UNEP

Convention on Biological Diversity

SUBREGIONAL WORKSHOP FOR SUBSAHARAN WEST AFRICA ON VALUATION AND INCENTIVE MEASURES
Ouagadougou, Burkina Faso, 14–17 May 2013

ENVIRONMENTAL AND ECOSYSTEM ACCOUNTING

Water Accounting

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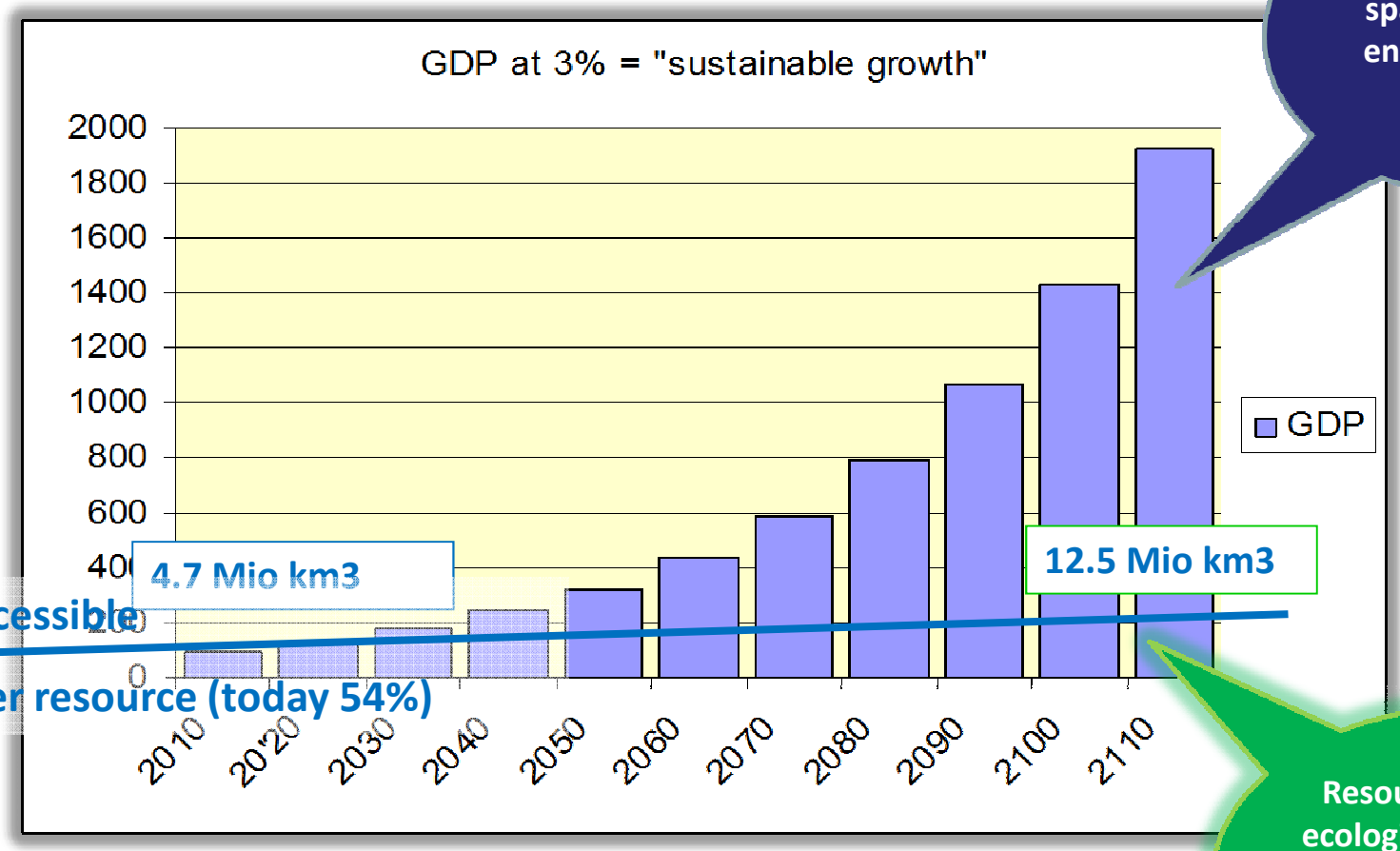
Macro-economics: GDP growth and the need to account for natural resource use & ecosystem capital degradation



Resource efficiency = sparing materials & energy (technology, consumption patterns)

Use of accessible freshwater resource (today 54%)

Resource efficiency = ecological management of land, soil & water, ecosystem capital maintenance

➔ Beyond GDP 2008

➔ "Stiglitz-Sen-Fitoussi" report 2009

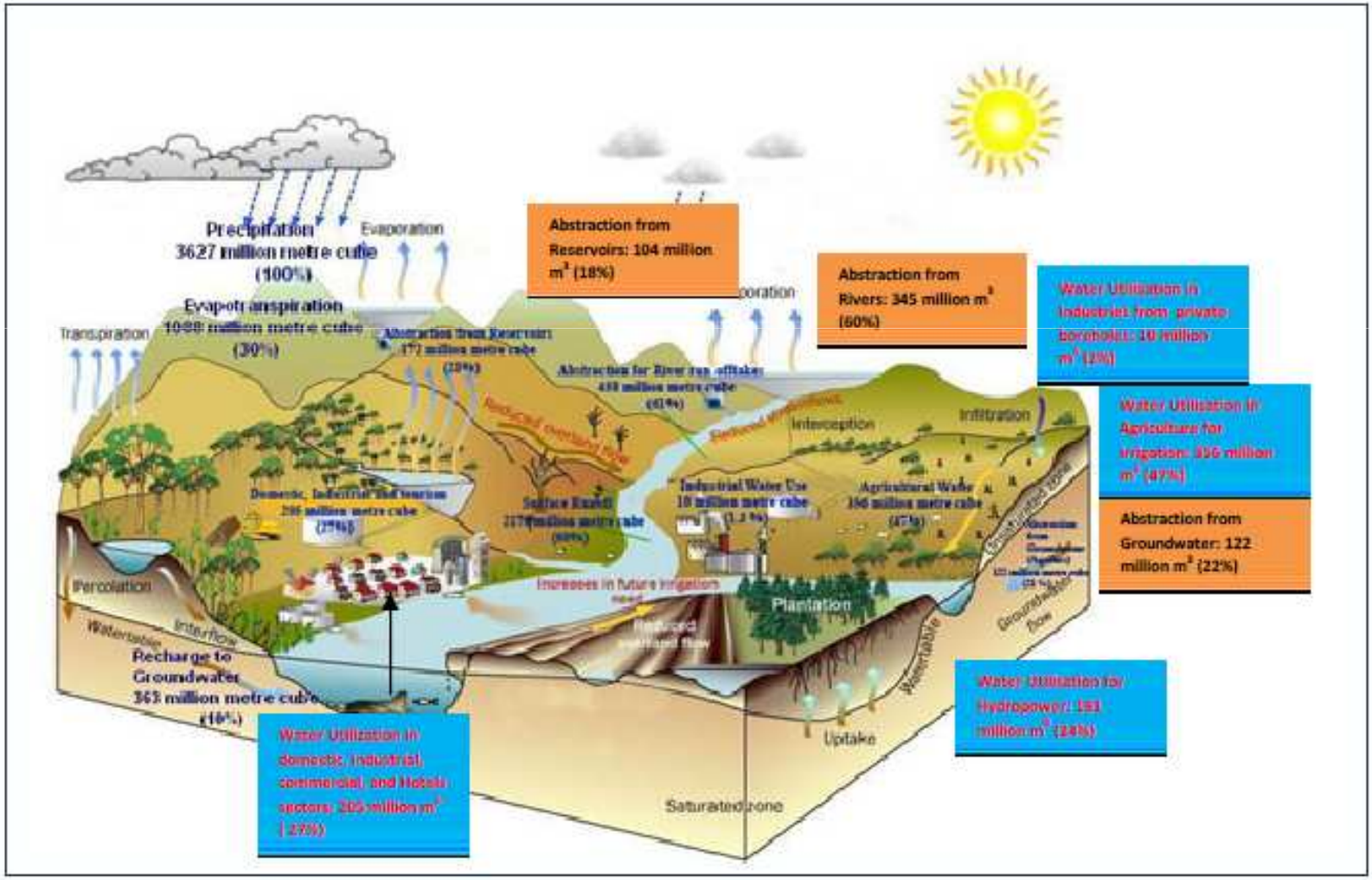
➔ TEEB 2008-2010

➔ WAVES/ WB Partnership 2011-2015

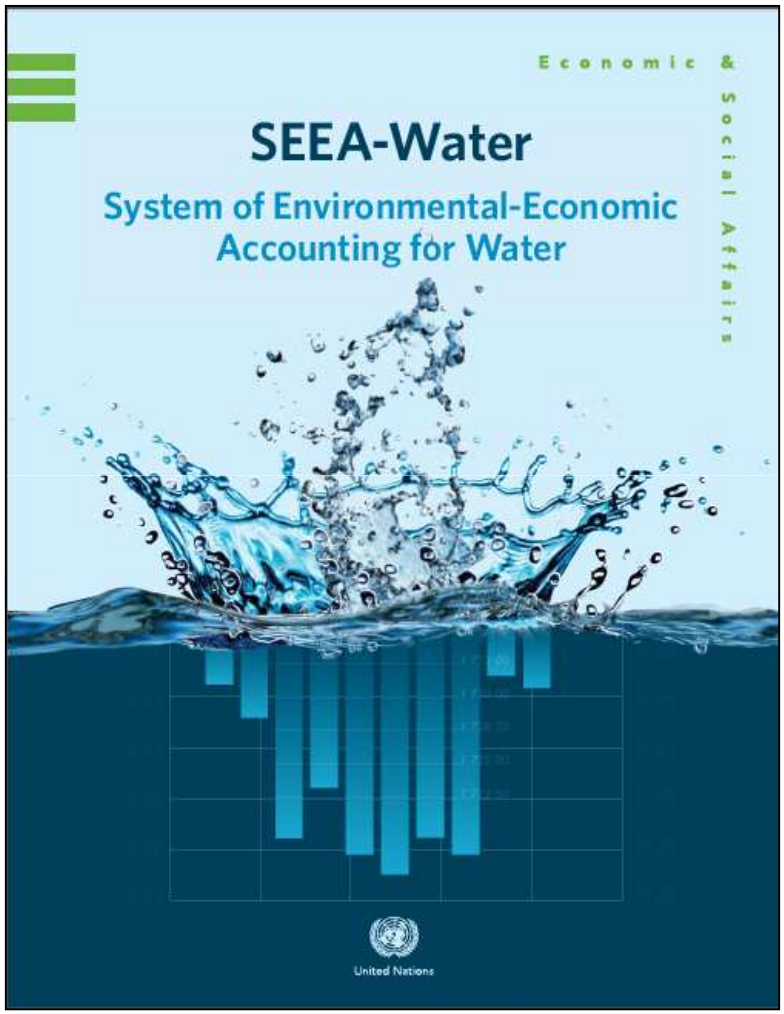
➔ SEEA2003 / rev. 2012-13

What is water accounting about?

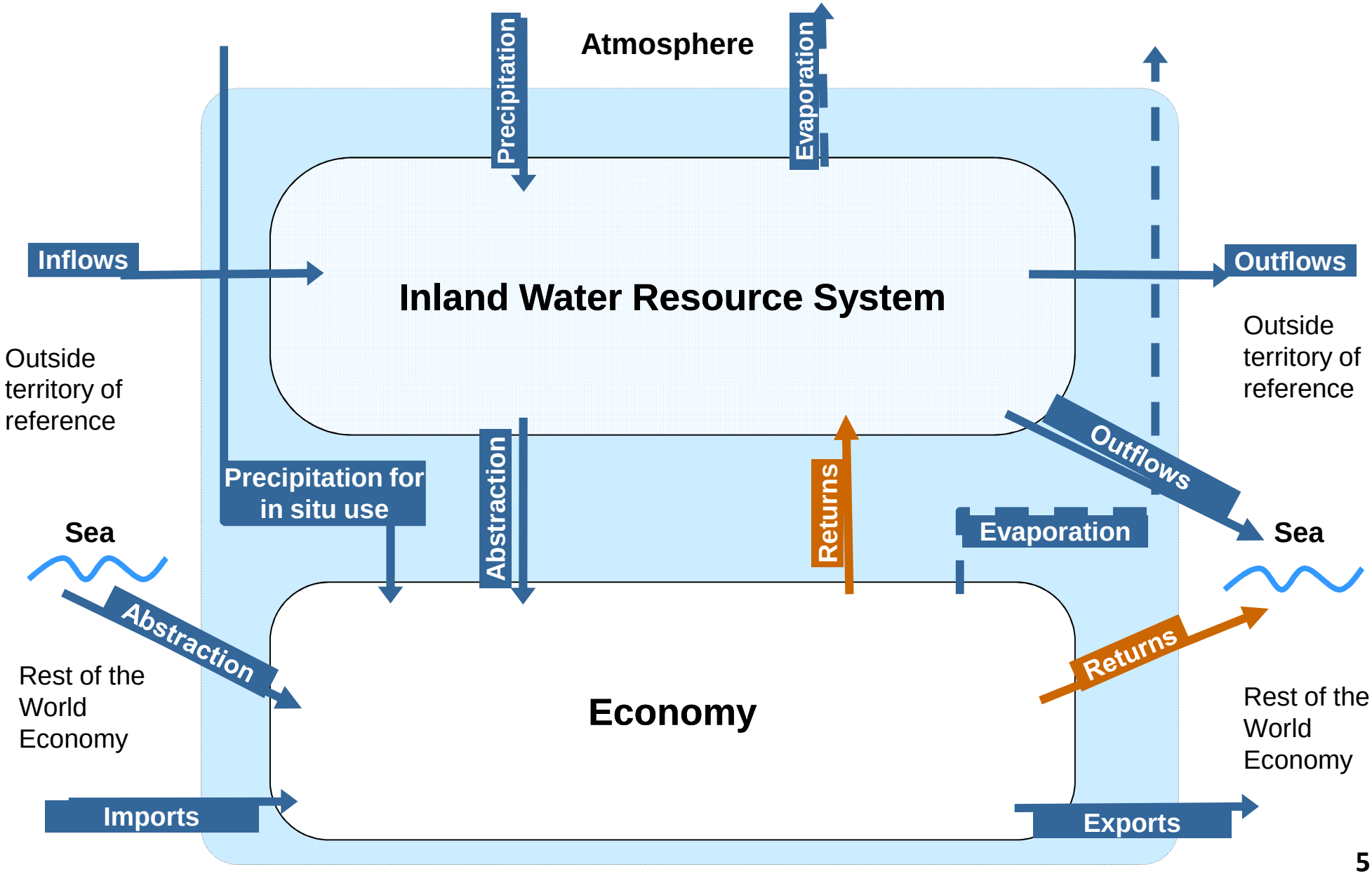
Figure 2(b) – The hydrological cycle with water balance, abstractions and utilizations for Island of Mauritius, 2011.



SEEA Water: “**Interim standard**” 2007



SEEA-Water is based on a stock-flow model comprising two main subsystems: the inland water resource system and the economy.



The details of each subsystem are shown in the following diagram

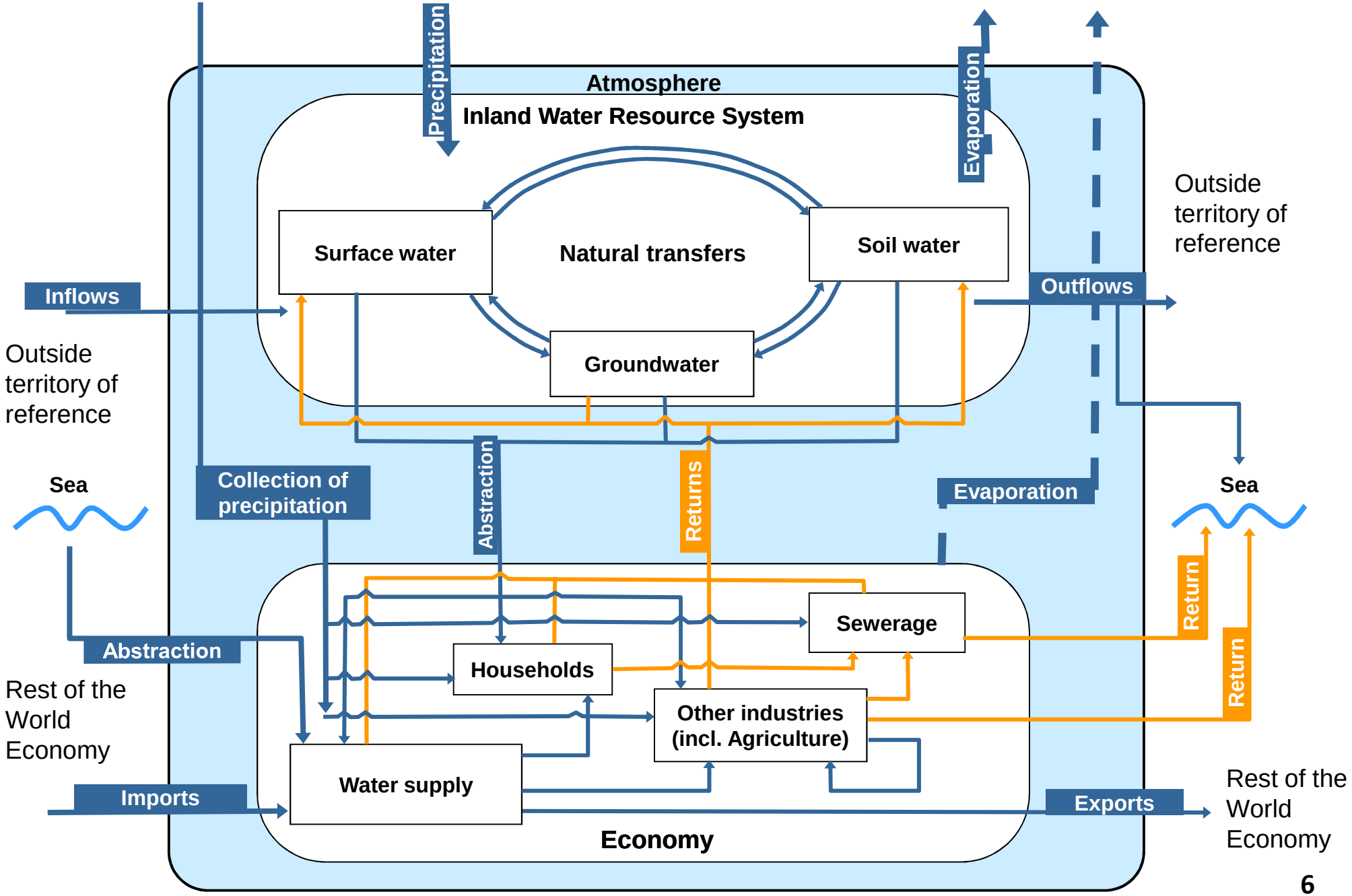


Table 1 - Detailed Physical water Use Table, 2011

Million m^3

		Industries (by ISIC[a] categories)							Households	Rest of the world	Total
		1-3	5-33, 41-43, 38,39, 45-99	3510 Hydroelectricity	3510 Cooling Thermoelectricity	36 Water utilities (drinking water)	37 Sewerage	Total			
From the environment	**1. Total abstraction** (=1.a+1.b=1.i+1.ii)	**356.0**	**10.0**	**181.0**	**0.0**	**205.0**	**0.0**	**752.0**			**752.0**
	1.a. Abstraction for own use	356.0	10.0	181.0	0.0	0.0	0.0	**547.0**			**547.0**
	Hydroelectric power generation			*181.0*				***181.0***			***181.0***
	Irrigation water	*356.0*						***356.0***			***356.0***
	Mine water							***0.0***			***0.0***
	Urban runoff							***0.0***			***0.0***
	Cooling water										
	Other		*10.0*					***10.0***			***10.0***
	1.b. Abstraction for distribution					*205.0*		**205.0**			**205.0**
	1.i. From water resources:	356.0	10.0	181.0		205.0	0.0	**752.0**			**752.0**
	1.i.1 Surface water	*350.0*	*5.0*	*181.0*		*94.0*		***630.0***			***630.0***
	1.i.2 Groundwater	*6.0*	*5.0*			*111.0*		***122.0***			***122.0***
	1.i.3 Soil water							***0.0***			***0.0***
	1.ii. From other sources	0.0	0.0	0.0		0.0	0.0	**0.0**			**0.0**
	1.ii.1 Collection of precipitation							**0.0**			**0.0**
	1.ii.2 Abstraction from the sea					0.0		**0.0**			**0.0**
Within the economy	**2. Use of water received from other economic units**		**23.0**				**40.0**	**63.0**	**76.0**		**139.0**
	of which:										
	2.a. *Reused water*							***0.0***			***0.0***
3. Total use of water (=1 + 2)		**356.0**	**33.0**	**181.0**	**0.0**	**205.0**	**40.0**	**815.0**	**76.0**		**891.0**

[a]: International Standard Industrial Classification (see below)

Table 2 - Detailed Physical water Supply Table, 2011

		Industries (by ISIC categories)							Households	Rest of the world	Total
		1-3	5-33, 41-43, 38,39, 45-99	3510 hydroelectricity	3510 Cooling Thermoelectricity	36 Water utilities (drinking water)	37	Total			
Within the economy	**4. Supply of water to other economic units**					**99.0**		**99.0**	**40.0**		**139.0**
	of which:										
	4.a. Reused water							**0.0**			**0.0**
	4.c. *Desalinated water*							**0.0**			**0.0**
	4.b. Wastewater to sewerage							**0.0**	40.0		**40.0**
To the environment	**5. Total returns** (=5.a+5.b)	**71.2**	**26.4**	**181.0**	**0.0**	**106.0**	**40.0**	**424.6**	**4.8**		**429.4**
	Hydroelectric power generation			*181.0*				*181.0*			*181.0*
	Irrigation water	*356.0*						*356.0*			*356.0*
	Mine water							*0.0*			*0.0*
	Urban runoff						*40.0*	*40.0*			*40.0*
	Cooling water										
	Losses in distribution because of leakages					*106.0*		*106.0*			*106.0*
	Treated wastewater						*0.0*	*0.0*	*1.5*		*1.5*
	Other							*0.0*	*3.3*		*3.3*
	5.a. To water resources	71.2	26.4	181.0	0.0	106.0	40.0	**424.6**	4.6		**429.2**
	5.a.1. Surface water	0.0	26.4	181.0			40.0	**247.4**	0.5		**247.9**
	5.a.2. Groundwater	71.2				106.0		**177.2**	4.1		**181.3**
	5.a.3. Soil water							**0.0**			**0.0**
	5.b. To other sources (e.g. sea water)							**0.0**	0.2		**0.2**
6.Total supply of water (=4+5)		**71.2**	**26.4**	**181.0**	**0.0**	**205.0**	**40.0**	**523.6**	**44.8**		**568.4**
7. Consumption (=3-6)		**284.8**	**6.6**	**0.0**	**0.0**	**0.0**	**0.0**	**291.4**	**31.2**		**322.6**
of which:											
7.a. Losses in distribution not because of leakages											

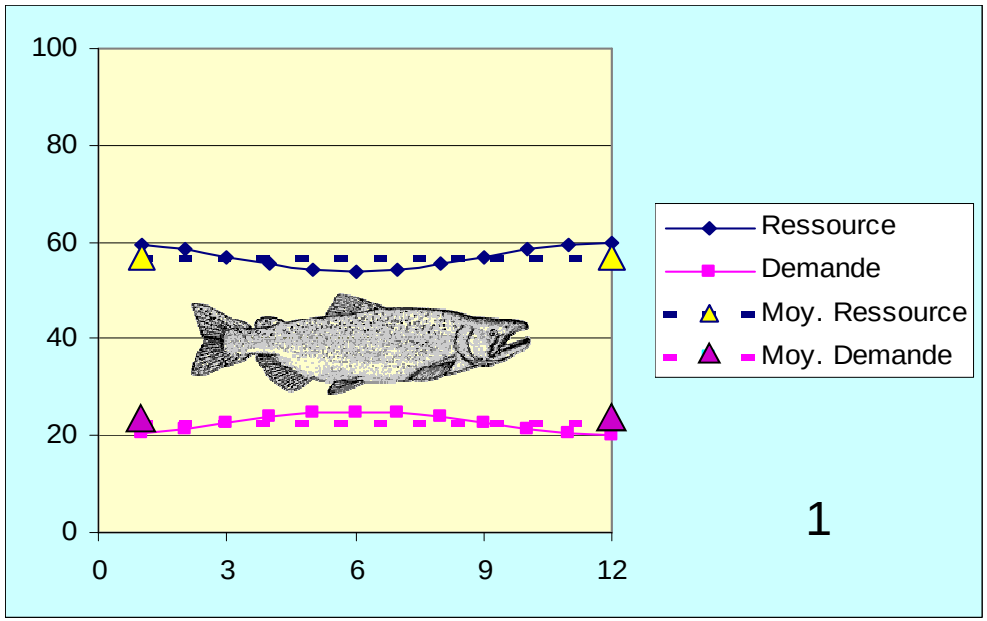
SEEA-Water limitations

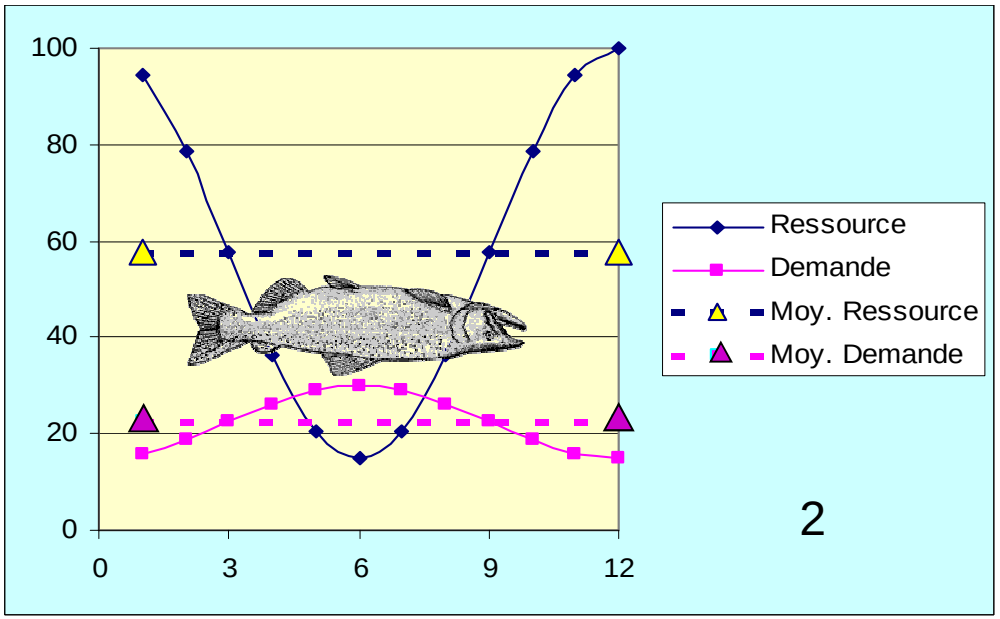
- Accessible water resource not defined ➔ misses a simple indicator of water use stress
- Quality de facto ignored
- Implemented for the hydrological system from questionnaire instead of data-mining from water agencie's databases (meteo, gauging stations…)
- **Starts with annual x national accounts,**
  instead of seasonal x basin accounts

Need relevant time frame for monitoring impacts on ecosystems: e.g. water resource/demand

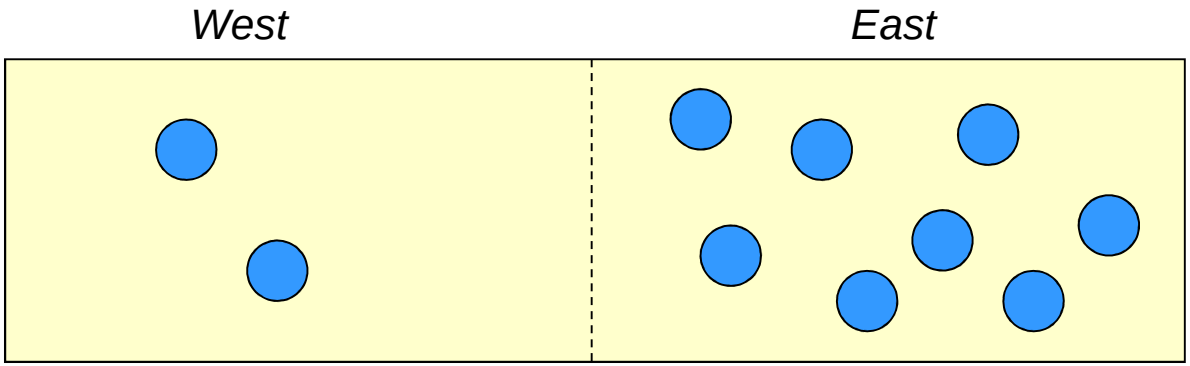
Mean annual resource is in both cases > mean annual demand

No water shortage in case 1, important seasonal stress in case 2





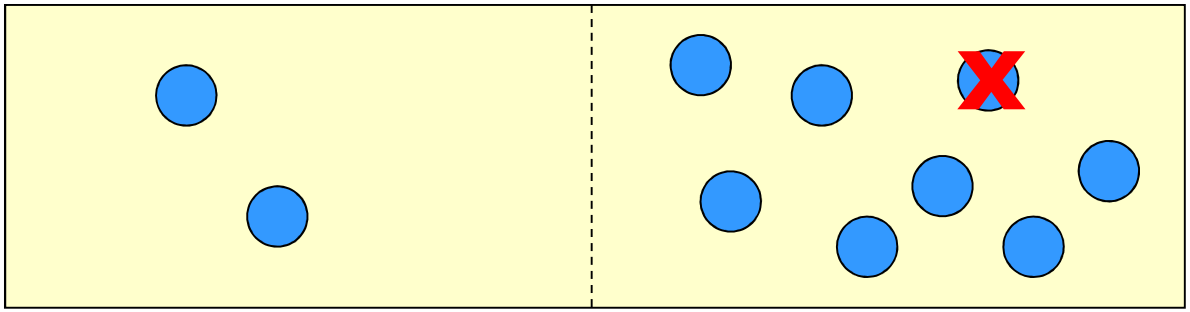
Importance of accounting by relevant functional units to measure impacts (e.g. catchments)



The total water resource of the country **10 lakes** distributed over **2 catchments**. The western catchment with 2 lakes is close to a scarcity threshold while water resource is abundant in the eastern catchment (8 lakes).

Scenario 1: 1 lake is lost in the east

Scenario 2: 1 lake is lost in the west.

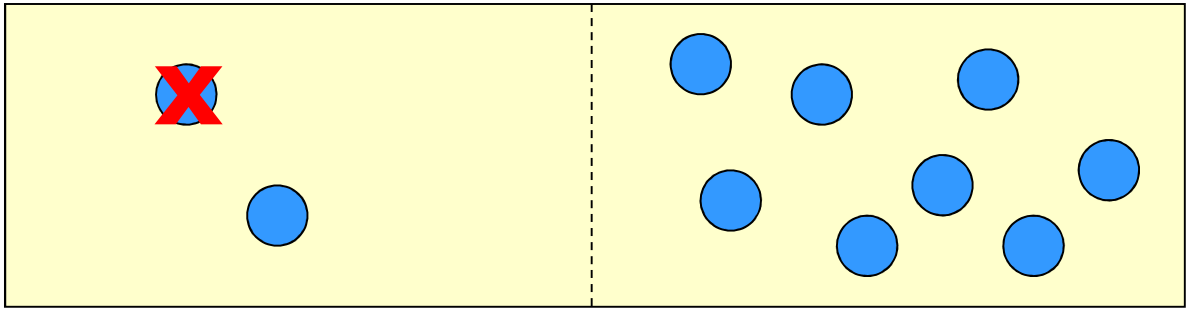


<u>Resource loss of 1 lake in the **eastern** catchment</u>

(a) Aggregated national loss (without catchments): (10-9)% = **10%**

(b) National average of loss by catchments:

$$\frac{(2\text{-}2)\% + (9\text{-}8)\%}{2} = \mathbf{5.5\%}$$



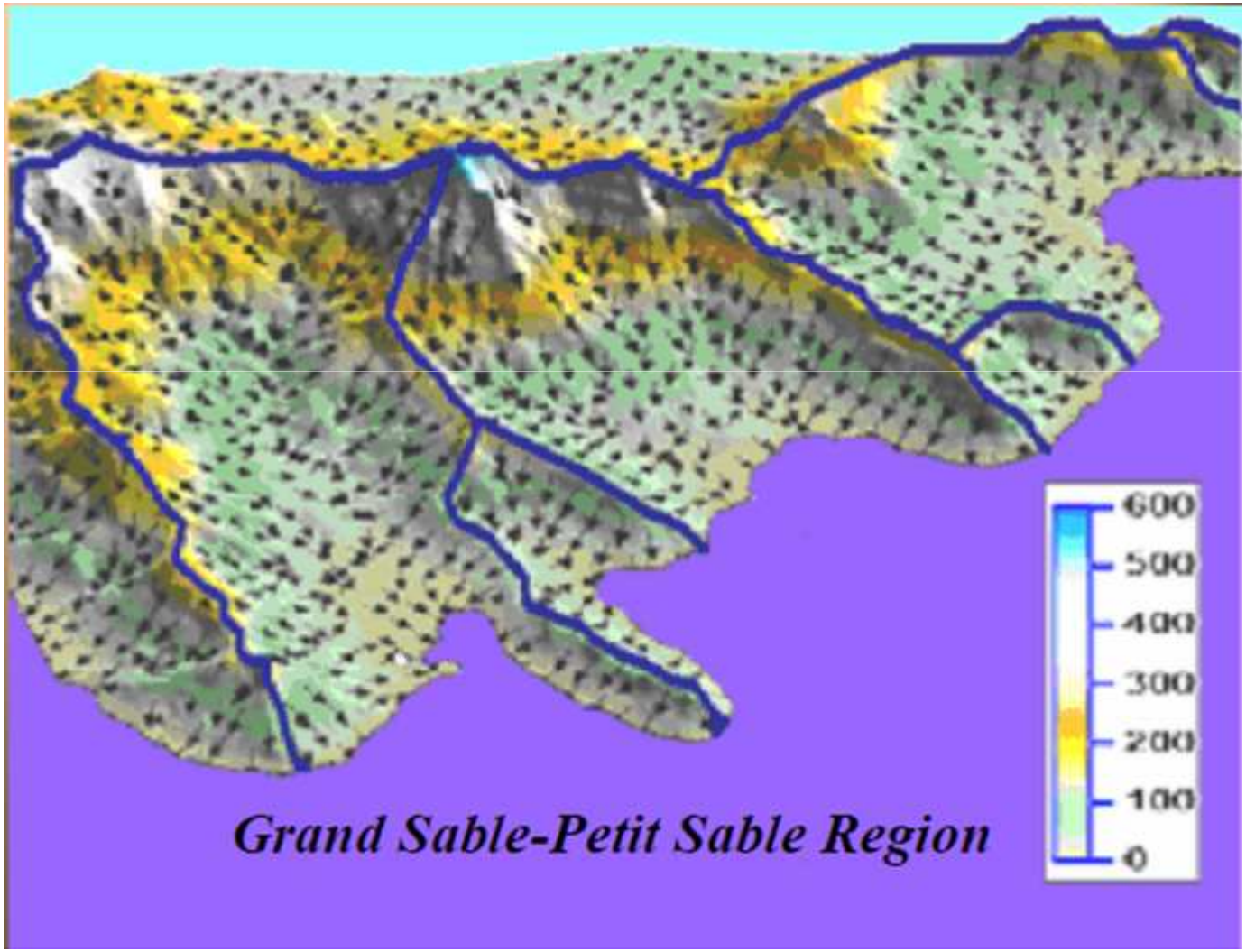
<u>Resource loss of 1 lake in the **western** catchment</u>

(a) Aggregated national loss (without catchments): (10-9)% = **10%**

(b) National aggregation of loss by catchments:

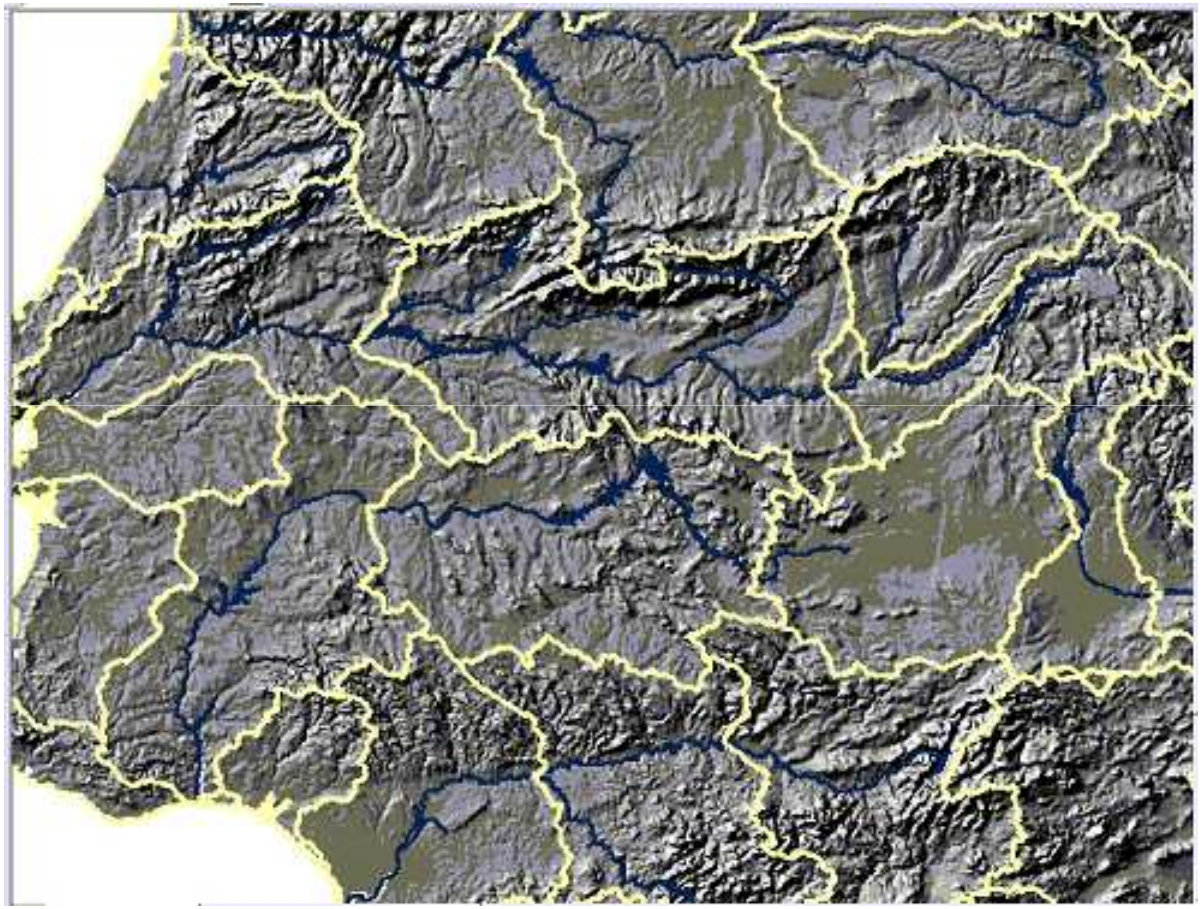
$$\frac{(2\text{-}1)\% + (9\text{-}9)\%}{2} = \mathbf{25\%}$$

Importance to account for water within drainage basins limits



Importance to account for ecosystems within drainage basins limits

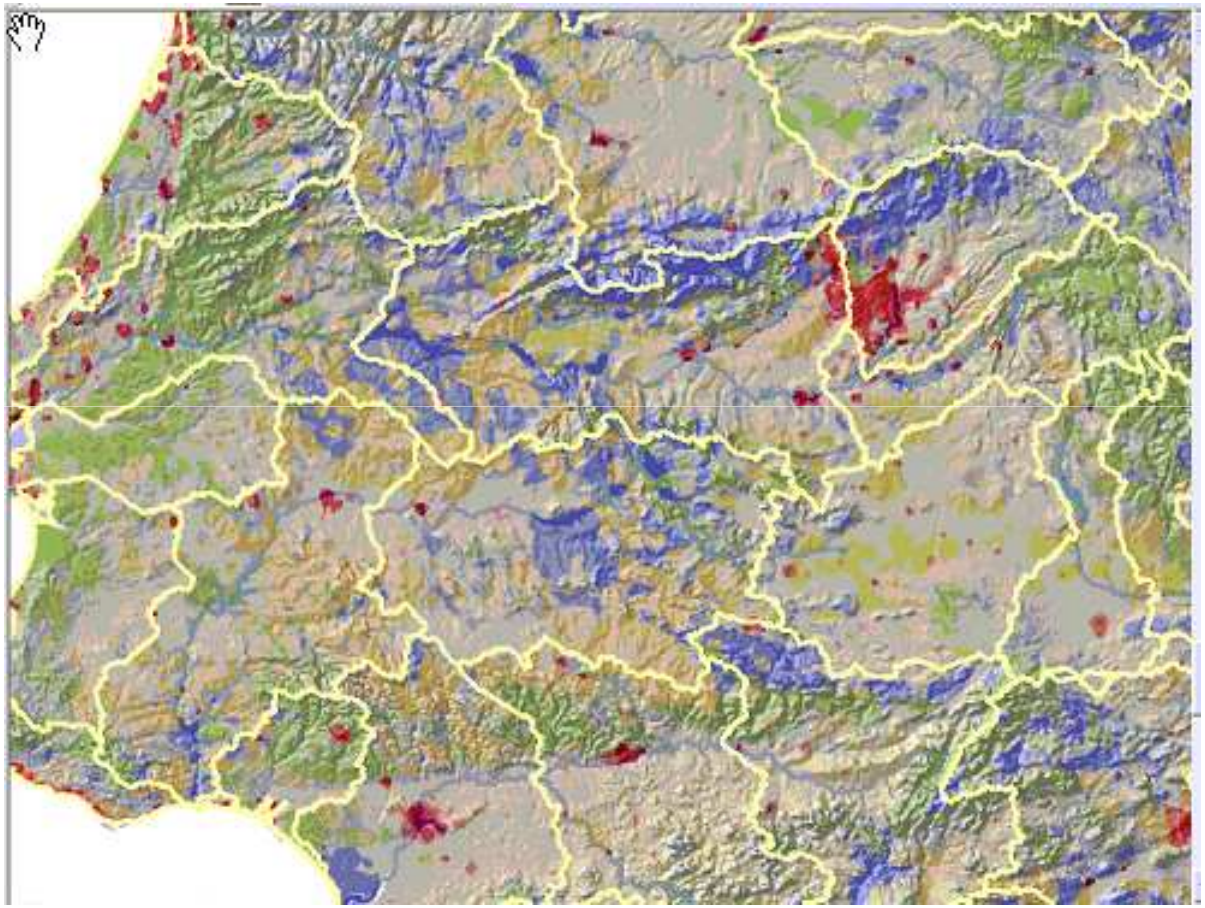
Mapping & classification of ecosystem accounting statistical units (or Socio-Ecological Landscape Units – SELU) **1- river basins and 2- relief**



Courtesy Emil D. Ivanov, 2011

Mapping & classification of ecosystem accounting statistical units (or Socio-Ecological Landscape Units – SELU)

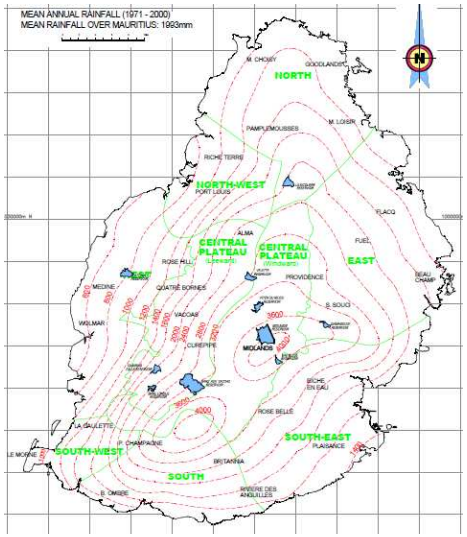
3- dominant landscape types (and land cover functional units (red= urban, yellow = agriculture, green = forest, blue = grass and shrubs, grey = mixed land cover…)



Courtesy Emil D. Ivanov, 2011

Estimating water balances by drainage basins

From the MU_CLEWS report (IIASA, GAEZ FAO methodology)



Rasterisation 1kmx1km

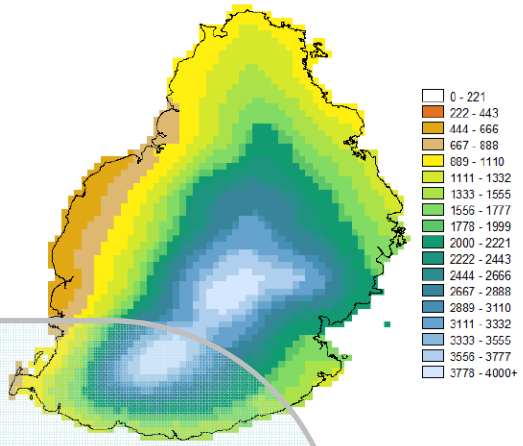


Figure 2. Mean annual rainfall (1970-2000) (30 arc-second grid cells)

Mauritius Meteorological Services

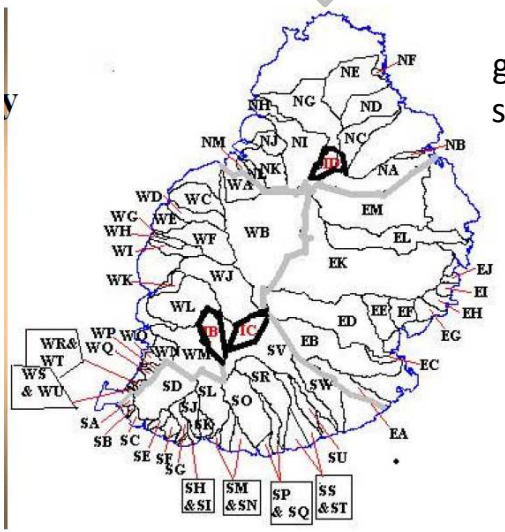
Region: North

Station: Pamplemousses

MONTH	TEMPERATURE				HUMIDITY	WIND		SUNSHINE		RAINFALL LTM	NO OF DAYS WITH	NO OF DAYS WITH
	Mean Max	Highest Max	Mean Min	Lowest Min	%	Mean Wind Speed	Highest Gust	Daily	Mean			
	1971-2000	Recorded	1971-2000	Recorded		Km/h	Km/h	Hrs per day	Monthly	1971-2000	RAINFALL > 1 MM	RAINFALL > 5 MM
January	31.1	35.2	22.1	16.1	82	10.4	159	8.1	250.2	206.2	16	8
February	30.8	35.5	22.2	16.3	84	11.9	238	7.7	216.9	239.9	16	9
March	30.6	34.0	21.7	14.5	83	10.4	134	7.6	235.5	158.9	15	7
April	29.8	33.6	20.8	13.1	84	9.6	89	7.4	223.3	157.6	15	6
May	28.1	32.0	18.6	11.0	83	9.3	72	7.6	235.9	99.2	12	5
June	26.5	30.0	16.7	9.2	82	9.3	72	7.4	223.0	68.1	12	4
July	25.7	29.0	16.1	9.0	82	11.3	70	7.6	236.8	72.9	14	5
August	25.9	29.9	16.2	10.0	80	13.3	78	7.7	237.7	75.1	13	4
September	27.0	30.5	16.6	10.7	78	12.2	72	7.5	225.0	46.0	9	2
October	28.4	32.5	17.7	12.0	77	11.9	69	8.2	255.2	47.9	8	2
November	30.0	35.0	19.1	12.9	78	12.2	105	8.7	260.9	49.5	8	2
December	30.7	35.4	20.9	15.0	80	10.7	201	8.0	248.8	127.5	10	5

Note: LTM = long term mean
Temperature in measured in degrees celsius
Rainfall is measured in millimetres

Meteo montly report for regional monitoring stations



Drainage basins and their gauging stations

Next step: Simplified basic water balances by basins

A simplified basic water balance

Precipitation *

- Spontaneous Real EvapoTranspiration **

+ Net infiltration to soil/subsoil ***

+ *Inflows from upstream runoff*

+ Returns of used water & irrigation μ

= ***Available water resource***

- Use of water by activities & households μ

- Evapotranspiration by activities

= ***River basin runoff***

Sources:

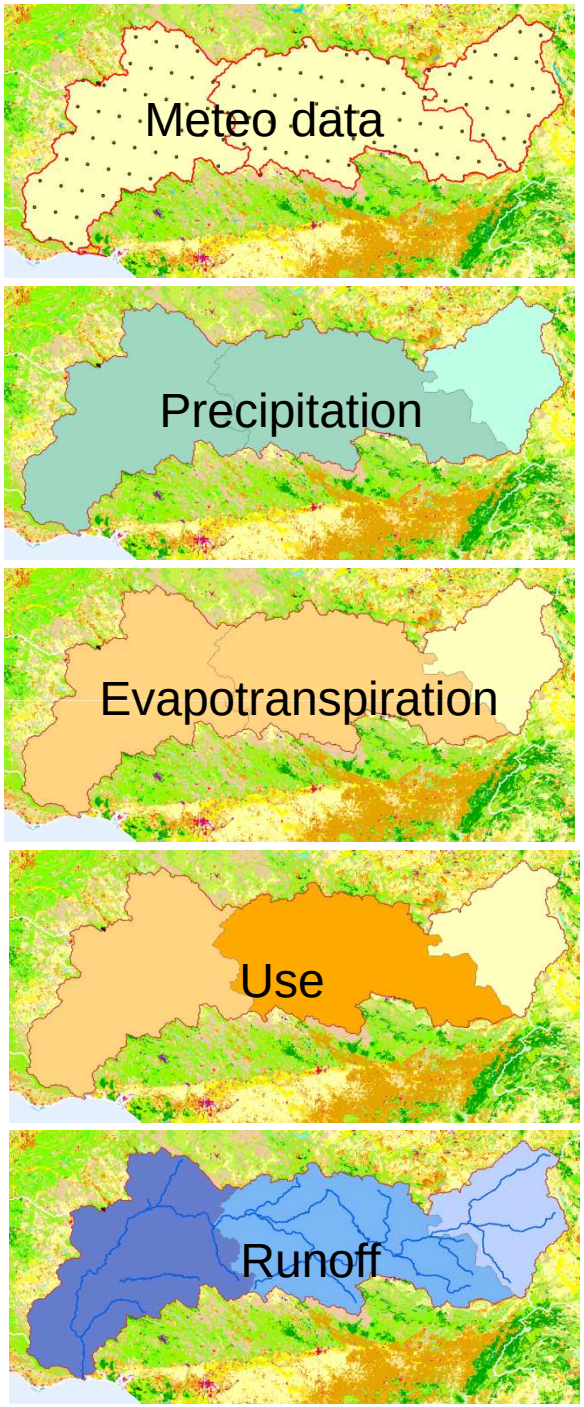
* Meteo

** Modelling from meteo data, land cover & NDVI

*** Hydrogeological modelling

μ Estimation from land cover & socio-economic statistics

Bold Ital: accounting balances



Ecosystem water accounts

		Artificial reservoirs	Lakes	Rivers and streams	Glaciers, snow and ice	Groundwater	Soil/ Vegetation (by land cover)	**TOTAL WATER ASSETS**
Basic water accounts								
1. BASIC BALANCE/ *STANDARD RESOURCE ACCOUNT*								
WA1	**Opening Stocks**							
1.1 INCREASE IN STOCKS (NATURAL AND SECONDARY WATER RESOURCE FLOWS)								
WR10	Precipitation							
WR20	Net internal spontaneous transfers of water (received minus provided)							
WR21	*Internal spontaneous water transfers received (+)*							
WR22	*Internal spontaneous water transfers provided (-)*							
WR30	Natural inflows from other territories							
s/t (WR10+20+30)	***Total natural renewable water resources (TRWR $_{natural}$)***							
WR40	Import of water from external territories and the sea							
WR41	*Import of water from external territories*							
WR42	*Withdrawal of water from the sea*							
WR50	Waste water discharge to inland water assets							
WR51	*Dischage of untreated waste water (incl. urban runoff)*							
WR52	*Discharge of treated waste water*							
WR60	Returns of abstracted water to inland water assets							
WR61	*Losses of water in transport and storage*							
WR62	*Return of abstracted water for irrigation*							
WR63	*Return of water from hydroelectricity production*							
WR64	*Return of mine water*							
WR65	*Return of water from other production (incl. cooling)*							
WR66	*Other returns of water*							
s/t (WR40+50+60)	***Total secondary water resources (TSWR)***							
WR1	**Total increase in stocks (natural and secondary water resource flows)**							
1.2 DECREASE IN STOCKS (WATER ABSTRACTION, CONSUMPTION AND OUTFLOWS)								

Ecosystem water accounts

1. BASIC BALANCE/ *STANDARD RESOURCE ACCOUNT*	
WA1	**Opening Stocks**
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WR65	*Return of water from other production (incl. cooling)*
WR66	*Other returns of water*
s/t (WR40+50+60)	***Total secondary water resources (TSWR)***
WR1	**Total increase in stocks (natural and secondary water resource flow**
1.2 DECREASE IN STOCKS (WATER ABSTRACTION, CONSUMPTION AND OUTFLOWS)	

Ecosystem water accounts

WR1	**Total increase in stocks (natural and secondary water resource flow**
1.2 DECREASE IN STOCKS (WATER ABSTRACTION, CONSUMPTION AND OUTFLOWS)	
WR70	Abstraction from water assets
WR71	*Abstraction for distribution*
WR72	*Abstraction for own use by agriculture (incl. for irrigation)*
WR73	*Abstraction for own use by hydroelectricity production*
WR74	*Abstraction for own use by other production (incl. cooling)*
WR75	*Abstraction for own use by municipal and household use*
WR80	Direct actual evapo-transpiration
WR81	*Direct actual evapo-transpiration from rainfed agriculture and pasture*
WR82	*Direct actual evapo-transpiration from forests*
WR83	*Direct actual evapo-transpiration from natural land*
WR84	*Direct actual evapo-transpiration from water bodies*
WR85	*Direct actual evapo-transpiration from artificial land*
WR90	Actual evapo-transpiration induced by irrigation
WR100	Evaporation from industry and other uses
s/t (WR80+90+100)	***Total evaporation & actual evapo-transpiration***
WR110	Natural outflows to other territories and the sea
WR120	Export of water to other territories and the sea
WR130	Other change in volume of stocks (+ or -)
WR2	**Total decrease in stocks**
WR3 = WR1-WR2	**Net Ecosystem Water Balance (NEWB)**
WA2	**Closing Stocks**

Ecosystem water accounts

2. BASIC BALANCE/ *TABLE OF TOTAL WATER USES*	
WU10 = WR70	Abstraction from inland water assets
WU11	*Abstraction for distribution*
WU12	*Abstraction for own use by agriculture (incl. for irrigation)*
WU13	*Abstraction for own use by hydroelectricity production*
WU14	*Abstraction for own use by other production (incl. cooling)*
WU15	*Abstraction for own use by municipal and household use*
WU20	Direct use of precipitation water
WU21 = WR81+WR82	*Precipitation water feeding agriculture and forestry (green water)*
WU22	*Collection of precipitation water (rainwater harvest)*
WU23	*Urban runoff (urban stormwater)*
WU1	**Total use of ecosystem water**
WU30 = WR41	Water imported from external territories
WU40 = WR42	Withdrawals of water from the sea
WU50	Use of water received from other economic units
WU60	Re-use water within economic units
WU2	**Total water uses**

Ecosystem water accounts

3. BASIC BALANCE/ *ACCESSIBLE BASIC RESOURCE SURPLUS*	
3.1 TOTAL INCREASE OF WATER RESOURCES STOCKS	
WR1	**Total increase in stocks (natural and secondary water resource flow**
3.2 ADJUSTMENTS OF RENEWABLE WATER RESOURCES	
WS10	Irregular renewable water resources (regular as > 90% of time) (-)
WS20	Legal reserved runoff (for dilution (BOD), aquatic life, navigation…) (-)
WS30	Inflow not secured through treaties, agreements, regulations or laws (-)
WS40	Outflow secured through treaties, agreements, regulations or laws (-)
WS50	Water natural resource unusable due to quality (incl. salinity) (-)
WS60	Non-renewable water resources (deep aquifers) (-)
WS70	Exploitable irregular renewable water resources/ annual storage (+)
WS80	Previous net accumulation in water stocks (+ or -)
WS90	Other accessibility adjustments of natural water (+ or -)
WS1	**Total adjustment of natural renewable water resources**
s/t (WR10+20+30) + WS1	***Exploitable (or manageable) natural water resources***
WS100	Secondary water resource unusable due to quality (-)
WS110	Other accessibility adjustments of secondary water (+ or -)
WS2	**Total adjustment of secondary renewable water resources**
s/t (WR40+50+60) + WS2	***Exploitable (or manageable) secondary water resources***
WS3 = WR1+WS1+WS2	**Accessible basic water resource surplus**

Cf. FAO AQUASTAT: exploitable resource http://www.fao.org/nr/water/aquastat/water_res/indexglos.htm

Ecosystem water accounts

4. TABLE OF INDEXES OF ECOSYSTEM STATE/DISTRESS	
4.1 INDEX OF INTENSITY OF USE IMPACT [IF<1, = overuse, dilapidation; IF>1, accumulati	
WH1 = WS3/WU2	**Water intensity of use impact**
4.2 COMPOSITE INDEX OF ECOSYSTEM HEALTH CHANGE	
WH10	Bio-chemical quality
WH20	Nutrients excess, eutrophication
WH30	Change in species diversity
WH40	Water borne diseases
WH50	Dependency from artificial inputs
WH60	Change in probability of water stress
WH70	Other…
WH2	**Composite index of change in ecosystem health**
4.3 ANNUAL CHANGE IN INTERNAL ECOSYSTEM STATE/DISTRESS INDEX OF WATER RESO	
WH3 = AVG(WH1+WH2)	**Annual change in resources internal ecosystem state/distress index**

= Accessible basic water surplus / Total use of ecosystem water

It should be always > or = to 1 ; when < 1, stress on resource ➔ degradation

Data requirements for ecosystem water accounting

- The data used for the national SEEAW accounts,
- Meteo data on precipitation (by regions, monthly, 10 years), evapotranspiration (or variables to compute it)
- Isohyets maps
- Gauging of water discharge, if possible 1 by drainage basins
- Main uses of water by key economic sectors, with regional breakdowns…
- Mapping of irrigation, firstly for sugar cane
- Population data by municipalities
- Tourism data
- Wastewater discharge to the environment (map)
- Aquifers stocks, abstraction (at boreholes) and pollution (if any)

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