



Superimposing various biophysical and social scales in a rapidly changing rural area (SW Niger)

Christian Leduc, Sylvain Massuel, Guillaume Favreau, Bernard Cappelaere, Marc Leblanc, Salifou Bachir, and Boureïma Ousmane

IRD, UMR G-EAU, Montpellier cedex 5, France (christian.leduc@ird.fr)

In SW Niger, close to Niamey, a detailed hydrological survey has been developed for the last 20 years (international experiments HAPEX-SAHEL and later AMMA), investigating the distribution of water in atmosphere, surface, soil and aquifers. It covers an area of about 10 000 km², with a series of imbricated scales of instrumentation, in time and space. This dense long term field observation led to many major scientific results. Among them, one of the most original and paradoxical is the continuous rise of the water table, even during the severe droughts of the 1970s and 1980s (about 3 m in the last 30 years). In spite of a large apparent homogeneity of the biophysical environment throughout the region, numerous heterogeneities exist at different scales, complicating the hydrological analysis.

On the surface, the hydrological system was, ~6000 years ago, a structured drainage network leading to the Niger River. It was later broken into much smaller elements by aeolian dunes deposited during arid episodes and the study area now appears as a juxtaposition of hundreds of small endorheic catchments (most often 1 to 20 km²) where the surface runoff finally ends in temporary ponds. During most violent rainy events, erosion can be locally very severe and modify durably the size of the catchment and the local hydrology. Conversely, during smaller rainy events, surface runoff may never reach the ponds because it infiltrates in more permeable zones at mid-slope. The actual surface area of the catchment contributing to the surface runoff thus varies considerably with time. Because of their great number, only a few catchments are instrumented and extrapolation of measurements to ungauged catchments is an additional difficulty.

Most of water temporarily stored in ponds infiltrates and recharges groundwater. The Continental Terminal (CT) aquifer system is made of three independent layers, of which the upper one (CT3) is only considered here. The CT aquifer systems is a transboundary aquifer that extends far beyond the study area, over about 150 000 km². It is also heterogeneous. Like surface flows, but at a different scale, groundwater flows are marked by a strong endorheism. For example the Dantiandou closed piezometric depression extends over about approximately 5000 km². These natural closed depressions are explained only by evapotranspiration uptake, weak in absolute terms (a few mm.a⁻¹) but with a very high impact on hydrodynamics because of poor permeability and porosity. Both density of observations and hydraulic continuity of the CT3 aquifer give a fine idea of groundwater changes in the whole area.

Human activities, continuously adapting in this poor rural area, add another complexity to the hydrological diversity in surface and ground water. The replacement of the natural vegetation with millet fields and fallow increased the surface runoff, and consequently water accumulation in temporary pools and then CT3 recharge. In the SE part of the study area, the water table has risen up to outcropping in the lowest valley bottoms. These new permanent ponds reflect groundwater while temporary ponds still reflect surface dynamics. This new component of the hydrological landscape induces several consequences, in physical and human dimensions. Evaporation strongly affects the permanent water and increases its salinity while the natural mineralization of groundwater is very low. The easier access to water resources allows a significant development of local gardening, which modifies the social functioning of villages (e.g. land rights between villages and within a village, diversification of crops and sources of income, new sales channels).

Different physically based models (for surface and ground water) were built, with a significant discrepancy between their respective quantification of water flows at the region scale. Extrapolation of surface fluxes from the few instrumented catchments to a much larger mosaic of non-instrumented catchments is only partially compatible with the geochemical and hydrodynamic calculations for the CT3 aquifer. This leads to many questions about the representativeness of instrumentation (in spite of dense observations), the heterogeneity of the landscape (perhaps even stronger than supposed, complementarities and differences between methods, etc.).

Similarly, the diversity and evolution of human behaviours facing new situations (population growth, environmental changes) are essential elements to take into account, not always easily accessible to hydrologists.

