A Comparative Study between Flash Floods in Arid and Semi-arid Basins with Respect to Economic Mitigation Measures

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Introduction

Flash floods have been highlighted in the 21st century for the damage they have caused particularly, in the more arid regions of the world, as climate change intensifies. In 2007, for instance the Gonu Cyclone caused 4 billion USD worth of infrastructure damage and 49 deaths (Wang and Zhao, 2008). In order to better understand this flash flood phenomenon in each basin a Hydrological Rainfall Runoff Model was used to accurately assess impact and range of flash floods.

Objectives

1-Formulate general comparison of arid and semi-arid from a varied perspective (considering climate, the aridity, hydrology, etc)

2-Assess flood hazard level based on the flood index calculation (average water inundation depth per basin area) from different rainfall return periods.

3-Compare efficiency of different mitigation measures on flash floods, based on concentrated and distributed dams scenarios.

Study Regions

Wadi Aday and Sume Basin were selected for their representativeness (from a climatological and hydrological perspective) for the arid and semi-arid climates respectively. **1-Wadi Aday**: Located in the Muscat Region in Oman with a population of 1,288,300 inhabitants and an area of 372km.

2-Sume Basin: Located in Northern Brazil in Paraiba, it has a population of 51,000 inhabitants and an area of 128km

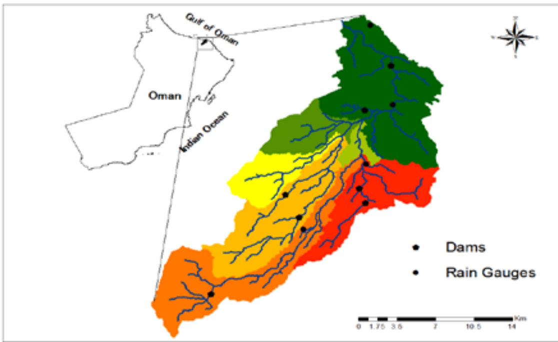

Figure 1: Wadi Aday Basin Map in Oman.

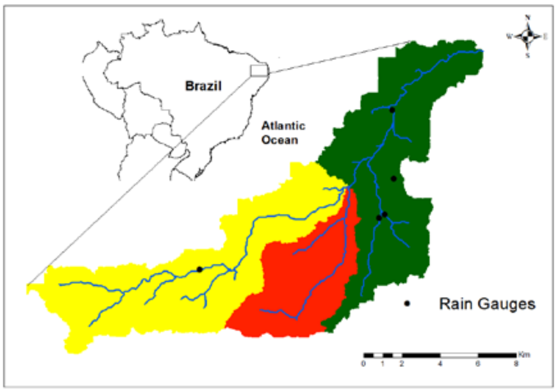

Figure 2: Sume Basin Map in Brazil.

Comparison of arid and semi-arid basins

Arid and semi-arid basins were compared, from a climatological, hydrological and geophysical perspective. Using the aridity index from FAO and hydrological data from (Xiao Lin, 1999) Table 1 was formulated.

Table 1: Comparison between arid & semi-arid basins

Parameters	**Semi-Arid**	**Arid**
Average Annual Rainfall (mm)	200-400	<200
Annual Runoff Depth (mm)	10-50	<10
Aridity Index (AI)	0.2<AI<0.5	AI<0.2
Global Land Area	17.7%	12.1%

Methodology

The hydrological model utilized is called Rainfall-Runoff Inundation (RRI), capable of simulating rainfall-runoff and flood inundation simultaneously. A 2D diffusive wave model is used to calculate the flow on slope grid cells, while a 1D diffusive wave model is used for channel flow (Sayama, T., 2013). This study focused on the case where there was no lateral saturated hydraulic conductivity, to consider saturated subsurface and saturation excess overland flow.

Data Processing

Rainfall and discharge data spanning from 1983 to 2015 as measured from 6 rain gauges was used for Wadi Aday in Oman and rainfall data from 1982 until 1991 taken from 5 rain gauges for Sume in Brazil. Satellite-based rainfall, GSMaP data was also used to simulate the 2007 Gonu Cyclone in Oman and the 1985 March big floods in Brazil.

Model Calibration and Validation

Calibration was based on the June, 2007 Gonu Cyclone in Wadi Aday following the criteria and steps as listed by Abdel Fattah et al., 2016. The simulated discharge peak was compared to the measured and the parameters were thus accordingly calibrated. Peak biased was estimated to roughly 2.9% as in Figure 3. The model was then validated using discharge data from the December 2006 floods, to evaluate the reliability of the established parameters.

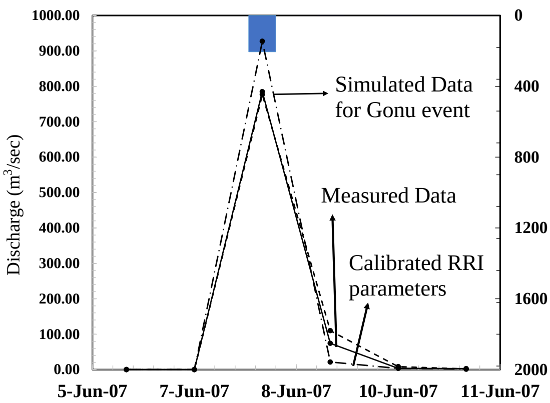

Figure 3: Calibration for Wadi Aday 2007, the difference obtained between the measured and calculated was of 2.9%.

Evaluation of Mitigation Measures

There is currently one dam built out of a 7 dam project Calibrated RRI parameters in Wadi Aday that were strategically selected by the government of Oman. On the basis of this, the different mitigation scenarios simulated are illustrated in Table 2.

Table 2: Mitigation scenarios

Scenarios	**Details**
SC_1	No mitigation measures
SC_2	1 concentrated dam
SC_3	3 concentrated dams
SC_4	7 distributed dams
SC_5	Channel Improvement

Economic Mitigation Measures

Due to a never ending water limitation and flash flood disaster problem in Oman, mitigation of flash floods has become crucial. In lieu of this, the return rainfall period for 5, 10, 20, 30, 50, 100 and 1000 were estimated (based on the 2007 Gonu Cyclone) to obtain the flood index as shown in Figure 4. Although the scenario of 7 distributed dams caused a more considerable reduction in the flood index, the 3 concentrated dams showed a reduction of over 20% in the flood index until the 50 year return period. Indeed, concentrated dams have its advantages: namely cheaper construction costs and are more effective for groundwater recharging.

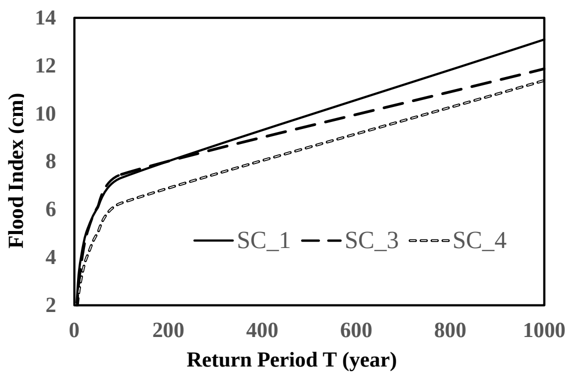

Figure 4: Flood Index calculated for various rainfall return period for cases SC_1, SC_2 and SC_4