of Nile water. So, Egypt should use novel sources of water, one of which is flash floods water. Flash floods are dangerous, but they present major source to refill aquifers and can become useful by retaining flood water using dams or any suitable water harvesting system.

Flood mitigation is classified to structural and nonstructural choices. Structural procedures as dams, levees, and floodwalls, retarding basins, spur dikes, and etc. alter the features of flood and decrease probable of flood in locations of interest. While nonstructural measures alter the influence flood and have minor influence on flood features. Integral information gotten from remote sensing with other datasets in spatial and non-spatial formats provides enormous possibility to monitor and estimate flood. Level of flood mitigation should be suitable using economic analysis of expenses for rising structure level to the desired heights and direct and indirect revenues achieved by flood mitigation level. A lot of wadi areas in Sinai Peninsula, Eastern desert, Western desert, and South Egypt are prone to flash flood. Studies for flash floods in some Wadi in Egypt are mentioned briefly in this article.

1. Introduction

There are several types of floods in terms of how they happen, the damage they cause, and how they are forecasted. The four common types of floods are flash flood, fluvial (riverine) floods, pluvial (Surface) Flood, and coastal flood. One definition of a flash flood is a rapid increase of water level in streams, storm drains and creeks that causes a threat of property and life of citizen. Other definitions are a flood which is caused by intensive or enormous rainfall in a small time, within six hours of rainfall occurrence, or floods distinguished by their fast occurrence leading to a very restricted chance for preparing and issuing of warnings, [2, 4, 8, 10, 12, 13, 16]. Flash floods are commonly occurred by heavy rainfall, but dam or levee break can also lead to flash floods. In arid regions, flash flood risk area is frequently distinguished by irregular precipitation result from severe thunderstorms, steep slope terrain and a scarcity of vegetation. Flash floods are commonly occurred in mountain regions prone to repeated heavy thunderstorms. They are often leading to other risk as landslip and mud flows, which have destructive effect on bridges, buildings and property, psychological harm to people and in extreme cases leads to death.

Drainage basin streams are items of hydrological cycle. They transmit remaining water from upstream parts to downstream parts after losses of evaporation and infiltration, [5, 7]. Collection of cumulative surface water amounts of different wadi branches toward the downstream cause accumulation of surface water, which may lead to immersion of lowlands. Precipitation is the greatest significant reason causing flash flood, but factors such as basin characteristics, land use, soil type or human activities at floodplains increase the occurrence of flood, [16]. When rain fall duration increased, infiltration capacity decreases and causes more runoff.

Flood mitigation aims to protect communities and properties. Flood mitigation measures can be divided into structural and non-structural mitigation, [4]. Types of used flood mitigation methods are based on the locality and nature of floods. Flood defenses are constructed along watercourses to store water and control flood, whereas reduction of flood peak requires interventions to decrease or slow down runoff. Non-structural flood mitigation aims to modify the method that persons interact with floodplain, flood risk, and aims to transfer citizens away from flood exposed areas.

Several flash floods happen yearly in Egypt. Studies for flash floods in Wadi El-Arish, Wadi Watir, Wadi El-Ambagi, in Sinai, and Wadi Gharib, Wadi Khurm El Ayun, Wadi Garf, Wadi Darb, Wadi Khuraym and Wadi Umm Yasar in Eastern desert, Egypt are mentioned briefly in this article.

2. Agents influencing flash floods.

Intensive precipitation can cause extra runoff, but terrain conditions occasionally are more importance. Seasonal shifting of precipitation, maximum precipitation, characteristics of wind, relative humidity and temperature are important to predict behavior of rainfall in any terrain and to obtain precise results from hydrological modeling, [5, 7, 16]. When rain fall duration increased, infiltration capacity decreases and causes more runoff.

Watershed is an area with one outlet for runoff. Surface water motion resulting from rainfall towards outlet of drainage area depends on shape and size of this area. Elongated catchment is less prone to high runoff peaks. For fan shaped watershed, figure 1, runoff from the nearest tributaries to watershed outlet arrives before runoff from the farthermost tributaries, so resulting peak runoff is less. On the contrary, in broad (circular) shaped watershed, runoff from all tributaries reach the outlet nearly at the same time, so resulting peak flow is bigger, [5, 7, 16].

Another significant characteristic of a watershed is stream density, which define as the summation of lengths of all tributaries in watershed divided by area of watershed. Stream density of a watershed with a few of tributaries is smaller than stream density of watershed with larger number of tributaries. The big stream density permits for the topographic terrain to drain more runoff and in contrary of low stream density.

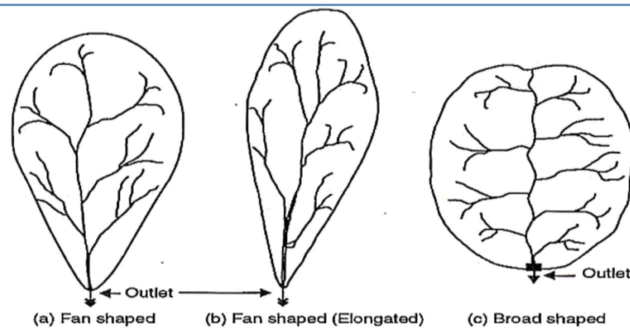

Figure 1: Shape of catchment (watershed)

Infiltration rates vary according to type of soil, so runoff is great influenced by soil type. Porous soil like sand has high infiltration rate and less runoff rate. Closely compacted soil and soil of fine particle like clay have high rate of runoff and less infiltration rate.

If a basin is covered with heavy vegetation, vegetation intercepts rainwater and stores it, and decrease runoff. Also, vegetation decreases erosion of riverbanks and increase sediment deposition. Urbanization close to river or in floodplains decreases infiltration and increasing surface runoff. Roads, parking lots, and buildings produce impervious surfaces and accordingly increase surface runoff.

3. Floods and Drainage Basin Characteristics

Flood immersion maps are based on topographic and geomorphologic characteristics of a drainage basin, that are most subjected to flash flood risk. Flood risk maps are prepared to illustrate the risky zones to instruct decision makers, and local community.

3.1 Topographic Map

Topographic maps illustrate contour lines which mark points of equal elevation and indicate the roughness and smoothness of earth surface, and they provide main bases to identify geomorphological characteristics that are necessary for hydrological modeling. These maps are two-dimensional space clarify the three-dimensional landscape of Earth.

Important flood data that may be gained from topographic map can be summarized as watershed area, level difference between level of watershed outlet and highest watershed level, length of main channel, slope of main channel, total drainage length of natural streams convey runoff to outlet of watershed, Stream or drainage density which indicates capability of topographic terrain to drain runoff. As stream density increase, runoff water increases at outlet point.

3.2 Digital Elevation Model (DEM)

This method (DEM) provides the most widely used methods for obtaining of necessary topographic and elevation data, [6, 16]. DEM provides three-dimensional digital picture for any part of land terrains. This method is more utilized for optical analysis of topography, landforms, and modeling of surface topography. Currently, satellites offer stereo pictures having high resolution to produce DEMs which are inserted in GIS or software with obtainable geographic data and map information for geomorphic and landscape analysis.

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3.3 Flood Map

Flood maps are needed in urban and suburban zones to assign sites with different hazard and contribute into local and organized planning. Most of flood disasters in urban areas are due to the missing of flood immersion maps. Preparing of immersion maps joined with flood hazard maps for important zones should be as follows:

1. Topographic maps or DEM data. 2. Geometrical descriptions of stream critical cross sections.
3. Cross section features. 4. Hydro meteorological quantities.
5. Indicating the risk levels and inundation boundaries on the topographic map.
6. Flood discharge estimation related to climatic and watershed characteristics.

3.4 Watershed (Drainage basin or Catchment)

The terrain characteristics of watershed have great influence on runoff, floods, recharge of groundwater, and causing orographic rainfall, [5, 6, 16]. The runoff computations require relationship between discharge and various geomorphological agents. Watersheds are specified by water divide line on a topographic map, as illustrated in figure 2.

Watershed can be divided into three main portions, upper part (up-stream), middle part (middle-stream), and lower part (down-stream) based on weather, terrains, geologic, and hydrologic characteristics. Upper part of Watershed has steeper grades, greater surface water speed, larger erosion, small recharge of groundwater, better quality of groundwater and more precipitation intensities than middle and down portions. Stones in arid and semiarid regions fill streams and valleys while the other portion of terrains is rock, but in wet zones, forestry and vegetation are main covers of surface. After rainfall event covers whole Watershed, surface water might be distinguished into two portions, the first is over surface as sheet flow and the second is transmitted through the channels as illustrated in figure 3.

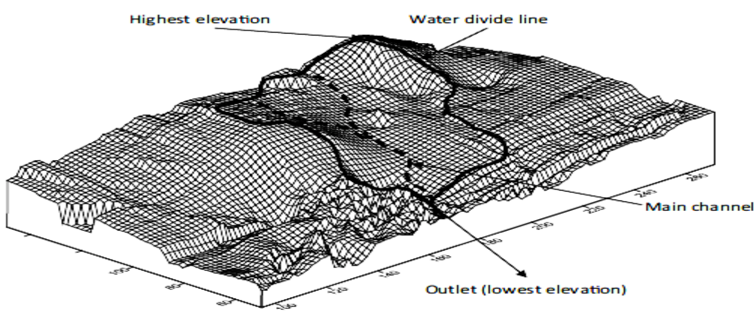

Figure 2: Geomorphology of a wadi

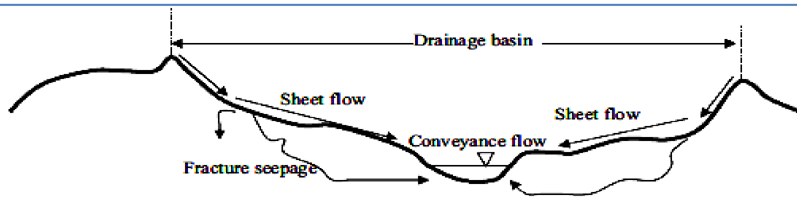

Figure 3: Sheet and channel flows

4. Flood Mitigation

Flood mitigation aims to protect communities and properties. Flood mitigation measures can be divided into structural and non-structural mitigation, [4]. Types of used flood mitigation methods are based on the locality and nature of floods. Various kinds of works and interventions are used in structural flood mitigation measures to control flood or reduce flood peak. Flood defenses are constructed along watercourses to store water and control flood, whereas reduction of flood peak requires interventions to decrease or slow down runoff. Non-structural flood mitigation aims to modify the method that persons interact with floodplain, flood risk, and aims to transfer citizens away from flood exposed areas.

Structural flood mitigation aims to prevent, eliminate, or reduce the impacts of flood hazards on properties or whole watersheds through building or modify of flood mitigating structures. Structural Mitigation Strategies are summarized in the following sections.

4.1 Dams and Reservoirs

Dam is a construction across watercourses or rivers to preserve water and then control its release. Dams or reservoirs are used commonly to store excessive rainfall. They can be built with different materials and ways. The possible functionality of dam is attained by good investigation, planning, design, and suitable building techniques. Dams can be built for purpose of water storage and diversion, flood protection, navigation, electric power generation, or for multiuse, [15]. Flood mitigation is another important function of dams; they provide protection against floods and store water for different uses. Flood protection dams are designed to reduce flood peaks by about 30% to 50% and provide time for warning and evacuation of downstream zones.

Reservoir is formed because of dam building and can slow river flow towards downstream. Flood control reservoir stores a part of flood water temporarily to attenuate flood peak. Reservoir may be preferably located immediately upstream of protected area. All the inflow into reservoir more than safe channel capacity is retained till inflow becomes less than channel capacity and the retained water is released to restore storage capacity for subsequent flood, [4, 17].

Multipurpose reservoirs are constructed nowadays, where a space is assigned completely for flood mitigation, typically above crest level of spillway by shutting down crest gates of spillway and is conveyed when needed. Capacity of reservoir must be computed by considering cost of decreasing peak with profit gained.

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4.2 Retarding Basins

Retarding basins are built only to mitigate flood. Retarding basin has big spillway and small orifices without gates, [4]. When reservoir is full, excess water discharges over spillway as illustrated in the following figure. Spillway exists for emergency when height of flood water becomes more than maximum design height of retarding basin. When basin is full, released discharge must equal safe discharge of channel downstream. Retarding basins are constructed on relatively small tributaries whereas storage reservoirs are built across big rivers to regulate flood water.

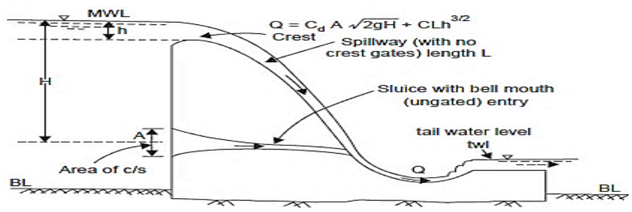

Figure 4: Retarding basin

4.3 Levees

A levee is an embankment constructed by engineers using earth-fill material and stone to avoid the flooding of water freely in certain site or residential zones, [4, 9]. Design and building of levees are identical to design and building of earthen dams. Levees are built outside the meander belt of rivers as illustrated in figure 5. Levees do not change rivers courses. They need continuous monitoring and rehabilitation after receding of flood water. Levee geometry depends on levee types, earth-fill material, loads, foundation, height, and availability of land space. Homogeneous levees, figure 6, may contain berms, revetments, cut-offs, filter layers, toe drains, and relief walls according to the materials of levee fill, types of foundation soils, and expected external loads. A berm composed of earth-fill is constructed as an extension on one side of levee system or on both sides to increase levee stability. Zoned levee formed of permeable material and relatively impermeable material as illustrated in figure 7. Zoned levee may be used when materials of different permeability are existed in quarries areas.

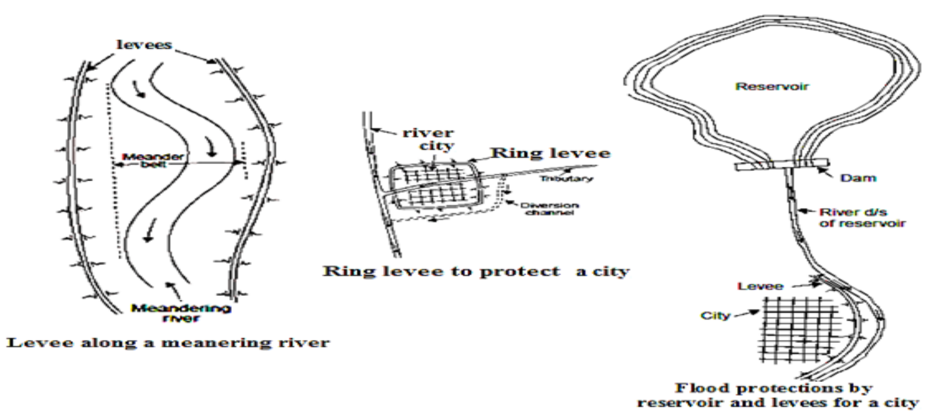

Figure 5: Different procedures for flood mitigation using levees

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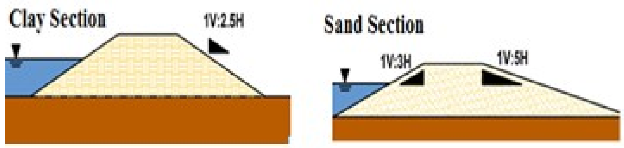

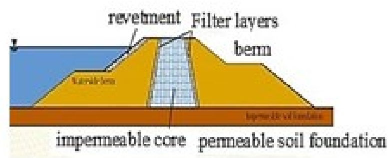

Figure 6: Homogeneous levees **Figure 7: Zoned levees.**

4.4 Flood walls

Flood walls may be constructed using concrete, steel, or masonry to control movement of flood waters and prevent the flooding at certain areas, [4]. Floodwall Stability should be examined against sliding failure, overturning failure, excessive soil pressure failure. A high floodwall may become costly to be constructed and maintained and may need more area for drainage. Thus, residential floodwalls are practical only up to a height of 3 to 4 feet above earth surface. Figure 8 indicates cross section for gravity walls, cantilever walls, buttress walls, and counterfort walls. Gravity floodwalls and cantilever floodwalls are the most usually used walls, [19].

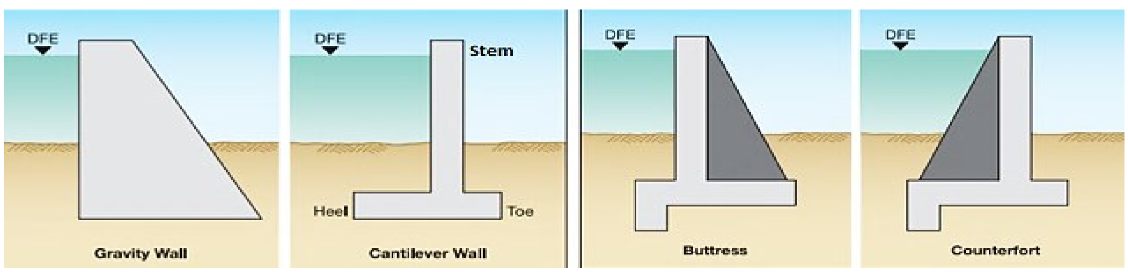

Figure 8: Types of flood walls

4.7 Spur dikes

Spur dikes are widely utilized to mitigate flood, improve navigation, and prevent banks erosion. They can be defined as extended obstructions have one end on stream bank and the other end outstanding into the current, [4]. They may be pervious, allowing water to pass through it at little velocity; or it may be impervious to prevent water flow. They can be constructed using concrete, timber, stones, or wire mesh filled with rocks and stones (gabion structure) as shown in the following figure.

Figure 9: Mitigation of flash flood using spur dike.

4.8 Channel Improvement

Channel development rises discharge capacity of the stream thus decrease flood duration and height. [4] Flood conveying capacity may be increased by increasing cross section area or velocity along river. Enlarging section is tried only in small watershed for tight and shallow channels. Deepening is favored more than broadening, where hydraulic mean radius increases more with depth, so the velocity increase. Roughness could be decreased by get rid of sand bars, fallen trees and obstructions, avoid planting on riverbanks, and get rid of sharp bends of meanders by using cutoffs as shown in the following figure. Deepening can be utilized only when cutoff is used, where channel slope increased due to decrease in flow length.

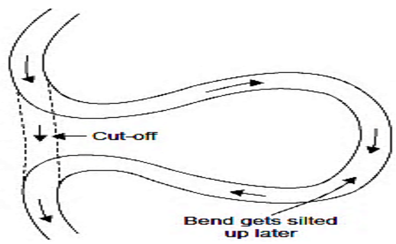

Figure 10 Cut-off in a meandering river

4.9 Flood ways (Canals)

They are engineering water structures used to gather and conveyance water flow to sea or to area selected as a floodway. Flood ways are utilized also around towns to protect the residential and industrial areas against flood hazard. Building in floodways zones is not permitted, where these areas are used for recreation or agricultural when there are no floods risks.

4.10 Culverts

Culvert is closed conduit conveys runoff under railroads, highways, or another embankment, [18]. Culvert shapes which commonly used are circular, rectangular, pipe, arch, or elliptical. Expenses of construction, restriction for elevation of upstream water surface, height of roadway, and hydraulic performance govern selection of culvert shape. Culverts have an inlet to direct the flow into culvert barrel and exit for water flow out of culvert barrel. Culverts are usually built using reinforced or non-reinforced concrete, or corrugated aluminum or steel as illustrated in figure 11. Also, culvert may be created using high-density polyethylene (HDPE) or (PVC).

Figure 11: Concrete box culvert and corrugated metal pipe.

5 Rainwater harvesting

They are the procedures used to gather and storage of rainwater and convey it wherever it is required to meet human, animals, and plant needs. Because of climate fluctuations, water resources may dry up and negatively influence organisms. By employing modernization and technology, improved methods of rainwater harvesting can be used to increase volume of stored water, [3, 4, 13, 16]. Harvesting rainwater is very important in mitigating the impacts of floods. In rainwater harvesting methods, the movement of water is controlled to avoid water accumulation on one site, which can cause flooding. Therefore, harvesting rainwater provides an efficient method to reduce negative influences of flood catastrophe. Some of water harvesting methods are very efficient and help collecting water for commercial uses whereas others are suitable for domestic use. The common methods for harvesting rainwater for commercial uses are summarized as follows:

5.1 Surface Water Collection Systems

Precipitation falls on earth generally flows down slopes towards a depression site where water can be gathered. Surface water gathering systems are used to gather rainwater. Storm sewers can be utilized to direct rainwater to rivers, ponds, or wells. Water may then be drawing and used for different requirements.

5.2 Dams

Dams are barriers used to trap water. Water gathered in dams is generally utilized for irrigation, industrial and domestic purposes. Dams can be used to harvest a lot of water. In the contrary of ponds, Measurements are taken to decrease the seepage of water into ground.

5.3 Underground Tanks

Underground tanks are created by excavating holes into ground, and then lining them to decrease water seepage. Tank top is closed, and water is gained using a pump through pipes immersed into the tank. They are effective for collecting water due to reduction of the rate of evaporation.

5.4 Water Collection Reservoirs

In this method, collected water from pavements and roads may be polluted but still can be used for irrigation.

5.5 Trenches

Harvested rainwater in this great method is used for purpose of irrigation. In this method the rainwater is directed to farm by utilizing trenches. Trenches method is an old system used for gathering water and still used till today.

5.6 Gully Plugs (Sills)

Clay, stones, and bushes that exist in site across streams and small gullies running down the hill slopes are used to construct gully plugs as illustrated in the following figure. Gully plugs are the better selection where slope breaks to insure storage of some water behind. Gully plugs also prevent soil erosion and conserve its moisture.

Figure 12: Harvesting of Rainwater using gully plug

5.7 Contour Bund

Collecting of rainwater using contour bund is effective to preserve soil moistness in catchment for lengthy time as illustrated in the following figure. This method is suitable in area of low-density rain fall by building bunds on sloping grounds along contour lines. Distance between two successive bunds determined according to soil permeability, slope of land and its area. As soil permeability decrease, the distance between two successive contour line bunds should decrease.

Figure 13: Contour Bund to harvest rainwater

5.8 Gabion Structures

Gabion structure is a type of check dam usually created across minor tributaries to preserve their flows. Gabion structure is made across the stream by putting boulders existed in site inside a mesh of steel wires and anchored to banks of stream. Gabion Structure height 0.5 m is usually utilized in watercourses with width smaller than 10 m. Some water is retained behind gabion to recharge aquifer. Silt content in stream water is deposited in pores of boulders and with vegetation growth; bund becomes impervious and assist in storing runoff for enough period after precipitation to renew ground water.

5.9 Percolation Tank

A highly permeable land is submerged in its reservoir so that surface water is infiltrates and recharges the ground water as illustrated in the following figure. Percolation tank must be created on highly fractured rocks. Aquifer in downstream direction must have enough wells and agricultural land to get profit from increase of water in aquifer. They are built commonly as earth fills dams except spillway which build using masonry. Percolation tanks are created to insure water height of 3 - 4.5m.

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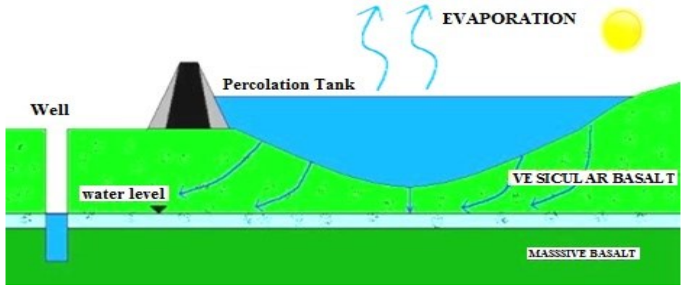

Figure 14: Rainwater Harvesting through Percolation Tank

5.10 Check Dams

They are built across little streams with mild slope. Check dam is constructed in sites have thickened pervious bed or weathered configuration to ease recharge of stored water in short period. Check dams may be constructed using masonry or concrete as illustrated in the following figure. The water retained by check dams is generally restricted to stream course. The height of check dam does not exceed two meters and extra water is flow over wall. To exploit runoff in stream, series of check dams may be built to renew ground water on local scale.

Figure 15: Check Dams

5.11 Recharge Shaft

Rainwater Collecting by Recharge Shaft is effective technique with acceptable cost to recharge unconfined ground water lying below poorly pervious layers. Shaft may be manually excavated with diameter more than two meters. The shaft must terminate in pervious layer underneath top impervious layer. Unlined shaft must be filled by boulders and cobbles in the lower part and with gravel and coarse sand in the upper part. Recharge shafts are beneficial for ponds when clay layer obstructs water infiltration to the aquifer. Building of recharge shafts of 10 to 15 m deep and 0.5 to 3 m diameter is depended on availability of surplus water. The top of recharge shaft is preferred to be at half of full shaft height as illustrated in the following figure.

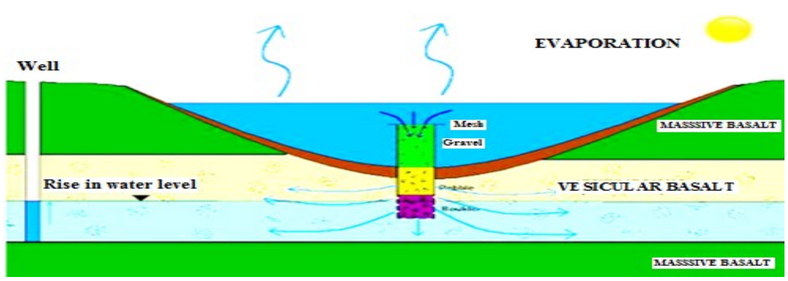

Figure 16: Rainwater Harvesting through Recharge Shaft

5.12 Dug well Recharge.

Current and deserted excavated wells can be used as recharge well after cleaning. Water is recharged directly through pipe from a chamber used for removing silt to the bottommost of well or under water surface to prevent bottom erosion and air bubbles in aquifer. Water must free of silt, so runoff water must push within desalting room or filter room, as illustrated in the following figure. Chlorination should periodically be done to avoid bacteriological pollution.

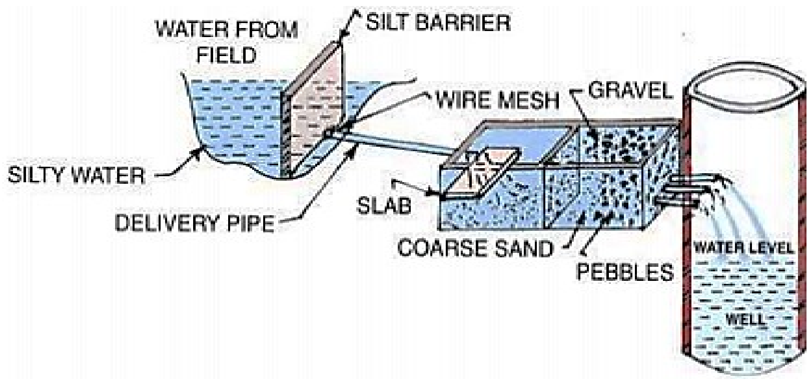

Figure 17: Well Recharge

6. Economics of flood Mitigation

In a flood mitigation scheme, degree of flood control should be acceptable using economic analysis of costs of increasing structure level to the needed heights and direct and indirect profits gained by flood control up to that level, [13]. Commonly, flood level for which ratio between annual benefits and expenses is a maximum and appropriate for design of flood control project as indicated in figure 18. Protection against flood of infrequent occurrence is uneconomical due to large investment required to get small profits and thus there is a certain volume of flood hazard participated.

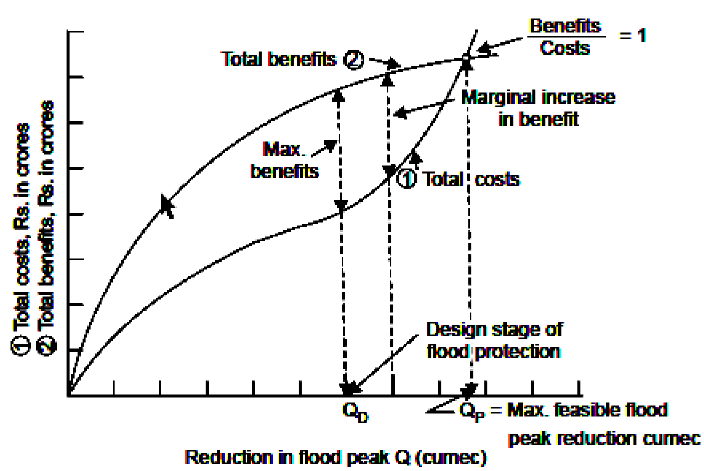

Figure 18: Expenses-profit analyses for design level of flood control

7. Some Studies of Flash Flood in Egypt

Sabry, I., Al Zayed, et all, in 2013, [3], evaluated water harvesting possibility, water scarce and exposure to flashflood, in semi-arid Wadi Watier, South Sinai. Tremendous damages of lives and structures in Wadi Watier are caused by flash Floods. Flood analysis is depended on guidelines of Integrated Water Resources Management (IWRM). Social, economic, environmental, and institutional analyses were done. Possible runoff was assessed by applying SCS method using Hydrologic Engineering Center model (HEC-1). ArcGIS software was utilized to study the proposed locations. Outcomes clarified the possibility of water harvesting within the area by impounding water in specific locations upstream. Water harvesting systems in wadi and outside wadi were suggested using six methods as cisterns, percolation ponds, detention dams and check dams. Water harvesting could offer further traditional water sources and simultaneously mitigate flashflood risks downstream by retention of water in definite sites upstream.

Abd-El Monsef, H.A., 2015, [1] demonstrated that the El Quseir–Quena highway could possibly be harmed by Wadi El-Ambagi flash flood at18 locations. These locations exist where sub basin of Wadi El-Ambagi convey water squarely to highway. Flood mitigation strategic was suggested including building sequence of stone bunds at upper portion of sub basins of Wadi El-Ambagi, and dams at downstream. They aimed to reduce scour and runoff velocity. Furthermore, building two retention dams along with storage reservoirs for flood mitigation and water harvesting were suggested downstream of Al-Hammariyyah sub basins and Wadi Karim.

El Sabri, M. A., Taha, M. M., et al, [11], in 2017, studied drainage network area in Wadi Gharib, Wadi Khurm El Ayun, Wadi Garf, Wadi Darb, Wadi Khuraym and Wadi Umm Yasar in Eastern desert. These wadis are formed of wide long straight channels with steep slope and steep sides. The study area is a hyper-arid climate with rainfall rate 50 mm per years. The agriculture in the area depends mainly on groundwater. Other resources of water as surface water after flash floods should be computed and manage to obtain a replacement for the scarcity of groundwater. In this study surface water runoff was estimated to be used for refilling shallow groundwater aquifer and developing agriculture in the area. Geomorphologically, the study area is divided into six geomorphic units. These are Red Sea mountainous shield, lowland areas, morphotectonic depressions, hydrographic basins, sabkhas (salt marshes) and coastal plain. Suitable controlling system was suggested at tributaries of hydrographic sub basins using retarding dams and rainfall collecting network to refill the alluvial aquifer and protect agriculture, industrial and tourism areas against flash flood risks in addition to conservation of soil and natural seeds.

Mohamed, S.A., and El-Raey M.E., [14], in 2019, investigated problems of flash floods in Wadi El-Arish, Sinai Peninsula. The study results showed that remote sensing information and their incorporation on Geographic Data Systems contribute greatly to flood studies and therefore, Risks may be avoided. They created compound flash floods weakness index depending on integrated physical and hydro-climatic weakness elements. The composite index was graded into low type, moderate type, and high type. The index can assist to detect strong and weak sites to strengthen decision-making procedure related to water administration as vital requirement for sustainable advance in Egypt. Final gained weakness map indicates that El-Arish having high weakness against flash flood. Furthermost subjected zones to flash flood include residential zones in El-

Arish. They recommended that information attained from their work must be used by decision makers for good planning and suitable adaptation strategies. This study recommended building of dams to control flash flood and harvest flood water for useful uses and that local authorities must use early warning system against flood and effective urban planning measures.

8. Summary and Conclusion

Flash floods are very hazardous and destructive climatic catastrophes, particularly in arid and semiarid zones. They commonly occurred in mountain regions subjected to repeated heavy thunderstorms and can arrive quickly to peak discharge in a little period. They are often leading to landslip which have destructive effect on structures and highways, property, and may causes deaths. Therefore, efforts are required to mitigate flash floods.

Water scarcity in Egypt has undoubtedly grown to become a serious problem. Ethiopian Renaissance Dam may decrease Egypt's share of Nile water. So, Egyptians must find new sources of water, one of which is flash flood water. Despite of flash floods are amongst greatest calamitous occurrences; they present major source to replenish aquifers throughout infiltration process. Also, flash flood can become significantly useful by retaining flood water using dams or any water harvesting technique.

Flood mitigation is classified to structural and nonstructural choices. Structural procedures as dams, levees, and floodwalls, retarding basins, spur dikes, etc. alter the features of flood and decrease probability of flood in sites of interest, while nonstructural measures change the influence or repercussions of flood and have slight to no influence on features of flood.

Harvesting rainwater methods are very important for flood mitigation. In these methods, water movement is controlled to prevent water accumulation on one site causing flood. The common methods for harvesting rainwater are dams, underground tanks, water collection reservoirs, gully plugs (sills), contour bund, gabion structures, percolation tank, recharge shaft, etc.

Level of flood control should be suitable using economic analysis of expenses required to increase structure level to the wanted heights and direct and indirect revenues attained by flood mitigation level.

Several flash floods occur yearly in Egypt. A lot of wadi areas in Sinai Peninsula, Eastern desert, Western desert and South Egypt are prone to flash flood. Studies of flash floods in Wadi El-Arish, Wadi Watir, Wadi El-Ambagi, in Sinai, and Wadi Gharib, Wadi Khurm El Ayun, Wadi Garf, Wadi Darb, Wadi Khuraym and Wadi Umm Yasar in Eastern desert, Egypt are mentioned briefly in this article. Researchers recommended building dams, check dams and retention basins.

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9. Recommendations

Owing to water scarcity in Egypt and building of Ethiopian Renaissance Dam every drop of water must be preserved. So, Wadi systems in Egypt must be studied extensively to define method of flood mitigation and preserve water. More funds must be provided to use water harvesting systems broadly in Egypt to conserve flash floods water.

REFRENCES

[1] Abd-El Monsef, H., "A mitigation strategy for reducing flood risk to highways in arid regions: a case study of the El-Quseir–Qena highway in Egypt". Journal of Flood Risk and Management, (CIWEM), and John Wiley & Sons Ltd, 2015.
[2] Al-Rawas, G.A., "Flash Flood Modelling in Oman Wadis", Phd. Thesis, University of Calgary, Alberta, Canada, 2009.
[3] Al Zayed, I.S., Ribbe L., and Salhi, A.A., "Water Harvesting and Flashflood Mitigation-Wadi Watier Case Study (South Sinai, Egypt)", International Journal of Water Resources and Arid Environments,pp. 102-109, 2013.
[4] Alessandro G. Colombo, A.G., Hervås, J. and Arellano, A.U., "Guidelines on Flash Flood Prevention and Mitigation", Institute for the Protection and the Security of the Citizen Technological and Economic Risk Management Natural Risk Sector 1-21020 Ispra (VA) , Italy, 2002.
[5] Bedient, P.B., Huber,W.C., Vieux, B.E., "Hydrology and Floodplain Analysis", 6th Edition, Pearson, Inc., UK, 2018.
[6] Borrell, V.E, Llovel,D.D., "Flash flood forecast hydrological model", WIT Press, Ashurst Lodge, Southampton, UK,2002.
[7] Chow, V.T., Maidment,D.R., Larry, W.M., "Applied Hydrology", McGraw-Hill, Inc, USA , 1988.
[8] Cools, J., Vanderkimpen, P., El Afandi, G., Abdelkhalek, A., Fockedey, S., El Sammany. M., Abdallah, G., El Bihery, M., Bauwens, W., and Huygens,M., "An early warning system for flash floods in hyper-arid Egypt", Natural Hazards and Earth System Sciences, Copernicus Publications on behalf of the European Geosciences Union, pp.443-457, 2012.
[9] Departement of Water Resources, "Urban Levee Design Criteria", California, USA, November 2011.
[10] Eliwa, H. A., Murata, M., Ozawa, H., Kozai, T., Adachi, N., and Nishimura, H., "Post Aswan High Dam flash floods in Egypt: Causes, consequences and mitigation strategies", Bulletin of Center for Collaboration in Community, Naruto University of Education, Tokushima, Japan, pp.795-807, 173-186, 2015.
[11] El Sabri, M. Sh., Taha, M. N, El Shamy, I. Z., and Fouad, Y. M., "Applying GIS and surface water model to avoid flash flood disasters on Shagar area, Eastern Desert, Egypt", https://www.researchgate.net /publication/ 333310935, 359–372, 2019.
[12] Hapuarachchi, H.A., and Wang Q.J., "A review of methods and systems available for flash flood forecasting", Report for the Bureau of Meteorology, Australia, 2008.
[13] Giuseppe Rossi,G., Harmancioglu, N., Yevjevich, V., "Coping with Floods", Springer-Science+Business Media, B.V., Nato ASI Series, Italy.
[14] Mohamed, S.A., and El-Raey, M. E., "Vulnerability assessment for flash floods using GIS spatial modeling and remotely sensed data in El-Arish City, North Sinai, Egypt", Springer Nature B.V., 2019.
[15] Novak, P., Moffat, A.I, Nalluri, C., and Narayanan, R., "Hydraulic Structures", Fourth Edition, Taylor & Francis, New york, USA, 2007.

[16] Şen, Z., "Flood Modeling, Prediction, and Mitigation", Springer International Publishing AG, Switzerland, 2018.
[17] United States Department of the Interior Bureau of Reclamation, "Earth Dams and Reservoirs", A Water Resources Technical Publication, 1987, USA.
[18] U.S. Department of Transportation, "Hydraulic Design of Highway Culverts", Third Edition, Federal Highway Administration, April 2012.
[19] Wang, L., Gong, C. "Abutments and Retaining Structures.", Bridge Engineering Handbook, Boca Raton: CRC Press, 2000.