SIMULATIONS OF HYDROLOGICAL EXTREMES IN JAMAICA- CASE STUDIES OF HOPE, YALLAHS AND OUTRAM RIVER WATERSHEDS

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WCRP CONFERENCE FOR LATIN AMERICA AND THE CARIBBEAN: DEVELOPING,LINKING AND APPLYING CLIMATE KNOWLEDGE

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INTRODUCTION

Flooding from high intensity rainfall associated with or without tropical storms and hurricanes, is a major hydro-meteorological hazard affecting Jamaica, the third largest island of the Caribbean. Centred on latitude 18°15' N and longitude 77°20' W, Jamaica has been negatively affected by severe weather and repeated flooding events (2004, 2007, 2008, 2010, 2012 and 2014) which have been very costly in terms of both lives and livelihoods. The island has been affected severely by floods resulting from tropical storms and hurricanes owing to its location in the Atlantic hurricane belt. The Planning Institute of Jamaica estimated that in ten years (2001-2010) the island experienced damage of over US $1.27 Bn due to severe weather systems including hurricanes and tropical storms. Frequencies of floods as well as tropical storms and hurricanes have increased at the end of the 20th century and into the 21st century with the period 1990-2000 having maximum occurrences of flood events (Figure 1)

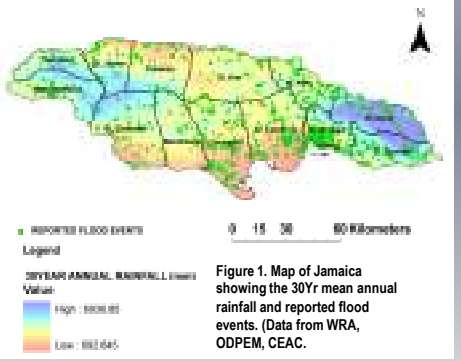


Figure 1. Map of Jamaica showing the 30Yr mean annual rainfall and reported flood events. (Data from WRA, ODPEM, CEAC.

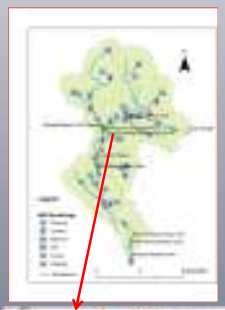
AIM : CREATE HYDROLOGICAL MODEL OF THE WATERSHEDS TO SIMULATE RUNOFF FROM RAINFALL FROM EXTREME EVENTS, CREATE PRESENT AND FUTURE FLOOD INNUNDATION MAPS FOR THE YALLAHS RIVER WATERSHED

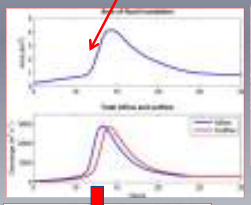
In the present study, emphasis was given to the two major affected watersheds of Hope and Yallahs in Eastern Jamaica. Simulations of flow was done for the two major events i.e. Tropical Storm Nicole in September 2010 and Tropical Storm Gustav in August 2008. The storm caused flooding of the Yallahs & Hope Rivers and US$210 M in Damage & Loss.

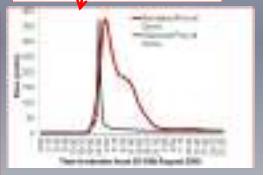
METHODOLOGY:

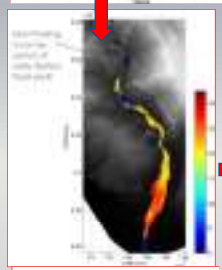
- Used 24-hr rainfall data from Mavis Bank gauging station for Yallahs and 15 minute rainfall intensity data from Grove for Hope watershed for Tropical Storm Gustav.
- Used 5 minute rainfall intensity data for Tropical Storm Nicole for Hope watershed.
- NRCS Type II method used to generate hourly rainfall for Yallahs.
- Flows generated from rainfall data using USDA – Soil Conservation System Curve Number method for Loss estimation in HEC HMS

RESULTS : SIMULATIONS IN YALLAHS AND HOPE RIVERS FOR TROPICAL STORM GUSTAV

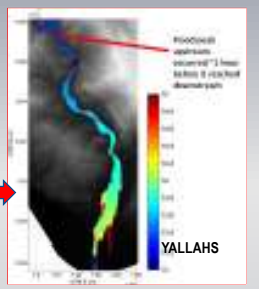








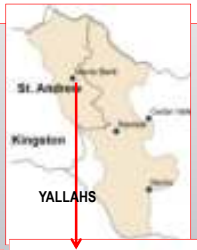
Time of initial inundation- Tropical Storm Gustav

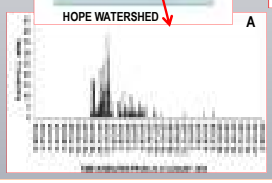


Time of maximum inundation- Gustav

FLOOD HAZARDS AND MAJOR AFFECTED AREAS

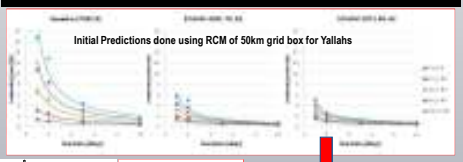
Figure 3. Damage to urban areas of Port Maria St Mary (A), Gordon Town (B), Harbour View (C), Kintyre, & Kingston (D), from tropical storms and hurricanes. (HOPE , YALLAHS AND OUTRAM WATERSHEDS). (Pictures from WRA and Gleaner archives)

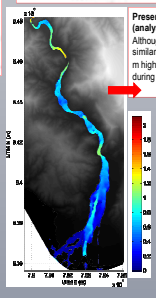




24 hour rainfall distribution for Mavis Bank Station . Rainfall used as input.

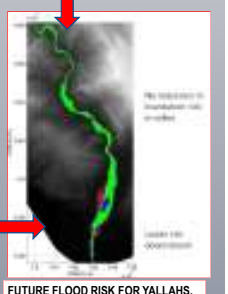
FUTURE CLIMATE IMPACT FOR YALLAHS





Present return periods (analysis of gauge data). Although the flood extents are similar, water depths are up to 2 m higher on the floodplain during a 100-year event.

Future return periods (ECHAM 2040-2070 and 2070-2099). Future predictions done from baseline data obtained from the Regional Climate Model for the Caribbean available for grid box of 50km by 50km. Simulated flow for 25, 50 and 100year future flows.

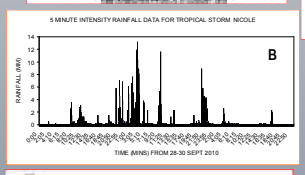


FUTURE FLOOD RISK FOR YALLAHS.

WATERSHEDS UNDER STUDY

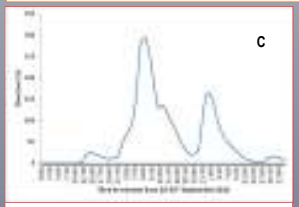
HOPE WATERSHED

YALLAHS WATERSHED



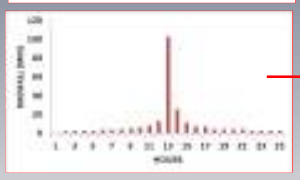
A) 15 Minute rainfall intensity data for Tropical Storm Gustav for Grove station in Hope watershed.

B) 5 Minute rainfall intensity data for Tropical Storm Nicole for Hope watershed. Rainfall used as input into the HEC HMS models

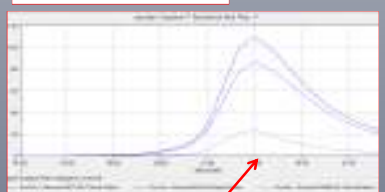


C) SIMULATION OF FLOW AT GROVE FOR THE HOPE STATION FOR TROPICAL STORM NICOLE – FLOW LIKELY TO IMPACT THE COMMUNITIES AROUND e.g KINTYRE (Fig 3D)

FLOOD EXTENT MAPPED POST INTENSE FLOODING FROM COLD FRONT ON 23-24TH NOVEMBER, 2006, IN PORT MARIA IN THE OUTRAM RIVER WATERSHED. MAXIMUM HOURLY RAINFALL WAS 240MM LEADING TO FLOOD LEVELS OF 2M , INUNDATING THE TOWN AND LEADING TO COLLAPSE OF A NEWLY-CONSTRUCTED BRIDGE.



24 hour rainfall distribution for Port Maria Station for the Nov 23-24, 2006 flood event.- Data used as input for the model.



PRELIMINARY SIMULATIONS FROM HEC-HMS FOR THE OUTRAM WATERSHED FOR NOV 2006 FLOOD.

SIMULATED FLOW :120CMS

Conclusions:

- Hydrological modelling of the watersheds shows high runoff from high intensity short duration rainfall. Steep slopes (>30 degree) associated with presence of impermeable rock types (volcanoclastics, volcanics) allows high runoff causing flooding in communities located downstream in all the watersheds. Estimation of flows from extreme events was not done previously and hence this offers new insight on the time taken for water to travel downstream as well as the volumes of water involved.
- Flood inundation maps created for the Yallahs watershed show 12-14m of flood depth in the downstream end of the river with only 1 hour difference between the flood peak upstream and downstream. Return period analysis shows that although the flood extents are similar, water depths are up to 2 m higher on the floodplain during a 100-year event compared to a 25year event.
- Future flood inndundation map created with ECHAM 2070-2099 climate data shows no reduction in inundation risk in the valley.

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