IPI International Potash Institute

Assessment of the Impact of Targeted Use of Fertilizer

Irrigated rice in Asia

INTERNATIONAL POTASH INSTITUTE

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Front cover pictures: IRRI and IPI

INTRODUCTION

Rice (*Oryza sativa* L.) is grown on a harvested area of 162 million ha (2010), with 91% produced in Asia. It is the main staple food crop in Asia, providing more than 50% of calories in some countries. Worldwide, about 93 million ha of irrigated lowland rice (57% of rice production area) provide 75% of global rice production.

In Asia, rice is grown on 30-83% of all irrigated land. Rice provides 19% of global human per capita energy and 13% of per capita protein. But to provide for the future needs of the growing world population, rice production needs to grow annually by 1.2-1.5% over the coming decade (GRISP, 2013).

VARIABILITY IS **A CHALLENGE**

Plots dedicated to producing rice in Asia are typically small. In addition, large variations in nutrient balances and nutrient requirements often exist across small distances within a landscape. This may be due to differences in retention of crop residues, historical fertilizer use, input of organic materials, inherent soil fertility, and variations in crop yield that result from other farm management practices (Buresh *et al.*, 2010). Existing blanket fertilizer recommendations for large areas or agro-ecological zones fail to respond to these variations in needs of rice for added nutrients. Hence, farmers need 'actionable' information matching their specific situation.

ABOUT **SSNM**

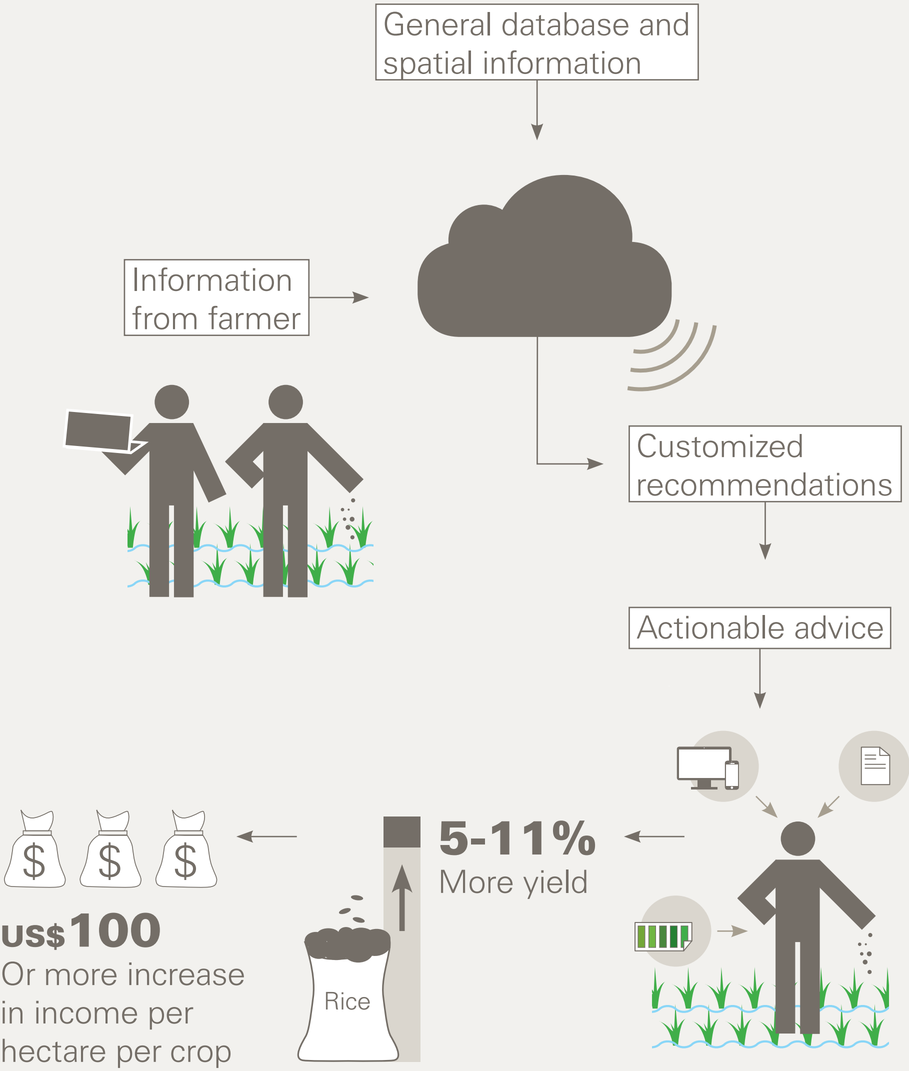
Site-specific nutrient management (SSNM) is a field-specific approach that uses scientific principles to dynamically apply optimal rates of fertilizer as and when needed. Some of the tools used to facilitate farmer adoption of SSNM principles include the leaf color chart (LCC) (as an indicator of leaf N status), videos, CDs, short printed guides, and the Nutrient Manager – a decision tool that is extended to farmers through the internet and smart phones.

Since 1997, the development and dissemination of SSNM in rice across South, East and Southeast Asia has been supported by donors and the fertilizer industry. Implemented through the International Rice Research Consortium (IRRC), supported largely by the Swiss Agency for Development and Cooperation (SDC), SSNM has been applied in irrigated rice systems across Asia.

ABOUT **IRRC**

IRRC was established in 1997 with the aim of providing a platform to facilitate identification, development, dissemination, and adoption of natural resource management (NRM) technologies suitable for irrigated rice-based ecosystems in several Asian countries. With funding support mainly from SDC from 1997 to 2012, IRRC has provided a mechanism to support the development of partnerships between national agricultural research and extension systems (NARES) and scientists from IRRI. SSNM has been adopted in seven Asian countries: Bangladesh, China, India, Indonesia, Myanmar, Philippines and Vietnam.

The SSNM approach



IRRC operated through five work groups

1. Labor Productivity and Community Ecology
2. Post Production Work Group
3. **Productivity and Sustainability Work Group**
4. Water Savings Work Group
5. Crop Health and Climate Change Work Group and Coordination Unit and Communications Team

Meta-Impact Assessment of the IRRC

Through short field visits and study of easily accessible data, a 'meta' assessment of the impact of the IRRC was carried out. The assessment aimed to determine the impact of technologies developed or disseminated by the IRRC on many different levels, including economic, environmental, institutional, scientific and socio-cultural, as well as the impact on policy. It also aimed to document the factors and processes that led to successful technology adoption.

Plate 1. Rice farmers participating in a group discussion on SSNM. Philippines. 2008.

ECONOMIC IMPACT OF IRRC (1997-2012)

Total research investment ~US$18.5 million
Total economic benefits ~US$70.5 million
Benefit cost ratio (BCR) 4:1
Donors: SDC = US$11.9 million
Additional investment by others (including the fertilizer industry) ~US$6.6 million

ECONOMIC IMPACT OF SSNM (1997-2016)

Between 1997 and 2012, IRRC's Productivity and Sustainability Work Group (working on SSNM) received investment amounting to ~US$6.6 million, of which US$5.3 million was provided by SDC and US$1.3 million came from the fertilizer industry (International Fertilizer Association (IFA), International Potash Institute (IPI) and the International Plant Nutrition Institute (IPNI). The analysis made by the IRRC Meta-Impact Assessment focused on Bangladesh, Indonesia, Philippines and Vietnam.

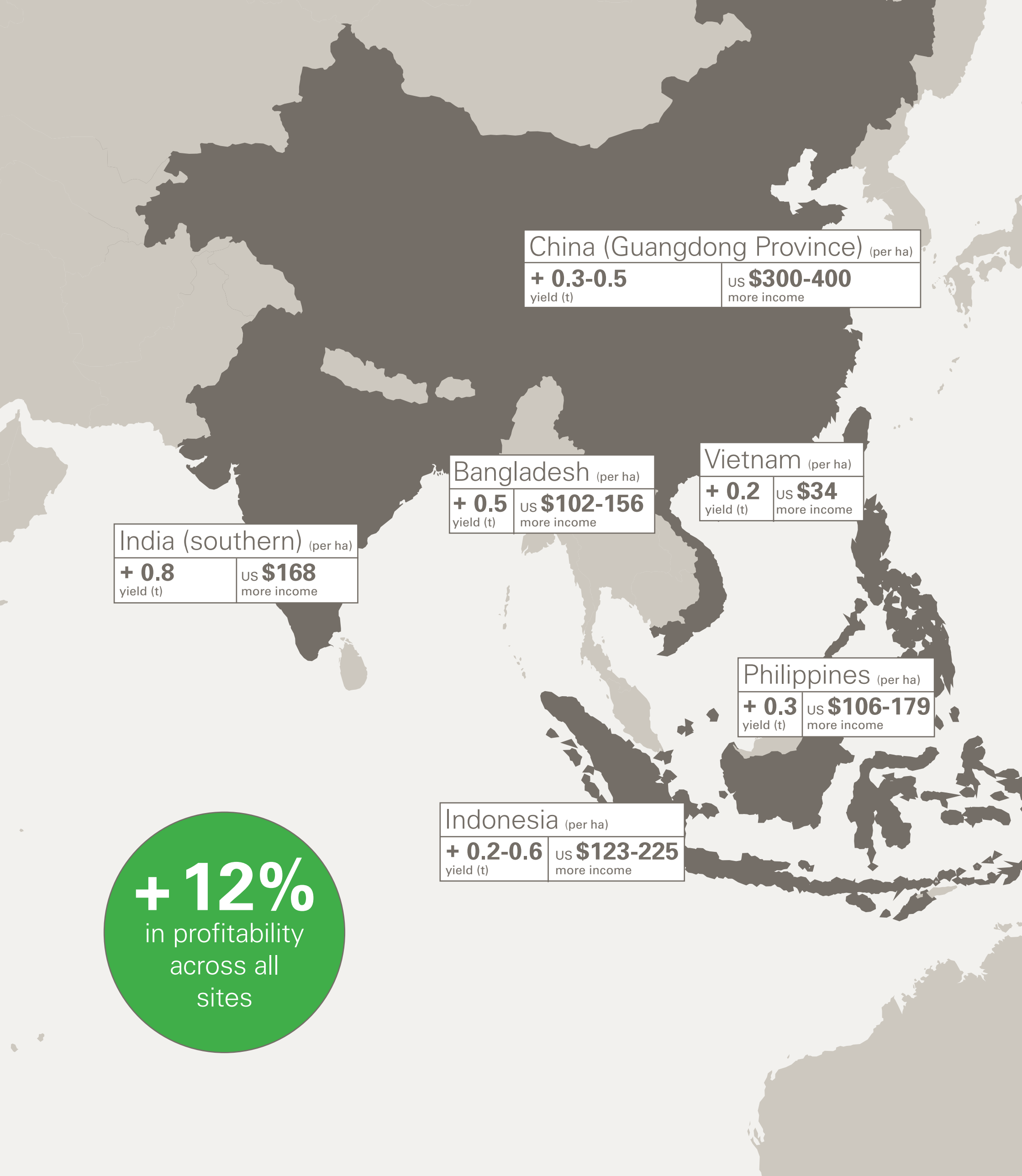
Table 1. Costs and benefits from improved nutrient management for rice (SSNM applied through IRRC). Source: Adapted from Rejesus et al., 2013.

Period	Total discounted costs	Total discounted benefits	Net present value (NPV)	Benefit cost ratio (BCR)	Internal rate of return (IRR)
	in US$ millions				
1997-2012	6.6	22.8	16.1	3.4	0.24
1997-2016	6.6	76.3	69.7	11.5	0.32

Note: Total discounted benefits and the calculations based on this are from Bangladesh only, and therefore, the overall benefit from SSNM technology far exceeds the figures in Table 1.

During 16 years (1997-2012), investment in nutrient management resulted in total discounted benefits of US$22.786 million, which generated a net present value (NPV) of US$16.147 million. If additional benefits from 2012 to 2016 (due to the adoption of 'Nutrient Manager and Crop Manager' (http://cropmanager.irri.org) and additional training and dissemination activities) are taken into account, discounted benefits rise to more than US$75 million, increasing NPV to more than US$70 million (for Bangladesh only).

SSNM increases farmers' income



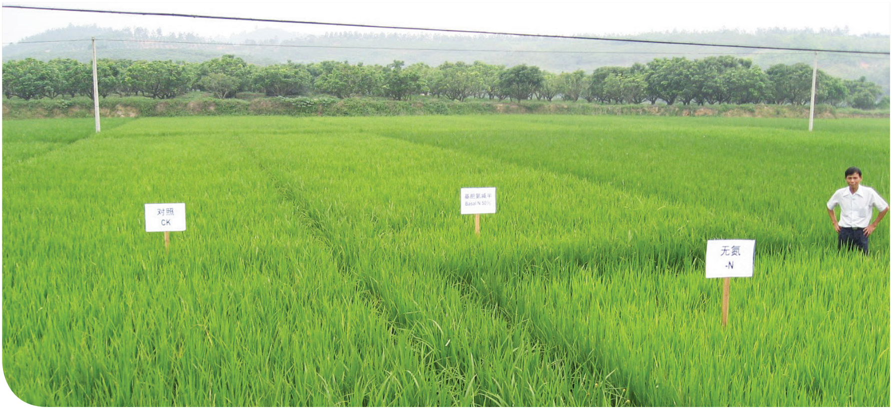


Plate 2. *SSNM plot in China. Photo by Xuhua Zhong.*

Table 2. *Summary of agronomic and economic benefits from SSNM.*

Country	Typical yield increment for SSNM (t ha^{-1})	Typical income increment for SSNM (US$ ha^{-1})
Bangladesh	0.5	102-156
India (southern)	0.8	168
Indonesia	0.2-0.6	123-225
China (Guangdong Province)	0.3-0.5	300-400
Philippines	0.3	106-179
Vietnam	0.2	34
Across all sites	5-11%	34-400

Typical yield increase after implementing SSNM varies between 5-11%. Income is affected by additional yield and reduced expenditure on N fertilizers. Average increase in profitability reached 12% across many Asian countries.

MAPPING THE **SSNM BENEFITS**

Farmers' income *(Pampolino et al., 2007)*

- Average grain yields across countries for SSNM adopters have been observed to be 8-11% higher than for non-SSNM adopters.
- In SSNM plots, income increased by an average of 12% across all sites and four successive rice crops.
- Economic analysis of SSNM in farmers' fields demonstrated an added net annual benefit of US$34 ha^{-1} $year^{-1}$ (Vietnam), US$106 ha^{-1} $year^{-1}$ (Philippines), and US$168 ha^{-1} $year^{-1}$ (India).

Soil health *(IRRI, 2014)*

- In 2014, the world's longest running continuous rice experiment (the Long-Term Continuous Cropping Experiment - LTCCE) celebrated its 150th harvest.
- Beginning in 1962 and growing rice crops continuously for 52 years, the experiment has succeeded in maintaining rice production throughout.
- Despite not applying either crop residues or organic fertilizer, soil organic matter (an indicator of soil fertility) did not decline in the last 30 years.
- Sustainable rice production depends on proper fertilizer application, sufficient irrigation water, good crop management and use of high yielding rice varieties.

Plant health

- Results from China showed that the application of SSNM led to the highest N agronomic efficiency and higher rice yields, whilst also dramatically decreasing the infestation of sheath blight disease (Li *et al.*, 2012).
- As disease intensity and yield loss from sheath blight increases with increasing N rates, the magnitude of yield loss also varies among varieties. This suggests that N fertilizer should be managed more precisely and differently for different varieties and plant types in order to reduce disease development and maximize grain yield in irrigated rice systems (Tang *et al.*, 2007). In order to reduce the risk of sheath blight diseases, high N application must be integrated with pest and disease control.

Environment

- The SSNM approach aims to apply nutrients (N, P and K) at optimal rates and times to achieve high rice yields and high efficiency of nutrient use by the crop. It does not specifically aim to either reduce or increase fertilizer use. However, it has been shown that improved timing of N fertilizer often contributed to increased yields and increased efficiency of N fertilizer use. For instance, SSNM in the Philippines and Vietnam showed greater yields with less N fertilizer through improved fertilizer use efficiency.
- In several provinces of China, SSNM reduced farmers' use of N fertilizer by one third, while increasing yields by 5%. A site-specific N management strategy was able to increase uptake efficiency by almost 370% on the North China Plain.
- Application of SSNM also results in reduced nitrate runoff and greenhouse gas emissions (particularly nitrous oxide). Reduced incidence of pests has also been shown to reduce the use of pesticides in some study sites. And increasing the productivity of N fertilizer (yield per unit of N fertilizer applied) could also provide environmental benefits associated with producing and transporting less N fertilizer per unit of grain produced.
- Tests at 180 sites in eight key irrigated rice domains of Asia found that the system led to a 30-40% increase in N-use efficiency, predominantly due to improved N management.

Plate 3. Explaining SSNM: Dr. R. Buresh, Head of Productivity and Sustainability Work Group, discusses SSNM with extension workers (2011).

CONCLUSIONS

- The long-term investment and commitment of interested stakeholders and donors participating in SSNM led to a tangible improvement in the welfare of farmers, along with improvements in environmental performance.

- Economic benefits from SSNM resulted in a BCR of 3.4, while generating an NPV of more than US$16 million with an IRR of 0.24.

- Farmers who use SSNM-based recommendations increase efficiency of fertilizer use, increase their yields, and increase their income through better matching of nutrient inputs with crop needs.

- Improved timing of N fertilizer, including by use of LCC, frequently contributed to increased yields as well as increased efficiency (30-40%) of N fertilizer use across all sites.

- Application of K fertilizer was optimized through adjustments for inputs of crop residues, manure and K in irrigation water.

From 1997 till 2012 the Swiss Agency for Development and Cooperation (SDC) supported the International Rice Research Consortium (IRRC).

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Swiss Agency for Development and Cooperation SDC

IRRC

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International Fertilizer Industry Association

INTERNATIONAL POTASH INSTITUTE

IPNI International Plant Nutrition Institute

FACTS & FIGURES

634 Million t

ASIAN RICE PRODUCTION (2010)

6.6
MILLION US$
INVESTED IN SSNM

7 ASIAN COUNTRIES ADOPTED THE SSNM APPROACH

19% OF HUMAN ENERGY
IS PROVIDED BY RICE

BY 2016, SSNM'S NPV WILL FAR EXCEED THE
US$70 MILLION
PREDICTED FOR BANGLADESH

SCIENTIFIC PUBLICATIONS
133

1,000,000
FARMERS RECEIVING A LEAF COLOR CHART (LCC) IN ASIA

1.2
MILLION
farmers have been reached by the technologies promoted by IRRC

US$ 100
OR MORE, PER HECTARE INCREASE IN FARMERS INCOME USING THE SSNM

16
YEARS OF RESEARCH

220,000 **FARMERS WERE TRAINED**
IN THE USE OF THE LCC

201
TRAINING ACTIVITIES

9
(million t)

Annual increase in rice production is needed to **provide future needs** of growing world population

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