Public policy and international collaboration for sustaining and expanding the rice revolution

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Introduction[1]

Rice, being the second largest consumed cereal (after wheat), shapes the lives of millions of people; more than half of the world's population depends on rice for 80 percent of its food calorie requirements. The "revolutionary" feature of rice is its steady, long-term evolution with societal change. Certainly, rice has been a good partner to humankind, and adaptive ecological, economic, and technological changes around rice facilitated this "partnership between man and rice." For instance, in times of rapid population growth, soaring rice demands were met largely due to the Green Revolution. We must continue to nurture this partnership.

The rice environment today is more complex than ever before. For one, the policy environment for rice is changing. Particularly in Asia, where rice is the main staple, public policy has always been attracted to all production, distribution, and consumption aspects of rice, as well as its environmental implications. Traditionally, governments have sought to maintain stable prices for consumers in urban areas and to provide input subsidies to farmers. However, now that many Asians are diversifying their diets, a shift in public policy is noted; governments have been increasingly pulling out of managing rice, thus enabling more engagement from private enterprises. Additionally, new science in rice focusing on its diet quality aspects, gives rice a "health food" aspect, which is enabling rice to become an agent of change in terms of tackling the complex malnutrition issues across the developing world. The actors in rice research have also become more diversified; for decades, almost all rice research was done by the public sector through national and international agricultural research centers, but now, with advances in crop technology, the private sector, which in the past only played a minor role, is expected to engage more actively in rice research. The appropriate mix of incentive-oriented policies for private sector orientation and of public investment policies in support of agricultural research requires increased attention.

The purpose of this paper is to consider the emerging issues in the rice policy environment and recognize the risks and challenges ahead, with the objective of identifying opportunities for effective collaborations between the public and private actors at national and international levels. The paper outlines policy challenges and options to sustain and expand the rice [r]evolution, given the new demands for rice quantities and qualities and its ecological properties. It starts with the elaboration of a conceptual framework outlining the three key policy domains along the four main segments of the rice value chain. Then, using this framework, these main policy domains are reviewed. Subsequently, risks and opportunities and the need for international cooperation in science and trade policy for rice are highlighted. Finally, the conclusions delineate priorities for coherent rice policies. It is important to note that policy priorities will differ across developing regions and countries, given the diversity in the importance of rice in people's diets, and the diversity in the level of economic development achieved.

I. Emerging issues for rice and a framework for analysis

Key issues along the current **rice value chain**, starting from the consumers' end**,** include:

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1. A value chain increasingly driven from its consumption and retail ends, rather than the production front. In effect, consumers' demand for higher quality rice and improved standards and regulations in the processing and marketing of rice are becoming important determinants of the future of rice.
2. An increasing demand for processed rice products.
3. The continued relevance of productivity gains, not only in terms of "producing the pile of rice" efficiently per unit of land or water, but increasingly also in terms of labor productivity.
4. The predominant concern of natural-resource use of rice ecosystems and the increasing stress on water resources.

In this context of the value chain, sustaining and expanding the rice [r]evolution entails a more comprehensive set of policy objectives that go beyond just increasing rice yields. In view of the close linkages between production, markets, and consumption of rice, any outlook on rice must take a holistic perspective, and the future of rice cannot be assessed without due consideration of the broader economic context and developments related to other foods, especially other cereals, and the expansion of high-value agriculture competing for resources. Moreover, achieving these objectives requires action in a wider array of policy areas, and also requires more extensive collaboration between the public and private sector, as well as the international community.

The **policy domains** affecting the elements of the rice value chain can be broadly structured into three categories:
1. Market, trade and price policies, including regulations and standards
2. Environmental and ecosystems policies
3. Research and development policies for innovations

As shown in Table 1, this gives us **a 3-by-4 framework** to analyze policies in the context of the value chain. The paper is structured along the lines of the four policy domains, and also considers some cross-cutting structural issues. The table in the Annex summarizes the suggested policy actions within the value chain, as well as those looking at cross-cutting structural issues.

Valuation of rice along the value chain becomes more complex when sustainability and externality issues are considered. Indeed, the value of rice today cannot just be assessed at prevailing market prices; broader economic and non-economic concepts such as the insurance value of rice for food security, the "existence" value (e.g. for traditional varieties, even for non-consumers), and the inheritance value (passing rice varieties onto coming generations) should be considered. To the extent these "non-use" values deviate from current market prices, public investment and other policy actions may be called for to assure the efficient production of these values.

The goals of efficiency, sustainability, equity and poverty reduction to be served by the rice related policy domains in Table 1 may become more conflicting, as is generally the case with complex sets of policy objectives. Ignoring these conflicts by simply postulating short-term productivity oriented policies, for instance, would be inappropriate and inefficient. Further, policymakers are called upon to handle policy processes around competition policy goals and

instruments that translate to competing group interests in society. If anything, rice is bound to be at least as "political" as in the past.

Table 1: Framework for analyses of policies on rice along the value chain

	I----------**The rice value chain**----------I			
Policy domains	Resource management	Farm production	Processing and marketing	Retailing and consumption
Market, price, and trade policies, incl. regulation, and standards	X	XX	XX	XX
Environmental policies and risk-coping policies	XX	X	XX	X
Innovation and R&D policies	XX	XX	XX	X

Note: XX, X indicate the degree of relevance of the policy domain for the respective elements of the value chain (XX= strong, X=less strong)

II. Public Policies and International Cooperation for Enhancing the Net Benefits of Rice

a. Market, price, trade policies, and standards

Market functioning, prices, and trade of rice are a result of demand and supply, and of policy interventions in either side of the market (or at borders). With approximately 650 million people living on less than one dollar a day in Asia,[2] any effort to reduce poverty will require attention to rice, as a large share of the incomes of poor households goes to purchase rice, and many poor farmers depend on rice production for their income. However, with urbanization and the increase in incomes beyond the level at which people begin to diversify their diets, the importance of rice in diets in most Asian countries will continue to decline over time. This pattern is not observed in other parts of the world, where rice consumption is increasing rapidly; in the Middle East and North Africa and Sub-Saharan Africa, the consumption of rice increased by about 50 percent since the early 1990s, while in Latin America it increased by approximately 20 percent. The industrialized world is also experiencing an increased demand for rice, particularly for high-quality special rice varieties (von Braun and Bos 2004).

Demand for rice: Key factors affecting demand for rice include population growth, income levels, urbanization, and changes in tastes. In terms of the relationship between income and demand, as income rises, rice becomes an inferior good because consumers tend to diversify their diet, shifting initially towards the consumption of wheat, and later to livestock and other products (IRRI 2002, Barker and Dawe 2002). Additionally, as income increases consumers' preferences move toward higher-quality rice varieties. These two trends are particularly evident

[2] This represents 64% of the total number of people living on less than a dollar a day

in Asia; although rice still accounts for a large share of calorie intake per capita, its share in total calorie consumption is rapidly declining (Table 2).

Table 2: Contribution of rice consumption to total daily calorie intake
(% of total calories/capita/day)

	1974	2003
Asia	38.0	29.4
Latin America	9.0	9.0
Africa	5.5	8.2
Near East	7.0	8.3
North America	1.0	2.5
Europe	1.0	1.5

Source: FAO 2006b

Urbanization has had mixed effects on the demand for rice; on the one hand, in countries where rice is a staple, growing urbanization has translated in changing eating habits, which in turn has resulted in reduced rice consumption (IRRI 2002). On the other hand, in places where rice is not the main staple, urbanization has meant an increase in rice consumption; in Africa, for example, demand for rice grew on average by 3.2 percent a year from 1990 to 2003. This growth is partly due to growing urbanization (and the different lifestyle that it entails, such as the increased participation of women in the formal labor force), which has meant that consumer preferences are shifting from traditional staples that require more preparation time (such as cassava, sorghum, millet, and maize), to rice (Hossain 2005).

Other socioeconomic factors such as the changing demographics of a country's population can also affect the demand for rice. For instance, growing demand in industrialized countries can be partly explained by increases in Asian and Hispanic populations, who generally prefer rice. Another factor that may be affecting rice demand in the West is increased consumer awareness and concern about health and diet quality (von Braun and Bos 2004).

Rice production and labor market: More than 90 percent of the world rice production takes place in Asia (Table 3). China and India are the two largest producers; in 2005, they jointly produced 51 percent of the world's rice and occupied 47 percent of the world rice area. In Africa, rice production has increased dramatically; from 1970 to 2005, rice production increased by over 130 percent (FAO 2006b).

Table 3: Total rice production by region

	World	Asia	Latin America and the Caribbean	North America	Africa	Europe
Production (1,000 Mt, paddy), 2005	618,441	559,350	26,431	10,126	18,850	3,340
Percentage of world production, 2005 (%)	100.0	90.5	4.3	1.6	3.0	0.5

Source: FAO 2006b

Most of world rice originates from **small farms**. Rice-related policies therefore are intimately connected to the challenge of the transformation of small farm agriculture, especially in Asia. In

general, the next generations of rice farmers aim to either get bigger, grow through high-value agriculture production, shift to part-time farming in combination with other rural employment, or move out of agriculture altogether.

The income and employment problem of today's small rice farmers cannot be effectively addressed just through yield-increasing technologies or new forms of cooperation in production and marketing, such as cooperatives or contract farming, for example. The gap between aspirations and the on-farm realities is too wide in most of the fast-growing Asian economies and the potential contribution of rice-specific interventions is too minor to make a difference in the long run. Thus, the small rice farmers' income problem needs broader rural and economy-wide policy actions, including rural infrastructure and education policies, in order to facilitate long run transformation of the rural sector. Nevertheless, in the coming decade, productivity enhancements and more efficient market functioning remain of importance for the incomes of poor rice farmers (Swaminathan 2005).

As a result of the economic challenges faced by small farmers, the rice market increasingly interacts with the labor market. The growing economic prosperity in Asia is reducing the incentives for farmers to engage in rice cultivation. The expansion of the non-farm rural sector and rising labor productivity have pushed up non-farm wage rates, which has motivated labor migration— particularly of the youth—from rural areas to cities and from farm to rural non-farm activities. Since traditional rice farming is a highly labor-intensive activity, increases in wages have pushed up the cost of rice production and reduced farmers' incomes and profits (Hossain and Narciso 2004).

Besides labor, the energy market, and in particular, rising energy costs, are increasingly affecting rice production. Among other things (such as typhoons, drought, flooding, diseases, and insect attacks), the rising cost of energy has contributed to rising production costs, translating in increasing prices for rice (FAO 2006c). Additionally, in order to insure their energy security, many developing countries are undertaking an aggressive growth in biofuel production, which has prompted concerns that biofuel production may be "crowding out" food production (Rosegrant et. al. 2006; von Braun and Pachauri 2006)

Rice trade and pricing policies: Developing countries dominate most of the rice trade, accounting for more than 80 percent of both imports and exports. The five major exporters are Thailand, Vietnam, China, the United States, and India; the main importers are Indonesia, Bangladesh, the Philippines, Brazil, Iran, and Nigeria. However, only about 7 percent of total rice produced is traded internationally. There are numerous reasons for this, including the residual nature of trade in national policies pertaining to rice; much rice is consumed where it is produced, as many rice-producing countries concentrate on meeting local demands (UNCTAD 2006, Gulati and Narayanan 2002). Further, both developing and developed countries protect their rice markets. During 2002-2003, OECD rice producers received US$ 22 billion in support per year, and developing countries' level of market price and producer support is increasing as well; in India, Indonesia, and Vietnam for example, the level of support has increase by as much as 30 to 40 percent (Orden et. al. forthcoming). Additionally, exchange-rate appreciation in Asia (e.g. China), may be the single biggest force in diminishing the competitiveness of rice, and may further increase the call for protection in the coming years.

Trade liberalization commitments for rice have been minor under the WTO. Still, the liberalization of rice trade has potential not only in terms of economic gains, but can also play a role in stabilizing rice prices. For example, when major floods hit Bangladesh in 1998 and negatively affected rice production, the government's reaction was to relax restrictions on rice imports. This paved the way for increased imports from India, which was crucial for avoiding major disruptions and spikes in rice prices that would have hurt poor households most (del Nino et. al. 2001).

One consequence of the small share of trade is large fluctuations in rice prices, reinforced by the lack of collective action among main rice-producing countries to expand international trade. This in turn may be a force behind national policy aimed at price stabilization and policy demand for high shares of domestic supply. During the past four decades, due to increased yields and a decrease in cost per unit of production, rice prices have shown a declining trend, but continue to fluctuate substantially. Indeed, 85 percent of rice exports are concentrated among the five major exporters, and any change in the production and/or consumption of rice in these countries would have a strong effect on prices.

Given the sensitive nature of rice, most Asian rice-producing countries have traditionally taken an interventionist role in rice markets. Nevertheless, the importance of private exporters is growing. In Thailand, for example, private trading has risen over the past 10 years from 20 percent to 80 percent. In Vietnam, private negotiators have also appeared progressively following national economic reforms that took place in the 1990s (UNCTAD 2006).

Regulations and standard setting policies: The growing consumer demand for higher quality produce and stricter food safety regulations has meant that national governments around the world (especially in industrialized countries) and private food companies are paying more attention to food quality and food safety measures. This is posing a number of challenges. For one, many producers in developing countries may not have the required resources to meet stringent quality standards. Second, there is a wide diversity of safety standards across the globe, and this can be a serious impediment to trade. European countries, having experienced a relatively higher number of food scares in recent years, tend to have more stringent food safety requirements. In addition, many developing countries do not have the required regulatory institutions to test food products to see if they meet quality standards (Umali-Deininger and Sur 2006; Henson and Jaffee 2006; Saxena and Singh 2002).

One of the more contentious issues in food standards is the use of genetically modified organisms (GMOs) in food production. While GMOs could potentially result in significant gains for both farmers and consumers, there remain concerns about risks (or simply aversion for other reasons). As a result, some governments have imposed restrictions on imports and/or have strict labeling requirements on GM products (Anderson and Nielson 2002). Thus, the discovery of GMO "contamination" can be disruptive to rice production and trade. For instance, in 2006, when food safety authorities in the United States learned that an un-approved, experimental GMO rice had been found in U.S. rice exports, it led to a suspension of U.S. long-grain rice imports in Japan; in Europe, importers were required to produce a certificate demonstrating that rice imports did not contain unauthorized GM rice. Additionally, rice futures prices fell by more

than 5 percent at the Chicago Board of Trade, and many supermarkets across Europe were forced to make product withdrawals (Mekay 2006). This GMO contamination case highlights the need for harmonizing quality and food safety standards at the global level. The WTO's Agreements on Sanitary and Phytosanitary Measures (SPS) and Technical Barriers to Trade (TBT) allow member states to set their own food safety measures and to impose trade barriers based on food safety measures, and so do not solve the problem. Of increasing importance are corporate rice standards and rule of origin criteria for the fast growing specialty rice qualities. Transparent labeling policies and / or trademarks are needed to facilitate efficient market functioning for these rice products.

b. Environmental policies and addressing risks

The chief concern related to rice today is increased pressure on **water and land resources.** By far, most of the rice produced in Asia depends on irrigation, and irrigation is the single largest user of water resources. However, inappropriate management of irrigation has contributed to environmental problems including water depletion, water quality reduction, water logging and salinization (Rosegrant et. al. 2002). Further, in many developing countries, average irrigation efficiency is low, thus contributing to wasteful use of water supply. In rainfed environments, to meet immediate food demands, farmers have expanded production into marginal lands; these lands are sometimes susceptible to environmental degradation (Rosegrant et. al. 2002). The biggest priority in sustainable management of rice ecologies today is water use efficiency.

Institutional reforms in **irrigation management** are therefore necessary, as Gulati et. al. (2005) highlight for India. Irrigation agencies were set up with little attention to long-term performance of the system, as among other things, the agencies were not financially autonomous, lacked accountability, and irrigation rates did not cover operations and management expenses. From their studies of irrigation management in two Indian districts, Rajasthan and Karnataka, Gulati et. al. (2005) conclude that reforms must address the incentives of water suppliers and users and lead to new arrangements for joint management of irrigation.

The mismanagement of irrigation systems is only part of the water scarcity story. The precarious future water supply situation in Asia, with potential macro-watershed change around the Himalaya due to reduced ice-cover, could have huge implications for rice ecologies, as some of the current production systems might become non-viable under such circumstances.

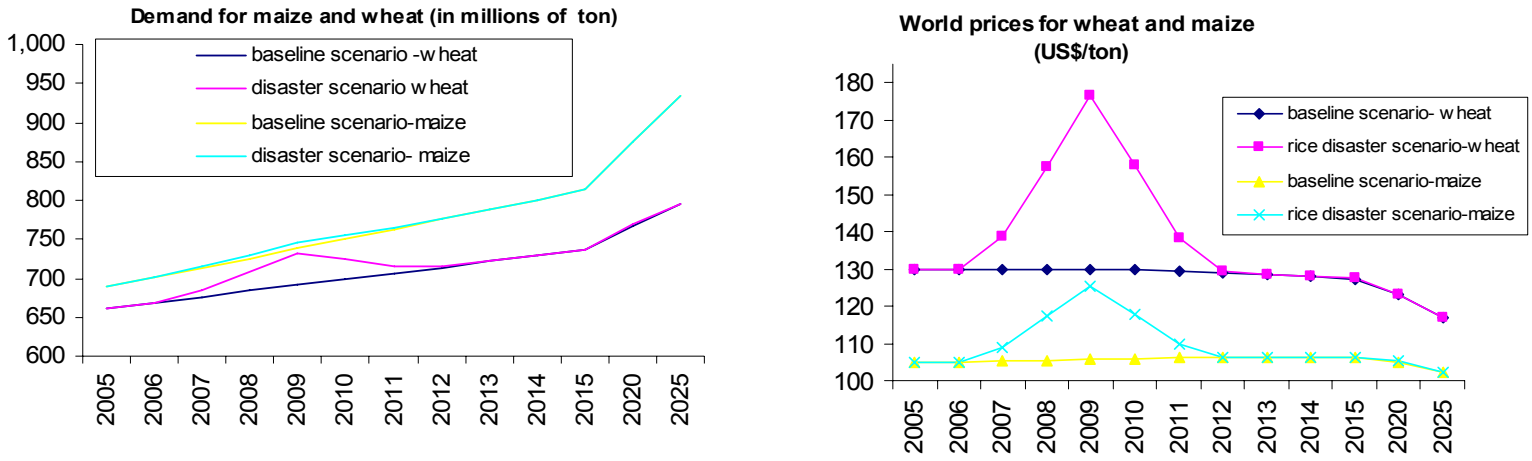
But what would be the impacts of a breakdown in rice yields, perhaps as a consequence of unforeseen or new pests and crop diseases? The consequences of such a hypothetical event are explored next.

Simulating a rice disaster. A significant drop in rice production will not only negatively affect farmers through the income effect, but will set off second-round effects through forward and backward linkages with other sectors through price effects. Given the global role of rice, the impacts of a rice disaster in Asia would also be global. In order to illustrate this, a simulation using IFPRI's IMPACT model is employed.[3]

[3] The objective of International Model for Policy Analysis of Agricultural Commodities and Trade (IMPACT) model, developed by Mark Rosegrant and his team at IFPRI, is to provide insights into the management of the

The simulation assumes a rapid decline in rice yield that gets progressively worse over three years (due, for instance, to a spreading pest or disease attack), corresponding to a low of 25 percent of the normal yield in the third year, and then returning to full "normal" yield over the following three years.[4] The results of such a (hopefully unrealistic) shock with regard to prices are dramatic: global rice prices would more than triple in year two after the shock and increase ten-fold in year three before coming down again.[5] The simulation exercise also looks at the potential impacts of such a rice disaster on the production, demand, trade, and prices of other cereals, particularly wheat and maize (Figure 1). The prices of the other cereals would increase too, making the crisis global, and not just Asian.

Figure 1: Global impact of a rice disaster on demand and prices of wheat and maize



Additionally, the potential impacts of a rice disaster on food calorie availability and child malnutrition are presented (Tables 4 and 5). One striking result is that an additional 12 million children across the developing world would be malnourished at the peak of the disaster, and would thereby be adversely affected for life.

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dynamic risks and forces that shape the factors affecting people's access to food and the links with malnutrition through appropriate policy actions. It allows the exploration of the potential impacts of different policy alternatives to manage hunger, malnutrition, commodity prices, demand, cereal yields, production, and net trade by projecting future global food scenarios in the medium and long term (See Rosegrant, et al. 2005 and Rosegrant et al. 2002 for detailed descriptions of the IMPACT model).

[4] The rice yield assumptions in the scenario are as follows: In the first three years after the shock, there is progressive decline of rice yields. In Year 1 yields are approximately 70 percent, in Year 2, 40 percent, and in Year 3, 25 percent of baseline scenario yields. Rice yields then start redressing in Years 4 and 5, when rice yields respectively account for approximately 40 percent and 70 percent of baseline scenario yields. Finally, in Year 6, rice yields get back to their baseline scenario level.

[5] The simulation results with respect to global rice prices are as follows: In the first three years, rice prices keep increasing; as compared to the baseline level, in Year 1, prices are 66 percent higher, in Year 2, they are 342 percent higher, and in Year 3, they are 937 percent higher. Then, prices start declining in Years 4 and 5; prices are 354 percent and 69 percent higher, respectively, than the baseline scenario prices. Finally, prices reach baseline levels in Year 6.

Table 4: Difference in the per capita calorie availability between the rice disaster scenario and the baseline scenario

	2005	2010	2015
South Asia	0	-265	-5
South East Asia	0	-632	-10
East Asia	0	-320	-5
Sub Saharan Africa	0	-111	-3
Latin America	0	-105	-2
West Asia & North Africa	0	-45	-1
Total developing countries	**0**	**-266**	**-5**

Table 5: Difference in the number of malnourished children aged 0 to 5 (in thousands) between the rice disaster scenario and the baseline scenario

	2005	2010	2015
South Asia	0	4,277	66
South East Asia	0	3,609	48
East Asia	0	2,298	35
Sub Saharan Africa	0	1,496	36
Latin America	0	499	9
West Asia & North Africa	0	1,69	5
Total developing countries	**0**	**12,349**	**199**

The modern and globally integrated food system may suggest that the negative impacts of a rice disaster could be somehow mitigated through trade and substitutions, but in the case of rice, due to the weight of the rice crop and its specialized production capital, this may not be the case. Thus, there is no better insurance against such risks than continuous investment in yield risk-reducing research and appropriate safeguarding of the diverse genetic resource base of rice. This remains an international task for generations to come. Moreover, the emerging global climate change may pose increased risks for yields and thus requires accelerated investment in adaptation of rice ecologies. We currently lack the capacity of comprehensive risk assessment at the large scale.

c. Research and development policies for innovations

Future rice research and development (R&D) has to focus mainly on a set of goals that are on the one hand driven by rice consumers, and on the other hand by the ecological effects of rice. The former entails yield stability, quality traits of relevance for the poor (i.e. micronutrient content as a latent demand) as well as those demanded by high-income consumers, and processing qualities that can facilitate further use of rice in fast foods (maybe competing with noodles). The latter entails resource efficiency (especially water use) and adaptability to climate change.
Given the current context of rapid globalization and the speed at which new technological innovations are emerging, an adequate institutional framework needs to be urgently put in place in order to facilitate the development and distribution of pro-poor technological innovations. And, even as the private sector is increasingly getting involved in rice R&D, pro-poor public rice R&D remains relevant and important.

Providing adequate institutional frameworks: Institutions provide the environment of incentives for technologies to flourish, and, conversely the absence of adequate institutions blocks innovations. In India for instance, the Agricultural Prices Commission and the Food Corporation were established in 1965 to make possible the success of Green Revolution technologies and to lift the food equation to a higher balance.

Current and future rice technologies such as hybrid, GMO (including pest-resistant and drought resistant strands), and micronutrient-enhanced rice also need institutional arrangement to facilitate them in productive and safe ways. In particular, institutional frameworks for intellectual property rights (IPR) and biosafety are needed, and both require clarity in rules as well as transparency and reliability in implementation, and need to be worked out through international cooperation.

The global IPR regime remains inadequate. For one, instances of biopiracy—the appropriation of indigenous knowledge and innovation by foreign bodies through patent rights—occur. A recent case involving Basmati rice, the high-quality, long-grained aromatic rice known for its unique flavor and aroma, is a good illustration of this.[6] Secondly, as the research environment gets increasingly proprietary and exclusive, progress in public goods research may be hindered and the systems of global exchange of plant genetic resources may increasingly be constrained. In order to prevent this, public–private and international collaborations are needed.

Regarding *regulatory issues in bio-safety and GMOs*, what is observed is that there is a general consensus on the usefulness of transgenic corps, but that the related biosafety policies are complex and slow to implement. From an economic perspective, biosafety and biotechnology should follow essential safety standards and cost efficiency. And, by adding many layers of complexity to regulatory work, there is a risk of not allowing crops to get to the market.
In many countries, biosafety policies are often developed by isolated government ministries or departments with different priority standards, which can become a major reason for conflict and can in turn cause delays in the implementation process. Thus, in order to make the process more efficient, inter-ministerial coordination is necessary.

Furthermore, on the international arena, the regulatory decisions made at the Cartagena Protocol on Biosafety should be the object of rigorous cost/benefit analysis. In particular, regulations on labeling, documentation, liability, transboundary movement, or adventitious presence will play a significant role in the development of GMO technology.

[6] Basmati rice has been cultivated for centuries in Northern India and Pakistan, and has deep cultural value in both countries. It also has important economic value, as it represents India's primary rice export. The Basmati dispute started in 1997 when a U.S. company, RiceTec Inc., was issued a patent by the United States Patent and Trademark Office (US PTO) for the use of the word "Basmati" for an aromatic rice variety grown in the United States. After three years of intense research and investment, the Government of India (GOI) reacted in 2000 by filing a "request for re-examination" with the US PTO, and also, by filing a legal petition, along with Indian and U.S. non-governmental organizations, with the U.S. Department of Agriculture and the Federal Trade Commission (FTC) to regulate the use of the term "Basmati" to rice grown in India and Pakistan. The results of these filings were mixed. While the US PTO re-examination rejected most of RiceTec's claims, which led the company to change its patent name from "Basmati Rice Lines and Grains" to "Rice Lines Bas 867, RT 1117, and RT 1121," the FTC said the term 'basmati' is generic and cannot be region specific (Subbiah 2004).

In terms of labeling policies, it is important to note that labeling will not address safety concerns; these issues should be handled at the food approval stage, which comes before labeling. For the same reasons, GM food labeling should not be introduced for safety reasons but for consumer choice or consumer right to know. Further, introducing labeling in developing countries, be it either voluntary or mandatory, is a major challenge, but the cost of labeling should be accounted for.

The role of public R&D for rice: Given the slow progress in tackling malnutrition across the developing world, rice research needs to be accelerated. While several of the innovation needs such as the market-valued quality traits (which can be identified by corporate labeling or are visible in the products) can be left to the private sector, pro-poor research needs and the ecological properties must be addressed by public research and at an international level. This requires increased funding for public research.

In Asia, the large national rice research systems, particularly in China and India, can address these issues in cooperation with the international agricultural research system (IRRI and more generally the CGIAR). However, the transmission to small countries with weak research systems may become a growing problem as research needs become more and more sophisticated. The International Rice Research Institute (IRRI) can play a significant role in facilitating this transmission.

III Conclusions and Policy Implications

There can be no doubt that rice is important enough to be addressed with special policies. But rice policies must not be formulated in isolation from other food and agriculture policies related to markets, technology, and the environment. As the demand for rice and the perceptions of rice-related external effects in consumption and environments are changing, the optimal policies along the rice value chain must change accordingly.

Here the needed policies within each of the three policy domains used to structure the paper are highlighted:

(1) Where they are high, **transactions costs between and within all elements of the rice value chain must come down**. This can be done through reforms and improvements in market information flows, institutions, and organizations. Improved access to information and communications technologies and improved rural infrastructure provide significant benefits for productivity. In many locations, connecting rice farmers to the fast-changing retail industries and supermarkets through cooperatives and contracts will be beneficial. Providing favorable legal conditions for that is also important. Rice, despite being the most important food item in the fastest globalizing economies of Asia, has been largely kept out of trade dynamics. A gradual opening up of rice markets seems overdue.

(2) One main task for policy related to rice is the **facilitation of increased water use efficiency**. This would include a complex package of irrigation management, crop management, and rice research and development. These measures are partly location specific and need local capacity strengthening.

(3) The rice crop cannot be taken for granted. Environmental risks must be considered, especially as environments are changing with global climate change. **Continuous research efforts are needed to ensure the stability and security of the rice crop** as such research addresses the insurance value of rice in the global food system. International cooperation remains significant for that because no single country may sufficiently invest in this task. The fact that at least an additional 2 billion people—mainly living in Asia and Africa—need to be fed in the next generation cannot be overlooked. Rice will be one of their main food items. Thus, efficient supply from sustainable production of rice will be a challenge for research and science policy.

(4) Genomics allows the biological properties of the rice crop to be increasingly better understood. This knowledge can be brought to use for adaptation of rice to the emerging challenge. **Sound regulatory institutions and their transparent operations are needed**.

(5) The policy objectives related to rice are highly varied, and, include ecological, nutritional, risk-reduction, and productivity-increasing goals. It will be increasingly challenging to identify **coherence among the policy domains**. This requires economic and environmental assessments that take risks and opportunities explicitly into account, and involves participatory policy processes. The rice [r]evolution must continue for the benefit of people/poor and sustainable development. At the front line remain the technology innovators, researchers and farmers, the institutional innovators, and the bold policymakers providing the needed support.

Annex

POLICIES ALONG THE RICE VALUE CHAIN				
POLICY DOMAINS	RESOURCE MANAGEMENT	FARM PRODUCTION	PROCESSING AND MARKETING	RETAILING AND CONSUMPTION
Market, price, and trade policies, including regulation and standards	-Introduce economic incentives in the allocation of water.	-Support farmers to adapt to higher quality standards -Invest in irrigation infrastructure in rainfed areas - Safety regulations and standards: o Harmonize quality and safety standards across the globe (across countries as well as between private and public standards), incl. through labeling; o Improve quality and safety management and regulation capacity in developing countries (improving legislative frameworks, surveillance and inspection systems and procedures, etc.) - Markets and trade: Progressive trade liberalization Privatization of rice		Improve consumer understanding of food safety risks
Environmental policies and risk-coping policies	-Improve water rights for farmers and other water users -Reform irrigation systems - Biodiversity protection in rice	Promote environmentally sustainable production methods (e.g. minimizing pesticide use)	Ecological standards in processing and retailing	
Innovations and R&D polices	- Water and land saving technologies	- Labor saving technologies - Drought and insect tolerant varieties for improved productivity - Make new technologies available to small producers, i.e., link research results to farmers' realities- address the yield gap - Intellectual property rights issues: o Preventing biopiracy o Developing public–private partnerships for rice research o Addressing the challenge of access and exchange of rice plant genetic resources for public goods research	- Provide enabling environment for private-sector innovation in rice processing and in retail (e.g. addressing the needs of the increasingly time-constrained consumer with processed rice products)	- Responding to taste changes - Enhanced nutritional content of rice (e.g. biofortication)
POLICIES ENABLING STRUCTURAL CHANGE IN RICE DOMINATED SYSTEMS				

Enabling a sustainable transition for poor farmers in an increasingly globalized and commercialized system

- Diversifying the income of small rice farmers
- Enhancing market performance (market institutions and information)
- Investing in labor saving technologies

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