URAdapt

Managing Water at the Urban-Rural Interface: The key to climate change resilient cities

VENSIM Systems modelling and scenario analysis for science based city planning

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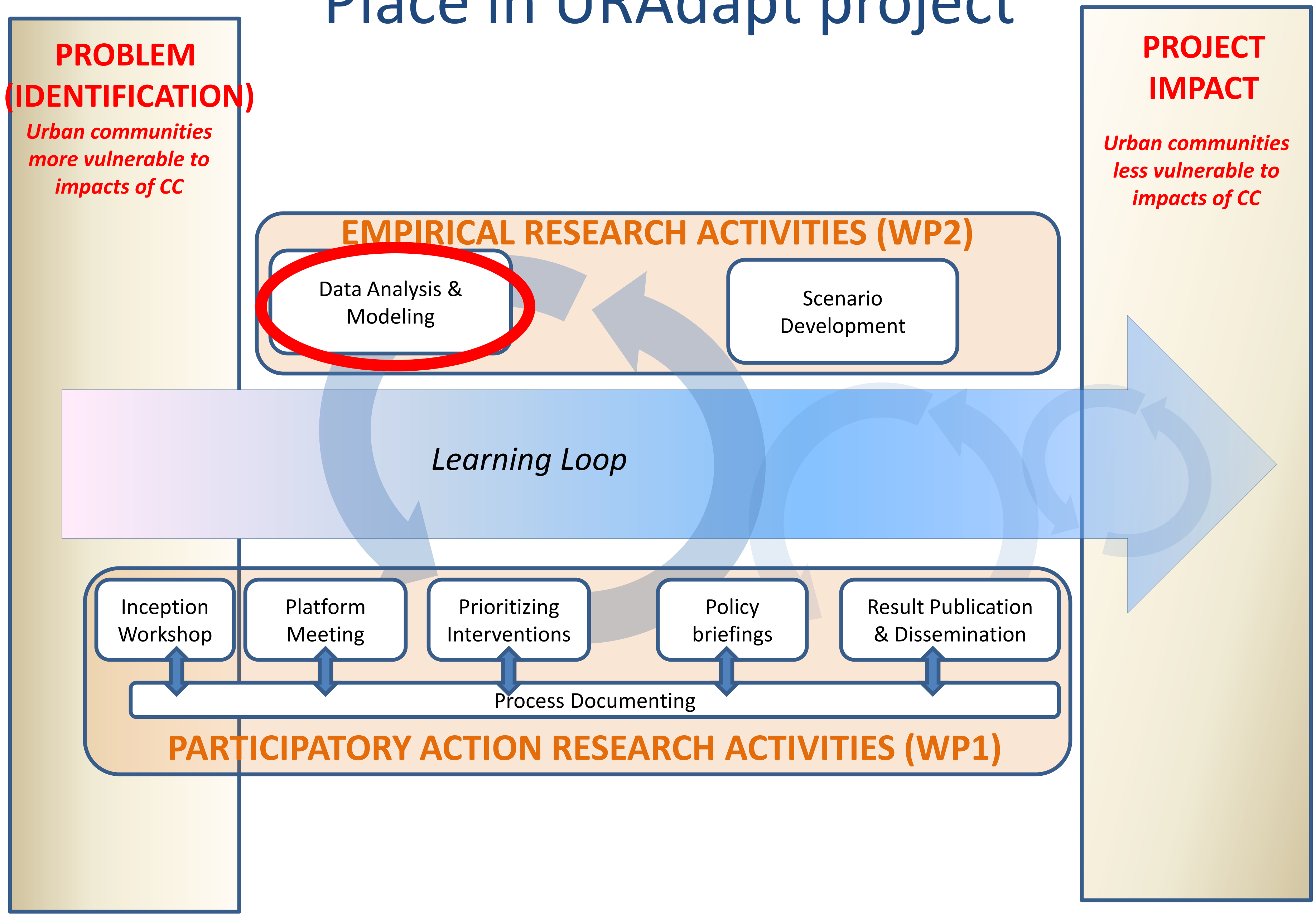
African Regent Hotel, 24 February 2010

Contents

- Place in the URAdapt project
- Accra urban water system
- Impacts climate change on urban water balance
- Scenarios in relation to the working of the model
- Model properties
- Outputs
- Planning of activities

Place in URAdapt project

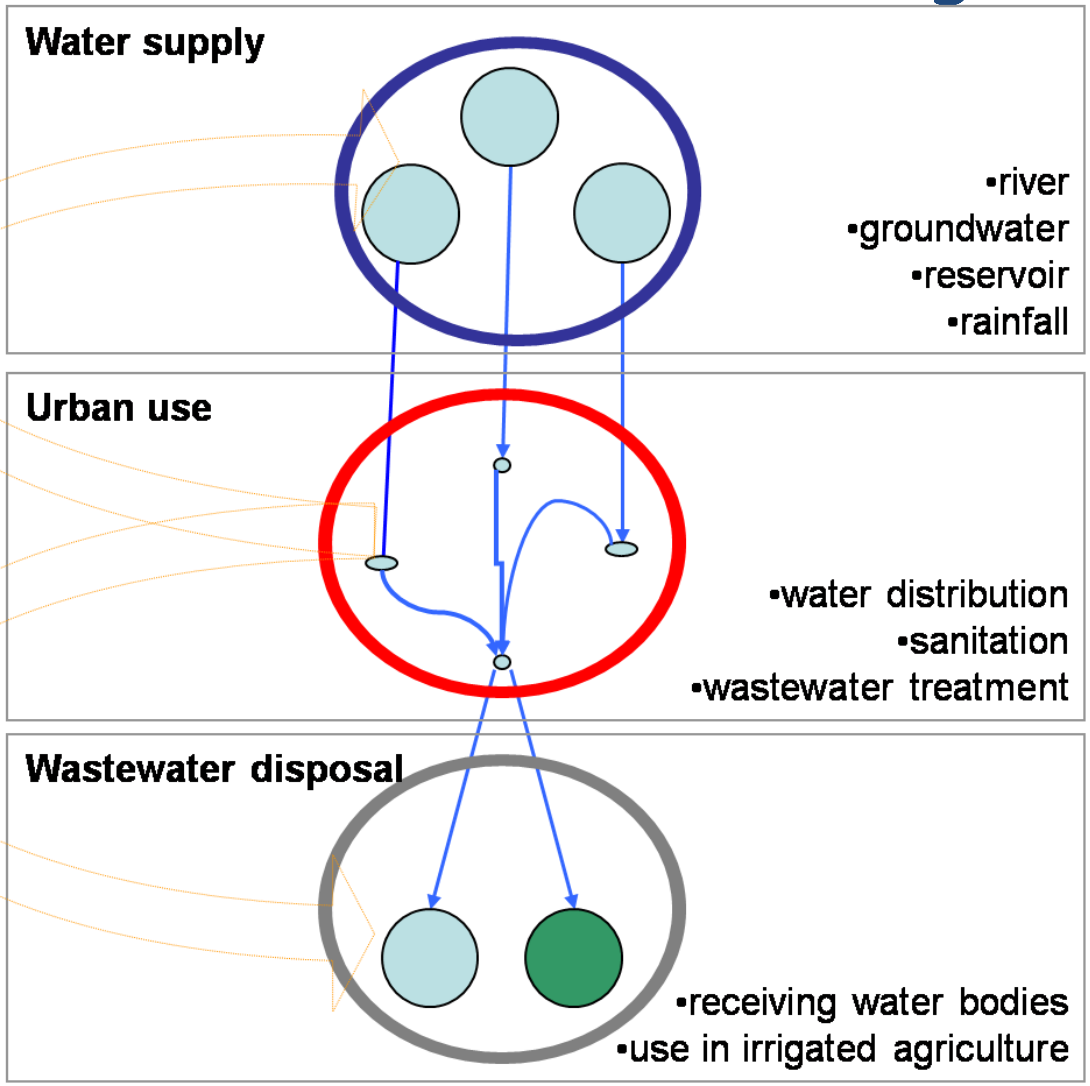


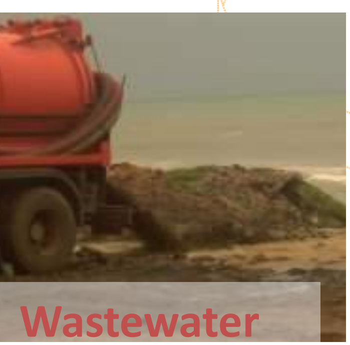
Objectives

- To generate needed knowledge and deeper understanding of urban water system and vulnerability
- To process demographic and water supply and demand scenarios
- To rationalize the discussion on climate change risks
- To provide decision support

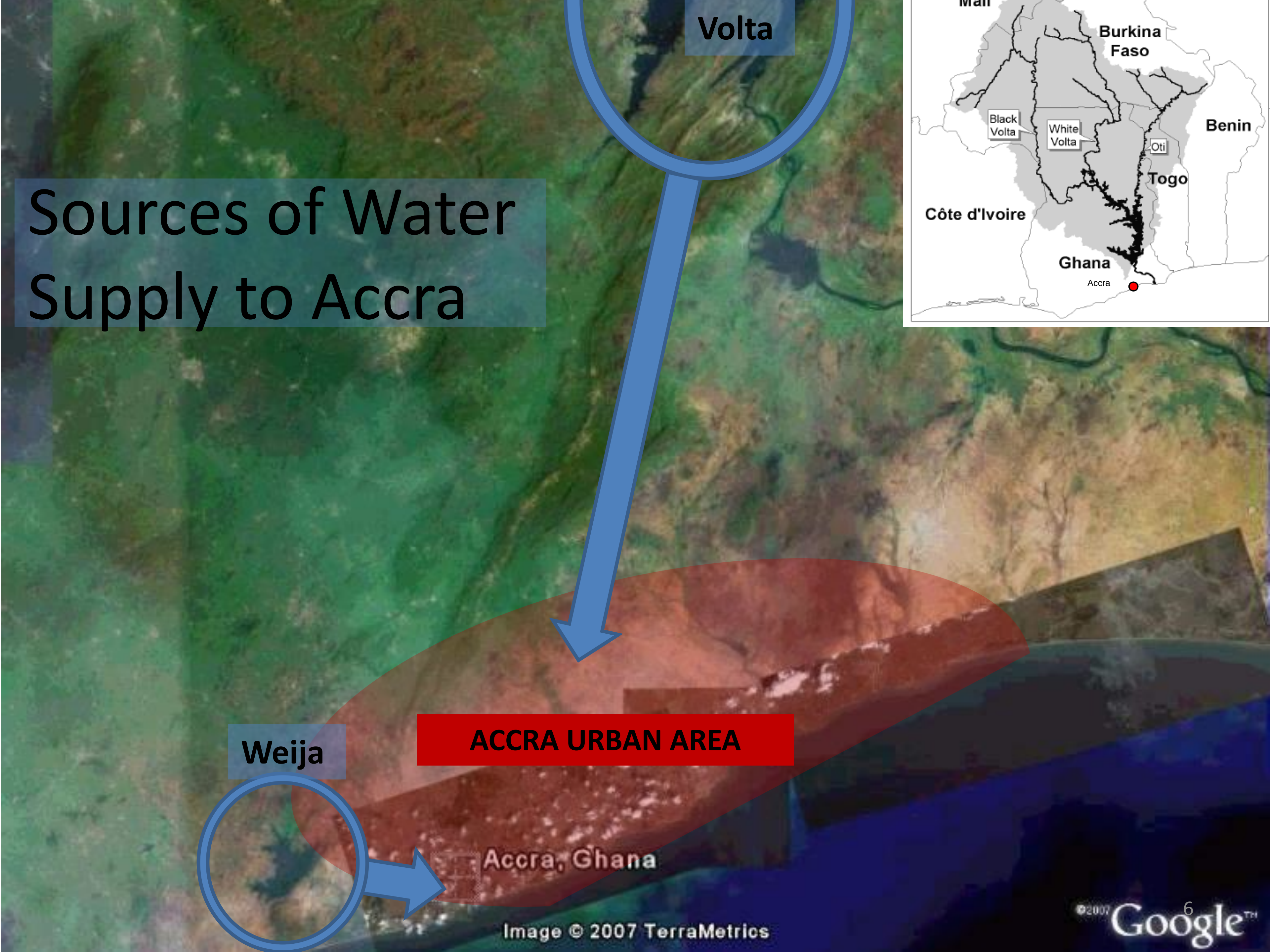
Accra Urban Water System.

What water are we talking about?

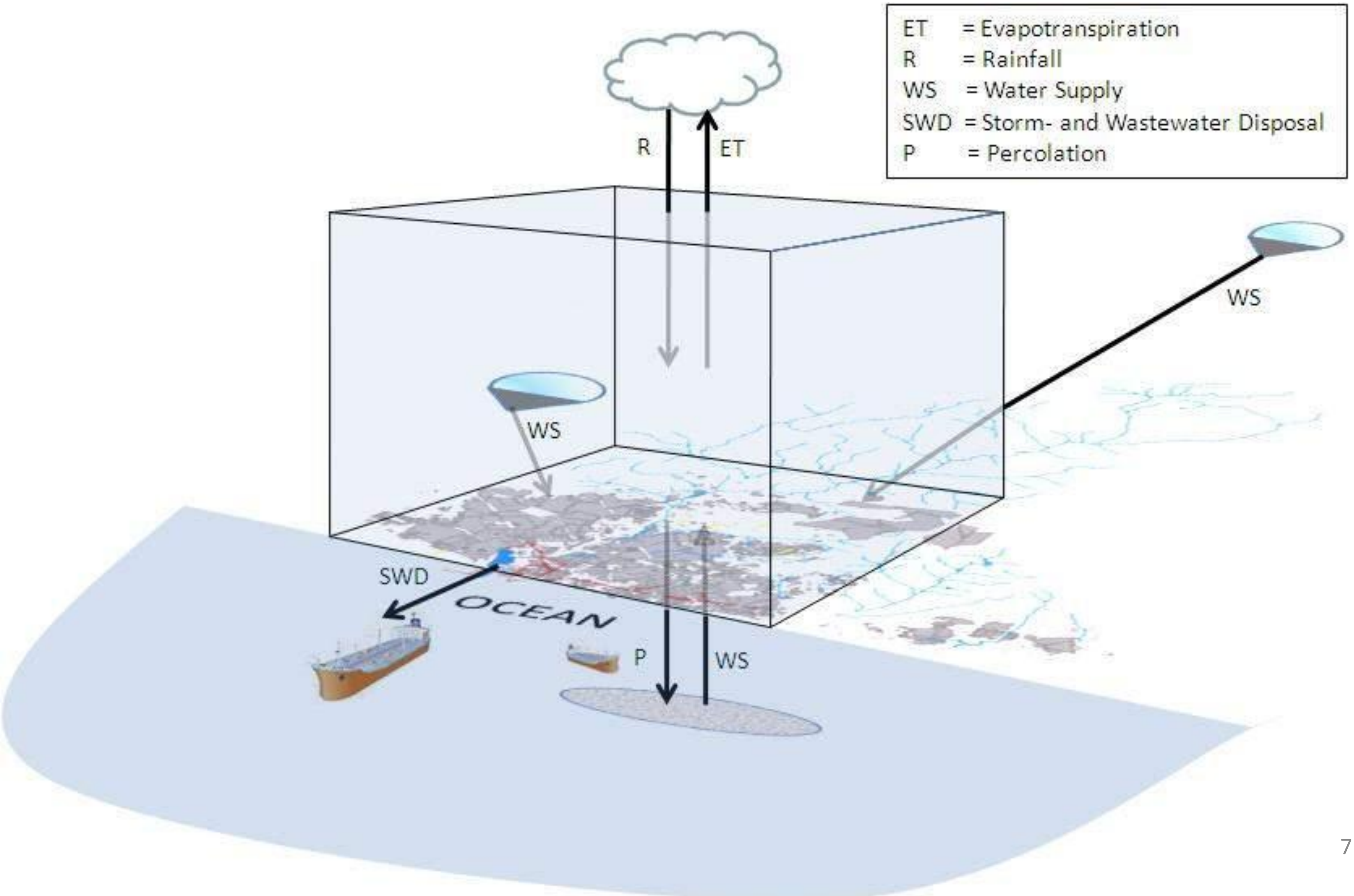




Sources of Water Supply to Accra



Impacts Climate Change on Urban Water Balance



CC impact scenarios in relation to the working of the model

CC Scenario: Rainfall events becoming more intense and frequent (city level)

Impact: More severe and frequent flooding in urban areas. Increased health risk due to mixing with untreated domestic wastewater.

Modeling results that can help develop adaptation strategies :

- Improving drainage system will reduce flood volume by X% (government)
- X% potential flood reduction through rooftop water harvesting (households)
- X% storm water reduction by increasing fraction green areas in the city, to improving infiltration (government)

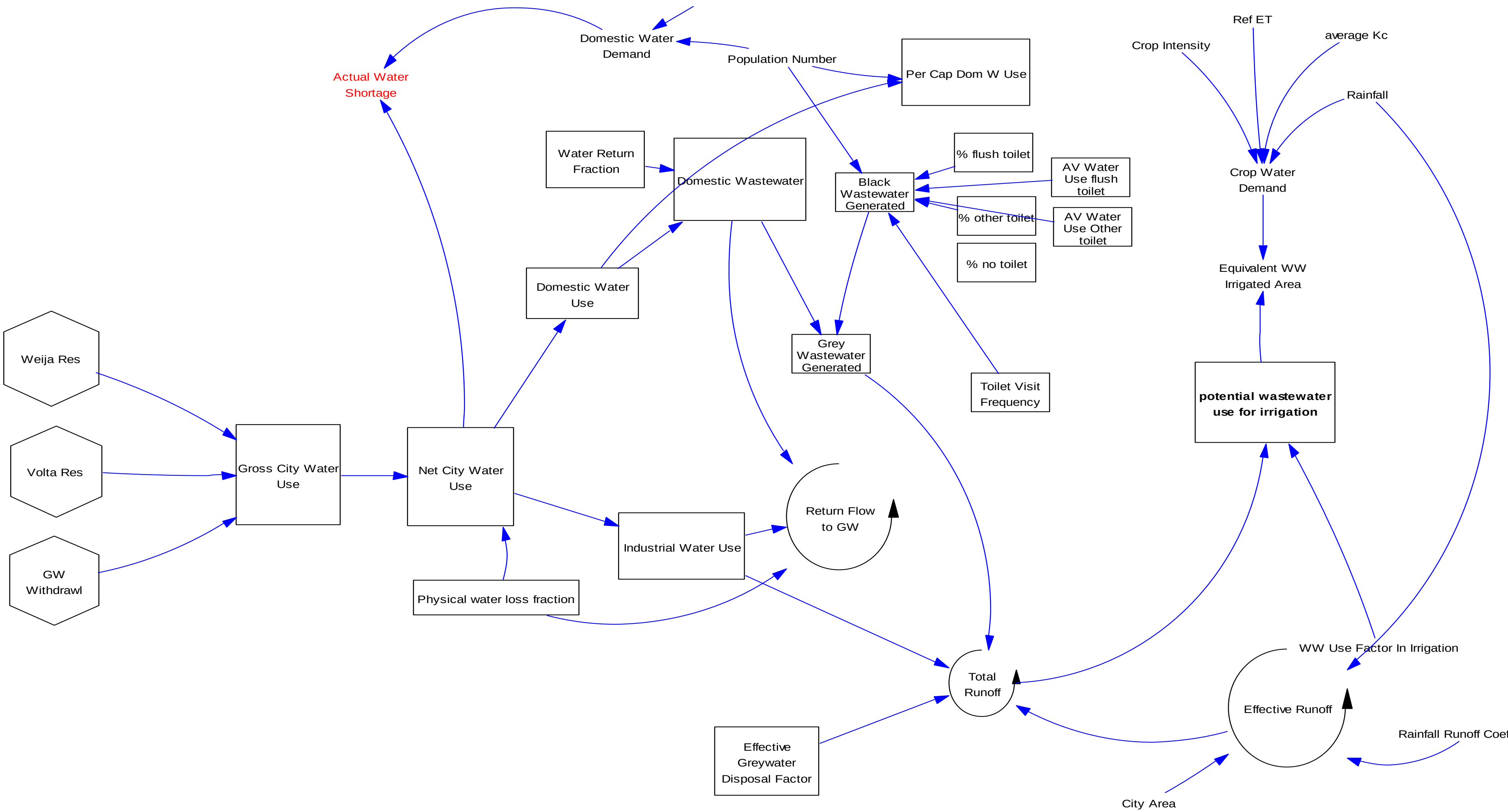
CC Scenario: Dry periods becoming more severe (drier) and recurring more often (catchment level)

Impact: Low water availability for all water use sectors.Reduced urban water supply.

Modeling results that can help developing adaptation strategies:

- Potentially X% of rainwater saved through rooftop rainwater harvesting (household)
- Shift X% of water use to more reliance on groundwater (city)
- Reduce physical losses by X% (utility)

VENSIM Model structure

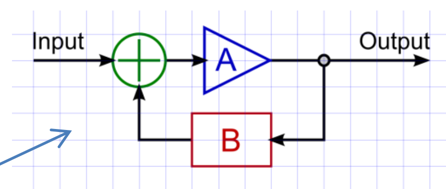


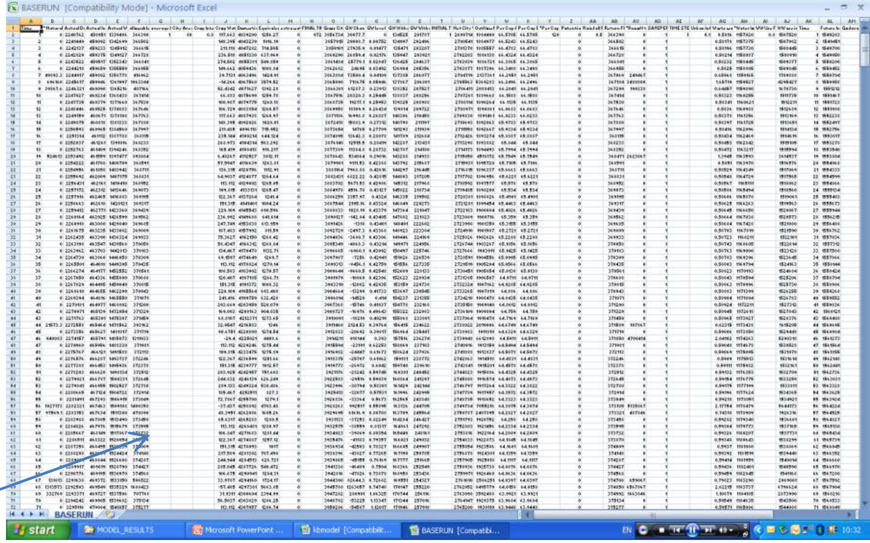
Van Rooijen et al 2005

Model properties

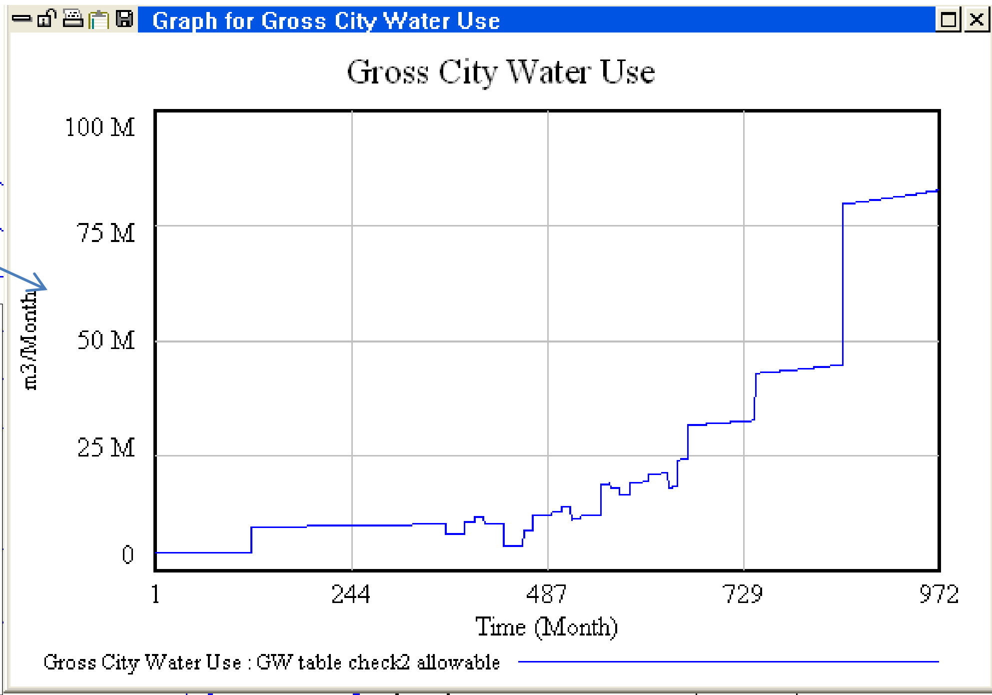
- Visualization of relationships between parameters and variables
- With each time step parameters can change; you can play with them..
  - You can explore and better understand interaction between system components
- Sensitivity analysis – easy to do.
- Automatic generation of:
  - Parameters (with units)
  - Equations
- Error messages when units are not compatible, when values become unrealistic during modeling, etc.

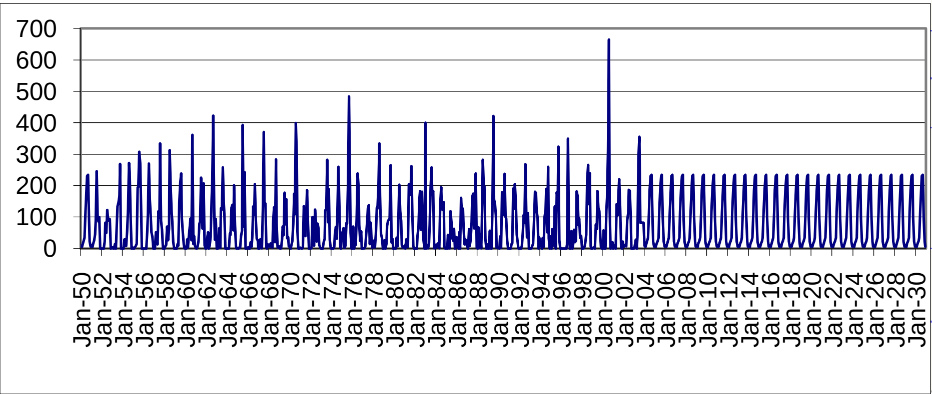
Working of the model



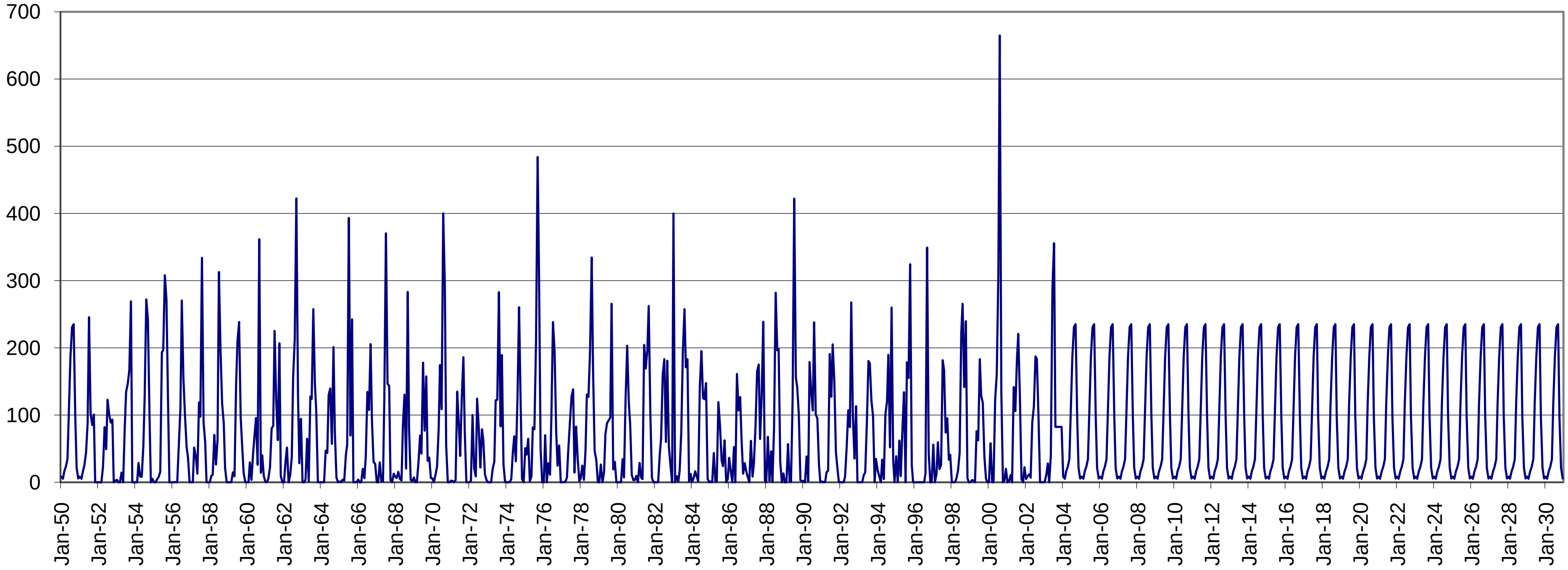


- System Dynamics
- No feedback loops applied – this is 'one flow through'
- Time series data input (ET, Rainfall, water supply etc)
- Outputs as xls format or VENSIM graphs





Time series input data:
Monthly rainfall, historic and future scenarios.



Model Parameters

(01) Area= 200 Units: km2

(02) "Area irrigated (base case)"=40000 Units: ha

(03) "Av. Irr. Inflow Rate"=Irr Gross Diversion Rate / (30 * 24 * 3600) Units: m3/s

(04) Catchment area=1000 Units: km2

(05) Change GW Elevation=Change GW Storage / (GW Area * 10^6) / Storage Potential Factor Units: m

(06) Change GW Storage= Natural Yield - GW Withdrawl + Irr Return Flow to GW Units: m3/month

(07) Crop Intensity= 80 Units: percent

(08) Demand Factor= 0.8 Units: (x/y)

(09) demandperCap=200 Units: l/day

(10) Domestic Water Demand=Population Number * demandperCap * 30/1000 Units: m3/month

(11) Domestic WW Return=Domestic Water Demand * (1-Projected Treatment) Units: m3/month

(12) Equivalent Area WW Irrigated=Net WW supply / ("Irr. Demand" / ("Area irrigated (base case)" * Crop Intensity / 100)) Units: ha

(13) ETref= 5 Units: mm/day

(15) GW Area=200 Units: km2

(16) GW Recovery Factor=0.3 Units: (x/y)

(17) GW Withdrawl=Domestic Water Demand + Industrial Demand + Irr Gross Diversion Rate - Water harvested in Catchment Area Units: m3/month

(18) Industrial Demand= INTEG (Industrial Demand * Industry Growth Rate, Industrial Demand Base Case) Units: m3/month

(19) Industrial Demand Base Case=5e+006 Units: m3/month

(20) Industrial WW Return=0.65 * Industrial Demand Units: m3/month

(21) Industry Growth Rate=0.01 Units: growth/Year

(22) "Infiltration + Percolation Factor"=0.125 Units: (x/x)

Model Parameters Cont'd

(23) INITIAL TIME = 0 Units: Year The initial time for the simulation.

(24) Irr Gross Diversion Rate= Demand Factor / "Irr. Efficiency" * "Irr. Demand" Units: m3/month

(25) Irr Return Flow to GW=(1 - "Irr. Efficiency") * Irr Gross Diversion Rate * GW Recovery Factor U nits: m3/month

(26) "Irr. Demand"=(ETref - (Rainfall/30 * 0.7)) * Kc * 10 * "Area irrigated (base case)" * (Crop Intensity/100) * 30 *10 Units: m3/month

(27) "Irr. Efficiency"= 0.65 Units: percentage

(28) Kc=1 Units: x

(29) Natural Yield=(Rainfall/1000) * (Area/10^6) * "Infiltration + Percolation Factor" Units: m3/month

(30) Net WW supply=Domestic WW Return * Use Factor Domestic WW + Industrial WW Return * Use Factor Industrial WW Units: 3/month

(31) Population Growth Rate= 0.05 Units: growth/Year

(32) Population Number= INTEG (Population Number * Population Growth Rate, Population number Base Case) Units: number

(33) Population number Base Case=1.5e+006 Units: number

(34) Projected Treatment= 0.3 Units: percent

(35) Rainfall=200 Units: mm/month

(36) "Runoff factor R/O"= 0.22 Units: (x/y)

(37) SAVEPER = TIME STEP Units: Year [0,?] The frequency with which output is stored.

(38) Storage Potential Factor= 0.05 Units: (x/y)

(39) Surface Recovery Factor= 0.4 Units: (x/y)

(40) Surface Return Flow= (1-"Irr. Efficiency") * Irr Gross Diversion Rate * Surface Recovery Factor Units: m3/month.

(42) Urban Water Use= Domestic Water Demand + Industrial Demand Units: m3/month

(43) Use Factor Domestic WW= 0.9 Units: (x/y)

(44) Use Factor Industrial WW= 0.5 Units: (x/y)

(45) Water harvested in Catchment Area= Catchment area * Rainfall * "Runoff factor R/O" * 1000 Units: m3/month

Outputs for the project

- Database
- Scenarios
- Impact assessment (through modeling)
- Urban Water model (part of decision support)

Planning of WP2 Activities

- *Inventory of available climatic and hydrologic models (properties and usefulness).*
- *Define main scenario types.*
- *Data collection: climatic data generated from downscaled climate scenario results*
- *Data collection: demographic data and urban water system*
- *VENSIM model set-up*
- *Data analysis and modelling of scenarios*
- *Generating and incorporating input and feedback from platform*
- *Finalize scenarios and modelling in collaboration with stakeholders*

Thank you!