APPLICATION OF REMOTE SENSING AND RAINFALL RUN-OFF INUNDATION MODEL TO COUNTRY-WIDE INUNDATION MAPPING

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INTRODUCTION

Kenya has continued to suffer economic losses and loss of lives from floods every year. Intensity of floods has been increasing over years and subsequently the losses. Insufficient hydro-meteorological data has led to design of structures (dykes) that are not very functional and lack of early warning system in place. Responding agencies and evacuation efforts are often frustrated due to lack of proper knowledge of the inundated areas. To support flood management in Kenya, It is important to identify inundated areas and quantify inundation characteristics (extent, depth and duration). The objective of this research is to use remote sensing data and a hydrological model for near real time inundation map. This research uses satellite rainfall data from TRMM, 3B42RT rainfall data for Rainfall Runoff Inundation (Sayama et al., 2012) model simulations and satellite data from MODIS 8-day surface reflectance data to calibrate the RRI model.

METHODOLOGY

Simulations of inundated area is performed by the RRI model; this is a 2-D model that is capable of simulating rainfall-runoff as well as inundation depth simultaneously. The model deals with slopes and river channel separately with an assumption that the slope is located within the same grid cell as the river channel. The flow on the slope grid cells is calculated using 2-D diffusive wave model while the channel flow is calculated using the 1-D diffusive wave model. This model simulates lateral subsurface flow, infiltration and surface flow. Flow interactions between the river channel and the slope is estimated based on overflow formulae depending on water level and levee height.

To compute the lateral flow on the slope grid cells, equations are derived from mass balance and momentum equations for gradually varied flow. For 1-D river routing, 1-D diffusive wave model is applied to the river grid cells with an assumption that the geometry is rectangular. The depth and width of the channel are estimated by using a function of upstream area. Water exchange between slope grid and river grid is computed based on slope water, river water, levee crown and ground levels relationship.

RRI model input files/data include; rainfall data (obtained from Tropical Rainfall Measuring Mission by NASA) for a period of 5years (2008-2012), flow accumulation (30seconds), flow direction (30seconds) Digital Elevation Model (30seconds) downloaded from Hydrosheds and landuse file (30seconds) obtained from GLCC. The landuse, flow accumulation and flow direction and Digital elevation Model are corrected and then scaled up to 60seconds. The landuse file is divided into 5classes; dryland, cropland & pasture, cropland/woodland mosaic, shrubland, savanna, and Barren & sparsely populated. The output of RRI model include discharge hydrograph (as in figure 3) and inundation map (extent &depth). The inundation data obtained from RRI is then displayed in ArcGIS to show the peak inundation (as shown in fig1).

Identification of flooded areas using MODIS images is done by computing the NDWI (Normalized Difference Water Index) (Islam et al. 2009); given by

$$NDWI = \frac{band2 - band6}{band2 + band6}, 0 < NDWI < 1 \quad (1)$$

RESULTS AND DISCUSSIONS

RRI simulations indicate that the Eastern part of the country Tana and Nzoia basins to be inundated with most inundation observed in the Eastern parts. In comparison to RRI output, MODIS analysis shows no inundation in the Eastern parts of the country but inundation is observed in the central parts. These disparities can be attributed to cloud cover errors in MODIS images, soil properties and infiltration rates used in the RRI model. The hydrograph for River Nzoia and Tana River have similar trend which is attributed to high rainfall in the country during the simulation period, it is however observed that the discharge for Tana River is much higher than that of River Nzoia throughout the period, this is because Tana River has a larger capacity and basin than River Nzoia.

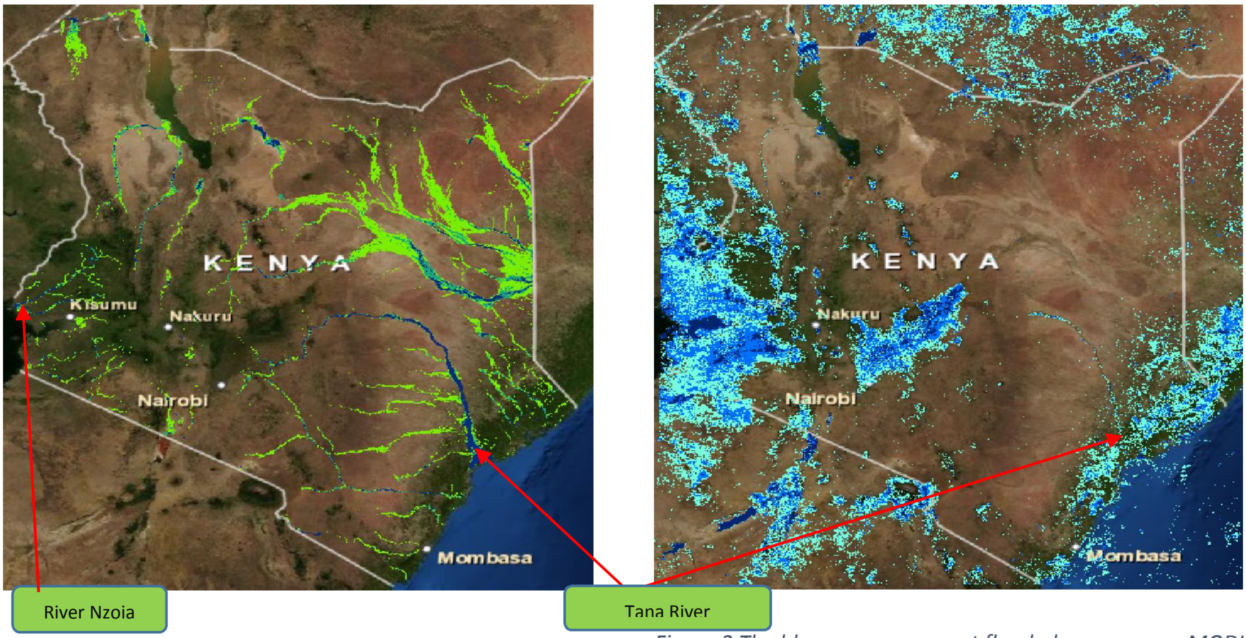

Figure 1 green areas represents the peak inundation extents for 9th May 2009 from RRI simulation

Figure 2 The blue areas represent flooded areas as per MODIS image of 9th May 2009

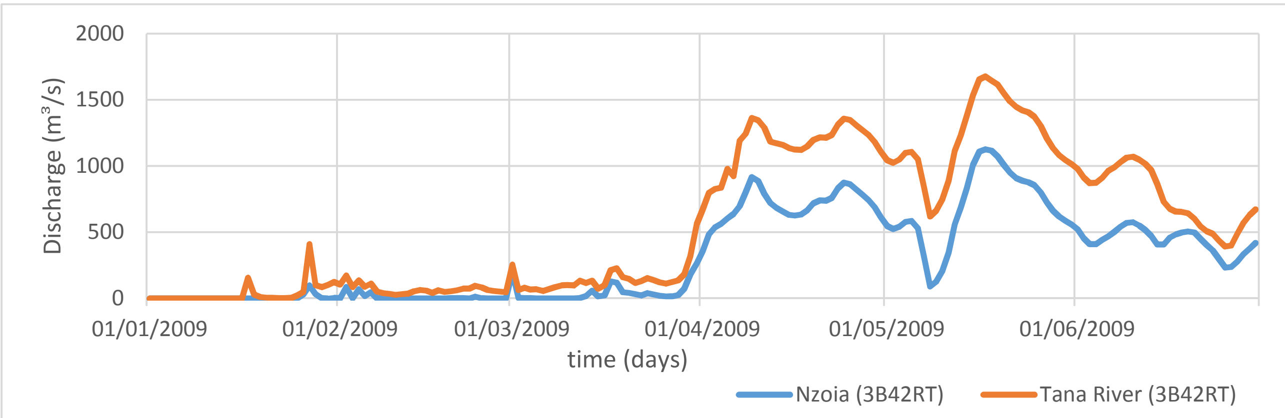

Figure 3Hydrograph of River Nzoia Mouth derived from discharge output by RRI for the period Jan 2009-June 2009

CONCLUSION

Floods in most of the river basins were detected by results from MODIS image analysis. Use of MODIS Images and satellite rainfall data therefore presents a good alternative to floods monitoring in areas that lack or have insufficient data to aide in proper flood management.

REFERENCES

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Keywords: Remote sensing, rainfall run-off inundation model, country-wide inundation mapping, MODIS,
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