

## Omani Experience in Flash Floods, Disaster Risk Reduction and Water Harvesting

Ahmed Said Al Barwani

Water Resources Expert, Ministry of Regional Municipalities and Water Resources, P.O. Box 2575, Ruwi, P.C.  
112 Sultanate of Oman

Email: ahmed.albarwani@gmail.com

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Floods in the Sultanate of Oman occur as flash floods with little warning, causing property damage, community disruption, and at time loss of lives. The main cause of floods is not limited to geology or weather, but also the distribution of human populations near water. The historical floods in Muscat shows that the areas have been flooded several times; as example: 1974 flood, 1981 flood, 1987 flood, 1990 flood, 1997 flood, 2003 flood. Furthermore during the recent years Oman experienced three main cyclones namely Gonu in 2007, Phet in 2010 and Ashoba 2015. All of these cyclones caused major floods and devastation.

Disaster risk reduction and water harvesting has been a priority by the Government of the Sultanate of Oman. The government has taken several efforts in dealing with disaster risk reduction including but not limited to establishment of hydro-meteorological network, setup guidelines for development in flood prone areas, production of maps showing flood risk zones, establishment of National Committee for Civil Defense (NCCD) to deal with all kinds of disaster including floods, construction of dams, improvement of drainage systems especially in major cities, introduction of flood warning systems and establishment of Multi Hazard National Center.

It must be emphasized that major natural disaster phenomena such as tropical cyclones and widespread flash floods cannot be prevented from occurring, but the probability and extent of serious damaging effects can be minimized. All concerned parties including government and non-government organisations should continue taking serious actions in mitigating and harvesting of flash flood which should include structural and non-structural measures. There is a need of cooperation between countries and sharing of knowledge between experts from different international organisations in disaster risk reduction which would lead to save of lives and property.



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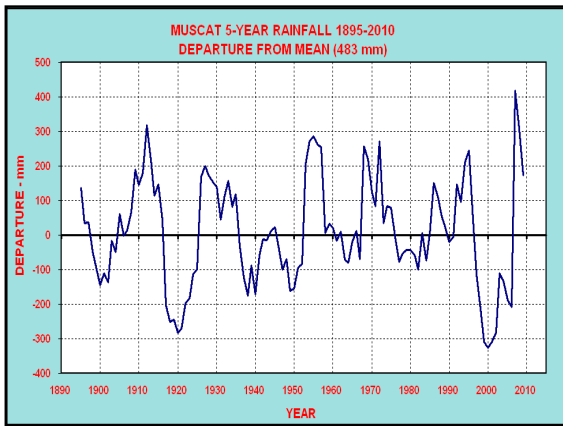
### Climate

- Oman is an arid country; the average annual rainfall in Muscat is 100 mm, while the average of the whole country is only 51 mm varying from less than 20 mm in the internal desert regions to over 350 mm in the mountain areas.
- The potential evaporation ranging from 2000 to 3000 mm. The average temperature varies between 28°C to 38°C while the highest temperature could reach 48 °C in summer.

- ### Characteristics of Arid Regions
- Rainfall is highly variable, in time and space.
  - Floods are damaging and difficult to quantify.
  - Data are limited –in extent, quality and record length.
  - Absence of base flow.
  - Sparsity of plant cover.
  - High transmission losses.
  - High potential evaporation and evapotranspiration.
  - Groundwater recharge is extremely uncertain.
  - Prevailing low infiltration rates of the rocky terrain and high infiltration rates of the sandy/gravelly alluvial beds in ephemeral watercourses.

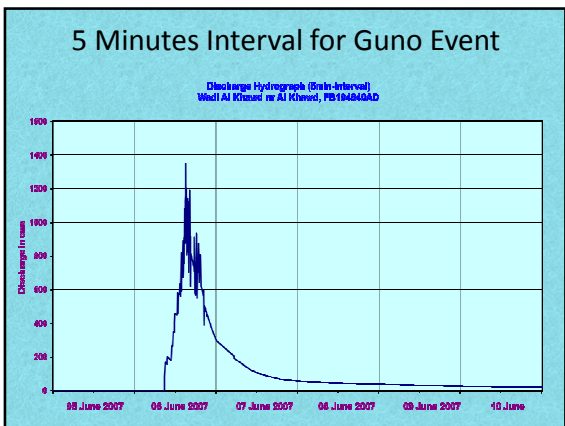
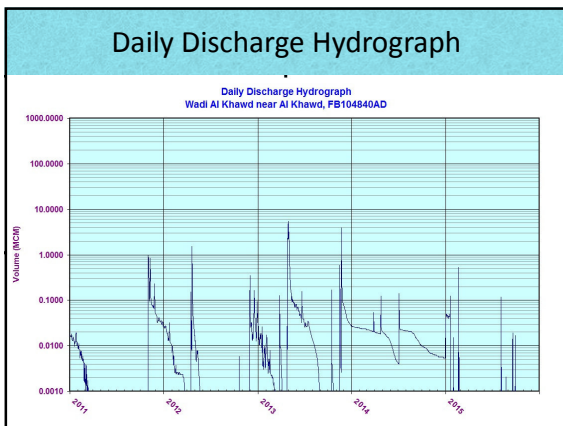
- ### Oman Water Resources
- Renewed Water Resources are estimated at around **1318 million m<sup>3</sup>/year**.
  - The **individual share** of the renewed water is about **340 m<sup>3</sup>** annually. International indices regard this level as water poverty threshold.
  - A comprehensive development and constant increase in water demand.
  - Agriculture consumes more than **83%** of the renewable water resources.
  - The average water resources deficit is estimated at **316 m<sup>3</sup>/year**.
  - Occurrence of drought for **more than five years** is very common.

- ### Rainfall
- Four Principal Mechanisms that cause Rainfall in Oman are:
- **Convective Rain Storms** – Can develop any time of the year but mostly during the summer months.
  - **Cold Frontal Troughs** – Originating over Atlantic Ocean or Mediterranean Sea which are common during winter and early springs.
  - **On Shore Monsoon Currents** – Occur between June to September in a form of drizzle and effect the southern part (Dhofar).
  - **Tropical Cyclone** – moving in from Arabian Sea and results in very heavy rainfall in the Muscat, Sharqiyah and Dhofar coastal regions.



### Flash Flooding in Oman

- In areas of steep topography and /or a small drainage basins, floodwaters can rise very quickly in wadis with little or no warning. This condition is known as flash flooding.
- Floods Tends to be an intense Short-term event, High velocities, Entire incident last only 4 -6 hours from start to finish.
- Damage usually begins to occur within one hour after significant rainfall.
- Rainfall in arid areas tend to be very localized, intense with short duration falling on bare land with limited or sparse vegetative cover generating flash floods.



### History of TC that Affected Oman

- June 1890 Tropical Cyclone (285mm) Muscat & Sohar
- May 1963 Tropical Cyclone (269mm) Salalah
- Nov 1966 Tropical Cyclone (202mm) Salalah
- Dec 1971 Cyclonic storm (99mm) Masirah
- Jun 1977 Tropical Cyclone (430mm) Masirah & (122mm) Salalah
- Mar 1999 Low pressure-Sur
- Oct 1999 Deep Low Pressure (69 mm) Salalah
- May 2002 Cyclonic storm (58mm) Salalah
- Sep 2004 Low Pressure (116 mm)
- June, 2007 – Cyclone Gonu (626 mm) struck Muscat and eastern parts of Oman.
- June, 2010 – Cyclone Phet (603 mm) struck Muscat, eastern and interior part of Oman.
- June, 2015 – Cyclone Ashoba (204 mm) struck Masirah, eastern part and Muscat.

### Damages caused by Flash Floods

- Damages caused as a result of flash flood are enormous both on human lives and loss of property.
- It is reported that flood disasters account for about a third of all natural disasters by number and economic losses.
- Floods are responsible for over half of the deaths associated with all such disasters.
- The following pictures are some of the examples of flood damages in Oman.





### Disaster Risk Reduction

Disaster Risk Reduction includes structural and non-structural measures.

The non-structural measures taken in Oman are:

- Establishment of Hydro-meteorological network.
- Establishment of guidelines for development in flood prone areas.
- Production of maps showing flood risk zones.
- Establishment of National Committee for Civil Defense (NCCD) to deal with all kinds of disaster including floods.
- Introduction of flood warning systems.
- Establishment of Multi Hazard National Center.

### Hydro-meteorological Network

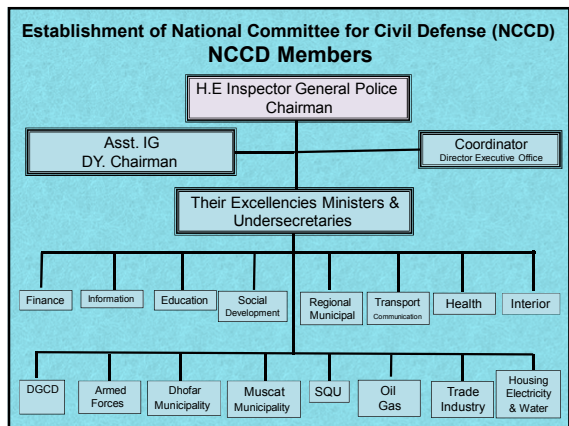
- The Ministry operates 4640 different stations, 45 Telemetry stations. The Telemetry network is now being expanded to cover 333 rainfall stations and 96 wadi stations and 12 weather stations.
- While the meteorological department operates more than 40 automatic weather stations and have recently installed 5 weather radars.

### Guidelines for Development in Flood Prone Areas.

- The developer or property owner must seek comments and prior approval from MRMWR before a project in a flood risk zone is allowed to proceed for final determination by the planning authority.
- If a proposal for any major development in a medium or high risk flood zone will cause a significant reduction in channel flow capacity, the developer or property owner is required to demonstrate to the planning authority and MRMWR that the proposal will not significantly increase flood levels.
- For projects in a high-risk flood zone, it is mandatory to incorporate foolproof evacuation measures.

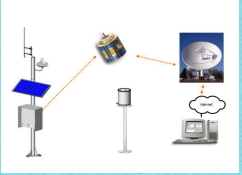
### Flood Risk Maps

- The ministry prepared a series of maps for flood-risk zones for major cities.
- The ministry is now in the process of updating these maps and also plans are on the way to cover other areas which have not been covered by these maps.
- These maps are used for town planning and also valuable in helping to determine the value of insurance premiums on properties against flood damage.



### Flood Warning Systems

- The Ministry has recognized the need for the early flood warning systems and consulted several concerned organizations.
- Expansion of Hydrometric stations and installation of telemetry stations using GSM and satellite communication.
- The Ministry is working together with the Meteorology Department on deploying the Flash Flood Guidance for the whole country.



### The Structural measures

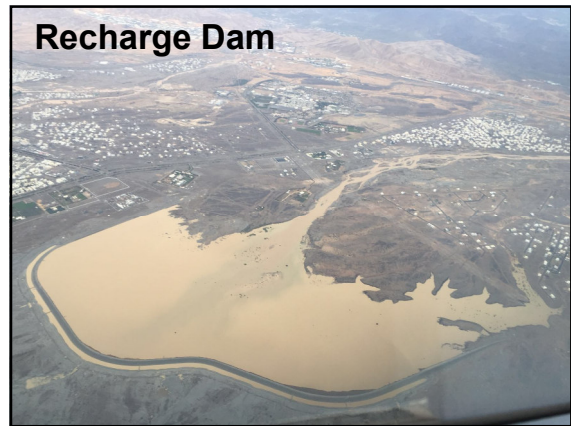
- Construction of dams.
- Improvement of drainage systems especially in major cities.
- Introduction of flood protection schemes..



### Construction of Dams

- Construction of **14** flood protection dams **44** groundwater recharge dams and more than **111** storage dams in various governorates of the Sultanate.
- Since their implementation and until June 2015 the dams retained about **1928** million cubic meters of water. About 57% of this quantity recharged the groundwater aquifers.
- Implementation of the first phase of the biggest storage dam (also act as flood protection dam) in the Sultanate (Wadi Dayqah in Wilayat Quraiyat)
- Studying a number of options with regard to flood protection dams in some of the regions exposed to floods danger.

### Recharge Dam



### Storage Dam



### Flood Protection Dam





### Improvement of Drainage Systems

- The drainage system in many cities of the country are either poor managed or not available.
- Actions have been taken to clean the available drainage and open the wadi channels.
- The Muscat Municipality has just completed a master plan on drainage for the greater Muscat area.



### Flood Protection Schemes

The Government has recently initiated several flood protection schemes within the Main Wadis including:

- Construction of Flood Protection Dams.
- Improvements of drainage systems in several major cities.
- Working on proposal for Identification of Wadi protection zones for each wadi system.
- Several bridges and bypasses have been constructed to allow the traffic to move smoothly during the flood events.

### Flash Flood Videos

- Do not underestimate the Flash Floods strength



- Bridge and Culvert should be properly Design



- Do not Play with flash floods



### Conclusion and Recommendations

- Application of integrated flood management including structural and non structural flood measures.
- Continue with the government efforts on flood protection and flood risk measures.
- Further work is recommended on upgrading of the existing monitoring network by automate the data processing, provision of real-time data transmission and network modeling.

### Continue....

- Determine the wadi hydrology parameters in arid climate including (topography, morphology, land cover, climate etc.) for representative wadis.
- Training and Public awareness ought to be strengthened in the future to improve the way we deal with floods and use of water efficiently.
- Encourage more scientific research to improve the current knowledge base on water resources and coping with the water resources problems.
- Strengthen the international cooperation through exchange of research and experiences.

