Potential for Cross-Regional Interaction in Research for Improved Water Management in Semi-Arid and Semi-Humid Rainfed Cropping Systems in Asia and Africa

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Abstract

Rainfall variability is a common problem in areas of Asia and Africa with alternating wet and dry seasons in semi-humid (900-1400 mm annual rainfall) and semi-arid (400-900 mm) environments.. Effects of rainfall variability are compared in examples from Thailand in Southeast Asia and Mali in West Africa. In a village in Khon Kaen Province, Northeast Thailand (1,092 mm annual rainfall), sample farmers reported 36% of landholdings in paddy. Over 35 plot-season units, yield was less than normal in 52% of the cases, and lack of water was the primary cause. Where water from small-scale ponds was available throughout dry periods, yields normal or better were obtained in 4 of 5 years, but where pond water was not available, crop failure occurred in 3 of 5 years. In Southeastern Mali, rainfed rice is grown in low areas called *bas-fonds*. In a semi-arid area (893 mm annual rainfall), good rice yields were obtained in *bas-fonds* in only 2 of 5 years in one village, while only 10 of 40 ha of *bas-fonds* were planted in rice in 2000 in a second village. Small-scale ponds, as in Thailand, could be a potential option for *bas-fonds*. For upland rainfed crops, temporal and spatial assessment of rainfall patterns within small areas (village or district) is needed for strategic prediction of rainy season outcomes. Weather monitoring in 29 farmers' fields in two villages in 2001 showed average CVs / week of 31%-56%, and maximum variation in precipitation between fields was 8-fold over one week. As little as only 9% of rainfall may available to crop plants depending on soil type and toposequence. The risk to farm households of rainfall variability also depends on household economic and livelihood vulnerability. Participatory assessment in the two Malian villages indicated that factors reducing risk vulnearability were number of draft animals, total cattle herd size, retail commerce, exterior financial aid, and number of months of food stock deficit or surplus. These factors varied between villages and households within villages. For example, food deficit households were only 10% of total households in the semi-humid zone village but 51% in the semi-arid zone village. These examples indicate the potential for cross-fertilization in extending technologies tested in one region to another and in developing a global framework of knowledge for improved water management, crop production, and farm household livelihoods in the semi-arid

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and semi-humid tropics.

Introduction

Rainfall variability is a common problem in areas of Asia and Africa with alternating wet and dry seasons, but the nature of its impact varies on a continuum from semi-humid to semi-arid environments. There is some variation among agro-climatologists and farming systems researchers as to where to divide this continuum[5], but Ruthenberg[9] and Berthé *et al.*[2] have used 900 mm annual rainfall as a dividing line between semi-humid and semi-arid zones. In this short paper, following Berthé *et al.*[2], we consider the zone where annual rainfall is between 1400 mm to 900 mm as semi-humid, and the zone where annual rainfall is between 900 mm to 400 mm as semi-arid. There are differences in the constaints and opportunities for improvement of cropping systems between these two zones, but increasing the proportion of rainfall available to crops and developing methods for more efficient crop use of water are common needs for improving productivity and reducing farm household economic and livelihood vulnerability in both zones. In this paper, as a concrete perspective on the framework presented by Ito *et al.*[6] to start this session, we contrast a Southeast Asian example from Thailand with a West African example from Mali. Our objective is to provide comparisons to show how research results in one region may be relevant in the other, with the long-term goal of developing a global framework of knowledge of biophysical and socio-economic conditions and strategies for the application of different technologies across the semi-arid and semi-humid tropics.

Rainfed rice in Northeast Thailand

In semi-humid environments, water can be more easily collected and held in low areas for rainfed paddy rice production. In Khon Kaen City, Khon Kaen Province, Northeast Thailand, mean annual rainfall from 1985 to 1995 was 1,092 mm[1]. In a survey of two transects in one watershed in one village in this province, farmers on the transects reported total landholdings of 36% paddy and 64% rainfed upland fields[4].

Rainfall variability can result in periods of inadequate water for rice growth and lead to reduced yields or even crop failure. On the transect in Northeast Thailand not affected by sand deposition due to erosion, over a total of 35 plot-season units, yield was less than normal in 52% of the cases, and lack of water accounted for 88% of the reasons given for the reduced yield. Small-scale ponds can provide insurance irrigation in such dry periods. On the same transect, where supplemental water was available during approximately half of the dry spell periods, farmers achieved at least half their normal yield in 3 of 5 years, and normal or greater than normal yields in 2 of 5 years. On a fourth plot, where pond water was available throughout the dry periods, yields normal or better were obtained in 4 of 5 years. Conversely, in the plot without supplemental water on the same transect, crop failure occurred in 3 of 5 years[4]. Small-scale ponds can also serve as a source of small-scale irrigation for dry-season production of horticultural crops that can reduce farm household vulnerability. Determining the optimum number of ponds in relation to soils in a given watershed, improving pond water-retaining capacity, and developing small-scale irrigation methods can increase water availability to crops.

Rainfed rice in Southeastern Mali

In Southeastern Mali, rice is grown in low areas called bas-fonds that become flooded in the rainy season. According to the Compagnie Malienne du Développement de Textiles (CMDT), in 1996 there were approximately 43,000 ha in total of *bas-fonds* in Southeastern Mali. Information and technical support for improved management of *bas-fonds* involves only 1,588 ha of this total (personal communication, February 2001, CMDT Office, Sikasso, Mali). Techniques introduced include small dams, water management, and variety, fertilization, and seeding date recommendations. The opportunities for improved management of these areas are large.

The economic and livelihood impact of improving water availability and use depends on the degree of farm household dependence on rainfed paddy rice production relative to other sources of food and income. The same sources of supplemental income that could be allocated to investment in small-scale ponds and water management may be needed in the off-season for the purchase of food to supplement inadequate food production. Other sources of income often depend on work in the non-agricultural season. In this way, agricultural production and consumption activities are linked in the farm household economy. To determine sources of revenue for investment in improvements, identify current farm household choices in use of supplemental income, and estimate the potential economic and livelihood impact of improvements in small-scale ponds and irrigation, an understanding of both the total farm household production-consumption economy over the entire year and farm household rationales in prioritization of income use are needed. Baseline data collection is essential for developing a full understanding of this farm household economy. Participatory methods both reveal household members' rationales and enable them to define priorities and thereby have substantive input into the direction of research whose impact depends on their decision-making.

In semi-arid areas, total rainfall becomes inadequate for concentration of water in large areas of lowlands for paddy rice. Mean annual rainfall from 1954 to 1994 at the N'Tarla Experiment Station in the Koutiala District of eastern Mali was 893 mm, just below the annual rainfall dividing semi-arid and semi-humid zones. One village approximately 20 km east from this station has 20 ha of *bas-fonds*, but during the past 5 years, good rice yields were obtained in only 2 years. A transect survey revealed that one branch of the *bas-fonds* had been abandoned in recent years (PRA appraisal, May 2001). In another village 60 km north, only 10 of 40 ha of *bas-fonds* were planted in rice in 2000, and this was with the aid of a dam built to increase water holding at one end (PRA appraisal, February 2001). The *bas-fonds* are long, with branches from which water flow moves into the central *bas-fonds*. The feasibility of constructing small-scale ponds at the entrance points of the branches, and thereby extending rice cultivation further upstream, is undetermined. In currrent systems, the impact of rainfall variability on upland crops is more important, but the potential of small-scale ponds for extending the area of lowlands available for rice in the semi-arid zone could also be explored.

Upland crops in Southeastern Mali

Rainfall variability includes both the total quantity of rainfall over the cropping season as well as quantities during different periods of crop growth with greater or lesser tolerance of drought. Total rainfall and its temporal distribution together determine rainy season outcomes for productivity of upland crops. Assessment of rainfall patterns and relationships with wind and other climatic variables is needed for strategic prediction of rainy season outcomes. Since spatial variation is high, assessment needs to be done on a small scale, to determine probabilities of rainy season outcomes not only in relation to time, but also for a given field in a given area. Farmers in three different villages independently indicated that current meteorological forecasts made in Mali to aid production decisions often do not reflect their specific conditions, and expressed a need for more fine-tuned forecasting at the district or sub-district level (PRA appraisals, February 2001). Using small-scale, inexpensive automated equipment that was not available even five years ago, we have for the first time established a network of weather monitoring stations in 29 farmers' fields in two villages, one in the semi-humid zone and the other in the semi-arid zone of Mali. Results from 27 of the fields in 2001 showed average CVs / week of 31% (semi-arid zone, wet year, total precipitation 542 mm over 8 weeks) and 56% (semi-humid zone, dry year, 504 mm over 9 weeks). Variation between the field with the smallest amount of precipitation and the field with the largest amount was as much as 8-fold over one week[10].

These outcomes are further affected by interactions with soil type and location on upland toposequences. The amount of water available to crop plants can be as low as only 9% of water reaching the field from rainfall[7]. Agronomic research is needed to develop guidelines for crop production choices most appropriate for different rainfall outcomes on different types of upland fields. In Niger, factors such as the ratio of the density of cowpea to millet, variety, and use or non-use and amount and timing of fertilizer have been varied depending on the timing of the start of the rainy season. With an earlier start and higher probability of greater rainfall, more investment in intensification of millet was justified, whereas with a later start and less expected rainfall, farmers were advised to reduce investment in millet and increase the proportion of cowpea in the association[8].

The risk to farm households of different rainfall outcomes depends on overall household economic and livelihood vulnerability. Participatory assessment indicated that key factors affecting the ability of households to manage risk in the two Malian villages were number of draft animals, total cattle herd size, retail commerce, exterior financial aid, and number of months of food stock deficit or surplus. In the village in the semi-humid zone, 56% of its 125 households had access to exteriour financial aid, while this was not present in the 135 households in the second village in the semi-arid zone. Households with a surplus of food stocks comprised 75% of the households in the semi-humid zone village, and food deficit households were only 10% of the total. In the semi-arid zone, food surplus households accounted for only 39% of the total, and food deficit households comprised 51%. Farmers attempt to compensate for this risk with larger land areas in the semi-arid village, but food stock vulnerability is nevertheless high[3]. Strategic rainfall prediction, improved water collection and storage, and improved agronomic practices coupled with decision-making information support, are needed to help make limited farmer time and capital go further to reduce risk.

Conclusions and Future Perspectives

The above examples illustrate the importance of integration of biophysical data on rainfall, soils, and water infiltration; agronomic data on cropping patterns, land use, and crop production techniques; socio-economic data on income sources and use; and farmer rationales for decicions made on agricultural production, non-agricultural income generation, and investment / consumption trade-offs. These examples also indicate the potential for cross-fertilization in extending technologies tested in one region to another. Technologies developed in the more constraining semi-arid zone can be extended to the semi-humid zone with greater confidence, while technologies developed in the less-constraining semi-humid zone may provide new options for testing in the semi-arid zone. Working across zones and regions can permit synergistic learning, and thereby shorten the time for reaching the goal of a global framework of knowledge of conditions and strategies for improved water management, crop production, and farm household livelihoods across the continuum of the semi-arid and semi-humid tropics.

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