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鳴門教育大学学校教育研究紀要

第29号

Bulletin of Center for Collaboration in Community
Naruto University of Education
No.29, Feb., 2015

鳴門教育大学学校教育研究紀要　29，173 － 186

Post Aswan High Dam flash floods in Egypt: Causes, consequences and mitigation strategies

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Abstract：Flash floods become one of the most recent common forms of natural disaster in recent-day Egypt. These floods are made up of sudden, unexpected and heavy rains or a strong surge of water, which usually hit the steep sloped mountainous catchments and inundate many regions, particularly along the Red Sea Coast and Sinai, Egypt. These floods often carry rocks, soil, and other debris, a matter which make them pose a significant risk to people and infrastructure, leading to death and destruction. Egypt recognized the challenges posed by disasters and strengthened and developed its national institutions and policy to meet the tasks of the Hyogo Framework for Action (HFA) on the Crisis Management and Disaster Risk Reduction (DRR). Egypt established a Crisis Management Affairs (CEMA) entity in 2000 and some good signs of progress have been made along several areas and sectors. The multi-sectoral approach is to be adopted and operationalized to ensure the full integration and harmony. Furthermore, in 2009, Egypt in collaboration with Belgium has installed the first early warning system called Flash Flood Manager (FlaFloM) in Wadi Watir, Southern Sinai.

Keywords：Egypt, flash floods, Mitigation, Disaster, Sinai.

Ⅰ. Introduction

Floods are among the costliest and deadliest natural hazards. Floods are caused by prolonged or heavy rainfall. Cyclones bring huge amounts of moisture inland from the ocean and are a major cause of floods, particularly in coastal areas. Thunderstorms sometimes occur and can produce very intense rainfall that can cause floods in smaller streams. Several factors determine the size of flooding including; rainfall intensity (the rate of rainfall) and duration (how long does the rain last); how dry or wet the land is, topography, ground cover and many more.

The most common form of flooding of Egypt in the past was Nile related floods due to the annual heavy rains much further south at the sources of the Nile - Blue Nile and White Nile - where the extra water floods and moves northward through the rivers. In the last four decades after the complement and operation of the Aswan High Dam in 1970s, the climatic changes-related heavy rains producing flash floods became the common and widespread type of flooding in Egypt. The areas south of the Aswan high dam still floods today. Also Egypt experiences landslides accompanied flash floods, earthquakes, dust storms, sandstorms, periodic droughts, and hot driving windstorms called Khamaseen, which occur in the spring as disasters. Overflow of drainage systems in urban areas can also be a major problem, particularly in heavily populated areas. Low lying coastal areas can be inundated by storm surges usually caused by tropical cyclones.

In 2009, 2010, 2013, and much recently on March and May 2014 different territories in Egypt have been subjected to heavy rain storms which led to flash floods and landslides and many other impacts including the loss of human life, the damage to property, destruction of infrastructure,...etc.

This report aims to discuss types, causes, and impacts of floods and their conditions and measurements, summarize the recent flash floods, and to provide the strategy plans for managing and reducing flood disasters in Egypt.

Ⅱ. Egypt Profile and context

Located in the north-eastern corner of Africa (Fig. 1), the Arab Republic of Egypt borders to the Mediterranean Sea in the north, to Palestine, Israel and the Red Sea in the east and south, and in the south, it is bounded by Sudan and by Libya in the west (CIA 2011c). Its size of 1.001.450 km^2 is divided

Fig. 1. General map of Egypt showing its location and ambient countries.

into 995.450 km² of land and 6000 km² of water inhabits around 86,895,099 citizens (CIA, 2014) (3rd largest rate of African countries), out of who 43.4% live in urban surrounding cities, in particularly the biggest ones, such as the Capital Cairo, and Alexandria (CIA 2011a, c and d; CIA, 2014).

1. Geography of Egypt

Egypt lies between latitudes 22° and 32° N, and longitudes 25° and 35° E covering a surface area of 1,001,450 km² (Fig. 2); it is the world's 30th largest country. Egypt's important role in geopolitics stems from its strategic position: a transcontinental nation, it possesses a land bridge

Fig. 2. Geographical map of Egypt

(the Isthmus of Suez) between Africa and Asia, traversed by a navigable waterway (the Suez Canal) that connects the Mediterranean Sea with the Indian Ocean by way of the Red Sea.

Apart from the Nile Valley, the majority of Egypt's landscape is desert, with a few oases scattered throughout. Egypt includes parts of the Sahara Desert and of the Libyan Desert. These deserts protected the Kingdom of the Pharaohs from western threats and were referred to as the "red land" in ancient Egypt.

2. Geology of Egypt

Egypt can be geographically distinguished into four main geographic regions (Fig. 3); Nile Valley and Delta, Sinai Peninsula, Eastern Desert and Western Desert.

1) Nile Valley and Delta

The Nile Valley and Delta cover an area of 35,000 km^2, mostly in the Delta and have fertile soils formed of deposits carried down by the River Nile. The Nile Delta is associated with the northern lakes (Maryut, Idku, Burullus, and Manzala). In the Nile Valley, the cultivated area mostly consists of a narrow strip of land surrounded by desert on both sides.

2) Sinai Peninsula

Sinai Peninsula is located in the northeastern portion of Egypt, and occupies a very small portion of the extremely SW part of Asian continent. The total area of Sinai is 61,000 km^2, its southern part is formed of a complex of igneous and metamorphic rocks.

3) Eastern Desert

The Eastern Desert covers an area of about 223,000 km^2. It is bordered by the Nile Valley on the West and by the Suez Canal, the Gulf of Suez and the Red Sea on the East. The backbone of this desert is a series of mountain chains (Red Sea Mountains), running parallel to the Red Sea and separated from it by a narrow coastal plain.

4) Western Desert

The Western Desert extends over a vast area occupying about 681,000 km^2. It is composed of large, rocky surface with the highest portion in the southwestern corner where Gebel (mountain) Oweinat is found. North of Oweinat, the Gilf El-Kebir plateau (100 m asl) formed of Nubian Sandstone occurred. This plateau is characterized by scarps which slope sharply towards large depressions in the East and North; Kharga and Dakhla depressions. To the North of this plateau, another plateau with arms extends in several directions. This plateau is composed of limestone and is lower in elevation than the Gilf El-Kebir plateau, and constitutes the main landform feature west of the Nile Valley. Hollowed out in the plateau surface are two great depressions, those of Farafra and Bahariya. The area of the former is more than 3000 km^2, and the latter has an area of about 1800 km^2. The Qattara-Siwa depression is considered to be part of a huge depression in the northern sector of the

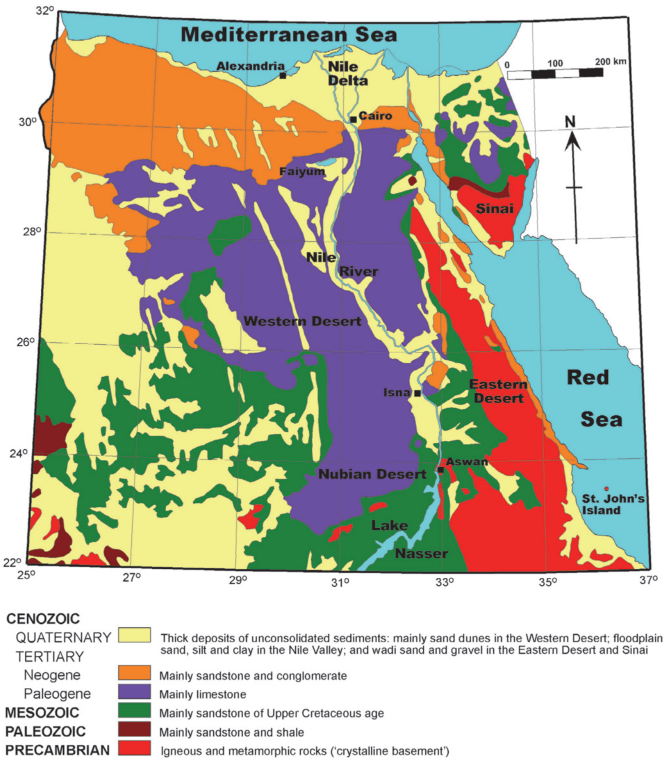

Fig. 3. Generalized geological map pf Egypt.

Western Desert.

3. Climate of Egypt

Most of Egypt's rain falls in the winter months (Soliman, 2007). South of Cairo, rainfall averages only around 2 to 5 mm per year and at intervals of many years. On a very thin strip of the northern coast the rainfall can be as high as 410 mm per year mostly between October and March. Snow falls on Sinai's mountains and some of the north coastal cities such as Damietta, Baltim, Sidi Barrany, etc. and rarely in Alexandria. A very small amount of snow fell on Cairo on 13 December 2013, the first time Cairo received snowfall in many decades (Samenow, 2013). Frost is also known in mid-Sinai and mid-Egypt.

Temperatures average between 26.7 and 32.2 ℃ in summer, and up to 43 ℃ on the Red Sea coast. Winter temperatures average between 13 and 21 ℃. A steady wind from the northwest helps lower temperatures near the Mediterranean coast. The Khamaseen is a wind that blows from the south in spring, bringing sand and dust, and sometimes raises the temperature in the desert to more than 38 ℃.

The climate of hot, desert summers and only short moderate winters places additional strains on Egypt's inhabitants and the environment through evoking natural hazards in form of wind- and sandstorms, flash floods..., etc. (CIA 2011c).

Fig. 4. Nile River Basin: its tributaries and branches

The potential rise in sea levels due to global warming could threaten Egypt's densely populated coastal strip and have grave consequences for the country's economy, agriculture and industry. Combined with growing demographic pressures, a significant rise in sea levels could turn millions of Egyptians into environmental refugees by the end of the 21st century, according to some climate experts.

4. The Nile and Lake Nasser

In Egypt, this indispensable almost exclusive source of water is the Nile, which reaches a length of 6,825 km (4187 mile), the longest river in the world, and is constituted by four main tributaries, namely; the Atbara, the Blue Nile, the White Nile and the Sobat (Roest, 2010) (Fig. 4). Those four river branches form the southern part of the Nile, originating in the Ethiopian highlands, Sudan and the Great Lakes region, from where they cultivate and split into several drawn-out river channels (Roest, 2010; APP, 2008). The Blue and White rivers meet at the Sudanese capital Khartoum and flow north through Sudan and Egypt to drain into the Mediterranean Sea. The northern top of the Nile from up to Cairo is shaped as a triangular that is beset with streams and arable land surrounding the two main Nile branches, the Rosetta (west) and the Damietta (east). The drainage area estimate varies between 3.1 million km^2 (FAO, 2007) to 3.3 million km^2 (CPWF, 2007). Ten countries fall within the Nile basin and these include Burundi, Democratic Republic of Congo, Egypt, Eritrea, Ethiopia, Kenya, Rwanda, Sudan, Tanzania, and Uganda (Molden *et al*., 2010).

The Nile basin is always impacted by the La-Nina and El-Nona phenomenon that affected the region through cyclic occurrence of floods followed by droughts, which have become endemic in the Nile Basin leading to loss of lives and social disorder, destruction of infrastructure, reversal gains on economic and social development, health and degradation of the environment (NBCBN, 2005).

Egypt has available another meaningful water source, called Lake Nasser, extending from Egypt's south to Sudan's north (Fig. 5) (Shaltout, 1998). This lake therefore stands in direct relation to the Nile, because near the city Aswan the river lead (through the Aswan Dam) into the lake. It represents the water bank of Egypt and moreover, is the second largest manmade lake in the world that stretches 500 km south of the Aswan High Dam and reaches a 6 km average width with a capacity of 164 billion m^3 and a depth of up to 182 m (Strzepek, 2006; Shaltout, 1998). The lake area has no measurable rainfall, and evaporation losses are high, 2.7 m *yr-1* (Omar and El-Bakry, 1981) and the mean annual inflow of the Nile at Aswan is 84.1 gm^3 yr^{-1} (mean of 1900-1950) (Molden *et al*., 2010).

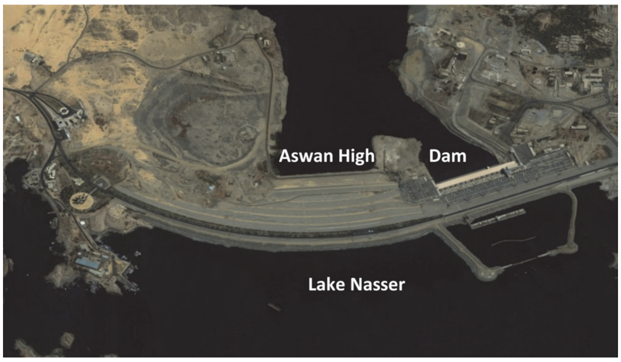

Fig. 5. Aswan High Dam and Lake Nasser

Ⅲ. Flood Characteristics

Floods usually occur when there is enough rain in a short enough time to swell a river over its banks or when a storm forces large amounts of water from the ocean inland. Flash floods can occur in dry ecosystems when water gathers in previously dry valleys and washes through them.

1. Definition of Flood

Flood is defined as an overflowing of a body of water over land that usually is dry or not usually submerged (Olajuyigbe *et al*., 2012). In the context of Risk Management, floods are defined as a phenomenon of an unusually high stage or flow of water over land or coastal area, which results in severe detrimental consequences in terms of social, physical and economic impacts (Leuchanka *et al*., 2010).

2. Types of Floods

Three types of flood hazards (http://www.preventionweb.net/files/28208_highriskzonesreportfinalpublication.pdf) can be identified; river floods, flash floods, and coastal floods/Storm surges.

1) River (Riverine) floods

River (Riverine) floods are known in Asia as “*monsoon*” floods. These floods are usually caused by heavy rainfall over large catchment areas, or by melting of the winter's accumulation of snow or sometimes by both of rainfall and melt. There are two types of river flooding (ADPC 2005):

- *Slow Onset Flood (Inland Rivers)* is often slow and may last for one or more weeks, or even months on some occasions.

- *Rapid Onset Flood (Mountain/Coastal Rivers)* can occur more quickly in the mountain headwater areas of large rivers, as well as in the rivers draining to the coast, mainly after periods of intense rainfall.

2) Flash floods

Flash floods are generally defined as a rapid onset flood of short duration with a relatively high peak discharge (World Meteorological Organization; NOAA, 2010). Flash floods can be triggered by a variety of events including intense rainfall, failure of a natural (e.g. glacial lake debris) or manmade (e.g. dam, levee) structure that is impounding water, or the sudden impoundment of water upstream of a river ice jam. Hydrologic influences of the ground surface can have a major impact on the timing, location, and severity of flash flooding. The hydrologic influences of the ground surface on the flash floods include the soil (moisture, permeability and profile) and basin features (size, shape, slope, roughness, stream density, land cover and use) characteristics.

3) Coastal Floods/Storm surges

Coastal Floods/storm surges occur in the coastal regions and are associated with cyclones and high tides. The Storm surges are an abnormal rise of water generated by a storm, over and above the predicted astronomical tides or wave conditions. In other meaning, surge storm is the increase in water surface elevation above normal tide levels due primarily to low barometric pressure and the piling up of waters in coastal areas as a result of wind action over a long stretch of open water. Storm surge causes sea levels to rise for a relatively short period of time (typically four to eight hours, though some areas may take much longer to recede to their pre-storm levels) often resulting in extensive coastal flooding that can weaken or destroy coastal structures. Coastal floods are extremely dangerous, and the combination of storm surge, tides, river inflow, and waves can cause severe damage.

3. Causes of the floods

The causes of floods and flood hazards are a complex mixture of meteorological, hydrological and anthropogenic (human) factors (Michaud and Pilon, 2006).

4. Flood Intensifying Conditions

The flood intensifying conditions can be grouped into the following three categories; Characteristics of Drainage Basins (area, shape, slope, Bifurcation Ratio, and density), types of Drainage Basins (trellis, dendritic, parallel, and rectangular; Fig. 6; Twidale, 2004), and Characteristics of Channel.

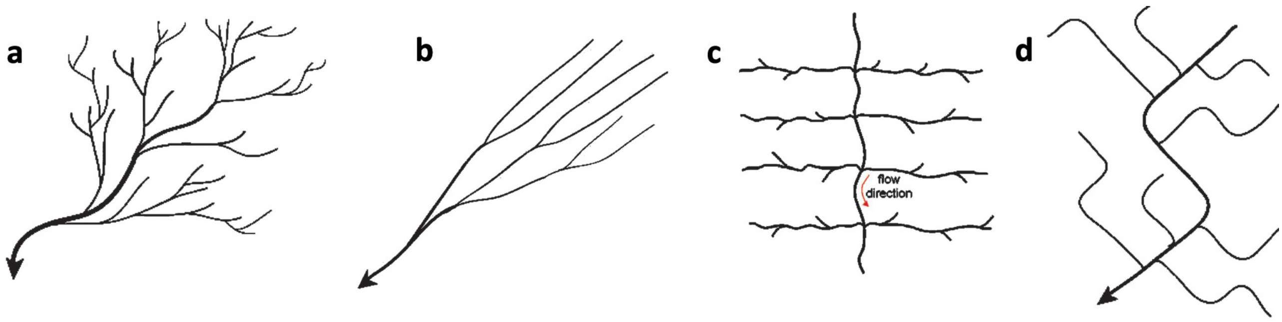

Fig. 6. Drainage network patterns: a. Dendritic, b. Parallel, c. Trellis, and d.Rectangular. (source: Twidale, 2004)

5. Magnitude Levels of Floods

Four levels of flood magnitude have been identified; *normal* flood (e.g. 1 year flood), *medium* flood (e.g. 5 year flood), *severe* flood (e.g. 20 year flood), and *catastrophic* flood (e.g. 100 year flood).

6. Effects of Floods

Typical effects resulted from floods are classified into three types; *Primary* Effects (physical damages and casualties,..), *secondary* effects (landslides, soil erosion and land degradation, direct/indirect health effects, sedimentation, effects on traffic , water pollution, waterlogging/salinity, exposure of community, diseases,..), and *Tertiary*/long-term effects.

Ⅳ. Pre Aswan High Dam Nile Fluctuations and Floods

In the past era, before the construction of the Aswan High Dam, Egypt has frequent Nile floods which were considered as disasters. The flooding of the Nile has been an important natural event (cycle) in Egypt since ancient times. The Egyptian year was divided into the three seasons of Akhet (Inundation), Peret (Growth) and Shemu (Harvest). Akhet covered the Egyptian flood cycle. This cycle was so consistent that the Egyptians timed its onset using the heliacal rising of Sirius, the key event used to set their calendar. The first indications of the rise of the river may be seen at the first of the cataracts of the Nile (at Aswan) as early as the beginning of June, and a steady increase goes on until the middle of July, when the increase of water becomes very great. The Nile continues to rise until the beginning of September, when the level that remains stationary for a period of about three weeks, sometimes a little less. In October, it rises again and reaches its highest level. From this period, it begins to subside and though it rises yet once more and reaches occasionally its former highest point, it sinks steadily until the month of June when it is again at its lowest level. Flooding reached Aswan about a week earlier than Cairo, and Luxor 5 - 6 days earlier than Cairo. Typical heights of flood were 13.7 m at Aswan, 11.6 m at Luxor and Thebes and 7.6 m at Cairo (Budge, 1895; Gill, 2003). By the completion of the High Dam at Aswan in 1970, the annual flooding cycle came to an end in Egypt, but flooding still occurs above the dam in modern-day Sudan.

1. Timing of Nile flooding

One of the most salient features of the Nile is its summer flood. Around mid-July, water, mostly from Ethiopia, begins to reach Egypt. By the middle of August, the inundation reaches its peak. For approximately three weeks the Nile level remains stationary. In October, it may rise again, but by the end of October the inundation wanes and water begins to subside.

2. Nile discharge at Aswan

The plots of the natural discharge of the river at Aswan from the year 1870, the year systematic measurements started, to 1988 (Fig. 7) shows that the discharges of the last years of the 19th century were considerably higher than those of the 20th century (Said, 1993). The average discharge of the period 1870-1899 was 110 billion cubic meters per year. The highest discharge during this period was that of the year 1878 when it reached a record high of 141.6 billion cubic meters. The lowest was that of 1877 when it reached 77.4 billion cubic meters. The average discharge of the 90 years period of the 20th century, on the other hand, declined to 84 billion cubic meters per year. There were only 13 years in this 90 years period which had a discharge above the 100 billion cubic meter mark compared to 21 years out of the last 30 years of the 19th century. The average discharge during the low months of February to June decreased from 13.2 billion cubic meters for the 1870-1899 Period to 10.7 billion cubic meters for the 1900-1988 Period. The average discharge of the flood months (August to October) also decreased from 66.1 billion cubic meters for the 1870-1899 period to 50.1 billion cubic meters for the 1900-1988 period.

Years with higher flows than the long-range average of the century are concentrated in the periods 1946-1967 and 1974-1978. Years of exceptionally low flows are concentrated in the periods 1968-1973 and 1979-1992. The discharges of the years 1945-1967 increased to an average of 90 billion cubic meters per year. From 1967 on there was a decline in the Nile discharges which dropped to an average of 75 billion cubic meters per year for the years 1968 to 1988.

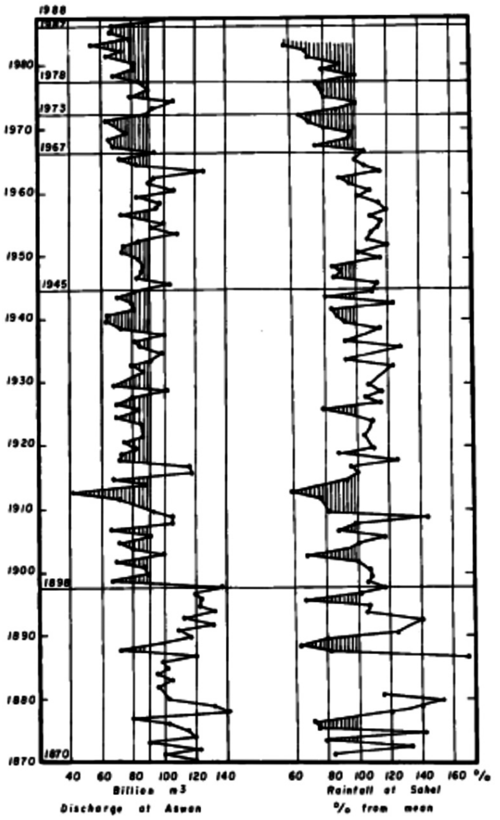

Fig. 7. Average yearly discharge at Aswan and the rainfall of the Sahel (plotted as percentages from the mean)

It has been suggested that the years of low Nile discharge may be connected also to the El Nino Southern Oscillation (ENSO) climatic event which affects the coasts of Peru, Ecuador and northern Chile, but which is now recognized to have world-wide effects on the climate (Glantz, 1987).

Corrected and calibrated data of the primary historical annual records of Nile minimal and maximal flood levels reveal that Nile floods discharge during the Medieval Climate Anomaly (MCA) interval from AD 930 to 1350 were not constant (Hassan, 2011). Instead, this period is characterized by multi-decadal long episodes of major low Nile flood levels from AD 930 to 1070, and from AD 1180 to 1350, as well as periods of major high Nile flood levels from AD 1070 to 1180 and from AD 1350 to 1470 (Fig. 8). Hassan (2007) reveals that the onset of the MCA was marked by a dramatic increase of extreme low floods. The percentage climbs from 0-3% to 20% during the period from AD 930 to 1070 and to 14% from AD 1070 to 1180, in spite of an overall increase of the volume of flood discharge during that latter period. Subsequently, from AD 1180 to 1350, the number of extremely high floods increased at the expense of extremely low floods. This period, characterized in general by a decrease in Nile flood discharge, coincides with the epic droughts that occurred from AD 1209 to 1350 in Californian mountain ranges (Stine, 1994), suggesting a global climatic tele-connection. Apparently slight climatic changes in mean global temperature from the 9th to the 15th century were associated with pronounced hydrological responses. This is confirmed by the simulation of the hydrology of the Nile in response to different climate change scenarios (Conway and Hulme, 1996): precipitation anomalies were found to produce larger changes in runoff of about threefold magnitude. The high sensitivity of Nile flood discharge to changes in precipitation is further confirmed by recent historical changes with a 20th century (AD 1900-1984) average of 85 billion cubic meters compared to 110 billion cubic meters from AD 1870 to 1899 (Said, 1993).

V. Post Aswan High Dam Flash Floods and their Disasters

Egypt is one among several arid and semi-arid countries that faces the flash flood and water scarcity hazards. In such environments, a major concern is flash flooding, an event which may develop within a very short period of time (Foody *et al.*, 2004). Flash floods in arid mountainous regions are destructive natural disasters. A flash flood can be generated instantly during or shortly after a rainfall event, especially when high intensity rain falls on steep hill slopes with exposed rocks and lack of vegetation (Lin, 1999; Wheather, 2002).

After the completion of the establishment of the Aswan High Dam and Lake Nasser, the crisis's situation in Egypt had changed where the natural disasters related to water, especially the Nile floods successfully stopped and after that time, Egypt experiences only the catastrophic flash flooding, which has recently become very common in the Red Sea coastal areas and Sinai, particularly where storms hit large settlements. These coastal areas are occasionally subjected to heavy showers during winter times, followed by sporadic torrential floods that may cause disastrous damage to roads and the sporadic settlements (Azab, 2009). The development of an effective flash flood potential, mitigation, and efficient utilization of the renewable sources of floodwater in such areas become, as a consequence, more and more acute and

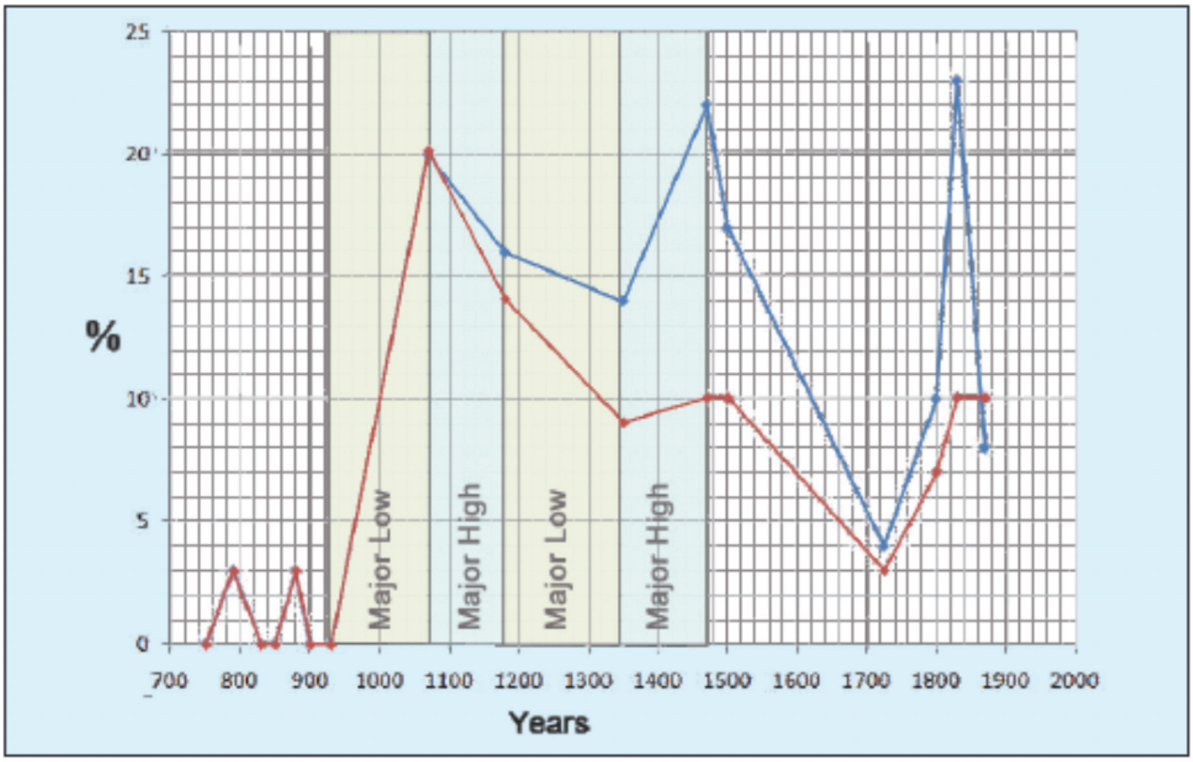

Fig. 8. Percentage of anomalously low floods (red) and of both extremely low and high floods (blue) superimposed on the major episodes of low and high Nile flood discharge (Hassan 2011).

pressing (Masoud, 2004).

1. Causes of flash floods in Egypt

Runoff events in the Sinai are usually caused by high-intensity, short-duration storms and are primarily dominated by overland flow (WRRI, 2004). Rainstorms in Sinai are affected mainly by the Active Red Sea Trough (ARST) which is a low pressure trough that originates from the south, and generates the largest floods in this region (Dayan and Morin, 2006; Greenbaum *et al.*, 1998; Kahana *et al.*, 2002; Schick, 1988). Kahana *et al.* (2002) concluded that the ARST occurs between September to November and March to May. It is a surface trough that extends from East Africa to the Red Sea towards the eastern Mediterranean accompanied by a pronounced trough at higher altitudes over eastern Egypt. This flood-causing system is characterized by the development of small convective rain cells, which cover areas between ten and several hundred square kilometers. These rainstorms typically have a short duration, but yield high intensities of up to 60 mm/h, with peak values of 120 mm/h (Greenbaum *et al.*, 2010; Katsnelson, 1979; Sharon, 1972; Sharon and Kutiel, 1986). Flood Discharges are either into the Gulf of Suez or into the Red Sea on the one hand and into the River Nile on the other hand. The Western Desert is discharging both into the Mediterranean Sea and/or into the New Valley.

2. Review of heavy rains/strong flash floods during the 1972-2014 period

The data of flash floods in the 1972 - up to now period is based on the available published articles, reports, meteorological authority magazine, dissertations and newspaper archive as well as eye witnesses, as follows:

1) As'Ssaf, Southern: Giza/1972

Heavy rain and flash flood hit the As'Ssaf area, Southern Giza and resulted in that 180 houses demolished, several reclaimed farms and heads of cattle were drowned, 1500 people affected. Repetitive flash cycles cut-off roads, trap vehicles and cause damage to agricultural development schemes.

2) Wad El-Arish: 20-25/2/1975

Flash flood water submerged the coastal area and extended to about 200 km in central Sinai forming a deep lake (8 km x 3 km). The disaster impacts were 17 deaths, 280 houses swept away, and thousands homeless. Repetitive flash floods later on affect roads and infrastructures, swept away reclaimed soil and threaten the oil and natural gas development projects therein.

3) Kom-Ombo-Aswan region: May/1979

Flash floods produced 3 deaths, 200 houses demolished, 300 families homeless, 10000 acres of farmland drowned, 800 heads of cattle lost, and 100 bales of cotton destroyed.

4) Assuit-Idfu region: October/1979

Flash floods resulted in 18 deaths in Sohag, 1576 houses demolished, and 8841 homeless.

5) Kom-Ombo-Aswan region: October/1979

Three hundred houses demolished.

6) Wadi Watir, Sinai: 18/10/1987

Strong flash floods due to the intensive rainfall caused by ARST led to a disturbance at the top of mountains (1200 to 1400 m amsl). Historical records have indicated that only three to five sub-basins out of the 48 sub-basins of Watir area are flooding and cause the extreme damage (Abdelrahman, 1994). Watir experiences flash floods about once every two years; The 1987 severe flash flood lasted few hours to rarely more than one day (Abdelkhalek *et al*., 2009) and resulted in severe impacts including; damage to the highways, loss of life; the injury of 27 persons, Destruction of the main drinking water well, collapse of some parts of the surrounding dykes, damage of construction materials and electrical equipments for the National Radio station, and bring of boulders on the highway locations (WRRI, 2004).

7) Wadi Sudr: 6/1/1988

The flood happened about 60 km far from Sudr town and caused the death of 5 passengers inside a car.

8) Wadi Fieran: 13/10/1991

The flood originated in Saint Catherine area and partly or completely destroyed the main road following Wadi Feiran and some houses in El-Tarfa village.

9) Wadi El- Aawag: 20-22/3/1991

A big flash flood developed in Wadi Meiar and Wadi El-Mahash and destroyed some houses in El-Wadi village and some animals died.

10) Wadi Dahab: 09/1994

The flood water level reached more than 2.5 meters height. This flood resulted in the piling up of water upstream, the constriction and flooding of adjacent buildings, roads, and infrastructure in the area. The water entered residential houses, restaurants and hotels, and damaged main roads.

11) Wadi Watir: 29/10/2004

The flood developed in the whole Wadi Watir basin as a big runoff and destroyed 40% of highway to Nuweiba city.

12) North and South Sinai, Red Sea, and Aswan: 11/1/2010

Heavy winds and rains swept across four of Egypt's governorates; the rains flooded away homes, damaged infrastructures, and interrupted normal running of life within governorates of North Sinai, South Sinai, Red Sea, and Aswan. Losses claimed lives, destroyed houses, perished away roads denying access to affected areas, resulted in power cut offs, and above all many families were homeless and displaced.

In Sinai Peninsula and in Aswan, the heavy flooding has seriously affected several communities and the resorts of Taba, Nuweiba and Sharm El Sheikh on the Red Sea had temporary blackouts. The Sharm El Sheikh airport was closed for several hours after rains destroyed part of its ceiling, and the city's main telephone communications center was severely damaged. In Aswan, power outages put the entire city in darkness. Nearby villages were hit as the mud-brick houses of peasants were swept away by flood waters and hundreds had to evacuate.

According to the assessment of the Egyptian Red Crescent volunteers at branch level, the effects of the floods on the four areas are as follows:

- Aswan, three people have lost their lives and 14 are injured. Damage to several villages has been reported. At least, 3,500 people (500 families) have been affected or are homeless.
- North Sinai, Arish suburbs have been severely damaged. Six people have lost their lives and hundreds are injured. The central governmental hospital in Arish was flooded and patients were partially evacuated to nearby hospitals.
- South Sinai, heavy rains interrupted the main roads. Two people have lost their lives and 16 are injured. Mild damage has occurred to some Sharm El Sheikh buildings and several areas around Ras Sudr City were isolated.
- Red Sea area, roads were interrupted by heavy rains and mild damage occurred in suburbs of Hurghada. One person was killed and few mild injuries occurred.

13) Wadi Dahab and Catherine area: 1/10/2012

Heavy rain and flash floods blocked the main highways leading to Nuweiba and Sanit Catherine and Wadi El-Nasb dam and several nearby houses were destroyed by heavy flood waters. The floods have also led to power cuts.

14) Southern Sinai territory: 28/1/2013

Heavy rains and floods led to the death of 2 people and the injury of 19 others. The Nuweiba roads connecting to the surrounding region were partially destroyed by floods and telecommunication networks were cut-off.

15) Sinai and Red Sea heavy rains/flash flooding: 9/3/2014

Severe heavy rains and flash floods country started in Upper Egypt and Sinai specially, Southern Sinai. The heavy rains and flash floods drowned villages, collapsed roofs, and led to evacuations in the Red Sea, Cairo, Luxor, and other governorates (Fig. 9). Most areas had partially or completely badly affected by the heavy rains and flash floods. Part of the

Fig. 9. Damages of the 9/3/2014 flash floods: a. Central Sinai, b. Saint Catherina, Southern Sinai, c. Daniela Village, Dahab, and d. Hurghada highway collapse.

airport roof at the Red Sea resort town of Hurghada has collapsed; flooding has been reported from Sinai, and flooding of tunnels and ramps in Cairo has snarled traffics. Separate bus accidents in Asyut and Hurghada took 24 lives and at least two died in a house collapse, though that toll is likely to rise. Sixteen people have been killed in two weather-related bus accidents. A hotel's water stations were swept away, the cut-off of all telephone lines network in Taba. The main Taba-Nuweiba Road was closed off as well as many hotels and resorts in Taba area were damaged. The biggest damage was in the Red Sea and Suez where Ain El-Sokhna, Zafarna, Al Arish and Hurghada highways were destroyed and blocked. In Hurghada, the old airport in the city partially collapsed and leaked rain in it. Most villages in Sohag, Upper Egypt, were drowned and the roads cut off. One child was killed in Nuweiba. Two people also went missing in the floods (Bedouin eyewitnesses reported), 7 people were injured.

16) Taba flash flooding, Southern Sinai: 8/5/2014

Flash floods occurred due to one day of torrential rains and where flood waters did not follow their traditional route to the sea from the Watir valley but instead breached the road between Nuweiba and Taba. This disaster resulted in the destroying of exclusive parts of the Taba Red Sea resort area, one child was killed and 7 others were injured in addition to more than 70 families were displaced and an economic losses of the local tourist industry were considerable. The costs of flood damage were estimated to be ￡850 million. The government is now investing in spillways and building reservoirs to contain the floodwaters. The Governor appealed to Japan for further technical assistance to improve the early warning system.

Ⅵ. Management and reduction programs of flood disasters

Egypt recognizes the challenges posed by disasters as disaster loss is on the rise with grave consequences for the survival, dignity and livelihood of individuals, particularly the poor and hard-won development gains (CMDRS, 2008).

Egypt adopted and is implementing the Hyogo Framework for Action (HFA) through national activities and actively participated in the process of monitoring and reporting, which is an essential feature of the HFA, since it presents an indicator on the Monitoring Progress on implementation of the HFA. In this context Egypt has finalized the "HFA Monitor" in August 2008.

1. Objectives

Egypt's review aims at providing in-depth Assessment of Progress and the current state of efforts in the area of Disaster Management and Risk Reduction. This in-depth review will contribute to the analysis presented in the section on the HFA progress reviews of the 2009 GAR, which is being invited by territorial levels, and thematic areas.

2. Cooperation with other UN agencies

Egypt is a cornerstone for regional cooperation in disaster management and reduction, considering its geographical position at the northeastern side of Africa, central for the Arab region and sharing areas from the southern Mediterranean and Western Red Sea. Egypt has approved and achieved a level of progress through the cooperation with Arab and Euro-Mediterranean countries. Through the cooperation with Arab Countries in the Arab region and sharing areas from the southern Mediterranean and Western Red Sea, Egypt has actively participated in the process of developing the Draft Protocol on the Arab's Cooperation for the Prompt Responses in cases of Natural Disasters, Crisis and Emergency, under the umbrella of the Arab League. Besides, there are bilateral cooperation between Egypt and other Arab countries in cases of disasters and crisis. In the Euro-Mediterranean Cooperation, Egypt is one of the participating countries in the Euro-med initiative "Supports the development of Euro-Mediterranean system of mitigation, prevention and management of natural and man-made disasters, through technical assistance and capacity building".

3. National plan for management of flash flood disasters and their risks reduction

The National Plan to manage disasters of Flash Floods in Egypt and its risk reduction was developed and adopted in 2007. This plan consists of two main parts:

1) Outlines of the National Plan include six sections

Section 1. General Outlines and Methodology for the Plan Development; Section 2, Flash Floods Risks in Egypt; Section 3, Preparedness and Response; Section 4, Modalities and of coordination at different levels; Section 5, Legislations and National Laws, and Section 6, Conclusions and Recommendations.

2) Trends progress towards disaster risk reduction national objectives includes 11 items

Item 1, Policy, Institutional arrangements and Legislations; Item 2, The National Platform" The National Committee for Crisis Management and Disaster Risk Reduction "NCCMDRR"; Item 3, Roles and Responsibilities of IDSC/CMDRS; Item 4, The Scientific Advisory Board (SAB)/NCCMDRR; Item 5, Legal Framework; Item 6, Capacity Building; Item 7, Financing and Resources; Item 8, Risk assessment; Item 9, Database and Information System; Item 10, Developed Management and Contingency Plans, and Item 11, Early Warning System.

Although Egypt is facing several social and economic challenges, the government has set priorities to alleviate the impacts of disasters. Some steps have been taken, yet strong policy, technical and institutional capacities and mechanisms for disaster risk management, with a disaster risk reduction perspective are to be developed. Improving disaster preparedness capacities and mechanisms are systematically evaluated. Adequate resources (both financial and human) will enable the increase in readiness for managing disaster impacts and improving response measures.

Ⅶ. Warning System in Egypt

One effective way to reduce the risk of flash floods lies in the implementation of an early warning system, abbreviated as EWS. When warnings are issued before a flash flood event, additional time is created to take action and save lives and property. The unexpected arrival of a flash flood in combination with its force, limited understanding of the risks and small space-time scales provide explicit challenges for the development and implementation of an early warning system for flash floods, even in the most advanced regions of the world. The range of flood warning information includes; An Alert, Watch or Advice of possible flooding, A Generalized Flood Warning that flooding, Warnings of 'Minor', 'Moderate' or 'Major' flooding, and Predictions of the expected height of a river.

Wadi Watir is situated in the South Sinai governorate of Egypt (Fig. 10). It is one of the most active wadis in Sinai with respect to flash floods. The catchment has an area of 3580 km^2 and classifies as a hyper-arid catchment (Lin, 1999). Average annual rainfall is 35 mmyr^{-1}, ranging from 10 mmyr^{-1} in the low coastal areas to 50 mmyr^{-1} in the highland areas.

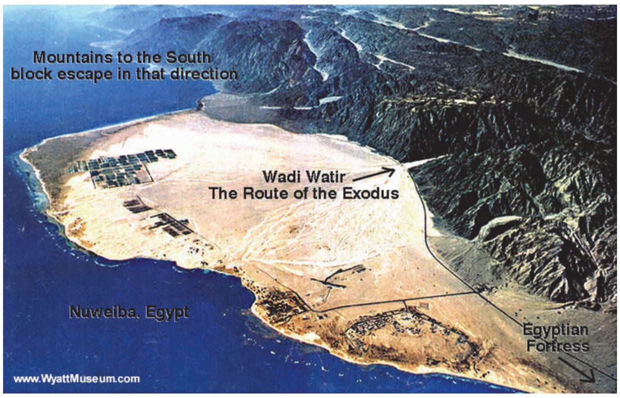

Fig. 10. Satellite image for Nweiba area showing Wadi Watir which drains to the Gulf of Aqaba through the Nuweiba city.

Wadi Watir with its outlet located at Nuweiba City is one of the most active wadis in Southern Sinai, Egypt. The Nuweiba city is located at a distance of 30 km upstream El Egma Plateau (～ 1400 m asl). Due to the steep gradient of the main wadi, the desert rainfall storms generate flash floods at the outlet. These flash floods are characterized by its enormous flow, which carries large amount of sediments and debris to Nuweiba City.

Regardless its destructive impact, flash floods are considered a main source of fresh water in the area. Nuweiba City is of great importance for regional development as it is a Tourist hub and has an international harbor. An early warning system called FlaFloM (Flash Flood Manager) has been installed in Wadi Watir, Egypt by Antea Group (Belgium), the Vrije Universiteit Brussel (Belgium) and the Water Resources Research Institute (Egypt). This software environment is able to predict the water levels at the outlet of the wadi several days in advance. Flash floods in Wadi Watir have been responsible in the past for loss of life and damages (roads and so on).

Once a flash flood is forecasted, time is available to take actions to avoid potential loss of life and minimize damages. The FlaFloM System consists of models for rainfall forecasting, rainfall-runoff modeling, hydraulic modeling and a warning system, each one sending his output to the next model. Only the first step of the system worked in 2010, so that many of the results are available for the first time.

Ⅷ. Conclusions and recommendations

Egypt as an arid and semi-arid country, experiences the flash flood and water scarcity hazards. The crisis's situation in Egypt had changed by the complement of the Aswan High Dam in 1970, where the Nile floods successfully stopped, but catastrophic flash flooding has recently become very common in the Coastal Red Sea areas and Sinai. Along the Red Sea coast, flash flooding represents the main natural hazard posing greater threat on life, constructions and even marine life. In the time span between 1972 and 2014, heavy rains and flash floods commonly hit many territories in the overall Egypt causing damage to properties and infrastructures, collapse of high ways, and loss of life and eco-systems. The most recent flash flood, dated May 8, 2014, which inundated Taba- Nuweiba area, lasted one day and left 1 killed person, 7 others injured, 70 families homeless and infrastructures damage being estimated at ￡850 million.

Egypt recognizes the challenges posed by disasters and strengthened and developed its national institutions and policy to meet the tasks of the HFA on the Crisis Management and Disaster Risk Reduction (DRR). Egypt established a Crisis Management Affairs (CEMA) entity in 2000 and some good signs of progress have been made along several areas and sectors. The multi-sectoral approach is to be adopted and operationalized to ensure the full integration and harmony. Furthermore, In 2009, Egypt established an early warning system called FlaFloM (Flash Flood Manager) in Wadi Watir, in collaboration with Belgium.

We recommend that disaster risks must be involved as public concerns in the weighing process of planning on all planning levels like the environmental impact assessment through:

- Research:
  - Framework and indicators for geocoded risk assessment.
  - A definition of standards is needed, that not only embraces the aspects of the insurance industry.
  - Assessment tools and standards have to be integrated in the planning process.
- Urbanization planning:
  - The ability of controlling the urbanization growth is a key competence to shape the future that must be based on efficient disaster risk reduction by spatial planning.
- Dam constructions
  - Building more advanced early warning system.
  - Building dams and reservoirs at the downstream of main wadis along the coastal plain of the Red Sea and Sinai.

Acknowledgment

We wish to express our sincere gratitude to Prof. Dr. Tanaka Yuzo, the president of Naruto University of Education, for inviting the first author for inviting as Foreign Visiting Researcher (FVR) in the period of July-December, 2014 and tremendous support and help. We gratefully acknowledge the professors at the Geosciences Department for their kindness and hospitality. Also, we would like to take this opportunity to express our sincere and special gratitude and thanks to Ms. Noriko Onishi and Ms. Miyumi Harada for their great assistance and kind and moral co-operation. In addition, we would also like to thank Naruto University of Education staff for their kindness and co-operation. This work was supported by the foreign visiting researcher program 2014, Naruto University of Education and by the joint research project (O) of the joint graduate school (Ph.D.Program) in Science of School Education, Hyogo University of Teacher Education.

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