Water Resources

Catchment modelling and assessment of the impact of climate change on water availability in the Nariva River, Trinidad

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1. Introduction

Water availability is defined as the capacity of a water source to sustain additional water demand after considering current water uses and water conditions (IPIECA 2014). Water availability studies are often conducted to assess existing water sources and determine whether these resources can support future economic growth. One of the main factors currently affecting water availability is climate change, in particular precipitation and temperature. Changes in climate can have profound impacts on the hydrological cycle which in turn affects the amount of available water. In addition to reducing available water resources, climate change also influences the way water is used. Studies have shown that an increase in temperature and a decrease in precipitation leads to an increase in

evapotranspiration (Abtew and Melesse 2013). This increases the demand for irrigation water since the crops will need to remain cool and avoid heat stress.

In 2010 a study conducted by The Climate Studies Group based in Jamaica used a Regional Climate Model (RCM), PRECIS (Providing Regional Climates for impact Studies) to generate climate projections for the Caribbean. According to Campbell et al. it is expected that between the years 2071 and 2100 temperatures will increase by 1-4° C and precipitation will decrease by 25-50% under the A2 and B2 climate scenarios (Campbell, et al. 2010).The Small Island Developing States of the Caribbean face challenges in the management and allocation of their limited water resources among competing users in the face of climate change. Many of the Caribbean countries are considered to be water scarce while some such as Guyana and Belize have abundant freshwater resources. The effects of climate change may cause many of the countries to become more water scarce and those that are currently not may begin to experience water scarcity. These climatic changes can have significant impacts on the economies of the Caribbean islands since many of them rely on tourism and agriculture as a source of GDP. This makes them highly vulnerable to the impacts of climate change.

In Trinidad and Tobago 60% of all the freshwater used for both consumptive and non-consumptive purposes comes from surface water, 28% from groundwater and 12% from desalination. Agriculture accounts for only 0.4% of the country's GDP and utilizes the least amount of water compared to domestic and industrial users (WRA 2001). Agriculture does not contribute significantly to Trinidad and Tobago's economy however it does provide employment for many residents in rural communities. In the Nariva catchment alone there are up to 517 persons who earn a living through agriculture. This figure only

accounts for those with official leases and does not include hired laborers (EMA 2008). With an estimated 15% decrease in rainfall by the 2040s, it is expected that crop yield will decline and this can result in over 40 million USD in losses for Trinidad and Tobago's agricultural sector (ECLAC 2011). This will inevitably impact the livelihoods of farmers including those in the Nariva catchment.

Given the potential impacts of climate change on water resources in Trinidad and Tobago, it is important to assess how much water is currently available and the ways in which it is being used. This enhances understanding of the resource so it can be sustainably managed. The main objective of this project is to assess water availability in the Nariva catchment in Trinidad and how it is likely to be affected by changing precipitation patterns, using the Water Evaluation and Planning (WEAP) software. This is the first time such an approach is being used in Trinidad and Tobago so this research provides a starting point for integrating modelling into the management of water resources.

2. Methodology

This research project focused on describing the current water use and availability in the Nariva catchment. Climate scenarios were also built in order to assess the impact of climate change on water resources within two projected time periods (2035-2045 and 2065-2075). In order to meet these objectives a quantitative modelling approach was used to represent the system. Any model requires calibration and validation to give confidence that the outputs match observation. This however requires primary data that was not available at the time.

Data Sources

At the beginning of this project the existing literature was consulted to obtain background information on the Nariva catchment. A reconnaissance visit to the area was then conducted to develop familiarity with the area. The data needed to build the model was collected from primary, secondary and tertiary sources then the model was built and assessed to obtain results.

Most of the secondary data that was needed to conduct the analysis in WEAP was obtained from Water Resources Agency (WRA) and the Ministry of Agriculture. For parameters such as evapotranspiration, area and flow data for the reference years was either unavailable or had large gaps therefore historical data was substituted. This can impact the results of the model by either overestimating or underestimating water availability. Though the data sets were not ideal, it was the best that was available at the time of this project. There is some domestic water demand in the Nariva catchment however this project focused only on agricultural water use since it is the largest consumer of water resources in the area.

3. Results and Discussion

Assumptions

During the construction of any model some assumptions have to be made especially when there are data limitations. One such assumption made during this project was that water demand remains constant through all the scenarios. Water demand was calculated for the reference scenario using evapotranspiration data and crop coefficients. When the near term and long term scenarios were created, they inherited the water demand from

the reference scenario. Since the only factor being manipulated was precipitation, the water demand for all scenarios remained the same. In actuality this is unlikely since it has been proposed that all agricultural plots in the area should be utilized for agricultural activity throughout the year in the future (EMA 2008). The effects of climate change are also likely to result in increased crop water demands. With increasing temperatures plants will require more water, thus increasing water demand (ECLAC 2011). The constant water demand was used however since there was no information on how water demand is likely to change in the projected time periods. The area of land under agriculture also remained the same for each year in all scenarios. In reality the area of land being cultivated may vary from year to year.

Another assumption that was made in building the scenarios was that precipitation declines by a fixed amount over the selected time periods with no annual or monthly variations. In reality this would not be the case as precipitation patterns are unpredictable. Some years may experience an increase in precipitation while others may decrease below the expected percent for the time period. It was also assumed that the effect of climate change is uniform across all months which is not realistic. However since this is a 'proof of concept' piece of research some simplifications had to be made and further disaggregation may introduce more uncertainty into the model.

Model Building

The relationship between groundwater and surface water in the catchment was not considered since the groundwater potential in the area has not been thoroughly investigated.

The model also does not take into consideration the impact of water demand from outside the catchment which is being met by the Navet Dam. Water from the Navet Dam supplies domestic and industrial users in South and Central Trinidad. This therefore means that as water demand increases outside the catchment due to population and economic growth, more water will be transported to these users, further reducing the flow from the Navet River into the Nariva basin. This in turn decreases the water availability in the catchment.

The level of agricultural activity (i.e. the area of land under agriculture) used for this model was based on the number of registered farmers and may have underestimated water demand since it did not include any unauthorized water users (EMA 2008). Though the number of unregistered farmers is unknown it can still have a profound impact on water availability in the catchment. The model also allows users to input figures for distribution losses such as physical leaks however this data was not available at the time. It was therefore assumed that all the water that is abstracted from the river reaches the fields and is used by the crops.

Model Outputs

The results for unmet demand in the reference scenario showed that irrigation demand was not met for three consecutive years from 2003-2005. Following this there was a 1 MCM deficit in 2010. These results were expected since Trinidad and Tobago experienced drought conditions from 2002-2004 and from the end of 2009 to the first quarter of 2010 which severely impacted water resources throughout the country (ODPM 2013)

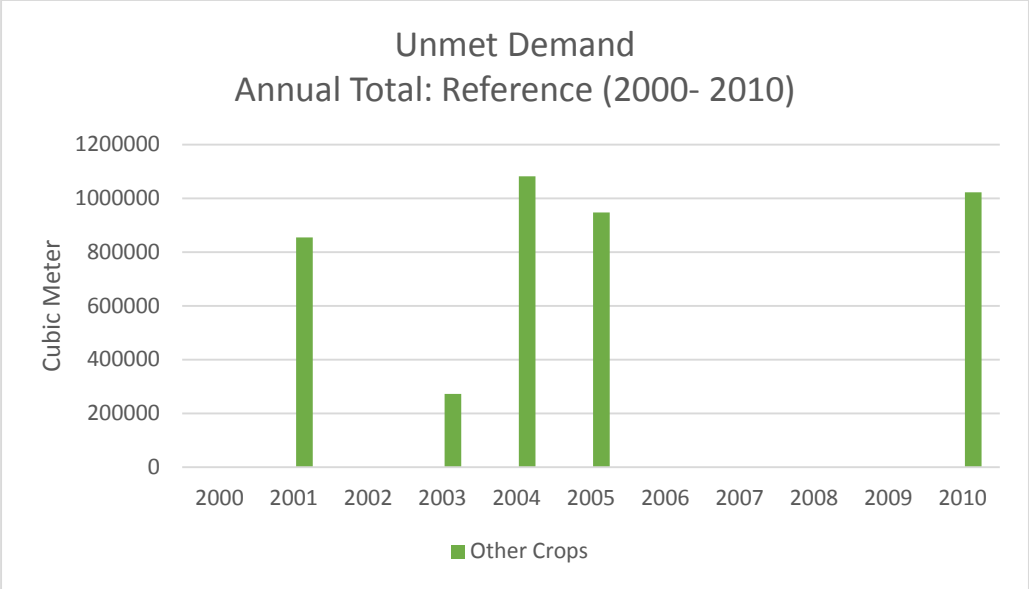

Figure 1 showing unmet demand for the Reference scenario

The projected climate scenarios show that in the absence of demand management strategies there will be an increase in the frequency and severity of water shortages for agriculture in both the near and long term.

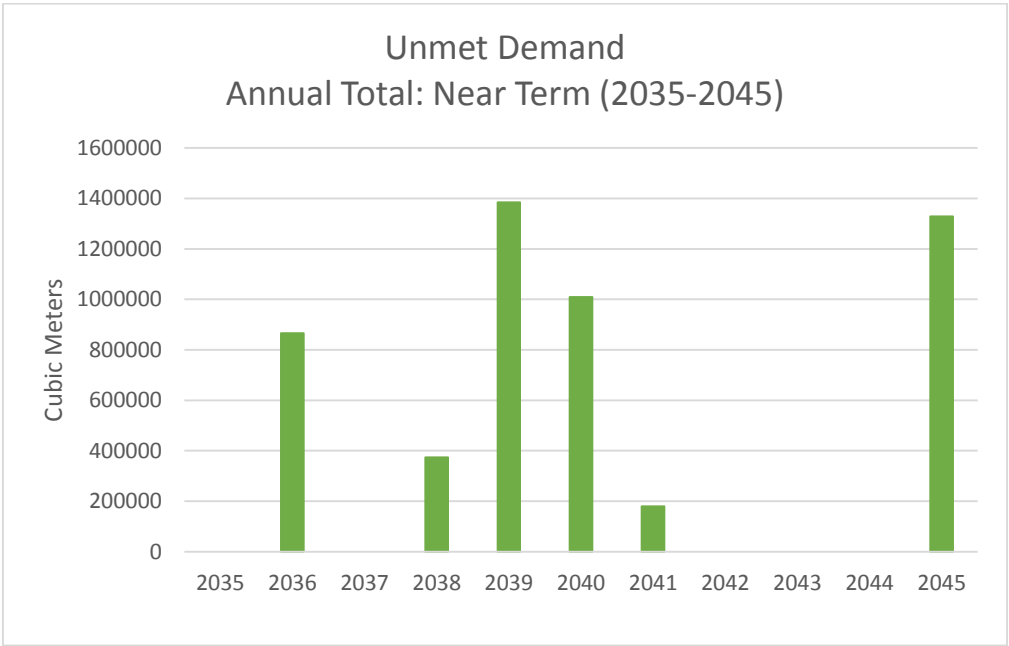

Figure 2 showing unmet demand for the Near Term scenario

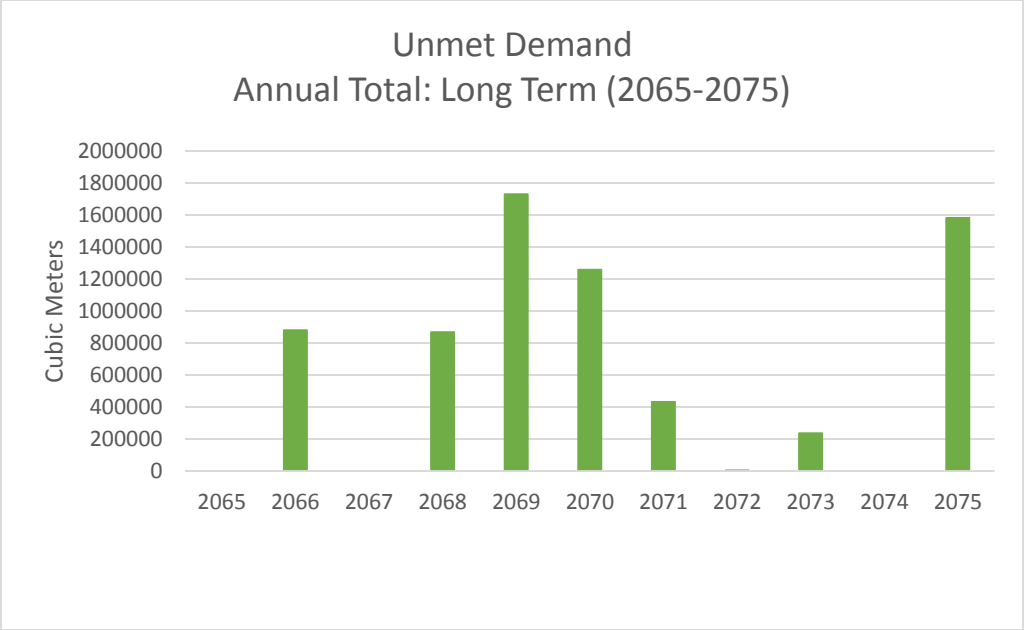

Figure 3 showing unmet demand for the Long Term scenario

Currently farmers are experiencing periods of unmet demand even during years where annual precipitation in the catchment exceeds the national average of 2000 mm. This is expected to worsen in the future due to the impacts of climate change. A reduction in precipitation can have severe effects on crop yield and household income since water is the limiting factor in crop production.

It is clear that water resources in the catchment are unable to sustain current and future agricultural demand. There is therefore a need to utilize Decision Support Systems (DSS) such as WEAP that can help identify the issues and provide a basis for the development of sustainable management options. This project was successful in meeting its objectives however it is important to note that this is a preliminary model and as more data becomes available it can be improved to provide more accurate results.

4. Recommendations

- As updated evapotranspiration and flow data for the baseline period becomes available it can be added to the model to generate more precise results. Up to date agricultural data can also be added to the model as it becomes available
- Future work can include investigations into current water demand as well as how it is likely to change in the near term and long term. When included in this model, this data would produce a clearer image of how water availability in the catchment is likely to change.
- With sufficient data the model can be calibrated and validated to assess its accuracy.
- This model can further be used by decision-makers to assess the impact of possible mitigation measures such as the construction of water storage infrastructure or demand management.

5. Conclusion

The main objective of this study was to investigate water availability in the Nariva catchment and how it would be impacted by climate change. The model was able to define the current water use in the catchment and simulate the impact that a decline in precipitation would have on water availability in the near and long term. The results showed that current water demand is not being consistently met and the situation will worsen should precipitation decline according to local projections for the catchment. Though WEAP was successful in modelling the Nariva catchment, the program would perform much better with updated data.

6. References

Abtew, Wossenu, and Assefa Melesse. 2013. *Evaporation and Evapotranspiration.* Springer Netherlands.

Campbell, Jayaka D., Michael A. Taylor, Tannecia S. Stephenson, Rhodene A. Watson, and Felicia S. Whyte. 2010. “Future of the Caribbean from a regional climate model.” *International Journal of Climatology.*

ECLAC. 2011. *An Assessment of the Economic Impact of Climate Change on the Agriculture Sector in Trinidad and Tobago.* ECLAC.

EMA. 2008. “Nariva Swamp Restoration Initiative- Development of a Reforestation Scheme and Assessment of its Social Impact on Communities of the Nariva Swamp.” Port of Spain.

IPIECA. 2014. *Identifying and assessing water sources: Guidance document for the onshore oil and gas industry.* London: IPIECA.

ODPM. 2013. *Hazards.* Accessed December 15, 2015. http://www.odpm.gov.tt.

WRA. 2001. “National Report on Integrating The Management of Watersheds and Coastal Areas in Trinidad and Tobago.”