Rice Green Revolution in Asia and Africa

In Honor of Dr. Cristina C. David

Kei Otsuka

Distinguished Honorary Professor, Kobe University

November 6, 2024

Tina initiated the project called, *Differential Impact Study* (DIS), in 1985

- High-yielding rice varieties were adopted mainly in irrigated and favorable rainfed areas in Asia.
- Many donors of IRRI criticized the Green Revolution by arguing that the Green Revolution neglected poor areas prone to drought and flood.
- Thus, they put pressure on IRRI to develop high-yielding rice varieties for such unfavorable areas.
- IRRI, however, had never succeeded in developing such varieties, even though serious efforts had been made, implying that huge amount of research fund was wasted. (Drought-tolerant and submergence-resistant varieties were more recently developed).
- DIS project asked if and to what extent poor people in unfavorable areas, i.e., landless and marginal farmers, migrate to favorable areas, where labor demand increased, to receive benefits of the rice Green Revolution.

KO participated in the DIS project in 1986. But I was a young useless inexperienced researcher.

- Tina guided me immensely and I really appreciate her guidance.
- Other participants in the DIS project included Tahlim Sudaryanto and Faisal Kasryno (Indonesia), Tumari Jatileksono (Indonesia), Somporn Isvilanonda and Sarun Wattanutchariya (Thailand), Mahabub Hossain et al. (Bangladesh), Hari Upadhyaya and Ganesh Thapa (Nepal), C. Ramasamy et al. (India), and Justin Lin (China).
- Unintentionally, we tested *the external validity*, which is currently hot issue.
- Prof. Yujiro Hayami was an advisor for the DIS project. He strongly opposed to the plan of the DIS project to cover 7 countries, as *it was too ambitious*. We ignored his advice, however.
- In 1994, Tina and I successfully edited a classical book on the Asian Green Revolution, entitled *Modern Rice Technology and Income Distribution in Asia* in 1994.

Tina David and Kei Otsuka eds.
Cited 531 times according to the Google Scholar Citations as of October 25 2024

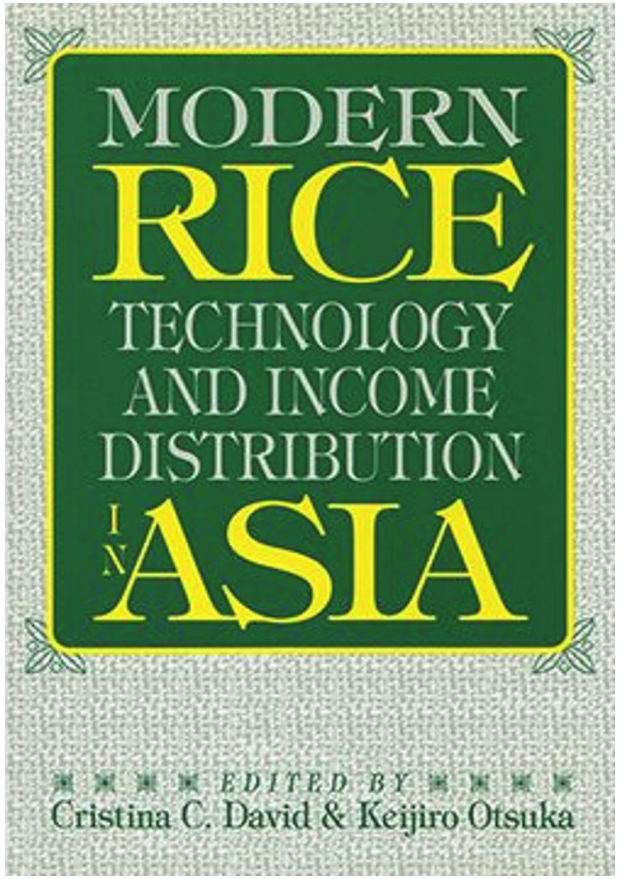


Table 1. MV Adoption (%), Yield per ha (t/ha), and Transplanting Wage by Favorable and Unfavorable Area in Selected Countries in the late 1980s

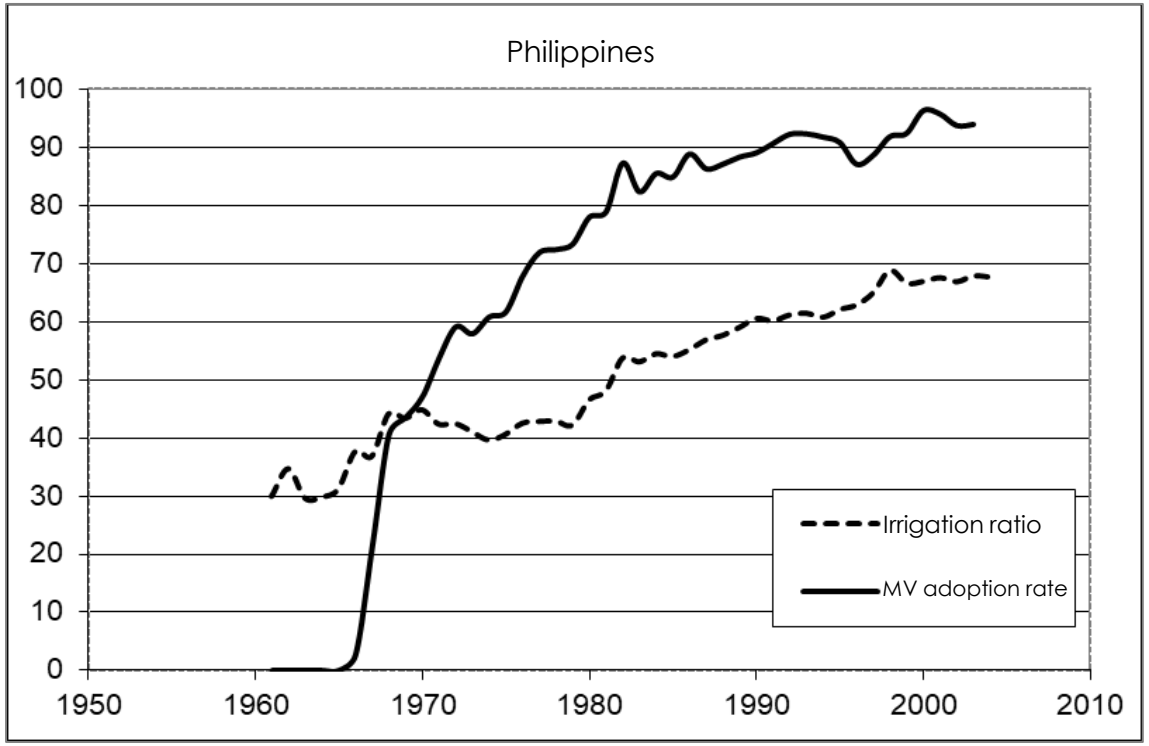
	Irrigated	Favorable rainfed	Drought-prone	Submergence-prone
Philippines				
MV adoption	97	99	33	50
Yield	3.6	3.3	2.1[a]	1.8[a]
Wage rate	22	25	29	
Indonesia				
MV adoption	98	81	-	0
Yield	5.8	4.4	-	1.7[a]
Wage rate	2,885	2,669	-	2,500
Thailand (Central plain)				
MV adoption	71	11	-	0.6
Yield	4.4	3.3	-	1.8[a]
Wage rate	56[b]	53[b]	-	55[b]
Bangladesh				
MV adoption	70	35	3.1	39
Yield	3.6	2.7	2.2	3.2
Wage rate	37	33	33	

a Traditional varieties.
b Harvesting wage.

Major findings

- As would be expected, MV adoption rates were significantly higher in more favorable areas.
- Accordingly, paddy yield per ha tends to be higher in favorable areas than unfavorable areas.
- *However,* wage rates tend to be equalized across production areas.
- This is because of the labor migration from unfavorable to favorable areas, which supported the main hypothesis of the DIS project.
- Thus, we contended that it is misleading to argue that the Green Revolution neglected unfavorable rice growing areas. Moreover, net consumers of rice benefitted from low rice price made possible by the Green Revolution.

Fig. 1. Changes in irrigation ratio and adoption rate of modern varieties (MV) in the Philippines and India (%)



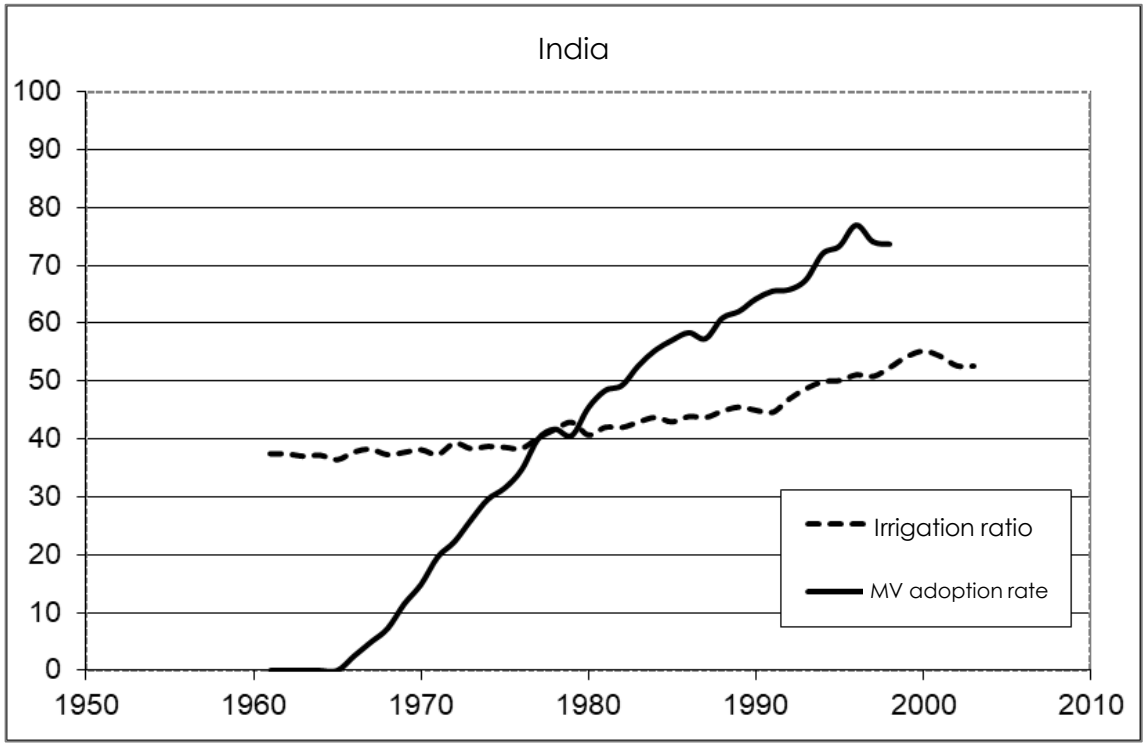
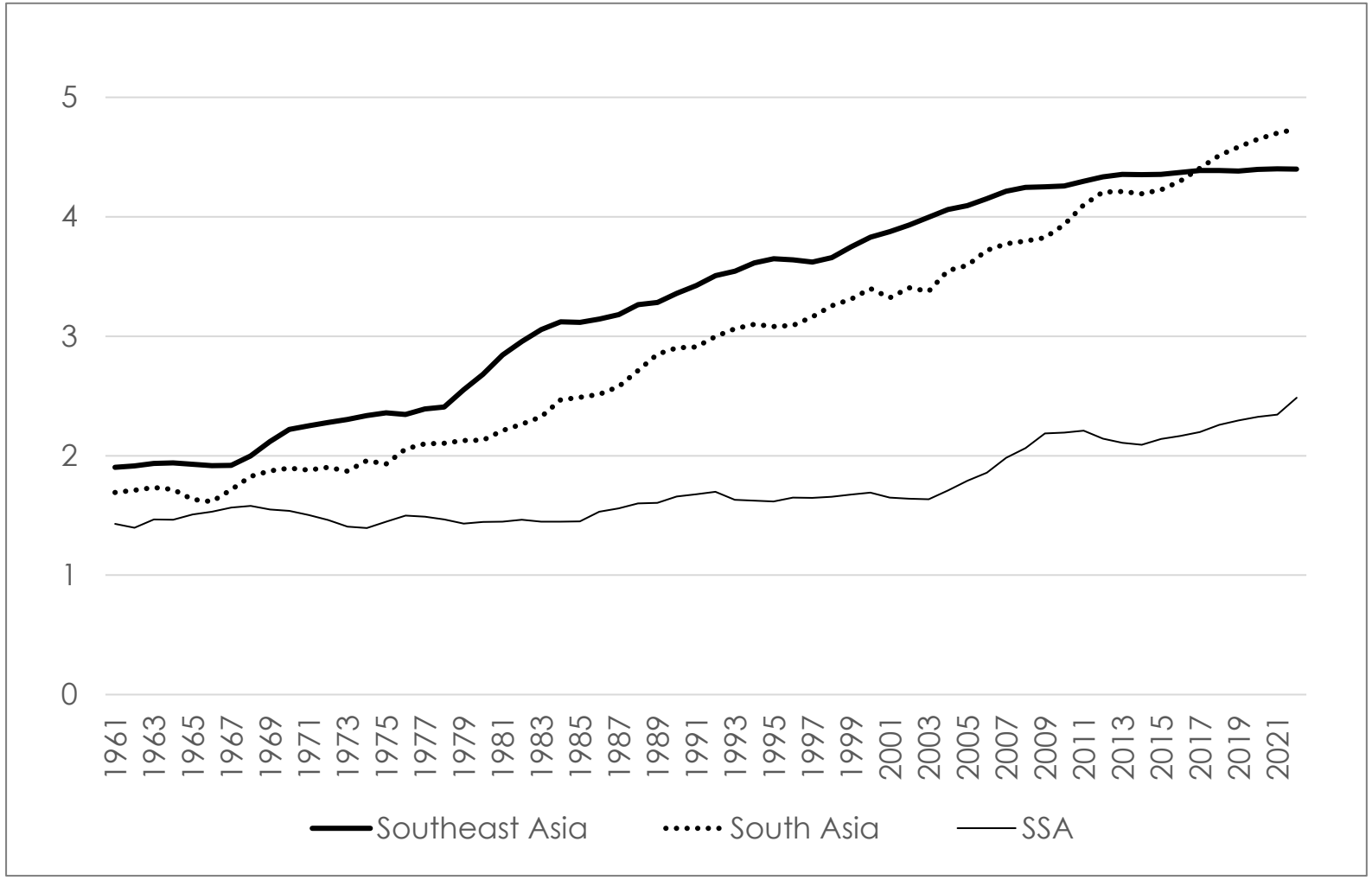


Fig. 2. Average paddy yield per ha in Southeast Asia; South Asia; and SSA; three-year moving averages (ton/ha)



Transferability of Improved Rice Technology

- Improved rice technologies were transferred from the Philippines to other countries in Southeast Asia, notably Indonesia and later Vietnam.
- Such technologies were successfully transferred to South Asia with time lag, as IRRI varieties were crossed with local varieties to enhance adaptability of improved varieties to local production environments.
- The Philippines ➔ Other Southeast Asia ➔ South Asia
- Why not transferred to SSA?

Is paddy area in Sub-Saharan Africa unfavorable for lowland rice production?

- Irrigation ratio is roughly 20% around 2005 in SSA. Thus, most areas are rainfed in SSA and so the production environment is not as favorable as in Asia
- There are no data on the adoption rate of modern varieties (MVs) in SSA.
- Since rice is not main staple food in most areas in SSA, areas unsuitable for rice production are planted to other crops, most importantly maize, cassava, sorghum, and millet.
- In my observation, as population increased, many farmers cut down trees in the forests and on the hills to expand upland fields; but now there is no more room for further area expansion in SSA. Then, they gradually realized that unused wetlands can be used for lowland rice cultivation, leading to rapid expansion of paddy fields.
- Such wet land is fertile, moist, and, hence, appropriate for lowland rice cultivation. Thus, I believe that such rainfed paddy land is more favorable for rice production than most rainfed areas located in flat areas in Asia.

Fig. 3. Changes in cultivated area per capita of rural population in tropical Asia and SSA (ha)

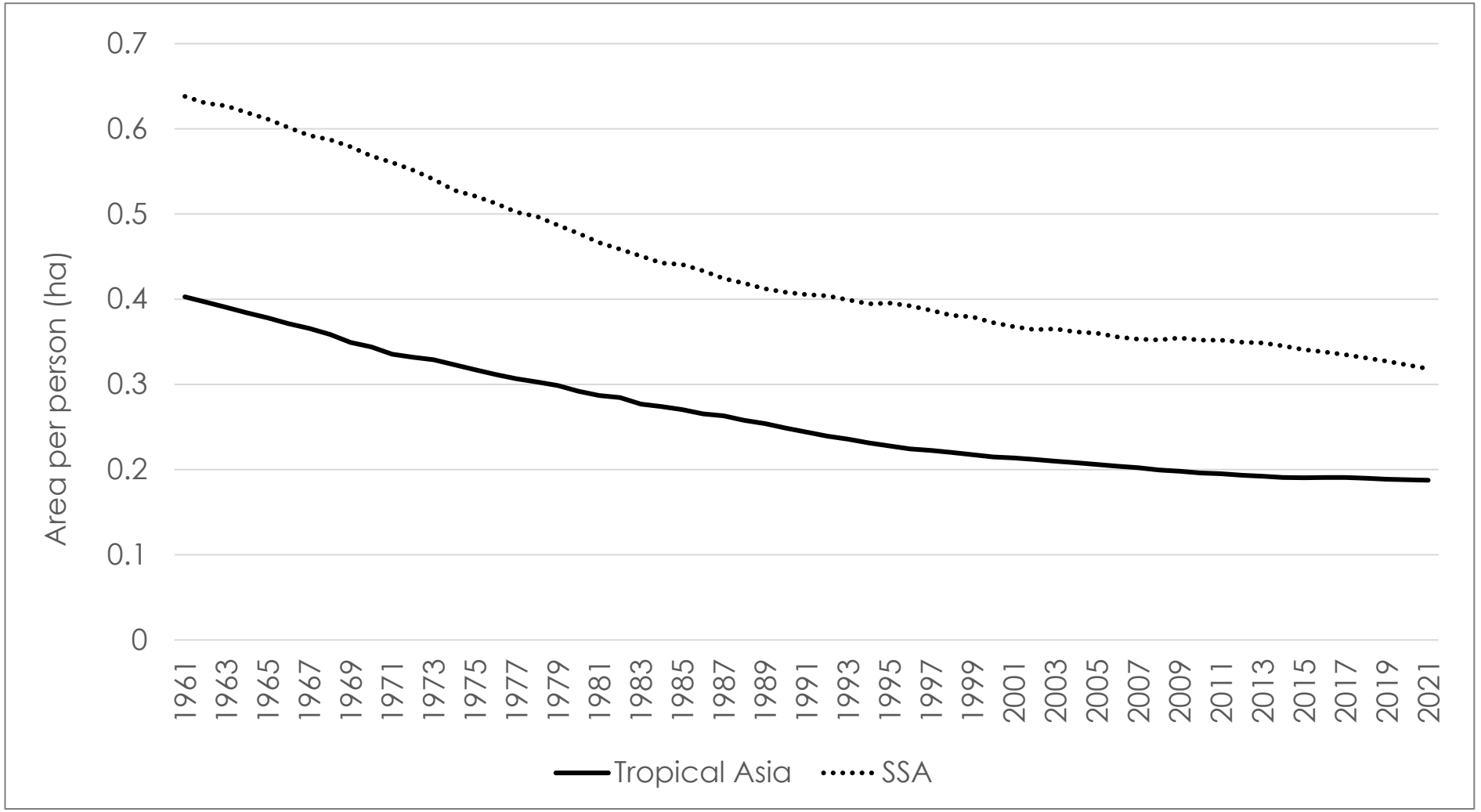
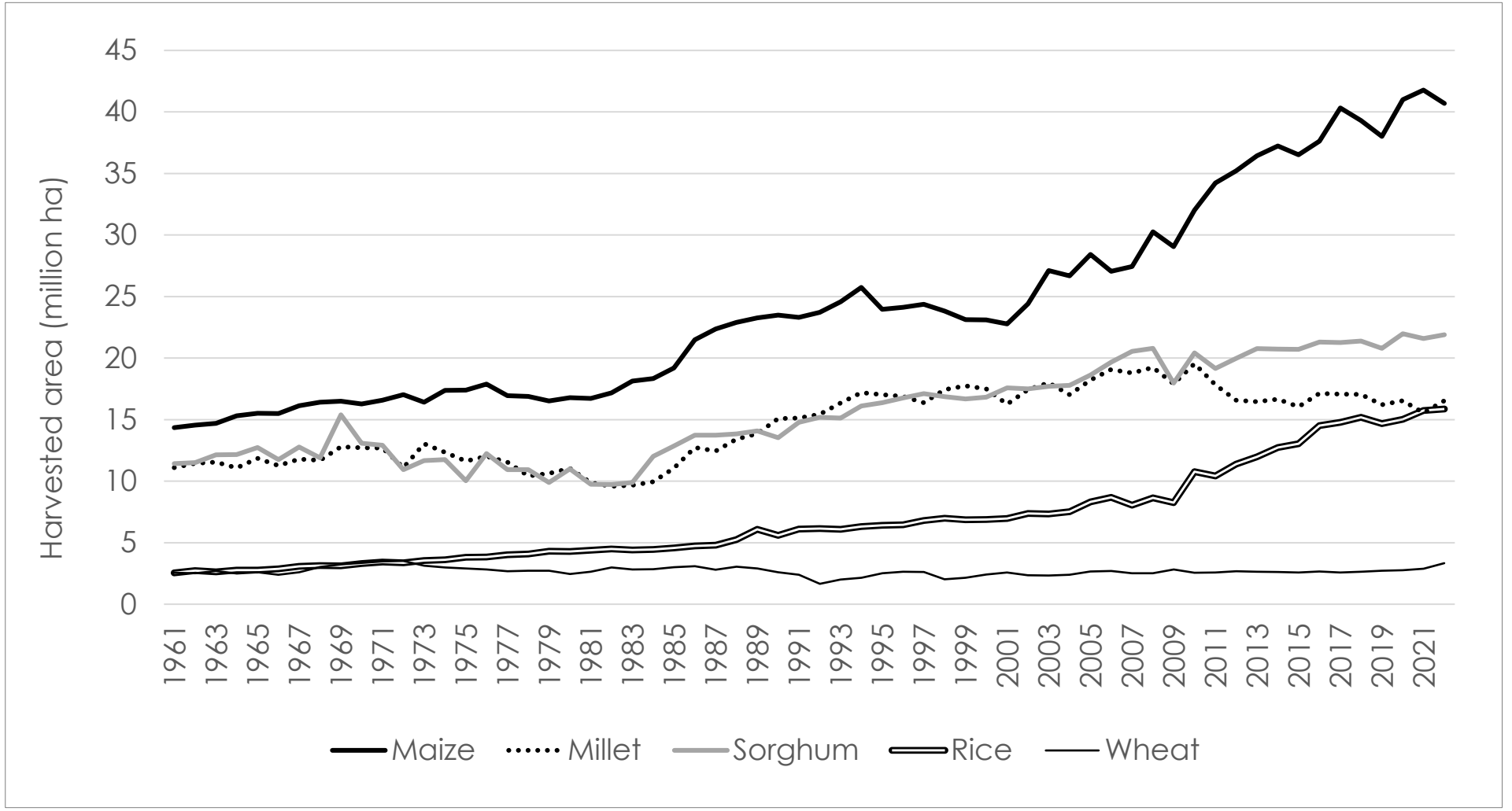
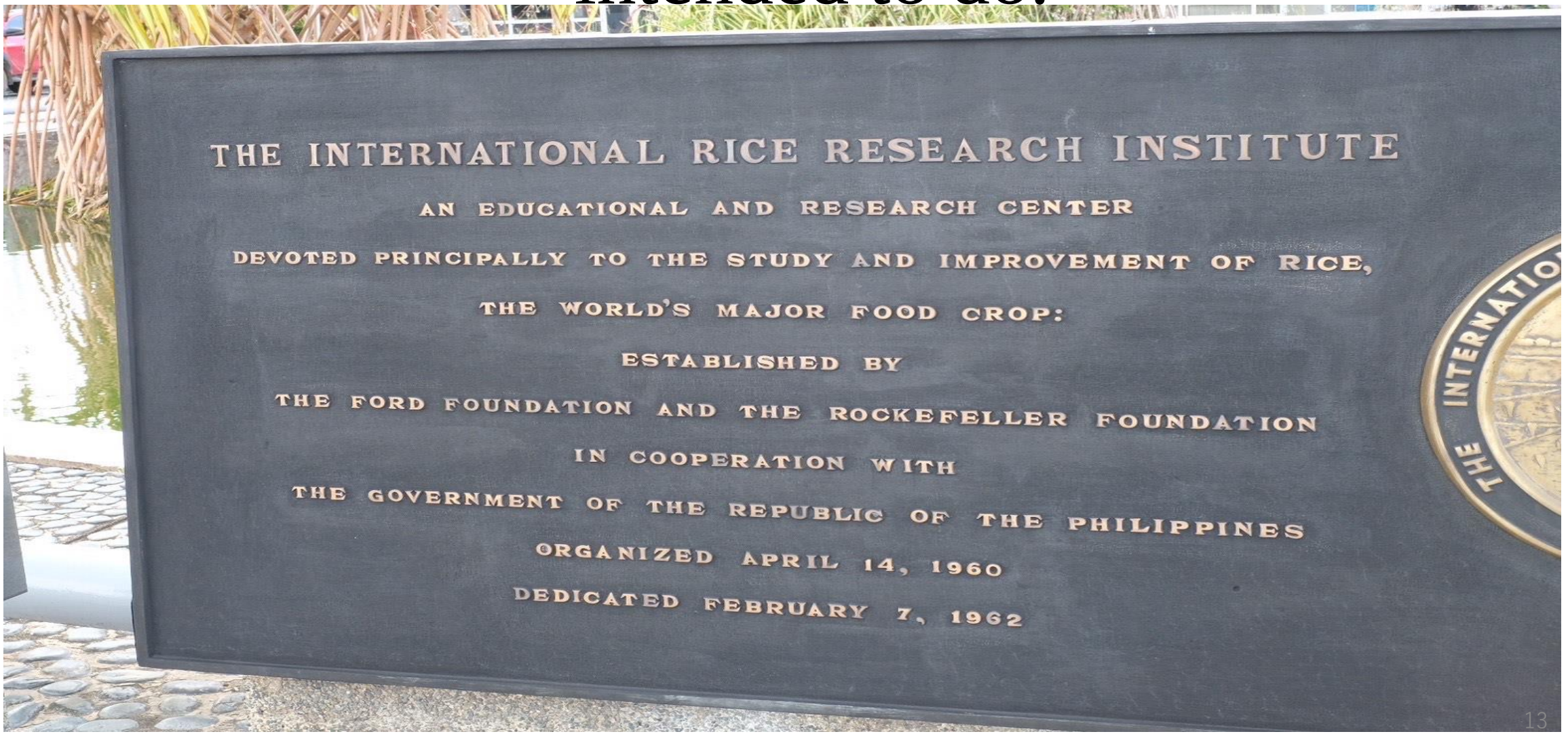


Fig. 4. Changes in the harvested area of major grains in SSA



We should never forget what IRRI originally intended to do.



It is understandable that IRRI is a research center.

- But why is IRRI “educational” center?
- What does “educational” mean?
- I have been thinking about these questions for four decades since the 1980s.

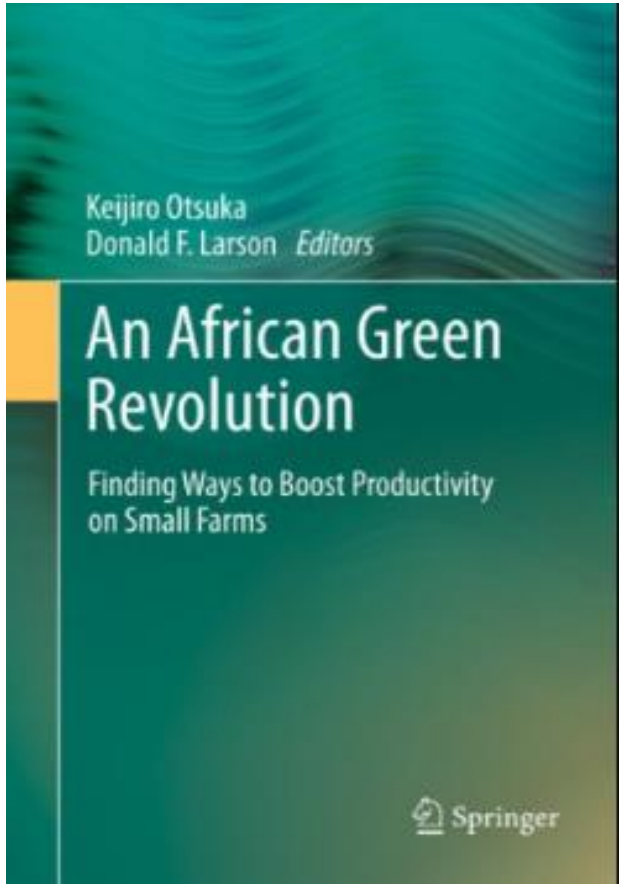
“Seed-Fertilizer Revolution”

- Bruce F. Johnston and John Cownie, 1969, “The Seed–Fertilizer Revolution …….” *American Economic Review.*
- Even as of now, many renowned agricultural economists, such as Doug Gollin and Michael Carter, assume that the essence of the Green Revolution is nothing but seed-fertilizer revolution.
- The majority of World Bank staff and staff of AfDB agree with this view. In fact, $80M contributed by Japanese government to the World Bank was used for distribution of free improved seeds and inorganic fertilizer to rice farmers in SSA. Production effect was only temporary.
- How can we reconcile the statement “IRRI is educational center” with the hypothesis “the Green Revolution is seed-fertilizer revolution”?

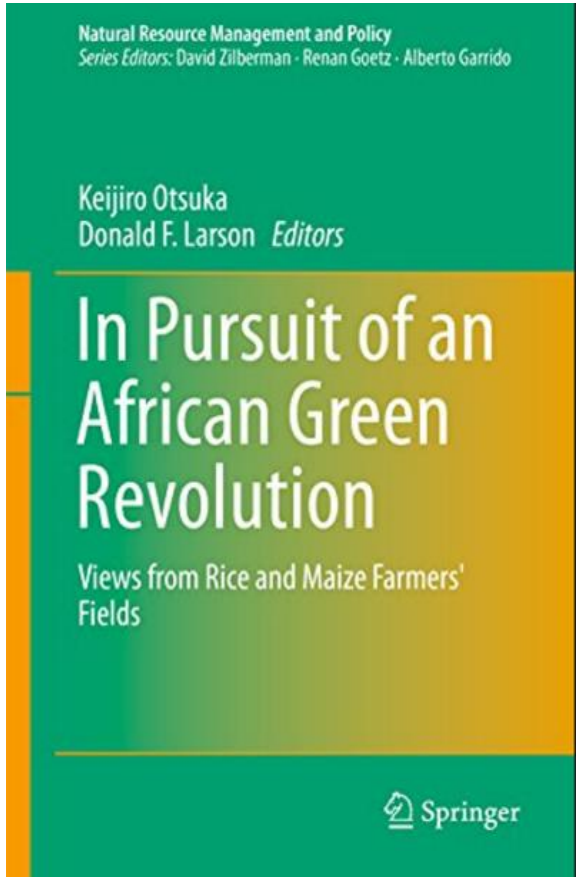
I have applied Tina-Kei approach to case studies of rice in Africa, which covered 7 countries

- In 2007, I recommended the Ministry of Foreign Affairs of Japan and JICA to undertake “rice production expansion program in SSA,” as I was very sure that rice is the most promising crop in SSA.
- JICA initiated international project, “Coalition of African Rice Development (CARD),” in collaboration with AGRA, in 2008.
- The goal of the CARD was to double rice production from 2008 to 2018, which has been successfully achieved.
- I formed research team of 7-8 most competent agricultural economists in Japan and conducted case studies in Mozambique, Tanzania, Kenya, Uganda, Ghana, Côte d'Ivoire, and Senegal.

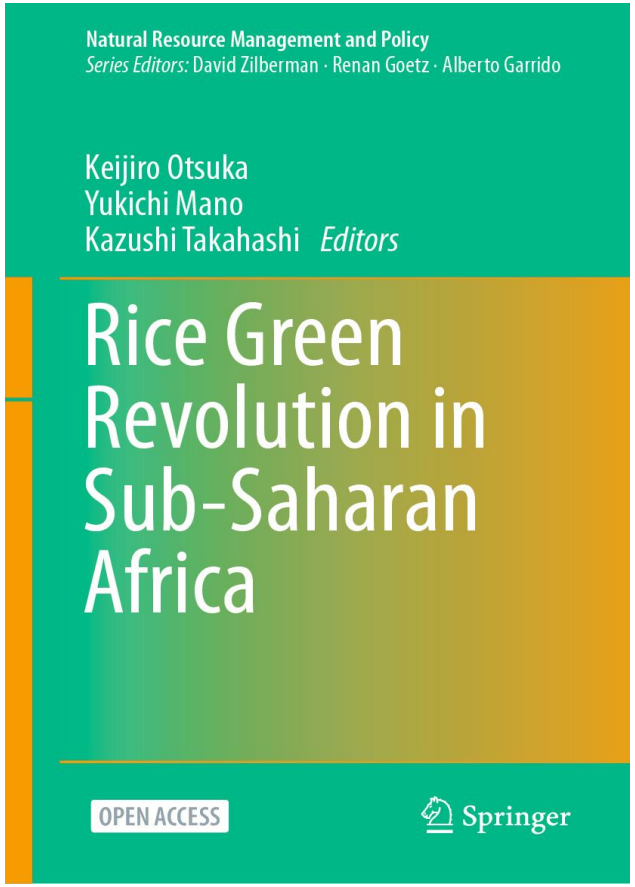
Fifteen years of case studies



Otsuka and Larson (2013)



Otsuka and Larson (2016)



Otsuka, Mano, Takahashi (2023)
Rice Green Revolution in Sub-Saharan Africa:
https://link.springer.com/book/10.1007/978-981-19-8046-6 (open access)

Main Messages of 3 Books

1. First book in 2013: Rice is likely to be the most promising cereal crop in SSA because of the high transferability of Asian rice Green Revolution technology. In contrast, maize technology is location-specific (Otsuka et. 2025).
2. Second book in 2016: Rice cultivation training programs are effective in dramatically increasing rice yields in SSA.
3. Third book in 2023:

(1) Rice Green Revolution is management intensive, which is not duly recognized in SSA.

(2) Impacts of rice cultivation training programs on productivity are not only significant but also sustainable with significant spillovers from training participants to non-participants.

(3) Mechanization of rice farming and the introduction of improved milling machines also play supportive roles in realizing full-fledged African rice Green Revolution (Mano, Takahashi, and Otsuka 2020; Mjago, Mano, and Otsuka 2022).

Paddy fields without bund?

No bund→ No stored water → Growth of weeds

Paddy field without bund

Another paddy field without bund

Paddy field with bund

Paddy field with excessively large bund

Leveling→Even distribution of water→Healthy plant growth
Straight-row transplanting → Easy weeding

Before and after Leveling

Straight-row transplanting

Why harvesting by knife?

Well-managed paddy field in Tanzania planted to IR51

There are many paddy fields in SSA without

- Bunds,
- Leveling,
- Straight-row planting,
- Weeding,
- Careful self-production of seeds,
- ……..

There are, however, areas where paddy production is carefully managed. See, e.g., yield growth of top five countries in SSA shown next.

Fig. 5. Average paddy yield per ha in Southeast Asia; South Asia; SSA; and top five countries (Kenya, Niger, Senegal, Benin, and Mali) in SSA, three-year moving averages (ton/ha)

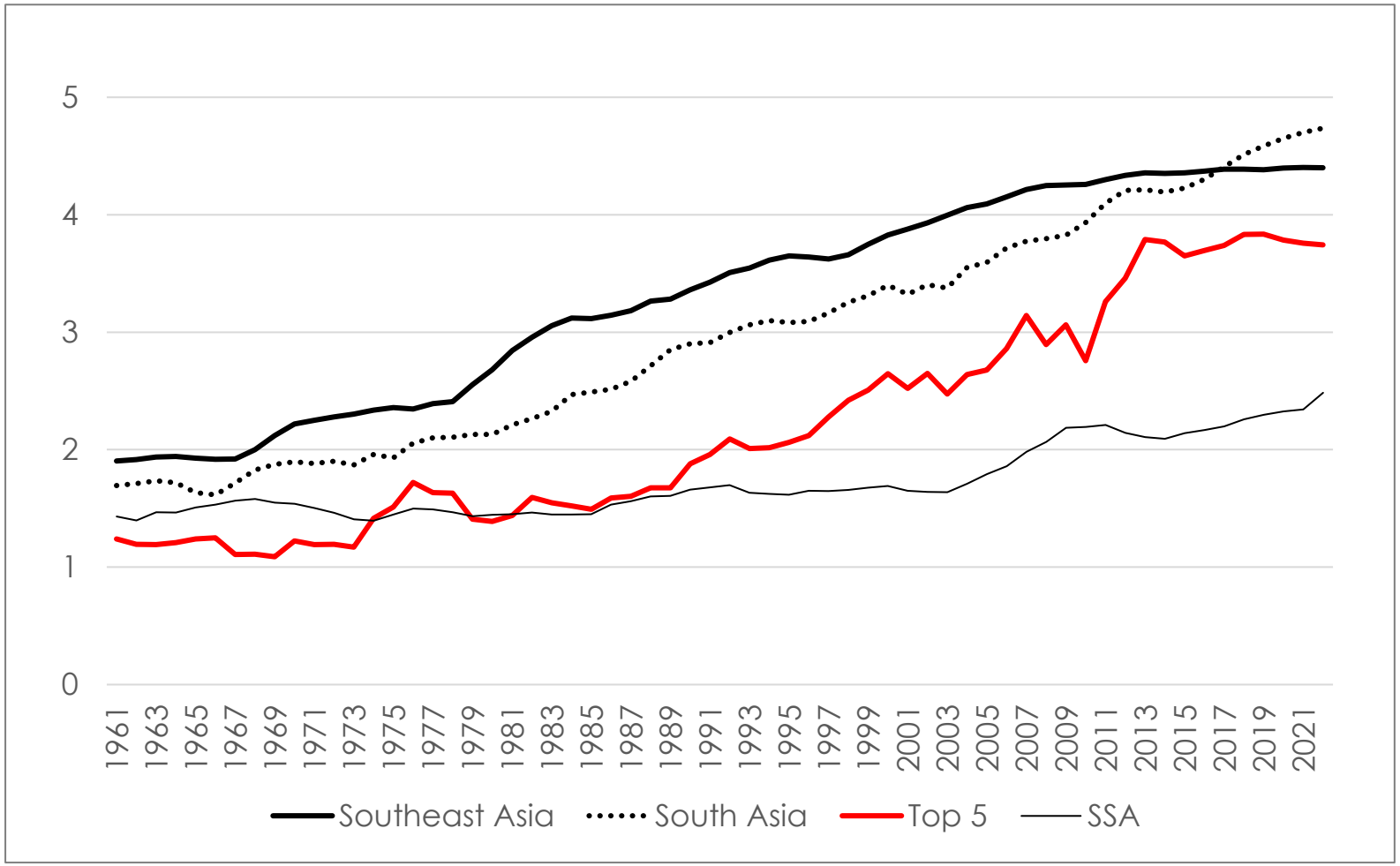


Table 2. Africans love rice and its consumption increased dramatically

	1980			2020		
	Estimated consumption (million tons)[a]	Production (million tons)[b]	Net imports (million ton)	Estimated consumption (million tons)[a]	Production (million tons)[b]	Net imports (million ton)
Maize	23.93	25.38	-1.45	86.85	86.43	0.42
Paddy Rice	9.21	5.90	3.33	48.17	32.90	15.26
Wheat	5.38	2.62	2.75	28.92	8.71	20.21
Millet	7.02	6.96	0.06	13.14	13.12	0.02
Sorghum	10.08	10.25	-0.17	24.85	24.43	0.42

Table 3. Comparison of yields and the adoption of selected cultivation practices among key farmers, intermediary farmers, and ordinary farmers in irrigated area in Tanzania

	2008	2009	2010	2011	2012
	Before training	Training year	1 year later	2 years later	3 years later
Key farmers					
Yield per ha (ton/ha)	3.07	4.40	4.81	5.34	4.67
Inorganic fertilizer application (kg/ha)	63.4	115.8	137.7	178.3	131.3
Adoption of leveling (%)	46.1	76.9	81.3	86.7	76.9
Adoption of straight row transplanting (%)	23.1	76.9	93.8	93.3	92.3
Intermediary farmers					
Yield per ha (ton/ha)	2.47	2.57	2.84	4.63	3.93
Inorganic fertilizer application (kg/ha)	22.2	49.0	79.1	103.9	95.2
Adoption of leveling (%)	43.5	70.4	74.2	79.2	62.5
Adoption of straight row transplanting (%)	13.0	44.4	64.5	45.8	58.3
Other farmers					
Yield per ha (ton/ha)	2.57	2.67	2.53	3.58	3.67
Inorganic fertilizer application (kg/ha)	46.5	58.3	69.7	85.8	83.2
Adoption of leveling (%)	54.8	64.1	69.0	76.2	66.9
Adoption of straight row transplanting (%)	11.1	19.0	25.8	26.9	36.9
Annual rainfall (mm)	1,027	869	917	1,547	651

Initial conditions were different between Asia and SSA

- Before the Green Revolution began in Asia before 1966, paddy fields were more or less bunded and leveled in Asia, even though straight-row planting was uncommon. That is why IRRI would have been concerned with "educational."
- In contrast, there are many paddy fields without bunds and levelling Moreover, seeds are seldom selected and timing of transplanting and harvesting is often too late. Thus, effective extension is the key to a rice Green Revolution in SSA, because rice cultivation is new for many African farmers.
- Our studies found that the impact of rice cultivation training are not only effective but also sustainable with information spillovers from training participants to non-participants.
- In other words, SSA needs *educational center* *to achieve full-fledged Green Revolution*, *as was recognized by IRRI more than 50 years ago*.

Thank you very much for your attention!

Related References

Otsuka, Kei, T.S. Jayne, Yukihchi Mano, and Kazushi Takakashi, 2015 (forthcoming), “Sustainable Green Revolution in sub-Sharan Africa: The Case of Maize and Rice.” *Food Policy.*

Mano, Yukichi, Kazushi Takahashi, and Kei Otsuka, 2020, “Mechanization in Land Preparation and Agricultural Intensification: The Case of Rice Farming in the Cote d'Ivoire.” *Agricultural Economics* 51(6): 899-908.

Njagi, T., Yukichi Mana, and Kei Otsuka, 2022, “An inquiry into the Process of Upgrading Rice Milling Services: The Case of the Mwea Irrigation Scheme in Kenya.” *Food Policy* 106: 102195.

Njagi, T., Yukichi Mana, and Kei Otsuka, 2016, “Role of Access to Credit in Rice Production in Sub-Saharan Africa: The Case of Mwea Irrigation Scheme in Kenya.” *Journal of African Economies* 25 (2): 300-21.