nature climate change

SUPPLEMENTARY INFORMATION

DOI: 10.1038/NCLIMATE1789

Integrated analysis for climate change, land-use, energy and water management strategies

1. The CLEWs Framework and scenarios for Mauritius

Given Mauritius' diverse climate, its focus to reshape agricultural land-use, its increasing dependence on energy imports, and its growing water stress, Mauritius was identified as a ideal case study for a CLEWS assessment. Mauritius was further chosen as it was known for its excellent data collection and dissemination[1], and due to the ease of defining its system boundaries by the natural borders of the island.

The inter-linkages between CLEWS were considered by soft-linking[2] individual resource models and orchestrating their model runs through ensuring common assumptions, clearly defined interactions between the individual models and an integrated calibration. The respective tools used were General Circulation Models (GCM) to estimate weather changes (IPCC, 1990; IIASA and FAO, 2012), the Long range Energy Alternatives Planning (LEAP) model (Heaps, 2008), the Water Evaluation and Planning System (WEAP) (SEI, 2011), and the Agro-Ecological Zones (AEZ) land production planning model (IIASA and FAO, 2012).

Special attention was paid to the sugar processing plants 'Medine' and 'F.U.E.L', where ethanol production was introduced in some scenarios. Medine is situated in the more water stressed western part of Mauritius, some 15 km south-west of the capital Port Louis. It processes the sugar cane of 5,700 ha of land, using the by-product bagasse to generate heat and electricity for its own use and for export to the national grid. It current capacity is 6 MW (CEB, 2009). F.U.E.L. is located about 20 km to the west of Port Louis, with an associated area of 9,500 ha. It produces electricity from both, bagasse and coal, at a maximum capacity of 27 MW (CEB, 2009). Like at Medine, waste heat from bagasse is used for sugar cane processing.

1.1 Scenario Families

All scenarios were developed to reflect current priorities and concerns of the Government of Mauritius. The models were set up to investigate the effects of increases in local ethanol production, taking climate change into consideration (Proag, 2006; Government of Mauritius, 2009). The produced ethanol is added to the fuel mix of the local car fleet in order to reduce gasoline imports, or exported if deemed beneficial.

In addition to a "Business as Usual" (BAU) case, the following two families of scenarios were set up:

- **Scenario family 1:** The sugar processing plants 'Medine' and 'F.U.E.L' are converted to produce ethanol instead of sugar from 2015 onwards. Both, first and second generation ethanol production is assessed.
- **Scenario family 2:** Additionally, the effects of climate change are simulated by decreasing rainfall linearly to 20.4% during the period from 2010 to 2030. This corresponds to a 'worst case' climate change scenario based on the different GCM climate models. The BAU and the first generation ethanol production scenario were

---

[1] E.g., via the website of the Central Statistics Office (CSO Mauritius, 2012).

[2] Opportunities for a single, fully integrated tool are currently being explored as part of a KTH (Royal Institute of Technology) Division of Energy Systems Analysis effort, and elsewhere.

reassessed. Further, the potential of a new crop to replace sugar cane at Medine and F.U.E.L. was investigated in.

2. REFERENCES

CEB, 2009. Taking the Lead in Conservation - 2008 Annual Report. Central Electricity Board, Mauritius.

CSO Mauritius, 2012. Central Statistics Office [WWW Document]. Statistics Mauritius. URL http://www.gov.mu/portal/site/cso/

Government of Mauritius, 2009. Long-Term Energy Strategy 2009 - 2025. Ministry of Renewable Energy & Public Utilities.

Heaps, C., 2008. An Introduction to LEAP. Stockholm Environment Institute.

IIASA, FAO, 2012. Global Agro-ecological Zones - Model Documentation (GAEZ v.3.0). International Institute of Applied Systems Analysis & Food and Agricultural Organization, Laxenburg, Austria & Rome, Italy.

IPCC, 1990. Climate Change: The IPCC Scientific Assessment. Intergovernmental Panel on Climate Change.

Proag, V., 2006. Water resources management in Mauritius. European Water 15, 45–57.

SEI, 2011. WEAP Water Evaluation and Planing System - User Guide. Stockholm Environment Institute, Somerville, MA, USA.

2. The CLEW Land Use model for Mauritius – the Agro-Ecological Zones Methodology

In the land-use analysis, a detailed raster based land use model of Mauritius was prepared using the Agro Ecological Zoning (AEZ) model developed by the International Institute for Applied Systems Analysis (IIASA, 2011). The model can be scaled to suit regional needs but also exists at a global level (GAEZ). With help of the AEZ the production potential of crop from farmland, as well marginal land for the total land area of Mauritius can be estimated. Moreover, the AEZ calculates irrigation requirements under different climate conditions as well fertilizer input required by different crops under different conditions. Additionally a crop calendar can be simulated showing most suitable planting seasons (e.g. depending on rainfall pattern) and possible crop rotations or crop cycles. The resolution for the model was deliberately chosen to be very fine with a raster size of approximately 250 by 250 meters.

For the Mauritius case, the crop productivity of the island was estimated and calibrated with historic output values. Inputs were calculated in order to keep these output levels constant under a changing climate. Based on crop water requirements and crop cycle water balance, estimates of the quantity of irrigation water required are made. Four General Circulation Models (GCMs) (HadCM3 (2012), ECHAM4 (2012), CSIRO (2012) and CGCM2(2012)) (that produce enough output to undertake AEZ (27)) were used to calibrate rainfall, temperature, wind speed, sunshine hours and relative humidity pattern changes for all IPCC (2009) scenarios (A1 to B2). The resulting irrigation requirements – calculated for each raster cell - serve as input into the WEAP water model.

(When this was done, the effect of changing from sugarcane to alternative bio-energy feedstock, cash crops, or food crops was estimated – though not reported in the Nature Climate Change perspectives piece. Crop potential yield and production were simulated under the assumption of high input and management circumstances.)

2.1 Agro-ecological zones

Crop cultivation potential describes the potential agronomic upper limit for the production of individual crops under given agro-climatic, soil and terrain conditions for a specific level of agricultural inputs and management conditions. The Agro-Ecological Zones (AEZ) approach is based on various principles of land evaluation (FAO 1976, 1984 and 2007). The AEZ concept was originally developed by the Food and Agriculture organization of the United Nations (FAO).

Geo-referenced global climate, soil and terrain data are combined into a land resources database, commonly assembled on the basis of global grids. The data comprise information on precipitation, temperature, wind speed, sunshine hours and relative humidity, and are used to compile agronomically meaningful climate resources inventories. Screening procedures to: identify crop-specific limitations of prevailing climate, soil and terrain resources and evaluation with simple and robust crop models; provide estimates of maximum potential and agronomically attainable crop yields for basic land resources units under different agricultural production systems and assumed levels of inputs and management conditions. These are referred to as Land Utilization Types (LUT).

2.2 Overview of AEZ procedures

AEZ first determines agro-climatic suitability and then adjusts the estimate according to edaphic suitability based on location specific soil and terrain characteristics. The overall AEZ model structure is illustrated in Figure 1. This structure allows for stepwise review or results.

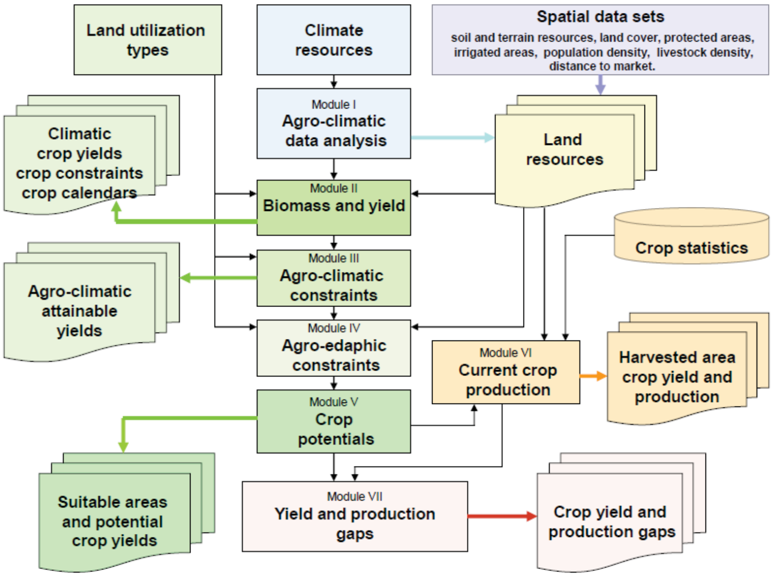


Figure 1. Overall structure of AEZ Model

Calculation procedures for establishing crop suitability estimates in AEZ include five main steps of data processing, namely Modules I through IV.

2.3 AEZ-Mauritius geographical input datasets

Climate data

Data of mean monthly temperatures and precipitation were extracted from the WorldClim 30 arc-second raster databases (Hijmans et al. 2005), a set of global climate grids with a spatial resolution of about 1 square kilometer obtained by interpolations of observed data for the period 1950-2000.

For precipitation, amap of Mauritius' mean annual rainfall 1970 – 2000 (Meteorological Services, Mauritius) was used. Further, monthly grids of precipitation were calculated using the within year WorldClim rainfall distribution (Annex – Map 1.)

For other monthly variables (incl. cloudiness, relative humidity, wind run and wet day frequency) data was obtained from the Climate Research Unit at the University of East Anglia, namely the 10 arc-minute latitude/longitude gridded average monthly climate data, version CRU CL 2.0 (New et al. 2002). Original monthly CRU 10 arc-minute climatic surfaces were interpolated to a 30 arc-second grid for Mauritius. For these variables a bilinear interpolation method was applied within the geographic information system's tool ArcGIS.

For the analysis of climate change impacts on agricultural production potential, available climate predictions of General Circulation Models (GCM) were used for characterization of future climates. GCM model outputs for individual climate attributes were processed to calculate differences of the respective means for 30-year periods with the GCM control run climate for 1961-1990. An inverse distance weighted interpolation to a 30 arc-minute grid was performed on these 'deltas' of the centre points of each grid cell in the original GCM. The changes for monthly climatic variables were then applied to the observed reference climate to generate future climate data.

Soil data

Soil data is based on the "Carte pédologique de l'Ile de Maurice" (Maps and explanatory note by P. Willaime (ORSTOM, 1984)) and soils types have been classified into six main groups according to the French CPCS system (Commission de Pedologie et de Cartography des Sols).

The soil map is supported by soil profile analysis data which provide information on texture, organic material, pH and nutrient absorption complexes. The locations of the near 250 soil profiles are associated with a soils type occurring in the 1175 individual soil map polygons. To obtain a complete soil attribute database covering all soil map polygons and all soil units, the following activities were undertaken:

(i) The soil map of Mauritius was used to subdivide association map units where applicable. Profile data was normalized in topsoil (0-30 cm) and subsoil (30-100 cm) layers, for compatibility with the Harmonized World Soil Database. The descriptions of all 70 legend units were merged with the normalized soil profile data. Further all soil map polygons have been characterized for land use / land cover characteristics and terrain slope conditions (SRTM data);

(ii) each (revised) polygon of the soil map of Mauritius was correlated with the FAO'90 soil classification system on the basis of published soil correlation tables between CPCS, available soil profile parameters and soil legend descriptions, supplemented with information on present land use and terrain sloping conditions;

(iii) from information contained in the map unit descriptions, the actual use of the land and terrain slope data, occurrences of gravel, stoniness, and depth of lithic contact and the prevalence of "meules" (piles of stones) were quantified and subsequently translated in FAO'90 compatible soil phase information, and

(iv) finally, normalized soil profile data derived from the WISE 2 (World Inventory of Soil Emission) dataset was linked to FAO'90 soil unit classification and topsoil texture designations. This was done by systematic data verification on polygon by polygon basis of Mauritius specific normalized soil profile data and the standard data as derived from WISE. On the basis of this comparison, adaptation requirements of the correlation between CPCS and FAO'90 were established and links with WISE2 updated accordingly.

The above procedures and the creation of an AEZ model compatible soil database enabled the use of the AEZ agro-edaphic crop suitability evaluation for the Mauritius soil inventory. (Annex – Map 2.)

For the agro-edaphic assessment in AEZ-Mauritius, soil attributes have been organized as described for the Harmonized World Soil Database (HWSD, Version 1.1, March 2009).

Elevation data and derived terrain slope data

A global terrain slope database was compiled using elevation data from the Shuttle Radar Topography Mission (SRTM) (Annex – Map 3). The SRTM data (Version 4) is available as 3 arc-second Digital Elevation Models (DEMs) (Jarvis et al. 2008). Data tiles covering Mauritius were downloaded from CIAT-CIS (at the CGIAR-CSI website) and processed to align with other data layers.

Land cover data

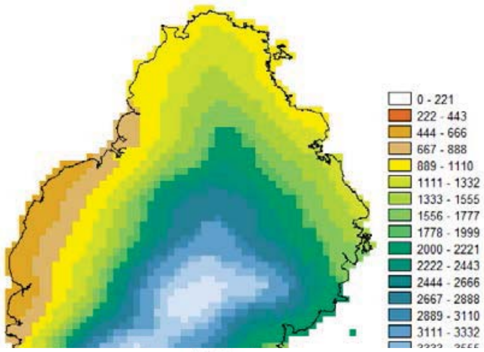
Mauritius has a total land surface area of 186,500 ha. The cultivated area is 106 000 ha, covering 57% of the total area of the island. Around 20% is occupied by built-up areas and 2% by public roads. The remaining area consists of forests, scrublands, grasslands and reservoirs (GisDevelopment.net, 2010).

For use in AEZ-Mauritius, three available GIS layers were combined, containing respectively information on (i) major land use/cover, (ii) irrigated areas, and (iii) inland water bodies. The resulting six land use/land cover categories, used for land accounting and to characterize each 3 arc-second grid-cell, are: (1) irrigated cultivated land; (2) rain-fed cultivated land; (3) forest land; (4) scrub and other vegetated land; (5) settlements; and (6) water bodies. (Annex – Map 4.)

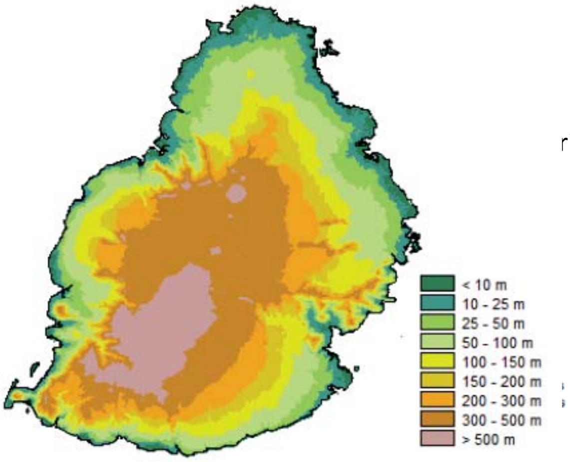
Protected areas

The World Database of Protected Areas Annual Release 2009 (WDPA 2009) and local data was applied to identify broad categories of protected areas, distinguished in the AEZ analysis as: (i) protected and (ii) strictly protected areas. The WDPA2009 includes both point and polygon data. The global polygon database was used to extract and delineate 3 arc-second grid cells of protected areas in AEZ-Mauritius.

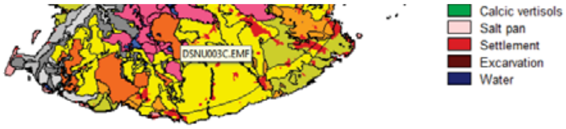
Annex – Model maps of Mauritius.



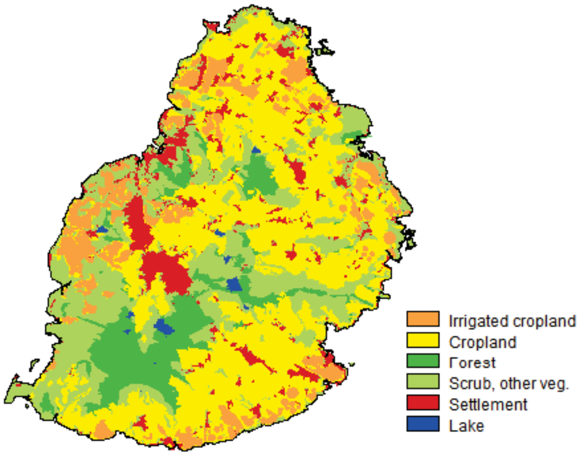
Map 1. M rid cells)



Map 3. Elevation (3 arc-second grid cells)



Map 2. Soil Map of Mauritius (FAO'90 dominant soils)



Map 4. Major land use/cover classes (3 arc-second grid cells)

References

FAO (1976). A framework for land evaluation. FAO Soils Bulletin 32. FAO, Rome, Italy.

FAO (1984a). Land Evaluation for Development. FAO, Rome, Italy.

FAO (1984b). Guidelines: Land Evaluation for Rain-fed Agriculture. FAO Soils Bulletin 52, FAO, Rome, Italy.

FAO (2007). Land evaluation, Towards a revised framework. Land and Water Discussion Paper 6. FAO, Rome, Italy.

Global Agro-Ecological Zones (GAEZ v3.0): Model Documentation. International Institute for Applied Systems Analysis, Laxenburg, Austria and FAO, Rome, Italy. Available online at: http://www.iiasa.ac.at/Research/LUC/GAEZv3.0/docs/GAEZ_Model_Documentation.pdf

Hijmans, R.J., S.E. Cameron, J.L. Parra, P.G. Jones and A. Jarvis (2005). Very high resolution interpolated climate surfaces for global land areas. International Journal of Climatology 25: 1965-1978.

Jarvis A., H.I. Reuter, A. Nelson, E. Guevara (2008). Hole-filled seamless SRTM data V4, International Centre for Tropical Agriculture (CIAT), available from http://srtm.csi.cgiar.org.

New, M., D. Lister, M. Hulme, and I. Makin, (2002). A high-resolution data set of surface climate over global land areas. Climate Research 21.

ORSTOM (1984). Ile de Maurice, Carte Pédologique á 1:50,000. Office de la Recherche Scientifique et Technique d'Outre-Mer 1983.

Van Engelen *et al.* 2005…

WDPA, (2009). World Database of Protected Areas, Annual Release 2009, Available at: http://www.wdpa.org/AnnualRelease.aspx.

CGIAR - Consortium for Spatial Information (CGIAR-CSI) website: http://srtm.csi.cgiar.org (2012-05-28)

Met Office. 2012. More information about HadCM3 can be found on website of the UK's National Weather station - "the Met Office" (UK). Available online: http://www.metoffice.gov.uk/research/modelling-systems/unified-model/climate-models/hadcm3 Accessed, May.

MPIM (Max-Planck-Institute for Meteorology). 2012. More information about ECHAM4 can be found on the website of the Max-Planck-Institute for Meteorology (Germany). Available online: http://www.mpimet.mpg.de/en/science/models/echam.html Accessed, May.

CSIRO (Commonwealth Scientific and Industrial Research Organisation). 2012. More information about CSIRO Atmospheric Research Mark 2b climate model can be found on IPCC websites. Available online: http://www.ipcc-data.org/is92/csiromk2_info.html Accessed, May.

EC (Environment Canada). 2012. The Second Generation Coupled Global Climate Model. Available online: http://www.ec.gc.ca/ccmac-cccma/default.asp?lang=En&n=40D6024E-1 Accessed, May.

HadCM3. 2012. More information about HadCM3 can be found on website of the UK's National Weather station - "the Met Office" (UK): http://www.metoffice.gov.uk/research/modelling-systems/unified-model/climate-models/hadcm3 (2012-05-29)

ECHAM4. 2012. More information about ECHAM4 can be found on the website of the Max-Planck-Institute for Meteorology (Germany): http://www.mpimet.mpg.de/en/science/models/echam.html (2012-05-29)

CSIRO. 2012. More information about CSIRO can be found on http://www.csiro.au/ (2012-05-29) and at the IPCC Data Distribution Center (http://www.ipcc-data.org/is92/csiromk2_info.html (2012-05-29))

CGM2. 2012. More information about CGCM2 can be found on http://www.ec.gc.ca/ccmac-cccma/default.asp?lang=En&n=40D6024E-1 (2012-05-29)

IPCC. 2000: Emissions Scenarios. Nebojsa Nakicenovic and Rob Swart (Eds.), Cambridge University Press, UK. pp 570. http://www.ipcc.ch/ipccreports/sres/emission/index.htm

3. The CLEW Energy Model model for Mauritius – LEAP

The energy model was set up using the Long Range Energy Alternatives Planning tool (LEAP) (Heaps, 2008). This accounting tool was used to calculate:

- the power plant dispatching and future capacity requirements;
- the ethanol production;
- changes in fuel imports to the island due to the substitution of gasoline with ethanol as well as the effects of changes in farming practices and rainfall patterns on electricity demand and generation;
- greenhouse gas emissions, both on the island, as well as external emissions associated with fuel and fertiliser supply to the island[1]; as well as
- water demand for ethanol production and power plant cooling requirements.

The energy system was set-up based on historical demand data from the period 2005 to 2009 and generation data from 2005 to 2008 (CEB, 2006, 2007, 2008, 2009; CSO Mauritius, 2007, 2008, 2009, 2010). The demand analysis focuses on electricity, petroleum products and fertilisers. Based on the previous trend, a general demand growth of 3.5% was assumed. Any additional electricity requirements for pumping for irrigation and desalination were explicitly entered in the model. Economic considerations are initially based on an oil price of 80 USD per barrel, a coal price of 60 USD per ton and a sugar export price of 420 USD per ton[2]. These figures were aligned with historic world market prices and are below the current price level. Sensitivity analyses were carried out for the individual scenarios to assess the solidness of the conclusions derived from the model.

To model the electricity generation, all power plants and co-generating processing plants that export electricity to the national grid were modeled individually, taking future power expansions plans into account (Government of Mauritius, 2009; Elahee, 2011). Efficiencies and capacity factors of power plants were calibrated from historical data. Power plants were dispatched giving priority to those with the lowest running costs. Capital, operating and fuel costs were chosen according to data based on assessments of comparable international plants (IAEA, 2008; IEA et al., 2010). Refer to the annex for an overview of key power plant input data.

While only a small fraction of the overall generation capacity, hydropower is strongly affected by the climate change assumptions of the scenario family 2. This is due to reduced inflows, potentially increased reservoir outflows and diversions to meet other water demand in times of shortage. A yearly ‘hydro factor’ was calculated to derate the hydropower

---

[1] Including those associated with oil refining, coal processing and fertiliser production. Note that in scenarios where sugar cane is used for ethanol instead of sugar production, external economic effects outside of Mauritius were not considered. Those could be significant, yet are difficult to assess. For example, the loss of area for sugar cane farming could be compensated by increases in farm land in other sugar producing countries, potentially leading to deforestation and associated greenhouse gas emissions.

[2] These figures were aligned with historic world market prices and are below the current price level. Sensitivity analyses of the costs would be essential to derive solid policy recommendations, but are less relevant for the purpose of this paper, which is to compares differences in key energy dynamics with and without CLEWS.

generation should the available storage volumes decrease below a certain threshold due to reduced water availability. The smaller hydropower plants which are not connected to reservoirs were assumed to reduce their generation by the same share the average river flow is reduced.

The following table provides the main input data for modelling the individual power plants.

Table: Power Plant Data

Power Plants	Efficiency	Maximum availability	Capacity credit	Capital cost	Fixed O&M cost	Variable O&M cost	Fuel cost	Life time	Feedstock Fuel
	%	%	%	Mio. USD/MW	1000 USD/MW	USD/MWh	USD/GJ	Years	-
Beau Champ	24	70.3	70.3	2.3	0	7.6	0	30	Coal, Bagasse
Belle Vue	24	65.9	65.9	2.3	48	5.4	1.2	30	Coal, Bagasse
Cascade Ceclie	100	13.2	4.5	4.3	0	5.8	0	30	Hydro
Champagne	100	11.4	90	2.4	0	2.1	10.9	30	Hydro
CTDS	25	91.6	91.6	2.1	48	6.5	2.3	30	Coal
CTSav	24	85	85	2.3	48	5.4	1.2	30	Coal, Bagasse
F.U.E.L.	24	73.3	73.3	2.3	48	5.2	1	30	Coal, Bagasse
Ferney	100	24.6	90	2.4	0	2.1	10.9	30	Hydro
Fort George	44.2	85	95	0.8	35	2.1	10.9	30	Oil
Fort Victoria	42	58	95	0.8	35	2.1	10.9	30	Oil
La Chaumiere	100	85	85	25.5	0	49.4	0	30	Waste
La Ferme	100	12.7	4.4	4.3	0	5.8	0	30	Hydro
La Nicoliere Feeder canal	100	60	60	4.3	0	3.5	0	30	Hydro
Le Val	100	12	4.1	4.3	0	5.8	0	30	Hydro
Magenta	100	20.4	7.1	4.3	0	5.8	0	30	Hydro
Mare Chicose Landfill Gas	100	76	76	2.9	0	33	0.4	30	Biogas
Medine	23	25.5	0	2.3	0	14.3	0	30	Bagasse
Mon Desert Alma	23	36.5	0	2.3	0	8	0	30	Bagasse
Mon Loisir	23	53.5	0	2.3	0	4.9	0	30	Bagasse
Mon Tresor Milling	23	41.3	0	2.3	0	6.4	0	30	Bagasse
New Geothermal	100	86	86	3.4	0	18.2	0	30	Heat
New PV	100	20	0	6	0	33.3	0	30	Solar
Nicolay	26	85	95	0.8	35	2.1	10.9	30	Kerosene
Pointe aux Caves	25	85	85	2.1	48	6.5	2.3	30	Coal
Reduit	100	25	8.6	4.3	0	5.8	0	30	Hydro
Riche En Eau	23	27.1	0	2.3	0	12.2	0	30	Bagasse
Savannah	23	40.1	0	2.3	0	7.3	0	30	Bagasse
St. Louis	39.2	85	95	0.8	35	2.1	10.9	30	Oil
Tamarind Falls	100	26	9	4.3	0	5.8	0	30	Hydro
Thermal not exported to CEB	24	85	85	2.3	48	3.5	0	30	Coal, Bagasse
Union St. Aubin	23	57.3	0	2.3	0	5.1	0	30	Bagasse

1. REFERENCES

CEB, 2006. Balancing our Responsibilities - 2005 Annual Report. Central Electricity Board, Mauritius.

CEB, 2007. Coping with Global Challanges - Annual Report 2006. Central Electricity Board, Mauritius.

CEB, 2008. Sowing the Seeds of Change - 2007 Annual Report. Central Electricity Board, Mauritius.

CEB, 2009. Taking the Lead in Conservation - 2008 Annual Report. Central Electricity Board, Mauritius.

CSO Mauritius, 2007. Digest of Energy and Water Statistics 2006. Central Statistics Office, Port Louis, Mauritius.

CSO Mauritius, 2008. Energy and Water Statistics 2007. Central Statistics Office, Port Louis, Mauritius.

CSO Mauritius, 2009. Digest of Energy and Water Statistics 2008. Central Statistics Office, Port Louis, Mauritius.

CSO Mauritius, 2010. Energy and Water Statistics 2009. Central Statistics Office, Port Louis, Mauritius.

CSO Mauritius, 2012. Central Statistics Office [WWW Document]. Statistics Mauritius. URL http://www.gov.mu/portal/site/cso/

Elahee, M.K., 2011. Sustainable energy policy for small-island developing state: Mauritius. Utilities Policy 19, 71–79.

Government of Mauritius, 2009. Long-Term Energy Strategy 2009 - 2025. Ministry of Renewable Energy & Public Utilities.

Heaps, C., 2008. An Introduction to LEAP. Stockholm Environment Institute.

IAEA, 2008. Electricity Generation System Analysis for Integration of Nuclear Power into an Energy System with a High Share of Co-Generation Technologies: A Case Study of Belarus. International Atomic Energy Agency, Vienna, Austria.

IEA, OECD, NEA, 2010. Projected Costs of Generating Electricity, 2010th ed. International Energy Agency, Paris.

IIASA, FAO, 2012. Global Agro-ecological Zones - Model Documentation (GAEZ v.3.0). International Institute of Applied Systems Analysis & Food and Agricultural Organization, Laxenburg, Austria & Rome, Italy.

IPCC, 1990. Climate Change: The IPCC Scientific Assessment. Intergovernmental Panel on Climate Change.

Proag, V., 2006. Water resources management in Mauritius. European Water 15, 45–57.

SEI, 2011. WEAP Water Evaluation and Planing System - User Guide. Stockholm Environment Institute, Somerville, MA, USA.

3. The CLEW Water Management Model model for Mauritius – WEAP

The water resources system of the Island of Mauritius was modeled using the Water Evaluation and Planning system (WEAP). The WEAP model is a demand driven water resource allocation model that includes the capability for simulating rainfall runoff processes (Yates, et al., 2005). The combination of the resource allocation and physical hydrology modules allows WEAP users to simulate the entire water resources system using meteorological data, infrastructure operations rules, and water demand characteristics as inputs. The combined system is ideal for analysis of the effects of climate change on water resources systems as the effects of climate change are introduced in the input meteorological data. For the model of Mauritius, over 70% of the island area was represented with 61 catchment objects which calculated inflow to 28 rivers. Catchment boundaries were delineated based on drainage basin boundaries and observed rainfall patterns. The highly orographic nature of rainfall in this setting required careful discretization of the model domain in order to capture the observed spatial variability. Within each catchment object, land area was subdivided between different land cover types including forest, brush land, settled areas, and cultivated land. For each land cover type, the model calculated hydrological fluxes including surface runoff, infiltration, evapotranspiration, interflow, and deep percolation to the groundwater system. Groundwater was represented using simple linear reservoirs with one representing each of the 5 major aquifer systems on the island. Water management infrastructure was built into the model including the 5 major water transfer systems on the island. These systems include 12 canals and 8 reservoirs. They serve to transfer water from the high precipitation areas of the central highlands to the municipal and agricultural demands in the northern and western portions of the island where rainfall rates are lower. Demands for water were represented as using spatially distributed population data, per capita water use rates, and industrial water requirements. For areas served by irrigation, crop water demands were calculated using the evapotranspiration algorithms provided in the catchment objects. All municipal, industrial, and irrigation demands were supplied with water from surface and groundwater sources with a preference for surface water supply.

Model calibration was focused on properly calculating sugar cane evapotranspiration rates as sugar cane cultivation is by far the single largest land cover type. The main calibration parameters were the monthly crop coefficients which scale reference evapotranspiration rates to produce sugar cane evapotranspiration rates. These rates were compared to those calculated by the methods described in FAO 56 (Allen et al, 1998) and observation data. Comparison of simulated and observed stream flows for catchments with relatively little water resources infrastructure show the model performed well (e.g. Figure 1). Model performance was not as good in catchments where major infrastructure alter the flow (Figure 2). This was due to a lack of information on system operations which could be included in future versions of the model.

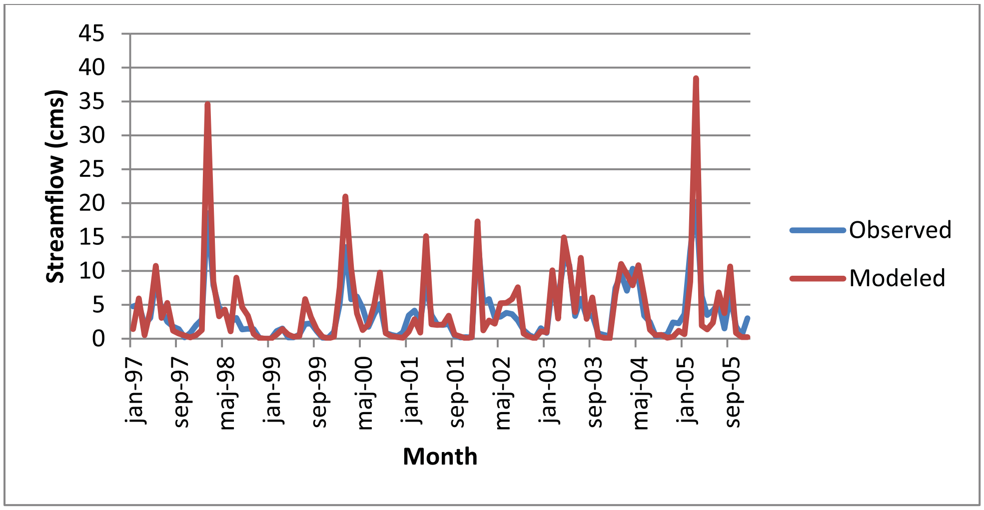


Figure 1. Observed and modeled stream flow at gage E13 on the Grand River South East (GRSE).

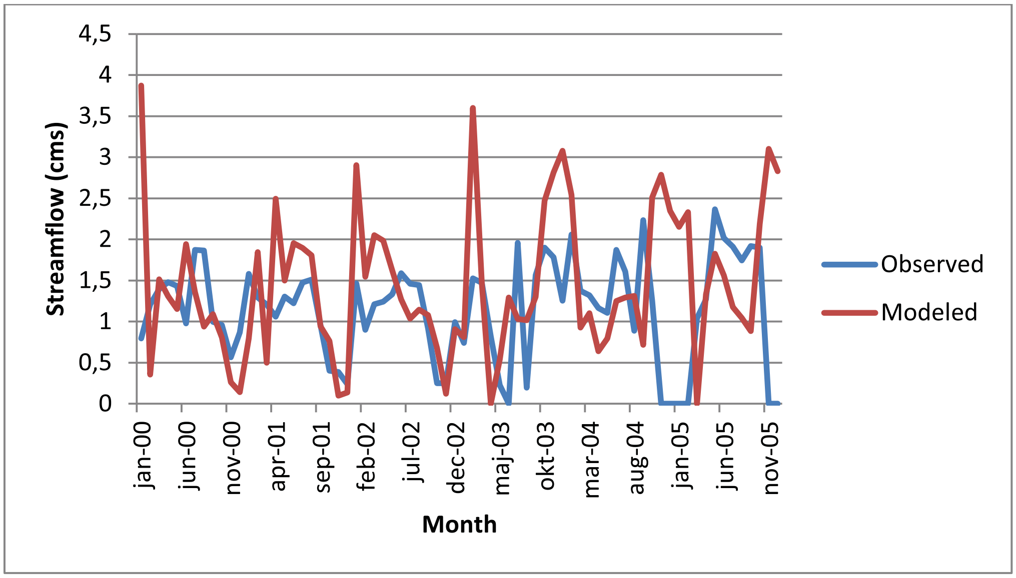


Figure 2. Observed and modeled stream flow at gage E008c, flow in La Pipe-Nicoliere feeder channel at Nicoliere Reservoir.

References

Allen, R.G., L.G. Pereira, D. Raes, and M. Smith, 1998. FAO Irrigation and Drainage Paper No. 56, Crop Evapotranspiration. United Nations Food and Agriculture Organization, Rome, Italy.

Yates, D., J. Sieber, D. Purkey, and A. Huber-Lee, 2005. WEAP21 – A Demand-, Priority-, and Preference-Driven Water Planning Model Part 1: Model Characteristics. Water International 30:487- 500.