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A GREEN REVOLUTION FOR AFRICA – DOES IT NEED TO BE SO CONTROVERSIAL?

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A Green Revolution for Africa – Does it Need to be so Controversial?

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Abstract

Due to sub-Saharan Africa's recurrent food-crises and enhanced difficulties to feed its growing population, calls for a Green Revolution – a substantially raised agricultural productivity by means of scientific modernization and supportive institutional reforms – are often aired. However, in other camps the Green Revolution is seen as undesireable generally and as particularly unsuitable for Africa.

This paper takes a closer look at this debate, analyses the arguments forwarded and discusses the pros and cons of a Green Revolution in Africa. It is emphasized that the Green Revolution – contrary to what many seem to believe – is not a static 'thing' to be imported whole-sale. On the contrary, it is highly dynamic and, due to recent scientific break-throughs, it may now – perhaps for the first time – be adapted to Africa's physical, ecological and socio-economic preconditions. The paper ends with some suggestions about what a Green Revolution 'African style' might look like.

[1] This paper is written within the framework of the *Afrint* research project, headed by professor Göran Djurfeldt, Dept. of Sociology, University of Lund, Sweden. *Afrint* stands for: 'African Food Crisis — the Relevance of Asian Models' and concerns itself with (possibilities for) intensification of food production in sub-Saharan Africa. The project is financed jointly by the Bank of Sweden Tercentenary Foundation and the Swedish International Development Cooperation Agency (Sida), which is hereby gratefully acknowledged. I would also like to express my gratitude to Astrig Tasgian, Suri Ratnapala and Magnus Jirström for valuable comments on an earlier draft and to Mikael Hammarskjöld for tirelessly looking up and supplying me with relevant texts.

Introduction

As we have just entered a new millennium, we are reminded of Africa's recurrent problems to feed itself.[2] The present food-crises in southern Africa and the Horn of Africa, involving at least seven countries and threatening millions of people with starvation, indicates that something needs to be done in order to dramatically and sustainably increase food security on the continent. With, in large parts of Africa, few natural resources such as oil or gas to exploit, industry only rudimentary devel-oped and scarce financial resources to pay for food imports, enhanced productivity in indigenous food production appears to be the only option available. Hence, calls for a Green Revolution are frequently heard – but are also criticised for being the wrong medicine. Why does this suggestion arouse so much controversy? There are probably several reasons for this and my intention is not to engage with them all. However, while sceptics sometimes do present good arguments, many critics appear to have an unwarranted static and simplistic view of the Green Revolution. Many also confuse technological issues with those of politics and ownership. Critics, therefore, often tend to overlook essential aspects of the problematic and risk throwing the baby out with the bathwater. This paper sets out to discuss some of the issues raised in this debate and, thereafter, to suggest what a new Green Revolution – African style – might look like.

The African Conundrum

In less than fifty years' time, the world population is expected to reach ten billion (UNFPA 1993). Africa has the highest population growth rate of all the world's major regions and Sub-Saharan Africa's population is expected to almost double from 750 million in 1998 to 1,3 billion people in 2025 (UN, 1999). According to the FAO, most African countries have experienced a slowdown in agricultural food production since the 1960s and per capita output of cereals decreased by 13% between 1961 and 2001 (FAO, 2002). This simple exercise has given cause for Malthusian concerns over Africa's future. However, it needs to be emphasized that there is more to it than just numbers. At present, bad policies in Zimbabwe and malpractices at high political-administrative levels in Malawi have at least contributed to the contemporary hardships. Also, a more equal distribution of food entitlement would, most likely, have reduced the severity of the present situation. Poverty or, to use an euphemism from economics, 'lack

[2] For reasons of simplicity, I will use the term 'Africa' although most of the discussion concerns sub-Saharan Africa.

of effective demand' often causes more suffering from famine than do food shortages as such (Sen 1982). But this does not imply that the need to improve productivity in food production should be overlooked. On the contrary, it seems imperative not only to spread food-entitlement in a fairer way, but also to enhance food availability. As noted by Griffin (1993:189), "[r]edistribution alone can go part way towards eliminating the worst forms of poverty, but it cannot go all the way. Sustained growth of per capita income is essential". In predominantly agrarian societies, such as those in Africa, this growth must come from an increase in agricultural productivity. However, when it comes to the means to increase food production, suggested remedies seem incompatible. This is most visible when it comes to *a:* interpretations of the Green Revolution, and *b:* statements about whether it is (or can be made) a suitable solution for Africa.

A Static View of the Green Revolution

By the term 'Green Revolution' in agriculture is commonly understood the incorporation of scientific advances in plant breeding coupled to the introduction or expansion of some supporting technologies giving rise to substantial increases in area-productivity of major food crops. Quite often, the Green Revolution is interpreted as a rather simple package of modern technology (seed, fertilizer, irrigation), introduced in – or imposed upon – more or less traditional agricultural systems, the productivity levels of which it seeks to improve. It had its heyday in the 1960s and 1970s when, in Latin America and Asia, substantial yield increases were attained due to the adoption of high-yielding varieties of rice, wheat and maize. Irrigation was often a prerequisite for these 'miracle crops' and they further needed the application of chemical fertilizer and pesticides to reach optimal productivity. Hence, it has been claimed that the Green Revolution is essentially a chemical revolution or basically a matter of irrigation (Madeley 2002). As such, it is often believed, it is not suitable for Africa.

This is too simplistic a description, however, and although technology does constitute the central part of the Green Revolution, the 'package' also contained "a range of policies that support the modern over the traditional" (Friis-Hansen 2000:6). Djurfeldt and Jirström (2002:17), highlighting these extra-technological aspects of the Asian Green Revolutions, write that they typically involved "a considerable degree of direct and indirect state intervention" in areas deemed crucial for agricul-tural development,

notably investments in research, roads and irrigation infrastructure, extension, credit and price controls. A broader conception than those commonly offered therefore seems warranted.

There is no doubt that implementing a Green Revolution strategy "places heavy demands upon the State" (Griffin 1993:238). And it remains to be seen whether – after Structural Adjustments – governments in Africa have the strength and the resources to carry it out. While highlighting this problematic, a short paper like this must limit its scope.[3] Hence, the following discussion will confine itself primarily to issues of technology. After penetrating this topic, a few words will be said about what a Green Revolution 'African style' might look like.

Size

First, the spread of the Green Revolution – both in terms of content and spatial coverage – appears to be much broader than what is generally claimed. For example, Africa is often said to have been 'by-passed' by the Green Revolution (e.g. ICRISAT 2001) but, as will be shown below, that is hardly a correct statement.[4] Moreover, it is sometimes stated that, in Africa – if and where it happened – the Green Revolution technology has primarily been directed towards cash crops for export such as cotton, cacao, coffee and groundnuts and, therefore, it has not improved food availability in the region (SANE 2001) and, implicitly, there is not much hope that it would. Even though this is a widespread belief, there is today substantial evidence that food crops – notably maize[5] – have for long been prominent objects of Green Revolution research *and* implementation in Africa south of the Sahara (see e.g. Beyerlee & Eicher 1997). It has thus been reported that the foundation of Zimbabwe's maize-based Green Revolution was laid

[3] This is one of the questions that the *Afrint* research-project aims to answer — in due time. Apart from raising the question, it would be premature to try and answer it at this stage (but see Larsson et al (2002) for discussions of this and related issues).

[4] It is true, however, that the Green Revolution has not been of the same magnitude in Africa as in Asia, but that does not imply that it 'never happened' in Africa.

[5] Rice has been another Green Revolution crop arousing much hope — and research investments — in Africa, and particularly in West Africa which is generally considered to have a sufficient irrigation potential. Rice research has been going on ever since the first attempts to transfer high-yielding Asian varieties were made in the 1960s. For various reasons, success did not occur until at the turn of the millennium when a break-through in high-yielding hybrid rice was reported from the West African Rice Development Association (WARDA) in Abidjan, the Ivory Coast. This superior NERICA-rice is an early maturing, drought and disease tolerant cross-breeding of Asian and African varieties, report-edly capable of increasing yields between 50 and 200 percent over traditional varieties (The Financial Gazette 2001, The Lancet 2002). The circumstance that this break-through did not occur until recently, is not an indication that food-crops such as rice have been neglected in Africa but rather an illustration of the long time commonly needed before this kind of crop research results in marketable products.

early in the century by commercial white farmers who initiated research on hybrid maize in 1932. In 1949 the first high-yielding variety was released, followed by improved varieties in the 1960s and 1970s (Eicher & Kupfuma 1997). Likewise, in Kenya, white commercial farmers initiated hybridisation programmes in the 1930s, allowing them to release the first synthetic in 1961 and the first hybrids in 1964 (Harrison 1970; see also Hassan & Karanja 1997). Also in Nigeria, a maize-based Green Revolution had an early start and maize became an important crop following the introduction of an improved open-pollinated variety in the mid-1970s (Goldman & Smith (1995); see also Lawrence (1988), Turner et al (1993), Smith et al (1997)). These findings suggest that the Green Revolution was indeed present also in Africa. Moreover, even if the African Green Revolution did not have the same impact as in Asia, it was not confined to cash-crops for export and it was initiated at about the same time as its more well-known counterparts in other parts of the world.

Scope

The Green Revolution is often defined as if it were confined to the three major cereals (rice, wheat and maize) (e.g. FAO 1996) and, therefore, it should not be suitable for Africa where, except for maize, other food crops (e.g. millet, sorghum, roots and tubers) are more important (see e.g. Asiema 2002). Also this is a too narrow and static definition of the Green Revolution. Actually, there were good reasons to start doing research on how to improve the yields of rice and wheat when such research started in the 1930s. After all, these are the most crucial sources of food for the large majority of the world's population and there was, at the time, a great "backlog of scientific and technical knowledge to draw on" which was missing for other crops (Hayami & Ruttan 1985:270). Focussing initially on these crops (but, as we have seen, maize was not neglected at the time) was not only 'natural' – considering the time and costs involved in this kind of research, it would have been difficult to justify an initial concentration of effort to issues of more limited foreseeable impact – but Green Revolution research did not stop there. It has since come to include a much broader range of crops, some of which are highly relevant in an African context. Among these one can mention improved varieties such as hybrid sorghum, high-yielding cowpeas, sweet-potatoes and bananas, as well as pest-resistant cassava and rice varieties adapted to African preconditions (Larsson et al 2002). Moreover, "the largest share of [the CGIAR's] research funding – around 38 per cent of an annual average of $280 mn over the past

five years – is for crops in sub-Saharan Africa" (Harsch 2001:1).[6] Over time, emphasis has also shifted from a common earlier focus on yields towards a current focus on early maturation, pest resistance and drought tolerance (ibid.).[7] This not only makes the Green Revolution broader than what is often believed, it also makes it more 'Africa-friendly' than it previously was. Hence, it would be a pity to dismiss the Green Revolution now on the ground that its scope is "too narrow".

Not Suitable for Africa?

There may be other grounds, however. One could be the technology's dependence on irrigation. In Africa, more than 90 percent of the farm area is rain-fed and irrigation, except for a few large projects such as the Gezira scheme in Sudan, is not widespread. This has made many believe that only few farmers in small areas would benefit from a Green Revolution in Africa. It has been claimed that, in Asia, where irrigation is much more extensive, high-yielding varieties of rice "have only benefited farmers with irrigation. About 40 per cent of the area under rice in Asia is not irriga-ted and farmers have seen no benefit" (Madeley 2002:22). This argument is a bit disingenuous. What the above sentence does say, is that more than half of the Asian rice acreage – and, hence, the peasants working that land – *has* benefited from the Green Revolution. This, actually, is not so bad. Moreover, in which other circumstances do we demand a close to one hundred per cent success in order to be satisfied? The claim that 'farmers have seen no benefit' is also too general and does not follow from the information provided (it is also contradicted by a substantial number of research reports).

It is, of course, a correct observation that improved varieties of the major cereals were primarily adopted in the "agricultural heartlands in well-endowed [i.e. irrigated] areas of Asia and Latin America" (Asiema 2001:1), and that Africa, with much less irrigation and a smaller irrigation potential, was to some extent "bypassed by the Green Revolution *of the 1960s/70s"* (ICRISAT, 2001; emphasis added). As mentioned above, Africa is not being bypassed – it would probably be more accurate to say that Africa's Green Revolution has largely been delayed – and, moreover, this need no longer be the

[6] CGIAR = the Consultative Group of International Agricultural Research, comprising of 16 collaborating regional and international agricultural research centers (of which five are located in Africa), each specializing in different research fields and with world-wide responsibility for different crops.

[7] This, however, is not to say that these objectives were neglected in earlier research. In e.g. Kenya, attention was directed to breeding for drought and pest resistance as well as early maturation already in the 1950s (Harrison 1970).

case. With the stronger emphasis today on drought tolerance and early maturation in agricultural research, the time might have come for Africa to share the benefits of the Green Revolution. Moreover, although the potential for expanding irrigated area is limited in Africa, the circumstance that "unpredictable droughts put (…) no less than 80% of the farmland under climatic risk" (SANE, 2001:1) actually points to a greater need for irrigation-based tech-nologies where such can be introduced. In the African case, irrigation (or, rather, water-control) may also have a greater potential in stabilising harvests than in boosting them (Holmén 2002a).

Exaggerations About Social Non-desirability

The social effects of the Green Revolution have also been seen as a reason to reject the 'package'. Not only are peasants, in some unspecified way, said 'not to have benefited' (see Madeley above), but also much critique claims that the Green Revolution has been skewed against small peasants, only benefiting the already well-off. Especially in the 1960s and 1970s, such claims about increased social stratification as a consequence of the Green Revolution were common (see e.g. Frankel 1971; Griffin 1974; Feder 1983). But this was before the effects of the Green Revolution could be more thoroughly documented and, as it appears, much of these claims were based on assumptions. They were aired too early and in many cases they seem to have been founded on a general hostility towards 'modernisation'. After all, these were the heydays of the 'dependence school' and the 'package' was opposed *inter alia* because it was believed to represent a "counter revolution" aimed at preventing the real, 'red' revolution which many at the time were anticipating (see e.g. Lappé & Collins 1973). In the words of Griffin (1993:144), it represented "an attempt to substitute technical change for institutional change". Hence, it has been stated that the Green Revolution represents "no more than another deceptive strategy by the national and foreign bourgeoisie to suppress the peasantry and ensure [Africa's] dependence for food" (Nzimoro 1985:*xx*). The same message is frequently aired today by a manifold of NGOs and 'counter culture' representatives attacking Green Revolution technologies because they are seen as part of a process of 'globalisation' that should be rejected.

Later research has revealed that, by and large, the technology has been scale-neutral (Griffin 1993; Tripp 1997; Mosley 2002). Both directly and indirectly, also the small cultivators have, actually, in many places benefited from the new technology (Lipton &

Longhurst 1989; Hazell & Ramasamy 1991; Jirström 1996; Mosley 2001; Djurfeldt 2001).[8] Consequently, the critique of the Green revolution has tended somewhat to shift focus. While the poor are still sometimes said not to have benefited (at all), it is also stated that "the incidence of poverty is particularly high among indigenous populations" (Madeley 2002:34), and that "eighteen of the 23 countries facing the most severe problems in feeding their people are African" (ibid, p33f). But African countries and indigenous peoples are those that, so far, have been the least affected by the Green Revolution. This can, therefore, not be an argument for it's rejection. On the contrary, it indicates that this is exactly where it may be needed.

Moreover, when poor people in areas where the Green Revolution has occurred have not benefited, this is often because of unequal access to credit, extension services, input supply and marketing of output reflect an already existing, stratified social order (Griffin 1993).[9] But these circumstances – while definitely belonging to the broader conceptualisation of the 'package' initially offered – are not part of the technology *per se.* Instead, they illustrate that at least some of the problems attributed to the Green Revolution should not be sought in its technology proper, but rather in how it has been introduced and supported (or not).

What all this amounts to, is (at this stage) a two-fold lesson. First, that whereas the Green Revolu-tion is not a genuine redistributive strategy of development, "the two have a number of features in common" (Griffin 1993:160) and it can, in fact, represent a pro-poor policy instrument (Mosley (2002). The second lesson is that we should be careful to avoid regarding the Green Revolution as a static phenomenon and/or merely as the introduction (imposition) of an unchangeable, once-and-for-all ready-made

[8] An interesting observation of the different sources of critique of the Green Revolution is provided by Freebairn (1995) who conducted a study of more than 300 reports about the effects of the Green Revolution published between 1970 and 1989. Freebairn found that authors from Western developed countries, those employing an essay approach and those looking at multi-country regions — i.e. outsiders with a generalizing, sometimes sweeping, and far-away perspective — tended to report increased income inequalities. On the other hand, authors of an Asian origin, using the case-study method — i.e. those basing their statements on close contact and first-hand knowledge — tended not to associate the new technology with increased income inequalities.

[9] In many places, these circumstances have been dramatically accentuated during the last two decades' externally imposed Structural Adjustment Programs. Prices on inputs (seed, fertilizer) and interest rates on credit have increased exorbitantly and prevent smallholders from using a technology they often say that they want. However, it would be pre-mature to assign the problems of unequal accessibility of either Green Revolution technology proper or credit singularly to market mechanisms and contemporary policy-shifts. Friis-Hansen (1994:3), reporting from pre-reform Tanzania, says that "a politically well-connected village could receive more than it demanded [of hybrid maize seeds], while other villages received only a fragment of their requirement."

technology package. Instead, I believe it is important to acknowledge its dynamic character. Also, the Green Revolution's dynamism is not confined to the above mentioned evolutions. Recent advancements in agro-bio-technology and, especially, genetically modified organisms (GMOs) not only show that the content of the Green Revolution changes and expands, it also opens up vast new avenues for research and implementation (more on this issue below).

Claims About Environmental Unsustainability

This, however, is not to say that all is well. Especially the environmental effects of the Green Revolution are often seen as being harmful or even disastrous (Djurfeldt 2002). It is widely claimed that "Green Revolution-style farming is not ecologically sustainable" (Rosset et al 2000:4; see also Madeley 2002). A frequently lamented loss of bio-diversity together with a prevalence of so-called 'second-generation problems', caused by "excessive use of modern inputs such as chemical ferti-lizers and agro-chemicals" (Babu 2000) are now presented as proof that 'another development' is more appropriate – also in agriculture. This critique can be divided into two categories, one claiming that the Green Revolution no longer revolutionizes agriculture, and the other arguing that it has back-fired.

Losing Momentum?

As for the first claim, it has frequently been observed that, after some decades of successful yield-increases, cereal yields seem to have levelled off in the major producing regions and reached what are commonly called 'yield-plateaus' (Jirström 1996; Pingali & Hossain 1997) or even that they have begun declining (Rosset et al 2000). Usually, such stagnation is said to be the result of declining soil-fertility and/or pest infestations caused by growing pest immunity to pesticides (Khor 2001). This may well be the case – at least in some places. However, critics sometimes seem to jump on this conclusion a little too hastily. After all, it would be astonishing indeed if yield-plateaus were *not* reached at some stage. Here, it is interesting to note that many of those who take the existence of ceilings or yield plateaus as proof that the Green Revolution is 'unsuccessful' other-wise tend to condemn the thought of 'eternal growth' as unrealistic. Apart from such considerations, non-ecological factors may explain at least part of this levelling-off tendency. Yield plateaus also emerge because many years

of falling world-market prices on rice and wheat reduce the incentives for peasants and governments alike to invest, and also because "demand from those who can pay has largely been met. Efforts to increase productivity tend to create an excess of supply which is beyond the market's capacity to absorb" (Gerremo 1998; see also FAO 2002). Hence, for many who have already adopted Green Revolution technologies, it would not make much sense to opt for more, at least not for the time being. But that does not prove that it would be impossible.

Moreover, increased pest problems are not necessarily – and, particularly, not uniquely – caused by growing sensitivity to pest infestations. As shown by Jirström (1996) in his study of the Green Revolution in Malaysia, higher agricultural productivity and increased wealth is accompanied by diversified labour-markets and higher costs for labour. Manual weeding gradually becomes too costly and peasants substitute technology (mechanisation, chemicals) for labour. Similarly, in Egypt, when labour-costs increase and child-labour becomes less available, manual picking of cotton bull-worm is replaced by chemical pest-control because it is cheaper (Holmén 1991). The reported pest-problems in Green Revolution areas (allegedly the singular cause for yield-plateaus) seem, at least partially, to be caused by higher costs (= greater problems) for pest-control – not, necessarily, by increased vulnerability to pests. It would, of course, be possible to maintain manual pest-control in those above referred settings – but only as long as labour has a very low price, *i.e.* on the conditions that people stay poor and that rural areas are not affected by development.

Nature's Revenge?

The second type of ecologically based critique centres around deteriorating soil, water and plant qualities. This may be a much more serious threat to future food production than (substantially raised) plateaus. Uninterrupted land-utilization demands large supplies of nutrients but prolonged supply of chemical fertilizer is held to exhaust the soil's natural nutrients and, hence, land becomes degraded and petro-dependent (Rosset et al 2000). It can be argued that, in Africa, these are lesser problems than elsewhere. Ten years ago, the average fertilizer consumption (NPK) per hectare of cropland in Africa was about 20 kg, against 300 kg in China and about 100 kg in the developed countries and "in African smallholder staple food crops, applications of less than 5 kg/ha [were] common" (FAO 1996:15). Most likely, smallholder application of

purchased fertilizer has declined rather than increased since then. Hence, there seems to be ample room for (increased) application of mineral fertilizers in Africa before ecologically hazardous levels are reached. In any case, there is "no escape from some simple facts of severe phosphate deficiencies in many African soils and the need to ameliorate highly acid soils in Africa … to obtain significant yield increases" (ibid).

Irrigation in hot climates has been found to lead to problems of water-logging and/or salinisation in some cases. To restore the natural fertility of such land is both time-consuming and expensive (and therefore, perhaps, less likely to happen). Irrigated Green Revolution agriculture has often implied mono-cropping[10], which is held to be particularly disastrous (see Madeley 2002). Mono-cropping increases the crop's vulnerability to attacks from insect pests and therefore demands the use of pesticides.[11] Pesticides, like fertilizer, tend to leak and turn up where they are not supposed to be found, polluting insect predators as well as groundwater, rivers and lakes. This, generally, is a bigger problem in temperate climates than in the tropics where evaporation is higher. In the latter, salinisation and mineralisation of the soil are often bigger or, at least, additional problems. How-ever, as indicated above, these risks are likely to be smaller in Africa than in, for example, Asia or the USA.

But, since pests have a tendency to become immune to pesticides, chemical 'solutions' will not eliminate the problem but merely be a temporary solution at best. Mono-cropping, moreover, has been seen as particularly disastrous because modern, 'scientific' agriculture tends to become increasingly dependent on a narrow genetic base of high-yielding varieties (Asiema 1994; Madeley 2002). Ironically, while the scientific modernization of agriculture aimed not only at boosting harvests but also at stabilizing

[10] The term 'mono-cropping' is mostly used to designate large-scale production units where only one or a few crops are grown, such as the big farms in the US corn- or wheat-belts, flood-plains in India or China, or the vast, terraced land-scapes of rice production in Indonesia or the Philippines. On this scale, mono-cropping can indeed be hazardous and tends to become increasingly pesticide-dependent. However, the concept 'mono-cropping' is also sometimes used to characterize individual fields — which need not be large at all — planted with a singular crop. This is then seen as equally hazardous and the 'only' remedy is mixed farming also at this micro-level scale (see e.g. Madeley 2002).

[11] It appears that the critique of mono-cropping often tends to be exaggerated and somewhat misdirected. The problem with mono-culture is not so much that 'entire' fields are planted with a singular crop, but the tendency to grow the same crop, notably rice, all-year round when possible. This (and the large-scale mono-cropping mentioned above) provides a large and extended breeding-period for pests. But this type of mono-cropping is not as common as the critics would have it. The Chinese, for example, have since a long time abandoned the idea of mono-culture and, e.g. in the Red River delta in Vietnam, peasants rotate two rice harvests with one vegetable crop, which gives a welcome break and reduces the risk of pest-infestations. The method is also called 'break-crop'-practice (Jirström, personal communication).

yields and eliminating hazards, because of this narrowness, the vulnerability of farming systems is seen to increase as modernisation proceeds. Such worries should not be ignored.

However, it has been questioned whether Green Revolution technologies actually do lead to loss of bio-diversity (see e.g. FAO 1996). Moreover, there is another side to this environmental aspect (and here I would like to quote Norman Borlaug – the 'father of the Green Revolution' – extensively). In order to feed a growing (and more prosperous) world population, by the year 2050 the world must produce nearly three times as much food as today. This necessary increase in food production has to come "from the farmland we are already using, in order to save the planet's wild-lands." Countering the environmentalist critique of the Green Revolution, he says that "[t]he high yields of the Green Revolution … had a dramatic conservation effect: saving millions of acres of wild-lands all over the Third World from being cleared for more low-yield crops" (Borlaugh 2002). Thus, "if Asia's average cereal yields of 1961 (930 kg/hectare) would have been maintained, the world would have needed nearly an additional 600 million hectares of the same quality to realize the total harvest of 1997" (Borlaugh 2000). Also, he says, there is no scientific evidence that modern foods should be less healthy than yesterday's and he further questions the critics' claim that the Green Revolution is risking the world's bio-diversity. "Some of the nay-sayers … apparently think that it's more important to save man-made biodiversity, such as antique farmers' varieties, than to save the rich web of unique species characteristic of a wild forest." The sad truth is, he says, that "low-yielding farming is only sustainable for people with high death rates" (Borlaugh 2002). I believe we should take such points *ad notam*.

Moreover, to a considerable extent, the above mentioned problems are not 'obvious' or unavoidable effects of the Green Revolution technology. There is a widespread reaction among environmentalist critics of the Green Revolution leading to calls for total abandonment of the technology. But while there, no doubt, are reasons for concern, I do not think there is ground for panic. Rather, the above mentioned adversities should perhaps best be seen as 'teething-problems' which are likely to disappear as technology – and its users – mature. In many cases they are the consequences of faulty implementation: irrigation without (proper) drainage, inefficient or insufficient extension services, untimely fertilization or fertilization in improper dosage, faulty

application of pesticides, etc.. Better preparation and improved handling of the technology could reduce, if not eliminate, the adversaries mentioned.

Nevertheless, warnings about modern farming's negative environmental effects often need to be taken seriously. It will often be wise to apply some kind of precautionary principle. But this is not to say that the Green Revolution technologies should be squarely rejected. Precaution need not be translated into prohibition. As will be argued below, it may well be the case that many solutions to the perceived problems are to be found within the modern paradigm itself. As with so many other debated questions, one-sided positioning and stubborn either-or declarations are likely to miss the key issues. Moreover, we often know too little about these issues, their extent and possible severity. Many warnings about ecological disaster have been found to be exaggerated and/or based on misin-terpretations (Helldén 1991; Leach & Mearns 1996), on methodological errors (Lomborg 1998) and even on deliberate disinformation (ibid.).

Time for a Second Green Revolution?

The issue of the Green Revolution remains highly controversial. Contemporary standpoints go in various directions. The debate is complicated, not only by the technicalities involved and a common lack of reliable data, but also by the emotions it arouses. It seems fair to say that, in part at least, this is a symbolic debate permeated by aspirations or anxieties about development that go far beyond the realm of agriculture. This is reflected in the vocabulary used, which tends to be permeated by "political purposes that ignore the complexities and subtleties of agricultural change" (Tripp 1997:24). Despite the heterogeneity of debaters involved, the contenders in this controversy are commonly grouped (indeed, are often grouping themselves) into two opposing 'camps' – for or against the Green Revolution. Although not entirely satisfactory, for reasons of expedience, I will follow this established pattern.

A Continued Green Revolution but of a Different Kind

As mentioned, it is widely believed that the Green Revolution has reached its limits – at least in those areas where it has so far been implemented. If it were to be extended to other, i.e. dryer, areas, it would need to be of a different kind – emphasizing other crops, short maturation, drought tolerance, etc. (Harsch 2001; World Bank 1997; ICRISAT

2001). Unlike the 'traditional' Green Revolution, which (with some exaggeration) was 'made for' the well-endowed, populous and easily farmed flood-plains and therefore could be introduced on a larger scale, a modified Green Revolution will need to be small-scale and able to adapt to a variety of agro-ecological environ-ments. Improved watershed management technologies, rainwater harvesting, conservation tillage and integrated (non-toxic) pest management technology are all part of this modified package. As shown above, this reorientation has already begun. In order to further adapt the Green Revolution to the world's dry-lands, more research will be needed and this will be a costly business (I'll return to this topic below).

It can be argued that the 'traditional' Green Revolution to a large extent meant an adaptation of the environment to the crop – enhanced water supply (or control), elimination (albeit perhaps only temporarily) of pests, enrichment of soil nutrients through fertilizer application. This ambition to modify nature for human purpose is often seen as a negative characteristic of modern agriculture. Since *all* agriculture implies the manipulation of nature and since *all* fields are to some extent artifi-cial eco-systems, I find this critique somewhat unfair. Also in an environment-friendly, 'doubly-green' revolution, it will still be necessary to manipulate nature. Nevertheless, in its modified variety the Green Revolution, to a large extent, is rather a question of "adapting the crops to their environments" (ICRISAT 2001). This accentuates the heated issue of genetically modified crops and animal breeds.

Through manipulation of crop-genes, proponents stress that many adversities of the older Green Revolution – as well as the vulnerabilities of many 'traditional' farming technologies – can be avoided. Prakash (2000), thus, finds that genetic engineering is "clearly the most revolutionary tool to impact agricultural research since the discovery of genetics by Mendel". By use of biotechnology, "crop damage can be minimized through disease- and pest-resistant varieties while reducing the use of chemicals" (ibid). Gordon Conway, president of the Rockefeller Foundation, believes that biotechnology is the "key to easing hunger" (Harris 2001). Using biotechnology and genetic engineering, crops can be made nitrogen-fixating, thus reducing the need for chemical fertilizers. This could dramatically improve the poor peasant's access to high-yielding varieties which s/he today often cannot afford to grow. More crops can be made high-yielding at the same time as a variety of crops can be made pest-resistant, nutrient- and

vitamin-rich, more suitable for storage, etc. Crops can be designed to suit different niches in a variegated agro-ecological environ-ment and at the same time reduce transport and storage costs as the use of agri-chemicals is reduced. This would finally make it possible to bring the Green Revolution to Africa's many poor, remote and less accessible areas. The GMO-technology, due not only to its high yield-potential but also because of its potential to stabilize harvests, can further save marginal lands from being farmed and, hence, reduce the risk of erosion and soil degradation.[12] But GMO-technology also frightens many people.

A Different Kind of Agriculture

Contenders today argue that this above sketched approach is unacceptable. Instead, it is deemed essential to reject and de-mask the "Green Revolution myth" (Rosset et al 2000). The above refer-red concerns about productivity plateaus and negative environmental impact are prominent argu-ments in this 'camp'. Moreover, it is asserted that a narrow focus on production increasing techno-logies "cannot alleviate hunger", because it does not address root-causes of skewed wealth distribu-tion and lack of food-entitlement. Instead, it is argued, a different – re-distributive and pro-poor – economic system is required. This, it is argued, will also promote an alternative kind of agriculture – small-scale and self-reliant, environment-friendly but highly productive and, hence, both socially and ecologically sustainable (ibid). This, apparently, is a widely embraced 'strategy', said to be particularly suitable for Africa.

Thus, for poor countries, the Green Revolution is seen to represent an inappropriate high-input/high-output technology aimed primarily at increasing profit for multinational biotech-giants. This so called *first agricultural paradigm,* "seeks to control nature in order to provide crops and animals with optimal growth conditions, at the same time as crops and animals are adapted so that they can utilise the improved environment" (Friis-Hansen 2000:6). The proposed alternative, the *second agricultural paradigm* instead takes as its starting-point "local environmental constraints and seeks possibilities to increase productivity by improving local peasants' existing farming systems without necessarily increasing their use of external inputs" (ibid). In this 'camp', it is

[12] Biotechnology applied to non-food crops can have the same effect. India, being the world's third largest producer of cotton, has a productivity per acre about half or a third of its major competitors. The country's recent acceptance of genetically modified, insect-pest resistant, BT-cotton is expected not only to allow it to dramatically reduce the use of pesticides, at the same time it can also save large amounts of land for other uses (or for no use at all).

emphasized that technologies should be developed in the environment where they are meant to be implemented. By learning from the local peasants, by using various participatory methods, by using traditional farming techniques like agro-forestry, inter-cropping, water harvesting, nitrogen fixating plants and biological pest control, etc. it is believed that low-external-input agriculture (LEIA) can be "highly productive" (Madeley 2002; see also Alders et al 1993).

This is more than likely and I am convinced that there are important lessons to be learned 'from below' – but if they really are that good, why then, so often, do traditional farming systems not produce enough food for those who manage them? Especially in regions where harvests fluctuate due to climatic instability and erratic rainfall – such as sub-Saharan Africa – it is questionable whether high productivity levels can be sustained over extended periods using LEIA. History, after all, seems to tell a different story. Moreover, it will be hard to convince me that extreme LEIA (so called 'permaculture', using no external inputs at all, not even credit) will increase output by 300 to 400 per cent (Madeley 2002:43f). And even if an example of this can be presented, will it be replicable?

Vandana Shiva (quoted in ibid. p27) even maintains that the productivity of traditional low-input agriculture can be "hundreds of times higher" than that of modern high-input agriculture. We need to ask ourselves whether the poor people on earth are really helped by such promises that alchemy is possible. Being a lay-man in natural science, I'm inclined to believe that low-input/high-output would be against the laws of nature except, perhaps, for very brief periods of time. The frequent reports about soil-mining that presently flood scientific journals indicate that I might be right in my assumption. To further support this stand-point, a recently released major study of organic farming found that while such agriculture does "leave the soil healthier", it can (under ideal conditions) be "*nearly as productive* as regular farms for *some* crops" (Science Now 2002; emphasis added). The question therefore remains whether low-input agriculture can also be able to sustainably feed a world population of eight or ten billion people? Objectively, it does not seem possible.

The Heated GMO-Debate

There is, however, in relation to this problematic, a matter over which we indeed need to be worried. That is the question of ownership of food-technologies. A great deal of anger and many calls for rejecting 'modern' agriculture in general, and genetically modified varieties in particular, are due to the fact that genetic codes are being patented by large, western, trans-national corpora-tions over which people have no (democratic) control. As the argument goes, these giant companies not only make agriculture dependent on their patented seeds and (appropriately designed) fertilizers and pesticides – their thus created monopolies do not cater for the farmer in the first place but tend to siphon-off any surpluses earned from agriculture. And this is only the beginning.

Due to WTO agreements on Intellectual Property Rights, it is now possible to patent any genetic code – and hence appropriate the 'ownership' of crops that peasants have grown for generations (for example, the recent American efforts to 'acquire' the ownership of traditional Indian Basmati rice). Bio-piracy and advanced laboratory research may eventually, if these economic giants have it their way, force every farmer and every small peasant on earth to pay royalties for planting seeds. And, as on-going court-trials in the US show, these corporations even try to make farmers pay who never planted the seeds! Even in the case where 'normal' plants were pollinated from genetically modified plants on someone-else's neighbouring fields, the corporation still claims its 'right' to royalties. This is really fantastic! If anyone has the right to compensation, it ought to be the innocent farmer who had his fields involuntarily polluted by unwanted substances from outside.

For such reasons, massive counter-attacks have been launched during later years. Much of this opposition is aired on behalf of people in poor countries. Poor people not only have weak bargain-ing power, but "[p]aradoxically, the poorest people in the world live in the world's biodiversity hot spots" (Limson 2002). These areas are potential sources for profitable gene-exploitation both for improved food-crops and for new medical discoveries. Africa in particular "stands to lose huge benefits from its biodiversity for lack of legal protection against bio-piracy" (ibid). But not only bio-piracy is a cause of contemporary worries. So-called "terminator"-genes lead to seed-sterility and, if distributed, will force peasants to buy fresh seeds every season instead of saving from

his or her own harvest.[13] If the biotech multinationals get away with it, they will soon control the whole global food-chain (PAN 2002; Carroll 2002). And this is a serious problem indeed. It should be addressed by intellectual property rights-reform and on this issue I agree with the critics of TNCs, western governments and the WTO. But it is not a good reason to reject bio-technology as such.

Neither is the frequently encountered claim that genetically engineered pest-resistance is incapable of offering permanent solutions. Critics argue that, for example, the BT-cotton (containing a gene, transferred from a bacteria, that makes the plant toxic to insects) has proved to be less of a success than claimed and that this and similar innovations will become *useless* because pests will develop resistance to the toxin (see Mason 2002). But 'useless' is a too strong word. It is misleading to dismiss technologies on the grounds that they do not offer instant and/or permanent solutions. They may offer fairly durable solutions and/or solutions to some problems, though. In a constantly evolv-ing system, that is as much as we can hope for. Also, implicit in the above critique (and sometimes explicit, see e.g. Giampietro 2002) is the idea that only one or a few pest-resistant varieties would be enough. It is, however, unrealistic to expect one GMO-solution to offer effective protection against all possible pests. And it is rather unfair to criticise GMOs on the grounds that they do not offer full-coverage solutions. Bio-technology is still in its infancy and in time it is likely to offer a bundle of (partial) pest-resistant alternatives. This requires prolonged and, most likely, enhanced investments in bio-technology research. The problem is not that this kind of research is a dead-end, but rather that future agriculture is likely to become more costly than we have been accustomed to.

To Have or Have Not

Critics of the Green Revolution generally and of biotechnology in particular tend to overlook not only that *all* agricultural systems are artificial eco-systems, but also that genetic manipulation is as old as plant-breeding itself. True, science has now reached a stage where it is possible to transfer a genetic code from one species to another, say,

[13] Due to heavy criticism from NGOs, development-aid organizations and LDC-governments, Monsanto — a leading biotech company with patent-applications for terminator technology in more than 70 countries (Madeley 2002) — last year "pledged to drop plans to market terminator seeds" (Harris 2001). However, it remains to be seen whether this was merely a tactical, temporary retreat or if the decision was final.

from a fish to a plant or from a bacteria to a cow, and that *is* a qualitative difference from previous practices. In a sense, mankind has now (not some hundred years ago) acquired the tools to create not only friendly varieties but also Frankenstein's monster. Whether we shall allow ourselves to tamper with the 'basic elements of life' is an ethical and philosophical dilemma which, perhaps, has not been sufficiently penetrated. However, as long as there is no general ban on genetic research and engineering – and I very much doubt that there will ever be one – we have to put this kind of knowledge to its best possible use.

Many people are worried today, because biotechnology takes us (i.e. you and me, among others, and we weren't even asked) into the unknown and this is perceived as a risky endeavour. However, "[t]he simple fact that there is 'hazard' associated with large-scale adoption of GMOs in agriculture does not imply *per se* that research and experimentation in this field should be stopped altogether. Current demographic trends clearly show that we are facing a serious hazard (social, economic, ecological) related to future food production, [but] … such a hazard applies to all forms of agricultural development also when excluding GMOs" (Giampietro 2002:469). It needs also to be remembered that, whereas traditional techniques for improved plant and animal breeding were uncontrolled and rather haphazardous, modern technologies and their products are rigorously monitored in ways that were never before possible. If only for this reason, the risk of creating 'frankenfoods' may be reduced with the new technology, rather than enhanced.

The way I see it, both 'traditional' Green Revolution technologies – now that they are no longer confined to a few crops in a few favoured areas – and the new 'Gene Revolution' technologies have a great potential to improve food availability for a growing world population. They may be particularly suitable for alleviating hunger problems in dry-lands such as Africa which, as the saying goes, have so far largely been by-passed by agricultural technology advancements.

Biotechnology may – finally – allow us to design crops suitable for variegated and less extensive agro-ecological environments. It can reduce the need for chemical fertilizer and it may eventually eliminate the need for pesticides. In short, it has enormous potentials. Today, however, biotechno-logies are misused and misdirected. Terminator

technology is only one aspect of this problem. Another is 'traitor-technology', i.e. seeds "designed to grow … only in conjunction with [specific] external chemical inputs" (Glover 2002:6; see also Mongelard & Warnock 2002). It is, for example possible to design plants that are toxic to insects and therefore do not need the application of pesticides. More such research is obviously needed. Instead, the biotech giants make other priorities. Monsanto, for example, has "inserted a gene into wheat that allows it to withstand the company's Roundup herbicide, which now kills everything growing in its path" (Fallding 2002). Under the prevailing economic logic, it is no doubt 'sound' policy for the agro-chemical corpo-rations to prioritise pesticide-tolerance over pest-resistance, at least in the short run. However, this is a perverted logic. In fact, it is as if Thomas Alva Edison in the 19th century, instead of inventing the electric light, would have said to himself: 'Electricity is a marvellous thing, it must have an infinite number of possible uses – I think I'll invent the electric chair'. This is reason enough to deny the biotech-industry their much desired right of gene-ownership.

The 'market', in many situations, is an effective and preferable allocator of rights, resources and entitlements. But there are differences between 'commodities' and commodities, and the 'basic elements of life' should not be treated as any 'tradable'. Hence, private interests should be denied patents on and 'ownership' of genetic codes. Instead, these (ought to) belong to all mankind and must be recognised as *common property*. Biotechnology research is costly and if the findings cannot be patented, no private corporations will engage in it. But we still need biotechnology. The problem is that governments have left this fundamental field to the whims of the 'market'. But the market operates for those who have an 'effective demand' and has hitherto been content with investing in the major crops for large-scale producers and/or a multitude of customers in populous, well-endowed and easily accessible areas. Not much market-based research has been directed towards the needs of small peasants (Spillane & Thro 2000) and the market, generally, has not deemed it worth-while to invest in less profitable research on odd crops or small agro-ecological niches. Hence, this appears to be the domain of the public and non-profit sectors.

However, here a major – and disturbing – change has taken place during the life-time of the Green Revolution. Whereas the research leading to the 'original' Green Revolution was "for the most part publicly funded, with international agricultural research centres

(IARCs) and national agricultural research institutes (NARs) playing an important role" (Mongelard & Warnock 2002:4; see also Djurfeldt & Jirström 2002), governments today have to a large extent given up on such ambitions. Not only have many governments been 'rolled back' in poor countries – especially in Africa – during the last two decades of 'structural adjustment', also in rich countries – which could afford spending on basic agricultural research – public funding for agricultural research, including bio-technology, has declined over a number of years (Asiema 1994; Hassan & Karanja 1997; Harsch 2001; Eicher 2001; World Food Price Foundation 2002; Greenpeace 2002).

At the same time, it is reported that this financial squeezing of governments poses a threat to bio-diversity that, perhaps, is greater than the frequently mentioned narrowing down of the (com-mercially utilised) genetic base of modern crop varieties. Due to declining financial resources, many of the world's publicly owned seed-banks (especially in the Third World) are on the verge of collapse. Some, like that in Uganda, have already collapsed. Gene- or seed-banks are "the treasure troves of mankind's agricultural heritage" and their collections represent a significant share of the world's crop diversity (Bowers 2002). "Most of the banks consist of rows of fridges in which rare seeds and germ-plasm is stored. But in many countries there is not enough money to keep the power running, let alone periodically grow and regenerate the stock. ... [Hence, before long] communities around the world may find their genebanks have simply turned to compost heaps" (ibid).

It is thus essential that governments in poor countries as well as in rich engage more in agricultural research and gene-technology and that more, not less, public money is again allocated to the preservation of gene-banks – for the common good. Since no national agricultural research institute can cover all relevant fields and no national seed-bank can preserve all species, international cooperation, division of labour and networking will be required. Hence, not only national institutes but, foremost, international institutions such as the FAO and the CGIARs, should be strengthened as they uphold the "principle of keeping as much research as possible within the public domain, where it can be made available to poor farmers without charge" (Harsch 2001).

Accordingly, it is not very fruitful to condemn technologies or, for that matter, for critics of scientific agriculture and/or the contemporary global (dis)order to 'reclaim the streets'. It rather seems more important to reclaim knowledge – particularly the public ownership of gene-technology and basic food-knowledge. When that is done, green and gene technologies can be put to humanly as well as ecologically sound use. To be sure, the new technologies allow GMOs to be tailored for odd crops and small ecosystems to a much greater extent than was possible with the 'old' Green Revolution package. Similarly, much more than previously, GMOs can be combined with – and improve – organic and 'biological' techniques for environment-friendly pest-control as well as enhanced fertilizer-use efficiency and/or biological nitrogen fixation, among other things (see e.g. Fixen & West 2002; Roy et al 2002). Even if today's technology is promising, it will not be automatically appropriate by itself. There is a need for engaged social scientists (and others) to influence the scope and direction of genetic and other agricultural research in order to safeguard its pro-poor potentials (see e.g. Lipton (1999) on this issue). This will require more cooperation be-tween scientists, peasants and local organisations and, especially, it will require more participatory and learning approaches. But this, I believe, is already in the pipe-line.

And it *can* be done – if opponents were more precise in their target selection. Madeley (2002) equalises Green Revolution technology with 'terminator technology' and, apparently, many agitated NGOs and environmentalists do the same. But this is a mistake. The question is not whether green or gene technologies are good or bad. Technologies are seldom good or bad in themselves and, as argued above, they can be used in various ways – for good or for not so good purposes. Hence, the question has to be reformulated into 'who owns the technology?' and 'who determines its use?'. Failing to do this – when, in only a few decades time, the world population is expected to reach ten billion people – many contemporary critics of the Green Revolution may regret finding themselves having thrown the baby out with the bath-water.

A Green Revolution – African Style

After fifty years of development promotion and despite the use of many different strategies of development, Africa remains poor and agriculture "has proven to be the Achilles heel of virtually every strategy for development [applied on the continent]"

(Mkandawire & Soludo 1999:112). Hence, as this paper has consistently argued, "Africa has yet to have its Green Revolution" (ibid. p54). Now the time for that might have come. Despite common simplifications and a widespread static view of the Green Revolution, it is not a static 'thing' and should preferably be seen as an adaptable and dynamic process. Its technological developments today offer a range of new possibilities which until recently were not available. Crop research has presented breakthroughs on some crops that are of major importance in Africa. These new varieties need less irrigation and they not only yield more, they are also often richer in nutrients, drought-tolerant, early maturing and pest-resistant. Hence, the new technology has the potential both to increase and stabilise yields, especially in areas where rainfall is erratic and unreliable. Finally, from the technological point of view, the Green Revolution has become Africa-friendly.

A Green Revolution in Africa has to take its departure in a smallholder setting. Moreover, the smallholders are dispersed over an agro-ecological landscape that is much more heterogeneous than were those areas where the original Green Revolution had its strongest impact, for example, in Asia's river-plains. But the new technology allows adaptation to such variegated natural precondi-tions to a much higher degree than what was previously possible. Linked to that, an African Green Revolution has the potential to be much more pro-poor than critics usually want to admit – provided, of course, that it's availability to smallholders with limited financial means is not restricted by artificial 'ownership' regulations. Ensuring the African smallholders better access to new technology is a pro-poor measure in it self. This potential is enhanced partly because of the technology's adaptability but also because of its scale-neutrality and its tendency to reduce risks for small cultivators (Tripp 1997; Mosley 2001, 2002).

This, however, is not to say that I expect, or even propagate, an immediate and large-scale flooding of Africa with hybrids and/or GMO-seeds. That is rather unlikely and, in any case, African agricul-ture does not *only* need the latest scientific innovations. Traditional and modern technologies are preferably to be seen as complementary, rather than as mutually exclusive. Much can be accom-plished by a combination of improved traditional techniques and selective introduction of modern seeds and practices, *viz.* there should be room for a parallel utilisation of improved traditional varieties and composite as well as hybrid and GMO-crops. Similarly, white (chemical) fertiliser does

not need to replace, but can coexist with brown (manure) and green (compost) fertilisers.

Moreover, Africa is too vast, many of its cultivators are too dispersed and there is, in many regions, a serious lack of infrastructure (roads, storage facilities, irrigation, markets and credit systems). This makes a rapid spreads of innovations less likely and an African Green Revolution will necessarily be a gradual, rather than an immediate change. At Africa's present level of development, "[s]upply-ing a wider range of varieties, including hybrids, [GMOs], improved open-pollinated varieties and landraces, could enable especially poor farmers to shift their little resources around according to changing circumstances" (Friis-Hansen 1994:12).

From a technological point of view, therefore, a Green Revolution in Africa is not only possible and necessary, it is also likely to have its own distinct 'style', distinguishing it from how agriculture developed in other parts of the world. The problems connected with an African Green Revolution are, thus, not so much to be looked for in the technology *per se* but rather (as initially mentioned) in State capacity and in the broader 'package' that either facilitates or mitigates the spread of agricultural innovations. Particularly worrisome in this relation are the effects of certain structural adjustment policies leading to "the suppression of rural credit schemes that offered credit at subsidized rates. … This effectively denies African agriculture a major instrument of agrarian trans-formation that others have used with success elsewhere" (Mkandawire & Soludo 1999:113).

Who's Voice Counts?

A multitude of lobby-groups, NGOs, political academics and various 'alternative' activists are now confronting (as they tend to perceive it) the 'unholy alliance of global biotech corporations, western governments and aid agencies' for trying to force GMOs upon poor and defenceless countries and populations assumed not to want these novelties. I believe this is largely a misdirected effort and, most likely, there is no conspiracy. Over the years, the Third World in general and Africa in particular, have been given a lot of bad advice. Recommendations to reject the Green Revolution is probably the worst of them all. While, no doubt, you may find people in poor countries who are worried about biotechnology, there are also many who regard it as a potential

solution to their problems. Hence, it has been stated – from the Third World, not (in this case) from the global agribusiness giants – that "application of biotechnology to agriculture is one of the most promising developments in modern science" (Babu 2000:108; see also Prakash 2000) and many African scientists are convinced that Africa needs, for example, genetically modified crops to survive (Pearce 2000; Harsch 2001; Cherry 2002; Kirby 2002). But not only scientists and politicians believe so. Modern crop varieties, whether the products of biotechnology or conventional plant breeding, "are recognized by farmers as offering significant advantages in stabilizing their production" (Tripp 1997:24; see also Paarlberg 2001). Interviewing smallholders in Africa reveals that they want access to modern technology, were it only available in time and at a reasonable price (personal information).

Hence, there is reason to be sceptical about whom the many (usually western) loud voices against the Green Revolution actually represent. Their claims of speaking on behalf of the people in poor countries are not always well-founded (Jordan & van Tuijl 2000; Holmén 2002b) and, perhaps, this is particularly so in relation to environment and development (Cleary 1997; Tripp 2001). Hence, it has been pointed out that consumers in the rich countries, being well fed and comparatively rich – the 'worried wealthy' – can afford, if they wish, to take a sceptical view toward new technologies (Paarlberg 2001). In contrast, those who live in countries where Green or Gene Revolutions have the potential of making a difference cannot.

> "If you live in Europe or the US, genetically modified food might sound like a luxury. But for people in poor countries, it's the difference between a square meal and starvation" (Florence Wambugu, quoted in Pearce 2000:40).

It appears that a lot of romanticism about 'small is beautiful' guides much anti-Green Revolution reasoning.[14] 'Development' has many definitions but if we can agree that one essential aspects is that the local becomes integrated into a larger and more complex whole, and that the parts of this whole tend to become increasingly differentiated and

[14] A less romantic explanation could be that many NGOs pursuing anti-Green Revolution strategies do so because they lack financial resources and technical competence to engage in more demanding undertakings. They "face a challenge of making their efforts sustainable" and this, apparently, they can best do by safeguarding their market-niche and opt for "small seed production and distribution enterprises at farm and village level" (Wiggins & Cromwell 1995:413).

functionally interdependent,[15] then part of this critique is actually anti-developmental. Hence, the frequent lamentations that commercialisation of agriculture will lead not only to its 'industrialisation' (Rosset et al 2000), but also to an unwanted kind of society (Shutt 2001). Apparently, many western agitators – nostalgic about a past which they never experienced – use the Green Revolution as a symbol, confusing technology with ownership and misuse with possible use. In the process, they tend to deny poor countries the development they desperately need. Similarly, some (urban) voices from the 'South', allegedly speaking on behalf of the African farmers, claim that by refusing to implement 'modern techno-logies', the latter aim to protect not only their food sovereignty but also to sustain "their livelihood systems" (Egzhiabher, 2002). In recent years, it has become fashionable to propagate 'sustainable livelihood'. But, for development to occur, livelihood systems have to change. If that is where the shoe hurts, then this controversy is largely symbolic and poor rural inhabitants in the Third World would probably benefit more if concerns were more directly aired.

[15] This applies to biology — from amoeba to wo/man, magnolia or eel — as well as to society: from small groups of hunters and gatherers, to increasingly larger and more complex socio-economic systems eventually ending(?) in some global entity. This analogy should not be stretched too far, however. When it comes to humans, the process is not *only* uni-directional. Whereas, for example, an eel or a magnolia will not be able to become part of some human group (people do have flower-pots and pets, but that is a different thing), larger human constructs — ethnic groups, states, cultures, economic systems — have the capacity to 'absorb' smaller entities (and to some extent transform them in the process). But that does not fundamentally contradict this understanding of 'development'.

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