Introducing vegetables upstream of irrigation areas may increase farm income and lead to equitable water distribution

In sub-Saharan Africa, the development of irrigated rice techniques have been promoted in response to increasing demand for rice, resulting in high yields. However, in recent years, the decline in the amount of irrigation water due to unstable river flows and deteriorating irrigation facilities, as well as uneven irrigation water distribution between upstream and downstream, have emerged as factors constraining further rice production and farmer economy. On the other hand, demand for horticultural crops is growing in local markets, creating a condition for farmers to increase their incomes through agricultural diversification.

We examined the effects of changing the cropping system on water-saving, productivity, and profitability, based on the idea that converting double rice cropping to rice-upland crop system will lead to more efficient water use without sacrificing farm income. The field experiments and farmer surveys were conducted in the Lower Moshi Irrigation Scheme in northern Tanzania.

The main results are summarized as follows. First, conversion of rice to maize reduces irrigation water by 77%. Vegetables, which require the least number of irrigation days, are expected to save even more water (Table 1). Second, land productivity measured by value added (gross output minus non-labor expenditures) is higher in the order of vegetables > lowland rice > lowland maize > upland maize, and labor productivity is higher in the order of lowland maize > upland maize > vegetables > lowland rice. In case of strict land constraints, vegetables and rice are economically rational, while for farmers facing labor shortage, maize is advantageous over rice and vegetables (Fig. 1). Third, income not counting family labor as a cost is higher in the order of vegetables > lowland rice > lowland maize > upland maize. When taking family labor into account as a cost, profit is higher in the order of lowland rice > vegetables > lowland maize > upland maize. If vegetables are introduced after rice in lowland, the income can be expected to exceed that of double rice system. However, for households with high opportunity cost for family labor, the economic incentive to introduce vegetables is weak (Table 2).

The above findings suggest that in irrigation schemes where rice cultivation has been increasingly constrained due to water shortage, introducing vegetables upstream and allocating surplus irrigation water downstream for rice may lead to efficient use of irrigation and farmer income increase for the irrigation scheme as a whole. It should be noted that first, to introduce commercial vegetables, due consideration of water drainage techniques, marketing arrangements, and risk management is crucial; and second, reducing staple food crops (rice and maize) and specializing in commercial vegetables, which have large profit fluctuations and no storage potential, may reduce food security at the household level.

(*S. Yokoyama*)

Table 1. Estimation of irrigation water requirements by crop (per crop season, 2018-19)

	Lowland rice[1]	Lowland maize[1]	Vegetables[2]
Irrigation period (day)	110	25	13.2
Daily irrigation amount (mm/day)	13	13	NA
Total irrigation amount (mm)	1,430	325	NA

1) Canal irrigation. Measured in cultivation trial. 2) Interviews (n=9) in the irrigation scheme, vegetables are grown by private pump irrigation due to lack of canal water supply. The pumps used by the farmers have a capacity of less than 15 mm/day. African nightshade, amaranth, onion, bell pepper, Chinese cabbage, and squash are produced for market.

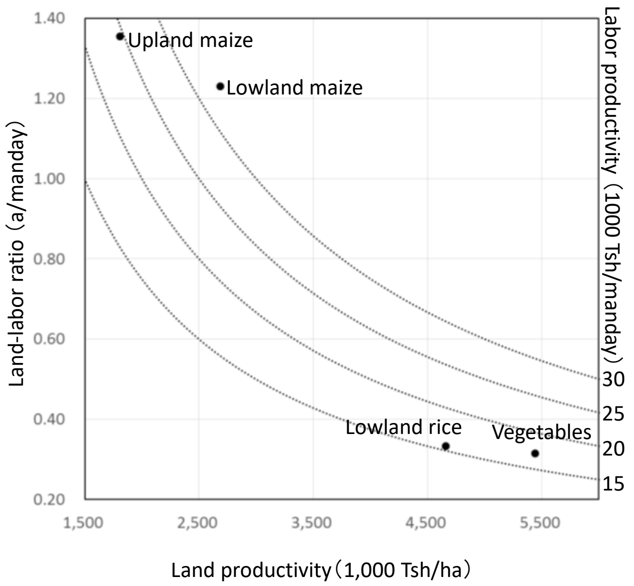

Fig. 1. Land and labor productivity by crop

1) Horizontal axis is land productivity (value added/area)
2) Vertical axis is land labor ratio (area/labor input) Higher values indicate land-use crops, lower values indicate labor-intensive crops
3) The dotted line is the iso-labor productivity curve Labor productivity (value added/labor input) = land productivity x land-labor ratio
4) Tsh is Tanzanian shilling
1 Tsh = 0.047 yen (November 18, 2019)

Table 2. Production cost and management indicators by crop (2018-19)

	Rice	Maize		Vegetables
Condition of irrigation （Sample number）	Irrigated lowland (78)	Irrigated lowland after rice (10)	Irrigated upland (5)	Well irrigation (9)[1]
Farm size (ha)	0.83	0.94	2.3	1.2
Surveyed plot (ha)	0.29	0.54	1.04	0.23
Yield (t/ha)	6.62	5.71	3.74	NA
Gross product: A (1000 Tsh/ha)	5,919	3,847	2,411	6,243
Cost (1000 Tsh/ha)				
Current input,	1,263	1,165	605	802[2]
Hired labor	973	395	403	1,165
Family labor: B[3]	480	541	378	2,088
Total: C	2,717	2,101	1,386	4,056
Income：A – C + B (1,000 Tsh/ha)	3,682	2,287	1,405	4,276
Profit：A – C (1,000 Tsh/ha)[4]	3,202 (0.44)	1,746 (0.95)	1,027 (1.19)	2,188 (2.28)

1) Private pump irrigation using shallow well. 2) Irrigation cost is imputed based on the rate for lowland maize. 3) Imputed based on market wage rate. 4) The number in parentheses is the coefficient of variation, representing the variability of profit as a proxy indicator of risk.

Reference: Yokoyama (2022) *Japanese Journal of Farm Management* 59(4): 69–74.