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Rice-based Cropping Systems in Inland Valleys

Sub-Saharan Africa has approximately 85 million hectares of inland valleys with almost three-fourths of them in West and Central Africa. These valleys, considered to be one of the most productive areas for growing rice and dry season root, tuber, grain legumes, and vegetable crops are flat-bottom and shallow varying in size and shape. With respect to hydrologic characteristics, they are either streamflow (run-off and seepage, main sources of water) or river-flow (over-flow from river, main water source). Water conditions or balances and soil fertility are two major physical factors which determine productivity of rice-based cropping systems.

An opportunity for increasing the productivity of rice-based systems in inland valley areas in the short to medium-run lies in alleviating labor bottlenecks during the peak periods of the rainy season, intensifying the cropping activities during the labor slack period of the dry season, and identifying high yielding but short season rice and other crop varieties.

Rice—a major crop cultivated in inland valleys—is the only crop adapted to flooded conditions. After the harvest, most parts of inland valleys are under fallow during the dry season. A small portion is cultivated in the dry season for growing other crops which require less water, such as sweet potatoes, cassava, groundnuts, maize, and short season vegetables. In very wet areas, farmers grow a large proportion of these crops in big mounds and ridges to avoid excessive soil moisture which damages sensitive crops.

In most cases in the inland valleys, the same farmers cultivate the lowland and upland fields, with the former constituting less than one-third of the farm size. They follow two systems of cultivation, depending upon the use of land during the dry season. For example, in about 65% of inland valley fields in the Makeni, Sierra Leone area and about 40% of the fields in the Bida area, they practice an annual crop rotation of rice followed by cassava, or sweet potatoes, or vegetables; in the remaining fields, a rice-fallow system is practiced (Figure 12). Dry season crops are mixed cropped on many fields. They not only provide food and cash income during the hunger period when market prices are 50–75% higher than usual but become an important source of seed or planting material for the upland fields. Although their yield rates are modest, they are very attractive in terms of labor productivity: a return of N14 to N16 per man-day compared with a wage rate of N5. (N = Nigerian Naira.)

An annual cycle of mounding and flat tillage is practiced on about 80% of inland valley fields, with the rice planted on flat seedbeds and dry season crops on mounds. This tillage system recycles the organic matter and soil nutrients by incorporating the crop residues and weeds while making and spreading mounds. An important economic implication of growing dry season crops is that the land preparation labor input for rice (which occurs at the peak period) is reduced by 30–50%.

Farmers' choice of rice varieties is related to method of planting and planting dates and somewhat to field locations, but not to the method of land preparation. In general, there are four or five varieties used for direct seeding and 10 or more for transplanting. Direct seeding has been a traditional practice of farmers in the Bida area and about two-thirds of the inland valleys are presently seeding this way. Transplanting is the most common practice in the Makeni area because of heavy rains and fields become quickly flooded. The choice of a rice planting method is determined by the field moisture condition and how soon farmers have finished planting and weeding upland crops. Although direct seeding takes less labor than transplanting, the latter has the advantage of delayed sowing and less risk. A higher labor input for transplanting on fringes than in valley bottoms makes the latter field location the obvious choice.

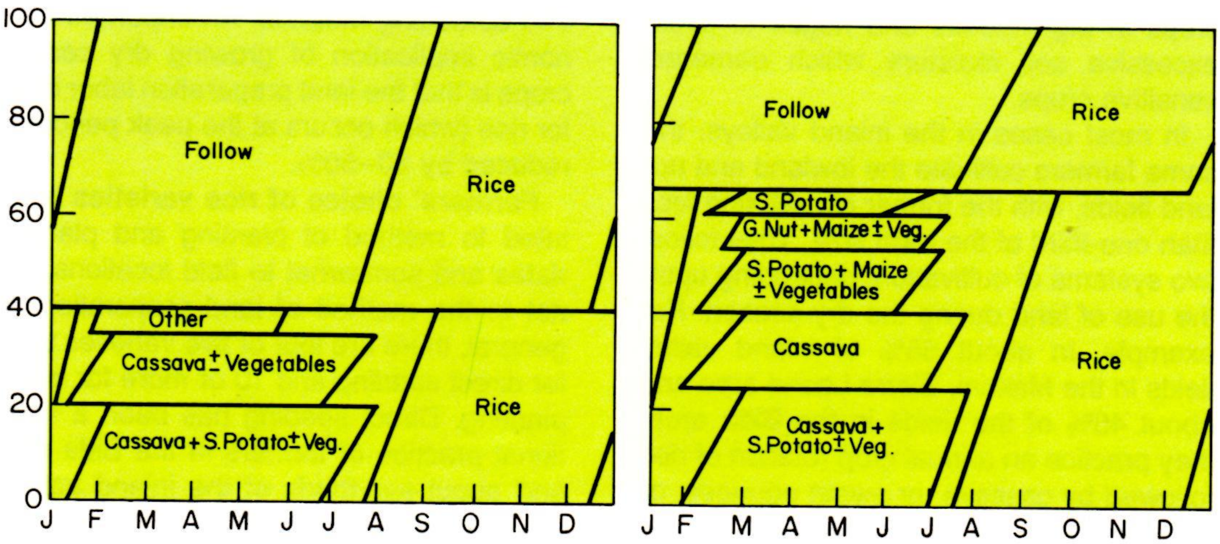
Rice and dry season crop production in inland valleys is constrained by physical, biological and socio-economic factors. One of the principal physical constraints is the lack of an organized structure and arrangement of farmers' rice fields. The plots are small, irregular in shape, and have either weak bunds or none at all. Lack of adoption of improved paddy systems involving levelling and bunding of rice fields in West Africa may be the reason for the slow progress and adoption of improved rice technology. The paddy field system in inland valleys of West Africa is still rudimentary. A properly maintained system can conserve water and increase sedimentation of clay, thereby improving soil fertility and crop production on a sustainable basis.

Low crop yields in inland valleys are also due to biological constraints such as weeds, insect pests and diseases, and to soil nutrient toxicities and deficiencies. Although high yielding rice varieties exist and are being grown by some farmers, yield potentials are not fully achieved because of the adverse effects of these factors.

Among the various socio-economic constraints impeding the productivity of rice-based systems are the shortage of farm labor, absence of efficient farm tools and farm machinery, lack of fertilizer and credit or cash capital to purchase farm inputs.

Aware of the constraints, IITA scientists are continuing research for the improvement of rice-based cropping systems. In a system approach, the improvement of inland valleys for increased and sustainable food crop production can be achieved through

Figure 12. Cropping patterns and crop calendars for inland valley fields in the Bida, Nigeria area (left) and the Makeni, Sierra Leone area (right).



Above, immediately after rice is harvested in December/January farmers in the Bida, Nigeria area make big mounds and/or ridges in inland valley fields and plant dry season crops. In April/May they move to upland fields to plant crops. In July/August they come back to inland valley fields to harvest dry season crops and plant rice; right, dry season crops of sweet potatoes, groundnuts, cassava, and maize grown on mounds in an inland valley in Sierra Leone.

improvement in soil and water management, crop varieties, and crop management. The former can be achieved with an improved paddy field system. During the 1986–87 cropping year, basic studies on water balance were initiated through detailed monitoring of ground and surface water of representative inland valleys in Bida where annual rainfall is about 1100 mm. Field research on simple paddy improvement was also established. The results: most of the bottom land can grow a crop of rice, whereas fields along the valley fringe have high drought probability and make rice cultivation risky; in paddies with continuous flooding for longer than 130 days, traditional, long-duration rice varieties can be grown; in those paddies with continuous flooding for 100–130 days, early-maturing improved varieties are suitable; and in those with less than 100 days of continuous flooding, rice cultivation becomes risky.

Nineteen farmer-managed trials showed the effect of field water duration on rice yields (Table 6). In fields where water remained more than half of the growth duration, rice yields were higher than in those fields with less than that. A yield difference of almost 100% can be obtained when fields are kept saturated or flooded for at least 50% or more of the growing period. Most paddies in the valley bottom maintained enough water to grow a rice crop, but those in the valley fringe did not retain sufficient water. Therefore, the rice crop suffered moisture stress, resulting in reduced yield.

Farmers' rice paddies are inefficient in retaining water and fertilizer nutrients. Preliminary on-farm trials showed water consumption considerably higher there (three to four times) than in improved paddies. Also, the response of rice varieties to fertilizer treatment was better in the improved paddies where yields were increased by 1.8–2.4 tons/ha (Table 7). These results suggest the need for research on low-cost

Table 6. Yield response of rice varieties to paddy water duration in small inland valleys; farmer-managed trials, Bida, Nigeria (1987).

Variety	Fertilizer level*	Paddy water duration** Less than 50%	More than 50%
		Yield (t/ha)	
Local	Farmer's	1.20	1.86
	Recommended	1.48	2.65
ITA 212	Farmer's	1.04	2.12
	Recommended	1.48	3.27
ITA 306	Farmer's	1.82	2.55
	Recommended	2.32	3.58
ITA 249	Farmer's	0.25	1.44
	Recommended	0.28	1.84
FARO 29	Farmer's	1.04	2.43
	Recommended	1.39	3.32
Fertilizer mean	Farmer's	1.07	2.08
	Recommended	1.45	2.93
Water duration mean		1.26	2.93

LSD (1%) for comparing means between water duration = 0.67 t
CV = 12.1%

**Farmer's level = 15-15-15 NPK (kg/ha).*
Recommended level = 90-60-30 NPK (kg/ha).
***Fields under water saturation or over saturation (flooded) for a period of less or more than half of the growing period.*

improvement of the paddy system in the inland valleys of West Africa and the development of more appropriate technologies for the natural conditions of the farmers' rice paddies.

Use of improved high yielding crop varieties suitable for inland valleys is by far the simplest technology that can be introduced to small-scale farmers. During the 1986–87 cropping season, on-farm trials with improved rice, sweet potato, and cowpea varieties were established in the inland valleys of Gara and Anfani, near Bida. Using grain yield and maturity as bases for farmers' assessment of the varieties, ITA 306 and ITA 212 were the most preferred. Their earliness and high yield attracted the attention of farmers (Table 8).

Sweet potatoes—one of the most common dry season crops grown by farmers in inland valleys following rice—are planted mostly on big mounds or ridges located in the lowest portion of the valley bottom where soil moisture remains throughout the dry season. Both the improved and local variety yielded about the same under the mounds but under the ridges TIS 2498 was superior. Overall, the improved variety outyielded the local sweet potato by about 1 ton/ha but it took longer to mature and harvesting was done about six months after planting. Earlier-maturing, drought-tolerant, and high-yielding varieties are needed in the drier areas and in wet areas varieties tolerant to waterlogging and tuber rotting. In each case, they should fit the traditional cropping system of local farmers.

Early-maturing cowpeas can benefit from residual soil moisture available immediately after rice is harvested. The results of variety trials conducted in farmers' fields in 1987 are shown in Table 9. Cowpeas are a potential short-maturing, dry-season crop in inland valleys but production depends mainly on the input delivery system and farmers' ability to purchase insecticides because

Variety	Fertilizer level*	Farmer's paddy; farmer-managed	Improved paddy: Farmer-managed	Improved paddy: Researcher-managed
Local	Farmer's	1.7	3.6	4.7
	Recommended	2.4	3.3	6.2
ITA 212	Farmer's	2.2	3.2	4.4
	Recommended	3.5	4.6	4.7
ITA 306	Farmer's	1.8	4.9	4.6
	Recommended	3.0	6.8	6.1
FARO 29	Farmer's	1.7	3.1	4.6
	Recommended	2.2	6.1	5.3
Mean	Farmer's	1.9	3.7	4.6
	Recommended	2.8	5.2	5.6

*Farmer's level = 15-15-15 NPK (kg/ha).
Recommended level = 90-60-60 NPK (kg/ha).*

Table 7. Rice yields (t/ha) from farmer's paddy and improved paddy; on-farm trial, Bida, Nigeria.

Table 8. Yields of five rice varieties in on-farm trials and percentage of farmers with better yields from the improved variety than from the local variety; data from 19 sites in Bida area, Nigeria (1987).

Rice variety	Yield (kg/ha)	Percentage of farmers on whose farm the improved variety outyielded the local
		At low fertilizer*
Local	1723	—
ITA 306	2396	90
ITA 212	1896	59
ITA 249	1168	21
FARO 29	2138	
Mean	1864	
SE (±)	465	
		At high fertilizer**
Local	2404	—
ITA 306	3314	74
ITA 212	2958	74
ITA 249	1511	26
FARO 29	2915	63
Mean	2620	
SE (±)	700	

*15-15-15 NPK (kg/ha).
**90-60-30 NPK (kg/ha).

they are required to obtain good yields.

High crop yields in rice-based cropping systems depend not only on better crop varieties but also on improved crop management practices: fertilizer application, water and weed control, seedling quality, mulching, and insect pest control. Farmer-managed trials and monitoring of their management practices in Bida showed the relative contribution to yield improvement in rice by some important crop management practices (Figure 13). Weed control resulted in the largest yield increase (150%) with improved water control and paddy improvement next (100%).

The high priority farmers in inland valley areas give to upland crops makes it impossible to intensify rice production during the rainy season by growing two crops. Therefore, the improvement of a crop rotation system involving rice and dry season crops for the lowlands is more consistent with the farmers' resource base. An improved system requires short to mid-season rice varieties suitable for variable moisture conditions and extra-early varieties of cassava,

Table 9. Grain yield of dry season cowpea varieties grown under residual soil moisture in inland valleys after the rice crop in Bida, Nigeria (1987).

Cowpea variety	Maturity (days)	Yield* (kg/ha)
IT82D-889	62	970
IT84E-124	64	1207
IT84E-1-108	56	925
IT84E-60	62	1174
Local check	75	899
SE		±76.1
CV (%)		14.5

**Two to three insecticide applications.*

sweet potatoes, cowpeas, maize, and soybeans for planting on residual soil moisture. Turn-around of rice fields to dry season crops is critical which requires the replacement of local photosensitive rice varieties by determinate rice types and efficient methods of cultivation and management of residual soil mositure.

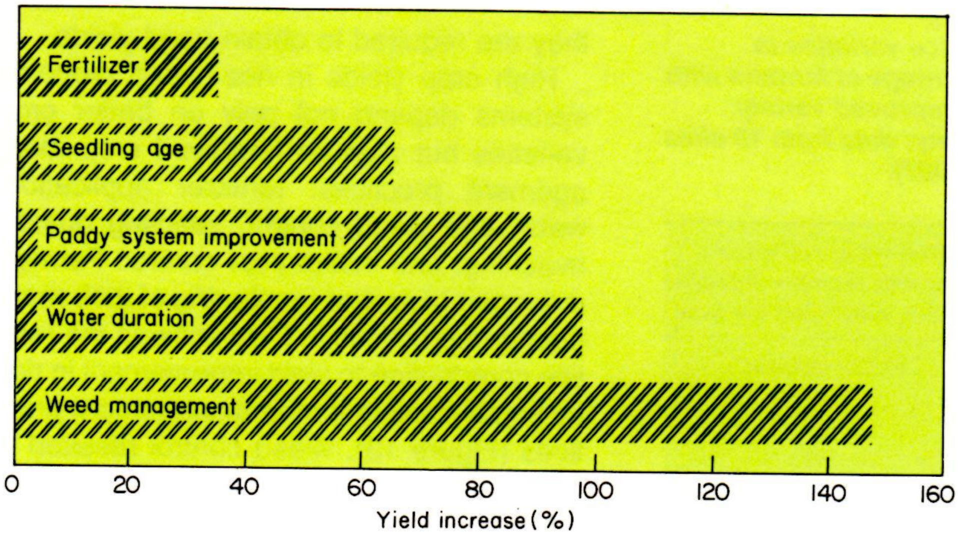


Figure 13. Relative contribution to yield improvement in rice by some agronomic factors in inland valleys.

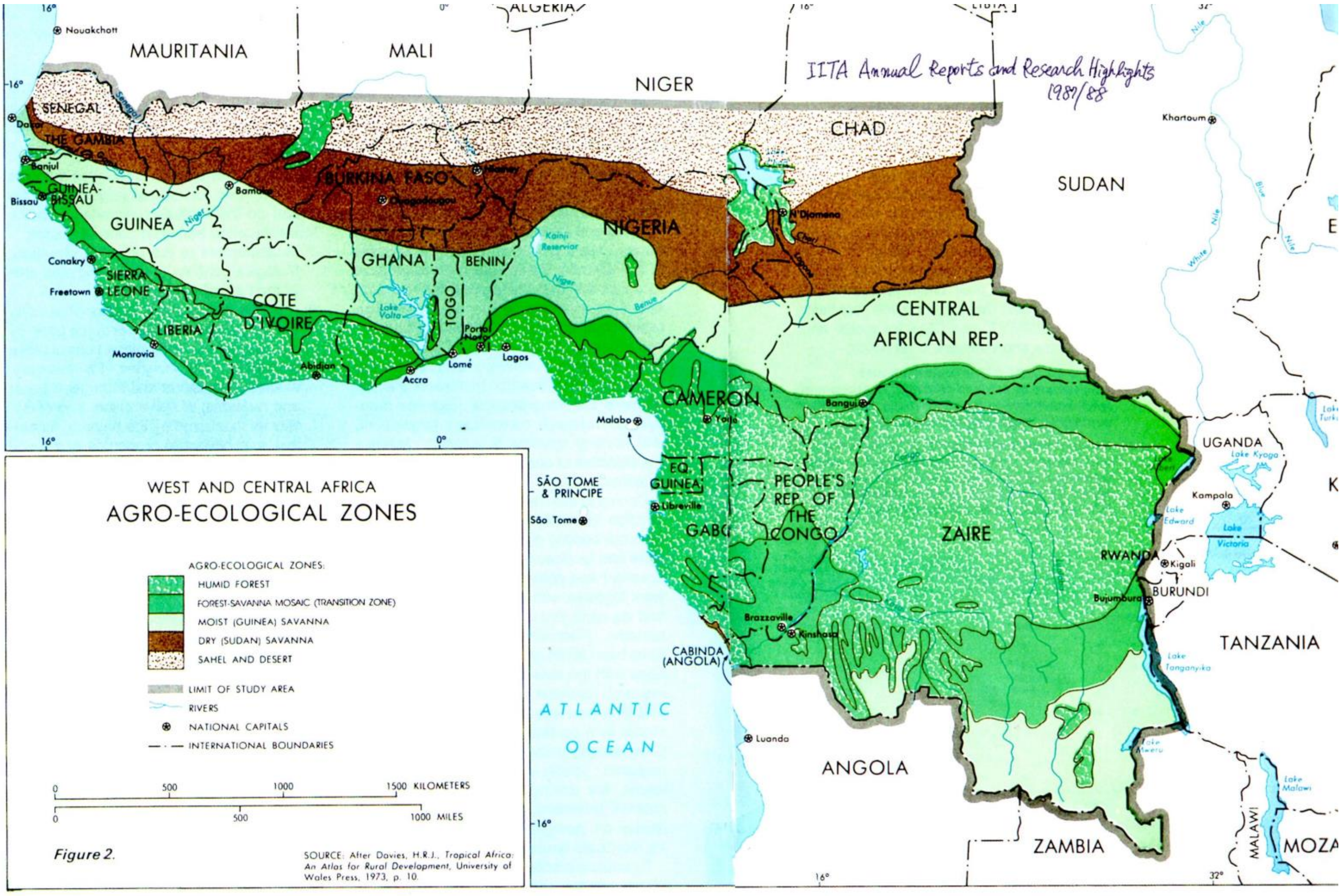


Figure 2.

SOURCE: After Davies, H.R.J., *Tropical Africa: An Atlas for Rural Development*, University of Wales Press, 1973, p. 10.