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Changes in Cultivation Pattern of Wheat and Rice as Influenced by the Key Innovations in Research, Policy and Institution Initiatives

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ABSTRACT

Background: The dynamic national innovation systems are viewed as collections of science and technology delivered by institutions that can act as the basis for technological development which should be translated into useful knowledge channels which concern governmental and public policies. The institutional approaches for relevant technological changes and governmental policies are necessary and effective to improve the third world agricultural production, research and development especially on wheat and rice as those two feed most of the world population. In the third world countries like India, innovation and technological changes in agricultural research can generate great returns where green revolution technologies have had a significant impact. **Results:** Zero-tillage technology, use of stress tolerating high yielding genotypes and genetically up-lifted popular cultivars, application of integrated nutrient and pest management for sustainable agriculture with proper use of water and finally the involvement of local government and non-governmental organizations entirely and by all means have improved the present status of wheat and rice cultivation system. **Conclusion:** But the threat of rapid increase of world population as well as emerging environmental instability will persist and hence new institutional initiatives that are now beginning to be introduced should be welcome and encouraged. This study reviewed the impact of scientists, scientific institutions and policy makers to increase global production of wheat and rice for mitigating increasing population demand and make it sustainable.

Key words: Wheat, rice, research, institution, policy, technology

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INTRODUCTION

Wheat (*Triticum aestivum*) and rice (*Oryza sativa*) are the two most important cereal crops contributing 45% of the digestible energy and 30% of total protein in the human diet, as well as a substantial contribution to feeding livestock[1] and they are the two most commercially important crops, accounting for more than 40% of global food production. Over about 13.5 million hectare of the Indo-Gangetic plains (IGP), these two crops are grown in rotation contributing more than 80% of the total cereal production[2,3] conferring employment, income and livelihoods for hundreds of millions of rural and urban poor of South Asia[4]. They were domesticated in different climates and differ largely in their growth environments: Rice is tropically cultivated in hot, wet climates, whereas wheat tends to be grown in cooler temperate climates. Though greatest yields of rice have been obtained from the temperate areas of Australia, USA, China and Japan[5,6], rice is the predominant crop of the tropics and subtropics. Wheat, on the other hand, has always been the predominant crop of temperate regions, though it is now grown with moderate success in tropical and subtropical climates[7,8]. However, both crops have been bred in similar directions. For example, the introduction of semi dwarf traits into rice and wheat from Chinese and Japanese varieties in the 1960s made a great contribution to increasing yield in both species[9]. The 1960s also witnessed establishment of an international agricultural research system, known as the Consultative Group for International Agricultural Research (CGIAR). The institutions established by the CGIAR included the International Rice Research Institute (IRRI) and Centro Internacional de Mejoramiento de Maize and Trigo (CIMMYT) which gave major boost to international research on rice and

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wheat, respectively in close partnerships with the national institution, including those in South Asia. The major objective set for this innovative network of national and international working in close collaboration with each other was to develop new varieties of rice and wheat to improve productivity. As agriculture transforms from subsistence to commercial level, farmers seek information on a wide range of issues to acquire knowledge or upgrade their skills and entrepreneurial ability. In a changing technological environment, farmers have to be actively engaged in search and learn activities to find and adopt better technologies. These are related to production technologies, input availability, input-output prices, input-output markets etc. Farm-producers in South Asia have little access to improved technologies mainly due to: (1) Lack of knowledge, (2) Weak input delivery system, (3) Lack of appropriate technology suiting the resource endowments of producers, (4) Lack of credit and (5) High risk and absence of insurance management. A majority of the producers in these regions are resource-poor and poverty-ridden and therefore, technologies, policies and institutional support need to be tuned to their socio-economic profile. A large untapped production potential of rice and wheat is to be harnessed through appropriate technology and policy intervention. Strategy to make grey areas green will lead to 'Second Green Revolution', which would demand three-pronged strategy, watershed management, hybrid technology and small farm mechanization. Environmental protection and sustainability are the major interventions today in the overall planning for agricultural growth and development. Although, the high-yielding varieties of rice and wheat are generally blamed for causing environmental degradation, these varieties had saved million of hectares of forests from being cleared to produce food to feed the bourgeoning population. Public sector research and development is an essential component of an effective National Agricultural Research Systems (NARS). While the private sector is expressing a strong desire, however, progress so far is limited. If allowed space to develop and with the help of supportive administrations, they could begin to transform possibilities for poverty reduction in precisely those parts of the third world that appear to most in need. That is why the establishment of essential complementarities between institutional and technological changes (institutional structures that permit the symbiosis of knowledge search with knowledge use), at least in the context of third world agriculture, is the key. The objective of this study is to analyze the influences of key innovations in research, policy and institution initiatives towards changes in cultivation pattern of wheat and rice.

Influence of key innovations in research: To date, the most widely adopted resource conserving technology in the Indo-Gangetic Plains (IGPs) of South Asia has been Zero-Tillage (ZT) wheat after rice, particularly in India. ZT wheat is particularly appropriate for rice-wheat systems in the IGP by alleviating system constraints by allowing earlier wheat planting, helping control the weed *Phalaris minor*, reducing production costs and saving water. ZT wheat after rice generates substantial benefits at the farm level through the combination of a 'yield effect' (a 5-7% yield increase, particularly due to more timely planting of wheat) and a 'cost savings effect'. The combined effect of a yield increase with a cost saving implies that returns to ZT adoption are pretty robust[10]. In the 1970s in India, several state agricultural universities tried ZT but their efforts failed due to technical difficulties, such as the lack of adequate planting equipment and the difficulty in controlling the weeds chemically. In 1994, the Rice-Wheat Consortium (RWC) of the IGP was launched as an eco-regional programme of the CGIAR. This consortium involves NARS from Bangladesh, India, Nepal and Pakistan and international centers including CIMMYT, IRRI and others. The RWC and its NARS partners pursued farmers' participatory research and further adapted the ZT technology to rice-wheat systems. The generally positive yield effects of ZT wheat in rice-wheat systems are mostly due to (1) Timely sowing and (2) Increased input use efficiency and weed control. To keep pace with the rapidly growing food demand, South Asia's farmers will have to produce more food from fewer resources while sustaining environmental quality. ZT is one technology that fits this need and is being rapidly adopted in the Indian IGP in wheat after rice.

The use of modern inputs like adoption of high-yielding varieties, irrigation, chemical fertilizers, pesticides etc. has reached a very high level in the IGP. The Rice-wheat Cropping Systems (RWCS) which cover about 10 million hectare of the IGP of India are showing multiple problems. The two major problems are related with (1) Production levels of rice and wheat and (2) Sustainability of soil and water resources. Crop diversification through introduction of legumes can play an important role in improving the sustainability of the production system. But the challenge is to break legume yield barriers and design innovative policies on risk and resource management as legumes complement cereals in both production and consumption.

The release of photo periodically insensitive cultivars of rice and wheat made timely sowing and harvesting of both crops possible in rice-wheat cropping systems. The dominant characteristic of that system is the repeated transition from the anaerobic conditions for rice

to aerobic conditions for wheat. This has great impact on the soil physical properties, as well as on the chemical reactions of indigenous and exogenous nutrients in the soil[11] and overall on the production.

Since the semi dwarf cultivars can use large inputs of nitrogen (N) fertilizer without lodging, the introduction of dwarfing genes allowed the production of varieties with high leaf N content and enhanced sink capacity. Rubisco is the primary carbon di oxide (CO_2) fixation enzyme and the amount and kinetic properties of this enzyme strongly affect the photosynthetic rate. Higher rates of photosynthesis in both wheat and rice may be caused by greater N allocation to Rubisco[12]. With increasing N supply, rice allocates an increasing proportion of N to Rubisco. By contrast, wheat allocates a constant proportion of N to Rubisco. Some elevated CO_2 experiments show that stimulation of photosynthesis is greater in wheat than in rice[13]. Since large amounts of N are invested in Rubisco, an attempt to decrease N allocation to Rubisco may lead to the improvement in photosynthesis per unit of leaf N content. In fact, antisense RBCS rice with theoretically optimal Rubisco content at elevated CO_2 concentrations shows higher rates of photosynthesis only under conditions of elevated CO_2[14]. This construction may be one of the model crops that perform better under low N input conditions in near future high CO_2 environments. In wheat, yield is affected by both the grain number and size since single grain weight varies depending on growth conditions[15,16]. But the single grain weight in rice is genetically constant irrespective of N application and growth environments[17], yield is simply determined by the product of grain number and the ratio of filled grains, both of which are affected by N application. Hence the targets for a high yield may be more complicated in wheat than in rice. Yoshida *et al*.[18] reported that the grain number per unit of plant N content is clearly higher in semi dwarf *indica* rice genotypes than in *japonica* rice genotypes. In addition, since improving source capacity could lead to a decrease in the amount of N required for a high yield, it will reduce the environmental impact of agriculture.

The widespread use of semi dwarf varieties of rice and nitrogen fertilizers and the increased use of insecticides have changed the status of pests from low to high economic importance in rice production. Integrated Pest Management (IPM) is the most effective method for controlling pests while improving productivity and caring for the environment[19].

The Gn1 allele, that increases grain number[20], from a semi dwarf *indica* rice genotype increases grain number by more than 40% in a *japonica* rice genotype. In addition, the introduction of semi dwarf traits into *indica* rice genotypes has led to a typical success for high yielding. For *japonica* rice genotypes, a new type of high-yielding and large-grain cultivar, Akita 63 has been released[21]. Grain mass in the modern high-yielding rice and wheat has reached about 60% of the total biomass above ground at harvest[9,22]. This is the highest in all cereal crops. Although, it is not apparent whether further increase in the harvest index is feasible[23], to substantially enhance yield in both crops will be difficult unless source capacity including photosynthesis is improved by genetic engineering. IRRI bred recent high yielders are IR77713, IR79511 which are early flowering as well as better quality grain producer. Makassane is the first IRRI-bred rice variety designed especially for Mozambique consumers and farmers. Makassane has significantly better grain quality and it is resistant to bacterial leaf blight and blast. It is tall enough to survive flooding but not too tall to fall over easily and it has many grain-producing heads, long attractive grains and a nice texture when eaten, hence well accepted by the farmers. Breeding work is already under way to develop other designer rice varieties. Indian Agricultural Research Institute (IARI) successfully pyramided resistance to biotic (bacterial blight, blast and brown plant hopper) and abiotic (salt tolerance and phosphorus uptake) stresses in Basmati back ground[24]. In 2011, three drought-tolerant rice varieties bred by IRRI in partnership with the Nepal Agricultural Research Council were released viz., Sookha Dhan-1, 2 and 3, which have shown a yield advantage of 0.8-1.0 ton per hectare over current varieties under severe drought. Golden rice, enriched with high levels of pro-vitamin A, holds promise for improving micronutrients in rice. Through a process known as Multiparent Advanced Generation Intercross (MAGIC), a team of IRRI scientists launched an ambitious and elaborate plan to breed multiple-stress-proof rice. The MAGIC approach provides opportunities for multiple rice types to exchange genes and traits with one another. Using this concept, the IRRI research team began crossing work in 2007. Multiple intercrosses were made within each of the *indica* and *japonica* populations to systematically increase the level of recombination. The team selected eight cultivars each for *indica* and *japonica* as founder lines. These cultivars are modern varieties from around the world known to be tolerant of a range of biotic and abiotic stresses, are high-yielding and have good grain quality. Since traits are tagged by molecular markers, researchers can insert these traits into new varieties faster than traditional trial-and-error breeding to identify varieties that carry desired genes. The *indica* and *japonica* MAGIC populations will be further crossed to expand genetic diversity and therefore improve

adaptation in various cropping conditions across the world, the results of which will be called the MAGIC global population[25].

Influence of policy: The rice-wheat based cropping system, spread in the most fertile areas, is the backbone of food security in South Asia. The IGP belongs to the irrigated agro-ecosystem and is the major production zone for both rice and wheat in not only India but the entire South Asia. Steep increases in the area and production of rice and wheat in IGP were achieved during the 'green revolution' period of the 1960s and 1970s. The initial momentum for the green revolution came from two international research centres comprising the CGIAR system-CIMMYT in Mexico for wheat and maize and IRRI in the Philippines for rice. A large proportion of the increase in food grain production during the Indian Green Revolution occurred in the 10% of districts with adequate local infrastructure-especially for water management, transport and electricity for tube wells. On the other hand, agricultural development in many areas of the region has been constrained by a lack of infrastructure. In particular, the shortage of roads in remote and sparsely populated areas pushes up transport costs for both inputs and marketed produce, while the lack of health and educational services reduces labour productivity. With the development of improved varieties of both rice and wheat and the use of irrigation and fertilizer, the rice-wheat farming system has shown remarkable increases in production. However, in recent years the declining or stagnant yields and factor productivity of the system have given cause for concern. Wheat sowing must follow immediately after the rice harvest if subsequent wheat yields are to be satisfactory. Over time, the system has expanded into areas where groundwater is not so easily accessible and because irrigation supply is unreliable, farmers have to transplant at the onset of the monsoon. In order to maintain flexibility they continue using traditional varieties but these are slow maturing. Consequently, all too often, wheat is sown late, thereby depressing yield as high temperatures affect the plants while they are setting seed. The private sector and farmers' organizations may play a bigger role in experimentation and advisory services; which may improve the efficiency of the dissemination of technical information. The majority of rice farmers in developing countries is poor and caught in a cycle of endless poverty. National policies often favour the consumer and the export market, not the farmer. After all the efforts spent in seeding, weeding, irrigating, harvesting and threshing, rice yields still do not provide farmers with a high income. Governments should strengthen policies to support equitable and efficient access to natural resources (particularly land and water). Policies must also stimulate investments, institutions, including private and nongovernmental ones, micro-finance and agricultural trade.

One high priority is to tackle the resource conservation issues; such as declining soil fertility, development of salinity and sodicity problems on irrigated land in western areas and groundwater depletion in zones irrigated by tube wells. Research is being conducted to develop technologies that can improve the level of soil fertility, which has fallen as a result of the continuous, intensive cereal production practiced since the Green Revolution started. However, governments sometimes pursue policies that work at cross-purposes with such research efforts. For example, the continuance of heavy subsidies on urea fertilizer in India, while at the same time deregulating the prices of phosphorus (P) and potassium (K) containing fertilizer, is causing an imbalance in fertilizer use among farmers-particularly resource-poor farmers practicing the rice-wheat rotation. As a result, there is continuous mining of P and K nutrients in the soil causing long-term damage to soil productivity. As mentioned above, an important factor contributing to the development of salinity and sodicity in irrigated areas of this farming system is the inefficient use of water, particularly at farm level. Shortages of groundwater in some localities have already started limiting the use of tube wells within the intensive rice and rice-wheat farming systems. The highly undervalued price of water from canal systems and the heavy subsidies-up to 100% on shallow tube wells, 25-50% on pumps, plus varying rates on electricity for pumping-are all incentives for excessive use of water by farmers, with consequent water logging. Depletion of water tables by indiscriminate sinking of tube wells has also been encouraged by these same subsidies, as well as by the absence of appropriate monitoring and regulatory mechanisms. While waiting for governments to deal directly with these policy issues, another option would be to improve moisture conservation by employing a range of techniques such as zero tillage, use of plastic and other mulches and planting of windbreaks. Improvement of irrigation security would also materially improve the system, by allowing the adoption of short-duration rice varieties, more timely wheat sowing.

Suresh *et al.*[26] documented many aspects of the Indian situation including the rapid increase in both rice and wheat cultivation in recent decades through intensification of cropping and increased input use, the rising costs of labour and the increasing use of mechanization. As Suresh *et al.*[26] indicate, even with emerging technologies, a number of factors in the economic environment influence the choice of technology. Policies that influence farmer investment in fixed improvements such as land leveling and irrigation

will continue to be important as well as those pertaining to subsidies on inputs, most notably electricity and nitrogenous fertilizers. It is reasonable to expect considerable progress on this broad policy front with the reforms emerging under globalization and trade liberalization and changing perceptions of the importance of better management of natural resources in an expanded environmental policy agenda. Thus greater attention in public policy to improved management of soil and water resources is doubtless to occur and this accords well with the current and likely future focus of the Rice-Wheat Consortium (RCW) for the Indo-Gangetic Plains, with its strong emphasis on Resource Conserving Technology (RCTs).

Another far-reaching change that is occurring in association with decentralization is the growing role of women in panchayat (local council) and district-level decision making. There is also an increase in public-private partnerships for agricultural development, land reforms which will have far reaching effects on deciding agricultural research priorities.

The major problem is the low and progressively declining producer price for rice resulting from unfavourable terms of trade. This can only be countered in the long run by using more efficient production practices, thereby increasing the comparative and competitive advantage of local rice production. An effective programme of research and extension to improve labour and factor productivity is needed to improve farmers' production practices. In order to maintain adequate incentives to farmers it will also be necessary to avoid urban bias in trade and economic policies. Some specific policy priorities should be as follows: (1) Investment in public agricultural research and development (R and D) in developed countries, (2) Rebuild and expand public agricultural research capacity in developing countries, (3) Harness agricultural biotechnology as a potentially important option, (4) Encourage complementarities between public and private agricultural research, (5) Help to mitigate risk, (6) Invest in better information and forecasts, (7) Support competitive and responsive agricultural markets, (8) Encourage investments that improve spatial market integration and (9) Improve the measurement of agricultural Green House Gas (GHG) emissions.

At present, use of fertilizers for paddy is constrained by low rice prices. The use of fertilizers in the coming decades will be influenced by fertilizer prices (likely to increase in real terms), commodity prices (likely to decrease), use of organic fertilizers (likely to increase) and fertilizer use efficiency (also likely to increase). The possibility of significant contributions from the use of Biological Nitrogen Fixation (BNF) cannot be discounted. In parallel with the increase in fertilizer use, the demand for agricultural chemicals has grown, although moderated somewhat by the spread of IPM. Rice has traditionally been the most important single crop in South Asia and it has increased in importance over the last 30 years-principally as a result of the green revolution-with yields increasing by an average of almost two percent per annum over the period 1970 to 2000. Rice area has also increased but more slowly, resulting in production of 2.5% over the last 30 years, to 184 million tons. Production is forecast to further increase in the period to 2030. Wheat production has shown by far the strongest growth among the cereals in recent decades with increases in both yields (nearly three percent per annum) and land area (1.4% per annum) to achieve an overall increase in production of more than 250% to almost 100 million tons in 2000.

Influence of institution initiatives: CIMMYT and International Center for Agricultural Research in Dry Areas (ICARDA) projects always feature four components for success: Quality seed, good agronomy, well functioning markets and farmer-friendly policies. According to their vision, demand for wheat in the developing world is expected to increase 60% by 2050. They identified ten areas that can help turn the wheel on food security by addressing wheat-based farming systems which are: (1) Technology targeting for greatest impact; this will be reinforced by improved policies, strategic analysis and institutional innovations that strengthen linkages among stakeholders along the wheat input-output value chain, (2) Innovation systems that encompass farmers and multiple institutions will enable 10-15 million farmers to adapt and implement sustainable, productive and profitable techniques. Total farm productivity and incomes from irrigated and rain-fed wheat systems will thereby increase by 15-25%, contributing to climate change mitigation and adaptation while reducing soil erosion and degradation, labour and fuel use, (3) Nutrient and water use efficiency, (4) Productive wheat varieties, (5) Durable resistance and management of diseases and insect pests, (6) Enhanced heat and drought tolerance, (7) Breaking the yield barrier-cutting-edge interventions will raise the wheat's genetic yield potential by as much as 50%, tapping into complementary expertise and the innovation capacity of the public and private wheat communities worldwide, thereby ensuring long-term food security for humankind, (8) More diverse wheat seed systems will offer developing country farmers quicker access to improved varieties, encouraging broader public and private participation, as well as alternative and innovative seed production and marketing by farmer groups and communities, (9) A researcher or breeder-oriented data platform that will foster and support comprehensive use

of the native diversity of wheat and its wild relatives, thereby accelerating breeding gains and counteracting climate change effects and water, land and nutrient scarcities and (10) Strengthening capacities-this initiative will train a new generation of wheat professionals, with a strong focus on women and young professionals, enabling national wheat improvement programs, in partnership with CGIAR institutions and other stakeholders, to improve the efficiency, impact and sustainable intensification of wheat-based cropping systems.

During recent decades investments in international commodity research have fallen and yield productivity gains have slowed; even more so in wheat, a crop for which there has been little private sector involvement. New technologies and an international alliance of concerted investments are required to meet wheat demand from expanding populations, both rich and poor. The success of wheat improvement within CGIAR has been remarkable and today more than 70% of all spring wheat cultivars grown in developing countries are CGIAR-derived, reaching 90% in South Asia, parts of West Asia and North Africa. CYMMIT and ICARDA coordination and increasingly fragmented, short-term funding has prevented wheat researcher in the CGIAR from tacking fundamental research and development issue. The diverse partners and stakeholder groups like wheat yield consortium, hybrid wheat consortium, the borlaug global rust initiative and the cereal system initiative for South Asia make efforts to tackle identified problems. The private sector has shown increasing interest in wheat. Training and engagement of young researchers as well as the women in the methods and approaches used in wheat are mandatory for local innovation, adaption and scale-out of wheat outputs[27]. Policies towards food secure South Asia have been outlined under the sub-heads (1) Arresting deceleration in total factor productivity, (2) Enhancing yield of major commodities, (3) Accent on empowering the small farmers, (4) Environment protection and (5) Strengthening of national agricultural research system[28].

Improvement of rice farmers' livelihoods requires functional institutions. There is a current need and indeed opportunity, to strengthen those national institutional capacities that enable government, civil society and community-based organizations and cooperatives to participate collectively in the formulation and implementation of rural-development policies and programs. Such strengthening is expressly needed to enable the poor to secure and to retain usage/ownership entitlements to land and water resources. National and local government policies need to be not only appropriate but also operational. For many rice-growing countries, a priority is to strengthen the institutional capacity to define and implement policies and procedures to enhance production, value-adding enterprises and the necessary rural infrastructure. Food and Agriculture Organization (FAO), through its mandate, undertakes studies and provides policy advice and program support for member countries to explore and identify alternative routes to sustainable rice production, food security and enhanced livelihoods.

For the irrigated and favourable rain-fed lowlands, the Ricecheck (concept that evolved in Australia) technology transfer programme has been highly successful in increasing national yields by bridging the yield gap. Farmers are encouraged to follow the best management practices based upon "critical checks" that are known to have major effects on yield. Postharvest value-adding activities, at the household level within rice-growing communities, also provide opportunities for creation and expansion of employment and for income augmentation. For example, the use of rice husks for cooking energy, rice straw for the culture of mushrooms, rice bran for oil production, etc., under the FAO-developed concept of "thriving with rice," could produce additional income for farmers[19].

IRRI has established national learning alliances in Cambodia, Vietnam and the Philippines to integrate researchers, extension workers, Non Governmental Organizations (NGOs) and civic organizations, farmer groups and private-sector actors. IRRI's "social science databank" paints a clear picture of how the growing adoption of modern rice production technology is changing socioeconomic and livelihood conditions including the growing role of women across Bangladesh. Several emerging trends can be observed from the databank are (1) Declining farm size, (2) Aging of the farming population, (3) Increased cost of crop production, (4) Increased mechanization in farming, (5) Increased adoption of high-yielding inbred and hybrid varieties of rice, (6) Diversification in farming practices, (7) Better access to agricultural support services, (8) The exit of agricultural labour to non-agricultural employment and (9) The declining importance of agriculture to rural livelihoods.

Agricultural research in South Asia has been strengthened dramatically over the past 40 years through reorganization of the NARS; with the establishment of central coordinating bodies, decentralization into regional research centres, greatly enhanced manpower and increased investment. The NARS in the region have benefited greatly from the strong linkages and networks they have established with International Agricultural Research Centers (IARCs), such as IRRI, CIMMYT and International Crop Research Institute for the Semi-Arid tropics (ICRISAT), building on their participation in the development of green revolution technology. More

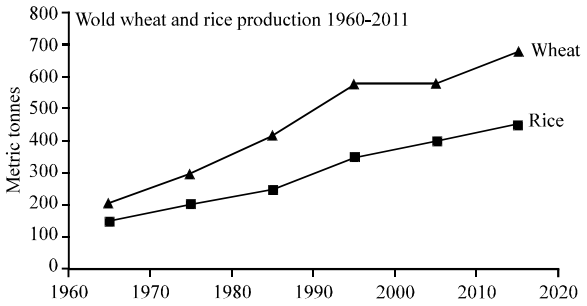

Fig. 1: World wheat and rice production 1960-2011 (Coutesy USDA)

recently, the many NARS have shifted their emphasis to meeting the post-green-revolution challenges of stagnant yields and resource management, by developing technologies for resource-poor farmers and farmers in sub-optimal crop environments.

The best policy and institutional responses will enhance information flows, incentives and flexibility. Policies and institutions that promote economic development and reduce poverty will often improve agricultural adaptation and may also pave the way for more effective climate change mitigation through agriculture. Business as usual among the world's poor is not adequate. Existing technology options must be made more available and accessible without overlooking complementary capacity and investments. Adaptation and mitigation in agriculture will require local responses but effective policy responses must also reflect global impacts and inter-linkages. Trade will play a critical role in both mitigation and adaptation but will itself be shaped importantly by climate change.

CONCLUSION

Despite technological advances, such as improved varieties, genetically modified organisms and irrigation systems, climate is still a key factor in agricultural productivity, as well as soil properties and natural communities. IRRI forecast 20% reduction in yields of rice over the region per °C of temperature rise. Innovative agricultural practices and technologies can play a role in climate mitigation and adaptation. The greatest crop yield at any site is achieved when the crop is sown at the optimum time with management that meets the requirements for water and nutrients and prevents ill effects of weeds, diseases and predators and increases the natural enemies of pests. Agricultural mechanization has been responsible for massively increasing rice and wheat production, productivity and profitability. For these, the use of certified rice seeds along with use of lower amount of seeds, pesticides, fertilizer, water and reduction in postharvest losses should be the must. More recent commodity research programs in wheat and rice are examining the genotype X tillage interactions of cultivars under zero-till, raised-bed and surface seeding situations for their ability to compete with weeds. These developments are also contributing to a broader debate about the need for modification of selection criterion in the breeding programs to accommodate new crop establishment and management practices. Locally adapted resource conserving technologies appropriate to resource endowments of farmers and the biophysical environment hold potential to improve management of natural resources and provide sustainable increases in productivity. Rapid growth in rice and wheat production and productivity achieved during 1960s, 70s and 80s, supported by public investment in infrastructure, government policies designed to foster food self sufficiency and green revolution technologies, has slowed or stagnated in recent years. The global wheat and rice production since 1960 to 2011 is shown in the Fig. 1 (Courtesy USDA). Figure 1 suggests the increased growth in production but it is not enough to meet the increasing population demand. This has raised concerns about future sustainability of the rice wheat systems and in the context of increasing demand for wheat and rice at prices affordable to the poor, about regional food security.

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