Potsdam Institute for Climate Impact Research

COOPERATION

Preliminary investigations for the development of a water allocation module in SWIM

Assessing the impact of prospective and conflicting irrigation and water resources management plans in the Inner Niger Delta (IND) and the Upper Niger Basin (UNB) under climate change conditions

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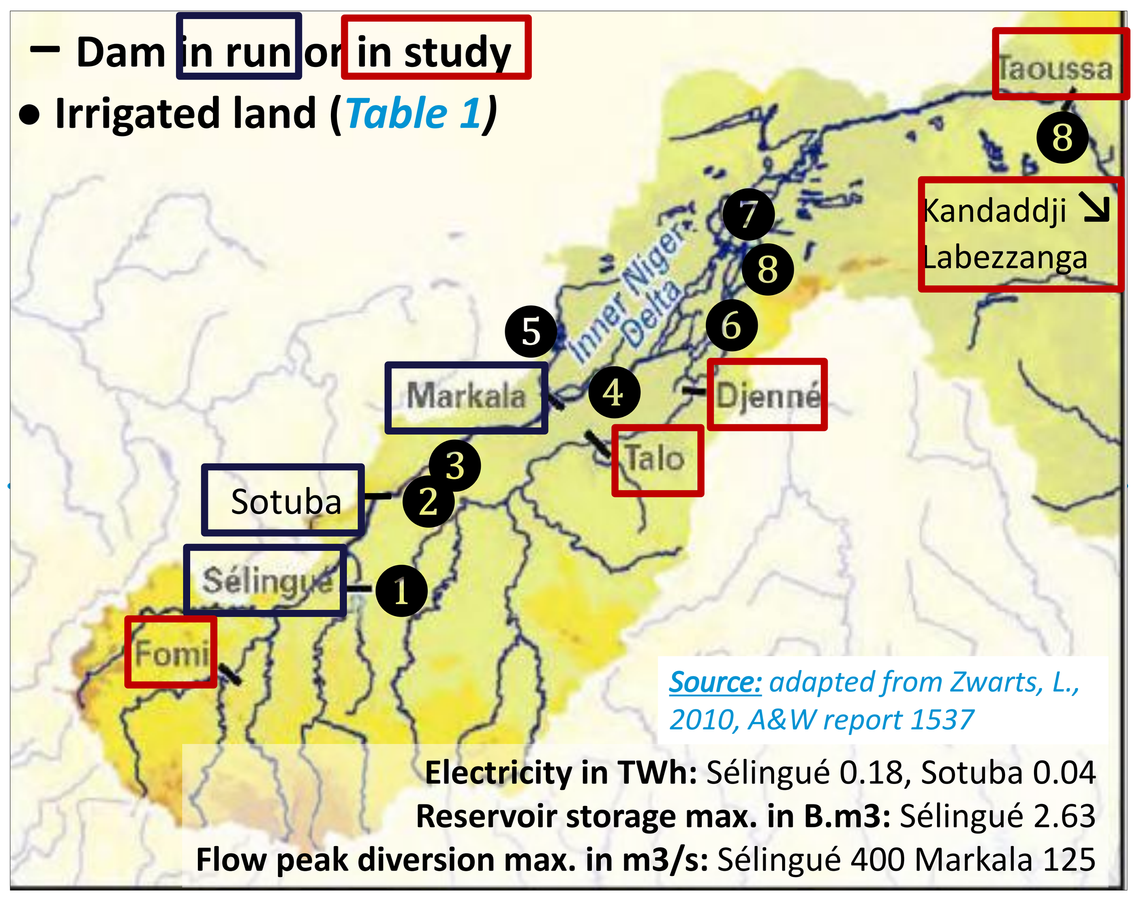
Niger basin

The IND is a network of tributaries, channels, swamps and lakes in the climatic sahelian zone which forms an inundation plain experiencing a drastic seasonal variation in discharge, and flood extent, from 8 to 25 thousands km². Consisting of the middle course of the Niger River; the third longest river in Africa with a transboundary watercourse of 4200km and a drainage basin of 2.1M.km², water serves multiple and conflicting functions for more than 1M. people in the sub- region.

Figure 1 Upper Niger Basin: Dams and Irrigated lands map



Climate vulnerability to drought

Figure 2 shows a significant rainfall deviation between decades especially 1990 and 1980 which were very dry. In general the northern section of the river basin seems to consistently show increasingly wet conditions, whereas in fact this arid area is very sensitive to slight increases in rain fall (even 1mm more can result in a large percentage increase). This river basin is very dependent on rainfall; changes in the timing or abundance of these events impacts the downstream users and the ecosystem.

Cclm and Watch data will be further used for projections of hydrological simulations.

Conflicting water uses between IND & UNB

The current infrastructure in the UNB is composed of dams, reservoirs and diversion channels ***(Figure1)***. In the coming decades these infrastructures will be reinforced allowing capacity to develop energy production and to expand fully managed irrigation system upstream ***(Table1)***. Coupled with the effects of climate change, these projects have a significant impact on the ecosystem and on the flow regime of the IND which compromise the perenniality of navigation, fishing and traditional river-fed agriculture, essential for meeting regional food security.

Table 1 Characteristics of irrigated land in Upper Niger Basin

ID	Name	Irrigation system	Water uptake M.m³/y	Crop	Yield t/ha	Area km²
1	Office de Sélingué	Gravity-governed full water control	33.6	Rice corn gardening tobacco	4.96	34
2	Office de Baguineda	Gravity-governed full water control	215	Rice corn millet sorghum	4.12	26
3	Office Hte Vallée Niger	Mixed system	575	Tobacco, rice, cotton dry crop	1.60	117
4	Office Riz Ségou	Controlled submersion	200	Rice	1.95	308
5	Office du Niger	Gravity-governed full water control	2562	Rice Sugar cane gardening	6.08	971
6	Office Riz Mopti	Controlled submersion	549	Rice corn millet sorghum	1.85	298
7	Directions Rég. Agriclt.	traditional river-fed	1678	Mixed	1.90	4510
8	Pump-assisted total-water-management irrigation		~ 1.4 km² (1998 estimation) 6 to 9 t./ha			

Source: Marie m. et al., 2007, Avenir du fleur Niger, IRD

SWIM Soil and Water Integrated Model

The ecohydrological model SWIM uses available regional data to simulate runoff generation, nutrient and carbon cycling, plant growth and crop yield, river discharge and erosion as integrated river basin processes at a daily time step, supported by a distribution function approach and GIS post processing. It was developed to investigate climate and land use change impacts at the regional scale.

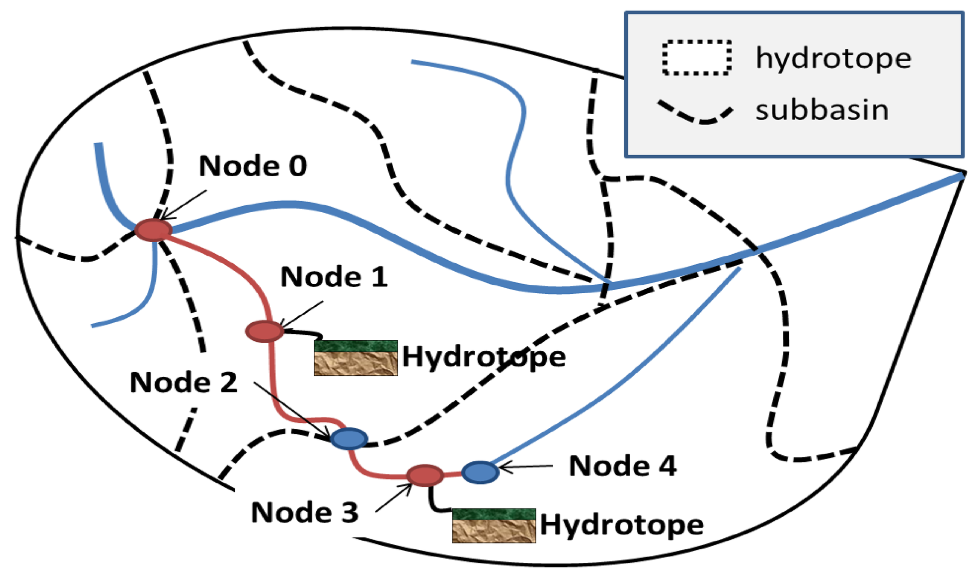
Brief review of irrigation approaches

Some models like WEAP are based on the FAO Penman Monteith dual crop coefficient method when In SWIM and SWAT, the EPIC approach governs the plant and crop water requirement. In SWAT, 3 independent modules (irr_rch.f , irr_res.f, irr_sub.f) rule the water transfer for irrigation from 5 uptake sources into a HRU (reach, reservoir, shallow or deep aquifer and external sources).

Solutions for SWIM implementations

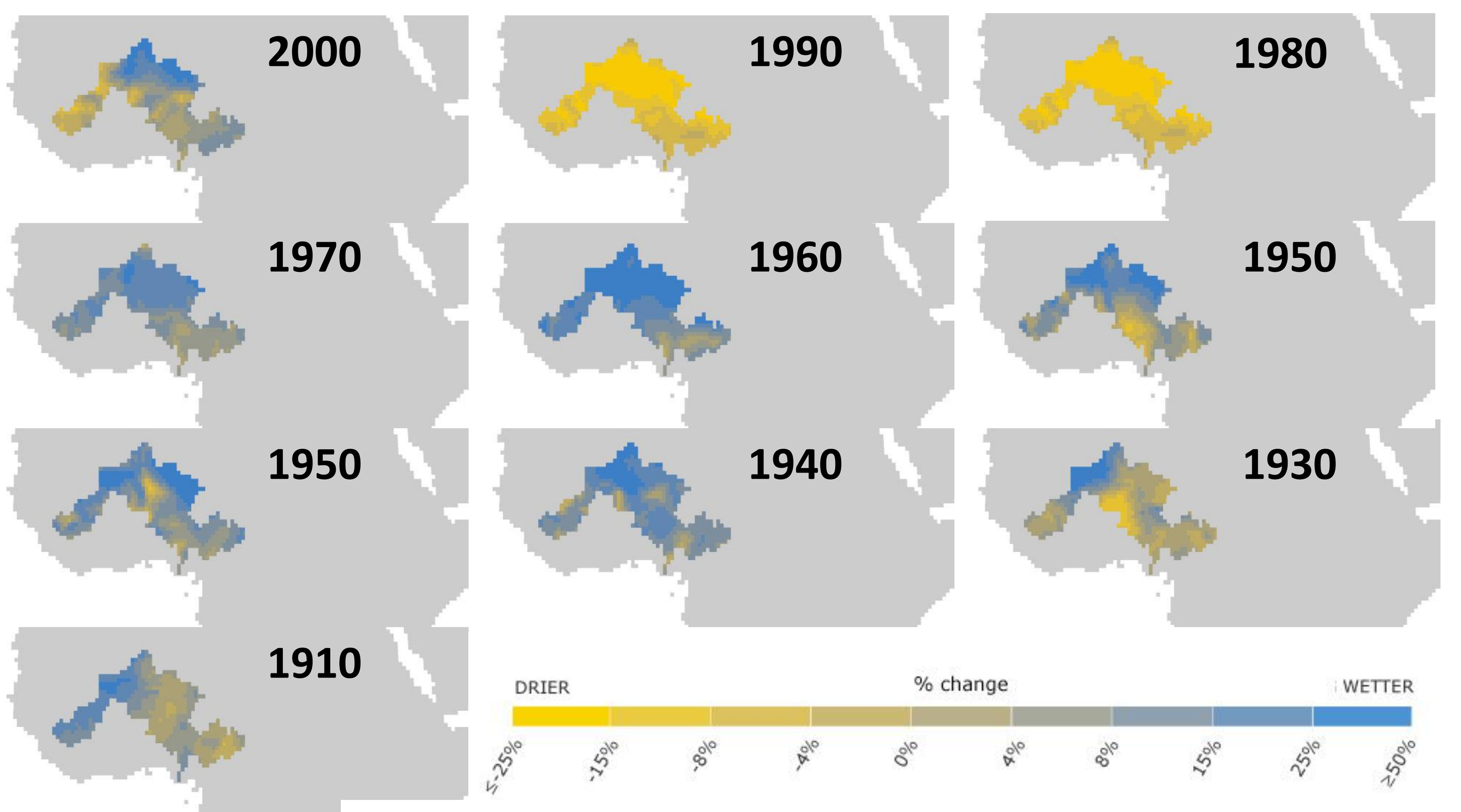
First, an *Inundation module* representing **traditional river fed** is under development [Liersch, S., *How to integrate wetland processes in river basin modeling?*, Swat conference, 2011]. Second, to represent a complex **gravity governed full water control**, the concept of a *water diversion module* with a parallel channel routing is also under investigation *(Scheme 1)*.

***Scheme 1** Water diversion schematic module concept*



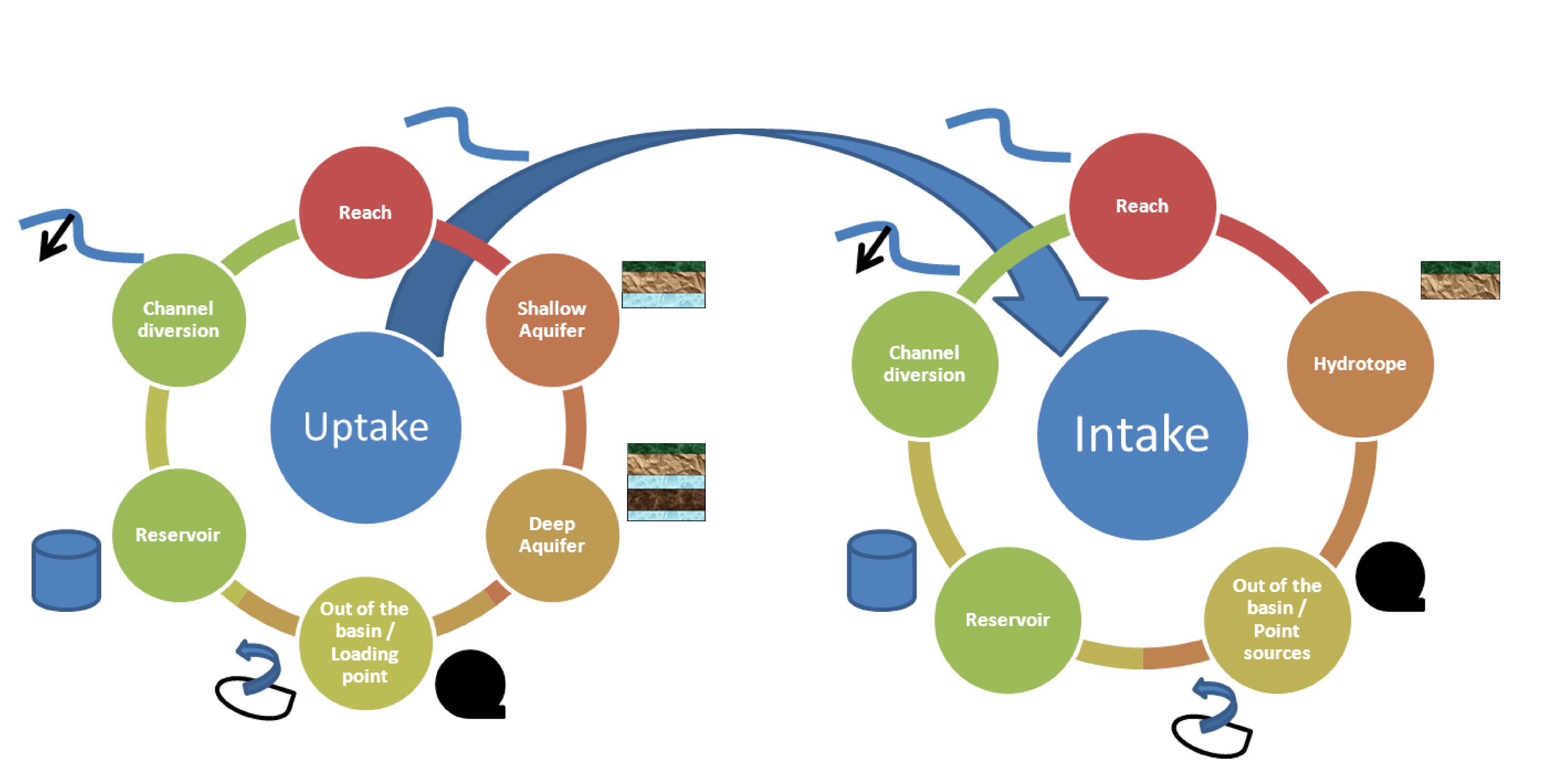
Finally, the concept of a *Water allocation module* aims to **transfer water between hydrotope, shallow or deep aquifer, reservoir, point source, reach and diversion channel** *(Scheme 2)* with the most flexible specifications for the water volume inputs and outputs (constant, yearly, monthly, daily values, fraction of volume, unlimited, triggered by plants, triggered by soil content …). Due to the large range of sources, the challenge is to create a module flexible enough to be called at different stages of SWIM process respecting the water balance fundaments.

Figure 2 Niger River Basin Percentage Change Rainfall by decade from the reference period 1961-1990 with CRU TS2.1 data (Climate Research Unit)



Source: WATCH fp6 projects http://www.waterandclimatechange.eu/

***Scheme 2** Water allocation module schematic concept*



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