# Water Resources Model for Kenneti Basin South-Sudan

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# Preface

The Governments of South Sudan (GoSS) and The Netherlands (GoN) initiated a program for the Water Sector in Eastern Equatoria State (ProWasEES). The focus of this program is on the Kenneti River, which is one of the permanent streams draining the Imatong Mountains at the southern border of South Sudan. The overall objective of this program is that "*Kenneti Watershed is managed in an integrated and sustained manner*".

FutureWater's role in this project was to develop an integrated land and water resource management (ILWRM) model for scenario development. The results of this work are described in this report. The model was developed using all the available local data, combined with global public domain data. Data collection for further fine-tuning can follow during operationalizing of the model.

The project was granted by ZOA on 30 April 2015 and ran from 4 May 2015 to September 2015.

The Consultants wants to express their thanks to staff of ZOA in supporting the project and provide information and feedback on earlier versions of the model and the report. Especially Harm Bouta and Peter de Lange have provided excellent support and input. The feedback and support for the capacity building component by Theo Hendriksen and Fabian Musila from NIRAS was essential. Finally, the participation staff from the various Ministries during the workshop was very enthusiastic and essential for fine-tuning of the model.

# Contents

# Tables



# Figures

# 1 Introduction

Kenneti River is one of the permanent streams draining the Imatong Mountains at the southern border of South Sudan. Administratively the river's catchment area falls within Torit, Lopa/Lafon and Ikotos Counties of Eastern Equatoria State (EES). Torit Township is a fast growing urban centre and its demand for domestic water development is sharply increasing. With the settlement of returnees throughout Kenneti Catchment also the demand for rural water supply water is growing fast. As a result of uncontrolled opening of new farms in the upper Kenneti Catchment, the vegetation cover in areas with higher rainfall is under pressure. This together with the fact that valley bottom farming is upcoming in the middle Kenneti Catchment makes that the water supply of downstream population is at risk of deregulation.

As there is an urgent need for informed decision making in ongoing and upcoming land and water resource development plans, the governments of South Sudan and the Netherlands (GoN) initiated a program for the Water Sector in Eastern Equatoria State (ProWasEES). It aims to contribute to a situation whereby: i) water-related natural resource conflicts are minimized and ii) the population of EES have access to safe drinking water and certified sanitation facilities. Focus will be on the Kenneti River Basin. The overall objective of this program is that "Kenneti Watershed is managed in an integrated and sustained manner".

In order to reach this objective an integrated land and water resource management (ILWRM) model is required, which is able to mimic past and current conditions, as well as analyzing a variety of future scenarios (Figure 1). This model was developed by FutureWater. Initially it will operate with a limited amount of local data, combined with global public domain data. Data collection for further fine-tuning can follow during operationalizing of the model.

This report summarizes building of a WEAP model to assess current and future water resources issues in the Kenneti Basin.

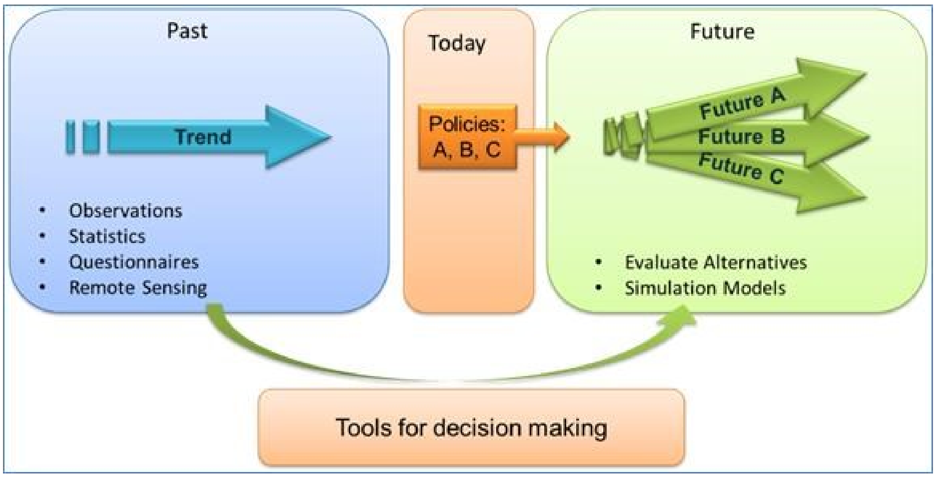



**Figure 1: Application of models to evaluate future water resources developments based on today's policies and different scenarios.**

# 2 Upper Kenneti Watershed

## 2.1 The Imatong Mountains

The Imatong Mountains are located in the Eastern Equatoria State of South Sudan, and extend into the Northern Region of Uganda. They lay mainly within Torit County (western part) and Ikotos County (eastern part), some 190 km southeast of Juba.

The highest point in the mountains is Mount Kenneti in the southeast at 3187 meters, which also makes it the highest point of South Sudan. The mountain range rises steeply from the surrounding plains, which slope gradually down from about 1,000 meters in the south to 600 meters in the north. The change in elevation between the lowest point at Torit (600 meters) and the highest point (3187 meters) is 2587 meters over a distance of only 65 kilometers. Between Katire (1000 meters) and the highest point the elevation is 2170 over just 16 km. The mountains are formed of crystalline basement rock and have dense forests supporting diverse wildlife.

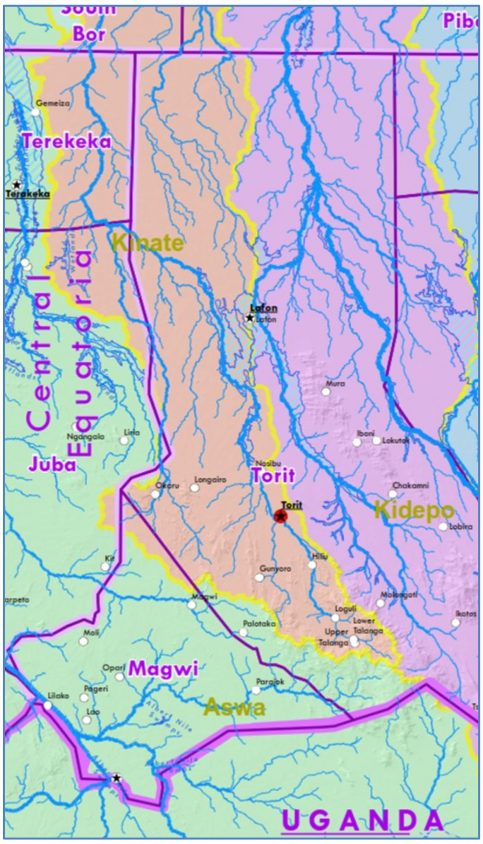



**Figure 2: Overview of Kenneti Basin (left) and bridge at Torit (right).**

## 2.2 Kenneti River

Several significant (year-round) rivers spring in the Imatong Mountains, including the Kenneti River, the Atepi River, the Koss (Koff) River; and the Agono River. The ProWasEES project focuses on the Kenneti Watershed (UKW is used in other reports for the area upstream of Torit only), while this project includes the area between Torit and Lafon as well. The total area of the current study extent is 3715 km$^2$. The Kenneti River rises on the slopes of Mount Kenneti, flowing down past Katire and Torit, ending up in the Badigeru Swamps. These swamps west of Jebel Lafon are 100 kilometers long and 5 to 25 kilometers wide, depending on the water level. The high slope of the mountains causes the water to rush down via a series of waterfalls. In the upper reaches the water flows slowly, sometimes forming swamps.

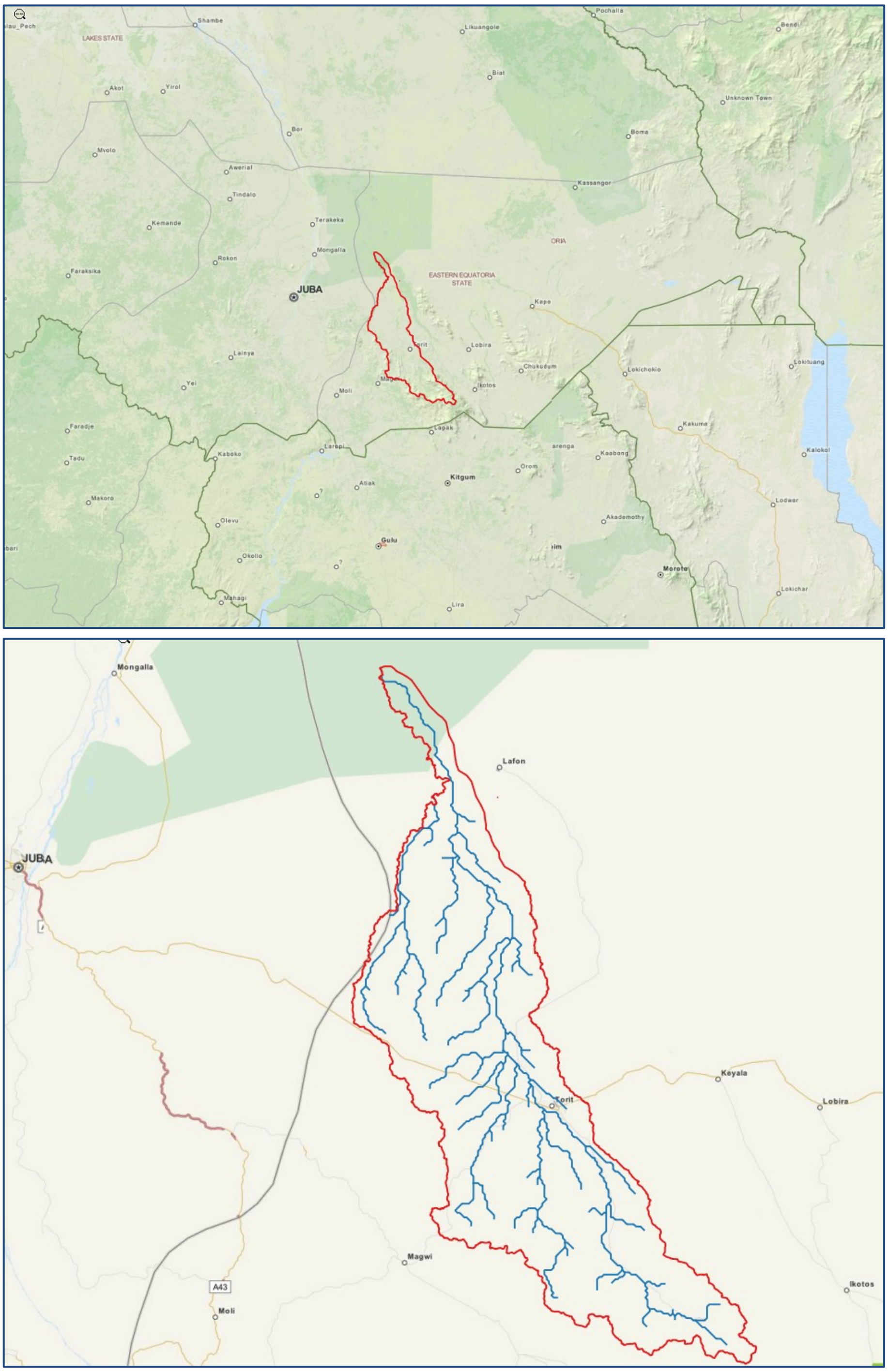



**Figure 3: Location of Kenneti Basin (top) and outline of the study domain.**

## 2.3 Climate

The region has an equatorial climate but varies strongly with altitude. Since the Imatong Mountains stand out high above the surrounding landscape they have a major impact on the climate in the area. Rainfall varies between 2200 mm/yr in Gilo to 989 mm/yr at Torit. The vast majority of the rain falls between April and the end of October and very little rain falls in the December – February period. The lowest average temperature is 14 ºC in November and December and the highest is 34 ºC in February.

# 3 Previous Studies

Other studies have been undertaken on the Kenneti River Basin and its water resources. However, some of these studies are outdated, while others lack reliable data or information or analysis. Recently the ProWasEES project has generated some useful reports. A summary of these studies is presented here, focusing on the availability of relevant information and data for the current study.

- **Jonglei Investigation Team** (1951)
  - The study has also collected some discharge data (1950-1952), but also this data could not be retrieved.

- **Bonifica** (1983). "*The development of hydro-electrical potential in the Southern Sudan*"
  - This study has collected some discharge data (1959-1963) but data cannot be retrieved.

- **African Wildlife Foundation** (2014) "*Assessment of water vulnerabilities and opportunities to build resilience through improved water management of the Upper Imatong Mountain watershed, Eastern Equatoria State*"
  - The study has no specific information on streamflow. Information on flows was based on results of the model SPATSIM (SPAtial and Time Series Information Modelling), which is based on the Pitman approach. It is a lumped hydrological model that runs on monthly time steps. Rainfall data was based on the CRU annual rainfall data.

- **Bilateral Programme in the Water Sector** (2012). "*Report on Reconnaissance and Scoping Mission in Eastern Equatoria State March 13 - 31, 2012 FINAL REPORT*"
  - The report describes the scope of the entire program and it recommends to focus in the western part of the state on "water for productive use" (hydro-power, agriculture, safe drinking water, animal husbandry and wetland protection) within a perspective of integrated water resource management. Therefore a deliberate choice was made for the Kenneti Watershed, extending from its source at Katire town to its mouth at Kud in Lafon/Lopa County.

- **SMEC** (2012). "*Water resources assessment study; Torit Eastern Equatoria State*"
  - The Zygos Model was used which is a lumped hydrological model. A monthly time step was used and model period was the period 1923 – 1937. The main conclusion is that total discharge from the Kenneti River is more than adequate for supplying the annual design water demand for Year 2032.

- **ZOA/NIRAS** (2015) "*Feasibility Assessment for Sustainable Irrigated Crop Production in the Kenneti River Catchment*"
  - The report describes the options to develop irrigated agriculture in the region.

- **ZOA/NIRAS** (2015). "*Importance and Potential of Wetland Resources Torit and Lopa/Lafon Counties, Eastern Equatoria State*"

  - The study provides a baseline ecologic and socio-economic situation and potential of Wetland Resources. It highlights the challenges and opportunities that exist as well as the possible areas for intervention.

- **ZOA/NIRAS** (2015). "*Assessment of soil erosion, run-off and vegetation cover status in relation to land management practices in the Kenneti River Catchment area of Eastern Equatoria*".
  - This extensive study found that current natural resource management systems have resulted in a decrease of vegetation cover both on the plains and in the Imatong Mountains. Also high levels of sheet erosion and ensuing gross soil losses in the Imatong Mountains have been monitored.

# 4 Methods and Tools

## 4.1 WEAP

Previous analyses and modeling activities in the Kenneti Basin revealed that water shortage might hamper further economic development in the region. However, these analyses and model studies are quite outdated because of using obsolete modeling frameworks and old datasets. In addition, they do not consider the most recent strategic plans and only focused on the upper part of the watershed north of Torit, while the downstream part of the Kenneti basin should also be included for a comprehensive picture. It was therefore decided to develop a new modeling framework for the Kenneti basin.

A user-friendly tool is needed to match water supplies and competing demands, and to assess the upstream–downstream links for different management options in terms of their resulting water sufficiency or unmet demands, costs, and benefits. It was decided to build the model for the Kenneti basin using the Water Evaluation And Planning (WEAP) system, which was developed to meet these challenges. More specifically, the WEAP tool was selected as it (i) is designed to work at basin scales, (ii) focuses on water demand with the link to water resources, (iii) has a strong scenario-based setup, (iv) is widely used, (v) is freely available to users in developing countries, (vi) has the amount of physical detail needed for this project (Figure 4) and (vii) has a user-friendly interface. WEAP is a commonly used tool in strategic water resource planning and scenario assessment and has been applied in many regions around the world. A summary of WEAP's capabilities is provided here, while detailed information can be found in the WEAP manual which can be freely downloaded from *http://www.weap21.org/.*

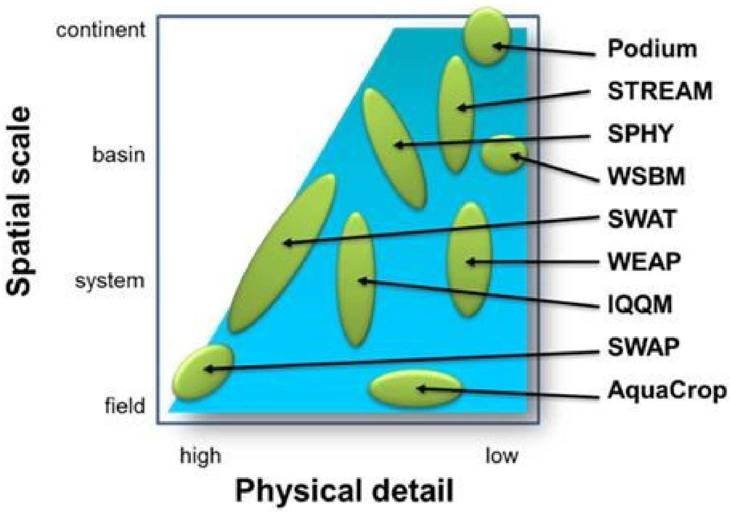



**Figure 4: Relation between spatial scale and physical detail in water allocation tools. The green ellipses show the key strength of some well-known models. (Source: Droogers and Bouma, 2014)**

WEAP uses the basic principle of water balance accounting: total inflows equal total outflows, save for any change in storage (in reservoirs, aquifers and soil). It represents a particular water system, with its main supply and demand nodes and the links between them, both numerically and graphically. Delphi Studio programming language and MapObjects software are employed to project catchment attributes such as river and groundwater systems, demand sites, wastewater treatment plants, catchment and administrative political boundaries in a spatial environment (Yates *et al.* 2005). Using the hydrological function within WEAP, the water supply from rainfall is depleted according to the water demands of the vegetation, or transmitted as runoff and infiltration to soil water reserves, the river network and aquifers, following a semi-distributed, parsimonious hydrologic model. These elements are linked by the user-defined water allocation components inserted into the model through the WEAP interface. The concept-based representation of WEAP means that different scenarios can be quickly set up and compared, and it can be operated after a brief training period.

Users specify allocation rules by assigning priorities and supply preferences for each node; these preferences are mutable, both in space and time. WEAP then employs a priority-based optimization algorithm to allocate water in times of shortage. The challenge is to distribute the supply remaining after satisfaction of catchment demand. Water delivery to various demand elements is optimized, according to their ranked priority and accounting for in-stream flow requirements. This is accomplished using an iterative, linear programming algorithm. The demands of the same priority are referred to as “equity groups”. These equity groups are indicated in the interface by a number in parentheses (from 1, having the highest priority, to 99, the lowest). WEAP is formulated to allocate equal percentages of water to the members of the same equity group when the system is supply-limited.

In order to undertake an assessment of water resources with WEAP, the following operational steps can be distinguished:

- The time frame, spatial boundary, system components and configuration are defined. The model can be run over any time span where runoff routing is not a consideration, a monthly period is used quite commonly.
- System management is represented in terms of supply sources (surface water, groundwater, inter-basin transfer, and water reuse elements); withdrawal, transmission and wastewater treatment facilities; water demands; and pollution generated by these activities. The baseline dataset summarizes actual water demand, pollution loads, resources and supplies for the system during the current year, or for another baseline year.
- Scenarios are developed, based on assumptions about climate change, demography, development policies, costs and other factors that affect demand, supply and hydrology. The drivers may change at varying rates over the time frame relevant for planning. The time horizon for these scenarios can be set by the user.
- Scenarios are then evaluated in respect of desired outcomes such as water sufficiency, costs and benefits, compatibility with environmental targets, and sensitivity to uncertainty in key variables.

# 5 Building WEAP for Kenneti Basin

## 5.1 Introduction

Building the WEAP model for Kenneti requires various sets of data. Data can be divided into the following main categories:

- Model building
    - Static data[1]
        - Soils
        - Land use, land cover
        - Population
    - Dynamic data
        - Climate (rainfall, temperature, reference evapotranspiration)
        - Water demands
        - Reservoir releases (if present)
        - Flow requirements
- Model validation/calibration
    - Streamflow

Data were obtained from various sources and combined into a consistent set of input for WEAP. The following sections will summarize the building of the model, details can be found in the model input data itself.

## 5.2 Data

### 5.2.1 River network

The river network was obtained from United States Geological Survey (USGS):

- http://hydrosheds.cr.usgs.gov/datadownload.php?reqdata=15rivs
- Dataset: af_riv_15s.zip (49.5 MB)
- Data were clipped to the Kenneti basin and surroundings

### 5.2.2 Gauging stations

At the moment no operational gauging stations are present in the region. It is planned to install nine gauging stations in the Kenneti River Basin. Three gauging stations will be placed in the main branch, the other six gauging sites will be placed in different tributaries of the Kenneti River. A detailed description can be found in the Annex. In the future, the resulting records of river discharge can be used for validation and fine-tuning of the WEAP model.

[1] Nota that static data can still vary over longer time frames, but are fairly constant over days/weeks

### 5.2.3 Digital Elevation Model

In order to delineate subbasins and to calculate runoff rates, models need information on elevation, often referred to as a Digital Elevation Model (DEM). The SRTM (Shuttle Radar Topography Mission) is the most widely used and can be downloaded for free from CGIAR-CSI:

- http://srtm.csi.cgiar.org
- Two files were needed to cover the required geographical extent:
  - srtm_43_11.zip
  - srtm_43_12.zip

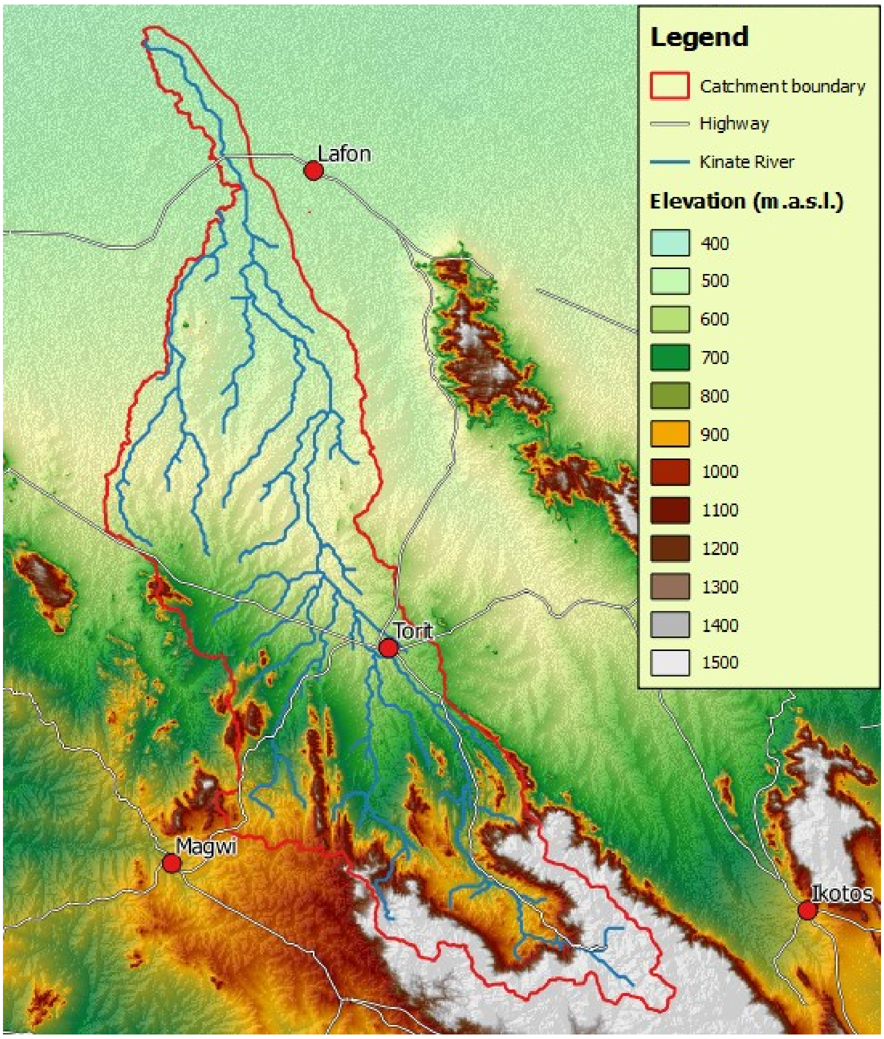



**Figure 5. Digital Elevation Model (source: SRTM)**

### 5.2.4 Land cover

Land cover information of the area is needed for the model to calculate hydrological processes such as slow runoff, fast runoff, and baseflow. Various land cover datasets are available. It was decided to use the one that is used by the ProWasEES project which is referred to as "sd-landcover-ge" and is based on AfriCover. To use the land cover data in WEAP some of the overlapping classes were combined resulting in a map with six classes. The map can be seen in Figure 6 and the distribution of land cover per catchment in Table 1.

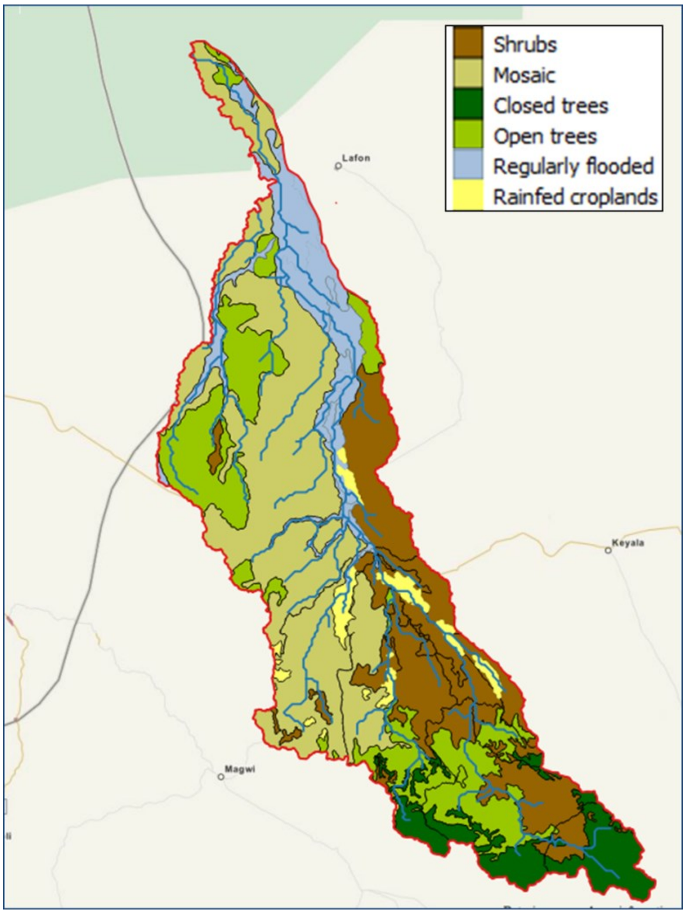



**Figure 6. Land cover data as used for the WEAP model.**

**Table 1. Distribution of landcover over the catchments in percentage of the total area of a catchment.**

| Catchment | km2 | Shrubs | Mosaic | Closed trees | Open trees | Regularly floode | Rainfed croplanc |
|---|---|---|---|---|---|---|---|
| High | 170 | 22.7 | 0 | 76.9 | 0.4 | 0 | 0 |
| Middle | 431 | 35.7 | 0 | 23.8 | 40.6 | 0 | 0 |
| Low | 161 | 86.7 | 0 | 0 | 0 | 0 | 13.3 |
| Iyodo | 529 | 37.6 | 28.1 | 11.1 | 19.1 | 0.1 | 3.8 |
| Lerere | 319 | 7.1 | 78.8 | 0 | 1.5 | 1.8 | 10.8 |
| Down | 1981 | 10.7 | 47.6 | 0 | 20.1 | 20.9 | 0.7 |
| Halihoi | 61 | 70.7 | 0 | 0 | 8.9 | 0 | 20.5 |
| Kiwa | 63 | 45.7 | 0 | 10.6 | 43.7 | 0 | 0 |

### 5.2.5 Climate

Starting from 1-Jan-2014 a meteorological station has been operational in Torit. Measured rainfall and temperature records are shown in Figures 7, 8 and 9. Total observed annual precipitation in 2014 was only 300 mm (Figure 7), whereas according to the SMEC report (page 10) the average annual rainfall for Torit is between 1000 and 1200 mm. It was therefore decided not to use these observations but make use of the satellite-derived rainfall from FEWS-NET (Early Warning and Environmental Monitoring Program) instead.

FEWS-NET data was downloaded and representative points were selected for the following four locations:

- Imatong mountains
- Katire

- Torit
- Lafon

Rainfall data for these four locations are plotted in Figure 9 and are used in the WEAP model.

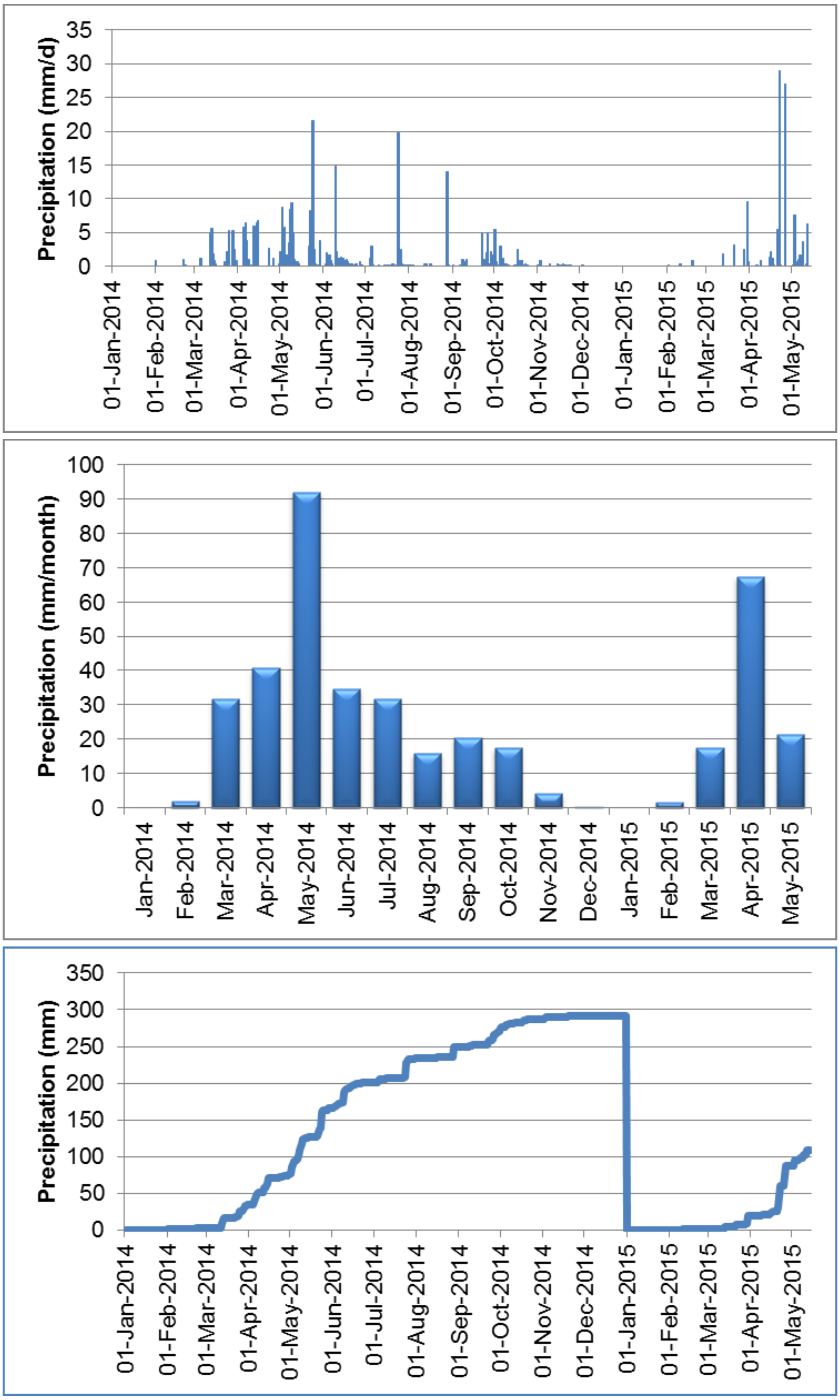


**Figure 7. Rainfall data Torit; daily (top), monthly (middle) and annual cumulative (bottom).**

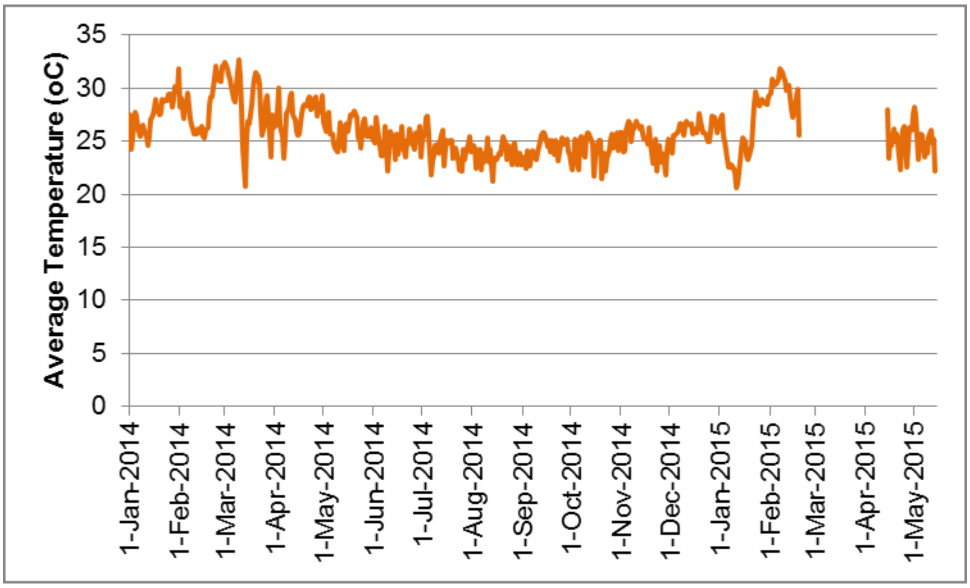
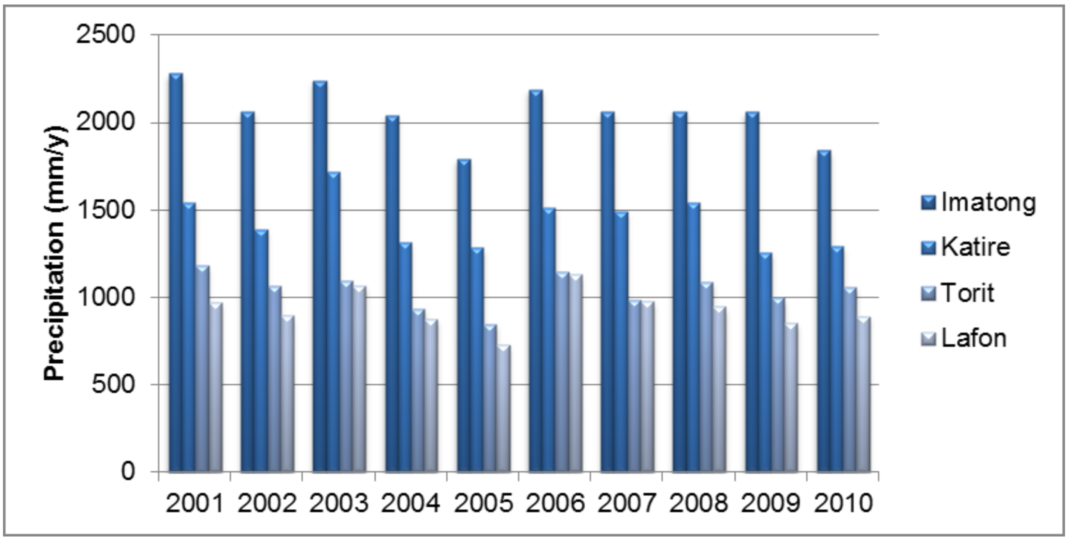



**Figure 8. Average daily temperature Torit as observed by the newly installed meteorological station.**



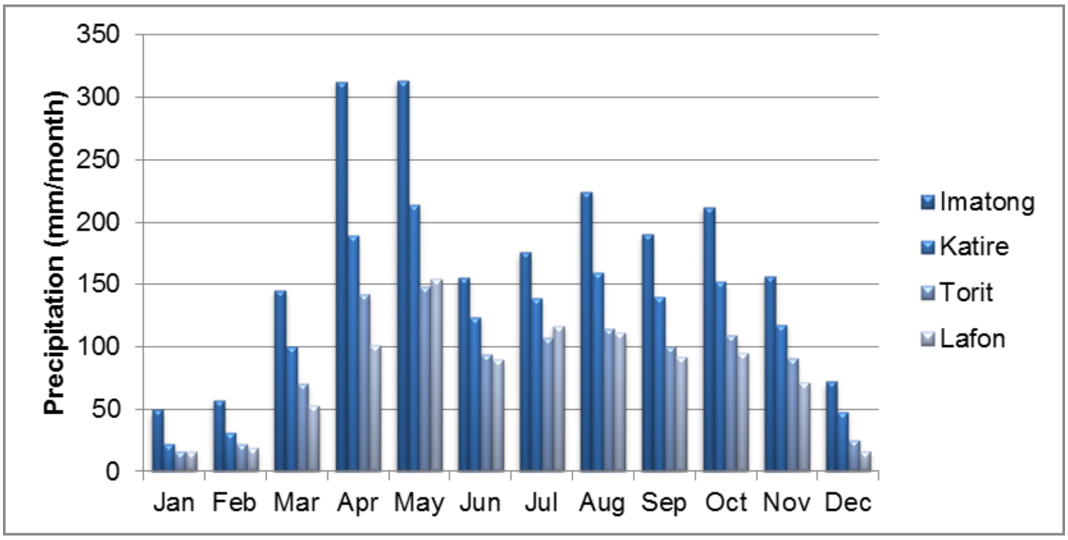



**Figure 9. Yearly (top) and monthly (bottom) rainfall for four locations in the Kenneti basin. (Source: FEWS-NET).**

### 5.2.6 Urban demand

Urban demand was defined as follows:

- Connected: 120 liter per person per day
- Not connected: 30 liter per person per day

### 5.2.7 Livestock water demand

- Per capita 0.1 cattle
- 35 liter per cattle per day

### 5.2.8 Crop water allocation

- Per capita 0.1 hectare
- No irrigation

### 5.2.9 Demand for downstream wetland

For the baseline environmental flow requirement for downstream was set to zero for the current situation. In the scenario analysis (see section 6.3 Future Developments) this will be further explored.

### 5.2.10 Boundary, area extent and background layers

The total area included in the model was 3715 $km^2$. The basin was divided into eight catchment (Table 1 and Figure 10).

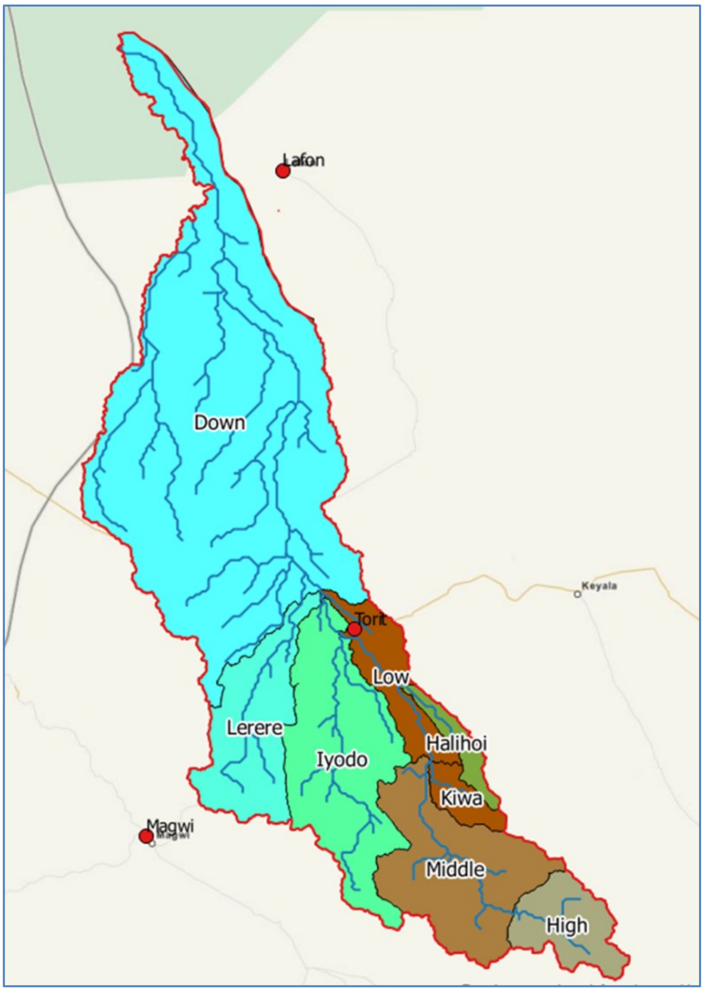


**Figure 10. Area and catchment included in the WEAP model.**

### 5.2.11 Landsat imagery

Since conflicting information on the water consumption of the downstream wetlands was received, it was decided to use Landsat satellite information. For some selected days during the season the greenness of the area was investigated.

These data can be downloaded freely using the following details:

- http://earthexplorer.usgs.gov/
- Select Landsat 8
- WRS2: Path 172, Row 57
- or coordinates: Latitude 4.40 degrees, Longitude 32.57 degrees
- Landsat Archive L8 OLI/TIRS
- Downloaded as “LandsatLook images with Geographic Reference” (7.7 MB)

From the imagery it was clear that the downstream wetlands receive water the entire year and that evaporation will be substantial from these wetlands (e.g. Figure 11). Details of the imagery can be found in the Appendix.

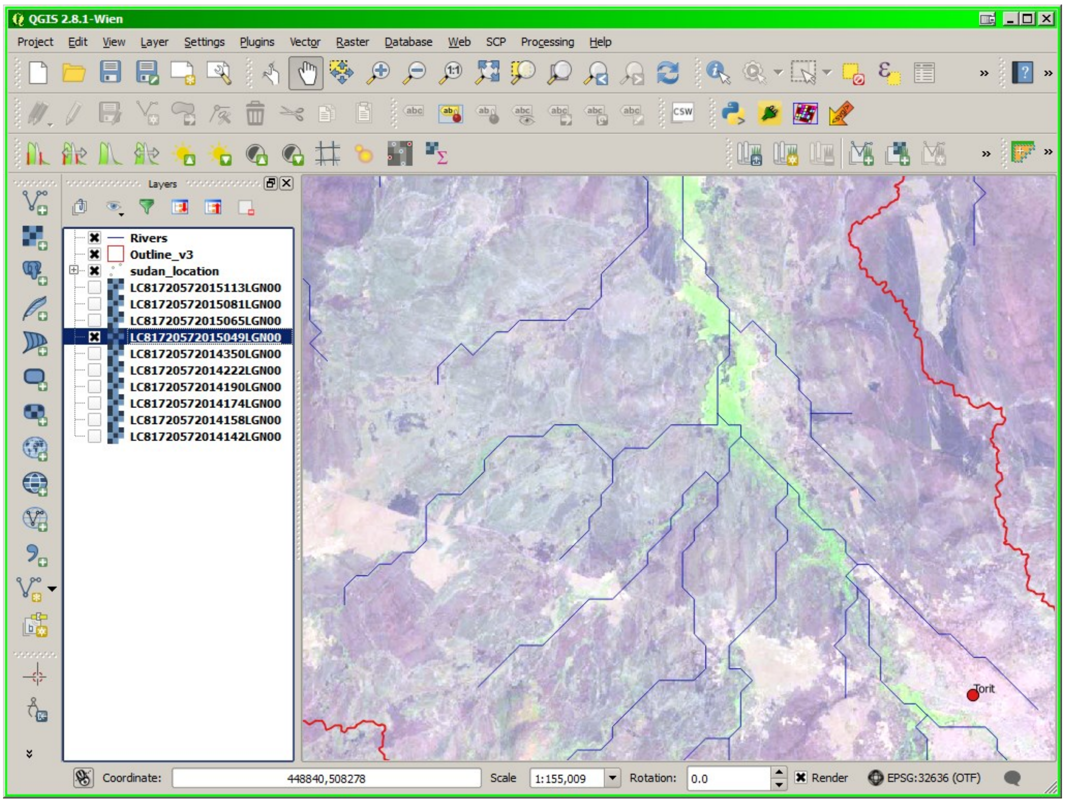



**Figure 11. Landsat image 2015_049 detail using color stretch.**

## 5.3 WEAP Schematic

Based on the available reports and information WEAP was set up using the following schematization (in brackets the number of nodes):

- River (5)
  - The main river is the Kenneti and four tributaries were defined: Iyodo, Lelere, Kiwa, and Halohoi
- Demand Site (7)
  - Demand sites include the cities of Torit and Lafon and five more rural demands (see Figure 13)
- Catchment (8)
  - The eight catchments are same as the one used for the entire ProWasEES program and encompass the four tributaries and four sub-catchments of Kenneti river.
- Runoff/Infiltration (8)
  - Each catchment has a runoff to the river
- Transmission Link (7)
  - Each demand sites needs to be connected to the river by a transmission link. Note that in WEAP terminology a transmission link can be everything ranging from a canal, a pipe, a water truck and simple buckets.
- Return Flow (1)
  - Return flows are needed to specify the flow back from a demand site into the river. Only for Torit a return flow was defined. It is specified that 20% of the water withdrawal from Torit will flow back into the river.
- Flow Requirement (1)

- Downstream of the study extent a minimum flow requirement was placed. For the current situation this was not used, for the scenario various values were defined.

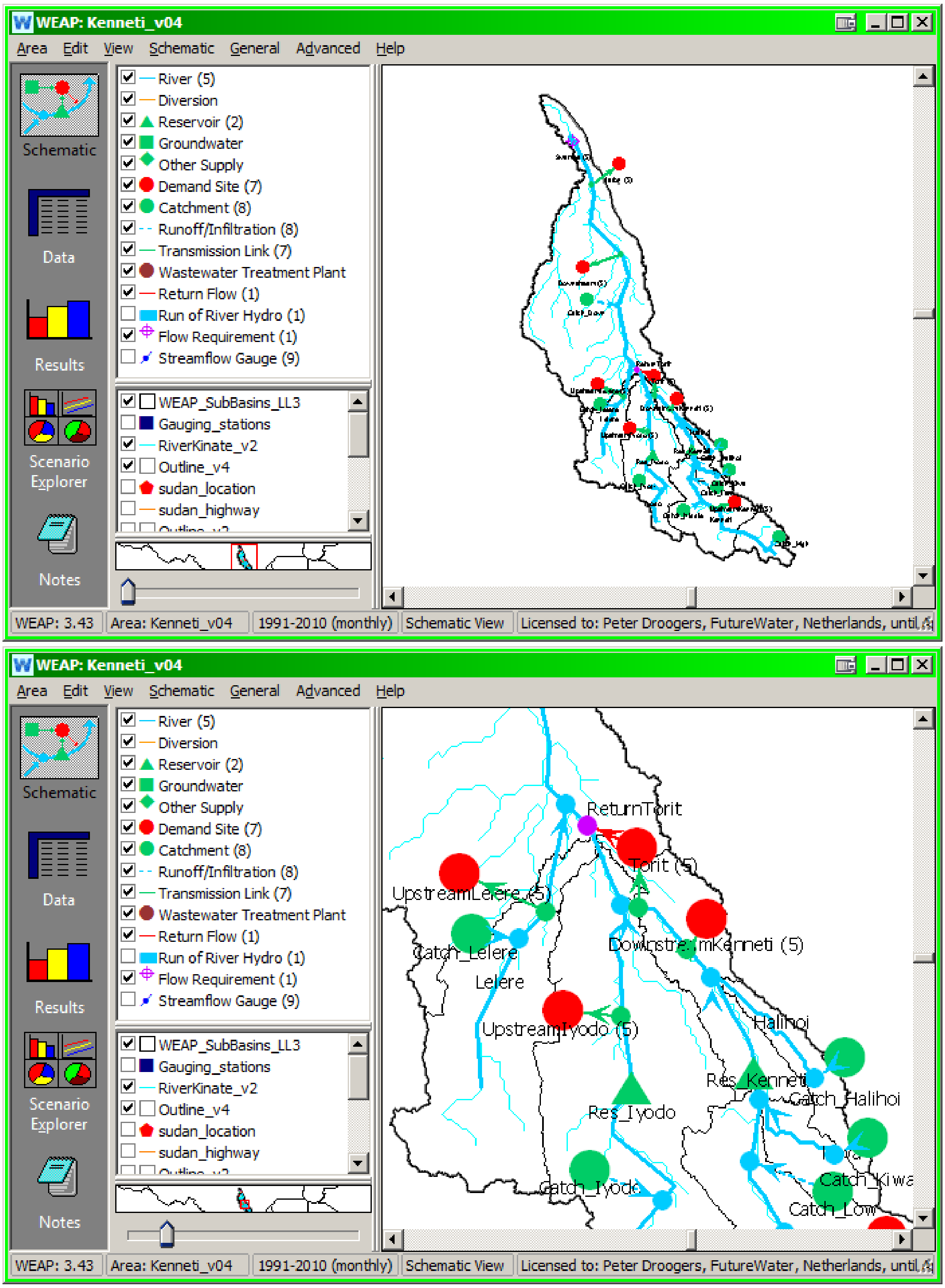



**Figure 12. Schematization of the WEAP model; overview (top) and detail around Torit (bottom).**

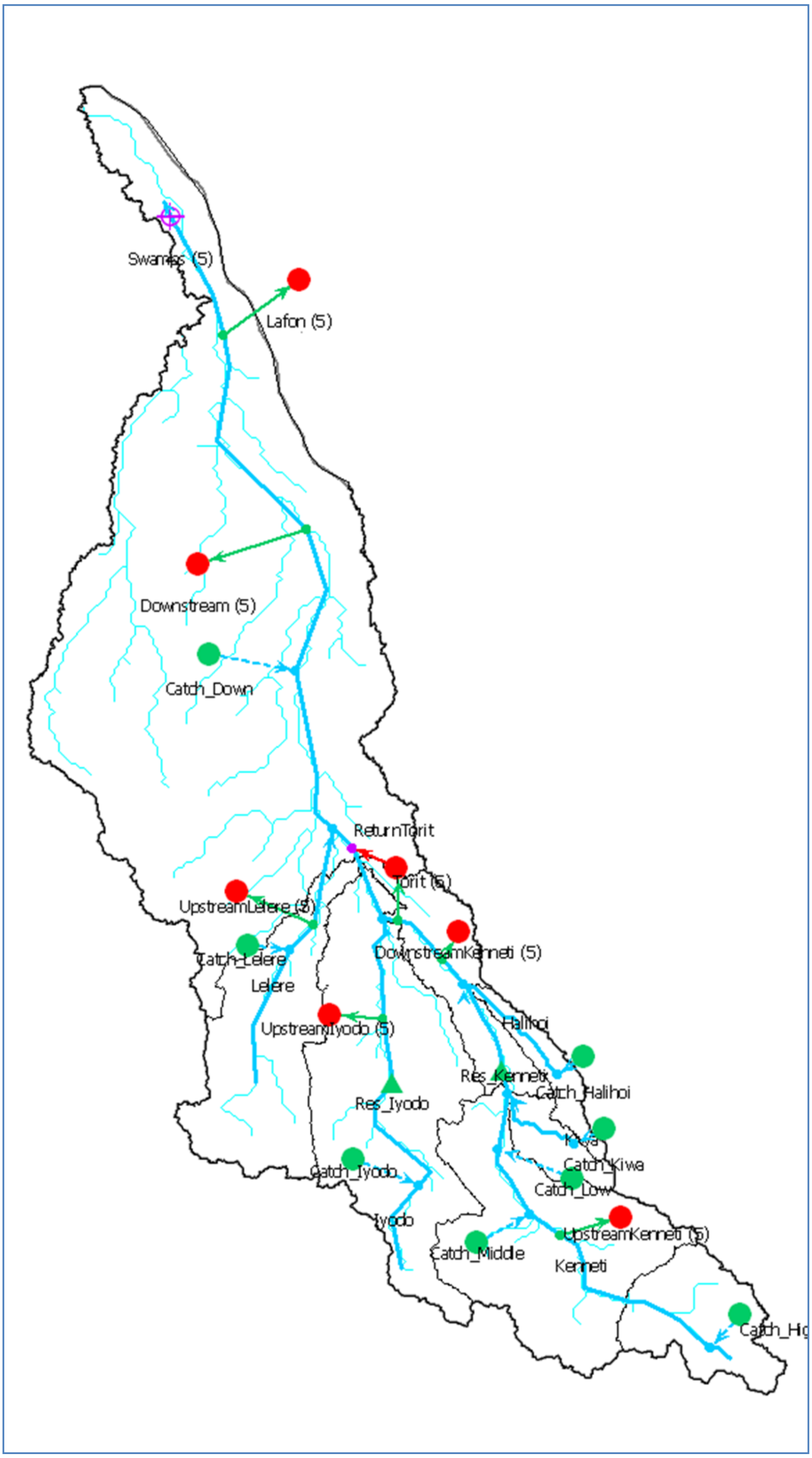



**Figure 13. Schematization of the WEAP model.**

# 6 Results

## 6.1 Model Performance

No actual streamflow measurements are available to undertake a detailed model performance analysis. Only some rough estimates of flows at the bridge over the Kenneti River on the Juba - Torit main road are reported. Two reports (SEMC 2012 and Bilateral Program 2012) provide the same information. In summary:

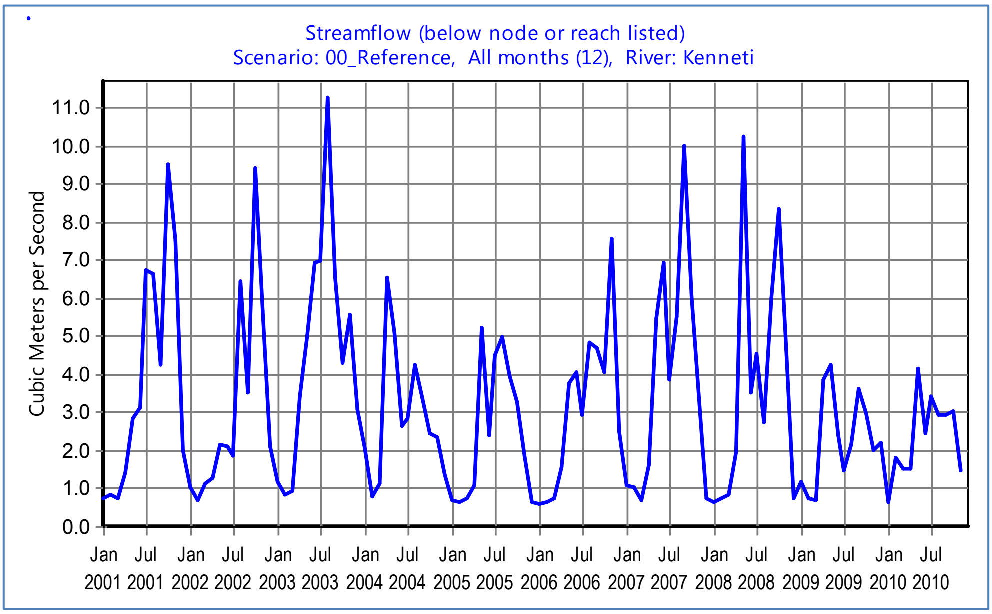
- On 23-09-2011 discharge was estimated at the bridge over the Kenneti River on the Juba - Torit main road. The flow depth was 2.5 m and flow velocity was estimated at 0.8 m/s. Hence the discharge rate was estimated at 4.0 $m^3/s$ after adjustment for losses.
- The discharge during periods of low flow was estimated at 0.5 $m^3/s$ and depths are 0.5 meters (SMEC draft, 2011).
- In an earlier study (DOT, 2008), during the dry season a flow rate was measured ranging between 0.73 and 1.01 $m^3/s$

The streamflow as generated by the WEAP model at the same location is shown in Figure 14. The long-term average flow according to the model is 3.2 $m^3\ s^{-1}$. Monthly variation is somewhere between 0.6 and 11.2 $m^3\ s^{-1}$. These numbers are comparable with the rough estimates as reported above.

Obviously, the accuracy of the model could be improved substantially in case measured flows would become available. In modeling such a process is referred to as “calibration”, which is a process where the more uncertain model parameters are adjusted so that simulated and observed streamflow matches. This can be done either by manually adjusting these uncertain parameters, or by using a computer automated calibration tool such as “PEST” (*http://www.pesthomepage.org/*). A sensitivity analysis was undertaken to identify the sensitivity of the model to the most uncertain input parameters. Details can be seen in the Appendix, while a summary is presented in Table 3. Results of this sensitivity analysis indicate that four parameters should be considered in a detailed calibration process that can be undertaken if streamflow data indeed comes available.

**Table 2. Sensitivity analysis. Details can be found in the Appendix**

| | Impact on: | | Low/high value for increased: | |
|---|---|---|---|---|
| Parameter | Average Flow | Peak Flow | Average Flow | Peak Flow |
| Kc | ++ | ++ | low | low |
| Soil Water Capacity | ++ | +++ | low | low |
| Deep Water Capacity | o | + | - | low |
| Runoff Resistance Factor | +++ | +++ | low | low |
| Root Zone Conductivity | +++ | +++ | high | low |
| Deep Conductivity | o | o | - | - |
| Preferred Flow Direction | o | + | - | high |



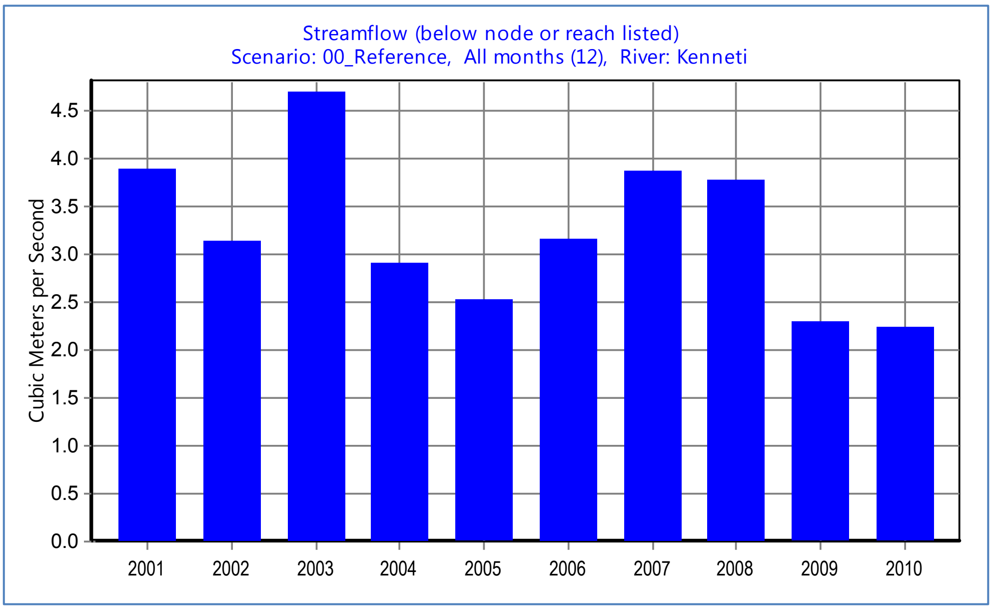




**Figure 14. Monthly streamflow at Torit (top) and average annual flow (bottom).**

## 6.2 Current Conditions

The current situation was modelled using data and information as described in the previous section. Main results are shown in the Figures and Tables hereafter:

- Figure 15: Total water demand in the study area is about 1.6 MCM average per year; which is about 0.05 $m^3 s^{-1}$. Highest demand is for Torit with about 0.7 MCM per year.
- Figure 16: Total runoff from all catchments is between about 129 and 245 MCM per year, depending on prevailing climate conditions. This translates to 4.1 and 7.8 $m^3 s^{-1}$ on average per year.
- Figure 17: Streamflow at Torit is on average 3.2 $m^3 s^{-1}$. Monthly variation is between 0.6 and 11.2 $m^3 s^{-1}$. The probability plot shows that monthly flows of 1 $m^3 s^{-1}$ or less occur

in about 20% of the months. Flows below 2 $m^3 s^{-1}$ in about 40% of the months. It should be noted that these are average monthly flows, while daily flows can fluctuate above or below these numbers.

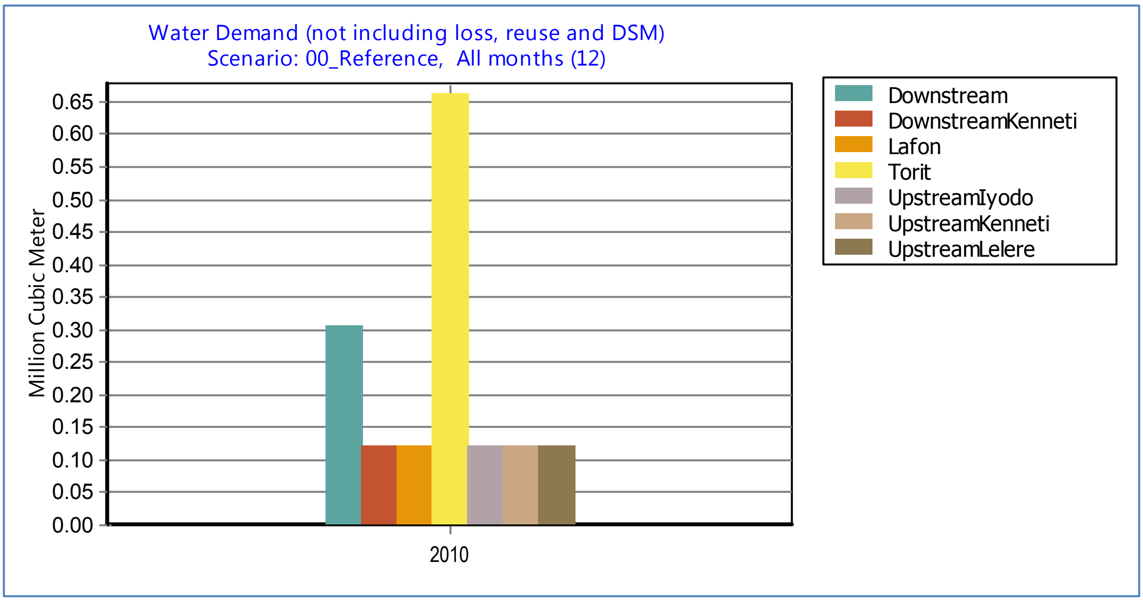
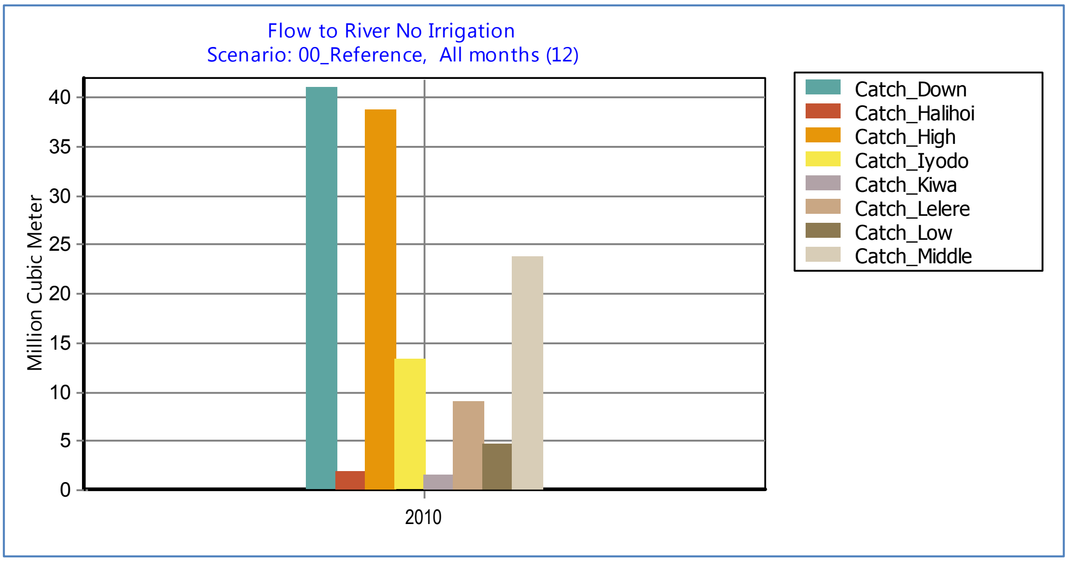
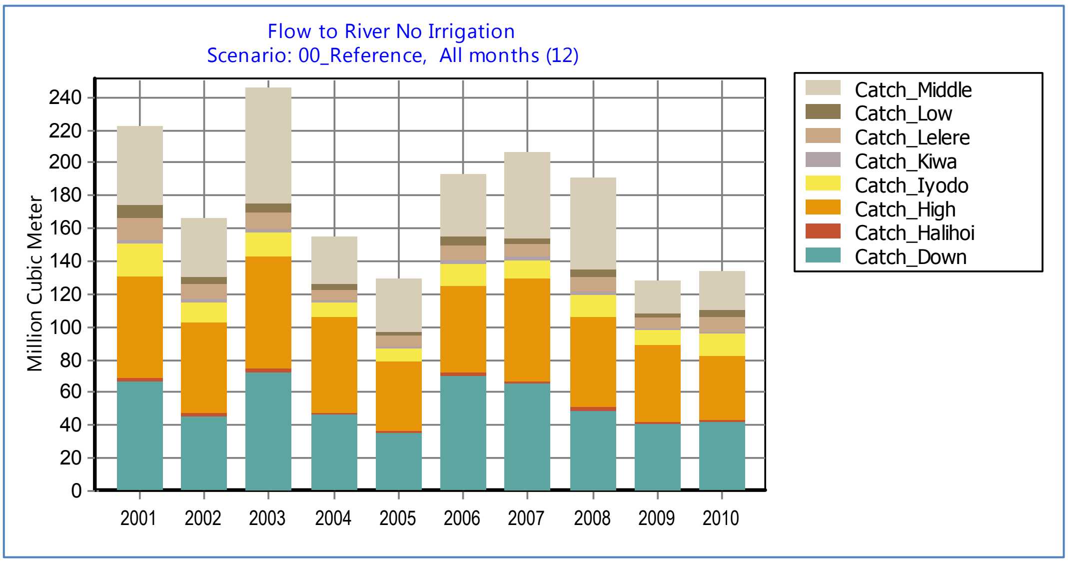



**Figure 15. Annual water demand for the main demand sites (MCM/y).**





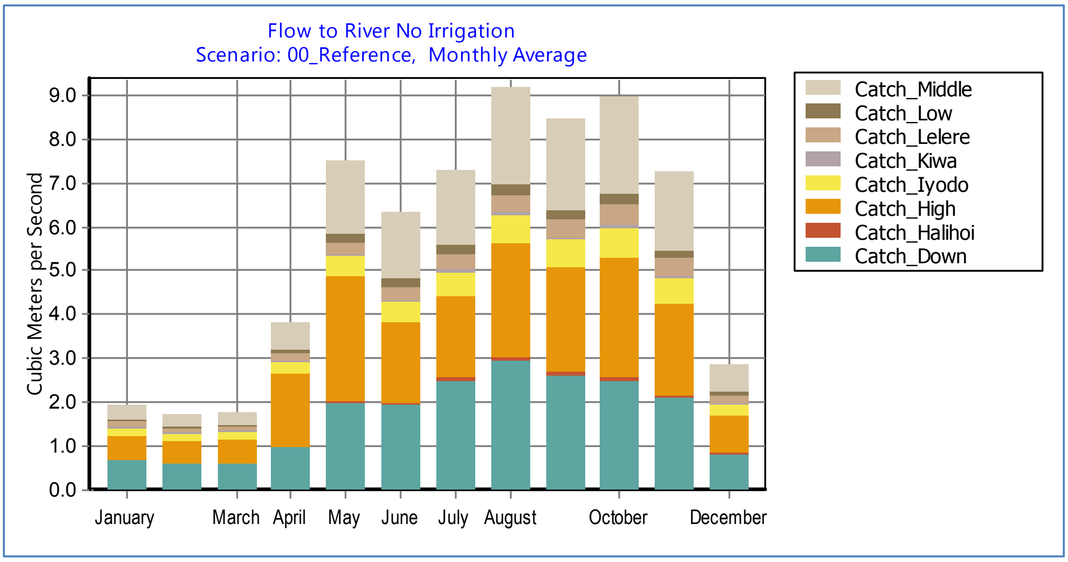
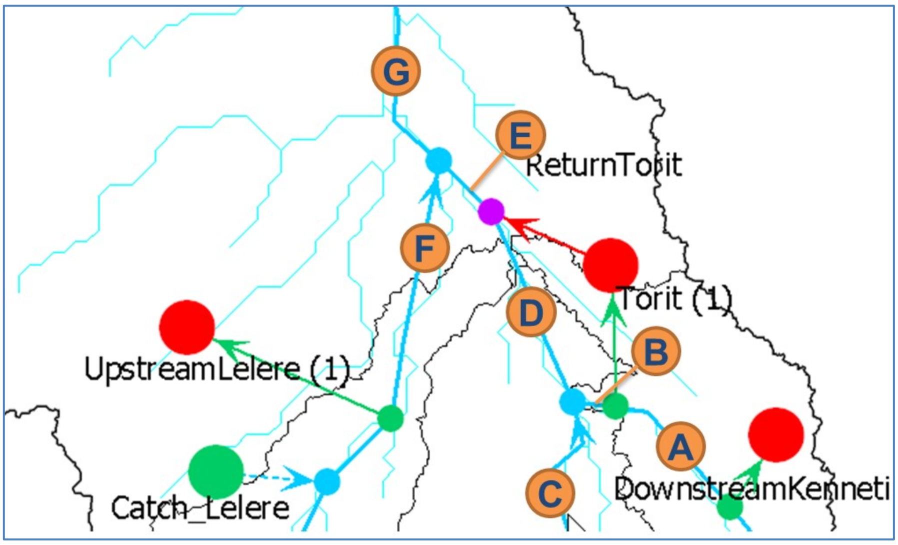
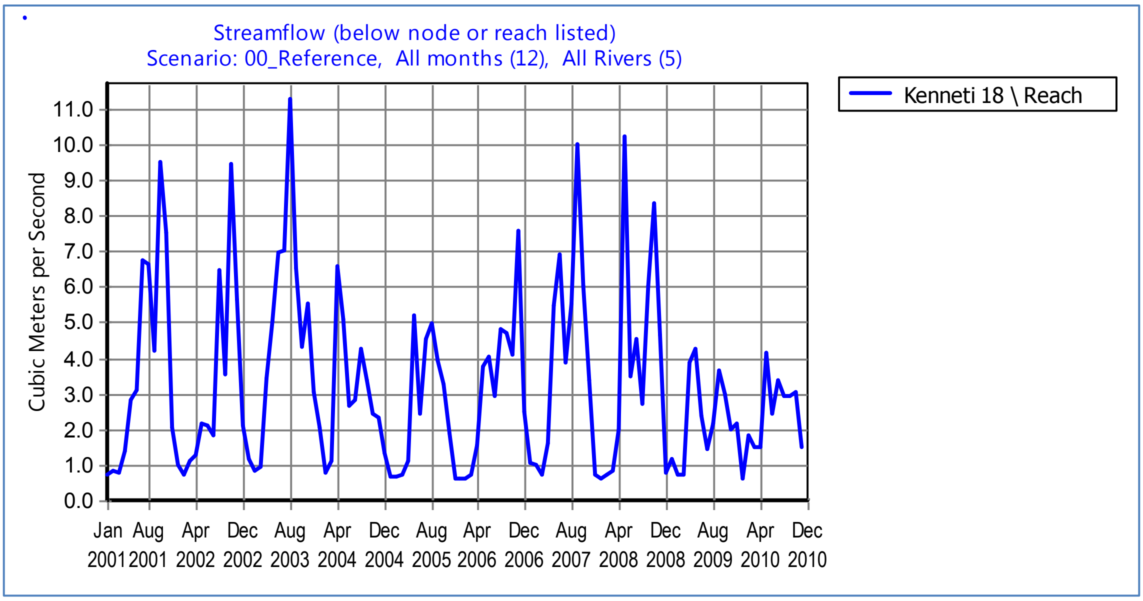



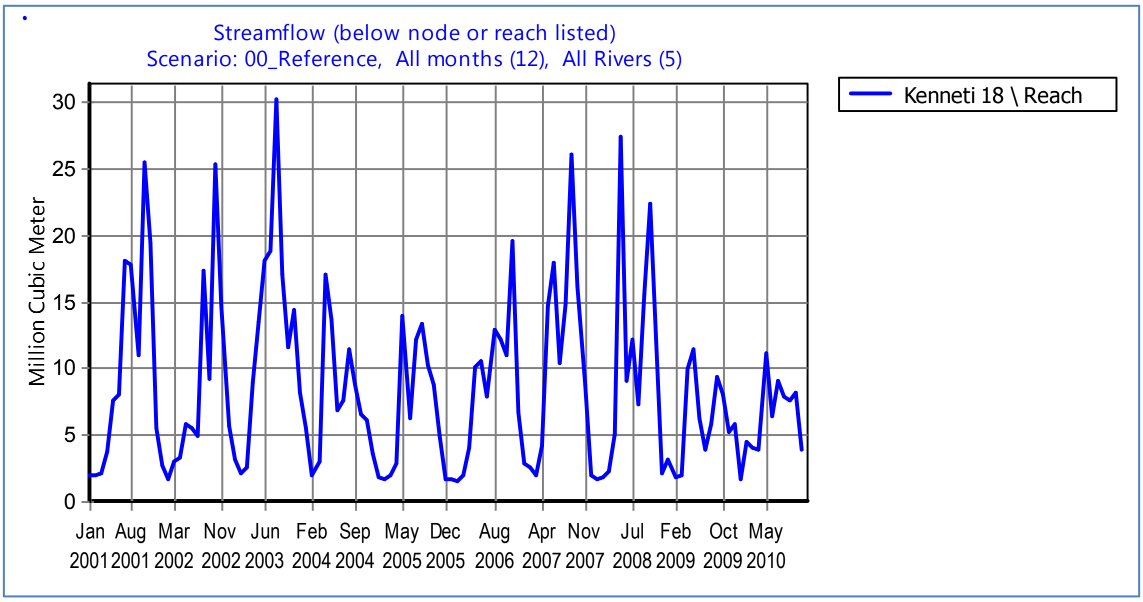

**Figure 16. Runoff from catchments in MCM for 2010 (top), in MCM for 10 years (middle) and m3/s monthly averages over these 10 years(bottom).**

**Table 3. Annual average flows at some specific points during a relative wet (2003) and dry (2010) year.**

| Point | River | WEAP_Name | CMS 2003 | CMS 2010 |
|---|---|---|---|---|
| A | Kineti | Kenneti 18 \ Reach | 4.68 | 2.23 |
| B | Kineti | Kenneti 20 \ Reach | 4.66 | 2.21 |
| C | Iyedo | Iyodo 4 \ Reach | 0.48 | 0.42 |
| D | Kineti | Kenneti 22 \ Reach | 5.14 | 2.62 |
| E | Kineti | Kenneti 23 \ ReturnTorit | 5.14 | 2.63 |
| F | Loleir | Lelere 4 \ Reach | 0.32 | 0.28 |
| G | Kineti | Kenneti 26 \ Reach | 5.46 | 2.91 |


G
E
ReturnTorit
F
D
Torit (1)
B
UpstreamLelere (1)
A
C
DownstreamKenneti
Catch_Lelere


Streamflow (below node or reach listed)
Scenario: 00_Reference, All months (12), All Rivers (5)
Kenneti 18 \ Reach
Cubic Meters per Second
11.0
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
Jan 2001
Aug 2001
Apr 2002
Dec 2002
Aug 2003
Apr 2004
Dec 2004
Aug 2005
Apr 2006
Dec 2006
Aug 2007
Apr 2008
Dec 2008
Aug 2009
Apr 2010
Dec 2010



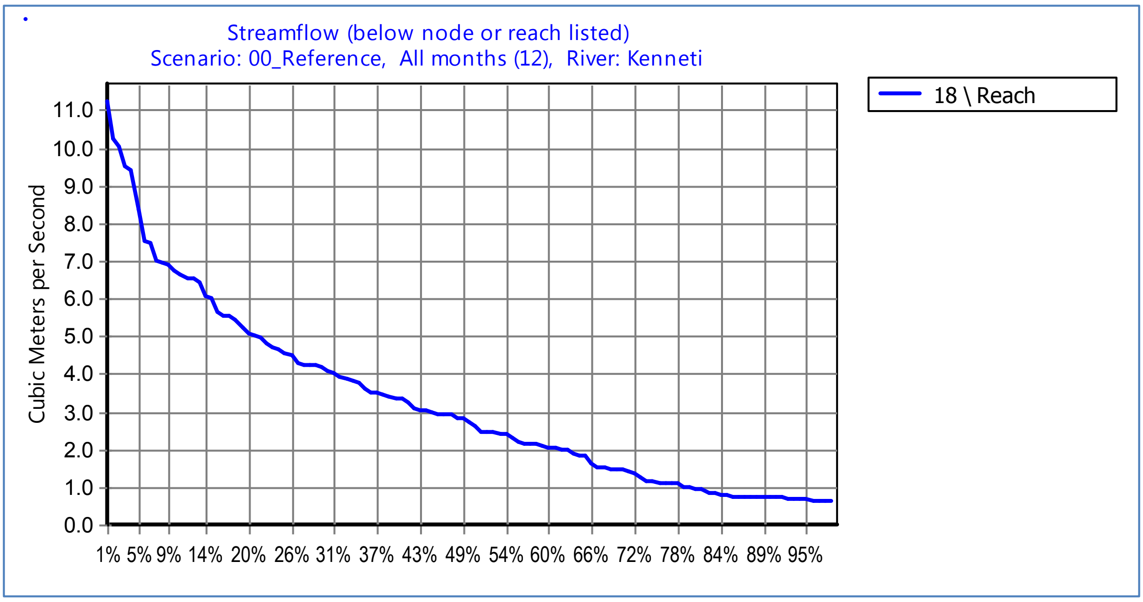




**Figure 17. Streamflow at Torit in $m^3$ $s^{-1}$ (top), MCM (middle) and as probability graphs of monthly flows at Torit in $m^3$ $s^{-1}$ (bottom).**

## 6.3 Future Developments

A number of development scenarios were defined and their impact on water resources was evaluated using the WEAP model. Two types of scenarios can be distinguished. The first type is the so-called impact scenarios or storylines that cannot be influenced directly by water managers or policies. Second are the interventions or adaptation strategies which can be actively influenced by policy making.

To evaluate these impact scenarios and adaptation interventions the WEAP model as described above was expanded to evaluate the results of these scenarios. Input data for the period 2001-2010 was changed for these scenarios to represent the situation around the year 2040. The variation in weather around the year 2040 is unknown, and therefore the weather variation as observed between 2001-2010 was used as proxy.

The following set was evaluated:

- Impact scenarios
  - 01_Population → A population growth of annually 2.8% is projected. This means that the population will be more than doubled by the year 2040 (more precisely: 1.028 ^ 30 = 2.3). Furthermore it was assumed that 100% of the population is connected to a drinking water supply system for this scenario (instead of 0% currently), which means the water use rate per capita increases from 30 L/d to 120 L/d.
  - 02_Climate → Rainfall in all catchments was assumed to reduce by 25% and temperature will increase by 2$^{o}$C.
- Interventions:
  - 03_MinFlowReq → Downstream users below Lafon, including people, animals and environment, should be assured to receive a certain amount of water. Three different flow requirements of (a) 1, (b) 2, and (c) 3 $m^3\ s^{-1}$ were evaluated.
  - 04_Deforestation → This scenario evaluates the impact of a reduction of 30% of forest cover in the upstream catchments.
  - 05_CatchProtect → By integrated land and vegetation measures catchments can be protected. It was assumed that by such integrated measures soil properties will change so that more water can infiltrate into the soil. Also, the runoff resistance would increase by vegetative measures.
  - 06_Irrigation → It was assumed that (a) 50, (b) 250 and (c) 750 ha would be developed upstream of Torit with a water withdrawal of 8000 m³/ha in the months of Feb, March and April.
  - 07_Boreholes → Currently 378 boreholes are present in Torit county of which 178 are located in the municipality. It was assessed what the impact would be if all water would come from a water treatment plant withdrawing from the river.
  - 08_Reservoir → An intervention considered is to construct reservoir in order to store wet-season surplus water that can be used during dry months. Four options are analyzed: reservoir upstream of Torit of capacity (a) 100,000; (b) 1,000,000 and (c) 2,500,000 m³, and a reservoir at Iyodo River of (d) 800,000 m³.
  - 09_Likely_No_Invest → In reality it is likely that a mix of the above scenarios will take place: climate will change, population will increase, minimum flow requirement should be met and irrigation will be developed. The following scenarios as defined above are therefore combined to generate a so-called “likely future”: 01 (but rainfall reduction limited to 10%), 02, 03b (2 $m^3\ s^{-1}$), 06c (750 ha).
  - 10_Likely_Limit_Invest → Same as scenario 09_Likely, but now with limited investment measures to overcome potential water shortage: 08_Reservoir in Kenneti of 1 MCM and in Iyodo of 0.8 MCM; 05_CatchProtect with 50% of the measures.
  - 11_Likely_Full_Invest → Same as scenario 09_Likely, but now with full investment measures to overcome potential water shortage: 08_Reservoir in Kenneti of 5 MCM and in Iyodo of 0.8 MCM; and 05_CatchProtect.

Results of these impact scenarios and intervention strategies are discussed and summarized in the following sections.

### 6.3.1 Population growth and Climate Change

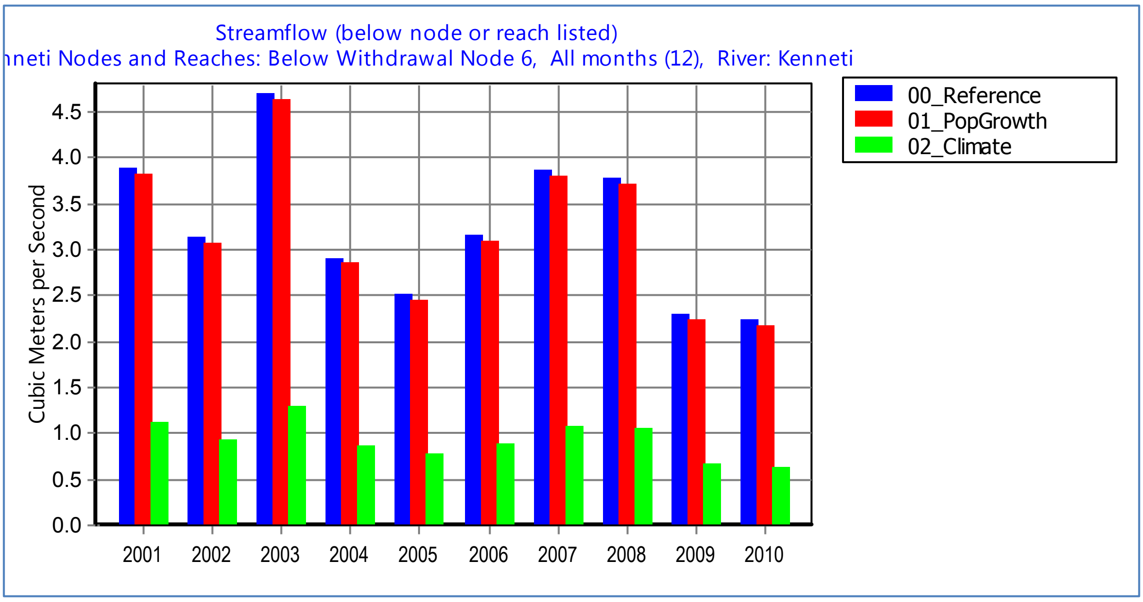
*01_Population*
*02_Climate*

There is sufficient scientific proof that the climate will change in the future. Exact numbers of these changes are not sure as the developed knowledge and tools (General Circulation Models, GCMs) are still not perfect. Also, it is unclear what policy decisions will be taken to reduce greenhouse gas emissions. A more detailed analysis for the region could be undertaken by using GCM output to refine the analysis. For this analysis it was assumed that rainfall will reduce by 25% and average temperature will increase by 2 degrees.

Similarly, population growth will occur, putting even more stress on water resources. An annual growth of 2.8% is projected which means that in about 30 years time (2040) the population will be more than doubled by the year 2040 (1.028 ^ 30 = 2.3).

The impact of climate change on water availability and streamflow is quite substantial (Figure 18). Streamflow at Torit will reduce dramatically and low flow conditions will occur frequently. Flows below 0.5 $m^3 s^{-1}$ can be experienced almost every year in the dry months. Given the current low water demands, no water shortage (unmet demand in WEAP terminology) is expected neither for the current situation nor under the climate change scenario.

Impact of population growth on water availability is relatively limited. Although population is projected to double by 2040 and more water is withdrawal as people are connected by domestic water supply, impact on flows is limited. The main reason is that the increase in water demand (from 0.7 to 5.6 MCM per year) for Torit is relatively small given total water availability in the basin. In order words, the demand for Torit increases from 0.02 to 0.18 $m^3 s^{-1}$, which is still very low compared to the current average flow at Torit of 3.2 $m^3 s^{-1}$.



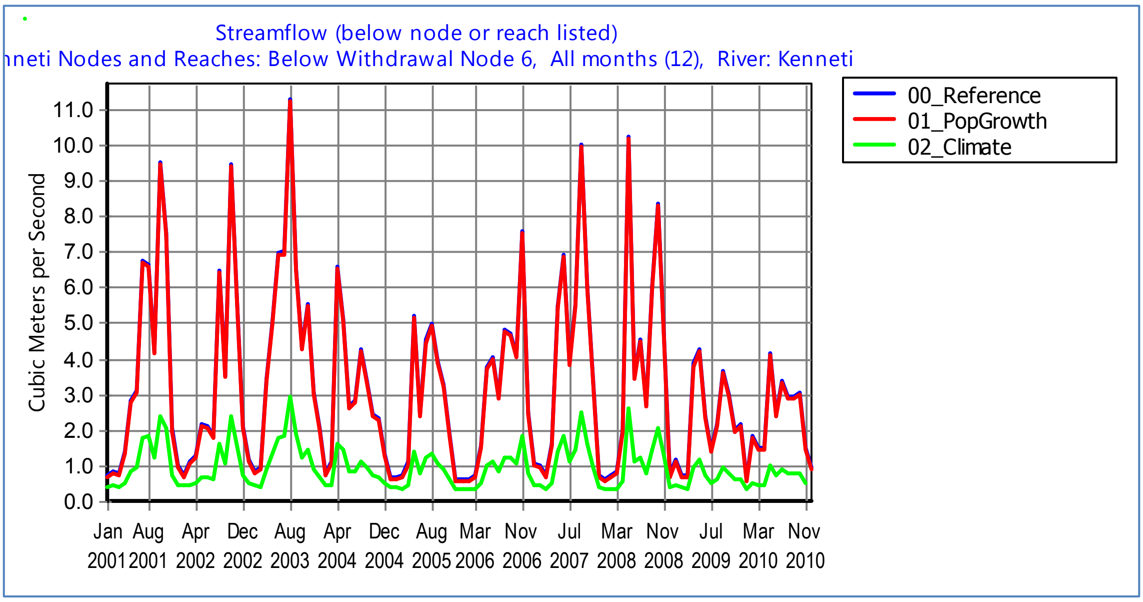



**Figure 18. Streamflow at Torit under the population growth and climate change projections as annual averages (top) and monthly averages (bottom).**

### 6.3.2 Minimum Flow Requirement

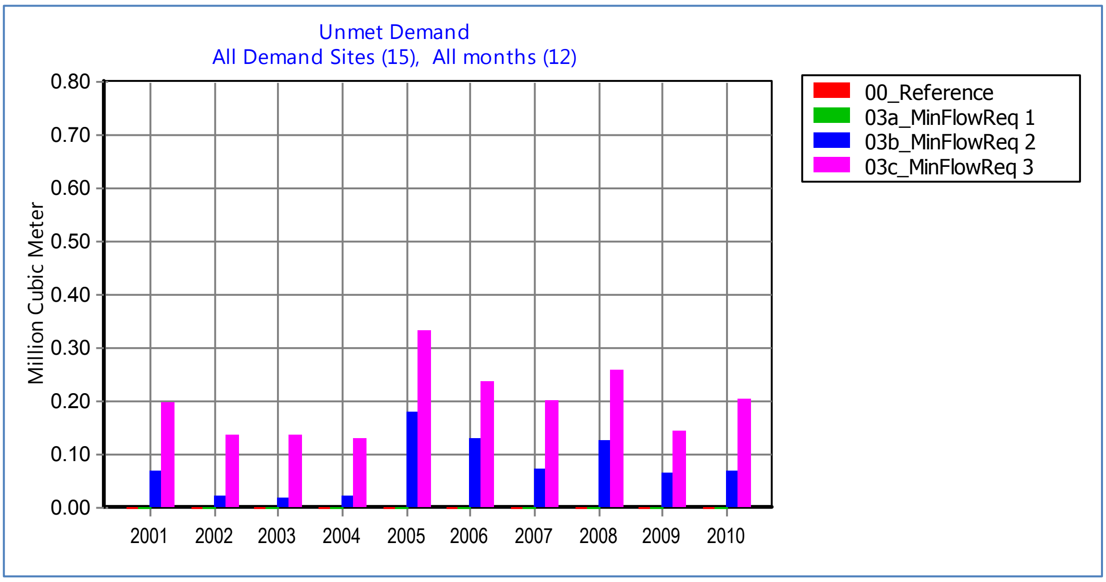
*03_MinFlowReq*

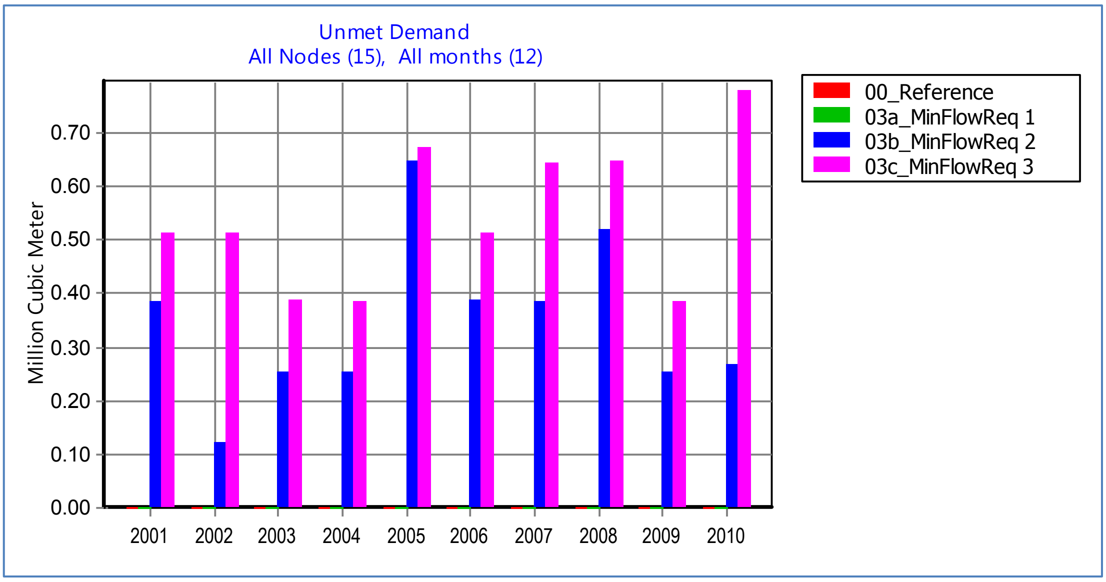
Currently, no provisions are set to ensure a minimum flow downstream Torit or Lafon. It is clear that the downstream wetlands and water users should be taken into the account, and it is likely that in the near-future policies for this will be developed. Three minimum flow requirements were defined (1, 2 and 3 $m^3 s^{-1}$) and the impact on flows and water shortages upstream are analyzed.

This minimum flow requirement can be implemented as a high and as an equal priority. Prevailing policies can define that this minimum flow requirement should always be met (high priority), even under low flow conditions. Such a policy can be set if a reduction in downstream water can result in irretrievable damages (e.g. wetlands, wildlife). On the other hand, policies can be defined where under dry conditions water shortages will be equally shared between upstream and downstream. In WEAP this can be defined by setting priorities to demand nodes.

The analysis shows that under a minimum flow requirement of 1 $m^3 s^{-1}$ no water shortage ("unmet demand" in WEAP terminology) will occur (Figure 19). However, higher flow requirements, e.g. 2 or 3 $m^3 s^{-1}$, cannot always be met. The consequences are that not only downstream lower flows will occur than required, but also upstream water shortages will occur. Of the total water demand in the basin of 1.6 MCM per year, about 0.1 and 0.3 MCM cannot be supplied under the high minimum flow requirement of 3 $m^3 s^{-1}$ (Figure 19 top). If policy defines a higher priority for the downstream flow requirement water shortage upstream will be even higher (Figure 19 middle).

Obviously, the flow that can be delivered to downstream fluctuates during the year. During the drier months of January, February and March, flow requirements of 2 and 3 $m^3 s^{-1}$ often cannot be met (Figure 19 bottom).



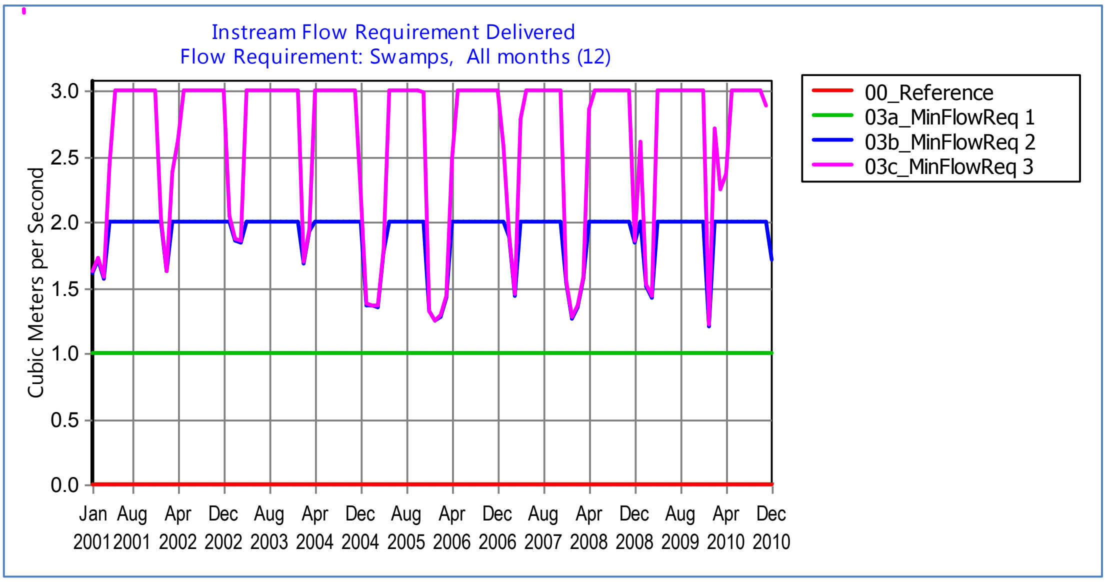



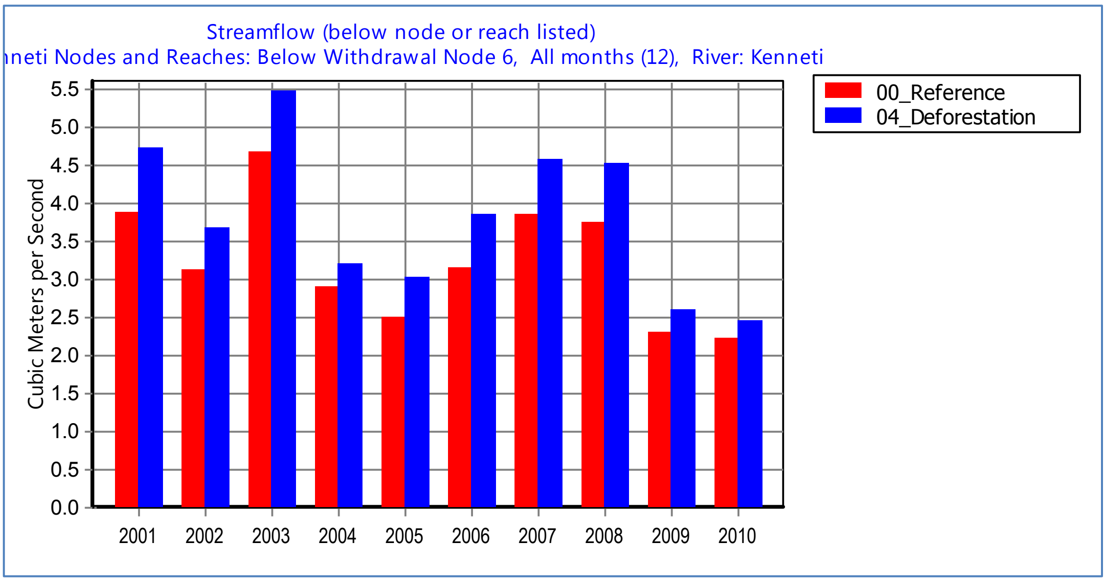

**Figure 19. Water shortage (unmet demand) if a certain flow requirement has to be met. Under equal demand priority (top), under highest priority (middle) and the delivered flow (bottom)**

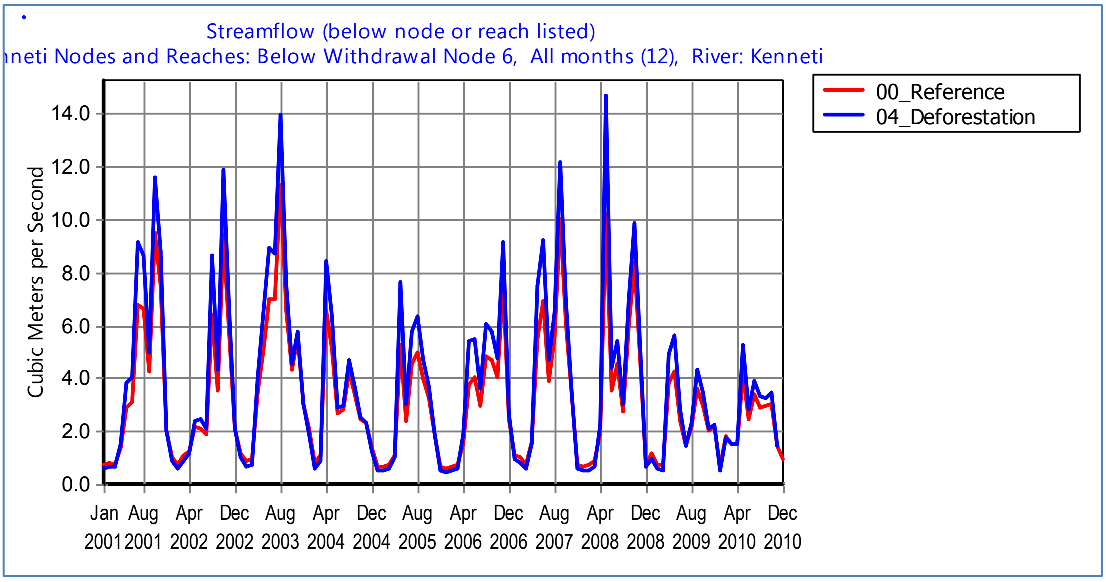
### 6.3.3 Deforestation

*04_Deforestation*

Deforestation is a threat to the catchments in the region. It is unclear to what extent this might happen, but for this scenario it was assumed that 30% of the forest would be cut. It is well known that in general cutting trees will increase the overall flow, as trees consume (evaporate) more water compared to degraded lands. At the same time, deforestation will increase soil erosion, and will reduce the buffer capacity of the catchment. The latter can result in more pronounced flooding.

Figure 20 shows that this well-known impact of deforestation would also occur in this region. Total annual flow will increase on average by about 10%-15%, while at the same time more flooding and slightly lower flows during the dry months can be expected. The probability graph (Figure 20, bottom) clearly shows that these peak flows will increase from 11 $m^3 s^{-1}$ to almost 15 $m^3 s^{-1}$. Also low flows have the tendency to be more profound in 25% of the months.



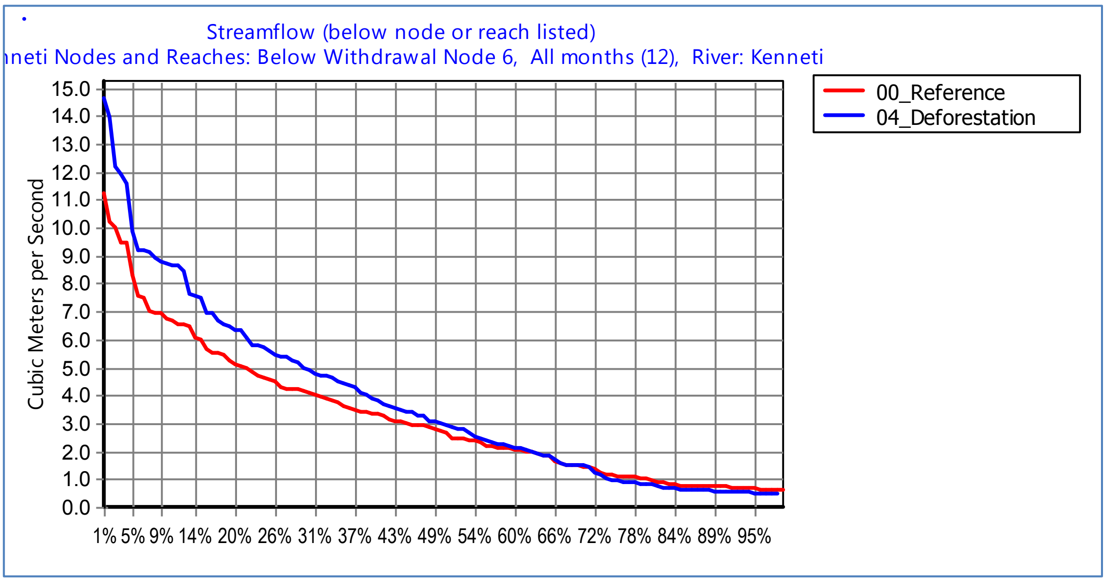


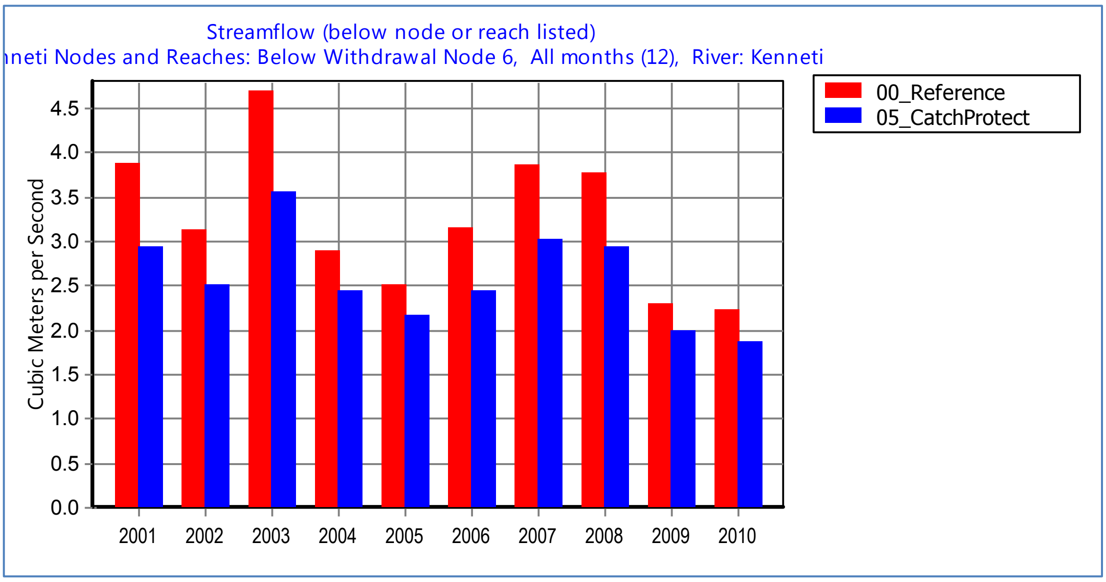

**Figure 20. Deforestation by 30%. Impact on streamflow at Torit. Average annual flow (top), monthly flow (middle), and probability plot of monthly flow (bottom).**

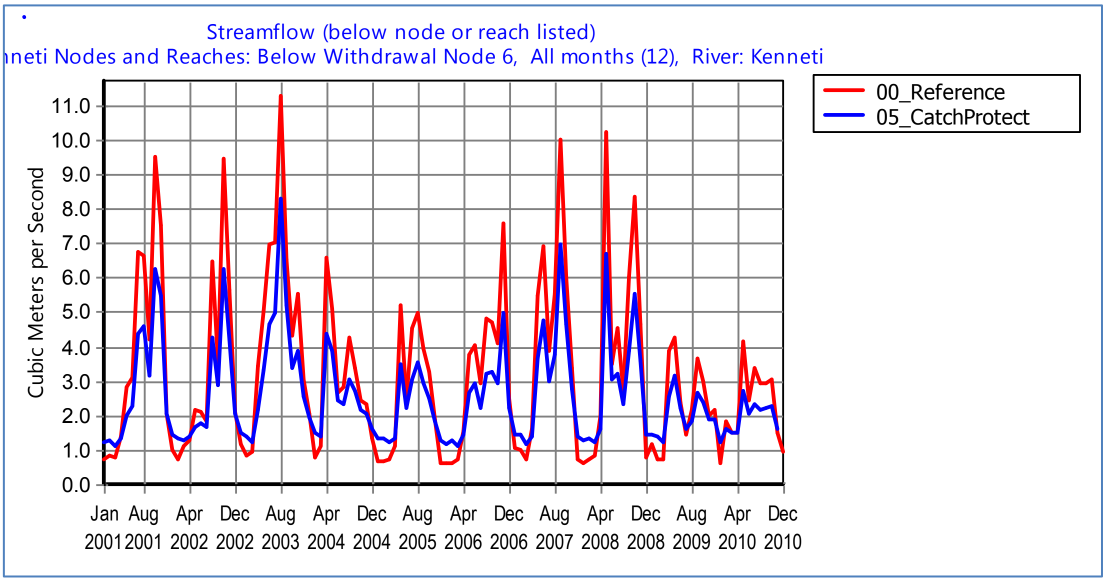
### 6.3.4 Catchment Protection

*05_CatchProtect*

In contrast to the previous scenario (deforestation) catchment protection measures can be promoted actively. This catchment protection can be implemented by various measures. A good overview of options is provided by WOCAT (World Overview of Conservation Approaches and Technologies). A detailed analysis of all these options is beyond the scope of this study and therefore some generic assumptions were considered. In this scenario it was assumed that a mixture of soil conservation by soil management and vegetation management will be taken. The result of these actions will be that soil properties will change so that more water can infiltrate into the soil. The vegetative measures will result in higher runoff resistance so less erosion and peak flow might be expected.

The impact of these measures is quite substantial. Interesting is that total water availability at Torit will decrease as more water will be available in the soil upstream, leading to increased evaporation (Figure 21 top). At the same time, flows are much more regulated resulting in a substantial reduction in peak flows and higher flows at Torit during dry months (Figure 21 middle and bottom).



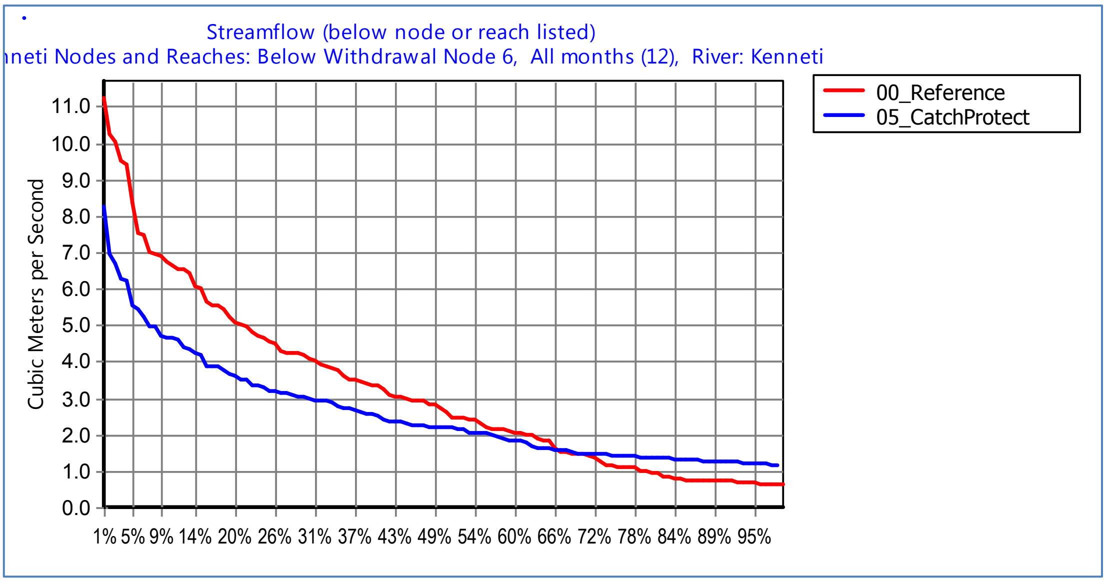



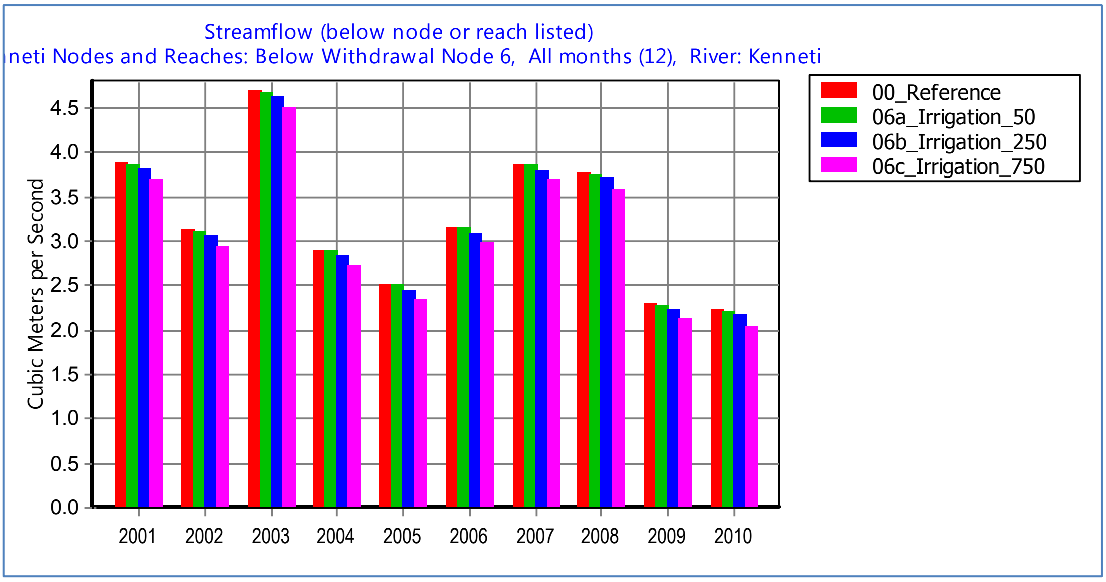

**Figure 21. Catchment protection. Impact on streamflow at Torit. Average annual flow (top), monthly flow (middle), and probability plot of monthly flow (bottom).**

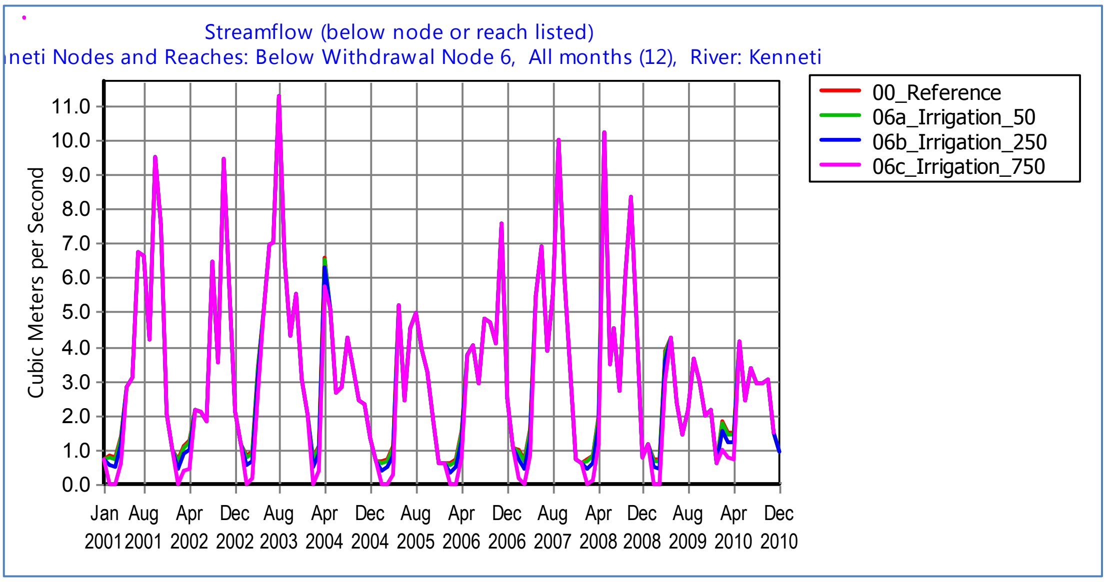
### 6.3.5 Irrigation expansion

*06_Irrigation*

Currently, hardly any irrigation takes place in the basin. It is however likely that to increase food security irrigation will be developed. Three irrigation scenarios were evaluated on their impact on water resources. It was assumed that (a) 50, (b) 250 and (c) 750 ha would be developed upstream of Torit with a water withdrawal of 8000 m³/ha in the months of Feb, March and April.

On the first hand, it looks like that sufficient water is available to develop irrigation. Impact on annual average flow seems to be minor (Figure 22, top). However, since irrigation is needed during the dry months, there is quite some impact on flows at Torit. From Figure 22 (middle) it is clear that especially the option to establish 750 ha of irrigation will result in unacceptable low flows during months of January, February and March. The probability plot Figure 22 (bottom) shows that under the 750 ha scenario in about 10% of the months the river will be completely dry.



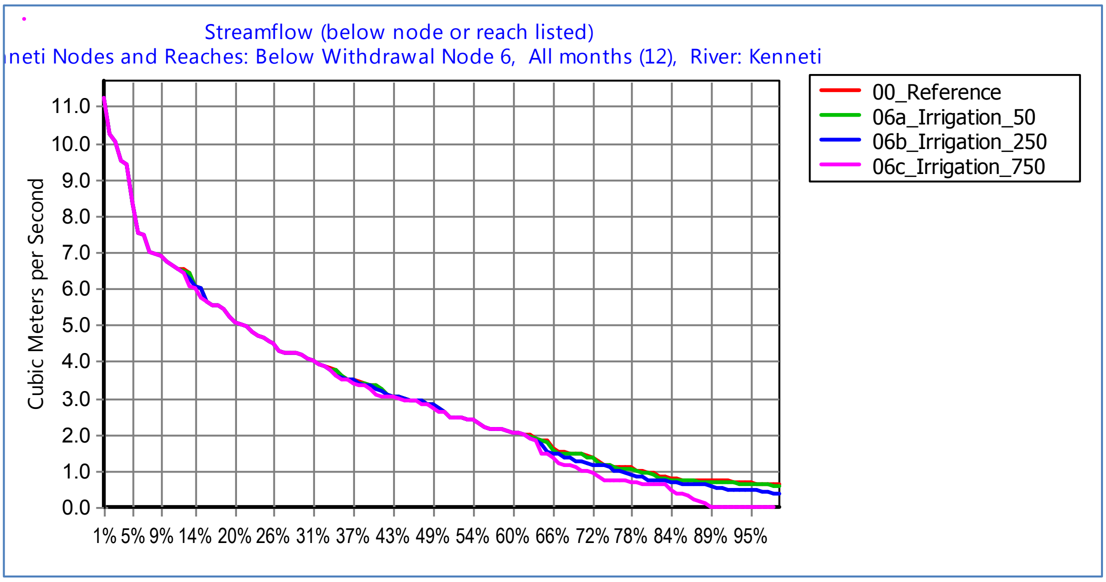



**Figure 22. Expansion of irrigation. Impact on streamflow at Torit. Average annual flow (top), monthly flow (middle), and probability plot of monthly flow (bottom).**

### 6.3.6 Water extraction from boreholes

*07_Boreholes*

At the moment there are 378 boreholes in Torit county of which 178 are located in the municipality. According to surveys about 67% of the population uses water from these boreholes. The average consumption from these boreholes is 30 liter per person per day. This means that in total 0.5 MCM per year is extracted from the groundwater. Even if the number of boreholes would be doubled it is unlikely that this will have a negative impact on groundwater resources. However, a detailed groundwater study is needed to confirm this first order estimate.

It is planned that urban water supply will be established and that less water will be abstracted from the groundwater. It is also well-known that people who receive piped-water consume more water compared by people who abstract water from pumps. The impact of the conversion from boreholes to piped-system was assessed using the WEAP model.

Figure 23 shows that if all water users would obtain water from a piped-system, the impact on the flows at Torit is hardly noticeable.

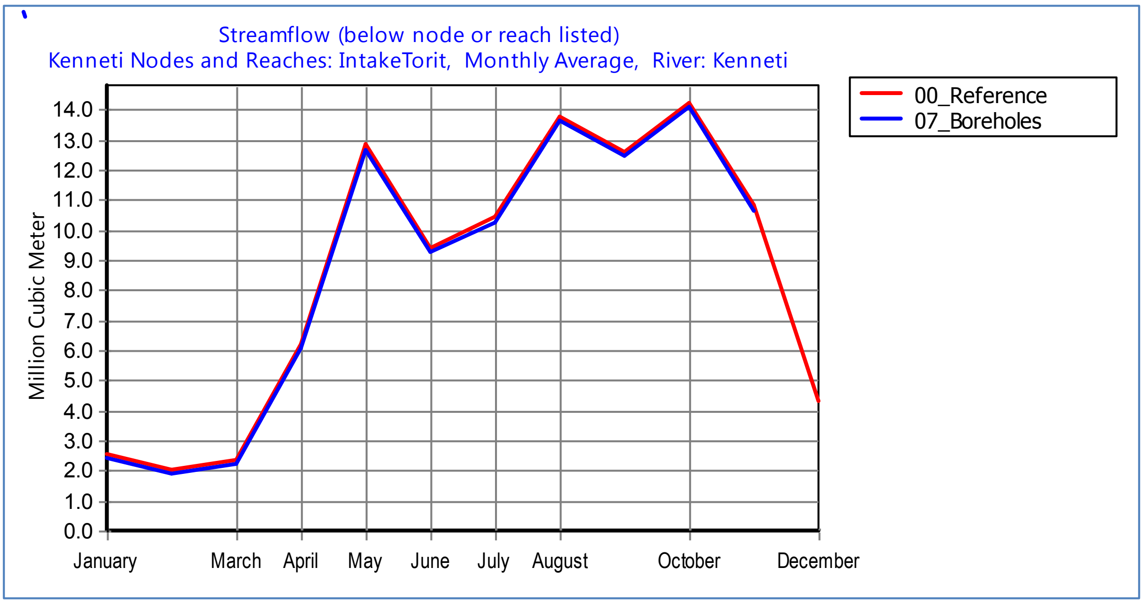



**Figure 23. Extracting all water from a future water treatment plant instead of from boreholes. Impact on streamflow in Kenneti at Torit.**

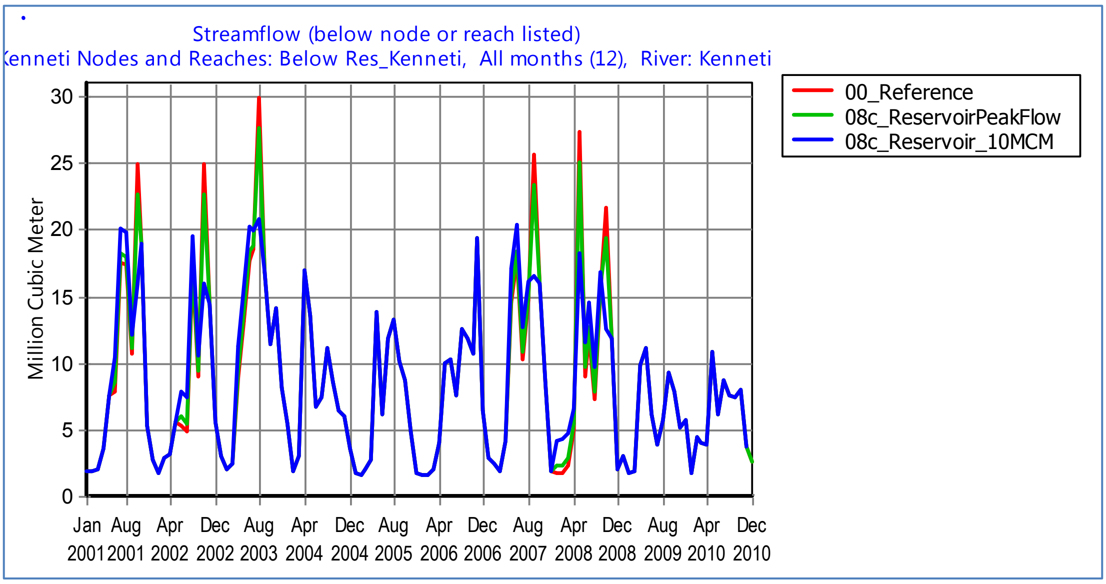
### 6.3.7 Constructing Reservoirs

*08_Reservoir*

In climates with big differences in dry and wet seasons, reservoirs can be very effective in providing water during dry periods and simultaneously avoid peak runoffs. Four options are analyzed: reservoir upstream of Torit of capacity (a) 100,000; (b) 1,000,000 and (c) 2,500,000 m³; and reservoir at Iyodo River Upstream of (d) 800,000 m³.

Under the current situation no water shortage exists so the construction of reservoirs is not needed to store water that can be used during dry periods. However, it can be expected that in the future, when development progresses, more water will be abstracted and reservoirs might be a feasible intervention. In the combined scenarios (09, 10, 11) the impact of reservoirs to reduce water shortage will be discussed (see next sections).

The impact of reservoirs to reduce peak flows is shown in Figure 24. Given the large flows, up to 30 MCM per month, the impact of relatively small reservoirs will be limited. Therefore only the scenario 08c (2.5 MCM) is evaluated and another one with a reservoir of 10 MCM is added as well as demonstration. For these reservoirs, operational rules were defined to reduce peak flows by releasing water just before the wet season to create storage capacity. It is clear that peak flows above 20 $m^3\ s^{-1}$ can be effectively reduced.



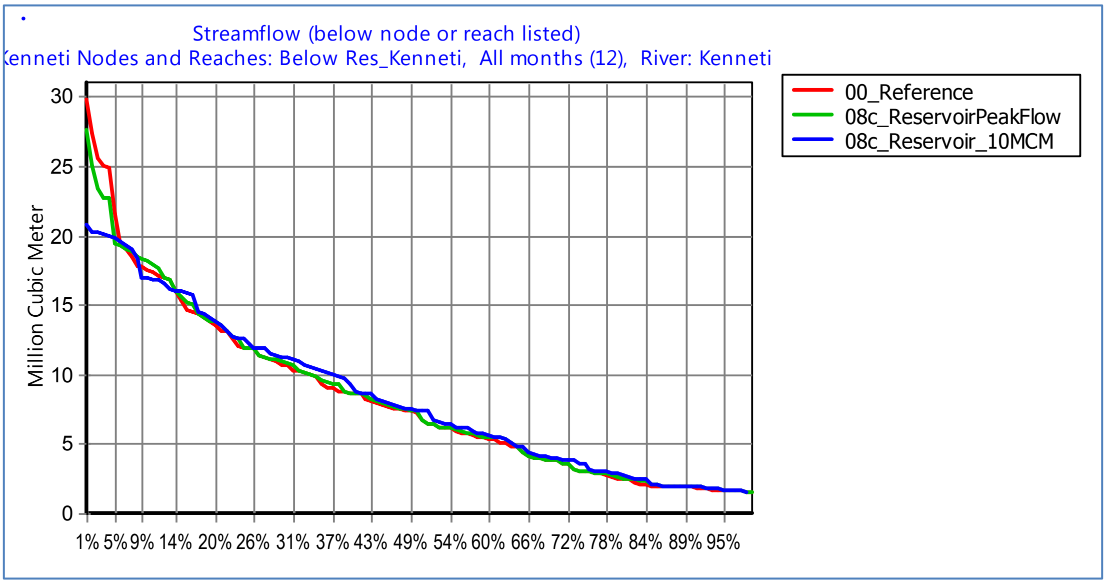




**Figure 24. Impact of building reservoir on reducing peak flows. Scenario 8c is reservoir in Kenneti of capacity of 2.5 MCM. Also result of a large reservoir (10 MCM) are shown.**

### 6.3.8 Likely Future

*09_Likely_No_Invest*
*10_Likely_Limit_Invest*
*11_Likely_Full_Invest*

All the scenarios described above are so-called “single” ones. Only one impact scenario or one intervention option is considered. Such an analysis is very relevant to indicate the potential impact of such a scenario and can be very effective to support policies. In reality however, the future is a mixture of various impacts scenarios on which water managers and policy makers will respond. Therefore three combined scenarios were evaluated. First one, which is called “likely and no interventions”, can be seen as a realistic future where population growths, the climate changes, irrigation will be developed, and a minimum flow is needed for downstream. In this worst-case (*09_Likely_No_Invest)* it is assumed that no single intervention will be taken to manage water better. This scenario is created by combining the following single-scenarios: 01 (with rainfall reduction limited to 10%), 02, 03b (2 $m^3 s^{-1}$), 06c (750 ha).

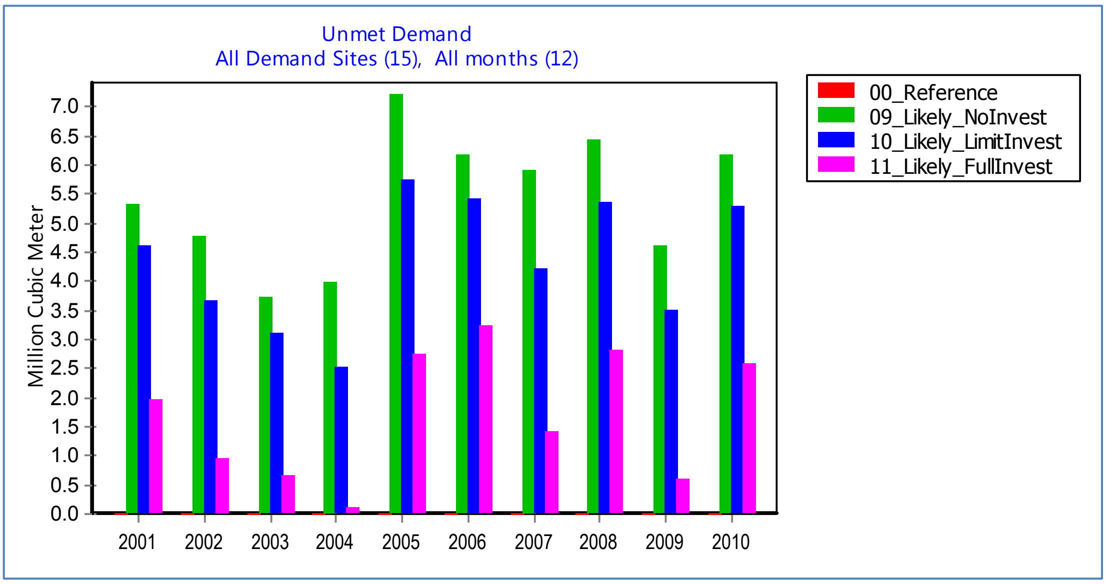
In addition to this worst-case scenario, two additional scenarios were analyzed where appropriate policies will be implemented to respond to these changes. Two sub-sets of interventions are analyzed: limited investments (*10_Likely_Limit_Invest*), and full investments (*11_Likely_Full_Invest*). The first assumes that the following interventions would be taken: *08_Reservoir* in Kenneti of 1 MCM and in Iyodo of 0.8 MCM; *05_CatchProtect* with 50% of the measures. The full investment scenario assumes *08_Reservoir* in Kenneti of 5 MCM and in Iyodo of 0.8 MCM; and full catchment projection *05_CatchProtect*.

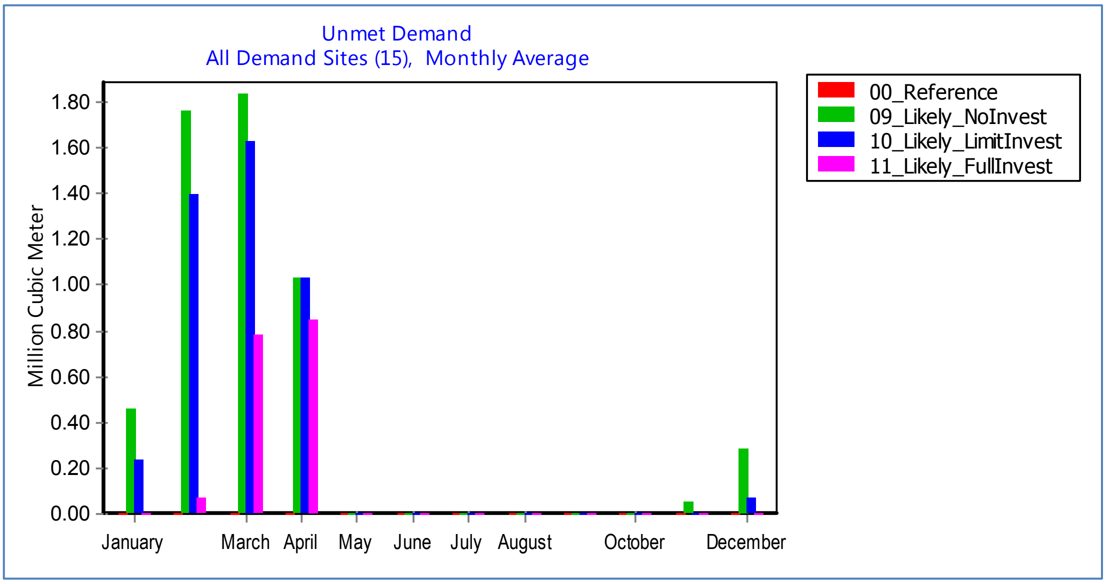
Obviously, the WEAP model as developed can be used relatively easily to analyze other sets of integrated scenarios and interventions, if desired.

Results of these integrated scenarios on water shortages (unmet demand) are shown in Figure 25. As mentioned before, under the current situation (*00_Reference*) no water shortage occurs. However, for the likely future water shortage can be substantial in the order of 3.5 and 7 MCM per year, depending on the amount of rainfall in a specific year (Figure 25, top). This water shortage is mainly restricted to the months of February, March and April and to a certain extent to December and January as well (Figure 25, middle). This water shortage can be also expresses as the coverage (= how much of the demand can be supplied). Figure 25 (bottom) shows that this coverage can go down to 40% in February and March if no interventions measures are taken.

If we consider that intervention measures will be taken, this water shortage can be overcome to a large extent. Under the full investments scenario (*11_Likely_Full_Invest*) coverage is for most months 100% and only during March and April this can go down to 80% on average. Note that for specific dry years this number can be lower.

Also the impact on streamflow was assessed (Figure 26). As expected flows will reduce significantly and especially the peak runoff will be considerable lower. However, low flows in the dry months will occur more frequently. Flows below 1 $m^3 s^{-1}$ can be expected from January to April if not intervention options will be taken (Figure 26, bottom). Under the full investment scenario these low flows can be overcome to a certain extent.



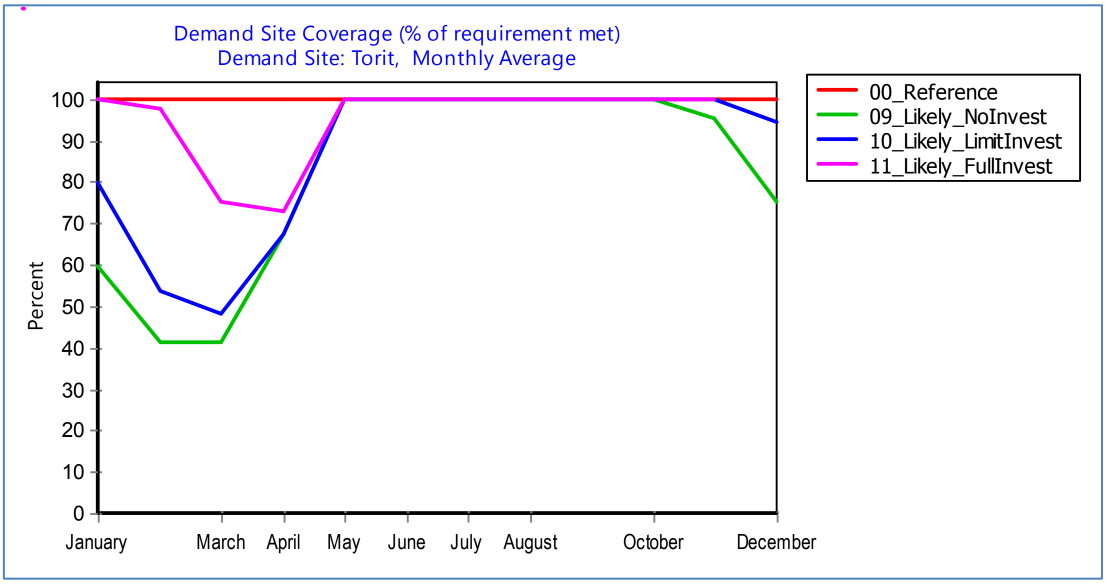
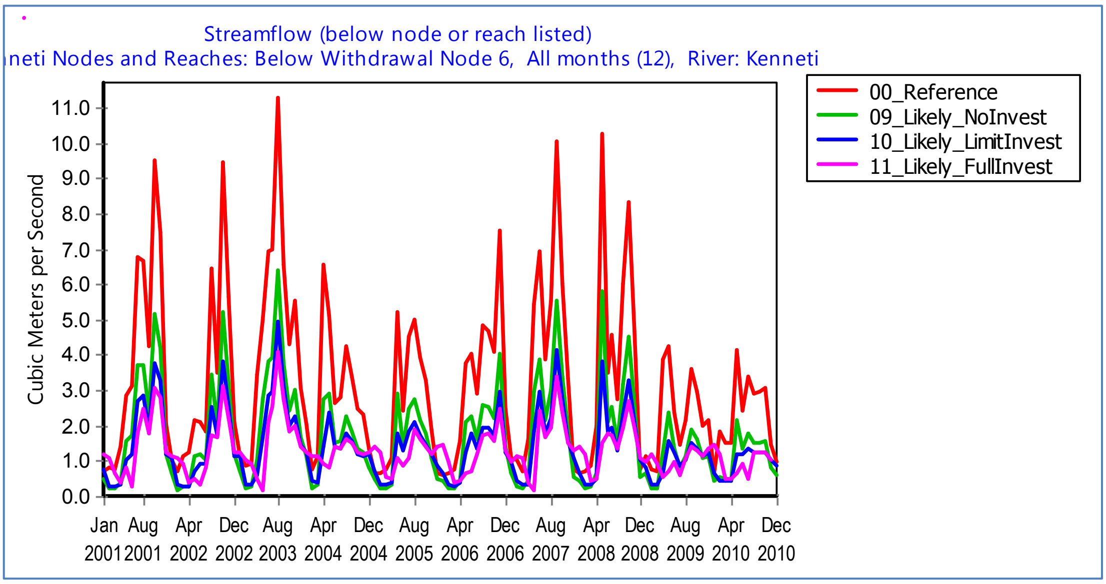
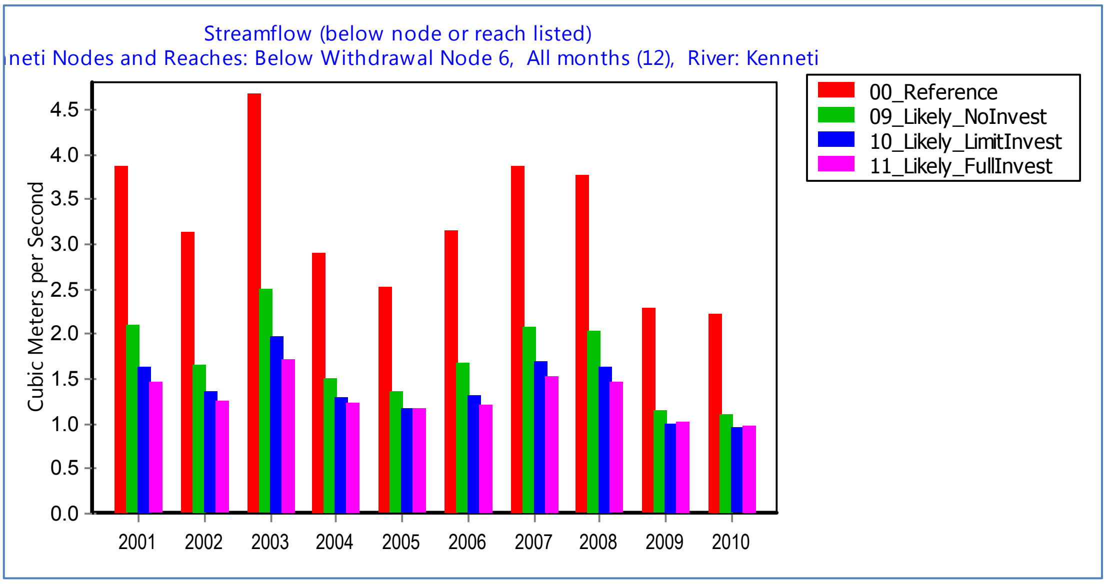




**Figure 25. Most likely future without adaptation interventions (09_Likely_NoInvest), with limited interventions (10_Likely_LimitedInvest) and full interventions**

**(11_LikelyFullInvest). Impact on water shortage (unmet demand) on annual base (top) and monthly averages (middle) for all demand; and monthly average coverage for Torit (bottom).**



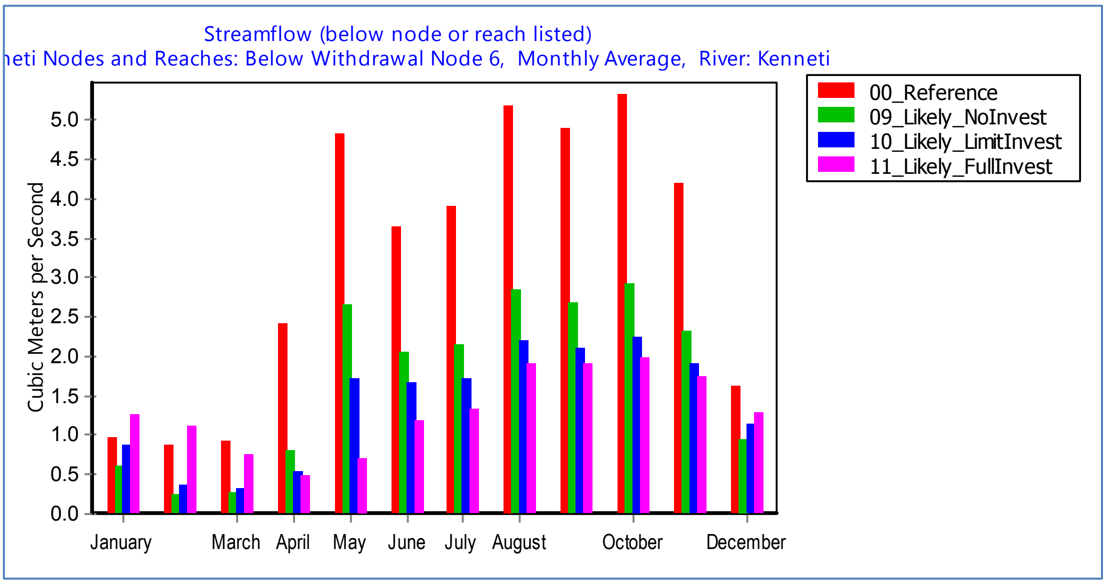



**Figure 26. Most likely future with and without interventions and the impact on streamflow at Torit.**

# 7 Conclusions and Recommendations

The ProWasEES program is a collaborated effort of the governments of South Sudan and the Netherlands (GoN) to ensure that “Kenneti Watershed is managed in an integrated and sustained manner”. Therefore, an integrated land and water management framework is needed to evaluate current and future water scenarios. In this report a description of the WEAP model as developed is provided and current and future options for water policies were evaluated with this model. Three sets of recommendation and conclusions emerge from the study.

- Current water resources
  - At the moment Kenneti water resources are sufficient to supply the current demand. Even during the driest months flows are sufficient to support the demand for water. Obviously, people living in the area are experiencing limitations in house-hold water since no piped water system occurs.
  - The developed WEAP tool is able to mimic reality based on a limited number of observations in the field and some historic reports. The tool can therefore be used to evaluate impact of future scenarios.

- Future threats and opportunities
  - A set of scenarios was analyzed. Climate change, a fixed downstream water requirement and irrigation development are the most critical ones in terms of competition for water. Population growth and deforestation are having a lower impact on water availability. However, deforestation might have adverse impacts on erosion and on additional flooding.
  - In reality, a set of developments will take place simultaneously. The combined impact of climate change, population growth and irrigation development shows that, without measures, water shortage will be substantial.
  - To deal with this increase in water shortage investment should be taken. A combined effort of constructing reservoirs and catchment protection measures should be considered.

- Further refinement of assessment tools and data
  - The current assessment tool is validated using the limited information available. However, by using the same tool for the current situation as well as for scenario analysis the relative accuracy (= comparing current with future) is probably higher than the absolute accuracy.
  - An extended measurement program is currently being set up. It is advisable that after about one year of data collection a first order validation/calibration would be done. Further fine-tuning can be undertaken if also data from a dry and/or a wet year is collected.
  - The number of scenarios analyzed so far can be refined and expanded. The tool is available for such analyses.

# APPENDIX: Proposed discharge measuring sites in Kenneti River and its tributaries

This Table is based on ''Hydrology Mission to Kenneti River Basin'' d.d. September 2014, Jan Lasse Wahlstrom. Confirmed by Fabian Musila d.d. 28 May 2015.

| | |
|---|---|
| **In Kenneti main river** | |
| 1.: Kenneti River at the foot of the mountains, Katire 2, upstream of Katire guest house (stations higher up will have turbulent flow). The station will monitor the inflow from the upper part, the steep mountain part of the Kenneti River course. | Longitude: 32.800909° East<br>Latitude: 04.033125° North<br>Elevation: 1009 m |
| 2.: Kenneti River approx. 150 m downstream of proposed dam site, DPK1. The station will monitor the flow in the middle part of the Kenneti River course and the outflow from the planned dam. | Longitude: 32.664307° East<br>Latitude: 04.267151° North<br>Elevation: 665 m |
| 3.: Kenneti River at Torit, behind the Ministry of Physical Infrastructure. The station will monitor the outflow from the middle part of the Kenneti River course to the lower part of the Kenneti River course, the outflow to the flood plain north of Torit (station sites further downstream are uncontrolled under high flow conditions) | Longitude: 32.572514° East<br>Latitude: 04.401125° North<br>Elevation: 606 m |
| **In tributaries to Kenneti main river**<br>Monitoring of selected tributaries will provide data for estimating flows in un-gauged catchments based on assumption of catchment similarities and specific catchment runoff calculations (runoff per area unit). | |
| 4.: **Kiwa River** at the bridge on the Torit - Katire road. | Longitude: 32.680317° East<br>Latitude: 04.20787° North<br>Elevation: 734 m |
| 5.: **Halihoi River** at the bridge on the Torit - Katire road. | Longitude: 32.642733° East<br>Latitude: 04.332394° North<br>Elevation: 644 m |
| **Iyodo River**<br>Two stations were selected which will provide data for estimating flows in un-gauged sub-catchments based on assumption of catchment similarities and specific catchment runoff calculations. Furthermore as it is impossible to measure directly the inflow from Iyodo River to Kenneti River at the confluence due to the flooding and flood plain conditions an estimate of the contribution from Iyodo River can be based on the provided data from the two stations: | |
| 6.: Iyodo River close to the Imurok Payam office. The site is close to the endpoint of the road from Torit, and it is therefore the most upstream site with easy access. The station will monitor the inflow from the upper part of the Iyodo River catchment. | Longitude: 32.546785° East<br>Latitude: 04.202214° North<br>Elevation: 708 m |
| 7.: Iyodo River at un-finished bridge close to the Torit - Imoruk road. The station will monitor the flow in the middle part of the Iyodo River course, the inflow to the | Longitude: 32.548824° East<br>Latitude: 04.279357° North |

| | | |
|---|---|---|
| floodplains south of Torit. | Elevation: | 657 m |

**Loleir River**

Two stations were selected which will provide data for estimating flows in un-gauged sub-catchments as well as the outflow to the floodplains north of the Juba - Torit main road:

| | | |
|---|---|---|
| 8.: Loleir River at the bridge on the Magwi main road. The station will monitor the inflow from the upper part of the Loleir River catchment. | Longitude: | 32.418578° East |
| | Latitude: | 04.298827° North |
| | Elevation: | 707 m |
| 9.: Loleir River at the bridge on the Juba - Torit road. The station will monitor the flow in the middle part of the Loleir River course and the outflow to the floodplains in the north. | Longitude: | 32.48371° East |
| | Latitude: | 04.436792° North |
| | Elevation: | 593 m |

In total 10 images were downloaded, from the following dates:

| Image | Year | DOY | Date |
|---|---|---|---|
| lc81720572014142lgn00.zip | 2014 | 142 | 22-May-2014 |
| lc81720572014158lgn00.zip | 2014 | 158 | 07-Jun-2014 |
| lc81720572014174lgn00.zip | 2014 | 174 | 23-Jun-2014 |
| lc81720572014190lgn00.zip | 2014 | 190 | 09-Jul-2014 |
| lc81720572014222lgn00.zip | 2014 | 222 | 10-Aug-2014 |
| lc81720572014350lgn00.zip | 2014 | 350 | 16-Dec-2014 |
| lc81720572015049lgn00.zip | 2015 | 049 | 18-Feb-2015 |
| lc81720572015065lgn00.zip | 2015 | 065 | 06-Mar-2015 |
| lc81720572015081lgn00.zip | 2015 | 081 | 22-Mar-2015 |
| lc81720572015113lgn00.zip | 2015 | 113 | 23-Apr-2015 |

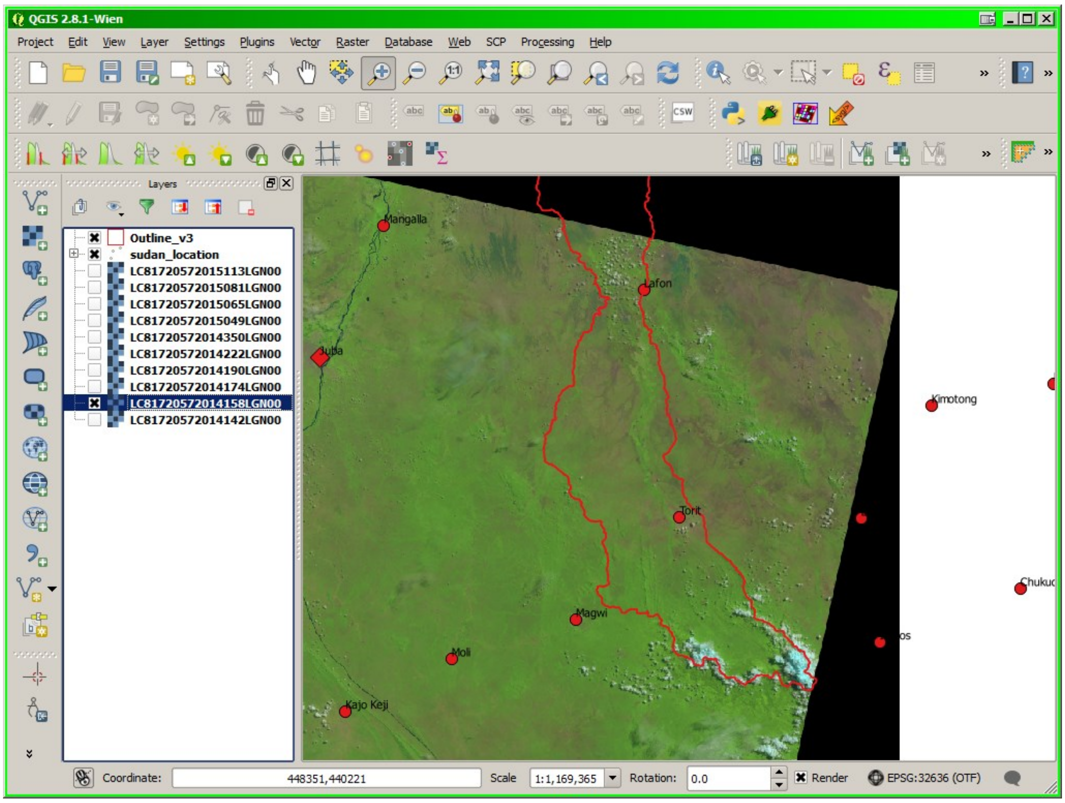



**Figure 27. Landsat image 2014_158**

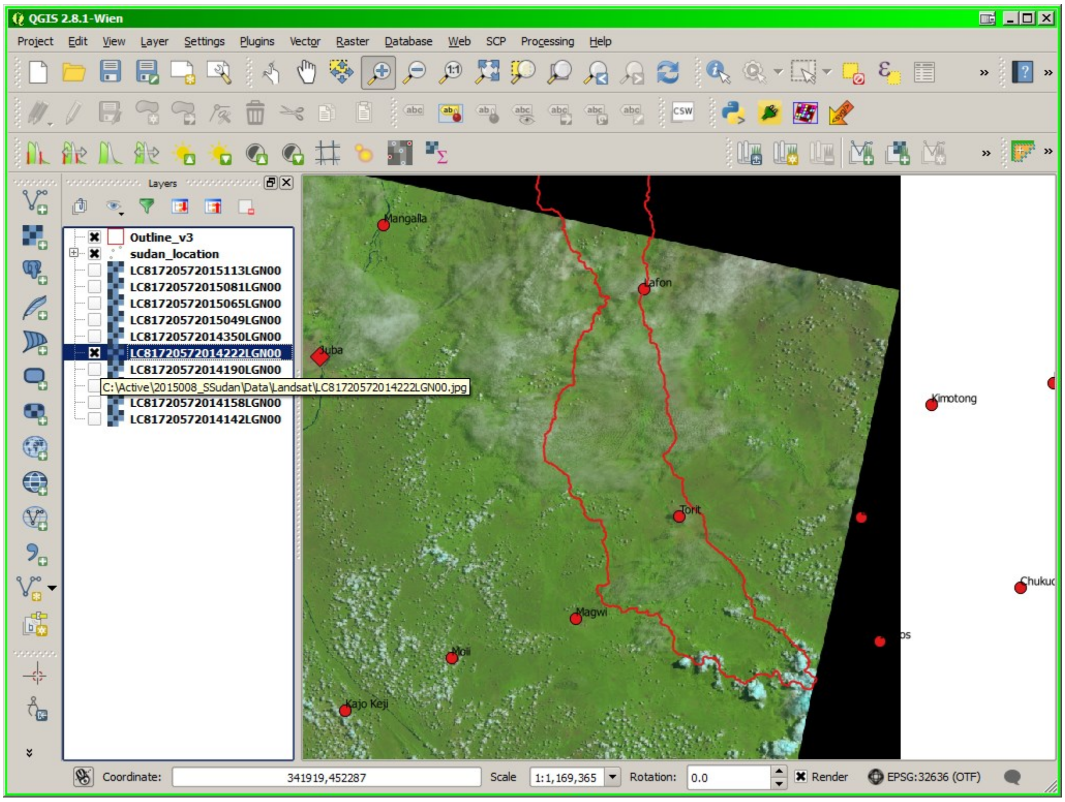


Figure 28. Landsat image 2014_222

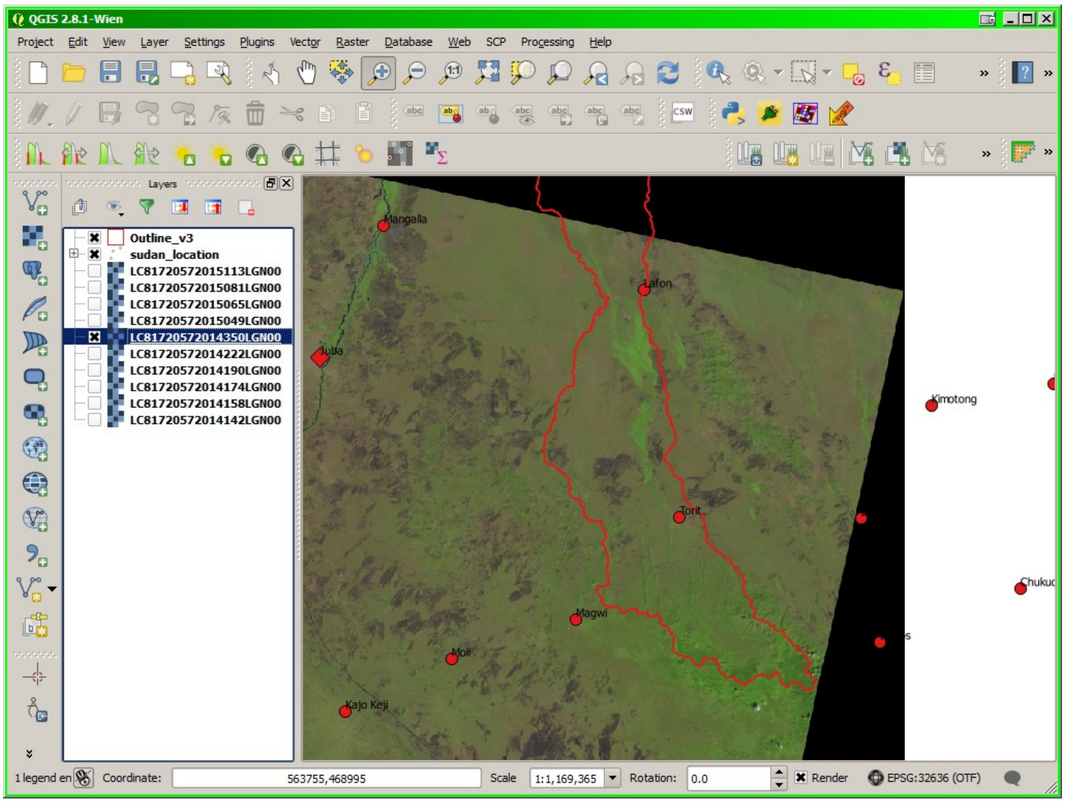


Figure 29. Landsat image 2014_340

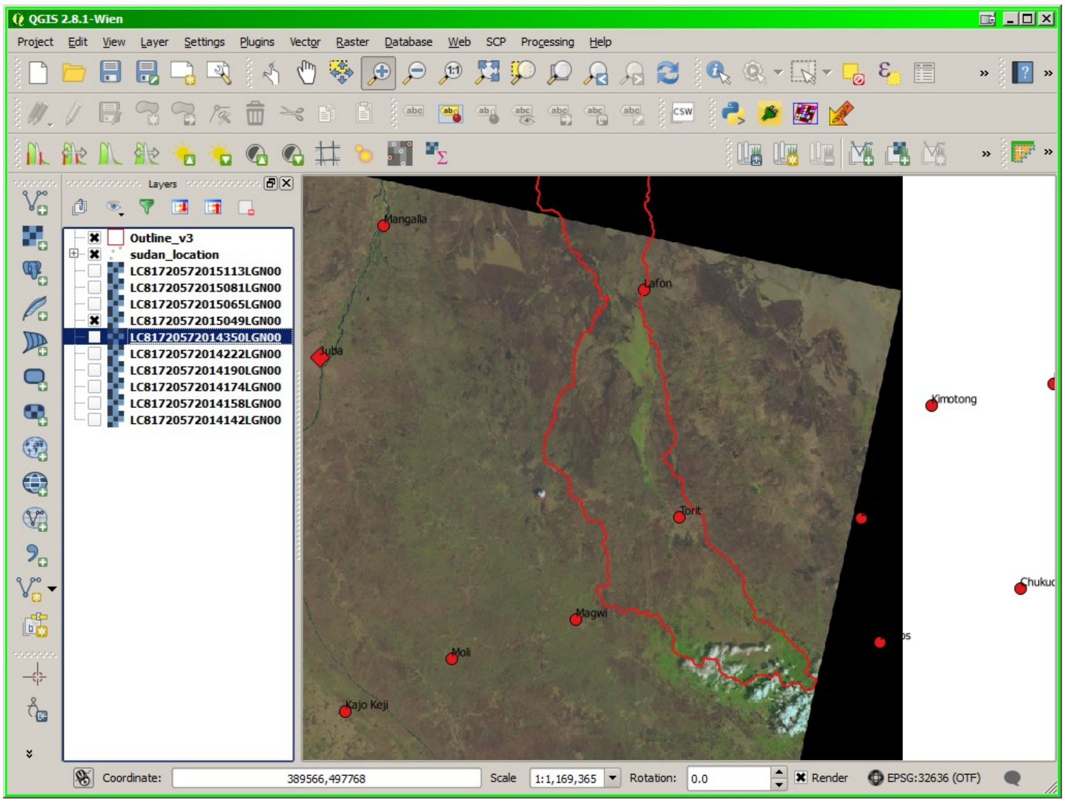
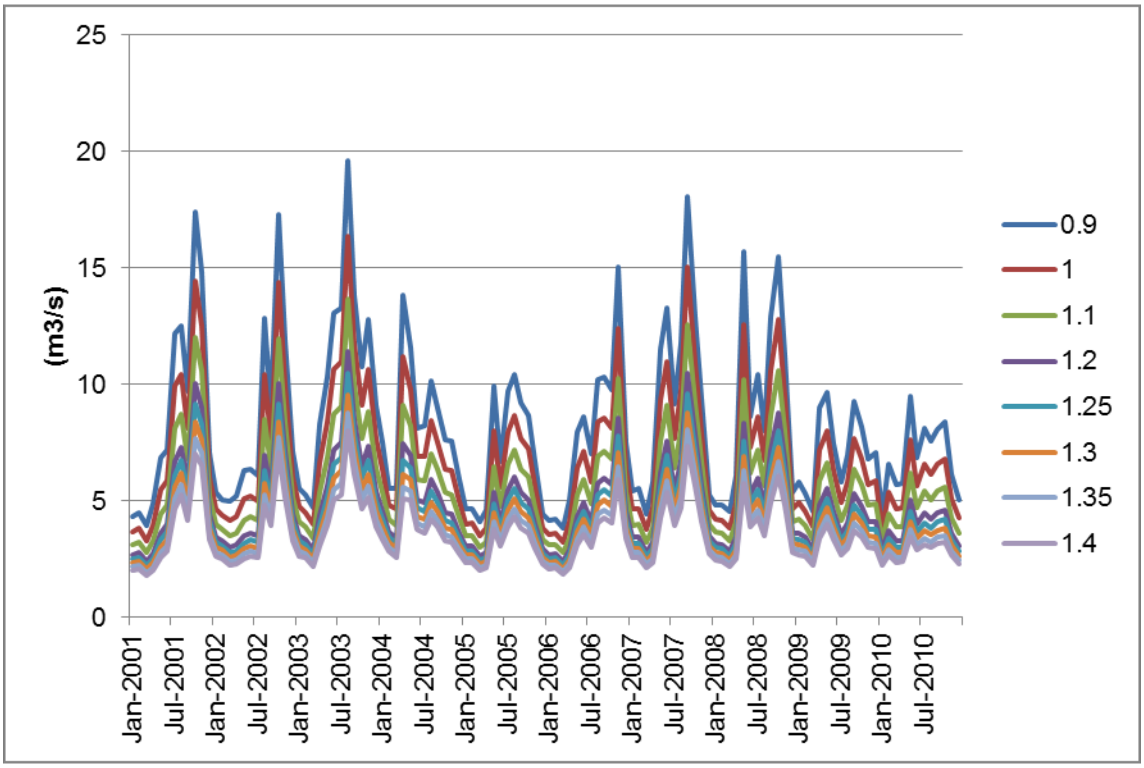
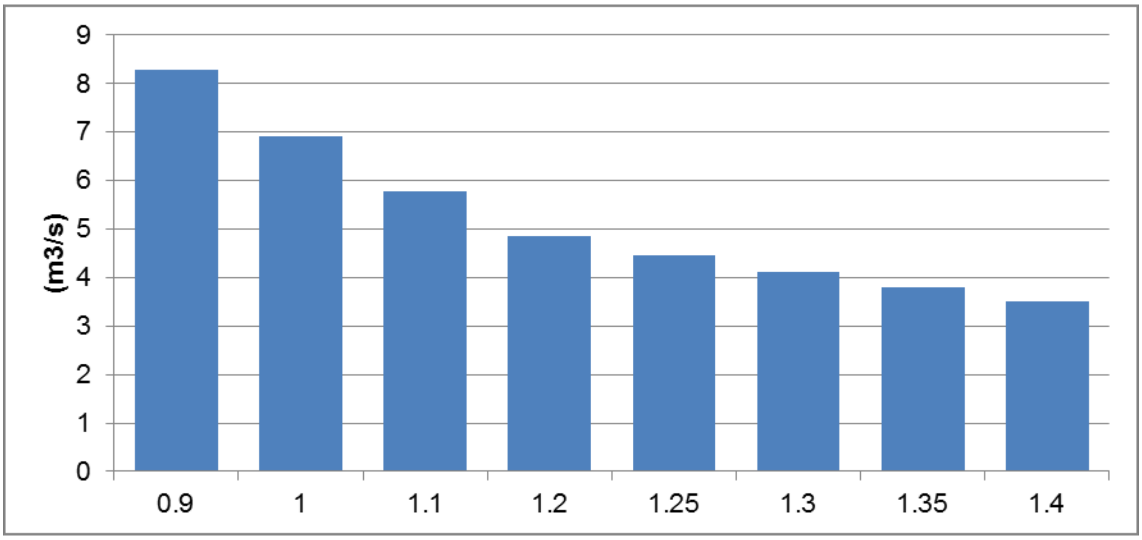



**Figure 30. Landsat image 2015_049**

**Kc**

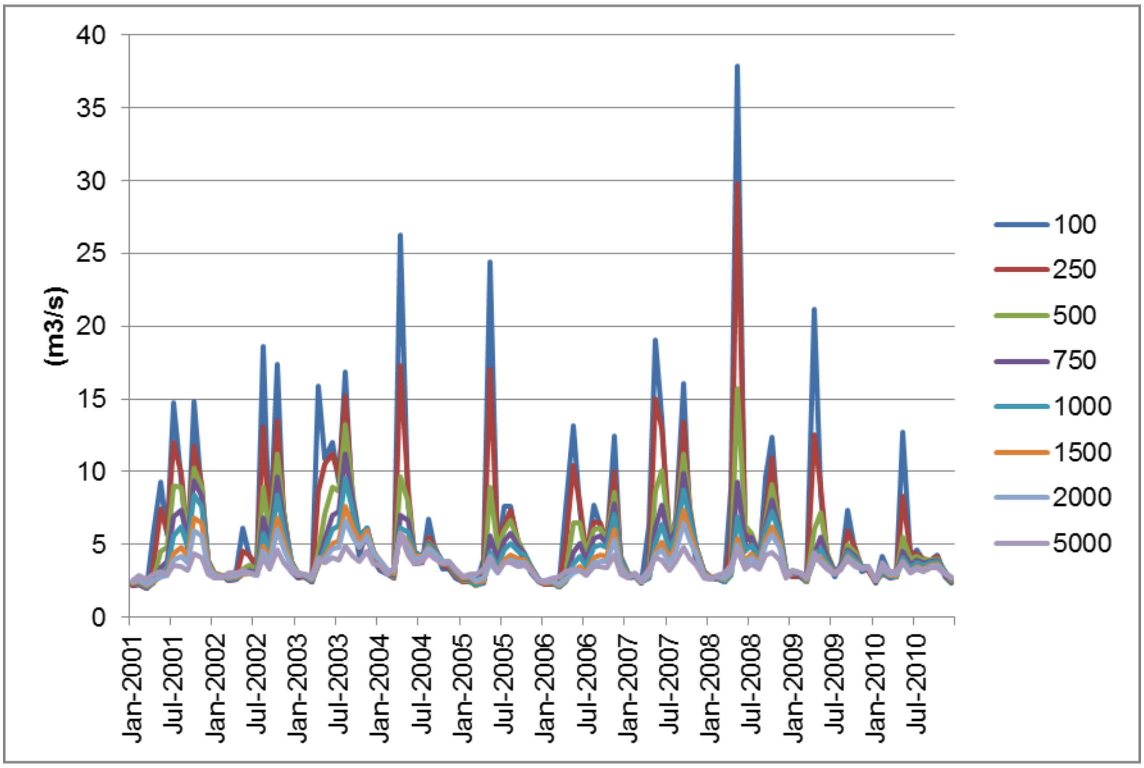
Default value: 1
Kenneti_v04 value: 1.3
Output: Streamflow at Torit inlet point
WEAP: (Supply and Resources\River\Kenneti\Reaches\Below Withdrawal Node 6)

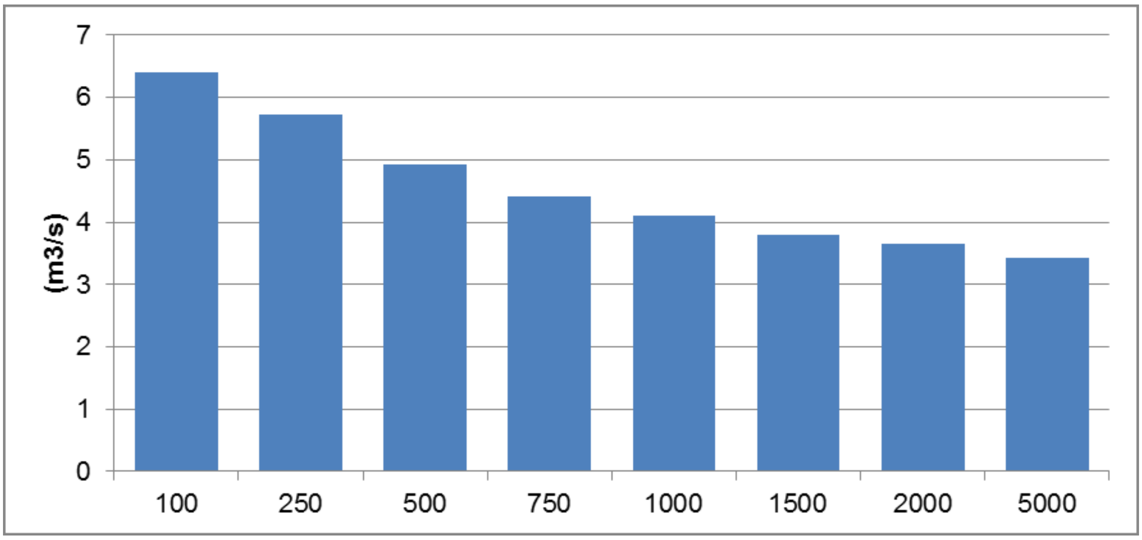


## Soil Water Capacity

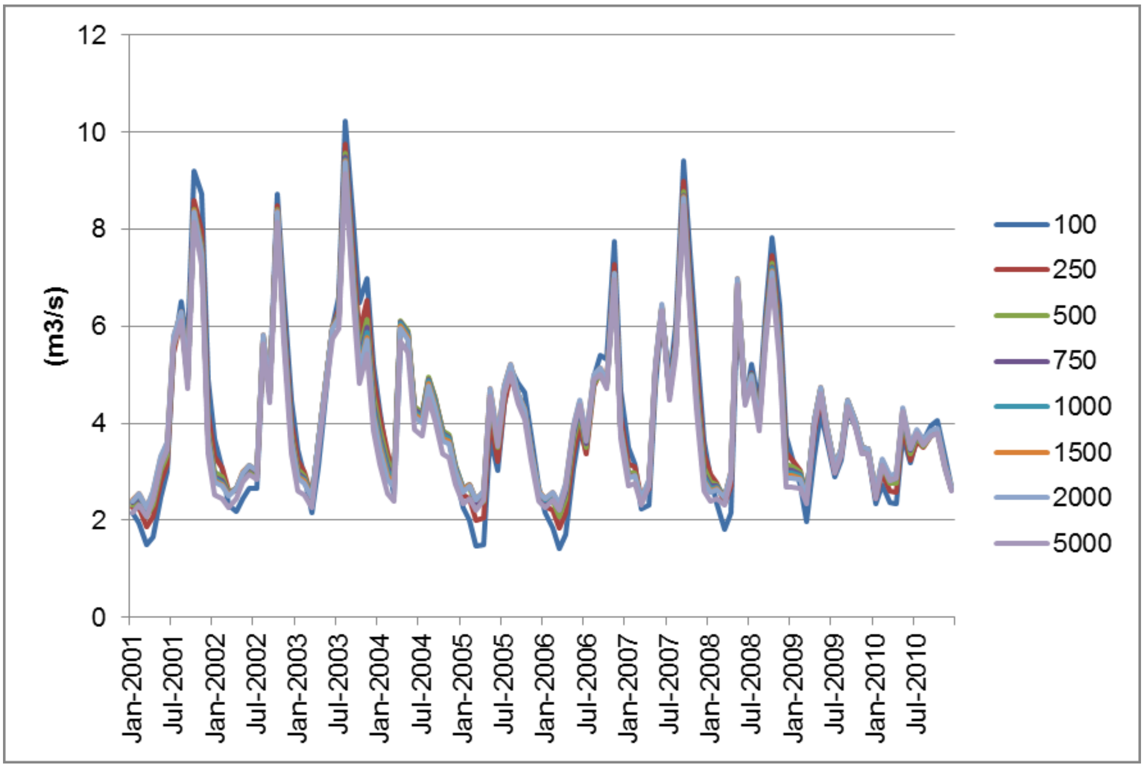
Default value: 1000 mm
Kenneti_v04 value: 1000 mm
Output: Streamflow at Torit inlet point
WEAP: (Supply and Resources\River\Kenneti\Reaches\Below Withdrawal Node 6)

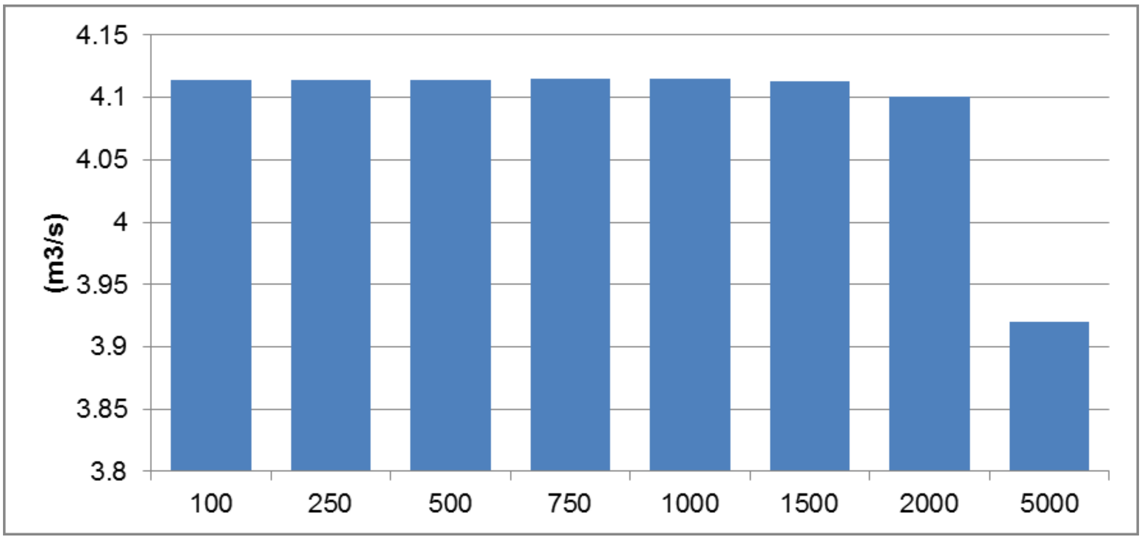


## Deep Water Capacity

Default value: 1000 mm
Kenneti_v04 value: 500 mm
Output: Streamflow at Torit inlet point
WEAP: (Supply and Resources\River\Kenneti\Reaches\Below Withdrawal Node 6)

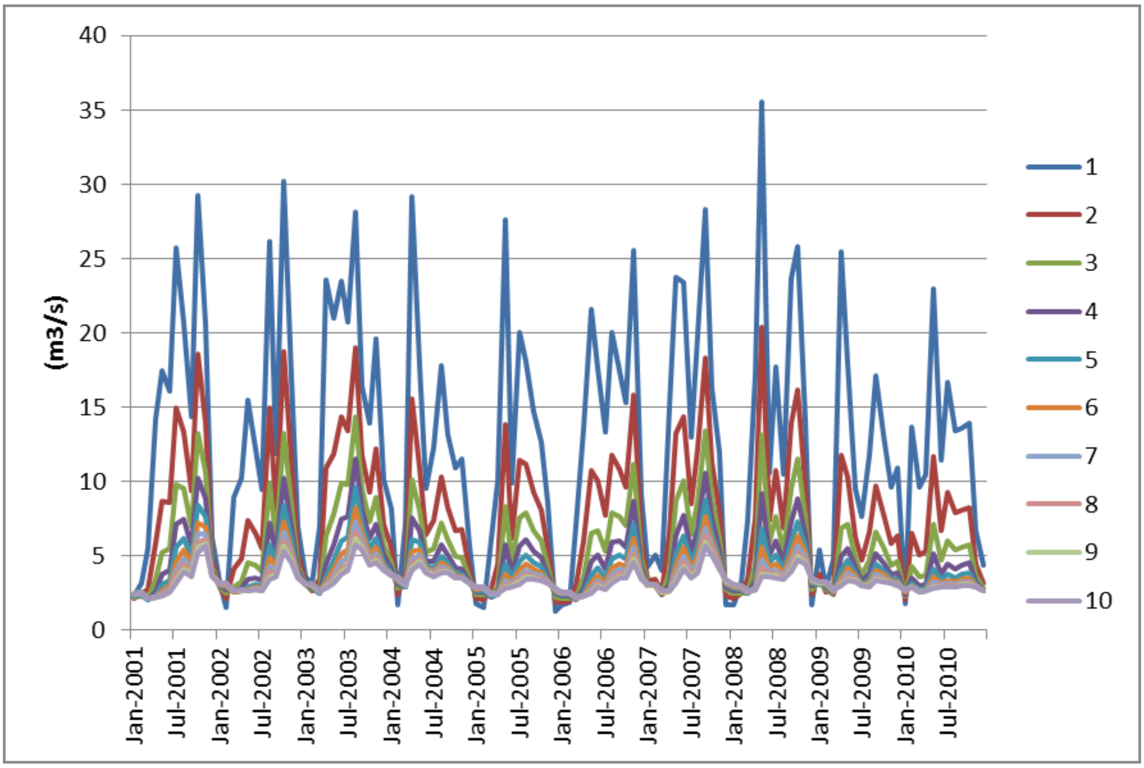


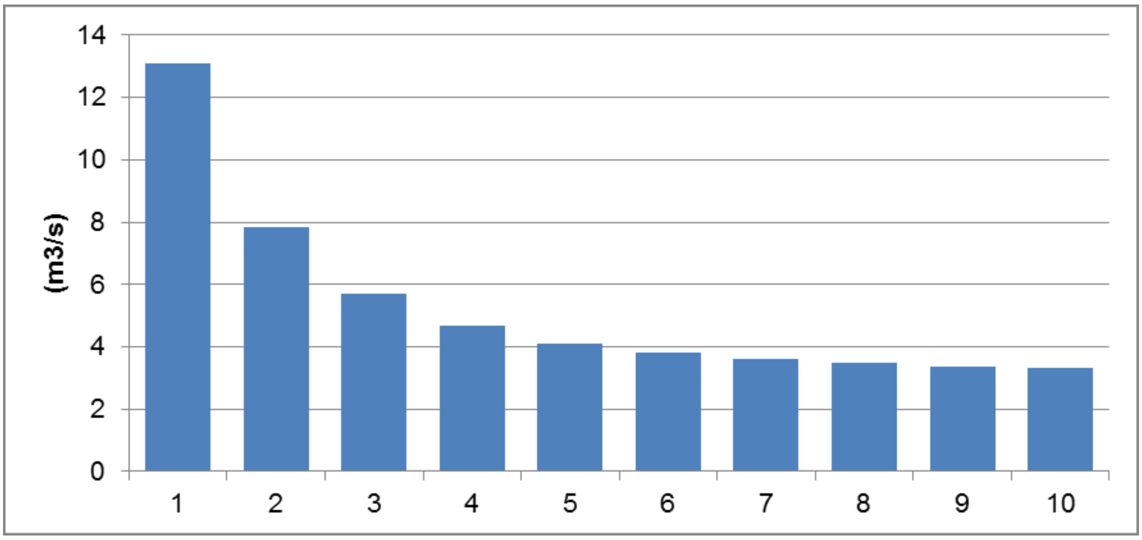




*Note: for Deep Water Capacity value 5000 mm no equilibrium in soimoisture 2 was achieved after 10 years.*

## Runoff Resistance Factor

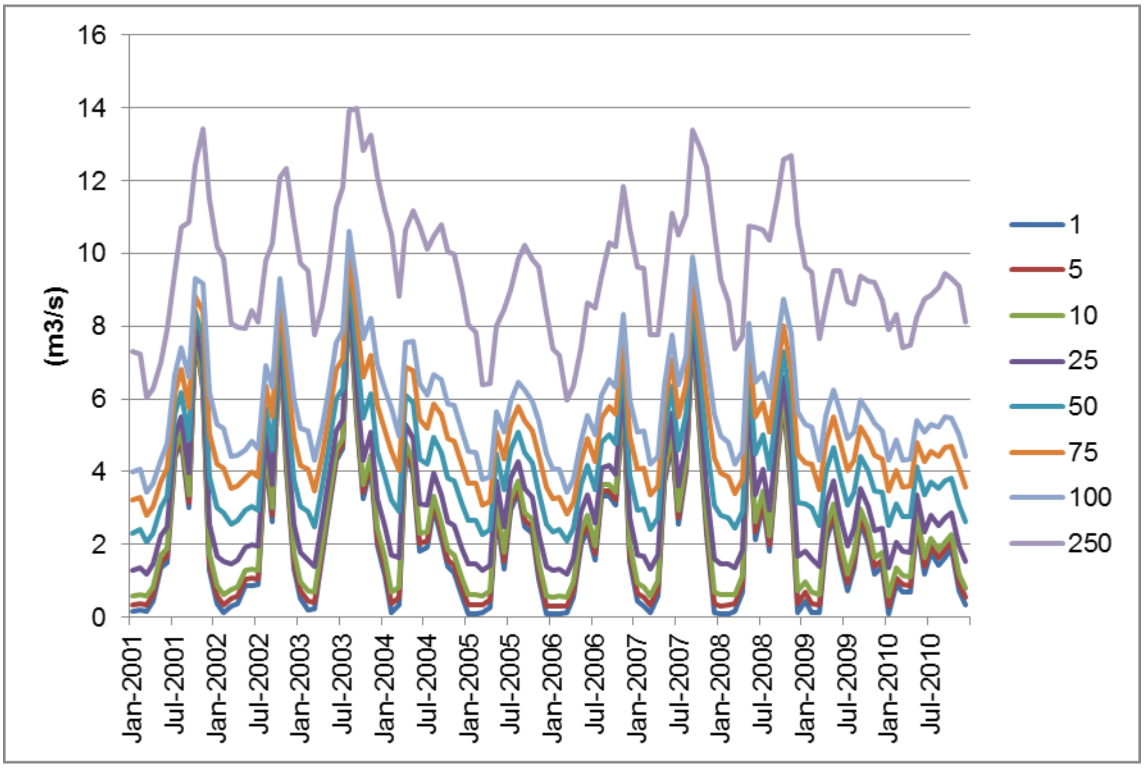
Default value: 2
Kenneti_v04 value: 5
Output: Streamflow at Torit inlet point
WEAP: (Supply and Resources\River\Kenneti\Reaches\Below Withdrawal Node 6)

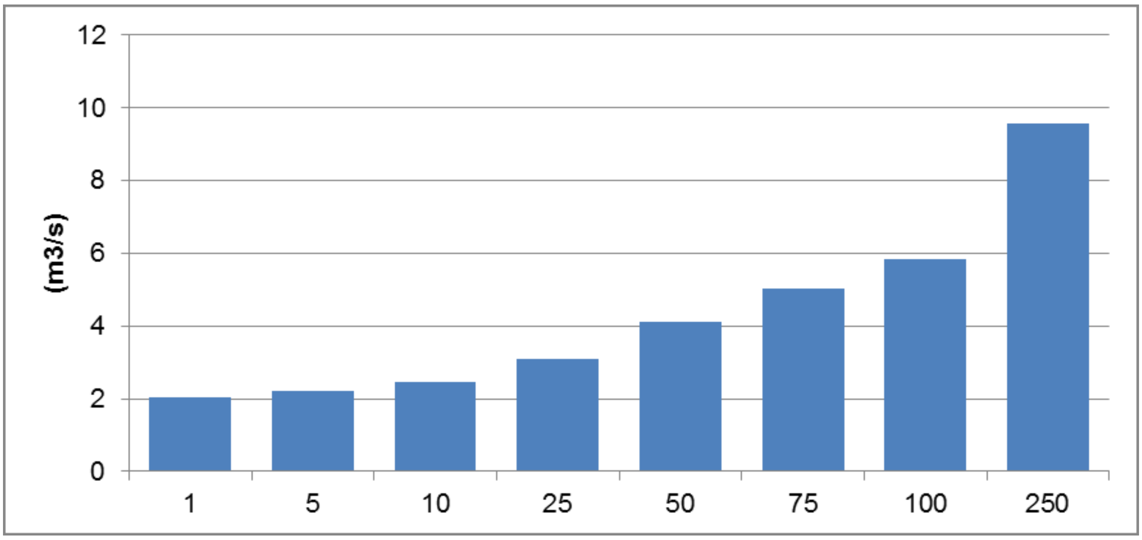


## Root Zone Conductivity

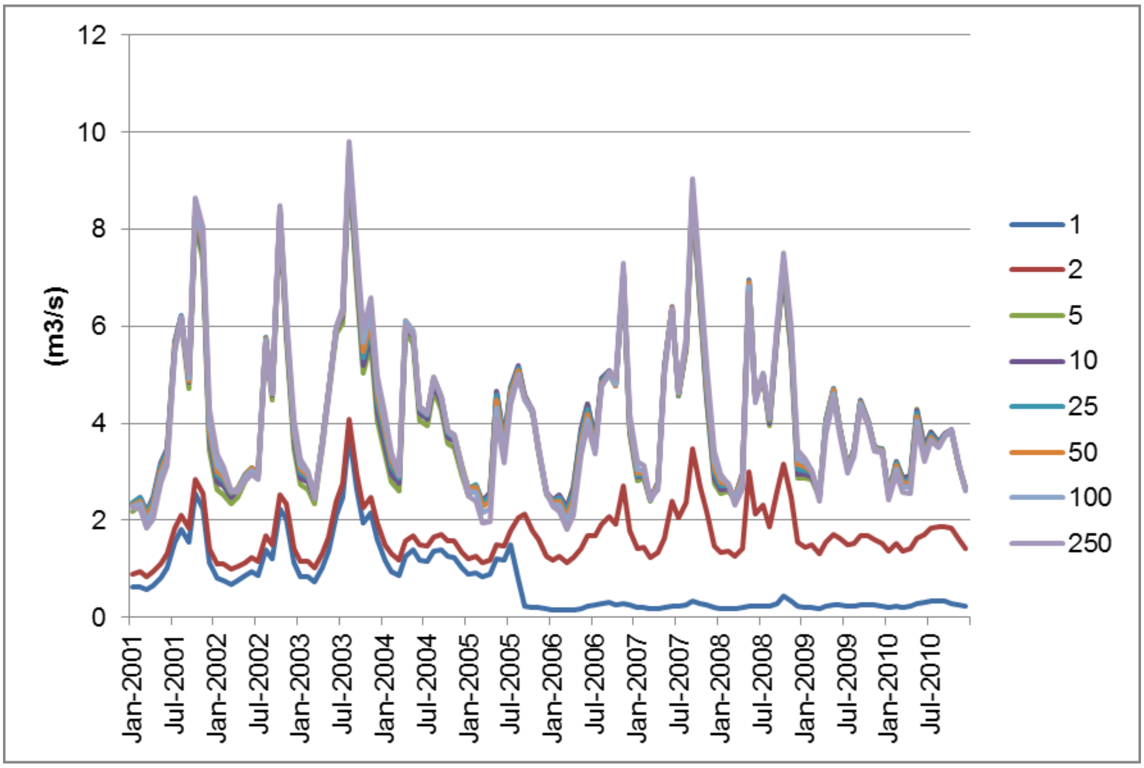
Default value: 20 mm/month
Kenneti_v04 value: 50 mm/month
Output: Streamflow at Torit inlet point
WEAP: (Supply and Resources\River\Kenneti\Reaches\Below Withdrawal Node 6)

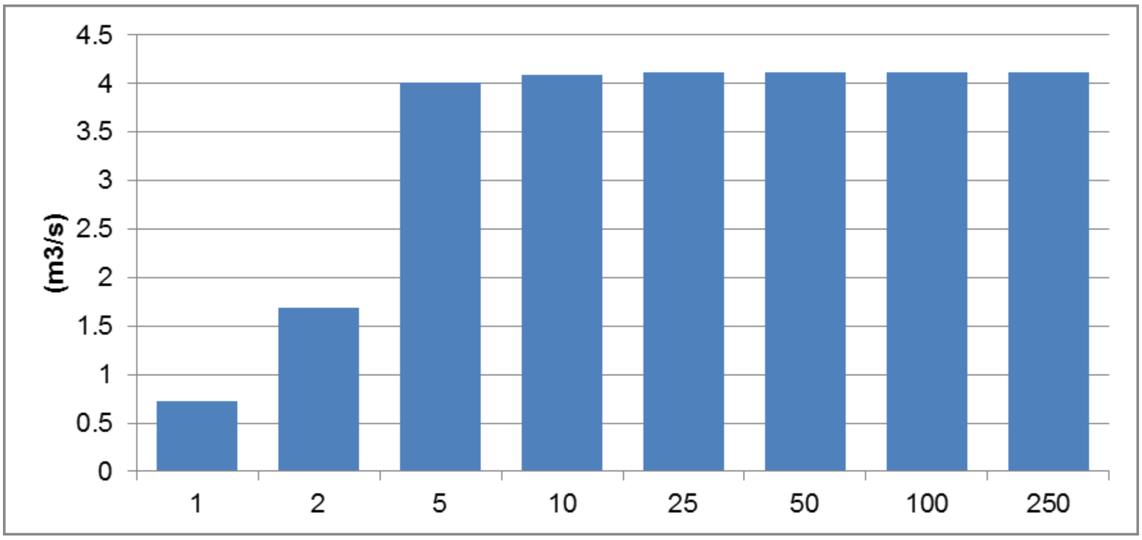


## Deep Conductivity

Default value: 20 mm/month
Kenneti_v04 value: 50 mm/month
Output: Streamflow at Torit inlet point
WEAP: (Supply and Resources\River\Kenneti\Reaches\Below Withdrawal Node 6)




*Note: for values 1 and 2 mm/month calculation errors: no convergence*

### Preferred Flow Direction

Default value: 0.15
Kenneti_v04 value: 0.15
Output: Streamflow at Torit inlet point
WEAP: (Supply and Resources\River\Kenneti\Reaches\Below Withdrawal Node 6)