Watershed management practices and hydrological modelling under changing climatic conditions in the semi-arid regions of Mali and Ghana

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Key messages

- ✓ Regional changes in climatic patterns have impact at both farm level and catchment scale.
- ✓ Low potential for surface water storage suggest that subsurface water management may be a viable option.
- ✓ Managing variability in terms of water storage solutions will help farmers with better coping mechanisms and adaptation to climate change.
- ✓ Provision of low cost and climate smart water lifting technologies will improve water access and availability from shallow wells.
- ✓ There is a clear need for field experimentation combined with systems modeling to provide insights that could address the impact of climate change on the regional water dynamics.

Objectives and approach

Objective: Improve smallholder agricultural productivity through sustainable intensification by managing water resources using a watershed approach.

Approach: (i) studying the seasonal variations of water levels in shallow wells at land scale level, (ii) establishing new sets of monitoring stations and field experiments to study the dynamics of water availability and land cover changes, (iv) water balance modelling from farm to watershed scale and, (v) regional climate change modelling.

Key results

- From a 57km^2 watershed located in southern Mali, analysis of 254 community managed shallow wells revealed a non-significant water level variation in both dry (p value 0.996) and rainy seasons (p value 0.996). This implies water can be accessed at a maximum depth of 12.5 m in 84 % of wells (dry season) and at 8 m in 76 % of wells (rainy season).
- A significant reduction in runoff (p value 0.018) was observed for farm fields treated with SWC practices (**Fig. 1**). Runoff rates vary from 24 to 26 % and 39 to 43 %, in farm fields with and without SWC practices respectively.
- Regional temperature trends indicate a steady annual increase based on data between 1961 and 2004 (**Fig.2**) which emphasizes the need to adequately manage water resources due to potentially high evaporative demands.
- Rainfall trends for the region revealed that there was remarkable increase in the regional rainfall amounts but unless these are harnessed it is wasted as runoff due to poor distribution patterns. This calls for more concerted management of water resources in order to optimize agricultural productivity.

Significance and scaling potential

- A watershed approach emphasizes proper management of natural resources through collective action. Through establishing and monitoring hydrological variables and modeling the interaction of water balance components, impacts of natural resources management (NRM) practices are evaluated from farm to watershed scale. This helps to identify and prioritize practices that are relevant to specific agro-ecological conditions.
- The small scale watershed activities in southern Mali and northern Ghana can be scaled widely through capacity building, integration of national and regional research centers and using established regional hydrological models.

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Water balance equation

Farm/Plot level:

$$P + D = RO + DD + ETc \pm \Delta SWc$$

P is precipitation , D is dew and atmospheric condensation (mainly ignored), RO is surface run-off, DD is deep drainage recharging the water table, ETc is evapotranspiration, ΔSWc is the change in profile water storage.

Watershed Level:

$$SW_t = SW_0 + \sum_{i=1}^{t} \left(R_{day} - Q_{surf} - E_a - W_{seep} - Q_{gw} \right)$$

SW_t is the final soil water content, SW_0 represents the initial soil water content on day i, R_{day} is the total precipitation on day i, Q_{surf} represents the amount of surface runoff on day I, E_a is the amount of evaporation on day i, W_{seep} is the amount of water that percolates into the vadose zone (area between the bottom of the soil profile and the top of the shallow aquifer) on day i, and Q_{gw} is the amount of base flow on day i, in which t is the number of days of the simulation.

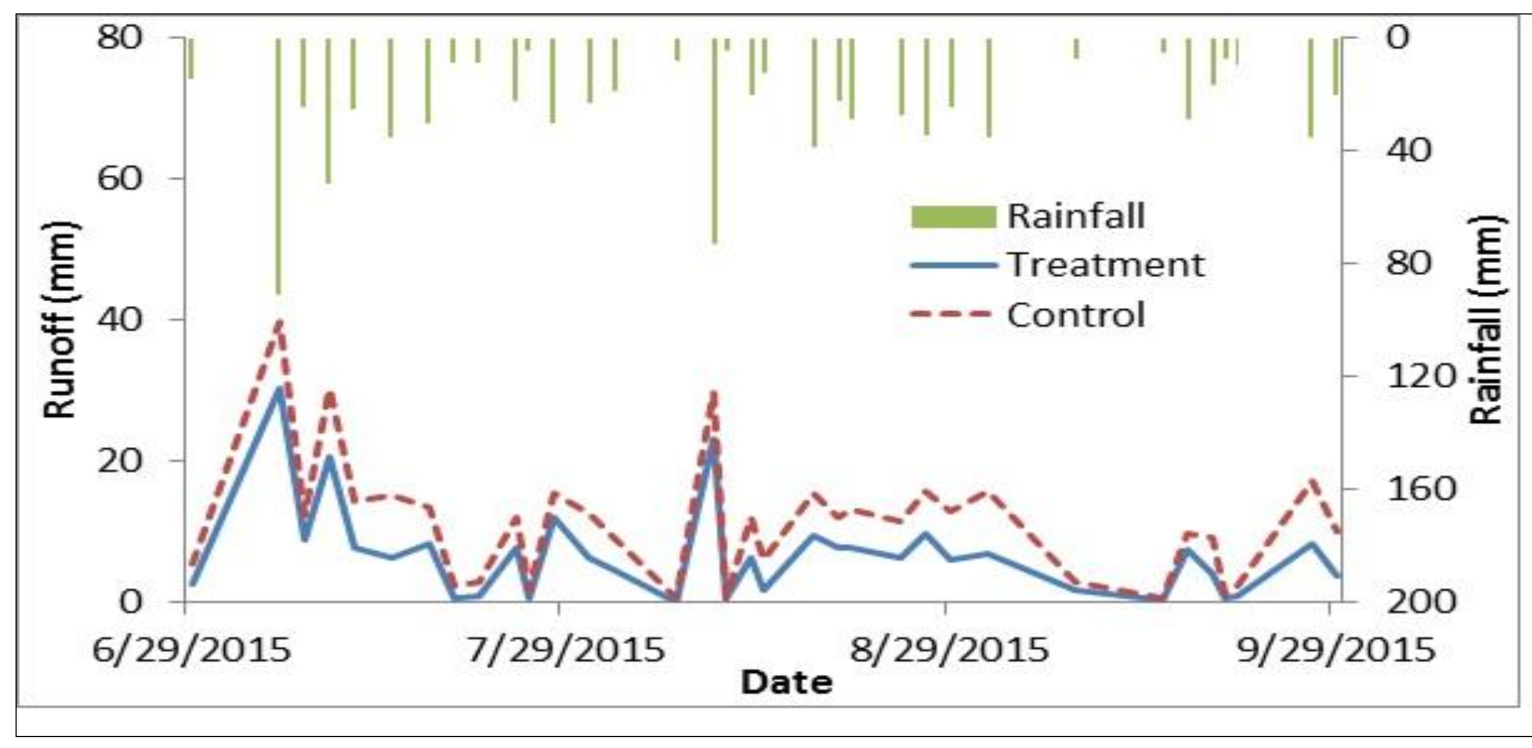

Fig. 1:Rainfall and runoff hydrograph from experimental station in Kani watershed in southern Mali

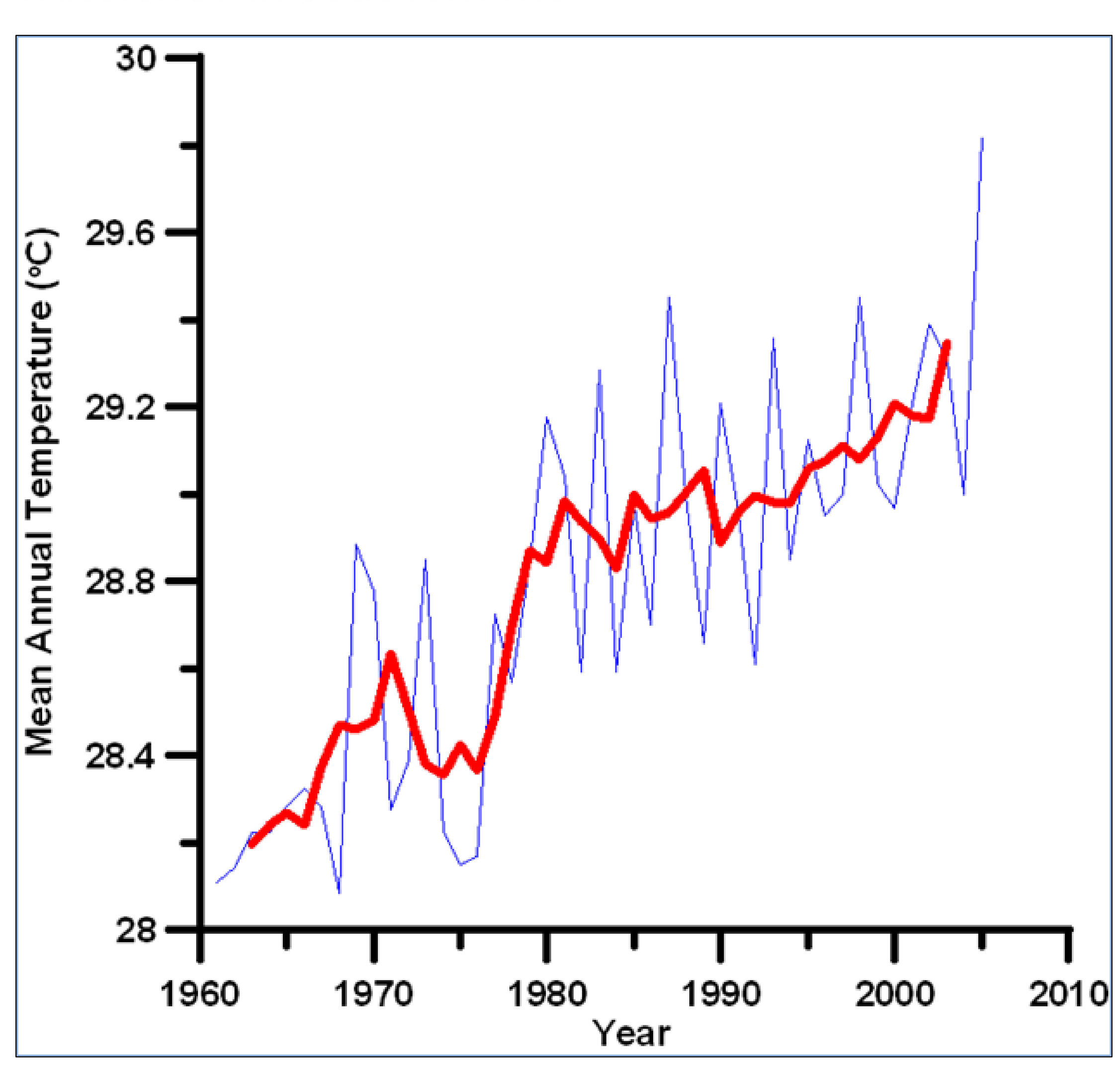

Fig. 2: Long term mean temperature for the Upper East Region from Bolgatanga station (Red depicts 30-day running average).