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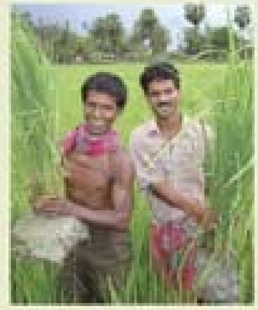

More RICE with Less Water

SRI - System of Rice Intensification

Seed is the main input for rice cultivation. Good quality and appropriate quantity are important factors for increased rice production and reduced costs

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Disclaimer

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Contents

Chapter 1
Introduction

At varying points of time on two continents, particularly from 8500 BC to 1000 BC, a wild strain of grass was domesticated. Today, we know the evolved form of that grass as rice!

Rice: The Earliest Cultivated Crop

- Cultivated rice varieties have been found in the Yangtze valley in China, dating from as early as 8500 BC, which signifies the late Pleistocene era. It is believed that later, in less than 2,000 years, *Oryza sativa*, which forms the basis of the most popular rice varieties today, was domesticated in southern China. Likewise, in the wet western regions of the African continent a local variety, *Oryza glaberrima,* is believed to have been domesticated 3,000 years later.

- In South Asia, remains of rice have been found in Lothal (2300 BC) and Rangpur (2000-1800 BC), both, interestingly, dry areas in the modern Indian State of Gujarat. Rice in wetter locations in what is today Bihar and West Bengal in eastern India dates to the same period.

- By 300 BC, rice cultivation had spread to peninsular India and by 100 BC Chinese traders had brought rice to early cultivators in the Philippines, leading to the creation of the vast terraced rice farms along the Philippine Cordilleras.

Rice – The staple food of the world

Lifeblood for billions of people, rice is now a way of life and is deeply embedded in cultures, rituals and myths. It is a staple food for more than half of the world's population. In Asia alone, more than 2,000 million people obtain 60 to 70 percent of their calories from rice and its products. Production and consumption of rice is expanding in Africa. Rice continues to be an important staple in Latin America. It is significant for food security in low-income and food-deficit countries. In Europe, it is a major food crop in certain regions of countries like Italy and Spain. Rice is indeed a global food grain.

This report:

- Highlights the relationship between rice, food security and water scarcity.
- Examines the contribution that the System of Rice Intensification (SRI) can make to address various challenges.

Thalambralu, a ritual in Andhra weddings in which the couple pour rice over one other's head in a joyful manner, seeking prosperity and abundance

For more than half of humanity RICE IS LIFE. This grain has shaped the livelihoods, cultures, diets and economies of several billion people in Asia. For them, life and livelihood without rice is simply unthinkable.

Rice is central to many cultures and its cultivation is intertwined with every facet of life: from births to weddings to deaths. In India, the ceremony heralding the birth of a child often involves the scattering of rice grains. It is equally important during wedding ceremonies and while offering prayers for the dead. A new bride tips over a pot of rice while ritualistically taking her first step into her in-laws' house. Diluted rice paste is used to make auspicious patterns on doors and on the front yard of houses.

Rice has inspired songs, paintings, stories and a rich variety of foods. Festivals have been dedicated to rice and rice cultivation — for example, the Land Opening Festival in China marks the beginning of the rice-sowing season.

Many Asian emperors and kings of the past considered rice to be of divine origin. The Japanese, even today, refer to rice as their 'mother,' and regard rice farmers as the guardians of their culture and the countryside. In China, a common pleasantry when people meet is: "Have you taken (rice) today yet?"[1]

Domestication of wild grasses and seeds changed the course of civilisation. It unified communities and stabilised them as 'inhabitants' settled in a given location. Agriculture also helped in bringing people together to reclaim and develop land; build and maintain farming systems; fight soil erosion and flooding, and develop irrigation networks. It put in place a system that offered protection from hunger, consolidating the links among the human race, land and food security.

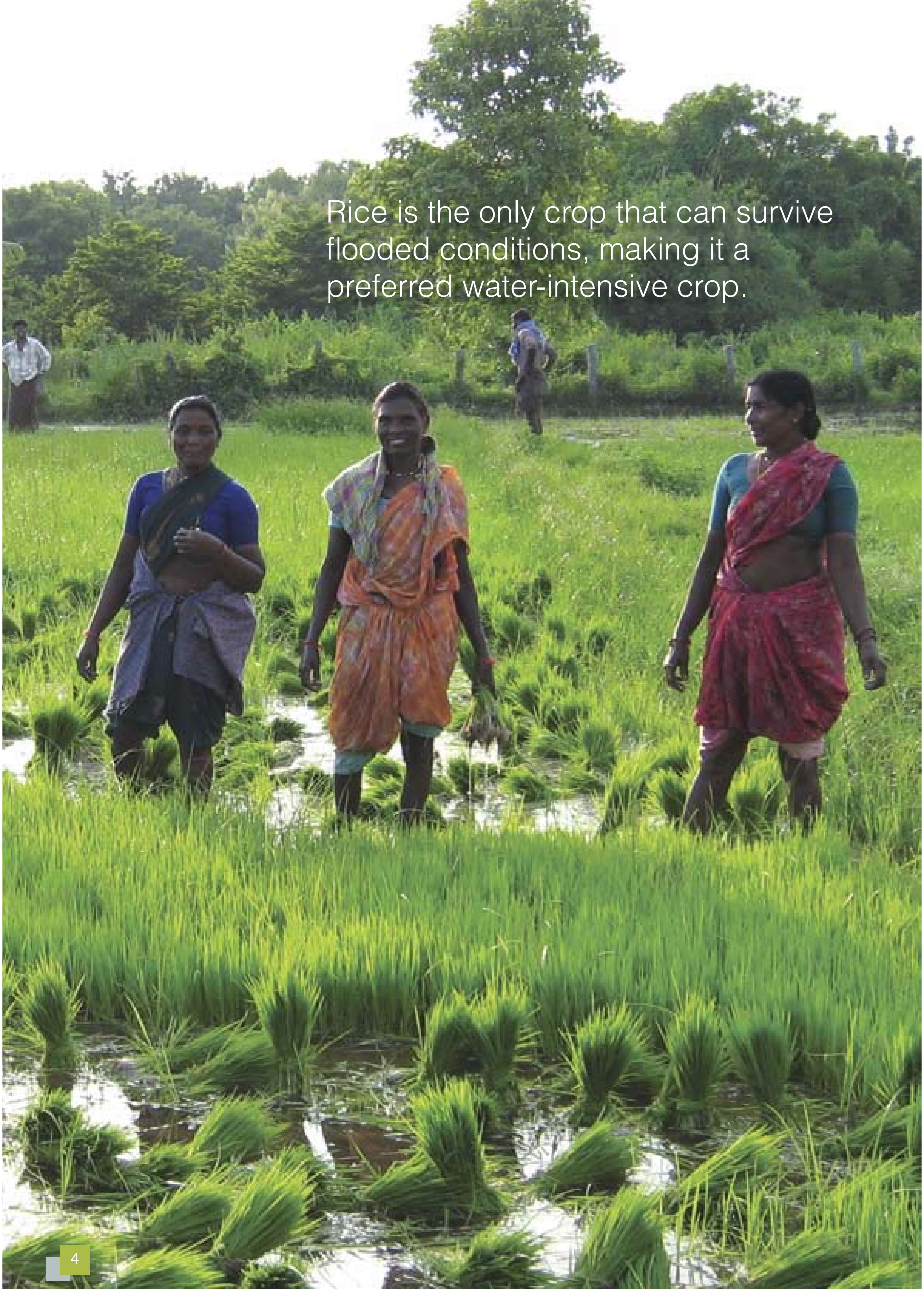
Expansion of rice cultivation is linked to availability of water. Rice cultivation expanded to many areas due to growing infrastructure such as dams, canals etc, facilitating irrigation. Modern methods of rice cultivation require irrigation, which implies dependence on large quantities of surface and ground water. Due to water scarcity, rice cultivation is becoming unaffordable and unpredictable in many areas across the world. This will have serious implications on food security in many countries.

This report focuses on India, which has the world's largest rice cultivated area and faces major water crisis and conflicts. The World Wide Fund for Nature (WWF) is working with farmers, scientists and national institutions to promote the System of Rice Intensification, as it will reduce pressure on freshwater eco-systems and improve food production. WWF's work with rice is part of its vision to improve productivity of major water-intensive crops like sugar, cotton etc. Although the report is based on Indian experience, the findings are relevant to many rice producing countries with appropriate modifications to suit local conditions.

When Seeds of Rice Banished Hunger

Rice is an integral part of native folklore across countries. In Myanmar, it is said that the Kachins were sent forth from the centre of the Earth with rice seeds and a directive that they should go to a country where life would be perfect and rice would grow well. In Bali, legend has it that god Vishnu caused the Earth to give birth to rice, while god Indra taught people how to cultivate it. And, Chinese folklore tells how, after a disastrous flooding in which all plants were destroyed with no trace of food, a dog ran through the fields one day with rice seeds hanging from his tail. The seeds yielded rice, and hunger disappeared!

[1] http://www.fgiworld.com/eng/resource.asp



Rice is the only crop that can survive flooded conditions, making it a preferred water-intensive crop.

Chapter 2
Rice ¸ A World Food Staple

Nearly 90 per cent of the world's rice is produced and consumed in Asia, which accounts for nine of the top 10 rice producing countries across the globe.

Rice is the only cereal that can stand water submergence. This explains the long and diversified linkages between rice and water, which, over hundreds of years, have affected rice ecosystems, primarily as a result of natural pressures such as drought, submergence, flooding as well as nutrient and biotic stresses.

The International Rice Research Institute (IRRI) identifies four rice agro-ecosystems and has categorised them as irrigated rice ecosystem, rainfed lowland rice ecosystem, upland rice ecosystem and flood-prone rice ecosystem (Figure 2.1).

Globally, rice is cultivated in 171m ha, of which about 55% is irrigated. While all the rice cultivation in the US, Europe and Australia is irrigated, in Africa there is more of upland rice cultivation than irrigated rice cultivation. The situation in Africa might change in the next decade or so.

Contrary to popular belief, rice is not an aquatic plant. Although it can survive in saturated soil, it grows best under anaerobic conditions.

Worldwide consumption of milled rice has increased by 40 per cent in the last 30 years.

Tolerating Water, not Thriving...

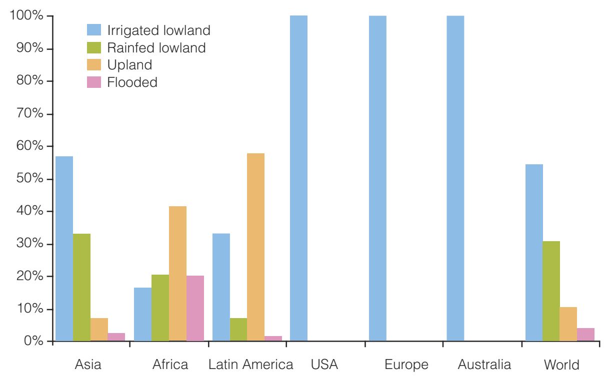
- Rice survives in submerged conditions because it forms air pockets (aerenchyma or a kind of secondary respiratory tissue) in its roots. Around 30 per cent of the cortex around the central stele (the xylem and phloem) of rice plants growing in submerged conditions disintegrates to form air pockets that allow oxygen to diffuse into root tissues. However, this adaptation limits the plant's ability to absorb nutrients.

- Most – about 75 per cent – of the roots in flooded circumstances remain in the top 6 cm of soil a month after transplanting, forming a 'mat' close to the surface in order to capture as much dissolved oxygen as possible from the water. Such roots fail to extract nutrients from a large volume of soil, resulting in dependence on inorganic fertilisers.

- Rice survives, but does not thrive, in submerged conditions. Standing water, in fact, suppresses yield by limiting the ability of the roots to respire. This slows down the plant's metabolism, ion transport and growth. The roots of rice plants that are submerged during the initial growth period do not grow deep into the soil. Under such conditions, about 75 per cent of the roots degenerate by the time of flowering and full maturity.

- The main benefit of flooding the rice plants is that it checks the proliferation of weeds, thereby saving labour.

Figure 2.1: Percentage of Rice Area by Agro-ecosystem and Region



Primarily a type of grass, rice, unlike most other comparable plants, has a remarkable ability to tolerate submergence. Farmers started out growing rice in low-lying land, where the conditions are congenial. They quickly learned that this method of cultivation could also keep weeds in check and reduce their labour requirements. As long as there is sufficient water supply, rice is protected against water stress and farmers save labour for weeding.

Production

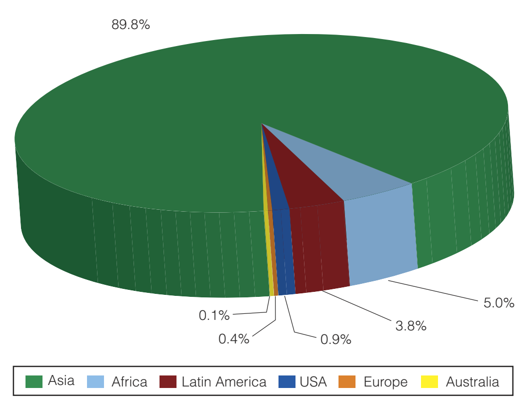
Given its history, it is not surprising that nearly 90 per cent of the world's rice is produced and consumed in Asia, where nine of the world's top 10 rice producing countries are located. At present, 114 countries are reported to be growing rice. Of these, China is the largest producer, followed by India and Indonesia.

Total production depends on yield as well as area. Technological improvements have led to yield enhancement, especially from the mid-1960s to the mid-1990s. Still, there is a wide variation in rice yields. The current world average is 4 t/ha, ranging from less than 1 t/ha to almost 10 t/ha, with such averages influenced heavily by how much of a country's rice area is irrigated and how much is rainfed.

There is a strong relationship between rice production and fish cultivation in many Asian societies. This affiliation is reflected in the literature from the ancient Tai and Angkor Wat civilisations as well as in the saying, "In the fields there is rice and in its water there are fish." The durability of this association depends both on maintaining sufficient quantities of water year-round and ensuring that the water is free of toxic elements.

Currently, the average yield from irrigated rice (paddy) production in India is about 3.1 t/ha (range 2.3 - 3.5 t/ha). However, much of India's total rice area is either un-irrigated or under-irrigated. In India, rainfed rice yields range between 0.5 and 1.6 t/ha, while the country's overall average is only about 2 t/ha. This means there is ample scope for gaining on the productivity front, instead of focusing only on augmenting irrigation for increasing yield (Figure 2.3).

Figure 2.2: Rice Producing Countries in the World



Source: UN Food & Agriculture Organisation (FAO)

China, India and Indonesia together produce and consume about 60 per cent of the world's rice.

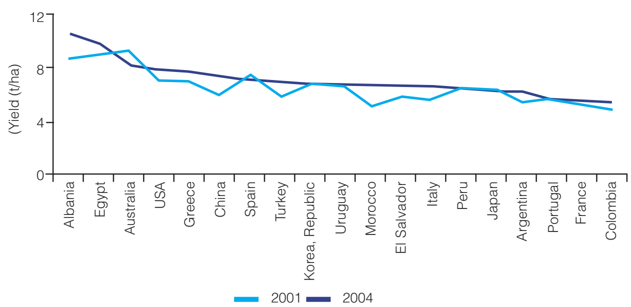
Rice is the main source of directly consumed calories for about half the world's population.

Consumption & Nutrition

Worldwide consumption of milled rice has increased 40 per cent in the last 30 years, from 61.5 kg per capita to about 85.9 kg per capita. In some countries, including China, per capita rice consumption is declining amidst rising incomes (Figure 2.5).

According to the International Food Policy Research Institute (IFPRI), rice provides 23 per cent of all the calories consumed by the world's population. It is the main source of directly consumed calories for about half the world's population (Figure 2.4).

Figure 2.3: Rice Yield in Top 20 Countries (t/ha)



Source: UN Food & Agriculture Organisation (FAO)

A typical rice market in India

All rice varieties do not have equal nutritional value, considering that they have varying levels of micro nutrients like vitamins, iron and zinc as well as protein, fibre and fat.

Aside from being a staple food, rice provides multiple benefits. It contributes fodder for livestock and straw for roofing and other construction uses. Husks from milling are used as cattle feed, for briquette making and as construction or packing materials.

Trade

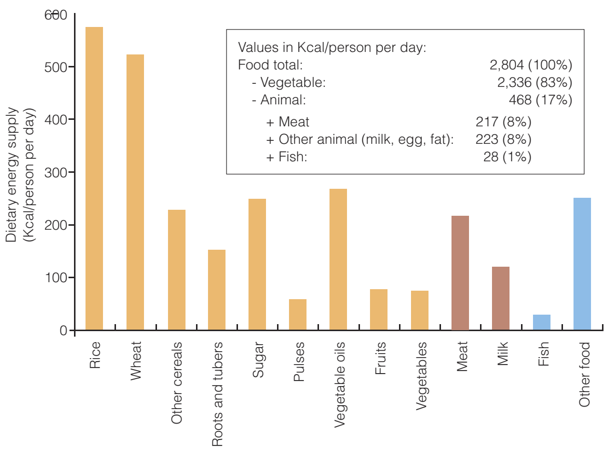
Rice is produced primarily for domestic consumption. Less than six per cent of the global rice production is traded internationally. The quantity that is globally traded is very small compared to other cereals such as wheat (Figure 2.6).

Thailand, Vietnam, India and Pakistan are the main exporters. However, the most significant markets for rice exports are shifting from Mediterranean Europe and the US to West Asia. In Africa and Latin America, consumption is expanding more rapidly than domestic production.

A shop displaying different varieties of rice for sale

Unlike other cereals such as wheat, less than 6 per cent of the global rice production is traded internationally.

Figure 2.4: Different Sources of Dietary Energy Supply (Kcal/person per day)



Source: FAOSTAT, 2005

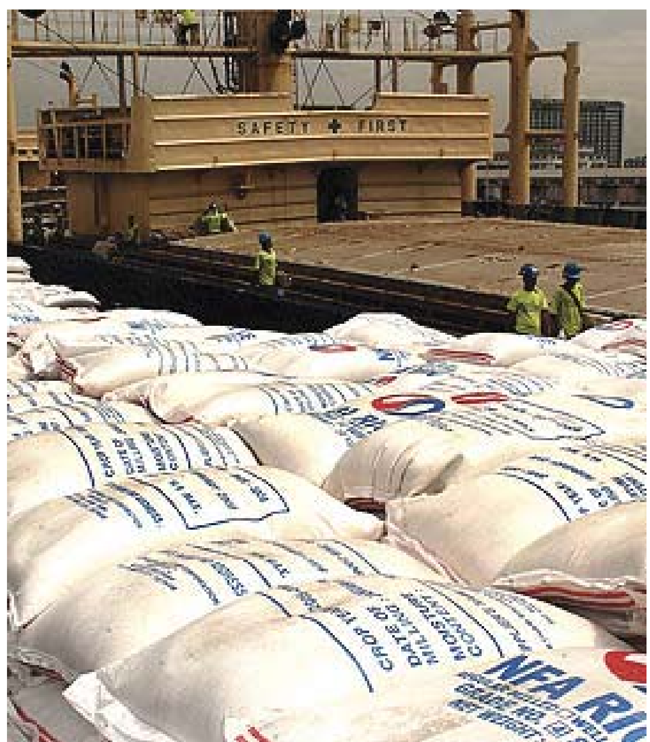
Note: Cereals, in particular rice and wheat, dominate food supply and provide the largest share of energy to the world's population. Although the livestock and fisheries sectors remain marginal in global terms, they play an important role in the supply of proteins. These global figures hide a large geographical variability in people's dietary energy supply.

Table 2.1: Main Rice Exporting and Rice Importing Countries

Rice Exporting Countries	Rice Importing Countries
USA	Nigeria
India	Bangladesh
China	South Africa
Thailand	Japan
Pakistan	Brazil
Vietnam	Malaysia

Emerging issues

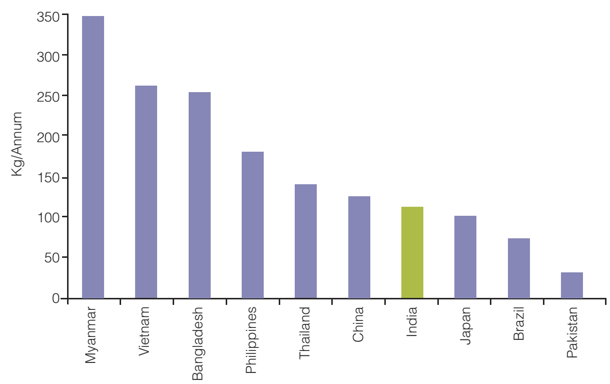
Demand for rice is expected to increase by about 38% by 2040. Yield-enhancing measures, including introduction of improved rice varieties and production technologies, are expected to help meet the projected increase. It is a different matter that effective application of research advances has been slow, often because of natural resource constraints and other adverse conditions. The other causes include institutional factors and farmers' poverty, creating a vicious cycle where producers' economic constraints keep them from taking up technologies that require greater purchasing power.



A shipment of rice imported from Vietnam uploaded at Manila, Philippines

Photo: IRRI

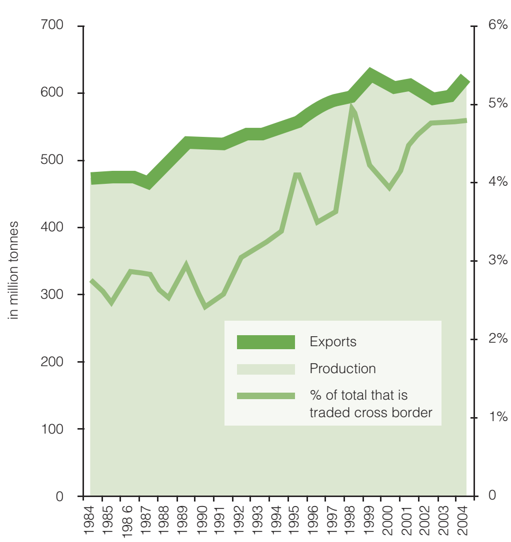
Figure 2.5: Top Ten Rice Consuming Countries (per-capita basis)



Source: FAOSTAT 2007

If we have to meet food needs without compromising on environmental integrity, it is essential to identify and adopt solutions that are environmentally more sustainable. That is, the methods adopted should reduce water consumption and increase productivity.

Figure 2.6: Rice Exports Compared with Total Production 1984-2004

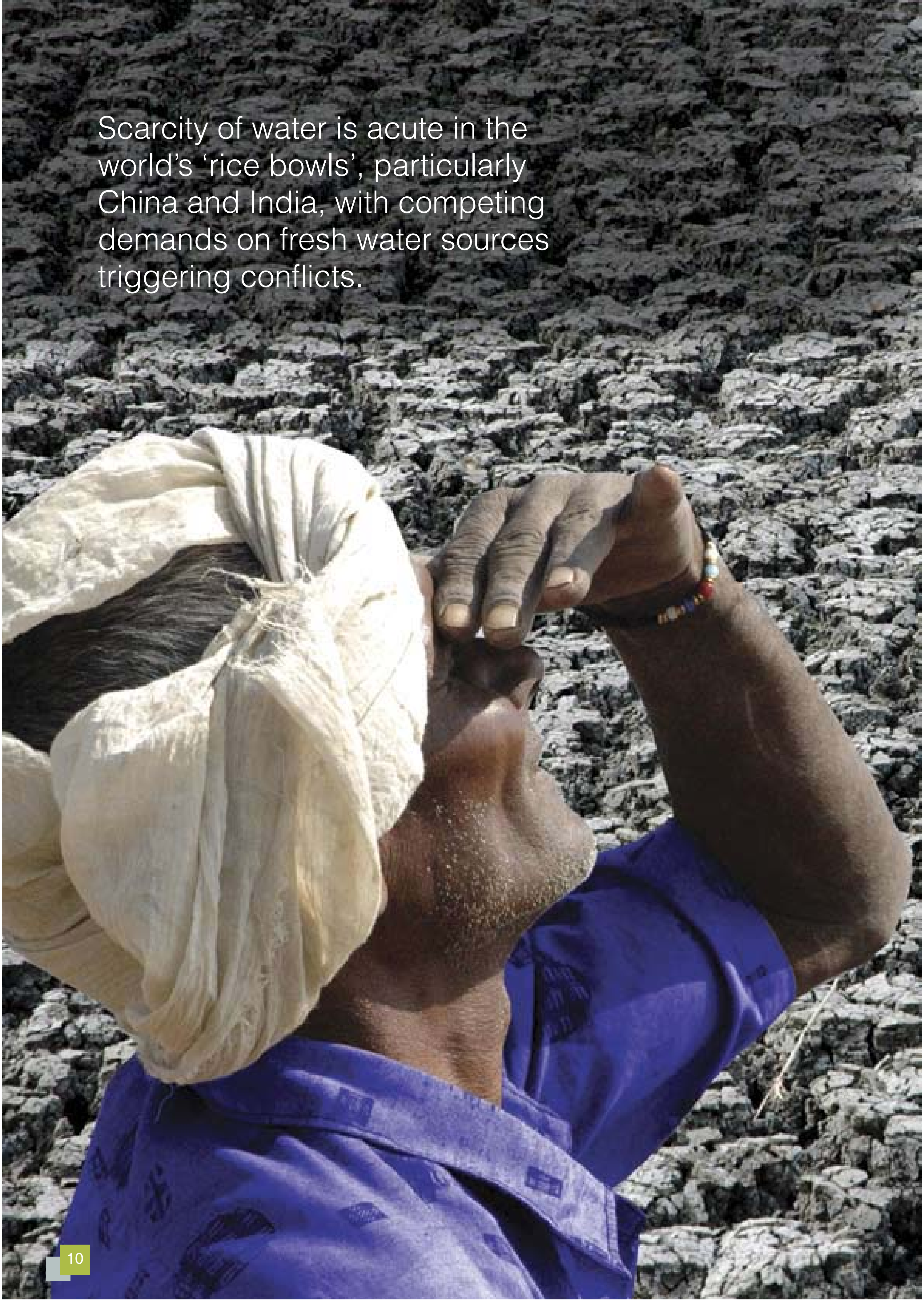


Source: FAOSTAT 2004

Improved technologies have certainly contributed to increased yields. But, there has been a slowdown in the growth rates for yield over the past decade in many countries. In the absence of substantial increases in yield levels, the ever-increasing demand for rice can be met only by bringing a larger area into cultivation, aside from extracting more and more water from ecosystems to meet the requirements of this 'thirsty' crop.

Currently, several emerging technologies intended to boost paddy yield per hectare require less water. Some of these technologies offer other economic and environmental benefits as well. The System of Rice Intensification is a well-documented methodology belonging to this ilk.

SRI can be better understood if one considers it in the backdrop of certain associated issues such as reducing dependence on agrochemical inputs (to diminish adverse impacts on the environment) and enhancing nutrient-use efficiency. The efficiency of nutrient use can be enhanced by mobilising biological processes and potentials in plants and by regulating their association with soil biota. Both plants and soil biota benefit from optimising, rather than maximising, water applications.



Scarcity of water is acute in the world's 'rice bowls', particularly China and India, with competing demands on fresh water sources triggering conflicts.

Chapter 3
Rice in a Thirsty World

Global rice production has to be increased manifold in a sustainable fashion. There are several options for doing this, but the ultimate outcomes need to be considered in terms of multiple criteria. Rice production today already faces serious problems, including depleted or depleting water resources, labour shortages and insufficient or inappropriate institutional support.

In India, the 'Green Revolution' has boosted the productivity of both rice and wheat. However, the 'Revolution' has given way to technology that thirsts for enormous amounts of water.

In India, the 'Green Revolution' has no doubt significantly boosted the productivity of both rice and wheat. The flip side is that this achievement has resulted in a situation where costs have been disproportionately rising primarily due to the increased use of resources, be it water, fertiliser or agrochemicals. In other words, the 'Revolution' has given way to technology that thirsts for enormous amounts of water.

Table 3.1: Average Water Requirement for Irrigated Rice

Sl. No.	Farm operation/ process	Consumptive use of water (mm)
1.	Land preparation	150 – 200
2.	Evapo-transpiration	500 – 1,200
3.	Seepage and percolation	200 – 700
4.	Mid-season drainage	50 – 100
	Total	900 – 2,250

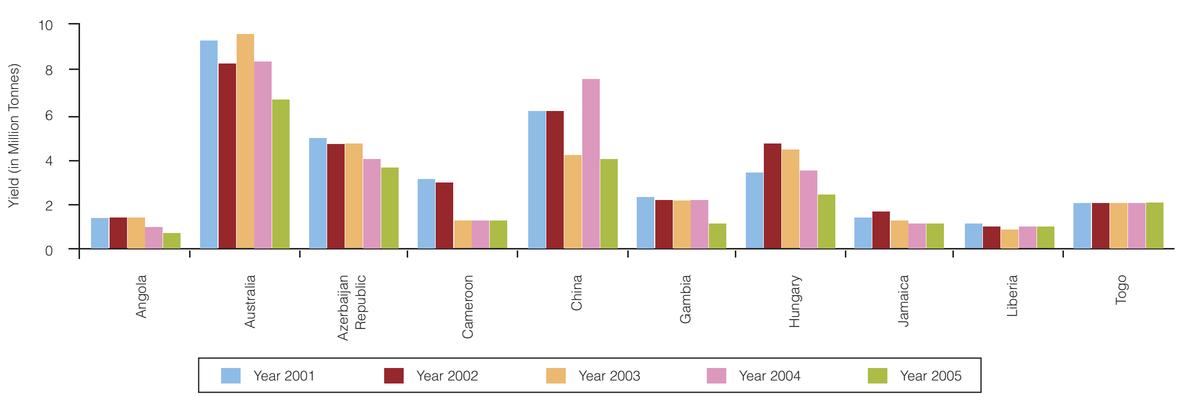
Source: FAOSTAT, 2004

In China, the area under fruits and vegetables has expanded from 3% of the cultivated area to 9% over the last two decades due to water shortages for paddy cultivation.

Rice production is declining, instead of increasing, in several areas across the globe, mainly due to contraction of yield and/or area. The area under rice in Japan, for instance, has declined by nearly 50 per cent since 1960. Six countries – Mozambique, Haiti, Brazil, Sri Lanka, Republic of Korea and China – are expected to decrease their total rice producing area by 2015 (Figure 3.1).

Rice farmers in many countries have switched to crops that are commercially more successful. In China, the area under fruits and vegetables has expanded from three per cent of cultivated area to nine per cent over the last two decades, with rice cultivation shrinking. In some districts, farmers are being advised to desist from sowing paddy as a way to reduce their dependence on water.

Figure 3.1: Country-wise Decline in Rice Yield



Source: Global food supply, 2002

Thirsty for Water

A significant increase in production of rice is constrained not only by paucity of land for cultivation, but also by water shortages. Scarcity of water is more common in areas where the conventional water-intensive method of irrigated rice cultivation through inundation is followed.

If we compare the relative water requirements of the world's three main cereal staples viz. maize, rice and wheat, we find that global paddy crop needs approximately up to five times the irrigation withdrawals needed by the two other major cereals combined. This is true even before any pre-saturation requirements and distribution losses are accounted for. Another way of conceptualising this is that the water needed to grow one kilo of rice with standard irrigation methods is similar to one person's daily water requirements for as much as four months (according to the standards of per capita minimum water requirements designated by the World Bank).

About 70 to 80 per cent of global freshwater withdrawals are for the agricultural sector, particularly irrigation, and rice accounts for about 85 per cent of this, mainly due to inundated production.

A girl is drawing water for her family needs from a village hole in a remote village of Tripura

Frequent water shortages result in poor growth of rice plants

Table 3.2: Water Requirement per Crop (litre/kg)

Crop	Typical water requirement (litre/kg)
Cotton	7,000 – 29,000
Rice	3,000 – 5,000
Sugarcane	15,000 – 3,000
Soya	2,000
Wheat	900
Potatoes	900

Source: FAOSTAT, 2004

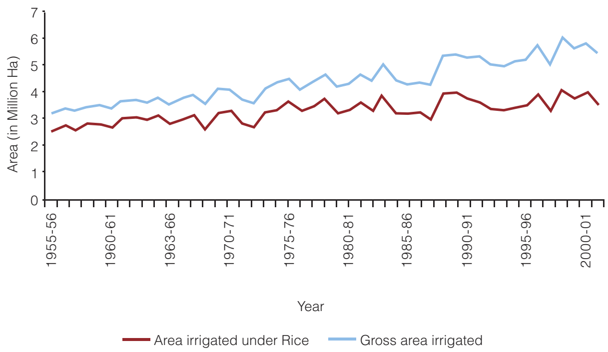
At the global level, around 63 per cent of all rice is irrigated, although regional ratios vary.

The irrigated rice area accounts for approximately 37% per cent of the global overall irrigated area. Looking more closely at the top ten rice producing countries, however, one can see a different pattern (Table 3.4).

Worldwide, rice cultivation absorbs 85 per cent of all irrigation water. In Asia, about 84 per cent of water withdrawal is for agriculture, used mostly in flooded rice irrigation. Rice cropping today accounts for about 45 percent of irrigated areas.

Barring some exceptions, in overall terms the acreage under irrigated rice cultivation increased during the 1970s, 1980s and 1990s at an average annual rate of about 0.9 per cent per year, or about 600,000 hectares annually. Thus, while in the late 1970s about 51 per cent of the total rice acreage was irrigated, the figure increased to 55 per cent in the mid-1990s and to about 59 per cent today (Figure 3.2).

Figure 3.2: Irrigated Area under Rice vs Gross Area Irrigated, A.P.



Source: Directorate of Economics & Statistics, Hyderabad

Water scarcity is already an intractable problem in many parts of the world. The United Nations estimates that about one-third of the world's population live in regions that experience water scarcity and that this will double by 2050!

Most of the rice cultivation in major rice producing countries is in irrigated areas. In India and Indonesia, the proportion is approximately 50 per cent and 47 per cent, respectively.

Water scarcity will have a significant impact on agriculture. Shortage of water for agricultural production has already become a major problem in some countries. In the world's 'rice bowls' — particularly China and India — the scarcity of water is acute, with competing demands on fresh water sources triggering conflicts.

It is estimated that close to 1.3 billion people worldwide are still without safe water supply, and the situation continues to deteriorate. Freshwater species, reckoned as an indicator of ecosystem health, have declined by 40% since the 1970s.

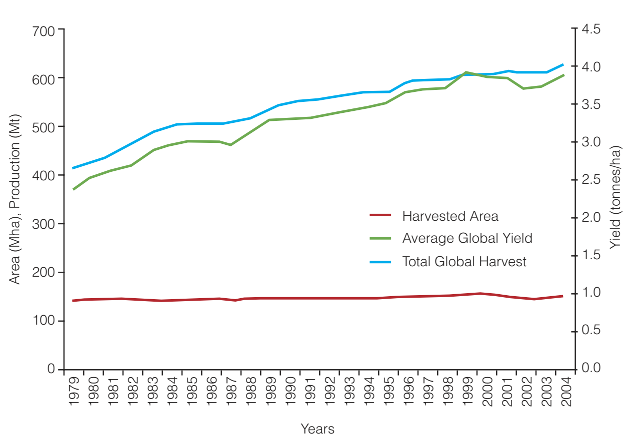
In this scenario of deepening water crisis and dwindling productivity under the inundation method of rice cultivation, a look at newer production methods that are relatively cost–effective and use water more productively becomes imperative.

Various studies and estimates lead us to expect demand for rice to increase by about 38 per cent by 2040. Considering that there is paucity of arable land required to expand rice cultivation and meet the projected demand, the gains in rice production must come largely from higher yields. With water supplies available for agriculture contracting rather than expanding, it is equally clear that a substantial increase in water inputs for boosting rice production to the required level would compromise human needs, economic growth and/or ecosystem integrity. Indeed, compromising the latter and disrupting hydrological cycles in various countries would amount to 'killing the goose that lays the golden egg,' since water will become more and more precious in the years ahead.

Given these constraints, the inundation method of rice cultivation will obviously become unaffordable, primarily in terms of water resources.

For most rice-rich and rice-dependent nations, there is a pressing need to adopt alternative, eco-friendly and pro-people production methods. Several such countries are beginning to realise that using rice cultivation methods that use water more productively, such as the SRI method, is imperative.

Figure 3.3: Global Trends in Rice Cultivation (1970-2004)



These countries know that without recourse to this option, any effort to increase rice production to meet the projected increase in demand will become untenable.

Table 3.3: Area Increase vs. Water Scarcity in South Asia

Country	Anticipated Increase (%)	Water Scarcity
Bangladesh	30.1	Economic
India	20.2	Physical
Nepal	69.4	Economic
Pakistan	46.3	Physical
Sri Lanka	Negative	Little or none

Source: Global food supply, 2002

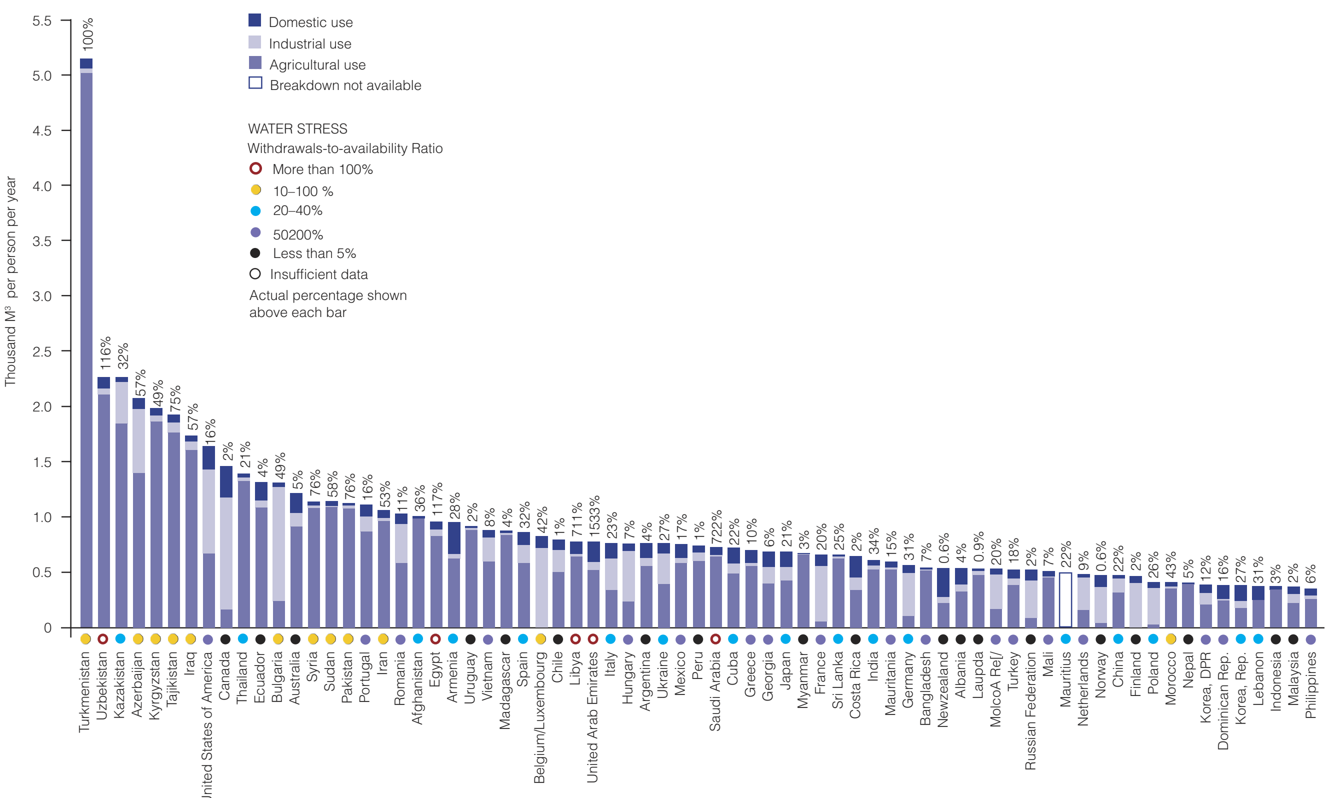
Table 3.4: Pattern of Rice Cultivated Areas

Ratios (by area)

Region	Rainfed (%)	Irrigated (%)
East Asia	29	71
Latin America and the Caribbean	49	51
Near East and North Africa	0	100
South Asia	48	52
Sub-Saharan Africa	79	21
Country	**Rainfed (%)**	**Irrigated (%)**
China	1	99
India	51	49
Indonesia	53	47
Bangladesh	45	55
Vietnam	46	54
Thailand	55	45
Myanmar	84	16
Philippines	51	49
Brazil	66	34
Republic of Korea	8	92
Top ten taken together	**37**	**63**

> In the most intensively cropped areas under rice, where groundwater is often used for irrigation, water tables have been falling at the alarming rate of one meter per year or more!

Figure 3.4: Country-wise Annual Per Capita Water Withdrawals (1998-2002)



Source: WWF Living Planet Report, 2006

Irrigated ecosystem contributes to 75% of India's rice production

Chapter 4

Rice in India

Rainfed Upland Ecosystem

The rainfed upland ecosystem is unbounded without surface or rhizosphere water accumulation. There is no soil submergence and it remains aerobic throughout crop growth. This type is spread over the States of Uttar Pradesh (eastern parts), Chhattisgarh, Bihar, Orissa, West Bengal and the hilly regions of Himachal Pradesh and Uttarakhand as well as Mizoram, Arunachal Pradesh and Nagaland. It encompasses very heterogeneous, primitive slash-and-burn shifting system *(jhoom)* as well as sparely improved and diversified cultivation methods. Due to their location in high rainfall and sloppy topographical conditions, the soils are prone to severe erosion/acidity. Seed is either broadcast in ploughed dry soil or dibbled in non-puddled soil. Productivity is low (about 1.5 t/ha) in view of several biotic and abiotic social constraints.

Average rice productivity in rainfed shallow lowlands is lower than in irrigated areas

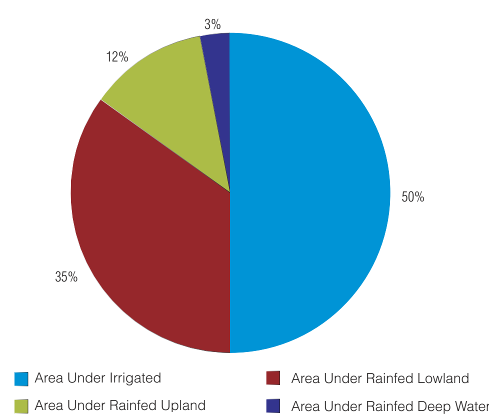
Rice Ecosystems

In India, rice cultivation is irrigated and/or supplemented by rainfed production. Of the approximately 45 million hectares under rice cultivation in the country, around 22.5 million hectares are irrigated. And about 17 (38%) million hectares of rice-growing areas are in rainfed shallow lowland and deep water areas. Less than 6 million hectares (about 12 per cent of rice-growing acreage in the country) are in upland unirrigated areas, with no access to irrigation. Depending upon the water regime, the area under rainfed rice is categorised as upland (unbunded without standing water), lowland and deep water (via 'green water'). (Figure 4.1).

Rainfed Shallow Lowlands Ecosystem

Depending on the duration of rainfall, rainfed shallow lands exhibit uncontrolled shallow water depth ranging 1 – 50 cm. The fields are less sloppy/flat and bunded. Owing to non-continuous flooding of variable depth, alternative aerobic to non-aerobic soil conditions are created. The system occurs mainly in the States of Uttar Pradesh (eastern parts), Chhattisgarh, Orissa, Bihar, West Bengal, Assam, Tripura and Manipur. Rice is directly seeded in puddle or ploughed soils. Because of a welter of biotic and abiotic stress, the average rice productivity in this system is lower (2.5 t/ha), compared to that in irrigated low land situation, although it is much higher than in other rainfed ecologies.

Figure 4.1: Ecosystem-wise Distribution of Rice Area in India During 2001-02



Source: IRRI Statistics

Ghansali-Uttarakhand paddy fields in the Himalayan valley

Rainfed Deep Water Ecosystem

Deep-water rice fields are unbounded, with maximum sustained water depth of 0.5 to 3 m. These environments are similar to rainfed uplands in initial stages, since seeds are broadcasted/drilled on ploughed dry soil. They occur in low lying/depressed locations where runoff water from catchment areas accumulates during later crop growth stages. The initial aerobic soil condition is converted into anaerobic soil condition on receipt of the runoff water. Specially adopted cultigens that literally float on water are grown, and they cope with rising water level by exhibiting undue stem elongation aided by ethylene production. This ecosystem occurs chiefly in the States of Uttar Pradesh (eastern parts), Chhattisgarh, Bihar and West Bengal. Its production is obviously very low (0.9 t/ha).

Irrigated Lowland Ecosystem

Rice fields under this environment have sufficient water available through the growing seasons, with controlled shallow water depths ranging between 5 and 10 cm. Continuous shallow submergence is a dominant and a unique feature of this system, which influences natural resource management.

Irrigated ecosystem is important, as it accounts for nearly 50% area and yields under it are higher (4.5 t/ha). It contributes to 75% of the country's rice production. Crop is mainly transplanted upon 25–35 days old seedling in puddle field, and continuous submergence is maintained throughout crop growing season. Thus, anaerobic soil conditions are created throughout crop growth.

Region-wise, irrigated ecosystem is predominant in the States of Punjab, Haryana, and western Uttar Pradesh in the North, and in the States of Andhra Pradesh. Tamil Nadu, Karnataka and Kerala in the South. These soils are put to intensive cultivation, raising 2-3 crops a year continuously. Farmers have relied on chemical fertilisers/ pesticides to ensure higher productivity since the Green Revolution. However, of late overall productivity of such lands has been observed to decrease due to several constraints.

Under irrigated ecosystems, soils are often put to intensive cultivation, with 2 or 3 crops raised throughout the year

Production and Productivity

Rice production in India increased 4.5 times during the last 57 years from 30.9m t in 1950 to 139.4m t in 2006. The national rice output level of 138.9m t expected this year (2006-07) is marginally lower than the all-time high of 140.7m t recorded in 2001-02.

Data relating to rice production and productivity across key rice-growing States during 2001-02 (Table 4.1) suggests that West Bengal, Uttar Pradesh, Andhra Pradesh, Orissa and Chhattisgarh are the top five rice producers. West Bengal and Uttar Pradesh are foremost in terms of rice area too, while Orissa, Andhra Pradesh and Chhattisgarh come next among the top five States where rice is widely cultivated. As for rice productivity, Punjab (5.32 t ha^{-1}) ranks first, followed closely by Tamil Nadu (4.79 t ha^{-1}), Andhra Pradesh (4.47 t ha^{-1}), Haryana (3.97 t ha^{-1}) and West Bengal (3.77 t ha^{-1}).

Rice production in India increased 4.5 times during the last 57 years. The enhanced rice production is deemed to be largely productivity-led, though rice productivity is now improving at a much slower rate.

Rice productivity increased three times, from 1.0 t ha^{-1} in 1950 to 3.1 t ha^{-1}, in 2001-02. The enhanced rice production is deemed to be largely productivity–led, since the harvested rice area for the corresponding period expanded from 31m ha to about 44m ha, accounting for a 42% increase. However, rice productivity is now improving at a much slower rate (deceleration), compared to that recorded during earlier decades.

The most disconcerting feature of rice growth is the slower growth rate of 1–1.5% per annum due to decreased total factor productivity. This is clear from an examination of rice productivity trends (Figure 4.2) between 1995 and 2004 across the country with regard to important rice producing States. The All India mean annual growth rate is literally stagnant at 0.54%. Only a couple of States like West Bengal (1.63%) and Andhra Pradesh (1.25%) could record mean annual productivity growth rates ranging between 1% and 2%. Tamil Nadu (0.94%) and U.P. (0.9%) come next, recording average annual growth rates of around 1%. The mean productivity growth in Punjab has almost levelled off. Bihar has recorded a decline (negative) in annual growth rate. Overall trends suggest that there are signs of imminent stagnation/plateauing/ decline in rice productivity trends across the country, requiring implementation of strategies that would reverse these negative features in the near future.

Mechanised winnowing of paddy

Low productivity is attributed to many factors, including high dependence on rains, delayed sowing, transplanting, inadequate plant population, low seed replacement rate, frequent floods and droughts, low sunshine hours with a cloudy weather, deficiency of micro nutrients and impaired soil health. The technological and nutrient-related constraints together have affected the total factor productivity, which has declined sharply over the years. This signifies reduced rate of response in terms of unit gain in productivity with application of similar inputs over time.

Production potential analysis of the available data indicates that further gains will have to come from some of the eastern States – including Uttar Pradesh (eastern parts), Bihar, West Bengal, Orissa, Assam; southern States, including Tamil Nadu, Andhra Pradesh and Karnataka, and central States, including Jharkhand and Chhattisgarh.

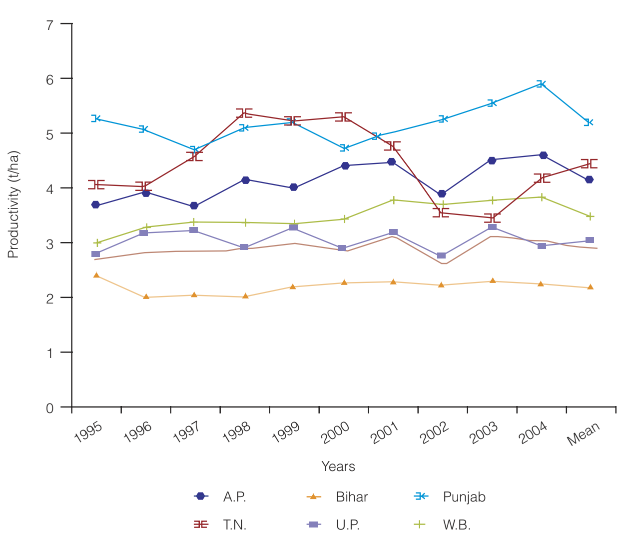
In terms of administrative blocks, 534 out of India's 604 districts grow rice. As rice plays a significant role in providing food security and meeting nutritional requirements, there is a crying need for substantially increasing rice production at the national level. The task ahead is uphill, considering deteriorating natural resources (land and water) and the process of switching from rice to alternative crops initiated in certain States such as Haryana, Punjab, Tamil Nadu and Uttar Pradesh (western parts) due to depleting groundwater reserves and soil carbon content.

Table 4.1: Rice Production in India across Key States 2001–02

S. No.	State	Area (000 ha)	% to the total area	Production (000 t)	% to the total production	Average yield (t/ha)
1	Uttar Pradesh	6071	13.89	19284	14.11	3.18
2	West Bengal	6069	13.89	22885	16.75	3.77
3	Orissa	4500	10.30	10723	7.85	2.38
4	Andhra Pradesh	3825	8.75	17085	12.50	4.47
5	Chhattisgarh	3810	8.72	7611	5.57	1.99
6	Bihar	3552	8.13	7804	5.71	2.2
7	Assam	2537	5.80	5781	4.23	2.28
8	Punjab	2487	5.69	13224	9.68	5.32
9	Tamil Nadu	2060	4.71	9876	7.23	4.79
10	Madhya Pradesh	1776	4.06	2539	1.86	1.43
11	Jharkhand	1521	3.48	2733	2.00	1.8
12	Maharashtra	1514	3.46	3977	2.91	2.63
13	Karnataka	1418	3.24	4851	3.55	3.42
14	Haryana	1028	2.35	4086	2.99	3.97
15	Gujarat	668	1.53	1560	1.14	2.34
16	Kerala	322	0.74	1055	0.77	3.27
17	Uttarakhand	299	0.68	922	0.67	3.1
18	Jammu & Kashmir	250	0.57	633	0.46	2.53
	India	**43707**		**136629**		**3.05**

Source: IRRI Statistics

Figure 4.2: Rice Productivity in Key States of India 1995-2004



Source: IRRI Statistics

As a way to increase rice productivity, the Government of India has launched programmes that encourage the use of high-yielding varieties, improved nutrient inputs and modern technological methods. These include the Special Rice Production Programme (SRPP) and the Integrated Programme for Rice Development (IPRD).

Table 4.2: Plan-wise Area Under High-Yielding Rice Varieties

SL	Plan	Period	Area in '000 hectares
1.	IV Plan	1969-70 to 1973-74	7,098.20
2.	V Plan	1974-75 to 1978-79	13,986.40
3.	VI Plan	1980-81 to 1984-85	20,255.40
4.	VII Plan	1985-86 to 1989-90	24,263.70
5.	VIII Plan	1992-93 to 1996-97	30,905.60
6.	IX Plan	1997-98 to 1999-00	33,994.20

Deepening Water Crisis

The Food and Agriculture Organisation's *'Report of the Expert Consultation on Bridging the Rice Yield Gap in the Asia-Pacific Region'* published in October 1999, says: "Countries like India and China are approaching the limit of water scarcity." Along the same lines, the International Water Management Institute (IWMI), in its Working Paper No 23, mentions that India is already experiencing "physical water scarcity," which is defined in terms of the magnitude of primary water supply (PWS) development relative to potentially utilizable water resources (PUWR).

The Mini Mission II on Technology Mission on Rice is the latest programme launched as part of the National Food Security Mission. It envisages increase in rice production to 11 m t by 2011-12. The goal will be achieved primarily by improving productivity in 20m ha located in 136 identified districts of 10 States, with a financial outlay of Rs 2,598 crores (USD 637 million) during the XI Plan i.e. 2008-09 to 2011-12. The States – Andhra Pradesh, Assam, Bihar, Chhattisgarh, Jharkhand, Karnataka, Orissa, Uttar Pradesh, Tamil Nadu and West Bengal – have been identified on the basis of area under rice, level of irrigation, and potential for increase in productivity. The System of Rice Intensification (SRI) is among the identified interventions for enhancing productivity.

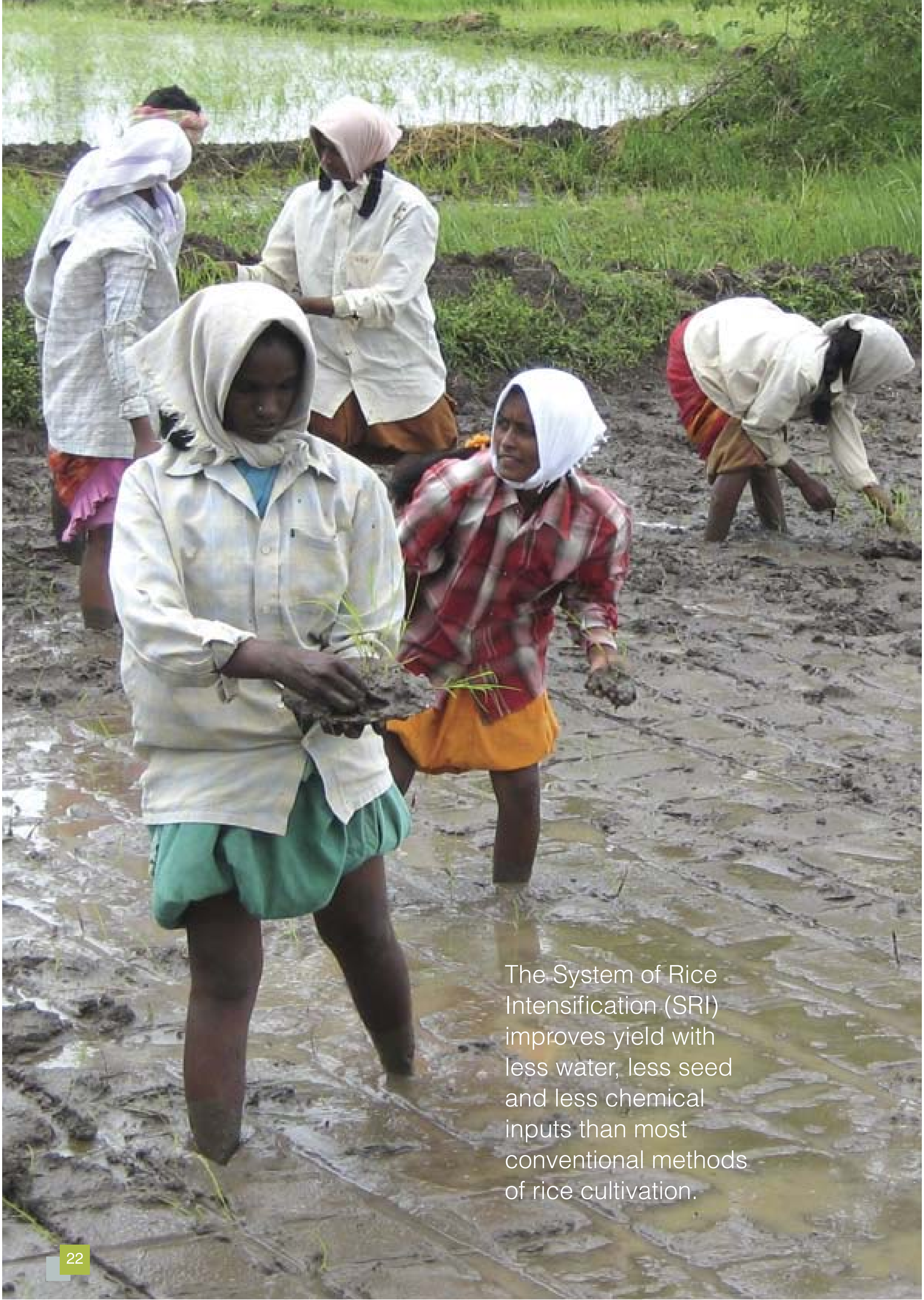
Poverty rates are higher in the tail-ends of systems where water is less and productivity is low.

Physical water scarce condition is reached once a country's primary water supply exceeds 60% of its PUWR. This level means that even with the highest feasible efficiency and productivity of water, the country's PUWR is not sufficient to meet the demands of agriculture, domestic and industrial sectors, while addressing environmental needs.

Experts have estimated that by 2025 the gap between supply of, and demand for, water for irrigation in India will be 21 billion cubic meters (BCM). In addition, several micro and macro level factors such as improper management of water resources, lopsided farm management, poor crop husbandry, ineffective infrastructure and unplanned capital development plague agriculture in India.

A study by the Asian Development Bank, entitled *'Pro-Poor Intervention Strategies in Irrigated Agriculture in Asia'*, which was released in July 2005 following field surveys of irrigation systems in Andhra Pradesh and Madhya Pradesh, states: "Poverty rates are higher in the tail-ends of systems where water is less and productivity is low. Strangely, though, poverty rates are not necessarily lower in the head reaches, even though they are nearer to the water source. Poverty rates are consistently higher in non-irrigated rather than irrigated areas. However, in rainfed areas surrounding the studied systems, poverty levels were reduced by factors of non-farm income, larger landholdings and groundwater use. Within systems, the poor generally receive less irrigation water than the non-poor in both dry and wet seasons."

The situation is worsening in India (and elsewhere) due to political unwillingness to adopt demand-management approaches to water-resource limitation. Studies under way in Chhattisgarh have shown that the preferred asset-building approach of expanding water supply directs additional withdrawals into under-productive uses, leaving even less for wise allocation throughout the water economy.



The System of Rice Intensification (SRI) improves yield with less water, less seed and less chemical inputs than most conventional methods of rice cultivation.

Chapter 5

SRI ¸ The System of Rice Intensification

The conventional rice cultivation method under irrigated condition involves land levelling and construction of irrigation channels. During land preparation, rice seeds are soaked, ahead of planting. Seeding is mechanised in some developed countries. In most developing countries, including India and China, the process is manual, with the seeds sown either directly or into nursery beds for later transplantation. In the latter case, traditionally seedlings are transplanted in bunches from nursery beds into flooded paddies after 20-50 days of growth, although direct seeding, bypassing transplantation, is currently becoming more common. The average seed rates result in roughly 200-300 seedlings per square meter. The rice fields are inundated with water for about three months or so, and are drained only before the harvest.

Currently, mainstream technological options to improve rice production focus mainly on selection of varieties; introduction of improved seeds, including genetically-engineered and higher-yielding varieties; crop nutrition; and weed, pest and disease control. Interestingly, SRI is an alternative that does not depend on such agronomic tactics. This all-encompassing system complements these requirements.

Eight Steps to A Healthy Mix

The System of Rice Intensification was developed in Madagascar and popularised in the 1980s by Henri de Laulanié, a French Jesuit priest. Developed quite experimentally and inductively, SRI is not a standardised technological method. More importantly, it is a methodology for comprehensively managing resources— changing the way land, seeds, water, nutrients and human labour are used. SRI is an amalgamation of multiple beneficial practices that Father de Laulanié observed.

Young rice seedling with roots, seed and soil mass intact

SRI has eight basic principles:

- Preparing high-quality land
- Developing nutrient-rich and un-flooded nurseries
- Using young seedlings for early transplantation
- Transplanting the seedlings singly
- Ensuring wider spacing between seedlings
- Preferring compost or farmyard manure to synthetic fertilisers
- Managing water carefully so that the plants' root zones moisten, but are not continuously saturated
- Weeding frequently

Land preparation: The required moisture level has to be maintained uniformly. For best results, SRI requires careful ploughing, puddling, levelling and raking, with drainage facilitated by 30 cm wide channels at two-meter intervals across the field.

Nurseries: The seedbeds have to be nutrient-rich and established as close to the main field as possible. This will enable quicker and easier transportation between the nurseries and the fields, minimising both transport time and costs so that the seedlings are efficiently transplanted. No chemicals are applied to the seedbeds.

Transplanting: This has to take place when the seedlings are just 8 to 12 days old, soon after they have two leaves, and at least before the 15th day after sowing. The seedlings must be transplanted with their roots intact, while the seed sac is still attached. They must not be plunged too deep into the soil, but placed on the ground at the appropriate point on the planting grid. Transplanting should be at 1-2 cm depth at the most. Transplanting should be done quickly, after gently removing seedlings from the nursery bed. The roots should not dry out. Care should be take to avoid causing trauma to the roots.

Spacing: The seedlings should be planted at precise spacing, usually 25 X 25 cm, about 16 plants per square meter. Rice plant roots and canopies grow better if spaced widely, rather than densely. This exposes each plant to more sunlight, air and soil nutrients, and allows easier access for weeding.

Soil nutrients: It is better to use organic nutrients, as they are better at promoting the abundance and diversity of microorganisms, starting with beneficial bacteria and fungi in the soil. This will promote proper microbial activity, thereby improving production. Under SRI method, even farmers who do not have access to organic manure may use less chemical fertilisers.

Watering: SRI requires the root zone to be kept moist, not submerged. Water applications can be intermittent, leaving plant roots with sufficiency, rather than surfeit, of water. Such management encourages more extensive, healthy root systems, and avoids root degeneration.

More intensive management involves daily application of small amounts of water on a levelled field. Farmers can decide for themselves which system is feasible for them and most beneficial for their crop, given soil biota. Reliable and precise irrigation service delivery is important -- especially in the early growth period. Once the roots are well-established, irrigation can be halted for three to six days at a time to encourage downward root growth. Some drying out of the soil is beneficial for the roots and soil organisms. SRI uses much less water than conventional methods of rice cultivation.

Weeding: Since there is no standing water and no continuous submergence of rice plants under SRI, weeds tend to proliferate, requiring careful and frequent weeding. The first weeding has to be done within 10 to 12 days of transplantation, and further weedings may be required at intervals of 10-12 days. Weeding must continue until the crop has grown to such level that the canopy obviates weeding.

Cost-effective in Every Way

The System of Rice Intensification improves yields with less water, less seed, and less chemical inputs than most conventional methods of rice cultivation. This means that the returns on inputs are higher, making the method potentially more profitable than most of the traditional methods. Initially it does require significantly more labour – mainly for preparing land and weeding. Most SRI farmers have found that as they get to know the methods better and gain confidence in them, their pace of work speeds up, and SRI actually becomes labour-saving.

SRI could contribute to job creation in rural areas. It is a different matter that SRI is becoming popular more for the obvious overall productivity gains in land, labour, water and capital.

Young seedlings scooped from nursery bed along with soil are being taken for transplanting

Higher Yields

SRI improves the productivity of land, labour, water and capital used in rice cultivation. Implementation of SRI has helped improve the yield of local varieties by between 6 and 8 tonnes per hectare. With improved management, hybrid varieties have yielded between 10 and 12 tonnes per hectare under SRI. Often a 20 to 40% increase in yield compared to that under conventional methods is observed in SRI. However, the actual yield increases depend on how well farmers practice SRI.

SRI improves the productivity of land, labour, water and capital used in rice cultivation.

Periodical running of weeder improves aeration and incorporates weeds into the fields

- SRI uses 25-50 per cent less water than conventional rice cultivation methods.
- SRI uses 25-50 per cent more labour than conventional rice cultivation methods in the initial stages. Once farmers master the techniques, SRI more often will reduce labour requirements by about 10 per cent.

Source: Norman Uphoff, 'System of rice intensification responds to 21st century needs',

Rice Today, May-September 2004.

Women transplanting one week old rice seedlings at wide spacing with the help of a rope

SRI in India

- A study of 110 farms in Purulia district of West Bengal found that the SRI method improved paddy yields by an average of 32 per cent in two rainfed villages, one of which had been hard-hit by drought.

- In Balrampur block, which was not drought-affected, the average paddy output from SRI farms was 6.3 tonnes/ha, compared to 4.2 tonnes/ha from farms using conventional methods (49.8 per cent higher). Seed requirements for SRI farms were only 2.87 kg per acre, compared to 27.17 kg per acre in the case of conventional farms.

- In Gujarat, studies by Anand Agricultural University found that while conventional methods of rice cultivation yielded 5.840 tonnes/ha of grain, the SRI method yielded 5.813 tonnes/ha, but with 46 per cent less water usage.

- Tripura, which introduced SRI in 2001, today has about 14,000 ha of the total paddy area under the method. One can find large contiguous areas of 30-50 ha under SRI method covering groups of 20-50 farmers. Many farmers have reported higher yields. Some high yielding varieties yielded 5 to 8 tonnes per hectare under SRI method, compared to 3 to 5 tonnes/ha under conventional methods. Even the local scented and non-scented varieties showed improvements from 1.5 – 2.0 to 3.1 – 3.4 and 2.0 – 3.0 to 3.8 – 4.3 t/ha respectively.

- In Orissa, the experience of PRADAN, an NGO, is very encouraging. In Kharif 2006, of the total 1,100 SRI farmers about 67 per cent got yields of more than 6 t/ha, with the average under conventional methods being 2.5 t/ha.

- A study by the Acharya N G Ranga Agricultural University (ANGRAU), Hyderabad, covering 22 districts of Andhra Pradesh in 2003-06, found that on farms using the SRI method, seed reduction was 90 per cent, about 50 per cent less water was used, and yield improved on average by two tonnes per hectare (see Chapter 6).

SRI in China

- Experiments since 2000 have shown that rice yields under SRI have risen by 35.6 per cent, compared to yields from conventional rice growing.

Many farmers in India and elsewhere are still experimenting with SRI. Since it does not involve seed-based technology, farmers find it easy to adopt the method. Some innovate to adapt the method to suit local conditions. SRI offers unlimited opportunities for exploration and innovation for local adoption in most of the ecosystems. The challenge for those mandated to popularise and promote it lies in the adoption of extension methodologies.

SRI offers unlimited opportunities for exploration and innovation

Since SRI is still evolving, scientists should examine farmers' outcomes and experiments with an open mind so as to contribute to experts' overall understanding of the intricacies of the method. Like any scientific experiment, some of the farmers' SRI experiments might not result in successful outcomes. They need to appreciate the farmers' willingness to experiment with the adoption of new technologies, including SRI.

The table below summarises the key differences between conventional and SRI methods:

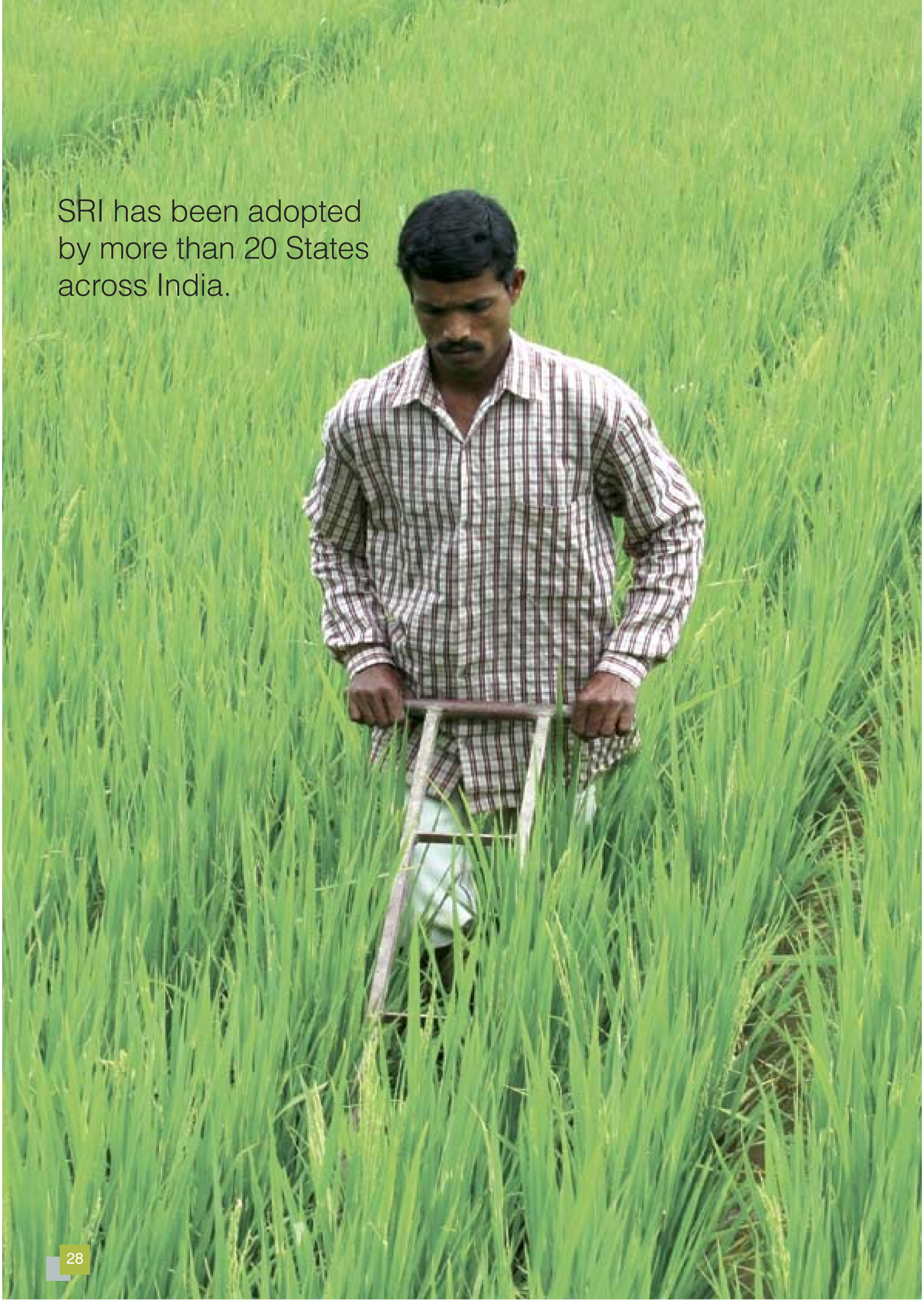
Table 5.1: SRI vs Conventional Methods of Rice Cultivation

Item	Conventional method	SRI method
Seed	50-60 kg /hectare	5 kg seeds/hectare
Transplanting	Seedlings about 30 days' old	Seedlings about 8-12 days' old
Number hills/sq.m	About 30-40 hills (clumps) are planted	About 16 hills
Number of seedlings/hill	Usually three or more seedlings are planted	Only one seedling
Fertilisation	Application of chemical fertilisers, pesticides, herbicides and insecticides	Preference given to organic fertilisation, non-chemical means of weed control; pesticides, insecticides usually not necessary
Water management	Continuous flooding	Only moist conditions
Weed management	Weeds manually removed from the field	Weeds turn down into the field by a weeder

SRI increases yields of traditional varieties too!

In 2006, Kishan Rao, an enthusiastic SRI Farmer from Khammam district of Andhra Pradesh, tried SRI method to grow *rakthasaali*, an indigenous variety of rice common in Puri district of Orissa. The variety is so named because the grains are red in colour, and locally it is believed that regular consumption of the grains would enrich blood quality. Cultivated for hundreds of years, it had remained untouched by modern-day breeders. About 400 grams of pre-germinated seed was sown on a piece of land measuring 685 sq. m. Only well-composted manure was liberally applied one month after transplantation. The crop grew vigorously and reached a height of 5 feet 9 inches. With healthy and profuse tillering, it yielded about 270 kg or 3.938 tonnes per ha in a crop period of 130 days. Disease incidence was not observed at all. This initiative demonstrates amply that even indigenous varieties perform well if SRI methodology is used and that SRI is ideal in giving impoverished rural communities the much-needed food and health security, while conserving scarce natural resources, particularly water.

SRI has been adopted by more than 20 States across India.



Chapter 6
WWF and SRI

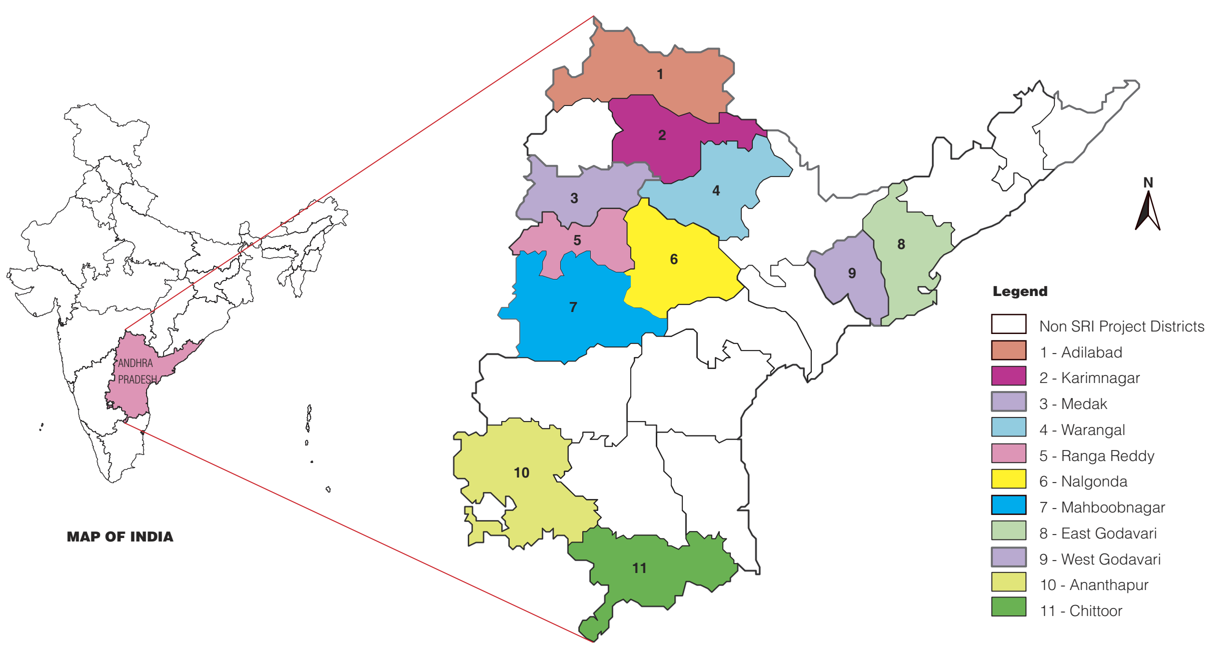
The FAO has forecast that by 2030 the global harvested area of rice will increase by 11 per cent, with South Asia accounting for an overwhelming majority of that increase (almost 75 percent). This corresponds to over 24% increase in South Asia's harvested area.

The moot question is: Where is the water for this phenomenal increase going to come from if methods of production, oriented towards continuous flooding of rice paddies, are to remain unchanged? This question assumes added significance if we consider areas where water scarcity is already a matter of concern and in irrigated areas where rice is known to take a major share of available water.

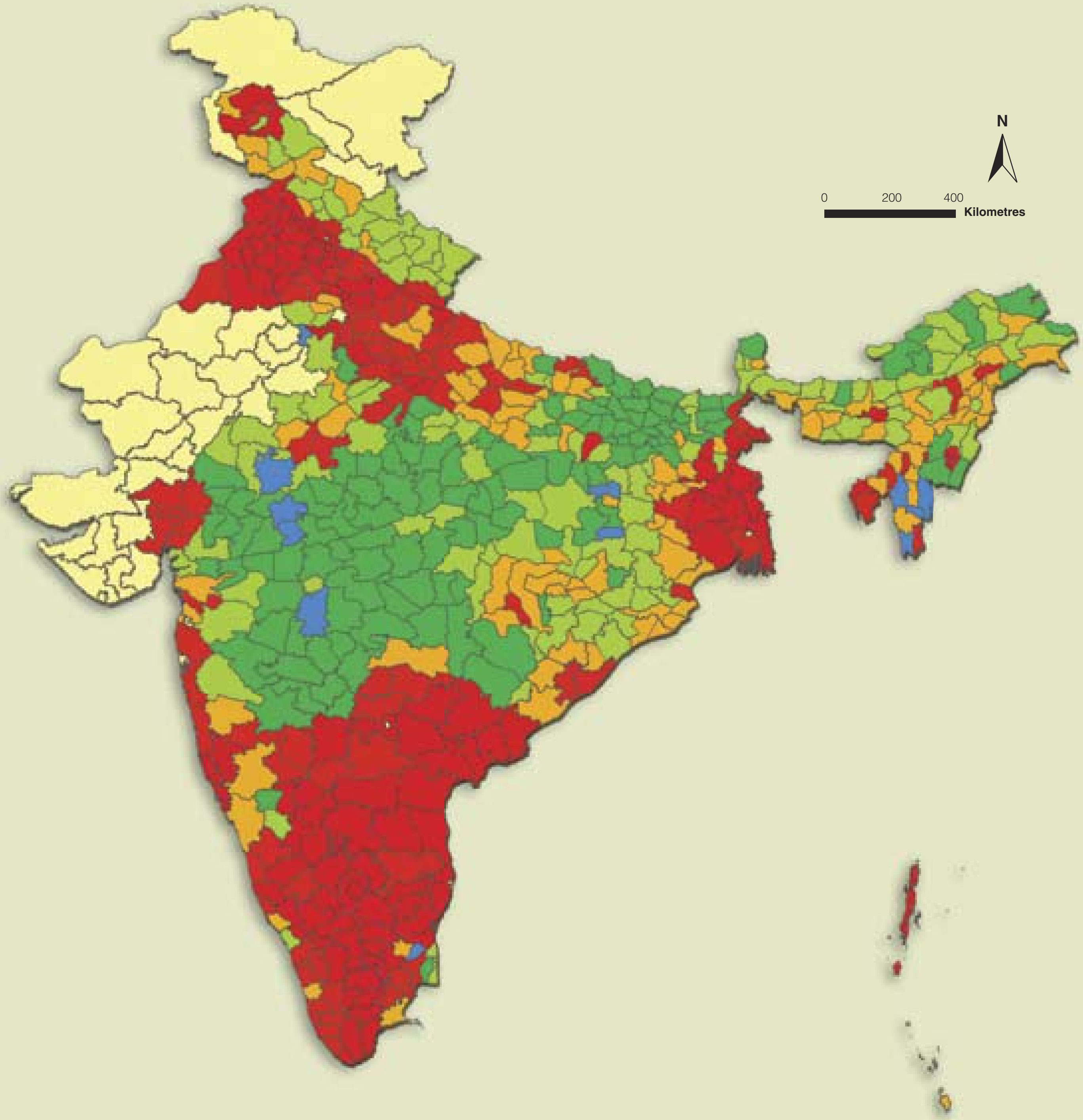
India has 604 districts in twenty eight States and seven Union Territories. According to *'Hand Book of Statistics 2006'* Directorate of Rice Development, Ministry of Agriculture, out of these 604 districts, 544 districts are under rice cultivation with area of 41.3 million hectares (which is about 13% of the geographical area of India), production around 82 million tonnes and average yield of 1,823 kg/ha. The major rice yielding States are Punjab, Andhra Pradesh, Karnataka, West Bengal and Tamil Nadu. Sangrur district of Punjab State recorded the highest yield of 4659 kg/ha. during 2004-05.

The World Wide Fund for Nature (WWF) has highlighted the need to properly evaluate, demonstrate and disseminate rice-cultivation methods that benefit farmers and consumers in the form of more remunerative crop and healthier rice respectively.

Figure 6.1: Location Map



District-wise Rice Yield in India – 2004-05

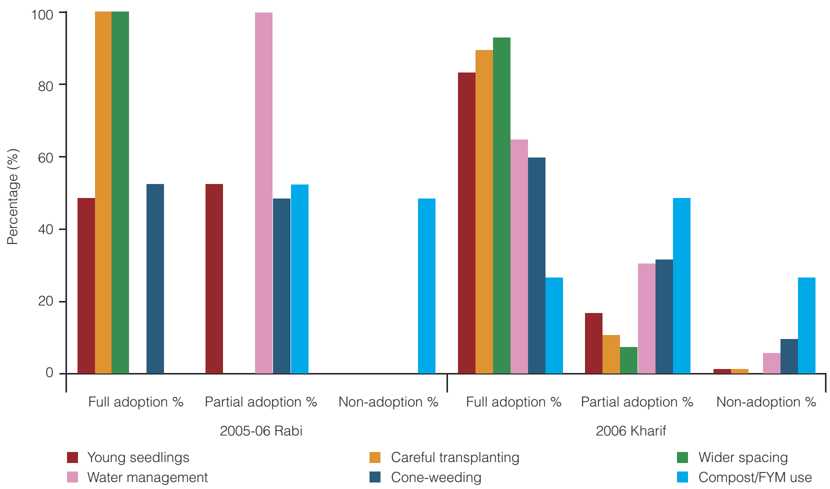


	No. of Districts	Area ('000 ha)	Production ('000 t)	Average Yield (t/ha)	Yield (t/ha)
	127	6867	4622	628	< 1
	113	7520	9143	1263	1 - 1.5
	98	8144	13849	1716	1.5 -2
	87	6107	13915	2291	2 - 2.5
	119	12712	40900	3219	> 2.5
	40	Non Rice Cultivation District			
	20	Data Not Available			
Total	**604**	**41350**	**82429**	**1823**	

Data used in the Map:
A Hand Book of Statistics 2006
DRD, Govt. of India

Note:
Data for Tripura & Tamil Nadu are of Year 2003-04

Figure 6.2: Adoption of SRI practices in AP farm demonstrations during 2005-06



Considering that not all have used all of the recommended practices, the results to date have been somewhat partial, leaving room for greater involvement by the project authorities to refine the method further.

With support from ICRISAT and in cooperation with Acharya N.G. Ranga Agricultural University (ANGRAU), Directorate of Rice Research (DRR), Indian Council of Agricultural Research (ICAR), NGOs and farmers, WWF has been assessing and publicising SRI under the auspices of the International Dialogue on Water, Food and Environment. Since 2004, SRI has been systematically evaluated and promoted in 11 districts of Andhra Pradesh – Adilabad, Anantpur, Chittoor, East Godavari, Karimnagar, Mahboobnagar, Medak, Nalgonda, Ranga Reddy, Warangal and West Godavari (see map on previous page). The farms on which trials were conducted vary with regard to soil type and access to water resources. On-farm trials were also conducted in the research stations of ANGRAU. With the assistance of ICRISAT and DRR, the WWF project also assessed microbial activity in soils associated with SRI, aside from water-saving and productivity experiments.

Training

The project organised initial training in SRI method for 616 farmers over four seasons extending between 2004 and 2006. The participants were given mechanical weeders and markers for indicating transplantation cross-points. The other aspects covered during the initial training included preparing nurseries, levelling land, constructing channels, maintaining soil moisture and draining paddies.

Awareness and training meetings convince farmers to adopt SRI

In addition, WWF organised a technical workshop to evaluate weeder designs. The workshop brought together people from academic institutions and farmer-innovators who had designed weeders that were modified versions of those originally distributed as part of the project. This led to improvements in the design of the implement as well as better control over weeds.

Results and Evaluations

Evaluations, which began in 2004, are now in their fourth year. Every season, about 200 farmers participate.

All participating farmers followed the recommended transplanting methods, which by themselves enhance crop performance. But, most of them failed to fully follow the recommended water management methods, since many lacked facilities designed to alternatively wet and dry the soil. The adoption of organic matter for soil fertilisation has been uneven, often limited but in some districts highly accepted: Ranga Reddy (78 per cent), Nalgonda (82 per cent), Medak (84 per cent), West Godavari (95 per cent), and Chittoor (100 per cent). The graph below shows the levels of adoption of SRI practices across the districts.

Women labour groups need training for new skills in SRI

With improvement in irrigation facilities and through operations that enable farmers to cultivate rice with less water, both yield and water saving should increase in future demonstration.

Multiple Benefits

One independent survey of 81 farmers in Mahabubnagar, Ananthapur, Warangal and East Godavari districts, where the farmers have been cultivating rice under the SRI method on 44 acres in all, found that the yield improved by more than one tonne per hectare. It also found that farmers overcame risks and could enhance their returns. The farmers also explored opportunities and made decisions concerning expansion.

Figure 6.3: Effects of SRI Methodology on Grain Yield during 2005-06

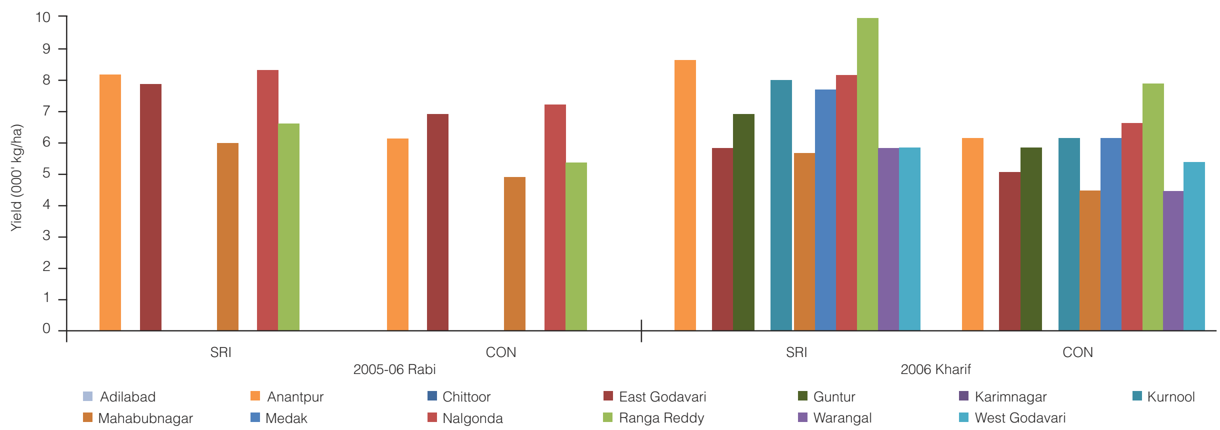
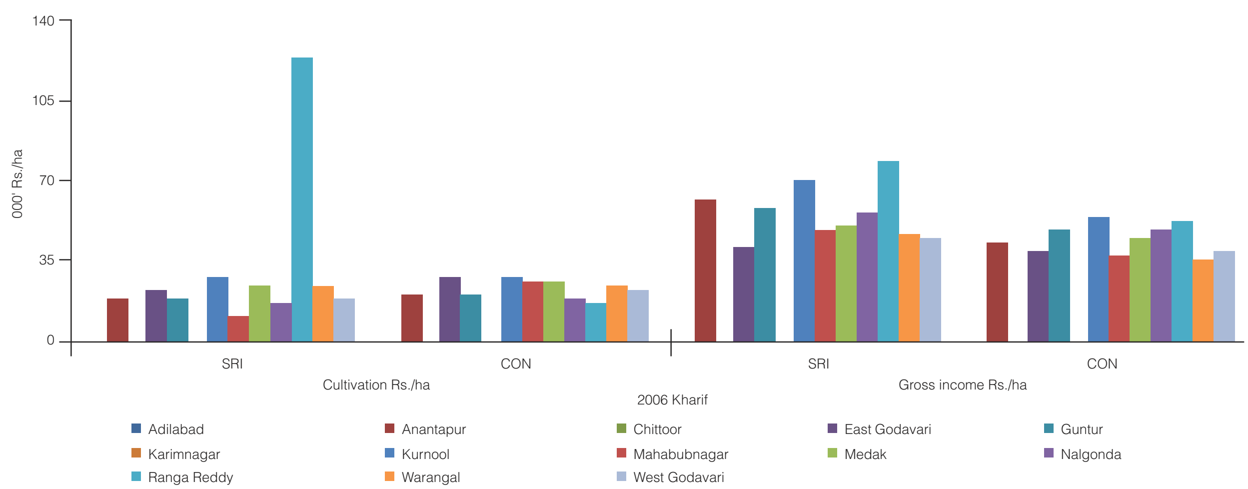


Figure 6.4: Economic Returns of SRI and Conventional Methods in Kharif 2006

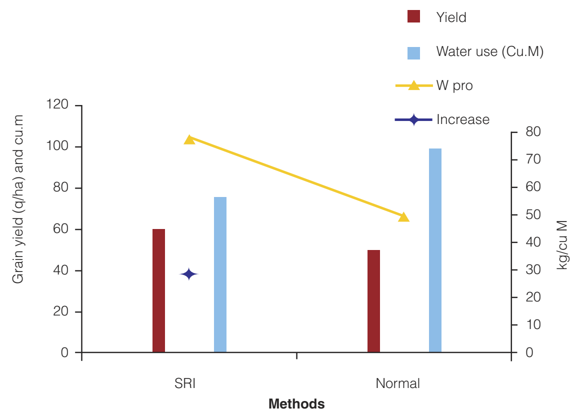


While social and peer pressure emerged as the principal reasons for non-compliance with some of the recommended measures, erratic and limited power supply was found to be the main reason for imperfect water management. Weeding was also a bottleneck for farmers who did not have access to good quality rotary hoes. With improvements in irrigation facilities and through operations that enable farmers to cultivate rice with less water, both yield and water-saving should increase in future demonstrations.

Water and Rice Productivity

Though the farmers physically observed water savings in their fields and were convinced that the SRI methodology helps reduce water consumption and increase the grain yields, scientific evaluation of water utilisation could not be definitively established due to certain field-level constraints. On-farm trials in DRR Research station, using high quality water meters, showed 20 per cent increase in water productivity over conventional flooding method (Figure 6.5).

Figure 6.5: Water Productivity in SRI and Conventional Flooding Methods



The need of the hour is a shift in policies so that authorities at the local, state and national levels can actively promote the SRI method.

Considering the use of differing levels of a given input (e.g. compost or fertilisers) by various partner farmers (sometimes it was different across two treatments of the same farmer), it was decided to compare the two crop husbandry systems of rice-cultivation in the fields of the Directorate of Rice Research located on the campus of ICRISAT, Patancheru. Studies for two seasons suggest similar trends in soil biology and microbiology properties.

Studies on root mass and root length density for two seasons each at farmers' fields and at the research station were revealing. The SRI plots always had bigger roots (both mass and density) than those in control plots, and the differences were statistically significant in general. Also, the roots from control plots were light brown to dark brown (less active), while those from SRI plots were generally whitish to brown (more active). Because soil microbial activity is generally bigger in the vicinity of roots (generally called root rhizosphere) than in soil away from it, we are considering developing an indicator that can jointly consider all soil properties and roots. In general, plants in SRI plots were greener than those in control plots, suggesting stronger photosynthetic activity in the former. This was measured using SPAD meter. The readings suggest that SRI plots have significantly bigger values than those of plants in the control plots. All these parameters together explain that yields under the SRI method are higher than under the conventional method of rice cultivation under inundated conditions.

Understanding Higher Yields by SRI Method

Thirteen soil attributes (involving population of different micro-organisms, soil biological and soil chemical properties) were studied in 27 farmers' fields having both SRI and conventional flooding treatments for three seasons. The findings suggest that in most of the fields SRI plots had bigger data values for a given property, compared to adjoining control plots in the same field. But on the mean basis i.e. mean of all the farmers (taken as replications) in a given season, the treatment differences for a given soil property were statistically insignificant in general. The notable exception was for *Siderophore*-producing bacteria (indicators of plant growth promoters), and that too during post-rainy season.

Interaction with SRI farmers convinced the Chief Minister of Andhra Pradesh, Dr. Y.S. Rajasekhara Reddy, to announce a package to promote SRI in the State

Advocacy

Following advocacy by the WWF project, in November 2005 the Andhra Pradesh Government announced 40 million rupees as grant for establishing SRI demonstration plots, one each in all villages of the State. The demonstration plots will help farmers see through the method and adopt it. A programme was initiated for training farmers and the agriculture department staff. Rice grown under the SRI method was declared to be 'irrigated dry crop.'

YSR announces 4-cr. programme for popularising SRI method

World Wide Fund for Nature, ANGRAU take up pilot project

ANDHRA JYOTHI 16 NOV, 2005

శ్రీ వరిసాగుకు ప్రోత్సాహం

Efforts are on to proactively establish partnerships across the country to encourage and provide critical support to the SRI method and to influence national level policies for introducing such water productivity enhancement methods.

Manual on SRI

The ANGRAU produced a manual on the SRI methodology in Telugu, the local language, and English. The publication was distributed widely. In addition, a video on the SRI method was also produced in Telugu and distributed. Both serve as effective training materials.

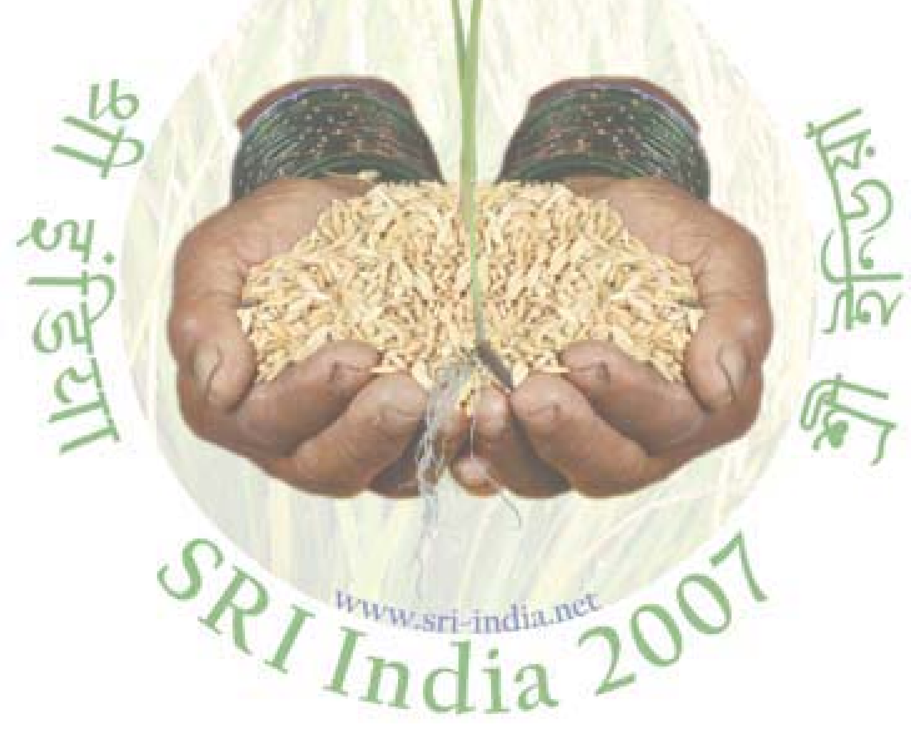
Strategic Partnerships

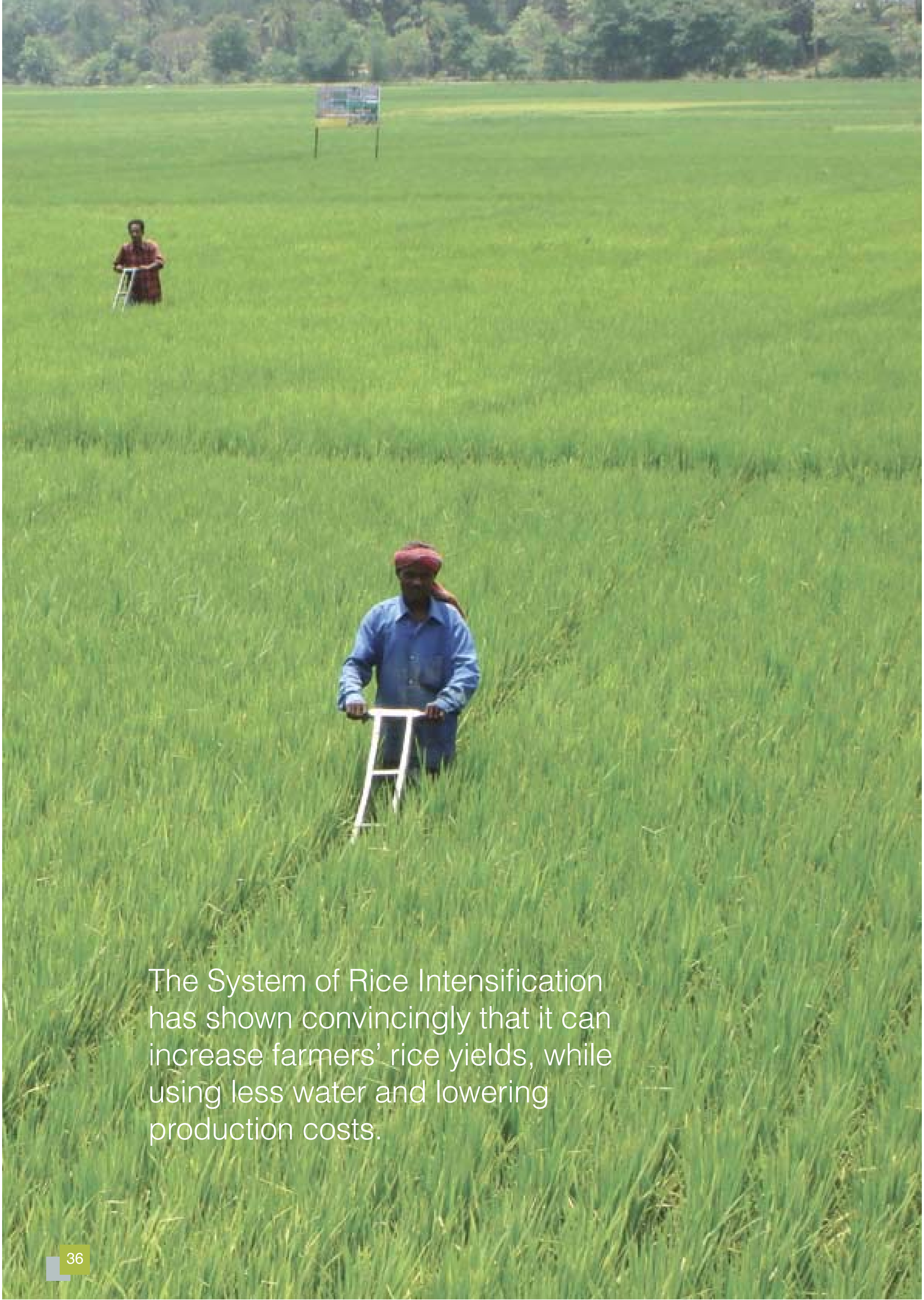
WWF established partnerships with rice research institutes, agricultural universities and civil society organisations, and encouraged them to work on SRI to assess its feasibility and popularisation. Farmers' interaction workshops, field-based resource centres, crop field days, media events etc., by partners attracted not only publicity for the SRI method, but also inspired many researchers to delve into the SRI method.

SRI has been adopted in more than 20 States across India. As there is no platform currently for sharing experiences and results, the WWF took initiative and supported the first national symposium on SRI held over two days in November 2006 in Hyderabad. Held in collaboration with WWF partners, the symposium brought together, for the first time, about 200 SRI researchers, promoters, practitioners, policy makers and critics from across the country. The gathering of luminaries facilitated cross-learning, initiated emergence of networks of interested groups, strengthened the efforts of farmer innovators, and set the immediate agenda for researchers involved in addressing issues concerning SRI.

In this context, the second national symposium on SRI will be held in October 2007 at Agartala, Tripura. In Tripura, a tiny State in the northeast, the government is supporting efforts to popularise SRI, with 8 per cent of the States irrigated rice area already under SRI. Tripura's example is worthy of emulation.

The logo (as given below - SRI India 2007) has been designed for the event and it may be used with minor modifications in vernacular titles for similar events on SRI anywhere in the country in future. A web site www.sri-india.net has also been developed and it is hoped that in due course it will become informative, interactive and knowledge base on SRI in India."





The System of Rice Intensification has shown convincingly that it can increase farmers' rice yields, while using less water and lowering production costs.

Chapter 7
For Global Impact

Although globally the SRI method has been demonstrated to be effective in 28 countries, the scale of its use leaves much to be desired. Use of SRI is expanding in Indian States like Andhra Pradesh, Tamil Nadu and Tripura and in countries like Cambodia and Indonesia. SRI can make a lasting global impact with far-reaching benefits, if large-scale support programmes are initiated. Such programmes need to be linked to systematic and critical evaluations, along with modifications that suit local conditions.

The Way Forward

Expanded rice production, particularly irrigated rice, will have to play a central role in reducing hunger and improving nutrition levels in India and elsewhere. But, this can happen in a sustainable and environmentally responsible fashion, only if water is used more productively in the irrigated rice sector. In development jargon, "get more crop per drop." Better management of natural resources, particularly water, is critical for addressing both production and productivity issues.

In this context, the focus should be on identifying and introducing rice cultivation methods that use water more productively than under the conventional (inundation) method of growing rice. The System of Rice Intensification (SRI) is the quintessence of such methods.

The WWF and its partners, having worked extensively with farmers, support the predominant view that this method could be part of the solutions identified for reducing water crises in many developing countries, at least those heavily dependent on rice production. This requires scaling up of SRI to such level that it will make a difference at the river basin level with nationwide implications.

The WWF has begun establishing partnerships with research institutions, NGOs, farmers, irrigation engineers, governments at various levels, as well as with international donors. The overriding objective is to scale up SRI as a method that can effectively address global water crises.

Despite its success in an increasing number of settings in India and several other countries, the SRI method has not yet become a major method of cultivation. Given below are some of the principal reasons:

- **Resistance to accept SRI:** Many agricultural establishments are still reluctant to recognise the potential of SRI. Preferences remain for emphasising varietal improvement. Hybrid rice, for instance, which could result in 15-20% yield increases, but with higher costs, continues to receive major attention and publicity. There is need to go to the town with the good news that the SRI method also enhances hybrid yields. The yields have increased by as much as 5 t/ha in Indonesia. There should be no conflict between genetic and management approaches.

- **Lack of training and extension facilities:** Training and extension facilities are not in place in many countries for SRI. Indonesia has begun to develop special programmes and centres.

The larger objective is to scale up SRI as a method that can effectively address global water crisis.

Capacity building of extension personnel is the key to scaling up of SRI in India

- **Absence of precise water management:** There are certain technological and institutional limitations when it comes to adoption of the SRI method, as it requires reliable delivery of small and regulated amounts of irrigation water.

- **Erratic power supply:** Farmers cultivating rice with their own water pumping facilities (bore well , dug wells, small lifts, etc.) find SRI attractive, especially in countries like India; but constraints like failure or improper electricity supply can be a disincentive because they interfere with precise and timed water delivery.

- **No scope for company profits:** As SRI is currently in the public domain, with no claims of intellectual property rights, the process of spreading its benefits could not be monopolised by anyone. This has reduced incentives for private promotion of SRI. Currently, there are no interest groups such as those prevailing for seed companies, fertiliser companies, etc. for promoting SRI. Some have a vested interest in maintaining the status quo.

- **Lack of proper information:** Early reports about SRI created some very high expectations with regard to yield increases. This did not translate to all farmers achieving the reported yield levels, and eventually some lost interest and discontinued. There was no way to make such farmers understand that SRI results are driven

In recent years, there has been a more favourable attitude toward SRI within agricultural establishments as evidence of the method's repeatable success continues to mount. The governments of Cambodia, India, Indonesia, Madagascar and Vietnam have given explicit endorsements and have begun supporting SRI extension. Others, like in Cuba, Nepal, Pakistan and the Philippines, are still in early stages of scaling up support. Researchers or NGOs in Bangladesh, Bhutan, Iran, Iraq, Myanmar, Sri Lanka, Thailand and Zambia are undertaking extension with their own available resources. Initial trials are scheduled in Afghanistan, Brazil, Egypt, Ghana and Nigeria. There is a growing realisation that now is the time for scaling up adoption of SRI.

Scientists and extension workers jointly visiting SRI fields in Tripura

not by changes in a genetic 'blueprint' or external inputs, but by mobilisation of endogenous processes and potentials within the plant and soil systems. The latter can vary widely according to many interacting factors, making SRI results highly variable. This is like any biological process, in contrast to chemical or engineering processes, which are largely predictable.

India needs to increase rice production almost by 2.5 million tonnes a year in order to meet its requirements in 2050. This translates to almost 92% increase on its current production. Clearly, India cannot produce so much rice using the 4000-5000 litres of water per kg of rice it uses today. India cannot expand its irrigated area to a level that can match production goals in any land-extension strategy, as there is paucity of additional land and water that can be mobilised. Therefore, India has to adopt methods like SRI. Other countries facing similar resource constraints in terms of quantity and quality also have no choice. In this context, the SRI method will progressively gain more and more acceptance.

In order to address water crisis, it would be better to start off with SRI or a similar water-saving method on some 10 million ha (out of the 25m ha of currently irrigated rice cultivation). This would save about 50 billion cu m (almost equal to the annual flow of Godavari river in certain years) of water, while increasing rice production by about 25 m t. Such a national-level programme would require spending about Rs.50-60 billion per year ($1-1.2 billion) for five years, including subsidies to farmers, extension work, research, etc. This is equivalent to the cost of constructing one major dam on the Godavari river.

The challenge now is to scale up the SRI kind of farm-based methods to reduce the water input for rice cultivation, while increasing production and reducing the need for use of agrochemicals, which could negatively impact soil and water quality.

Norman Uphoff (extreme left) interacting with scientist during a field visit

SRI warrants investment in human resource development, as it involves helping farmers modernise and diversify their production to register significant productivity gains.

Surely India can afford such a national scheme that is proven to benefit farmers, save river ecosystems, improve food grain production, and contribute to better climatic conditions (by not flooding rice paddies all the time and thereby reducing emission of methane as a greenhouse gas). The details for such an initiative need to be worked out. Such schemes are feasible and affordable, given the current economic growth of the country. In addition, there is the overriding need to protect natural resource systems and reduce rural poverty for sustainable and "inclusive" growth.

The governments need to revisit their policies concerning supply-side water management. Providing water almost free despite the ever-increasing demand for irrigation is not sustainable, as there is a lot of wastage of water. It is high time incentives were designed to improve water productivity in all sectors, more so in agriculture.

Despite SRI's multiple advantages, farmers need support and perhaps incentives to:

- Make the initial shift from one set of practices to another, requiring some relearning
- Absorb the additional labour costs during learning
- Level their plots to a higher standard to prevent accumulation of water
- Undertake appropriate water and weed management, the latter requiring some additional tools and time
- Take time for training, experimentation and evaluation

Large savings in water will come only if governments invest in improved irrigation service delivery in major irrigation schemes, because SRI yields more benefits under precise water management. Of course less of water is needed on the whole. But this supply should be reliable and well-controlled. Investments will be required in better design and management of canals, field channels and drains. Money will have to be pumped into developing devices that better regulate water delivery under SRI. Resources will have to be expanded by providing more staff to support water allocation and delivery. Training programmes for popularising the new methods will have to be scaled up. Water user associations need to be strengthened and streamlined.

Irrigation departments will need additional funding to improve the reliability and precision of their water delivery systems to suit SRI. In many cases, this will require institutional reforms and capacity building.

The best part is that by adopting large scale methods like SRI, the government can save money by:

- Avoiding expensive additional water supply structures
- Reducing water conflicts and related costs to society and individuals
- Improving access to water for the poor
- Ensuring that threatened ecosystems are made sustainable

With SRI and comparable methods, countries needing significant donor support can reduce and even obviate the need to borrow funds for water infrastructure. In such cases, donor assistance could be helpful to finance the kind of adjustments that are required to make the irrigation sector less 'thirsty' with respect to rice production. Such methods can give governments more

options for increasing food grain production, instead of just augmenting irrigation infrastructure to perpetuate production systems that are intrinsically less efficient in their use of resources.

What Can Development Partners Do to Promote SRI?

Already civil society organisations in many developing countries are actively promoting SRI, with many governments supporting them. For making the best of current knowledge-based results, all need to work closely with national and international research agencies, even if this poses difficulties initially. Controversies and claims about yields attributed to SRI should be understood and placed in proper perspective, since averages are of great importance to assess outcomes. While exceptional yields indicate potential, they can be attained only when soil biodiversity and fertility have been built up. Most soils in India are biologically too deficient to give best response to the SRI method.

Farmers should be informed that SRI is a proven method of increasing yields with less dependence on external resources and with reduced expenditure. They should be attracted to SRI by emphasising the most likely results, rather than the ones that can be possibly attained. Consistent yield improvements with less use of scarce irrigation water form part of an overall objective, which farmers, irrigation and agricultural departments, NGOs, researchers and government decision-makers should be able to agree upon.

Development partners who are supporting the Millennium Development Goals should mobilise suitable technical assistance for the project design and implementation.

Designing and making available appropriate implements and training materials is important. Civil society has played a major role in providing these, often with community participation. Still, much more needs to be done in quantity and quality.

Partnerships with government agencies will become more important in the future as scaling up is undertaken.

Development partners who are supporting the Millennium Development Goals (MDGs) can mobilise suitable technical assistance for project design and implementation. In addition, they should support capacity-building across the board and at all levels required for large-scale adoption of SRI, since the method can clearly help meet MDGs.

Specific opportunities exist to provide financial resources for sharing of experiences by supporting technical visits and farmer-to-farmer exchanges. There should be ongoing programmes for development of tools and implements and for concretising labour-saving methods of crop establishment, including direct seeding. The merits of SRI should be the main selling point, as these appeal directly to farmers.

Suggested Global and Country Targets

- Major rice producing countries such as India, China and Indonesia should convert at least 25 per cent of their current rice cultivation systems (with standing water) to SRI by 2025. As for new irrigation schemes, 75 per cent of the cultivation should be taken up using SRI kind of water-saving methods. This will save water, reduce conflicts, address some climate-change issues, save money, and help ecosystems.
- Developed countries which are supporting, directly or indirectly rice cultivation in developing and underdeveloped countries, particularly in Africa, whether through aid or loans, should invest at least 50 per cent of the money in promoting methods such as the SRI to save water and energy, while addressing food security.
- Research at national and international levels should focus on methods such as the SRI in a coordinated manner to improve, document, review, and promote positive results. Such research should have farmers' participation as a major component.
- An international panel should be established to critically review and verify the results of SRI. Such independent validation will help in quantifying the actual benefits, discounting unsubstantiated claims, facilitating methodological assessment of data, etc.
- Although less than 6 per cent of the rice produced is internationally traded; there is significant trade at the national level. Retailers and international food brands could help promote productivity gains and water saving by targeting their rice purchases (say 25 per cent SRI or similar water saving methods) as well as by supporting demonstration and education projects involving "pioneer farmers" in the regions from which they source grains.

A panoramic view of SRI rice fields in Andhra Pradesh

SRI needs support from governments, aid agencies and research organisations. As part of programmes designed to address global water crises, SRI and similar methods need greater attention. SRI has evolved through people's efforts.

Most, if not all, governments now have a clear responsibility to promote this in their own interests. Research organisations need to look at this method dispassionately and with an open mind. So far, investments in SRI from governments and research agencies have been negligible.

If world leaders are really serious about addressing water crises for ensuring food security in several regions across the globe, they will not fail to see in SRI a golden opportunity to realise their goals.

SRI farmers from a remote village of Tripura proudly showing the tall, robust and profusely tillered rice plant hills

SRI is a correction to the Green Revolution. (Under this) productivity is increased, and at the same time the environment is saved. SRI method of rice farming will really contribute towards saving our planet, our world and our country.

Mr. Susilo Bambang Yudhoyono,
Honourable President, Indonesia in Organic
SRI Harvest function on 30th July 2007

System of Rice Intensification technology (SRI) which requires less quantity of seeds, less nursery area, saves water and labour and enhances yield covering rice and other crops like sugarcane, should be popularised.

Dr. M. S. Swaminathan,
Eminent Agriculture Scientist and Chairman,
National Commission on Farmers, in India

Adoption of the System of Rice Intensification (SRI) method for paddy cultivation has increased productivity of rice from 2.5 tonnes per ha to about 3.5 tonnes per ha in Tripura.

Shri Manik Sarkar,
Tripura Chief Minister in a speech
at the National Development Council
in New Delhi on May 2007

The mission of WWF is to stop the degradation of the planet's natural environment and to build a future in which humans live in harmony with nature, by:

- conserving the world's biological diversity
- ensuring that the use of renewable resources is sustainable
- promoting the reduction of pollution and wasteful consumption

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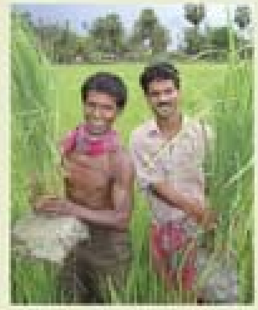

More RICE with Less Water

SRI - System of Rice Intensification