Assessing vulnerability of wetlands to change

Factsheet 7

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Gauging resilience to change

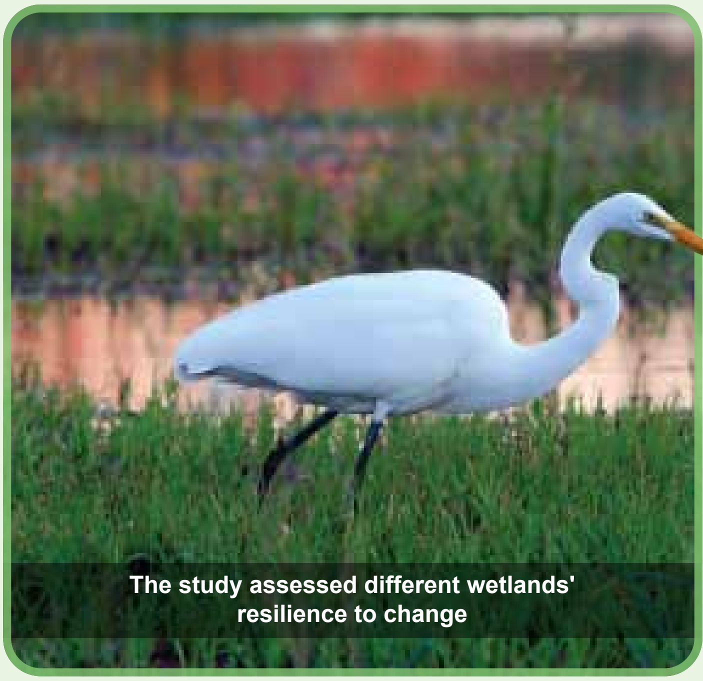
Vulnerability and resilience have become important to assess the impact of global and regional change on wetlands, but are conceptualized differently in different studies and are difficult to assess in concrete terms. In the WETwin project, a framework to assess vulnerability was developed for the following purposes:

- to explore potential future changes using scenarios;
- to assess the impact of drivers of change;
- to identify management solutions that are robust under changing conditions (including, but not limited to, climate change); and
- to raise awareness and improve understanding of challenges in the catchment and/or wetland.

Defining vulnerability

In the WETwin project, vulnerability is interpreted as being a function of External Impact (EI) and Adaptive Capacity (AC) (Figure 1). EI is the impact of stress originating from outside the wetland (e.g., current and planned upstream catchment activities, climate change, demographic trends. etc.) and is mainly related to biophysical stressors. AC is the extent to which these impacts can be withstood or mitigated through management options and solutions at the wetland scale. The change in vulnerability (residual vulnerability or ΔV) of the system as it moves from its initial state to a new state can be described by the sum of (usually negative) external impacts and (usually positive) adaptive capacity, that is:

$$\Delta V = EI + AC$$



The study assessed different wetlands' resilience to change

EI is quantified as the difference between the system state(s) after perturbation or under the 'business-as-usual' (BAU) scenario and the baseline scenario. AC is assessed by comparing the system states including management solutions with the system state(s) under the BAU scenario.

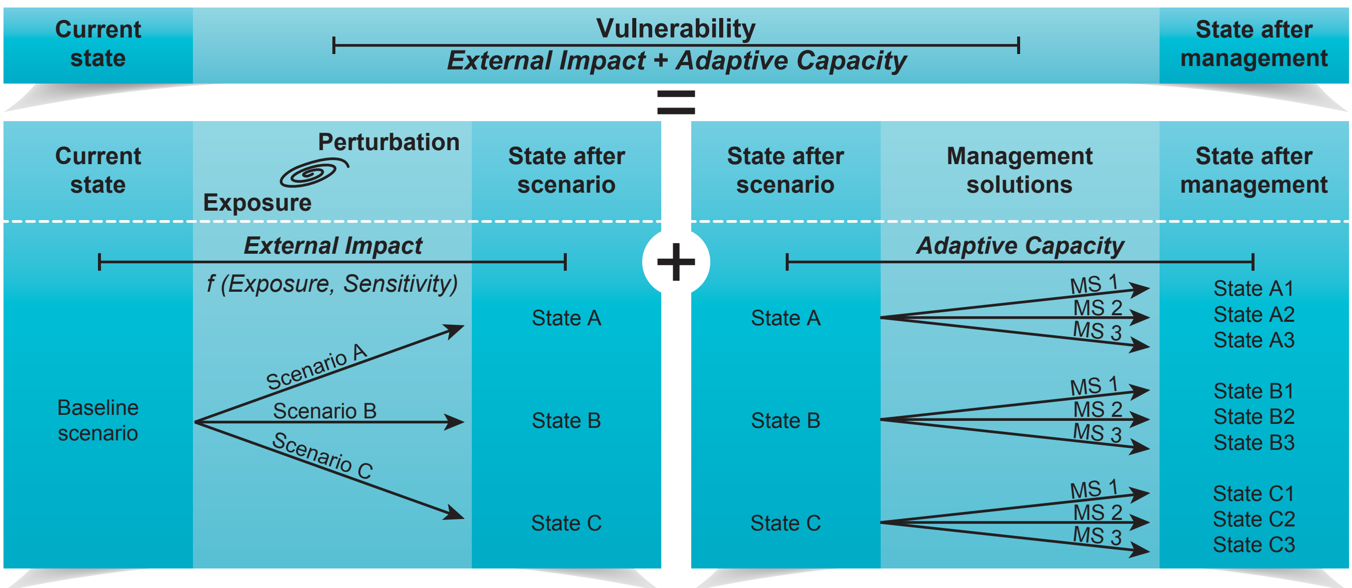


Figure 1: WETwin framework for vulnerability assessment

Where the adaptive capacity of the system exceeds the absolute value of external impacts (AC > EI, ΔV > 0), the system moves towards a resilient state; where external impacts exceed adaptive capacity (EI > AC, ΔV < 0), the system moves towards a more vulnerable state, as indicated by the length of the EI and AC arrows in Figure 2. This implies that the vulnerability concept is very closely related to the system state, which provides a rough estimate of the system's vulnerability.

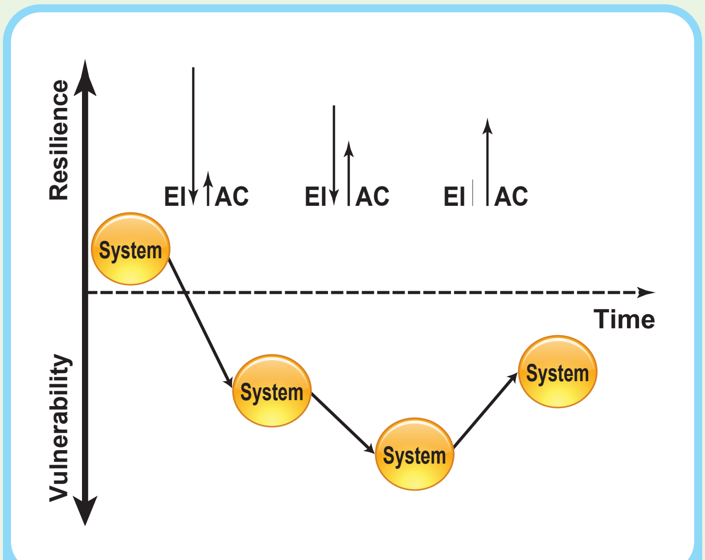


Figure 2:
System states, from vulnerable to resilient

A six-step assessment

The steps that need to be followed to perform a vulnerability analysis according to the WETwin framework are as shown below:

1. Precise definition of one or more research questions (story lines). It is important to define which system attributes (who or what) are vulnerable to what pressure and in what time period.
2. Identification of quantifiable indicators and their criteria or thresholds.
3. Simulation of a baseline scenario to represent the current state using integrated models.
4. Scenario building:
   a) Definition of perturbations/stresses the system is exposed to (e.g., climate change, population growth, etc.).
   b) Definition of management options (adaptive capacity) assumed to mitigate negative impacts.
5. Scenario simulation using integrated models.
6. Quantitative/qualitative assessment of the system's vulnerability.

Case study: Inner Niger Delta

The Inner Niger Delta (IND) is a huge riverine floodplain in West Africa. The catchment is subject to enormous seasonal and inter-annual variation in rainfall. The headwater regions receive up to 2,000 millimeters (mm) of rainfall during the rainy season (July to October) and the northern regions receive only 200-500 mm. The IND provides vital habitats for subsistence farming, fishing and livestock farming, and supports the livelihoods of 1.5 million people. The strong relationship between wetland inflows, inundation patterns and food production within the IND makes the community vulnerable to changing spatiotemporal inflow patterns and, therefore, to external and internal factors.

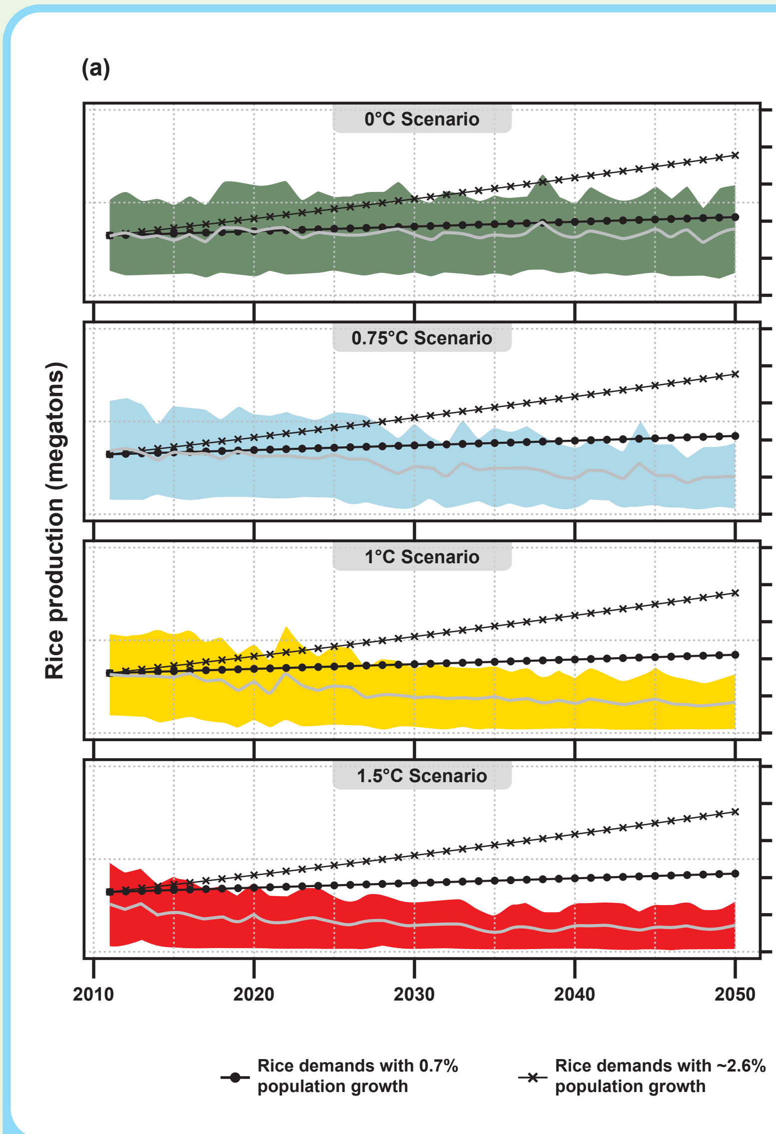
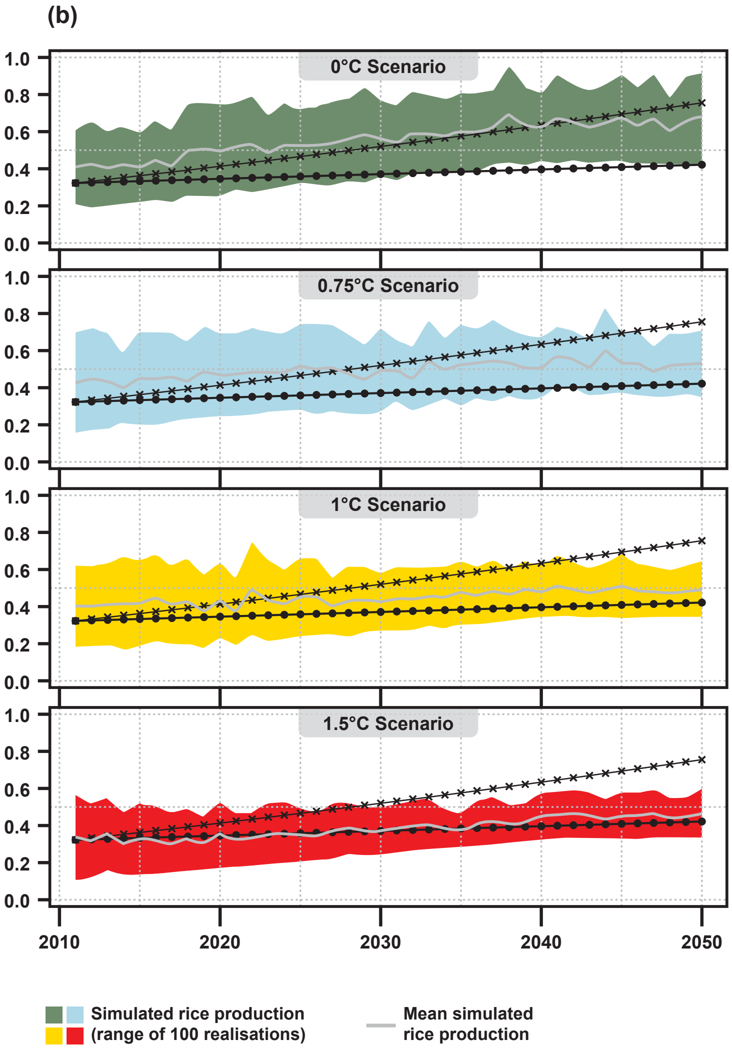


Figure 3: Impacts of climate change, population growth and
on simulated rice production (a) without adaptive mea

Increasing food and energy demands from the growing population put immense pressure on natural resources. To satisfy the energy demands, the Sélingué Dam was built in 1982, and a new dam in Guinea (Fomi) is planned. Increasing food demands require more productive farming; increased irrigation is likely. Projected climate change is adding further pressure.

How vulnerable is the Inner Niger Delta?

To address vulnerability, it is important to formulate a precise research question. An example for IND is: How vulnerable is food production in the Inner Niger Delta to climate change, upstream water management and population growth in the period 2011-2050? Due to the strong functional relationship between wetland inflow, inundation patterns and food production, a suitable indicator is the potentially usable area for production of floating rice. This area depends on inundation, determined by the criteria: inundated by at least 90 days and a water level between 1-2 meters. Figure 3 and Figure 4 illustrate some possible answers, gained by performing the vulnerability analysis.



upstream water management (including the Sélingué Dam)
sures (BAU scenario) and (b) with adaptive measures

The Soil and Water Integrated Model (SWIM), equipped with a reservoir and an inundation module, was used to simulate runoff and wetland inundation in the Upper Niger Basin including the Inner Delta. The time period representing the baseline scenario is 1970-2001. A set of four climate-driven scenarios, assuming temperature increases of 0.0 °C, 0.75 °C, 1.0 °C and 1.5 °C, were combined with two population growth scenarios (0.7% and 2.6% annual growth rate) and three water management scenarios: without reservoirs, with the Sélingué Dam (current situation), and with the Sélingué Dam and the planned Fomi Dam.

An increase in the irrigation area from 1,620 hectares (ha) in 2011 to 65,000 ha in 2050 is presumed for all scenarios. According to Mali's recent development program of the IND, the area for irrigated rice shall be extended to 65,000 ha. This additional rice production determines adaptive capacity (AC), since irrigated rice with 5-6 tonnes (t)/ha has a much higher productivity than floating rice with 1-2 t/ha. However, such developments will certainly lead to conflicts between different interest groups and jeopardize the status of the Ramsar site.

The impacts of climate change on runoff, wetland inundation and rice production were simulated by using 100 climate realizations (representing a range of dry to wet conditions) of each scenario. Food demand was calculated assuming annual cereal requirements of 214 kilograms (kg)/capita, represented by rice equivalents, the main staple food. The potential production was calculated on the simulated usable area and a productivity of 2 t/ha for floating rice and 5 t/ha for irrigated rice. Figure 3a illustrates the impacts of climate scenarios, population growth and upstream reservoir management (including the Sélingué Dam) on simulated rice production without adaptive measures under the BAU scenario. Figure 3b shows the potential effectiveness of the measures. The system state of the baseline scenario was quantified with a normalized value of 0.6 (Figure 4).

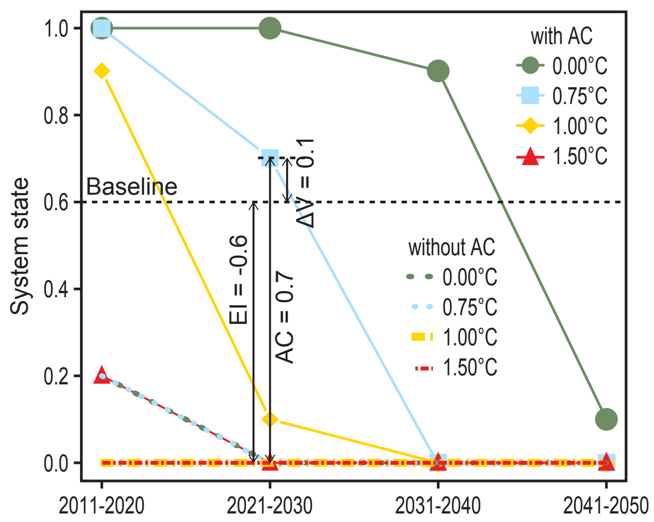


Figure 4: Outcomes under different scenarios (with the Sélingué Dam operating and population growth at 2.6%)

Figure 4 helps to interpret Figures 3a and 3b with a population growth rate of 2.6%. The system states under the BAU scenario (dashed lines in Figure 4) show the EI of climate change and increasing food demands in four time slices (EI = BAU scenario – baseline scenario). The simulated average rice production only exceeds the demands under the 0 °C and 0.75 °C scenarios in 20% of the years (2011-2020), and never under the 1.0 °C and 1.5 °C scenarios (see also Figures 3a and 3b). Due to the strong impact of population growth and climate change, all system states under the BAU scenario drop to 0.0 in 2021-2050.

The solid lines in Figure 4 represent the potential impact of the adaptive measure (AC). A quantification of the vulnerability components is given for the 0.75 °C scenario for the period 2021-2030. Without AC, the system state drops from 0.2 (2011-2020) to 0.0 in 2021-2030. Compared to the baseline scenario with a value of 0.6, the value of EI is, therefore, -0.6. The adaptive measure pushes the system to a value of 0.7 (AC = State [with AC] – BAU scenario). Consequently, the value of $\Delta V = EI + AC = 0.1$. Despite the strong external impact, the potential AC is as effective to push the system into an even better state than in the baseline scenario.

Increasing temperature and decreasing rainfall have a very high, negative impact on food production in the IND. The adaptive measure is as strong to outbalance increasing food demands under the moderate population growth scenario, and the combined impacts of climate change and upstream reservoir management. However, Figures 3a and 3b emphasize the strong role of population growth as an influential driver. Food security in the IND is, thus, extremely vulnerable to climate change, upstream water management and population growth.

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About WETwin

The WETwin project aims to enhance the role of wetlands in integrated water resources management for twinned river basins in the European Union (EU), Africa and South America in support of EU water initiatives. The objective is to improve community service functions while conserving good ecological status.

Partners

VITUKI Environmental and Water Management Research Institute, Hungary (coordinating partner)
Wetlands International, Mali
Antea Group, Belgium
Potsdam Institute for Climate Impact Research, Germany
WasserCluster Lunz, Austria
UNESCO-IHE Institute for Water Education, the Netherlands
National Water and Sewerage Corporation, Uganda
International Water Management Institute, South Africa
Escuela Superior Politécnica del Litoral, Ecuador

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Factsheet topics

1: Lessons learned from a comparative assessment
2: Enhancing governance in wetland management
3: Devising a Decision Support Framework
4: Balancing ecology with human needs in wetlands
5: Creating an effective Spatial Data Infrastructure
6: Wetlands in a catchment context
7: Assessing vulnerability of wetlands to change
8: Integrating health, urban planning and wetland management
9: Case study: Lobau wetland, Austria
10: Case study: Ga-Mampa wetland, South Africa
11: Case study: Abras de Mantequilla wetland, Ecuador
12: Case study: Gemenc floodplain, Hungary

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