

A NEW APPROACH TO DEAL WITH THE GLOBAL FOOD CRISIS

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Abstract

The global food crisis in 2008 made the World once again aware that investment in agriculture matters. In view of the long period of food surpluses and depressed food prices, many policy decision makers concluded that hunger is just a distribution problem. As a consequence, public funding for further crop improvements was cut back worldwide over the past two decades, while the private sector continued to invest primarily in the improvement of high value cash crops designed for large-scale and capital intensive farms.

A global food security strategy for the 21st century must end this divergence of public and private sector activities and create more incentives to invest in tailor-made technologies that facilitate the economic empowerment of the rural poor and enable a more sustainable use of natural resources.

1. Introduction

For more than a decade, world food consumption has been above world food production for staple food, and public investment in agricultural research and development (R&D) was cut back worldwide in spite of evidence of its high rate of return on investment in the farm sector (World Bank 2008). This combined with the more recent rise in oil prices, subsidies for farmers to cultivate food crops for ethanol and biodiesel production and harvest failures in several food exporting countries help explain why food prices have escalated in spring 2008 (Economist 2008a).

Even though food prices are decreasing again thanks to the easing of the short-term problems, the situation is likely to remain critical in view of a decade long-neglect of agriculture, the low level of global food stocks and the increasing consumption of meat and dairy products in emerging economies such as China and India (FAO 2008).

Poor people in Sub-Saharan Africa belong to those who are most vulnerable to a rise in world food prices. They live mostly in food-importing countries and food usually

represents the biggest share of the average household budget of a poor family. One may argue that it would at least benefit poor food producers in these countries because they can now sell at a better price; unfortunately almost 90% of African farmers are mainly involved in subsistence farming (Paarlberg 2008) and thus do not benefit from global food price increases because very few of them actively participate in international or even national agricultural trade.

In spite of substantial agricultural trade liberalisation and some delayed productivity increases from the Green Revolution, Africa's food imports per capita have grown sharply since 1990, and since 2001, it has imported more cereal grain per capita than any other region (Masters and Garcia 2008, Ng and Ataman 2008).

There are multiple reasons for the worsening food security situation in Africa. First of all, civil wars in some African countries have created an increasing dependence on food aid supplied by the World Food Programme (WFP). Second, the shift of power in the global food chain moved from the supply-side to demand-side. It induced large retailers to cater more strongly to the preferences and values of urban and semi-urban affluent consumers. Since these consumers tend to reject modernization in agriculture and believe it negatively affects food quality and the environment, retailers have become mainly concerned with private food safety and environmental standards that are supposed to signal to consumers that they are equally sceptical about the sustainability of modern agriculture.

Third, in view of the large dependence on foreign aid, conditional lending and market access, many African governments designed agricultural and development policies that please Western donors and investors but do not necessarily benefit their own people. A recent report published by the International Assessment for Agricultural Science and Technology for Development (IAASTD) expresses the public resentment towards modern agriculture in affluent non-agricultural societies most clearly (IAASTD 2008). Its recommendations provide some valuable ideas in how to address the environmental chal-

lenges of agriculture but they are not very helpful when it comes to efforts to improve food security and empowering the rural poor.

The implicit assumption of the report that the promotion of international agricultural trade and new technologies are the problems rather than part of the solution to the food and environmental crisis is representing the mainstream view in affluent societies for the past two decades. The export of this view to developing countries that face completely different conditions proved to do more harm than good as will be illustrated in this article by means of historical evidence. The nostalgic attitude towards agriculture among the growing share of people that is no more involved in agriculture led to policies on the national and international levels that discouraged investment in agriculture and agricultural research and development (R&D) in particular. As it used to be the case in colonialism, the affluent elites in developed and developing countries share common values and interests and tend to either despise or idealise the rural poor (Paarlberg 2008). The paper argues that this collusion of urban elites and their influence in agricultural and development policies help explain why rural poverty in Africa increased while its ability to feed itself decreased over the past two decades.

The development was different in emerging economies that are less dependent on European aid and agricultural trade and more obliged to be responsive to the growing domestic middle class. Countries such as China, India, South Africa and Brazil have invested in human capital on the countryside and home-grown agricultural technologies (Timmer 2008, The Economist 2008b). South Asia may still have more hungry people in total than Africa, but the situation there is improving rather than worsening.

The partial and general economic equilibrium models that are supposed to predict trends in agriculture and guide political decisions with respect to rural development and agricultural trade proved to be unable to explain the relative success of rural development in emerging economies compared to Africa because they fail to take into account the welfare effects of new products and services that result from investment in agricultural technology. In this paper we argue for a new direction in economics largely following the insights of New Growth Theory. We then show by means of the case of New Zealand, how an agricultural policy that is based on the principles of this new theory facili-

tates endogenous development that facilitates rural empowerment and innovative responses to environmental challenges.

The first chapter in this paper will explain in more detail the three main factors that contribute to the inability of Africa to feed itself. Chapter 2 then looks at theory and policies applied in the 20th century to address food security problems and relate them to the current situation and policy advice.

Finally, chapter 3 argues for a new perspective in economic theory and public policy that aims at mobilizing science and technology to effectively address the urgent agricultural, environmental and socioeconomic problems of the 21st century. For that purpose best practices will be illustrated in developed and developing countries.

2. Why Africa lost its ability to feed itself

2.1 Food Aid

There is no doubt that bringing food to regions that suffer from harvest failure or civil war is a humanitarian duty and the World Food Programme (WFP) is doing its best to fulfill this duty. Yet, the institutional environment in which the World Food Programme has to operate is often creating unintended side effects that harm agriculture in the affected regions on the long run.

One problem are the constraints the WFP faces in its freedom to buy its food stocks from domestic farmers close to the affected regions. These constraints are imposed by the US government which links its willingness to fund the WFP to the requirement of accepting a large share of its food stocks from US farmers. This hidden export subsidy for US farmers is clearly damaging farmers in developing countries who cannot compete with free food (Herald Tribune 2007). The US farm bill of 2008 once again endorses this practice probably in response to pressure from vested interest groups that benefit from producing or shipping the food to Africa. The farm bill further specifies that all food aid should be provided by in-kind food donations, meaning US agricultural commodities like bulk wheat or rice or processed agriculture products. The problem is not just US farmers that need to be weaned off from these subsidies but also US development organisations that benefit from it through the monetization program; beginning with the 1985 farm bill, certain U.S.-based relief organizations and cooperatives were allowed to sell a certain percentage of the

non-emergency commodities to cover food aid costs or, more importantly, to fund their own programs. Development organizations admit that monetization now represents a major source of their program funds (Liebhardt 2008). The United States is the only donor country that continues with these practices revealing its inconsistency in agricultural and development policies.

However, the heavily subsidised multifunctional agricultural system in Europe suffers from a similar inconsistency. European farmers get a large share of their income from their national governments and the EU. Their policy preferences are shaped by tax payers that are not involved in agriculture but prefer a countryside that is not yet spoilt by the advances of modern science and technology. Europe can afford to maintain such an expensive agricultural system that produces for affluent tax payers rather than poor consumers. But to assume, as many European politicians do, that such a system would also be appropriate for Africa, is problematic. It is partly responsible for Africa's failure to increase its agricultural productivity and promote rural empowerment through entrepreneurship (Paarlberg 2008). In addition, the EU tends to increasingly replace tariff trade barriers for developing countries by non-tariff trade barriers in the form of prohibitively expensive public and private standards for food imports that often show no evidence of increasing food safety (Ansell and Vogel 2006, The Economist 2008b). This discourages poor developing countries from adopting modern biotechnology in agriculture for fear of losing European foreign aid and being barred from European food markets. High food safety standards combined with European aid money that deliberately discourages growth in the agricultural sector breeds political engineering and stunts the investment and development of competitive agricultural markets.

2.2 The problem with large retailers

A second reason why Africa is increasingly unable to feed itself is the shift of market power in the international food chain moving from the supply side (products for farmers) to the demand side (products for consumers). Even though this shift had a lot of positive impacts in the form of increased consumer choice and the consideration of their values and preferences in the way food is produced, it also resulted in an increasing reluctance to invest in modern agricultural research and development (R&D) in Europe. The rejection of even clearly labelled genetically modified (GM) foods in

stores is just one manifestation of this fear of appearing to be in favour of modern technology in agriculture. Moreover, the high regulatory uncertainty with regard to new agricultural technologies created more market concentration on the supply side and the raising public and private standards in the retail industry successfully created barriers to market entry that also strengthened the incumbents on the demand side. As the new dominant players in the food chain, retailers account today for half or more of food sales world wide. In view of the dislike of wealthy urban consumers of agricultural modernisation – often portrayed as 'shared values' - they tend to side with concerned consumers and sport a view of sustainable agriculture that sees technology as the problem rather than the solution. It is often ignored that these shared values are not a given exogenous factor that emerges from a genuine cultural preference but are often endogenously shaped by stakeholder interests and values communicated through the mass media (Aerni and Bernauer 2006).

Large retailers use their marketing campaigns to communicate to the public that they share their values (even if they might just reflect simple prejudices) and ask the food suppliers to take them into account as well. This is a big difference to the past when consumer preferences were assumed to be simply driven by price and thus quite predictable and not very important in the policy decision-making processes. Food policy merely meant to improve links between farmers and suppliers. The Green Revolution of the 1960s, for example, provided new seeds and subsidised fertilisers but did not take into account taste preferences (Aerni 1999). This was obviously a big mistake that is now bouncing back into the other extreme not in the form of food quality but food safety.

Yet, in spite of portraying happy small-scale farmers in their advertising campaigns, supermarket chains must favour large-scale and capital-intensive farms as suppliers of food that can comply with their high private standards. They require uniform quality, minimum quantities, high standards of hygiene, and sometimes even evidence that farmers have an environmental conscience (as in the case of EUREPGAP). It is not surprising that average smallholders in Africa are ill-equipped to comply with such standards. Traders and supermarkets are therefore likely to benefit capital-intensive farms that are close to large cities rather than small farms in the marginal regions of Africa (The Economist 2008a).

In this context, it is misleading to believe that supermarket chains that increase the share of tropical organic

products in their assortment do so in support of poor African smallholders. The reality is that most of these products originate from highly capital-intensive farms located close to the airports of the large African cities and exclusively run by Western companies (Paarlberg 2008). The resulting new structure of agricultural trade is therefore largely shaped by large retailers in Europe and the United States. Their strategies look increasingly like a new form of colonialism that is based on the collusion of affluent urban elites in the European and African countries in favor of European interests and preferences. That was the case during the slave trade (Appiah 2007) and it is the case today when considering that, unlike the elites in Asian countries, the African elites hardly ever imposed conditions on foreign companies to facilitate technology transfer, collaborate with the local private sector and train local people. Foreign companies may contribute to economic and social development but their activities are mainly concentrated in urban areas and focused on pleasing Western consumers, tax payers and donors rather than the local entrepreneurs, especially when they are located in remote rural areas. Once again the rural poor in the periphery are particularly excluded from the benefits (Aerni 2006, Paarlberg 2008).

2.3 The 'anti-technology' framing of sustainable agriculture

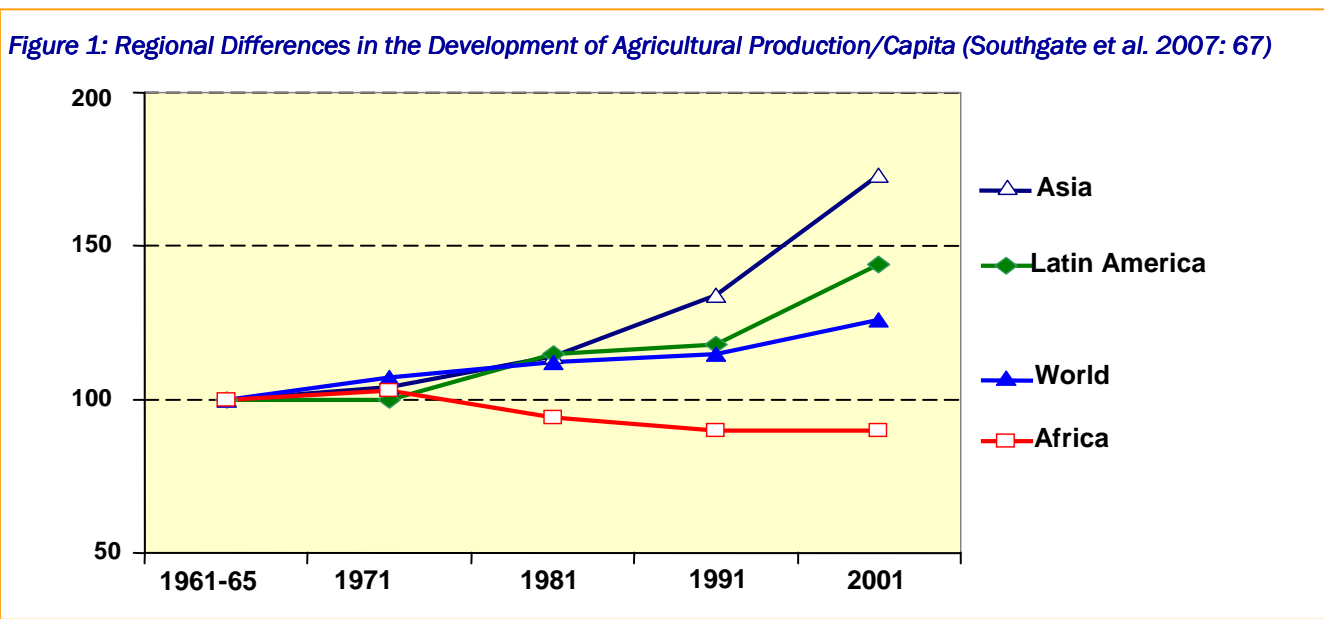
In Africa, 80% of the farms are smaller than 2 hectares and, unlike in Asian countries with a similar agrarian structure, crop yields are extremely low. The overall decline in production/capita of all major food crops (Aerni 2006) can be attributed to the fact that a large

majority of African farmers does not have access to fertilizer, improved seeds, and other inputs while mechanization is almost nonexistent. In contrast, the large-scale African plantations of cocoa, cotton, peanuts and sugar may be successful exporters to Europe, but they are almost exclusively run by Europeans and stem from the age of colonialism when Europeans still invested in research to improve these speciality crops (Paarlberg 2008).

Figure 1 shows the dramatic changes of agricultural production per capita in Africa compared to other regions in the world over the past five decades (starting from the period of 1960-65=100). While the numbers increased everywhere, Africa's production per capita decreased and is now still stagnating.

In spite of the appalling evidence that Sub-Saharan Africa needs more public and private sector investment in agriculture and improve rural infrastructure in order to better connect poor farmers to markets, a recent report published by the International Assessment for Agricultural Science and Technology for Development (IAASTD 2008) does hardly address this urgency. In its global summary for decision makers the World Bank-sponsored IAASTD report implicitly frames open agricultural markets and new technologies as the problem rather than part of the solution to sustainable agriculture (Stokstad 2008).

Even though the report contains a lot of valuable insights gained from agricultural research and correctly identifies the major problems in agriculture with regard to biodiversity, soil degradation and water use, it hardly addresses the challenge of how to produce more food with less land and water. Its recommendations are based on the popu-



lar but wrong assumption that hunger is a mere distribution problem and unrelated to production. If one would follow this insight and distribute the surpluses in subsidised agricultural systems freely among the people in poor food-importing countries, farmers there would have to abandon farming altogether in the receiving countries because they can not compete with cheap donations. This would thus further aggravate the ability to food self-sufficiency in these countries.

The report was initially meant to highlight the environmental problems of modern agriculture and its impact on smallholders in marginal regions. It was implicitly assumed that food security would not be an issue in a world that produces large food surpluses and consequently depresses food prices. The raising food prices therefore came as a surprise and the IAASTD report had then to be quickly portrayed as a potential solution for the World food crisis as well. Not everyone was buying it.

Even though the report claims to represent an interdisciplinary approach that involves researchers and experts from all areas, the steering group largely ignored the experts in biotechnology and molecular biology and showed no interest in the potential ability of the private sector to contribute to global public good character of sustainable agriculture and food security (Nature Biotechnology Editorial 2008).

The defendants of the right to food and food sovereignty who largely welcomed the IAASTD report (de Schutter 2008) tend to ignore that access to food does not happen by magic; neither can it be left to well-meaning distributors of free food. There are still the laws of demand and supply that determine the price of food and consequently access to food. So if access to food is to be improved without further harming the natural environment more food needs to be produced on less land. The IAASTD report is right to argue for more support of multifunctional small-scale agricultural systems that make sustainable use of the local natural resources and thus enable a more integrated approach to farming. But such systems may easily be combined with promising new agricultural technologies. This would make such agricultural systems more profitable for farmers, less labor intensive (allowing poor families to send their kids to school because they are less needed in the field) and more efficient in the use of the available natural resources. There are no scientific reasons why a combination of integrated farm manage-

ment and agricultural biotechnology should not be possible. But unfortunately, the report did not make an effort to go beyond the usual ideological division of small, low-tech farming versus big high-tech farming.

The inadequacy of the report in responding to the current situation of agriculture may be related to the fact that its main ideas, largely stem from 1970s and its heated controversy over the risks and benefits of the Green Revolution. In order to understand the continuing absence of new theories that would be more compatible with the reality of the knowledge economy of the 21st century one needs to look at the history of modern agriculture and the resulting change in values in affluent societies.

3. Globalisation and Agriculture

3.1 Policy responses to the first wave of globalisation in the 19th century

Modern agriculture has its roots in the 19th century. At that time, there were Malthusian fears about a looming global food scarcity due to the exponential population growth along with an only linear growth of agricultural production/capita. In spite of these alarming predictions, there was no international effort to avoid possible mass starvation because Malthusian predictions failed to take into account the breakthroughs in science and technology that revolutionized agricultural production, food processing and the means of transportation and made food more abundant and thus cheaper. These technological advances were mainly private-sector driven. National governments, in turn, were assisting farmers with public investment in applied agricultural research. Their goal was to ensure the successful participation of their farmers in the emerging international agriculture trading system.

The new reality of international agricultural trade is linked to the first wave of globalisation in the second half of the 19th century that led to a rapid decrease in transportation costs and erased many of the geographical barriers that previously protected local agriculture from foreign competition. This threatened the livelihoods of many farmers in the early stage of industrialization and governments started to get worried about the lack of agricultural competitiveness and the resulting impoverishment of the countryside. Yet, instead of protecting farmers from the forces of globalisation, governments decided to harness them for change. National agricultural research institutes were established with the pur-

pose of assisting farmers in their efforts to find innovative ways to cope with technological and economic change (Brugger 1956, Widder 2005). Researchers were actively encouraged to collaborate with farmers in a joint effort to convert new knowledge into products and services that generate increasing returns in farming (Aerni 2007a). Many of the big companies involved in the seed, machinery, trade and food businesses today have their roots in this fruitful joint collaboration of the 19th century. This collaboration was however not just spawning large companies but also improved life in rural areas. Entrepreneurial farmers felt that they are part of global change rather than its victims. They generated income and employment on the countryside and kept rural life vibrant and active. At the same time, they contributed to a global increase in agricultural productivity, which made food more abundant and accessible for the poor. In other words, it was not a global planning agency that helped avoid the Malthusian collapse but the hundreds of thousand of farmers, researchers and entrepreneurs that were encouraged by governments to find solutions and technologies that allow them to cope with global change and at the same time generate income and employment on the countryside. Food security and the end of starvation in Europe was a positive side-effect of increasing agricultural productivity and rural development. The success was related to governments that assumed the role as a coach of farmers rather than a protective nanny. This was possible at that time largely because, firstly, there were no vested interest groups that focused mainly on defending the status quo and, secondly, there were no public resources available to play a nanny (Olson 1962).

3.2. Social planning and welfare economics in the developed world

World War I and II changed everything. With the onset of World War I, globalisation came to an end and agricultural trade was strongly restricted. As a consequence, governments designed new agricultural policies that were largely focused on ensuring national food security (Rieder and Anwender Phan-huy 1994). Government agencies assumed a more active role in the research, production, processing and the sale of food. This government investment helped strengthening the already established firms in agriculture. After World War II, the Allies concluded that the only way to avoid war is to promote trade and international cooperation (Urquart 1990). This view enabled a new joint effort for trade liberalisation (GATT Agreement) and

gave birth to the Bretton Woods institutions (World Bank, IMF) and the United Nations. However, agriculture largely remained in the national realm of politics and was based on strong government intervention in view of possible food security problems resulting from the looming Cold War (Desta 2002). At the outset, state intervention was mainly justified in the name of managing the public good 'national food security'. For that purpose, agricultural economists were hired as social planners to ensure the effective management of this public good. The planning models they used (e.g. linear programming) to calculate how certain normatively set policy objectives can be achieved most effectively, were largely developed by scientists in the former Soviet Union (Baker and Swanson 1964). The concept of market failure in comparative-static welfare economics provided the theoretical justification for this approach.

In addition to that, welfare economics in agricultural policy embraced the theoretical concept of the so-called agricultural treadmill developed by Cochrane (1979). In this concept, farmers produce a homogenous and inferior commodity in the form of food. They are portrayed as passive price-takers in a market of perfect competition. The role of technology is reduced to its potential to increase agricultural productivity (while its potential to improve food quality and the environment is not addressed). Since farmers are standing in perfect competition they are assumed to produce at the level where their marginal costs just equal their marginal revenues. The agricultural treadmill induced by technological change is therefore a zero-sum game for farmers: they are forced to adopt a new cost-saving technology but since everyone who wants to stay in business will have to do it eventually, the farmer will never be better off in spite of producing more and offering it at a lower price.

The concept of the agricultural treadmill ignores that farmers are often innovators themselves and create new products and services with increasing rather than decreasing returns. It does also not capture the advantage of labor-saving technologies that allow a farmer to invest more in the education of themselves and their children. Finally, it ignores the environmental and social welfare effects that result from producing more with less. Based on this one-sided concept, agricultural economists concluded that the treadmill, and with it technological innovation, largely benefited food consumers at the expense of food producers. They argued that the agricultural treadmill is producing a sort of market failure since farmers would get poorer even though they produce more.

Moreover, the resulting modernisation of agriculture would destroy the environment and family farming and negatively affect the quality of food. This pessimist view of technology in agriculture provided the foundation of the widespread resentment of technological change in agriculture by respected economists. Their attitude probably influenced the anti-technology policies in agriculture in the Post-Cold War Period more than the environmental protest movements.

In the 1990s, agricultural economists admitted that certain agricultural policies produced 'sub-optimal' results despite the rational social planning. Yet, instead of recommending to return to the pre-War policies of the 19th century when the government assumed to role of a coach, agricultural economists preferred to stick to the nanny approach by recommending to merely switch from production-tied to income-support subsidies (Aerni 2007b). These could be justified in the GATT Uruguay Round as non-trade distorting green-box measures. The new objective was the maintenance of a strong, healthy and environmentally sustainable agricultural sector. It was labelled multifunctional agriculture. It provided the best justification to keep agricultural economists employed as social planners and continue to use the planning models that are focused on creating optimal allocative distribution in areas where the market presumably fails to do so. But did the market really fail? There is increasing evidence that the new agricultural policies and the new justifications for government intervention in agriculture did not bring the expected improvements and could therefore considered to be state failure (Rentsch 2006). Moreover, input providers and food retailers benefited from direct payments more than farmers. The former asked farmers to pay more for seeds, fertilizers and chemicals and the latter asked for a lower price of the agricultural products. Ultimately farmers had to pass on most of their income subsidies to the other actors in the food chain.

At the same time, the new normative goals of agricultural policy to promote environmental, social and economic sustainability through compliance schemes (e.g. agro-environmental measures/labelling schemes in return for more direct payments and premium prices) that aimed at mitigating the impact of agriculture did not meet the expectations (Kleijn et al. 2001). There also seems to be a correlation between the amount of direct payments a rural region receives and its economic decline (The Economist 2005a). This is not surprising in view of the fact that a high dependence on

direct payments is not an attractive way of life for local young people with big dreams; so they look for opportunities elsewhere to participate in the new knowledge economy. Apart from that, the private sector is reluctant to invest in heavily subsidised regions because of the receiver mentality of the people and high production costs (pushed up indirectly through direct payments).

3.3 The Green Revolution

After World War II, major scientific breakthroughs in plant breeding, the development of high-yielding varieties and improved irrigation systems triggered substantial productivity increases in crop cultivation. The US government decided that bringing the benefits of these new technologies to developing countries would contribute to global food security and more trust in a market-based economic systems in the relatively young states in the developing world. Guided once again by the principles of comparative-static economics it was assumed that the private sector is hardly in a position to serve poor farmers in developing countries. Therefore public investment in international agricultural R&D, fertilizer production and irrigation was declared to be a public good that must be managed by the public sector. The resulting global public sector initiative is today widely known as the Green Revolution. The United States Agency for International Development (USAID) and the Rockefeller Foundation were the main financial contributors to the establishment of the first Centers of the Consultative Group of International Agricultural Research (CGIAR) in developing countries (Anderson et al. 1991). These CGIAR centers enabled Western scientists to work in well-equipped research centres in developing countries and design high-yielding varieties of major food crops such as maize, wheat and rice. The new varieties were subsequently distributed in rural areas through government agencies. The private sector was hardly involved, even though it later benefited from the scientific knowledge generated through this international undertaking (Parayil 2003). The research at these centres (i.e. CGIARs) contributed to significant increases in agricultural productivity and technology transfer to local universities and national research institutes in developing countries (Borlaug 2007).

As such the Green Revolution greatly contributed to global food security. However, the interaction between Western scientists, who developed high yielding varieties, and local farmers in developing countries who adopted these varieties through the national seed distribution programs, was rather poor. This led to some long-term problems such as inadequate use of pesticides,

insufficient operation and maintenance of irrigation systems, little seed choice for farmers and monoculture practices (Aerni 1999), and a general neglect of farmers in unfavourable area (Byerlee and Morris 1993).

Left-wing development activists point at these unintended side effects of the Green Revolution and denounce them as the destructive forces of science and business, and they conclude that environmentally destructive monoculture practices must be part of the capitalist logic (Shiva and Bedi 2002). Yet, these undesirable side effects often turn out to be the result of too little rather than too much private sector involvement. For example, public sector researchers based at CGIARs did not have to bother much about the real and complex set of problems farmers are facing in the field or the particular consumer taste that is preferred by different cultures. They could just focus on plant variety traits that would increase yields and then select the elite varieties and hand them over to national agencies for distribution (Anderson et al. 1991). As a result, the private sector may have had little interest to invest in the development and commercialization of new varieties in developing countries. Thus, it largely stayed out of the Green Revolution. This explains for example why the greatest bottleneck in many poor countries is probably the absence of a local seed industry. It also explains why consumers in these countries still prefer the taste of the traditional varieties compared to the new hybrid varieties (Aerni 1999).

3.4 International Agricultural Research

After the end of the Cold War, the public interest in further investing in productivity improvements in agriculture quickly waned and priority in agricultural research shifted to agricultural monitoring as well as more strict food safety and environmental standards. Meanwhile, the adoption of new technologies in agriculture became increasingly suspicious in the eyes of public interest groups. This changing view of agriculture explains why federal funding for academic agricultural research, teaching and extension declined by 8% between 1988 and 2000 (Paarlberg 2008). The cut of public funding for agricultural research was even more radical in European countries. As a result of these cuts, annual public sector funding for international agricultural research conducted at CGIAR centers was reduced by roughly half the level of the 1980s (World Bank 2008) and the share of funding designed to enhance agricultural productivity fell from its original level of 74% in the mid

70s to just 34% in 2002 (Falcon and Naylor 2005).

The slump of public investment in agricultural productivity after the Cold War was not just related to the belief that the Green Revolution has fulfilled its purpose but the sudden pressure on governments to become more transparent and show more respect for tax payer and consumer perceptions and preferences. Taxpayers and consumers in affluent countries tend to dismiss the role of business and new technologies in agricultural development. Farmers should instead rely on their traditional low-input and low-tech practices. Researchers may assist them in finding slightly better techniques of soil fertility and integrated pest management but, in general, farmers are to be encouraged to use the agricultural practices they would use anyway. This perception had also an impact on Western NGOs and the way they invest in agricultural development in poor countries. It became a sort of alternative agribusiness: farmers were taught how to use the method of organic farming and comply with public and private standards in required in developed countries. The NGO then ensured that the agricultural produce is exported to their respective home countries where it was sold under different kinds of environmental and social labelling schemes (Aerni 2006c). Such a strategy resembles the top-down approach of the Green Revolution: both strategies assume that there is a sort of market failure because business would not care about the poor. The only difference is that one approach looks at modern technology as the solution whereas the other one sees it as the main problem. However, the ideological mindset of anti-technology NGOs is likely to harm poor farmers in developing countries more than the previous overemphasis on public sector R&D. Farmers need to become actively involved in the process of technological change and they need to learn how to take advantage of the emerging knowledge economy.

Throughout history, technological innovation served on the long-run as a tool of empowerment of the underprivileged. Once a technology becomes a mass-produced and easy-to-handle commodity it becomes affordable to the poor and enables them to use it in a way that helps them dealing with their daily economic and environmental constraints that are related to scarcity rather than affluence. The global knowledge economy offers a unique opportunity for the poor by facilitating the formation of international social networks that are problem-oriented rather than value-oriented. They bring actors from different areas of expertise together and build bridges between the privileged and underprivileged in a joint effort to fight

problems that seriously affect the livelihood of the rural poor (Aerni 2006a). Such an unseen global connectivity has become possible because of the revolution in communication and information technologies. When applied to the food and energy problems it is increasingly linked to the biotechnology revolution that is taking place simultaneously. Both technologies are in use for more than two decades and are about to enter the age of mass customization that makes them cheaper, easy to replicate for poor countries and more adjustable to and combinable with local practices.

4. The potential to integrate agriculture into the new knowledge economy

Information and communication technologies transformed the World and re-defined the rules of the game in many industries. Patents and other intellectual property rights have become a sort of intellectual capital that is highly valued (The Economist 2005a). At the same time the cost to replicate new knowledge and technologies are falling at a constant rate. Formerly secretive and dull multinational companies were forced to become more open, flexible and transparent in recent years in view of a fast-changing and uncertain world. In this World, Asian countries turned out to be very effective in copying new knowledge and technologies that help them create their own versions of it. At the same time, they produce the biggest pool of motivated talents in the high tech business and therefore force multinational companies to set up their new research centres in this region in spite of their concerns about weak intellectual property rights (The Economist 2008b). In fact, large companies in the IT as well as in the biotech industry are selectively going open source because they are dependent on continuous knowledge exchange and cannot expect this to happen unless they are also more willing to make their knowledge available.

Unlike in the old economy where most developing countries merely played the role of suppliers of primary commodities and lacked the critical base of domestic human capital to make use of modern technology to develop their home-grown technologies, the new knowledge economy allows them to participate in the global economy to a far greater extent and even challenge the established business in affluent Western societies.

The models of neoclassical welfare economics that still

rely on the classic textbook of Samuelson (1948) as well as the neomarxist theories developed after the first half of the 20th century (Prebisch 1951, Gunder Frank 1969) are unable to explain the sudden rise of emerging economies and the wealth they generated through the production of new goods and services in their countries. These new goods and services are also increasingly successful in the global market which is shifting from exclusive North-South trade to South-South trade (Newsweek Magazine, 2006).

There is however a more advanced economic theory called New Growth Theory, the economic theory of the new knowledge economy. This theory is based on the insight that it is monopolistic competition rather than perfect competition that creates rising standards of living, wealth and economic development. Unlike neoclassical welfare economics, it is able to take into account the welfare effects of new goods and services. New goods and services generate increasing returns, whereas established commodities are subject to decreasing returns. As such, they generate more capital and employment (Warsh 2006).

New Growth Theory rejects the idea of a social planner and sees opportunities where Welfare Economics just sees problems. It argues that knowledge applied in the process of innovation is a non-rival but partially excludable good (Warsh 2006). Investment in knowledge therefore generates increasing returns for a company through the creation of new markets in which it is initially in a position to set the price on its own terms rather than being a mere price taker and therefore confronted with decreasing returns as it is the case in the neoclassical assumption of perfect competition. Monopolistic competition allows a company to extract a small profit from the sale of the new product. This profit is then used to reimburse for the fix costs invested in research and development (R&D) and to reinvest in the improvement of the new good. This simple insight explains why the market economy continues to grow in spite of decreasing returns in existing commodity markets (Romer 1990). The old neoclassical growth model by Solow (1957) considers knowledge a public good that is produced exclusively in the public sector. It cannot explain why companies themselves invest in R&D. To date, his approach continues as to be the theoretical foundation of the analysis of R&D on agricultural development (Pardey et al. 2006, World Bank 2008)

Since knowledge applied in the innovation process is a non-rival good that is not subject to the laws of scarcity,

there is generally an underinvestment in knowledge. Neoclassical welfare economists can however not see this because they are mainly concerned with the optimal allocation of scarce resources (Warsh 2006).

If we want to improve our agricultural, development and environmental policies in the global knowledge economy to make a more effective use of our scarce resources, we need to focus on how to mobilize the production of knowledge, the only non-scarce resource, for the greater public good.

This would require the design of a new national and international institutional environment that is not just concerned with regulation but also provides more incentives for actors to invest in the acquisition of new knowledge. Companies that invest in new knowledge in order to generate new products and solutions not just for the affluent but also the poor, should be awarded accordingly. Such a shift from regulation to facilitation in public policy would eventually lead to a transition from a mitigation-based to a more adaptation-based concept of sustainable development as it is invoked in the new post-environmentalism approach (Nordhaus and Shellenberg 2007, Prins and Rayner 2007).

The increasing growth of knowledge increases the probability that new goods and services are generated through the commercial use of this knowledge. Knowledge therefore creates opportunities for nearly boundless growth, not by devouring more scarce resources (labour, land, natural resources) but by developing new ways (e.g. instructions, designs) how to make more efficient and creative use of existing resources. In other words, 'the raw materials that we use have not changed, but as a result of trial and error, experimentation, refinement, and scientific investigation, the instructions that we follow for combining raw materials have become vastly more sophisticated' (Romer 1994).

Knowledge therefore also holds the key to a more sustainable future. Investment in human capital and improved access to knowledge facilitates social empowerment through entrepreneurship and makes economic growth more compatible with environmental sustainability.

Current policies that still rely on neoclassical theories that did not prove to be very effective when applied to policies to improve the livelihoods and autonomy of the underprivileged poor people through their integration into the global knowledge economy. The failed integration of rural poor in the process of globalisation has

fatal consequences because it increases their dependence on outside support and makes them more vulnerable to external shocks. The sudden rise in food prices was not their fault, but they suffer most from it due to their lack of purchasing power. Food prices are decreasing again in view of the disappearing short-term factors but hunger and starvation is likely to continue, not so much in the noisy cities where the poor are well organised but in remote rural areas that are often not even connected to food markets (Aerni 1999). They face an increasing inability to produce sufficient food for themselves because their yields are subject to biotic and abiotic stresses that cannot be controlled because of lack of access to means of plant protection and improved varieties that are more resistant to salinity, drought or floods. Moreover since hardly anything has been invested into the genetic improvement of their orphan food crops and their livestock they are facing decreasing yields even in the absence of nature-related stress factors. An additional problem is that temporary yield surpluses often go waste because of lack of post-harvest facilities and lack of infrastructure to bring the surplus on the market in other regions (Aerni 2006b).

It is not that development organisations involved in North-South Collaboration do not see these problems but their focus on training these people to become self-sufficient rather than growth-oriented is preventing them from actively participating in the new opportunities that are offered by the global knowledge economy (Aerni 2006c).

This is in large difference to the growing South-South collaborations that are more focused on enabling the poor to participate in globalisation and improve their situation by combining their traditional knowledge with new knowledge and technologies. The emerging orphan crop research networks such as the Cassava Biotechnology Network shows how successful such a collaboration can become. Initially this was a classic North-South initiative but when agricultural biotechnology started to face an acceptance problem in Europe, public funding was cut for this highly interdisciplinary multi-stakeholder network. This weakened the influence of Northern donors and strengthened the role of Southern partners. The research priorities shifted accordingly (Thro et al. 1998). Even though funding has become more scarce, these crop networks are offering a new inclusive approach in research by facilitating more exchange between agro-ecologists, social scientists and molecular biologists and by setting research priorities in accordance with local farmer preferences and local private sector activities

(Aerni 2006a). The primary goal has become the development of useful products and services for resource-poor farmers that enable them to improve their livelihoods by actively participate in national or even international agricultural markets.

The Cassava Biotechnology Network is only one example of best practices that could be replicated in other areas and guide food as well as development and environmental policies. Interestingly, best practices in combining affordable technological solutions with local knowledge are mostly developed by people in developing countries themselves who have simply more experience and are more familiar with the constraints rural people face on the countryside. Frugal engineering enabled these countries to create entirely new markets that cater to the mass markets of the metropolitan areas of other developing countries rather than to large consumer markets of affluent societies (The Economist 2008a). The frugal engineering approach could now also be promoted through the establishment of institutions of higher learning in rural areas of developing countries. Their livelihoods are different from those in metropolitan areas and they have different needs and face more constraints. Low-tech innovations or successful and cheap combinations of high-tech and low-tech solutions developed by local people in rural areas could face a demand in other regions and thus create new markets that cater to rural businesses in developing countries (Rich 2007). In this context, New Zealand provides evidence that agriculture can be fully integrated into the global knowledge economy by enabling farmers to better take advantage of the new knowledge and technologies that are relevant in the business of agriculture. It has adopted the principles New Growth Theory to reform its agricultural policy in the 1980s.

4.1. Agricultural sustainability according to New Zealand

New Zealand has liberalized its agricultural sector in the 1980s. As a consequence of this agricultural reform that has removed production as well as income subsidies, government assistance in New Zealand is limited to support for research, pest and disease control, agri-environmental measures and climatic disaster relief (MAF 2003). Its reforms also caused the market focus in agriculture to shift from commodity to added value business and from a 'command and control' policy approach to a more bottom-up and incentive-based approach (Chamberlin 1996). At the same time the

national Crown research institutes were semi-privatized and encouraged to collaborate with farmers and the private sector to address the challenges of environmental sustainability and develop new agricultural products. This collaboration is increasingly contributing to a modern agricultural economy that is focused on added-value and, at the same time, a more sustainable use of natural resources. In spite of the agricultural reforms, the number of rural land holdings in New Zealand remained more or less constant at around 80'000 (approximately half are commercial farms and half are 'lifestyle blocks') (MAF 2003). New Zealand has a major interest in ensuring the sustainability of its competitive and export-oriented agricultural sector since an overexploitation of its natural resources would not just undermine its competitiveness in agriculture and harm its 'clean and green' image but also affect its large tourism industry. Yet, it pursues a different approach to address the challenges of 'multifunctionality'. The Resource Management Act (RMA) passed in 1991, is serving as the legal foundation for New Zealand's endeavour to improve agricultural sustainability. It is based on a highly decentralized bottom-up approach to environmental policy. Even though it authorizes the government to issue national environmental standards, it is up to the local authorities (Regional Councils) to choose the best approach on how to implement them. They set the context for development in their regions and provide a framework for district plans (PCE, 2005). Even though Regional Councils are often dominated by rural interests and slow in embracing bold environmental policies, they may at least ensure the proper implementation of the jointly developed strategy.

Apart from environmental regulation, the government as well as farmer organisations in New Zealand are committed to promote innovation and competitiveness in agriculture through investment in research and development. The Foundation for Research, Science and Technology (a branch of the Ministry of Research, Science and Technology) plays a major role in the funding of research on new ways to improve sustainable agriculture. It has established relationships with all the major research organisations and key users of science (private sector, local authorities, government agencies, and other public interest groups) that share the same commitment to convert New Zealand into a full-fledged sustainable knowledge economy (FRST, 2005). The focus on creating value and innovation in agriculture has not just triggered entrepreneurial activity in the research centres that focus on precision agriculture and biotechnology but also on those that are dedicated to ecological agriculture.

Their innovation focus generally enhanced national competitiveness through science, technology and innovation. In most areas where research projects are submitted to the Foundation, it is required that universities and the Crown Research Institutes show how their research contributes to a sustainable and innovation-driven economy. This has led to lots of public-private research projects that have resulted in new products that benefit the environment (FRST 2005). For example, Lincoln University and the fertilizer company Ravensdown have developed a nitrification inhibitor (eco-n) for cows that reduces nitrate leaching (resulting from cow urine patches) into the groundwater and leads to an emissions reduction of greenhouse gas nitrous oxide. Another example is a Rapid Pasture Meter/Sensor, a product jointly developed by the Centre for Precision Agriculture at Massey University and the company C-Dax. The technology helps farmers to optimize fertilizer and water application in livestock farming. Apart from these cases, numerous joint-ventures between public and private research laboratories are dedicated to the use the new tools of agricultural biotechnology to develop more sustainable and profitable new products (Aerni 2006c).

Overall, agricultural sustainability in New Zealand means something completely different than in Europe. The New Zealand government agrees that the farmers are not just producing food but must also ensure the sustainable management of natural resources, but not because these would reflect the postmaterial values of taxpayers but because it is in their self interest. For the New Zealanders, agriculture is still a business and therefore a nanny state is neither desirable nor affordable (Chamberin 1996). Interestingly farmers in New Zealand have become so independent that they invest themselves in research and development to solve particular short-term problems. Most producers in the livestock and dairy sector are members of farmer service organisations such as Dexcel (research and extension), Dairy InSight (industry good activities) and Livestock Improvement Corporation (animal welfare/breeding services). These organisations are mostly owned and funded by the farmers themselves and assist them with research on short-term problems in dairy and livestock farming. Similar organisations exist in other fields of agricultural production.

Farmers themselves have responded to environmental challenges by looking for new market opportunities (diversification), adopting new environmentally friendly

technologies, and adjusting their land use to the relative profitability of different products (cultivation in ecological fragile areas decreased significantly after the end of subsidies in the 1980s).

In terms of cultural aspects of sustainable development, the promotion of cultural rights of the native Maori community has become a major focus of the New Zealand government. Yet, the younger generation of Maori leaders argue that Maoris should not rely on mere state dividends for bad things that happened in the past because this would produce a passive grievance culture and a feeling of victimhood that prevents them from actively embracing social empowerment through entrepreneurship and the acquisition of scientific and technical knowledge. There is a general view that a minority culture can only survive in the process of globalization if it actively participates and changes. Government subsidies are important but they need to support cultural entrepreneurship rather than focus on cultural conservation (Wolfgramm 2007, Aerni 2007c).

It is not surprising that this mentality of being active and entrepreneurial across the different cultures in New Zealand has contributed to more self-confidence on the countryside, more food security, more agricultural diversification and innovative environmental management methods. In this context New Zealand served as an incubator for a new experiment in agricultural policy and as such falsified neoliberal and neomarxist thinking alike. The agricultural, environmental and developmental policies that are still based on these old theories may therefore have to be reformed and adopt a more adaptation-based approach to sustainable agriculture and embrace New Growth Theory.

The lesson of New Zealand also indicates that the policy approach applied during the first wave of globalisation in the 19th when the land grant college system in the United States (Widder 2005) and the national agricultural research institutes in Europe (Brugger 1956) were set up to support farmers in their efforts to find solutions to the changing economic environment, is gaining new relevance. Understanding the historical experience of agricultural development may therefore lead to more effective policies that better facilitate rural empowerment, prevent environmental degradation and ensure food security in the 21st century – and all this without having to revert to trade protectionism.

4.2 Lessons to learn for Africa

The New Zealand model of rural development may also be adjustable to countries in Sub-Saharan Africa. For too long African governments and international aid institutions have failed to invest in human capital on the countryside and neglected the role of national universities and the local private sector as engines of economic and technological change (World Bank 2008, Aerni 2007c). There are however significant differences between New Zealand and Sub-Saharan Africa that need to be taken into account. New Zealand could count on a lot of tacit knowledge that its people acquired in the course of the young history of this remote island. Europe was too far away and many products and technologies had to be re-invented in New Zealand. This is a big difference to Africa which is close to Europe and largely relying on European experts and technologies. It has little incentives to invest in home-grown technologies. Yet the institutional reforms of New Zealand that were created to encourage entrepreneurship and innovation on the countryside could also be partially adopted in Africa. This would require a switch from top-down social planning to a bottom-up approach that is primarily focused on best practices rather than social theory. The Cassava Biotechnology Network, for example, has shown that it is possible to combine low tech and high tech solutions in form of a participatory approach and hand out the new tools to local entrepreneurs that effectively commercialize them in marginal rural areas that normally do not benefit from any private sector investments (Aerni 2006a).

4.3 Harnessing the biotechnology revolution to address the food and energy crisis

Small local initiatives that enhance food security in remote rural areas are a very valuable contribution to the alleviation of hunger and poverty because there are still by far more people starving on the countryside than in urban areas, even though it is not on the radar screen of the mass media because it is not sufficiently noisy (World Development Report 1998, Masters 2005).

Yet, the trend clearly shows that World agriculture needs to increase its overall productivity if it wants to face the challenge of feeding 9 billion people in 2050 on this planet. They will all eventually desire to eat more meat and dairy products that require more water and energy in the course of production. In this context, it is not sufficient to just produce more food, it also needs to be achieved with less impact on biodiversity,

less energy consumption, less water and on less land (Diouf, 2008).

Agricultural biotechnology and genetic engineering can play a crucial role in meeting these challenges. Many people may not be aware of it, but genetic engineering may be able to stop rather than promote the loss of agrobiodiversity. This because many of the not so profitable crops that are only grown by subsistence farmers in developing countries are threatened by deadly plant viruses, pest infestation and/or genetic erosion. All these problems are threatening the abandonment and eventual extinction of these crops. Conventional breeding may help to make some of these crops resistant to a disease or pest but at high public expenses and with the side-effect that the multiple crossing with other varieties leads to the loss of the preferred taste of the original traditional variety which then also results in the non-adoption by the local farmers. Genetic engineering has the potential to ensure resistance without affecting taste. Instead of the crossing the local variety with more resistant varieties from elsewhere the gene construct that confers resistance is directly inserted into the plant. This allows it to preserve its local taste and thus makes it more likely that local farmers continue to grow it (Normile 2008). A recent study shows that it is possible to reduce photorespiration in a plant by means of genetic engineering. This may offer new opportunities to increase biomass for feed or energy. Production, not by applying more water and fertilizer, but simply using a more effective use of sunlight (Kebeish et al. 2007).

A recent report of the International Center for Strategic and International Studies argued that the global trend in industry to move from the petrochemical age into a new biology age must receive more investment because it is the only effective way to make a more effective use of our natural resources, manage climate change, reduce the likelihood of war and increase food security on this planet (CSIS 2006). Advances in agricultural biotechnology may well help to attract more public interest and more private sector investment. This would help accelerate the transition.

5. Conclusions

The future challenge of ensuring affordable food worldwide without further undermining our natural resource base can only be achieved if the promotion of technological innovation and the competent coaching of entrepreneurial farmers is assuming a more prominent role in

agricultural-, environmental-, and development policies. Facilitating such a bottom-up induced change would require a willingness of governments to return decision-making power to farmers and semi-privatise agricultural research institutes in order to make them more responsive to the needs of the farming business. This article provided an overview of successful community, research and policy initiatives that adopted this new policy paradigm and thus contributed to sustainable development on the local, regional and sometimes even global level.

The revolution in information and communication technologies is allowing the private sector to increasingly support the public sector in the effective provision of public goods (Heal 1999). The future management of global public goods in rural areas will therefore be largely based on public-private partnerships that aim at developing new agricultural products and services that generate increasing rather than decreasing returns. The resulting welfare effects for the respective rural regions are likely to reduce poverty and starvation and foster rural empowerment. Unfortunately, these welfare effects produced by new goods and services are not taken into account in neoclassical welfare economics because of the theory's implicit assumption is that all goods and services that could possibly exist, do already exist (Warsh 2006). As a consequence, this still dominant theory in economics does not allow for the possibility of increasing returns but only decreasing returns over time. It is also unable to recognize that it is monopolistic competition rather than perfect competition that creates innovation and wealth in society.

The hypothesis of the agricultural treadmill (Cochrane 1979) that technological innovation in agriculture would benefit consumers rather than farmers provides the underpinning for state intervention and income support for farmers during the Cold War period. After the Cold War, protectionist policies and farm support measures continued to stick to this comparative static but inadequate view of technology in agriculture. However instead of legitimizing state intervention in the name food security it was now justified with the purpose of maintaining a multifunctional agricultural system. In other words, neoclassical welfare economics continues to shape national and international agricultural policies even though the global knowledge economy has changed the rules of the game and would offer farmers new opportunities to address their agricultural problems through the development of new added-value

goods and services that have increasing rather than decreasing returns. The consequence of these continuing defensive agricultural policies are a generally hostile public attitude towards agricultural trade and farmer organisations that invest in political lobbying rather than research and innovation.

The adoption of New Growth Theory in agricultural policy could return decision making power to farmers and allow them to successfully participate in the global knowledge economy. New Zealand agricultural policy has applied it successfully over the past two decades and its results prove that the expected outcome does not just exist in theory.

New Growth Theory has also the potential to improve development and food security in Sub-Saharan Africa. The paper illustrates several examples on how low-tech and high-tech solutions have been successfully combined and applied in semi-subsistence agriculture. It led to the social and economic empowerment of farmers and improved local food security and wealth. In this context, agricultural biotechnology proved to be particularly useful. Tissue culture laboratories and local varieties that are resistant to biotic and abiotic stresses are of high value to small-scale farmers. In addition to addressing local food security problems, biotechnology will eventually also play a major role in helping to solve the food and energy crises through a generation of new crops that will contribute to a transition from a petrochemical-based industry into a more clean biology-based industry. The potential of agricultural biotechnology is however far from being reached mainly because of the ongoing ideological divides. The refusal to combine best organic farming practices with the best of agricultural biotechnology, and the failure to provide the necessary policy incentives for the private sector to invest in the genetic improvement of orphan crops reveals that winning the 'value'-discourse is still more important than solving the real problems of the rural poor.

References

- Aerni, P. (2006a) Mobilizing science and technology for development: The case of the Cassava Biotechnology Network (CBN). *AgBioForum* 9(1): 1-14.
- Aerni, P. (2006b) Agriculture in New Zealand. Making global competitiveness compatible with environmental sustainability. *Op-ed. CIS News*: 7-9.
- Aerni, P. (2006c) The Principal-Agent Problem in International Development Assistance and its Impact on Local Entrepreneurship in Africa: Time for New Approaches".

ATDF Journal 3(2): 27-33.

Aerni, P. (2007a) Agricultural biotechnology and its contribution to the knowledge economy. *Adv. Biochem. Engin./Biotechnol.* 107: 69-96.

Aerni, P. (2007b) Agriculture in Turkey: structural change, sustainability and EU compatibility. Editorial. *Int. J. Agr. Resour. Govern. Ecol.* 6(4/5): 429-439.

Aerni, P. (2007c) Exploring the linkages of commerce, higher education and human development: A historical review". *ATDF Journal* 4(2): 35-48 .

Aerni, P. (1999) Public Acceptance of Transgenic Rice and its Potential Impact on Rice Markets in Southeast Asian Countries". Swiss Federal Institute of Technology, ETH Zurich, Switzerland.

Aerni, P. and Bernauer, T. (2006) Stakeholder attitudes towards GMOs in the Philippines, Mexico and South Africa: The issue of public trust. *World Development* 34(3): 557-575.

Anderson, R.S., Levy, E., and Morisson, B.M. (1991) Rice Science and Development Politics. *Research Strategies and IRRI's Technologies Confront Asian Diversity (1950-1980)*. Oxford: Clarendon Press.

Anderson, R.S., Levy, E., and Morisson, B.M. (1991) Rice Science and Development Politics. *Research Strategies and IRRI's Technologies Confront Asian Diversity (1950-1980)*. Oxford: Clarendon Press.

Ansell, C. and Vogel. D. (2006) What's the Beef? The Contested Governance of European Food Safety. Cambridge, MA: MIT Press.

Appiah, A. (2007) What Was Africa to Them? *The New York Review of Books* 54 (14), September 27, 2007.

Baker, C. B. and Swanson, E. R. (1964) The Training of Agricultural Economics in the USSR. *Journal of Farm Economics* 46(3): 547-555.

Borlaug, N. (2007) Continuing the Green Revolution. *The Wall Street Journal Op-Ed*, July 18th, 2007.

Brugger, H. (1956) *Die Schweizerische Landwirtschaft in der ersten Hälfte des 19. Jahrhunderts*, Huber Verlag, Frauenfeld.

Byerlee, D. and Morris, M. L. (1993) Research for marginal environments: Are we underinvested? *Food Policy* 18 (5): 381-393.

Chamberlin, B. (1996) *Farming and Subsidies: Debunking the Myths*. Euroa Farms Ltd., New Zealand.

Center for Strategic and International Studies (CSIS) (2006) *Biotechnology and Agriculture in 2020*. Washington D.C.: The CSIS Press.

Cochrane, W. W. (1979) *The Development of American Agriculture: A Historical Analysis*. Minneapolis: University of Minnesota Press.

De Schutter, O. (2008) Adress by the UN Rapporteur on the Human Right to Food. High-Level Conference on Food

Security, Rome 3-5 June, 2008.

Desta, M. G. (2002) *The Law of International Trade in Agricultural Products: From GATT 1947 to the WTO Agreement on Agriculture*. London: Kluwer.

Diouf (2008) Speech delivered on behalf of Dr Jacques Diouf, Director-General of FAO. Conference on Fighting Food Inflation through Sustainable Investment, March 10, 2008. London. www.ebrd.com/country/sector/agri/conference/jd.pdf

Falcon W. P. and Naylor, R. L. (2005) Re-thinking food security for the 21st century. *Am. J. Ag. Econ.*87(5): 1113-1127.

FAO (2008) Soaring Food Prices: Facts, Perspectives, Impacts and Actions Required. Prepared for the High-Level Conference on World Food Security, 3-5 June 2008. Rome: FAO, April (50 pages). Available online, at [ftp://ftp.fao.org/docrep/fao/meeting/013/k2414e.pdf](http://ftp.fao.org/docrep/fao/meeting/013/k2414e.pdf).

Foundation for Research, Science & Technology (FRST) (2005) Statement of Intent 2005-2008. Wellington, New Zealand..

Frank, A. G. (1969) *Kritik des bürgerlichen Anti-Imperialismus*, Berlin, Wagenbach.

Heal, G. (1999) New Strategies for the Provision of Public Goods. In Kaul, I., Grunberg, I., Stern, M. A, (eds) *Global Public Goods: International Cooperation in the 21st century*. Oxford University Press, New York.

IAASTD (2008) <http://www.agassessment.org/>

International Herald Tribune (2008) Charity finds that U.S. food aid for Africa hurts instead of helps. By Celia W. Dugger. August 14th, 2007.

Kebeish, R., Niessen, M., K., Thiruveedhi, K., Bari, R., Hirsch, H-J., Rosenkranz, R., Stäbler, N., Schönfeld, B., Kreuzaler, F. and Peterhänsel, C. (2007) Chloroplastic photorespiratory bypass increases photosynthesis and biomass production in *Arabidopsis thaliana*. *Nature Biotechnology* 25(5): 593-599.

Kleijn, D., Berendse F., Smit R., Gilissen, N. (2001). Agri-environment schemes do not effectively. protect biodiversity in Dutch agricultural landscapes? *Nature* 423, 723-725.

Liebhardt, J. (2008) The Shrinking Effectiveness of U.S. Food Aid. Online Africa Policy Forum, International Center for Strategic and International Studies. May 5, 2008. <http://forums.csis.org/africa/?p=104&print=1>

Masters, William A. (2005), "Paying for Prosperity: How and Why to Invest in Agricultural R&D for Development in Africa." *Journal of International Affairs* 58(2, Spring): 35-64. (<http://jia.sipa.columbia.edu.>)

Masters, William A. and Andres Garcia (2008), "Food and Agricultural Policy: Stylized Facts and Explanations". Working Paper available online at www.agecon.purdue.edu/staff/masters.

Ministry of Agriculture and Forestry (MAF) (2003) *Agriculture*

- ture and Forestry in New Zealand. An Overview. Wellington.
- Nature Biotechnology Editorial (2008) Off the Rails. *Nature Biotechnology* 26(3): 247.
- Newsweek Magazine (2006) Flying South (by Mac Margolis). *Newsweek Magazine* January 2nd, 2006.
- Ng, F. and M. Ataman A. (2008), "Who are the net food importing countries?" Policy Research Working Paper 4457. Washington, DC: The World Bank. (<http://go.worldbank.org/99JY8FVKF0>.)
- Nordhaus, T. & Shellenberger, M. (2007) *Break Through: From Death of Environmentalism to the Politics of Possibility*. Houghton Mifflin Company, New York.
- Normile, D. (2008) Reinventing Rice to Feed the World. *Science* (321):330 – 333.
- Olson, M. (1965) *The Logic of Collective Action: Public Goods and the Theory of Groups*, Harvard University Press.
- Paarlberg, R. (2008) *Starved for Science. How Biotechnology is Being Kept Out of Africa*. Harvard University Press, Cambridge, MA.
- Pardey, P. G. , Alston J. M., Piggott R. (Eds) (2006) *Agricultural R&D in the Developing World*. International Food Policy Research Institute, Washington DC.
- Parliamentary Commissioner of the Environment (PCE) 2004. *Growing for Good: Intensive Farming, Sustainability and New Zealand's Environment*. Parliamentary Commissioner of the Environment, Wellington.
- Prins, G. & Rayner S. (2007) Time to Ditch Kyoto. *Commentary. Nature* 449, 973-975.
- Rentsch, H. (ed) (2006) *Der befreite Bauer*. Zürich: NZZ Verlag.
- Paralyil, G. (2003) Mapping technological trajectories of the Green Revolution and the Gene Revolution from modernization to globalization. *Research Policy* 32(6): 971-990.
- Rich, S. (2007) Anil Gupta and the Honey Bee Network. *World Changing*, March 21st, 2007. <http://www.worldchanging.com/archives/006333.html>
- Rieder, P. and Anwander Phan-Huy, S. (1994) *Grundlagen der Agrarpolitik*. Zürich: v/d/f Hochschulverlag AG, an der ETH Zürich.
- Romer, P. (1990) Endogenous Technological Change. *Journal of Political Economy* 98(5): 71-102.
- Romer, P. (1994) New goods, old theory, and the welfare costs of trade restrictions. *Journal of Development Economics* 43: 5-38.
- Rosenberg, N. (2000) *Schumpeter and the Endogeneity of Technology: Some American Perspectives*. New York: Routledge.
- Samuelson, P. A. (1948) *Economics* (18th edition published in 2004). New York: McGraw-Hill/Irwin
- Shiva, V. and Bedi, G. (Eds), 2002. *Sustainable Agriculture and Food Security: The Impact of Globalization*. Sage Publications Pvt. Ltd, New York.
- Solow, R.S. (1957) Technical Change and the Aggregate Production Function. *Review of Economics and Statistics* 39: 312-20.
- Southgate, D., Graham, D. H. and Tweeten, L. (2007) *The World Food Economy*. Blackwell Publishing 2007, Malden MA.
- Stokstad, E. (2008) Duelling Visions for a Hungry World. *Science* 319: 1474-76.
- The Economist (2005a) A market for ideas. A survey on patents and technology. October 20th 2005
- The Economist (2005b) The poorest part of America. December 8th, 2005.
- The Economist (2006) The battle for brainpower: A survey on talent. October 7th, 2006.
- The Economist (2008a) The New Face of Hunger. April 17, 2008.
- The Economist (2008b) Charlemagne: let them it cake. May 22, 2008.
- The Economist (2008c) A bigger world: A special report on globalisation. September 20th, 2008.
- Thro, A..M, Taylor, N., Raemaker, K., Puonti-Kaerlas, J., Schöpke, C., Visser R., Iglesias C., Sampaio M. J., Fauquet, C., Roca1, W. & Potrykus, I. (1998) Maintaining the Cassava Biotechnology Network. *Nature Biotechnology* 16: 428 – 430.
- Timmer, P. C. (2008a) staving off the food crisis. *Nature* 453, 722 – 723.
- Timmer, P. C. (2008) Rural changes stimulate rising giants. *Science* 331: 642.
- Urquart, B. (1990) The UN and its Discontents. *New York Review of Book* 37 (4), March 1990.
- Warsh, A. (2006) *Knowledge and the Wealth of Nations*. New York: W. W. Norton.
- Whitfield, J. (2006) Agriculture and Environment: How green was my subsidy?. *Nature* 439: 908-909.
- Widder, K. R. (2005) *Michigan Agricultural College. The Evolution and Philosophy of A Land-Grant Philosophy*. Michigan State University Press, East Lansing, Michigan.
- Wolfgramm, R. (2007) Continuity and vitality of worldview (s) in organizational cultural orientations: Towards a Maori perspective. PhD Thesis, University of Auckland.
- World Bank (2007) *World Development Report 2008: Agriculture*. Washington DC: World Bank. <http://econ.worldbank.org/WBSITE/EXTERNAL/EXTDEC/EXTRESEARCH/EXTWDRS/EXTWDR2008/0,,menuPK:2795178~pagePK:64167702~piPK:64167676~theSitePK:2795143,00.html>