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A systemic approach to landscape management for productive rainfed systems in Latin America, East and South Asia and Sub-Saharan Africa

Summary

Rainfed farming is the world's most dominant food production system. While opportunities for expansion of irrigation infrastructure are limited, investment is needed to maintain and improve crop water availability in rainfed agricultural production. Investment in improving rainfed agriculture through green water management holds the most significant potential for increasing crop yields, with the outcome of increased food security, income generation and resilient livelihoods. We recommend increased investment in the development of water infrastructure and adoption and adaptation of water-optimizing technologies and strategies. This will support production in rainfed systems and optimize available water for use by crops and livestock.

The global significance of rainfed agriculture

Rainfed farming accounts for 80 percent of global cropland and 60 percent of the world's cereal grain production. It supports rural livelihoods and provides food in urban areas. Rainfed agriculture accounts for 90 percent of farmed land in Latin America, 75 percent in the Near East and North Africa, 65 percent in East Asia, 60 percent in South Asia and more than 95 percent in sub-Saharan Africa.

There is a close link between the prevalence of food insecurity and poverty and investment in water-use infrastructure and technologies. Most communities with high levels of food insecurity and poverty live in regions with little water and low investment in water management. Analysis of production system trends across the globe point to an existing potential for increased rainfed agricultural production if water stress is eliminated or minimized. In South Asia, World Agroforestry (ICRAF) together with its partners have successfully developed and demonstrated agroforestry-based natural resource management interventions. These have significantly reduced runoff by 30–50 percent, enhanced water infiltration by 75 percent and have raised water tables by 2–3 metres. This has ensured year-round availability of water for drinking and agricultural purposes in the driest rainfed areas of India.

Governments around the world have paid little or no attention to the potential to increase food production in rainfed agricultural systems. In most governments, the ministries of agriculture, water and natural resources are separate and their limited interactions often lead to a fragmented and uncoordinated approach as well as conflicting policies in dealing with the challenges facing rainfed agriculture and landscapes.

Water resources face multiple barriers that impede their development (Figure 1). Investments in water infrastructure and trees in landscapes have been implemented traditionally. We recommend that investments be implemented as a system rather than as isolated structures, in combination with supportive policies. Key investment opportunities are as follows:

- enhancing and managing the role of trees and forests as prime regulators within the water, energy and carbon cycles, including in their roles as 'generators' of rainfall through 'downwind' evapotranspiration;
- introducing techniques for managing surface flows for water harvesting in the crop root zone;
- improving collection of rainwater for crop irrigation;
- increasing water-holding capacity of soil through higher soil organic carbon;
- enhancing hydraulic equilibration.

The balance between oceanic-sourced and terrestrially recycled rainfall depends on location, distance to coasts and prevailing wind directions. As a result, dependency on 'upwind' land cover is impacted by location. Support to crop-water relations through incorporating trees in cropped land (agroforestry) or maintaining neighbouring forest lands can result in higher levels of organic matter in farmlands, thus delaying sensitivity to dry spells by up to two weeks. Development of green water infrastructure for holding water can improve rainfed production by mitigating agricultural water scarcity attributed to non-productive losses.

The interaction between the green water-management structures outlined above and the available blue water (irrigation) infrastructure requires new types of system analysis. The human-made and natural infrastructure influencing water flows and storage by forests and vegetation around farmland affect rainwater use efficiency and the potential of rainfed agriculture. Improving the availability of water to plants after rainfall can be achieved through in situ water infrastructure that capitalize on green water and appropriate land and crop management systems. Emerging science suggests that developing water infrastructure that incorporates trees at the landscape and farm levels is essential to enhance (or even maintain) agricultural yields from rainfed systems.

Key findings

1. The topography of land is a significant component in rainfed agriculture and requires investments that will ensure rainfall events do not negatively affect yields and that surface runoff water is tapped and utilized using technologies such as micro basins.
2. There are several recognized practices that support improved water use efficiency in rainfed production systems, such as sustainable management of natural and agricultural landscapes, agroforestry for green water and soil fertility improvement, supplemental irrigation to reduce risks of crop failure under insufficient rainfall, creating basins and pits for the conservation of moisture and growing of crops and in situ rainwater harvesting and water-use efficiency technologies.
3. Well-maintained trees near rainfed agricultural land can have a high water balance after a rainfall event. Forest soils develop high organic matter content, and networks of soil macro-pores from decomposed plants and animal burrows can lead to a high rate of water infiltration (low surface flow) that can sometimes exceed rainfall intensity. This can result in very little overland flow, leading to a high recharge of aquifers as well as high soil moisture content, which can expand laterally into adjacent farms.
4. To capitalize on green water, appropriate land and crop management systems require infrastructure that can improve the availability of water to plants after rainfall, both temporally and spatially.
5. Optimizing water use at the farm level can be understood as the more effective utilization of water and moisture on farms. Effective management of rainwater and soil moisture entails the use of technologies that are water efficient, as well as the use of supplemental and small-scale irrigation in rainfed systems.
6. Appropriate water infrastructure for optimal yields in the rainfed system will include structures at the different levels of landscape and the agricultural farm.
7. Investment in water-use infrastructure for rainfed agriculture will accrue significant benefits to communities in terms of increased food security, poverty reduction, economic development and environmental protection.

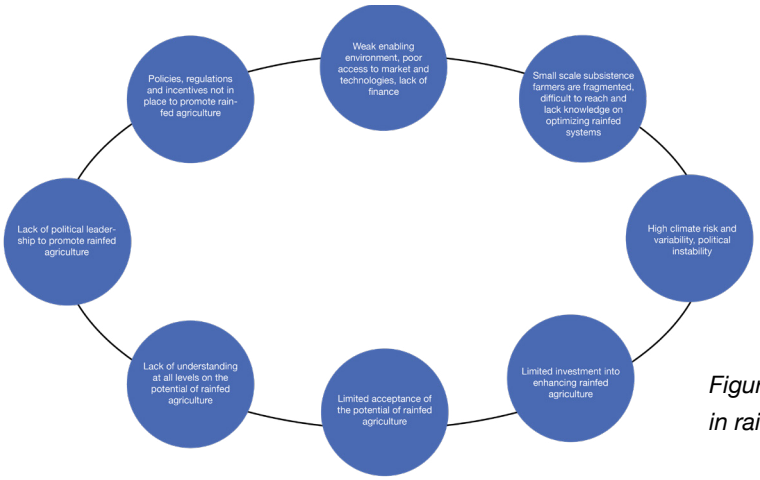


Figure 1: Multiple barriers impeding investment in rainfed agriculture

Box 1. Significance of trees in supporting rainfed agriculture

Trees act as 'generators' of rainfall through evapotranspiration and as a result they contribute to rain locally and in distant locations. In addition, they act as prime regulators within the water, energy and carbon cycles (Ellison et al. 2017). Furthermore, the impact of climate change and climate variability on intrinsic water use efficiency of trees and forests is becoming evident (Fernández-de-Uña et al. 2016) This impact may have a negative consequence on local and regional water cycles. Areas for further research, clarification and action include the importance of well-managed tree cover in farming landscapes, increased water productivity, regulated water flow and consequent catchment hydrology. As a priority, we recommend that a platform be created to enable key stakeholders to holistically address the issues of optimizing water use in rainfed agriculture.

Policy recommendations

Need for investment

Rainfed agriculture is primarily dependent on environmental conditions and is highly susceptible to variability in the frequency and distribution of rainfall, as well as stressors such as flooding and droughts. Land topography plays an important role in rainfed agriculture and is therefore a key factor in identifying the appropriate investments required to ensure that rainfall events do not negatively affect already low yields and to minimize the effects of climate change through adapting, mitigating or improving community resilience. Investments are required to manage forest and water resources, land restoration, agroforestry, water storage and water-use efficiency structures.

Capacity building in forest resources and water-use efficiency

A critical prerequisite for optimizing water use in rainfed systems is the development of human capacities to plan, develop and manage forest and water resources and the related infrastructure and technologies for optimal rainfed agricultural production. The technologies can be categorized at farm and catchment level and locations for storage, diversion and management of local runoff water resources.

Integrated infrastructure for green water management

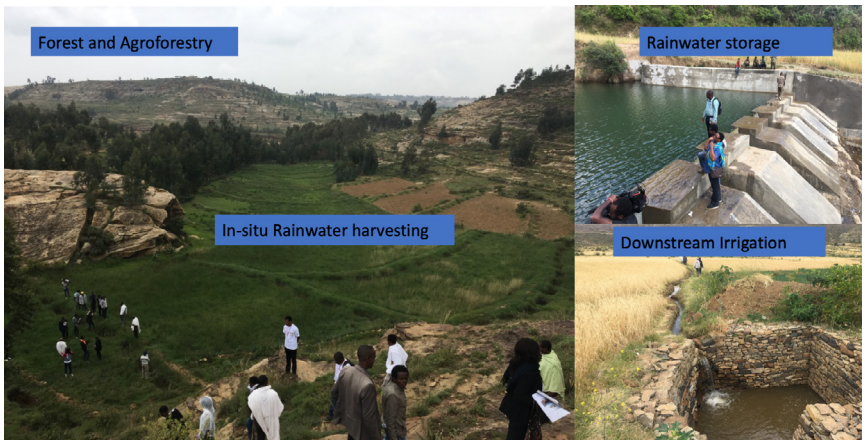
The highest potential for improved food production and poverty reduction lies with an integrated approach of enhanced rainfed farming that exploits tree-based agricultural systems and is enabled through proficient green water management. In addition, the role of trees in enhancing green water in any system is a key area that requires further research. In drought-prone areas of Africa, Asia and Latin America, farmers have already developed a wide range of rainwater-harvesting techniques, some of which involve trees to buffer water scarcity.

Economic incentives for management of landscape for hydrological functions

We recommend that incentives be provided to landowners to enable the adoption of sustainable land management practices that support hydrological functions in rainfed agricultural systems. Governments also need to develop strategies that enable the implementation of incentive systems to ensure landscapes are protected in order to support rainfed agriculture. Governments could also set aside funds to support micro and macro incentive systems such as payments for environmental services.

Rainfed agriculture policy

We recommend that governments prepare rainfed farming policies to guide operations and to ensure all production activities are carried out sustainably. These policies should also ensure that funds are allocated to support programmes that promote and improve rainfed agriculture.



Integrated water infrastructure for enhanced rainfed production (Tigray, Ethiopia)

Box 2. Optimizing rainwater use in rainfed agriculture

To effectively address food insecurity and poverty in developing countries, a new emphasis on water management in rainfed agriculture is required. Food production can be sustained with current water if water use in rainfed systems can be optimized. Key areas of intervention include the development of technologies and management practices that optimize water use, redirecting water policies and attract new investments towards optimizing water use in rainfed agriculture. Such interventions include rainwater harvesting and management technologies for micro and macro catchment and in situ rainwater-harvesting techniques which hold significant potential for improving rainwater-use efficiency and sustaining rainfed agriculture. However, optimizing rainwater use in rainfed agriculture is complex and requires a multifaceted approach that involves multiple stakeholders across sub-Saharan Africa, East and south Asia, and Latin America.

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Cover photo: Trees integrated on smallholder tea farms in Ndakaini, Kenya
Photo: Caroline Njoki/ICRAF