

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

The diagram illustrates the ORAdapt project framework, showing the flow from problem identification to project impact, mediated by empirical and participatory action research activities.

PROBLEM (IDENTIFICATION)
Urban communities more vulnerable to impacts of CC

PROJECT IMPACT
Urban communities less vulnerable to impacts of CC

EMPIRICAL RESEARCH ACTIVITIES (WP2)

- Data Analysis & Modeling (highlighted with a red circle)
- Scenario Development

Learning Loop

PARTICIPATORY ACTION RESEARCH ACTIVITIES (WP1)

- Inception Workshop
- Platform Meeting
- Prioritizing Interventions
- Policy briefings
- Result Publication & Dissemination

Process Documenting

The diagram shows a large blue arrow pointing from the Problem (Identification) to the Project Impact, representing the overall flow of the project. A large blue arrow labeled "Learning Loop" points from the Participatory Action Research Activities (WP1) back to the Empirical Research Activities (WP2), indicating a feedback mechanism. The Participatory Action Research Activities (WP1) are shown as a sequence of five steps: Inception Workshop, Platform Meeting, Prioritizing Interventions, Policy briefings, and Result Publication & Dissemination. A "Process Documenting" bar is located below these steps. The Empirical Research Activities (WP2) are shown as two steps: Data Analysis & Modeling (highlighted with a red circle) and Scenario Development. The entire process is framed by a large blue arrow pointing from the Problem (Identification) to the Project Impact.

**PROBLEM
(IDENTIFICATION)**

Urban communities more vulnerable to impacts of CC

Inception Workshop

PART

**PROBLEM
(IDENTIFICATION)**

Urban communities more vulnerable to impacts of CC

Inception Workshop

PART

The diagram is titled "EMPIRICAL RESEARCH ACTIVITIES (WP2)" in orange text. It features two white rounded rectangular boxes with blue borders. The left box is labeled "Data Analysis & Modeling" and is circled with a thick red line. The right box is labeled "Scenario Development". Two large, light blue curved arrows connect the boxes in a clockwise cycle: one from the bottom of the left box to the bottom of the right box, and another from the top of the right box back to the top of the left box.

EMPIRICAL RESEARCH ACTIVITIES (WP2)

Data Analysis & Modeling

Scenario Development

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EMPIRICAL RESEARCH ACTIVITIES (WP2)

Data Analysis & Modeling

Scenario Development

Scenario Development



Learning Loop

Inception Workshop

Platform Meeting

Prioritizing Interventions

Policy briefings

Result Publication
& Dissemination

Process Documenting

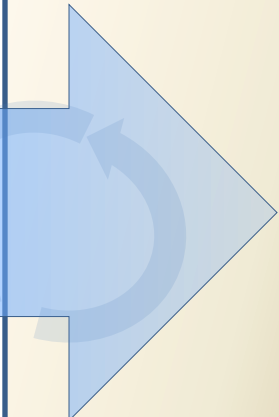
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graph LR
    A[Inception Workshop] --> B[Platform Meeting]
    B --> C[Prioritizing Interventions]
    C --> D[Policy briefings]
    D --> E[Result Publication & Dissemination]
    A --- F[Process Documenting]
    B --- F
    C --- F
    D --- F
    E --- F
    
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PARTICIPATORY ACTION RESEARCH ACTIVITIES (WP1)

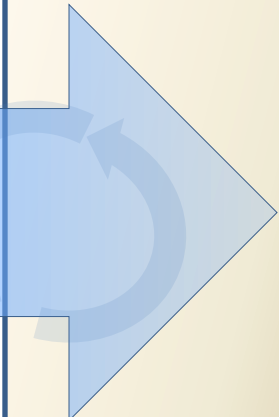
PROJECT IMPACT

*Urban communities
less vulnerable to
impacts of CC*

A large blue arrow pointing right, with a circular arrow inside it, symbolizing a cycle or process. The arrow is light blue with a darker blue outline. Inside the arrow, there is a circular arrow that starts from the left and curves around to the right, indicating a continuous loop or feedback mechanism. The entire graphic is set against a light yellow background with a dark blue border.

PROJECT IMPACT

*Urban communities
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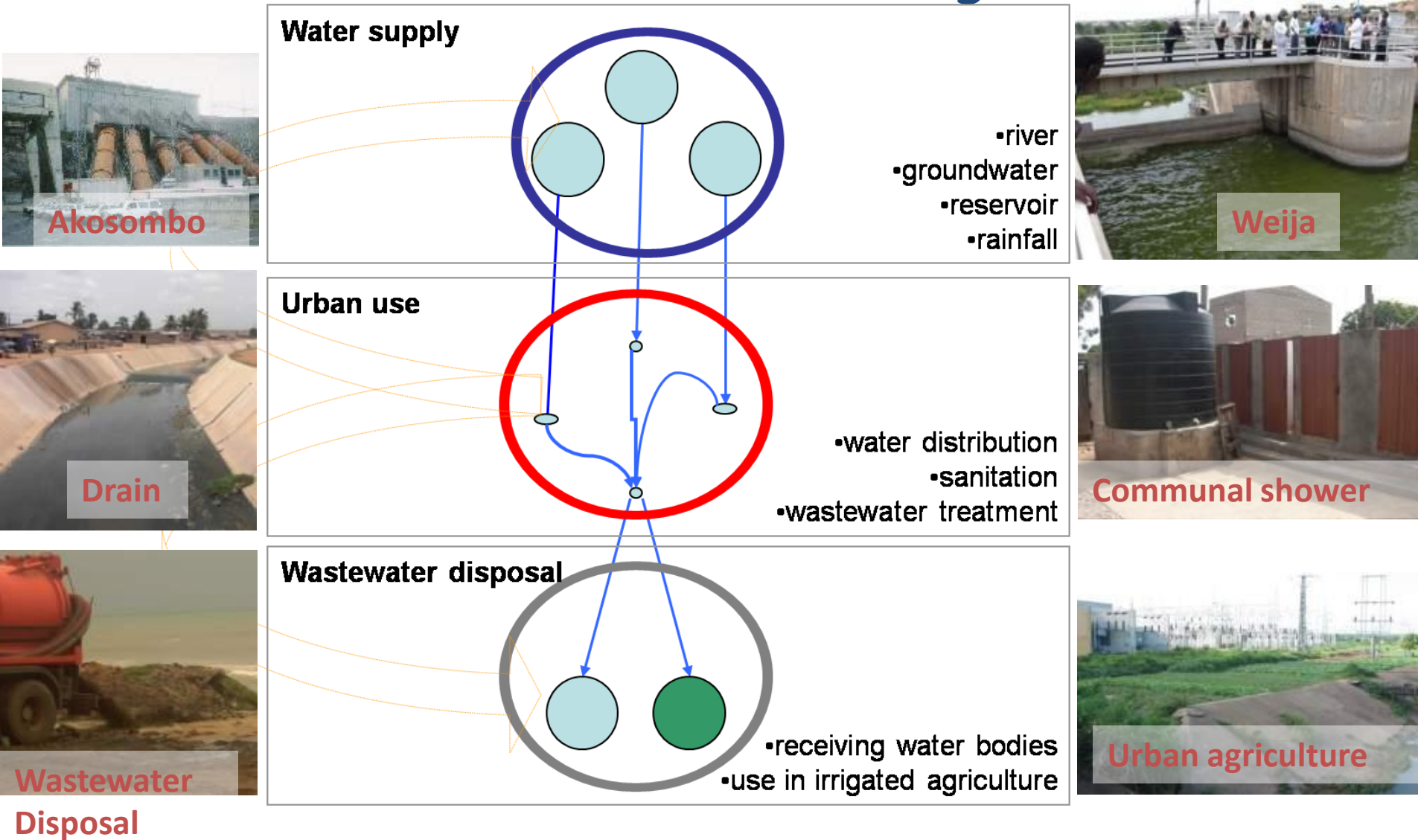
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Objectives

- 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

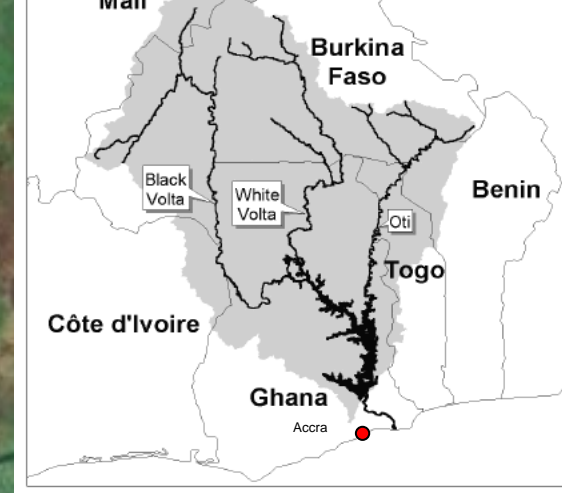
Accra Urban Water System.

What water are we talking about?



Sources of Water Supply to Accra

Volta

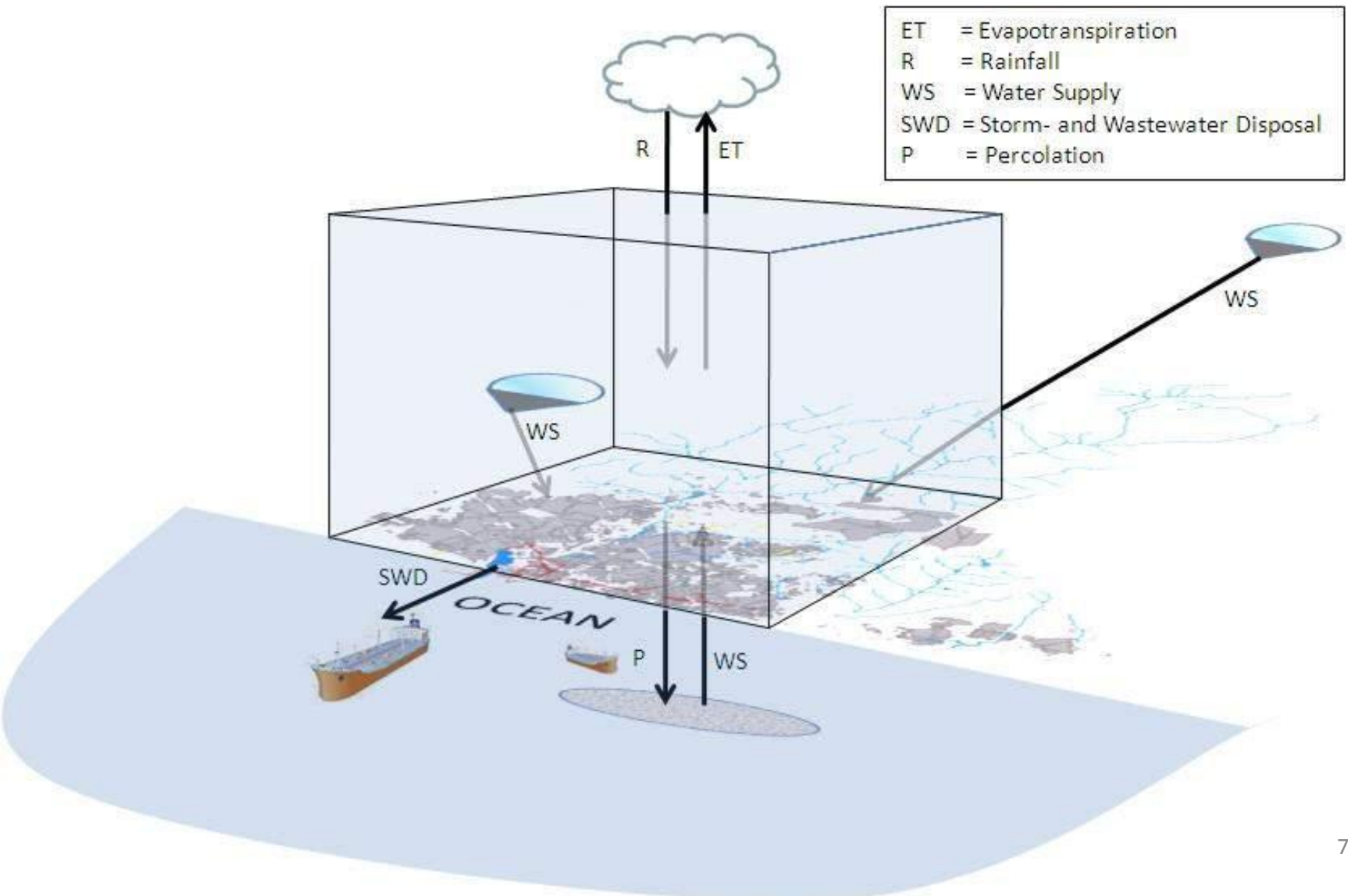


Weija

ACCRA URBAN AREA

Accra, Ghana

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)

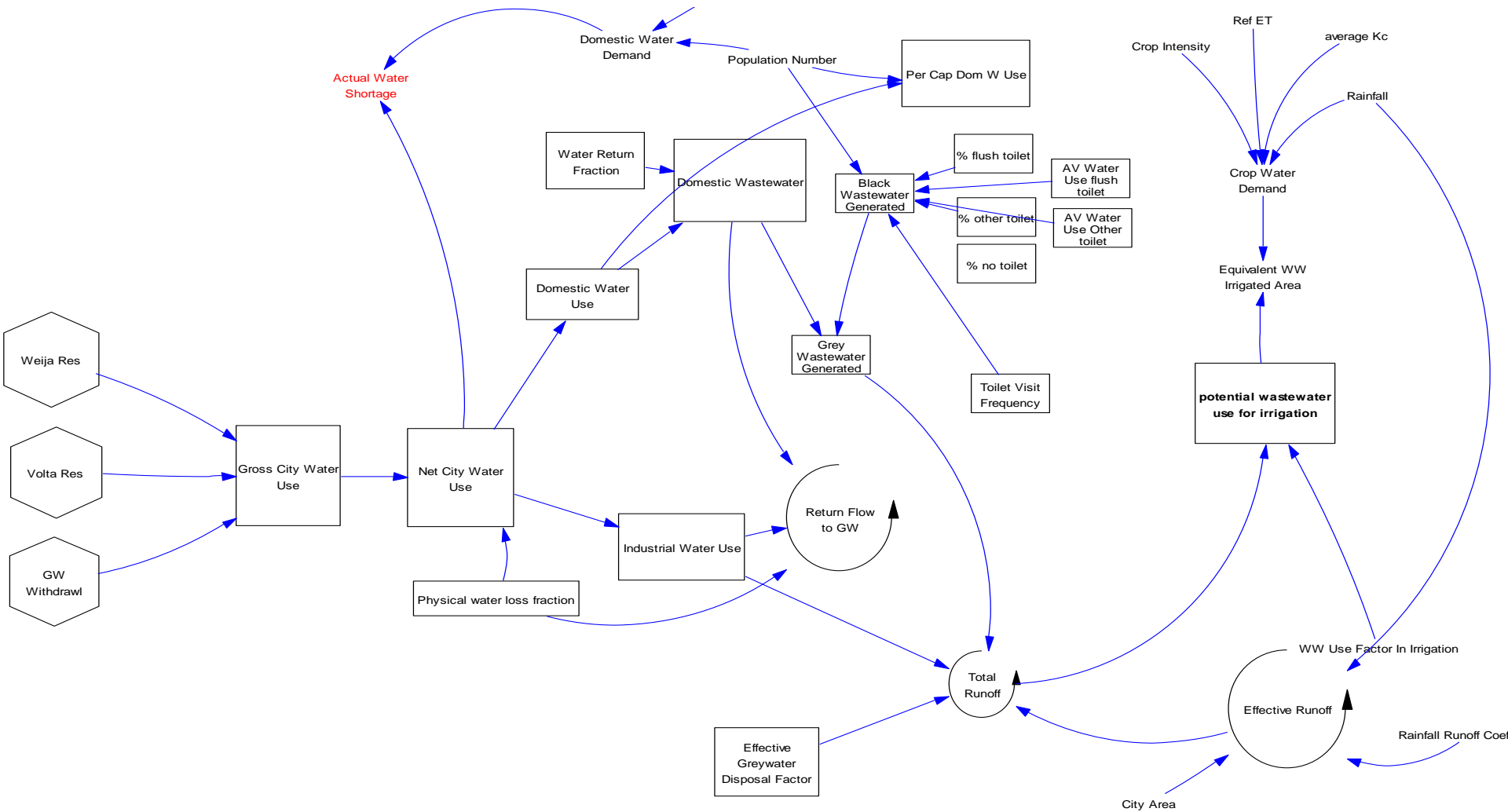
**CC Scenario: Dry periods becoming more severe (drier)
and recurring more often (catchment level)**

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)

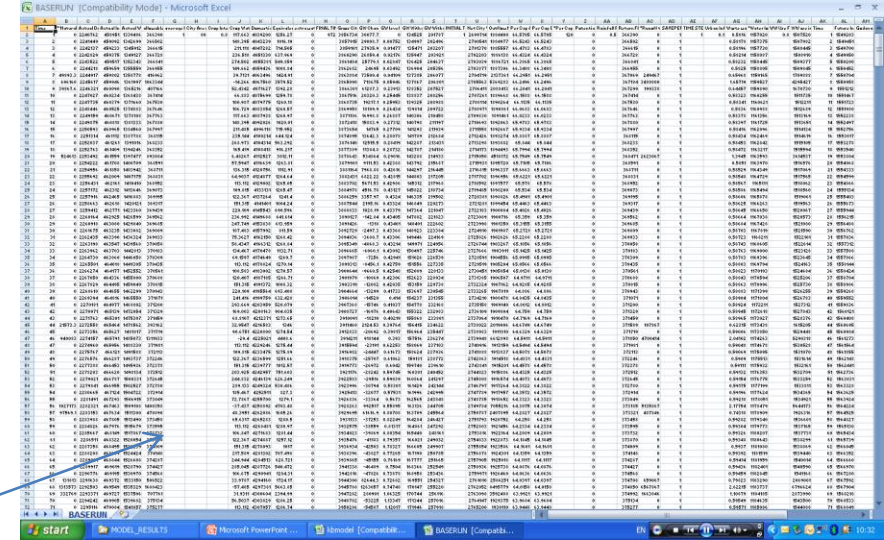
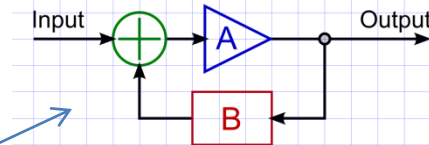
VENSIM Model structure



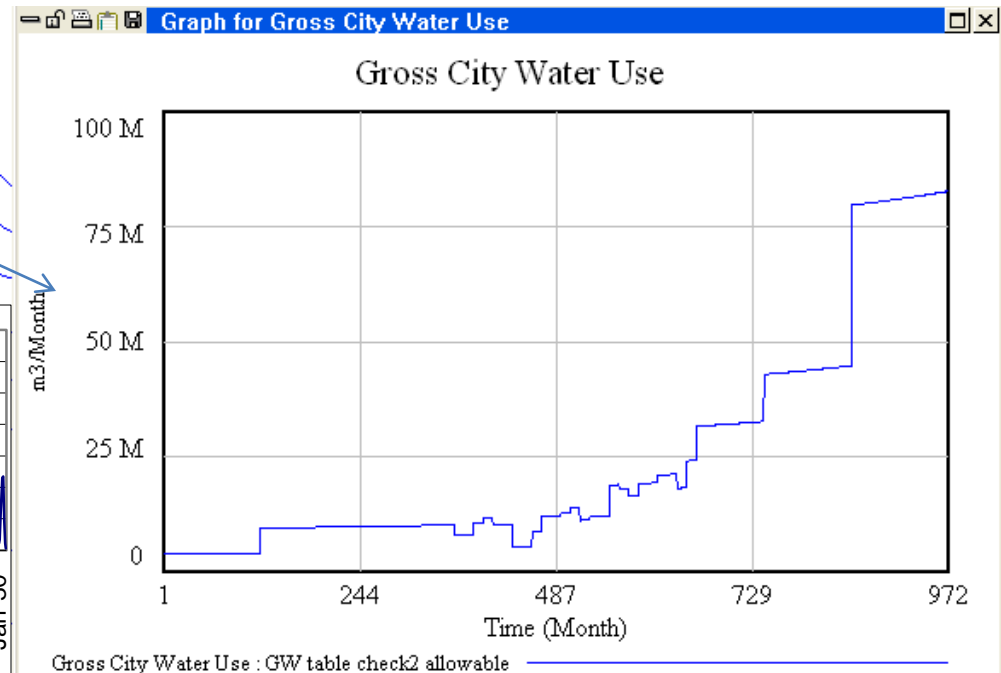
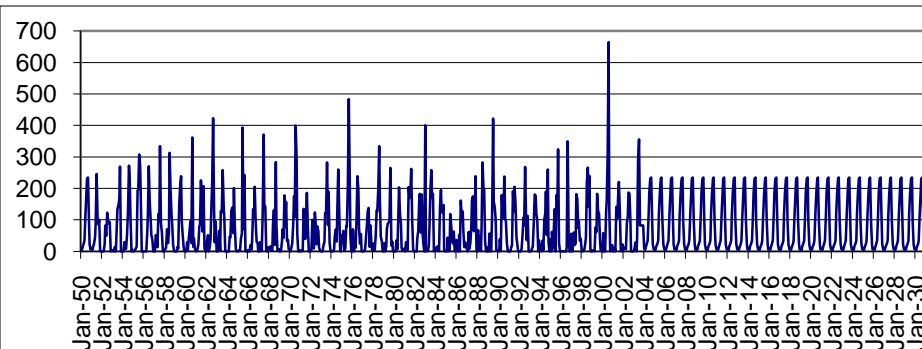
Model properties

- 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.

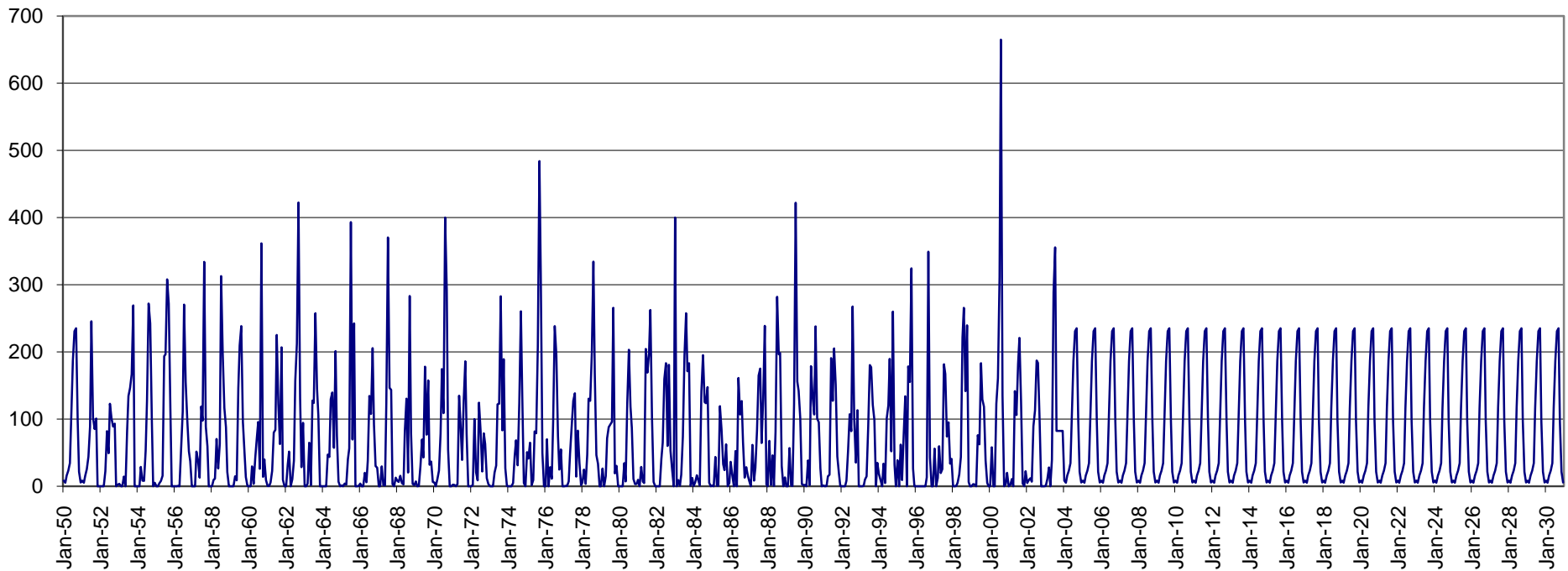
Working of the model



- 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		Units: 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!