IDS Working Paper 145

Agricultural biotechnology and food security: exploring the debate

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January 2002

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1 A background literature search, including a compilation of key quotes from a variety of policy actors representing a range of positions, was carried out by Dominic Glover at IDS.

ISBN 1 85864 401 1

Summary

Many claims and counter-claims are made about the potentials for new agricultural biotechnologies in improving food security, particularly in the developing world. This paper explores the various dimensions of the debate, looking at the assumptions of the arguments made by various protagonists and situating current discussions about biotechnology in broader debates about food security. After looking briefly at what we mean by the term 'agricultural biotechnology', the paper turns to exploring the multiple meanings of the term, food security. A number of policy narratives are identified, emphasising perspectives associated with productionist, sustainable agriculture, nutrition, trade, agri-food political economy, access and entitlements and livelihoods policies. The paper then looks at the arguments made for and against biotechnology by various actors in the current policy debate, and how these link to different policy perspectives on food security. A number of positions are identified, each with different underlying assumptions and implications for policy and practice. The paper then concludes with a review of some of the key axes of the contemporary debate, identifying points of dispute and conflict.

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Preface

Agricultural biotechnology and policy processes in developing countries Working paper series

Policy processes surrounding new agricultural biotechnologies today involve a wide and growing range of actors, including scientists, government officials, international organisations, local and transnational companies, and farmers' organisations among others. Policy processes occur at different scales, ranging from local negotiations around agricultural technology priorities to global debates surrounding property rights, biosafety regulation and biodiversity protection. Given the rapid pace of technological change and the fast-moving international regulatory environment, developing effective national policy processes is a major challenge. Yet relatively little work has been focused on understanding how particular national and local contexts influence policy processes. Similarly, at the international level, the globalisation of the biotechnology industry has not been matched by the internationalisation of effective regulation. Overall, there has been a lack of critical attention to the way in which the policy processes connecting local, national and international levels can be enhanced so that emerging policies and regulations support the livelihood needs of poor people in the developing world.

This Working Paper series emerges from a series of three interlinked projects which together address these issues. They involve collaboration between IDS and the Foundation for International Environmental Law and Development (FIELD) in the UK and partners in China (Center for Chinese Agricultural Policy (CCAP)), India (Centre for the Study of Developing Societies, Delhi; Research and Information Systems for the Non-Aligned and Other Developing Countries (RIS), Delhi; National Law School, Bangalore), Kenya (African Centre for Technology Studies, Nairobi) and Zimbabwe.

Three key questions guide the research programme:

- What influences the dynamics of policy making in different local and national contexts, and with what implications for the rural poor?
- What role can mechanisms of international governance play in supporting the national efforts of developing countries to address food security concerns?
- How can policy processes become more inclusive and responsive to poor people's perspectives? What methods, processes and procedures are required to 'democratise' biotechnology?

The work is funded by the UK Department for International Development (DfID) ('Biotechnology and the Policy Process in Developing Countries' and 'Globalisation and the International Governance of Modern Biotechnology') and the Rockefeller Foundation ('Democratising Biotechnology').

This paper is a product of the 'Globalisation and the International Governance of Modern Biotechnology' project. Other papers in the Biotechnology and Policy Processes series are:

IDS WP146, *Biotechnology and the politics of regulation,* Peter Newell
IDS WP147, *Science, policy and regulation: challenges for agricultural biotechnology in developing countries,* Ian Scoones

More details of these projects and downloadable versions of all papers in this series and other project outputs can be found at: www.ids.ac.uk/ids/env/biotechpubs.html. For further information please contact: k.hawkins@ids.ac.uk

1 Introduction

Many claims and counter-claims are currently being made about the potentials for new agricultural biotechnologies in improving food security, particularly in the developing world. With the dire warnings of prospects of major global food shortages being offered (Brown and Kane 1995), issues of food security are firmly back on the development agenda. With growing populations and declines in yield growth of basic food crops in the post-Green Revolution era, increasing yield outputs are seen to be an important challenge for agricultural research and development. New biotechnological applications are seen by some as a potential way forward. But others counter this position, pointing to issues of distribution rather than overall availability of food as the key issue, and suggesting other routes for increasing sustainable production of agricultural outputs for poor, food insecure people and regions.

This paper aims to explore the various dimensions of the debate, looking at the assumptions of the arguments made by various protagonists and situating historically the contemporary discussion of agricultural biotechnology in broader debates about food security. The first section explores what is meant by 'agricultural biotechnology', briefly looking at the range of technologies this broad term implies, as well as the actual and predicted applications of such technologies for food production. Next the paper turns to debates about food security, again exploring the multiple meanings of the term. A number of broad themes in the debate over the past 30 years are identified, which over time have emphasised, in different ways, supply or demand components, production or distribution issues and local or global solutions. By highlighting the contemporary context, the following section turns to examining how agricultural biotechnologies might respond to food security issues. Given this background the paper then looks at the arguments made for and against biotechnology by various actors in the current policy debate. A number of broad positions are identified, each with different underlying assumptions and implications for policy and practice. The paper then concludes with a review of some of the key axes of the contemporary debate, identifying the points of dispute and conflict.

2 What is agricultural biotechnology?

Much of the current debate about biotechnological applications in agriculture fails to make clear what is actually being talked about. Under the broad heading 'agricultural biotechnology' a range of techniques and processes can be undertaken. Working closely with conventional plant breeders, molecular biologists argue that the accuracy and speed of conventional breeding can be improved substantially, with particular desirable traits more easily incorporated into new varieties. But not all such approaches involve transgenic techniques, where genes from one species are inserted into another. Tissue culture, for example, has long been used as a relatively low-tech route to improving productivity. Also, marker assisted breeding can also help speed up conventional breeding programmes, and insights from gene sequencing and bio-informatics may have a variety of uses (cf. Tripp 2000).

The applications of such techniques have grown massively in recent years, but the growth of advanced transgenic applications has been concentrated in industrialised countries where efforts have been focused on the development of traits which are required for industrialised agriculture. Most current R and D is focused on non-staple crops, consumer quality and labour reduction (e.g. through herbicide tolerance). Such applications are not likely to have much of an impact on the food security in the developing world. Here the potentials of agricultural biotechnology are as yet largely unrealised. While some progress has been made in developing pest and disease resistant varieties, with some now being planted on a commercial scale (notably Bt cotton), the promises of drought or saline tolerant varieties or major increases in yield for basic food crops remain some way off.

Data on the current global distribution of transgenic crops shows how, with the exception of China and Argentina, there has been little impact in the developing world as yet (James 1999). Recent data also shows a significant slow down in the rate of growth of commercial transgenic plantings (James 2000). So, one might ask, what is all the fuss about? While current contributions of crop transgenics remains limited, there exists considerable potential for extending the molecular techniques and processes to other crops and other traits. This, some argue, is a highly significant technological breakthrough in agriculture, with radical implications, making previously only dreamt of possibilities potentially real.

Developing new crop biotechnologies is not cheap, however. Most current research is being carried out by private sector companies and in the developed world. Estimates vary, but the annual R and D spending of biotechnology companies overshadows all public spending in this area, particularly for developing world applications. In the mid-1990s, for example, only US$20m (around 10 per cent of all research funding) was being spent annually on biotechnology research by the International Agricultural Research Centres of the CGIAR system, some 10 per cent of the total Federal agricultural R and D budget for biotechnology in the US. National Agricultural Research Systems (NARS) in the developing world have even less capacity than the CGIAR system, with only a handful of countries having dedicated, publicly supported biotechnology research units (Byerlee and Fischer 2001; Qaim *et al.* 2000).

Agricultural research shows typically high returns on investment, particularly in developing countries where the potentials for yield and other improvements remain significant. Past studies have shown returns of up to 20 per cent, significantly higher than most development investments (Kerr and Kolavalli 1999). Yet, overall, publicly supported agricultural research and development funding is declining in real terms, both in the international system and in NARs (Pardey *et al.* 1995; Pardey and Alston 1996; Tripp and Byerlee 2000). The rigours of structural adjustment regimes and the requirements for fiscal discipline by Ministries of Finance the world over have put the squeeze on research funding, but particularly in poorer countries where food security and agriculture remain central to economic growth (Delgado *et al.* 1998).

A number of questions arise. Does it make sense to invest limited (and shrinking) public resources on agricultural biotechnology if the aim is poverty reduction and food security improvement, or are there other, more effective, means of tackling the same issues? Or are potentials so great, and the stakes so high, that new public money, and leverage of support from the private sector for investment for the 'global public good' for significant biotechnology investments, the only route forward? And, if agricultural biotechnology is, at least in part, an answer to food security issues, what should be the priorities for R and D investment?

These are of course big questions, which this paper will be unable to answer in full – such answers will inevitably be context specific and complex. However in order to sketch the broad parameters of the debate, we need to now turn to exploring the food security debate, and ask what are the key dimensions of food security?

3 Food security: a changing debate

'Food security' is a slippery term. There are multiple definitions of food security – over 200 were identified by Maxwell and Buchanan-Smith (1992), each carrying different emphases and connotations (see also Smith *et al.* 1993). These have changed over time as the debate has been framed in different ways. At the World Food Conference of 1974, for example, the emphasis was on food availability and supply at a global level. Here food security was defined as:

> Availability at all times of adequate world supplies of basic foodstuffs … to sustain a steady expansion of food consumption … and to offset fluctuations in production and prices.
>
> (UN 1975)

By 1986, in an influential report by the World Bank, the emphasis had shifted to issues of access, and the importance of individual well being, with food security being:

> Access by all people at all times to enough food for an active, healthy life.
>
> (World Bank 1986)

It is beyond the scope of this paper to explore all the variant definitions and their implications, but the shifts in emphasis seen between 1974 and 1996 are important, and highlight a number of key themes in the debate. As Devereux and Maxwell (2001: i, original emphases) note:

> Food security is no longer seen simply as a failure of *agriculture* to produce sufficient food at the *national* level, but instead a failure of *livelihoods* to generate access to sufficient food at the *household* level.

In the following sections, seven policy perspectives are identified, each with different implications for how food security policies are framed and the role of agricultural technologies as potential solutions. Each have been emphasised by different groups of policy players at different times, responding to events and broader debates about development in different ways.

3.1 Green revolution: *population growth and limits to agricultural expansion require new yield enhancing technologies to address growing food insecurity*

The earliest and perhaps most dominant 'policy narrative' has been associated with the potential benefits of so-called 'Green Revolution' technology. This was central to agricultural development debates in the 1960s and 1970s and was the basis for the foundation of the International Agricultural Research Centres who were to spearhead a publicly/philanthropically funded drive to increase food production in the developing world.

Major breakthroughs in plant breeding from the 1950s saw yield potentials increase massively. This started with maize hybrids, but was extended to semi-dwarf wheat and rice varieties, mainly in those parts of Asia and Central America with relatively reliable water supplies (Lipton and Longhurst 1989). This 'Green Revolution' had a number of effects. Food production increased significantly, and, with production increases rising faster than food prices, surpluses from sales resulted in opportunities for employment for the poor. Overall though, food prices declined, resulting in benefits for poor food purchasing consumers, including the growing number of food insecure poor in urban areas.

As has been widely documented, the impacts of the Green Revolution were uneven. The new varieties required regular water supplies and purchased inputs, thus the opportunities often by-passed drier, semi-arid areas and poorer farmers (Hazell and Ramaswamy 1991; Perkins 1997).[2] Reflections on the Green Revolution experience in the 1980s, for example, prompted searches for wider sets of technological solutions, particularly for the drier, risk-prone environments (see below). However, Green Revolution advocates argue, in significant parts of the world previously plagued by regular famine and chronic hunger, there were tangible benefits, even for the poor and landless, whose employment opportunities and purchasing power increased (Lipton 1999). Thus for many in large parts of Asia the spectre of regular famine and endemic hunger had been effectively eliminated. In those areas, notably much of sub-Saharan Africa, which had been left largely untouched by the Green Revolution, the challenge was seen to be transferring the same technologies into these environments with effective extension systems and credit support (Borlaug and Dowswell 1995).

In recent years though, the impressive yield growth seen in the 1960s and 1970s has tailed off, even in the high producing zones such as the Punjab in India (Byerlee 1996). Globally, production growth in cereals declined from 3 per cent per annum in the 1970s to 1.3 per cent in the decade to 1993. Projected growth is only 1.5 per cent in the period to 2020 (Pinstrup-Andersen *et al.* 1999). Such increases are insufficient to compensate for growing populations in most parts of the world. Opportunities for an expansion of cultivated area are limited and the costs of importation are growing. A variety of reasons for the drop-off in yield increases have been identified, including declining groundwater availability, pest build-ups and soil fertility decline. Thus, it is argued, there exist increased imperatives to invest in technological solutions involving irrigation, increased fertiliser and pesticide use and innovative crop breeding.

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2 Although recent evidence suggests significant lateral spread (Kerr and Kolavalli 1999).

3.2 Sustainable agriculture: *returns to high external input technologies are limited, particularly for marginal areas and poorer people, therefore a more integrated, sustainable agriculture is required to address issues of food insecurity in the longer term*

From the late 1970s there was an increasing recognition of the 'second generation' problems of the Green Revolution. In the more marginal areas and for poorer farmers unable to purchase inputs, the high input solutions of Green Revolution agriculture were clearly inappropriate responses to continuing problems of food insecurity. Even in the core Green Revolution areas declining yield growth was attributed to increasing pest and disease impacts, declining water resources and soil degradation (Conway and Barbier 1990).

With the emergence of farming systems research (Gilbert *et al.* 1980), agro-ecosystems analysis (Conway 1985) and agro-ecological approaches (Altieri 1996), a more holistic, integrated view of the agricultural system emerged, which looked beyond a vision of mono-cropped fields mirroring industrial styles of agriculture, and saw food security and agricultural production issues in a broader context governed by complex interactions of economic, social and ecological dynamics.

From the mid-1980s a growing concern with the environmental consequences of high input agriculture due to heightened worries about pesticide poisoning and fertiliser pollution (e.g. Conway and Pretty 1991), combined with the emerging discourse of 'sustainable development'. Sustainable development perspectives argued for an integrated approach, which took environmental concerns to the heart of development thinking. A production at all costs approach was replaced by concerns about environmental costs and risks, and a wider consideration of the benefits of alternative approaches.

The limits of the standard Green Revolution approach was pointed to by those who observed how yields on farmers' fields (particularly in more marginal, risk-prone areas) were far lower than the potential yields achieved in controlled, research station conditions. Thus, it was argued, an emphasis on investment in ever-increasing yield potential was misplaced, and instead limited research and extension efforts should be focused on increasing actual yields through improving agronomic practices and management on farmers' fields.

From the 1980s the range of farmers own 'indigenous' technologies was beginning to be explored in some depth (e.g. Richards 1985; Brokensha *et al.* 1980; Reij *et al.* 1996). Soil and water conservation measures, soil fertility management, local breeding attempts and integrated pest control approaches were all widely documented. Building on such local practices, rather than importing technologies from outside, was, some argued, the way to develop a low external input sustainable agriculture (van Veldhuizen *et al.* 1997).

A number of case studies from across the world showed how, under particular conditions, such approaches could result in significant increases in production, provided in a stable and sustainable manner (Pretty 1995). The marginal returns to such a 'farmer first' approach to sustainable agriculture (Chambers *et al.* 1989) were, it was argued, significantly higher than alternatives, particularly in the more risk-prone, remote areas and for poorer people, and thus was the most appropriate strategy for tackling issues of food insecurity.

Such a sustainable agriculture approach has increasingly entered (at least on the margins) the agricultural research mainstream. The CGIAR, for example, has system-wide activities on integrated natural resource management, integrated soil and water management, and participatory breeding (e.g. Ashby and Sperling 1995; Sperling *et al.* 1996). With the rising costs of inputs due to the removal of subsidies under structural adjustment, continuing poor infrastructural provision, and ineffective markets for both inputs and outputs, such an approach, while not denying the importance of high-input alternatives where appropriate, is seen to be the only viable alternative in many parts of the world.

The big question is, say the critics, is this enough? Can marginal increases in food production in marginal areas feed the world? While there is growing evidence that returns to agricultural investments may be higher in marginal or so-called low potential areas (Hazell and Garrett 1996; Pender and Hazell 2000), the bulk of food production will inevitably continue in those areas where water supply is assured and growing conditions are ideal. Expanding the high potential production zones through the application of technologies (irrigation, fertilisation, breeding etc.), the critics argue, is the only route to assuring food production on the scale required (Lipton 1999).

3.3 Nutrition: *food security is not just about amounts of food, but nutritional quality is important too*

Through the 1960s and 1970s the emphasis on aggregate food production as the route to solving food insecurity issues focused attention on the delivery of calories. Whether through high or low external input technological solutions, the key issue was filling the energy gap through bulk staple production. Certainly at an aggregate level, the Green Revolution period resulted in significant increases in supply. Calorie intakes rose by 18 per cent between 1969–71 and 1990–92 in the developing world (FAO 1996a, b) although with significant variations between and within regions. Big gains were not achieved in much of SSA and in parts of South Asia, and there were major gender and age differences in patterns of impact (Nuffield 1999).

A whole food security policy paraphernalia emerged out of the concern for increasing calorie supply at an aggregate level. Food balance models of production and consumption were created, elaborate early warning systems devised, and anthropometric measurement techniques employed to monitor progress (Pacey and Payne 1985; Frankenberger 1992; Eide *et al.* 1986).

But a number of critiques emerged of the food-energy focus. First, what is the benchmark calorie requirement? Many nutritionists noted how energy requirements are not universal – size, age, gender, activity differences determine how much food is needed. And what is 'need'? What is the minimum acceptable, and who is to define it? (Payne *et al.* 1994). In the end such choices are normative and necessarily context based. Universal measurements, standard monitoring systems and fixed benchmarks are perhaps inappropriate and more locally defined, participatory assessments of food security issues are required (Maxwell 2001). Second, others pointed to the broader nutritional requirements for human well-being beyond basic calorie intake. With increases in calories available in many places, issues of protein and later micro-nutrient supply came to the fore. Today, for example, iron deficiency anaemia affects an estimated 1.5 billion to 2.1 billion people, primarily women and children; over 200 million people are considered to be vitamin A deficient; and iodine deficiency disorders affects between 740 million and 1,500 million (Gillespie and Mason 1991; Graham and Welch 1996; FAO 2000; ACC/SCN 2000).

Such debates about nutrition of course affect the way agricultural technologies are thought about. Basic calorie supply is one thing, but crop breeding for protein and micro-nutrient inputs is another. With changing foci in the nutrition debate, therefore, the basis for identifying what is an ideal crop or crop mix has changed, presenting new challenges to crop breeders, biotechnologists and others.

3.4 Trade: *poverty and food insecurity can also be addressed by encouraging increases in marketed output to increase incomes to allow food purchases. Changing trade regimes make looking at the relationship between food security and trade an imperative*

A 'food first' approach has been long criticised by those who point to the potentials of marketed agricultural production and trade being an appropriate route to achieving food security. Policies focused on national or local food self-sufficiency, it is argued, are misguided because it may make better sense to import cheap food and export higher value commodities.

From the colonial era the promotion of cash crops has been seen as an important part of agricultural strategy. The sale of cotton, groundnuts, sugar cane, cocoa, rubber, and many other commodities could, some argued, result in higher disposable incomes for producers and the ability to purchase food on local markets. With plenty of food available on aggregate and with cereal markets being relatively efficient such a strategy could, advocates argued, meet food security needs effectively so long as appropriate safety nets were in place.

Such a position has gained momentum with the growth of niche markets for new agricultural and horticultural products. With improved infrastructure, low labour costs, effective supply chains and guaranteed markets for high value products, the growing of for example fruit, vegetables and flowers, for export has been seen as an important opportunity.

But such a strategy, as many commentators have pointed out, has its dangers. The longer term availability of cheap food for import is questioned, given increasing food prices (or at least growing fluctuations) resulting from agricultural restructuring elsewhere in the world, declining food aid, and changing trade regimes. Reliance on single commodities is also risky, given price fluctuations, potentials for substitution (e.g. sugar beet for cane) and shifting consumer preferences (e.g. reduced demands for chocolate or tobacco) (Stevens and Kennan 2001).

The assumption that efficient markets will result in effective distribution is also questioned. Market distortions remain, and particularly in more marginal areas where most food insecurity is evident, costs to consumers of purchasing food may be high due to high transport costs and low levels of competition. While current trade liberalisation measures initiated in the Uruguay Round may not have resulted in negative consequences for food insecure countries due to many preferential trading and elements of protection remaining, this may not last. In future rounds of trade liberalisation pressure to reduce export subsidies may increase, resulting in reductions in comparative advantage for those countries reliant on cash crops (Stevens *et al.* 1999). While not advocating a food self-sufficiency/food first approach, such analysts caution against a sole reliance on trade and international markets for food security.

3.5 Agri-food industry restructuring: *the changing nature of the agricultural and food system has resulted in a concentration of food production and marketing in the private sector, with major implications for food security. Addressing the political economy of the food system is a major challenge*

In order to capture the benefits of agricultural trade for food security most effectively the efficient structuring of agricultural production and marketing is seen as a key issue. In the colonial era cash crop production enclaves were often organised around integrated input supply, production support and marketing arrangements. This was most developed in the francophone colonies around the filiere approach, for example. In order to gain from economies of scale, ensure competitive access to markets, supply credit and inputs efficiently and in a timely manner, and guarantee quality control of products, it was argued, a well-organised, centrally controlled system was required.

Investments by commercial agri-business companies have been an increasing feature of agricultural economies in the past decades, with a range of models applied, ranging from the enclave approach, to variations of contract and sharecrop farming schemes (Little and Watts 1994). In the context of poor existing service provision, inefficient markets and limited infrastructure, it is argued, there are many benefits for poorer, food insecure households with engagement with such commodity based schemes.

However the changing structure of the agri-food industry has its downsides. A political economy analysis of such shifts points to a number of issues, with significant consequences for understandings of food security issues.[3] Goodman (1994; 1997) argues that the agri-food industry has altered from a post-war period of internationalisation, where engagement in international commodity exchange grew, to a period of multi-nationalisation, where multinational companies established relatively autonomous overseas affiliates linked to a parent company, to a phase of trans-nationalisation, which has seen the growth of importance of the vertically integrated, horizontally spread, global transnational company.

In the 1960s and 1970s neo-Marxist dependency theory analyses pointed to the growing global inequities of such production relations, and the class implications of such forms of capitalism. Adaptations of world systems theory (Wallerstein 1980) highlighted how changing international divisions of labour between the centre and periphery resulted in structural forms of dependency and inequality. Commodity systems analysis (Friedland 1994) took a more focused approach, looking at the nature of food regimes, in particular commodity complexes, and the growing multinational character of the agri-food industry. Nation centred political economy approaches (e.g. Goodman and Redclift 1991) observed forms of social and economic dislocation, changing labour patterns and the consequences for inequality.

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3 See for example: Bonanno *et al.* (1994); McMichael (1994); Burch *et al.* (1996); Marsden (2000); Lockie and Kitto (2000).

The more recent focus on the transnational character of agri-food industry restructuring has highlighted the increasing interdependence of different sectors (seeds, chemicals, finance etc.) and the growing incentives to create interconnected transnational conglomerates, which can link all aspects from the field to the plate on a global scale (Friedman and McMichael 1989; Goodman and Watts 1993; Heffernan and Constance 1994). Traditional sectoral distinctions and specialisations between production (agriculture, farming), processing, marketing, and consumption thus break down. Such companies can both innovate, offering significant research and development expertise, with new crops and technologies, as well as substitute, with farm based production being replaced by factory or laboratory based processes (Goodman *et al.* 1987).

These changes, it is argued, have major implications for questions of food security. In such processes there are winners and losers. Many argue that the increasingly liberalised market economies of the world allow more and more opportunities for accumulation by such transnational companies, unfettered by regulations, national obligations or accountability. The result is seen to be growing inequalities – both within developing countries and between 'north' and 'south'. The changing nature of the industry also has consequences for the livelihoods of poor people living in developing countries. Agri-food enterprises often require flexible, seasonal work, which offers low pay and limited security for workers (particularly for women). With the mobility of capital ever increasing and the need to respond adeptly to world market changes; the vulnerability of those relying on such companies grows (Bonanno *et al.* 1994). This, some argue, is beginning to result in forms of organisation against transnational capital through the emergence of social movements resisting its effects (Saurin 1997).

However, this overarching critique is qualified by others in a number of ways. Goodman *et al.* (1987), for example, argue that because of the biological nature of production, agriculture cannot be wholly subsumed by capital, making the agri-food industry distinct (cf. Fine 1994; Kloppenburg 1988).[4]

Buttel (1999) makes the case that many agri-food industries are not as 'foot-loose' as is sometimes made out, as many such industries retain a located, national character, even if connected to large global corporations.[5] Under such conditions national political and regulatory institutions do have some purchase. Even where they do not, others also argue that, because of growing concerns in consuming countries for environmental standards, labour rights and so on, there is a pressure from shareholders and within businesses themselves to apply a 'triple bottom line' to their operations to increase standards in overseas operations.

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4 Kloppenburg agrees that the reproducibility of seed creates barriers to the capitalist transformation of agriculture, but argues that these merely slow rather than prevent the penetration of capital beyond the farm gate. He argues that capital is using a combination of technology and social rules as vectors to facilitate the further commodification of the sector.

5 Nevertheless, as Saurin (1997) reminds us, 'globalisation' and 'neo-liberalism' are not the same thing. The power of transnational capital is characterised not only by mobility, but also by its ability to control resources at a distance: 'The crucial distinctiveness of the global organisation of the social order is to be found in (1) the use and disposal of material and ideational resources and authority which are not territorially delimited or restricted; and (2), following Giddens, there is a pronounced organisation of distantiated locales through the sophisticated global co-ordination of time and space.' (ibid: 108). This emphasises once more the importance of the *technology* and *regulation,* which make this control-at-a-distance possible.

Analyses of the consequences of globalisation, others point out, should not obliterate from view parallel processes of localisation (Appadurai 1997). An idealised view that commoditisation is necessarily bad, resulting in the destruction of somehow 'good' local customary practices needs to be questioned (Pottier 1998). Local processes of negotiation, accommodation and resistance are all part of everyday struggles which mean that local actors do have some agency (Arce and Long 2000) and are not simply 'passive pawns at the mercy of globalising forces' (Pottier 1998: 139).

3.6 Access and entitlements: *famines are caused primarily by entitlement failures, requiring institutional issues surrounding access and distribution to be addressed. It is not the amount of food but who gets it and when that matters*

Studies of the famine events of the 1970s, particularly in the African Sahel, pointed to the importance of access to food, rather than its availability as a key factor in explaining severe food insecurity and famine. This was related to institutional factors, most notably markets. Although food was available it was not being delivered to people in need. Amartya Sen in his classic book, *Poverty and Famines*, presented the case for an alternative approach to food security analysis based on an entitlement approach. Rejecting the 'food availability decline' hypothesis as an explanation, Sen argued that 'scarcity is the characteristic of people not having enough … it is not the characteristic of there not being enough. While the latter can be the cause of the former, it is one of many causes' (Sen 1981: 1). Thus entitlement failures – where there is a collapse in the means of command over food – are seen to be one of the main causes of famine and food insecurity.

Subsequent famine episodes during the mid-1980s – notably in the Horn of Africa – again put the spotlight on the issue of entitlement failure in the midst of food plenty (at least at the aggregate level). Thus during the 1980s and into the 1990s, most commentators approached food security issues through an 'entitlements' lens. There were a range of critiques, adaptations and extensions of Sen's original argument (e.g. Dreze and Sen 1989; von Braun *et al.* 1992; Watts 1991; Devereux 1996), but the basic argument that it was issues of access and control rather than production and availability which were the most critical remained largely undisputed.

The retreat of the 'food availability/production' focus during this period can be attributed to a number of factors. First, as already mentioned, the empirical examination of actual famine periods provided good evidence for entitlement failure. Second, the very real growth in food availability, particularly in previously food deficit areas as a consequence, at least in part, of Green Revolution technologies (see above). Third, a retreat of the neo-Malthusian arguments about population growth which dominated development discourse in the 1960s and 1970s in particular. Major demographic transitions were observed, or predicted, in many parts of the world (Dyson 1996), with the result that rates of population increase were predicted to slow and food demand increases decline.

A range of policy approaches were developed on the basis of the entitlements approach, focused on 'entitlement promotion' (e.g. infrastructure development, market reform, land/asset redistribution) and 'entitlement protection' (e.g. various safety net programmes) (e.g. Drèze and Sen 1989; Devereux 1993).

Early warning systems began to look at a range of other indicators beyond the availability of basic food-stuffs, and included issues of market function, asset disposal and so on (Buchanan-Smith and Davies 1995).

In more recent years, though, some have argued that the pendulum had swung too far towards a focus on access, without attention to issues of production and basic food availability. As Sen forcefully argued, these issues still matter, but are not the whole story. There are a variety of ways of creating entitlements for the poor, and growth in labour intensive agriculture, which generates employment and incomes, is an important route. This not only provides income-based entitlements for labourers, but also increases production and food availability (Lipton 1999).

3.7 Livelihoods: *a concentration on food alone is too narrow. A broader livelihoods approach, taking account of the range of activities making up people's livelihoods, is important*

Understanding food security in a broader context became a focus for research analysis particularly from the 1980s. Building on a long tradition of detailed village based ethnography, village surveys and farming systems research, new work focused in detail on how poor people cope with and adapt to food insecure situations (e.g. de Waal 1989; Swift 1989; Davies 1996; Scoones *et al.* 1996). A focus on sequences of 'coping strategies' (Corbett 1988) highlighted how a range of tactics was used by different people over drought periods. As De Waal (1989) pointed out for Darfur in Sudan, people were prepared to forego food in order to protect key assets. During drought periods when crops had failed, off-farm incomes, savings and asset disposal were all seen to be key (Swift 1989).

In other words, agricultural or pastoral production was only one element of a broader portfolio of livelihood strategies. Thus rather than talking of 'food security' a more appropriate term – 'livelihood security' – emerged. Food production and availability were seen, again, to be only one (if significant) part of the equation. For understanding vulnerability and coping strategies, a wider range of issues had to be looked at.

Building on these debates, a focus on 'sustainable livelihoods' became popular during the 1990s (Chambers and Conway 1992; Scoones 1998). This reflected an integrated, holistic view of rural dynamics, where livelihoods were seen to be composed from a range of sources. In studies of rural livelihoods, agricultural/livestock production proved to be the most significant component, but for particular people (often the poorest and most vulnerable) and at particular times (often in drought periods, or particular stages in the demographic cycle), attention to non-farm livelihood diversification and migration was seen to be key (Brock and Coulibaly 1999; Carswell *et al.* 2000; De Haan 2000; Ellis 2000).

Here again, while the importance of technologies for increasing agricultural intensification and broader growth of benefit to livelihood sustainability (cf. Delgado *et al.* 1998) was not ignored, a wider set of institutional and policy questions came to the fore. Without appropriate institutional and policy frameworks and processes, the prospects for improving the livelihoods of the rural poor were limited. It was these issues, it was argued, where development had badly failed in many parts of the world, and where increased efforts needed to be applied.

4 Food security debates in perspective: a commentary

As the previous section has shown, the debate about food security and the role of agricultural technology development has shifted in different directions over time. Different disciplines, different political and policy positions, different emphases on different scales have all influenced the emergence of this diversity of perspectives.

No one would deny the importance of increasing agricultural production as a component of food security policy, but the different perspectives emphasise this theme to greater or lesser extents, with implications for how important the role of new technologies and investment in R and D are seen. Broadly two groupings can be discerned: those focusing on food availability and production and those focusing on food access and control. The 'Green Revolution' position, in its various guises, is the most explicit about the role of yield enhancing technologies for food security. This has been driven by technologists (agronomists, breeders) and economists interested in aggregate patterns of demand and supply. The 'sustainable agriculture' perspective is also often technology focused, but recognises some of the limitations of high input options, setting a technology development agenda within a broader understanding of agro-ecology and farming systems. The 'nutrition' perspective, driven by nutritionists and health practitioners in particular, parallels much of the production gap debate, but emphasises the importance of the range of nutritional inputs rather than aggregate production.

The 'trade', 'agri-food industry restructuring', 'access and entitlements' and 'livelihoods' perspectives, by contrast, make less of the potentials of a 'food gap', but emphasise more the social, economic, political and institutional factors that encourage or impede access to food by poor people. The 'trade' perspective has been dominated by discussions by trade economists often working at a quite macro-level, with an increasing focus on global trading systems. The 'agri-food industry restructuring' commentators again look at the bigger picture, but from a more structuralist political economy angle. By contrast, those emphasising 'access and entitlements' and 'livelihoods' have usually developed their insights from detailed micro-level economic, anthropological and institutional studies.

All these perspectives have informed policy thinking to varying degrees over the last decades (Falcon *et al.* 1997; Maxwell 1996). Maxwell (2001) identifies different phases, moving from the concerns over global food security in the latter half of the 1970s, following on from the Sahelian famines of 1972–3 and the World Food Conference of 1974. With the highlighting of the issue of entitlements by Sen in 1981, and reflecting on the African droughts of the mid-1980s, a shift in emphasis could be discerned toward issues of access and entitlement. While Maxwell observes a reduction in interest in issues of poverty and food security during part of the 1980s due to the emphasis on macro-economic reform and structural adjustment, the latter part of the 1980s he describes as the 'golden age' for food security,[6] where issues of entitlement promotion and protection were at the top of the policy agenda. Finally, during the 1990s, the emphasis was broadened, he argues, from a narrow focus on food security to a broader concern with poverty, but with food security re-emerging as a key focus.

This was particularly apparent around the World Food Summit convened by the FAO in 1996 (FAO 1996a). In the discussions leading up to and during the summit, all the perspectives outlined in the previous section were put forward by various proponents. It was clear that no easy consensus could be reached between, for example, those advocating high-tech solutions, trade liberalisers, critics of the global economic system, environmentalists concerned with biodiversity, and those promoting food rights. Maxwell (2001: 14) notes that the 'extreme Malthusians were seen off', and 'a remarkably well-balanced' declaration emerged. However, to others this 'balance' was a fudged compromise between often significantly divergent viewpoints, with little consensus on strategic direction developed and practically no commitments associated with the Plan of Action.

5 Food security in the new millennium: new contexts?

In the five years since the World Food Summit, how have the debates moved on? What is the food security situation in different parts of the world at the turn of the century? What are the prospects for the future? Are there new contexts existing or emerging which influence the debate about the role of technology in the future of developing world agriculture?

Today almost 800 million people are estimated to be 'food insecure' (FAO 2000), with some 1,199 million living below the dollar-a-day poverty line[7] (World Bank 2001). Food insecurity and poverty is increasingly concentrated, particularly in Africa and South Asia (FAO 2000), where by 2010 some 70 per cent of the world's 'food insecure' people will live (FAO 1997). At a global level there is clearly enough food to go round, and, depending on the projections[8], this is likely to be the case for some time (Dyson 1996). If the world's food supply had been equally distributed in 1994, for example, it would have been enough to feed 6.4 billion people (Nuffield 1999: 4.8). But, as FSG (1996) observe: 'The main debates concern not whether the world can supply growing demand, but whether it can supply it in a sustainable manner at an affordable price'.

While much current discussion focuses on the need to feed a growing world population, the more extreme versions of Malthusian-style apocalypse are not evident. Instead, some talk of a 'demographic window of opportunity' (Lipton 1999) created by the slowing of growth in world populations.

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6 Quite who this was the 'golden age' for is not clear, but I assume that he is referring to the growing 'food security' industry in the aid agencies, rather than the people of the Horn of Africa.

7 US$1.08 per day at 1993 PPP.

8 A number of forecasting models have been developed to look at global food demand and supply (e.g. IFPRI's global food model, International Food Policy and Trade Simulation Model [IFPTSIM]). As with any models they are based on a number of assumptions, key among these are, on the supply side, projections of future crop yield growth and demand for grains through changing consumption patterns.

Nevertheless, the 'feeding a hungry world' narrative remains a core policy concern, and is reflected in the justifications for most policy positions of most international organisations concerned with food and agricultural issues (see below). A recent flurry of increasingly sophisticated – but inevitably assumption laden – models have rekindled a policy focus on global food security issues, and an emphasis on the need to increase production for growing populations. This has been further fuelled by debates about the implication of new trade regimes, with the prospect of a new round of trade liberalisation under the WTO. Such approaches, while acknowledging institutional and policy issues of access and control as important, have firmly re-established the debate on global food security issues, with scenario models, production gap predictions and Malthusian overtones reminiscent of the debates in the 1970s.

The influential report on 'World Food Prospects' produced by IFPRI (Pinstrup-Andersen *et al.* 1999) argues that due to increasing populations, growing urbanisation, and rising incomes, there will be a 40 per cent escalation of demand for cereals over the next 20 years. A growing demand for meat is resulting in a 'livestock revolution' (Delgado *et al.* 1998), which will require increasing volumes of grain as fodder. In order to meet this demand, yield increases are essential, as cultivated areas are only expected to rise by a fifth. With trends in yield growth predicted to continue downwards this will require a doubling of imports of grains to the developing world. Although food prices are, in historical terms low, they are unlikely to decrease and, as in the mid-1990s, may show either periodic or longer-term increases.

Projected population increases are concentrated in Asia, with India and China accounting for a third of the estimated growth to 2020. Of the next seven largest projected contributors to population growth, four are in Asia, and only one is an industrialised country (the USA) (UN Population Division 1998). In the IFPRI model, China is forecast to account for a quarter of global increases in demand for cereals, and two fifths of the increased demand for meat (Pinstrup-Andersen *et al.* 1999). Although population growth is not likely to be as significant in Africa (especially given the HIV/AIDS pandemic), and there remain opportunities for increasing production through expansions of cultivated area, all commentators agree that sub Saharan Africa is the region least able to deal with the consequences of declining yield growth and the prospects for increasing world food prices, especially given the declining availability of food aid.

Africa now accounts for around a quarter of all world cereal imports compared to only an eighth in 1975. Although production has increased threefold since 1961, imports have grown eight times over the same period (Stevens and Kennan 2001). Terms of trade have been reasonably favourable over this period, but under new trade regimes this may change if preferential trading of exports is reduced, and price distortions on imports are reduced resulting in higher cereal import costs (Stevens *et al.* 1999).

Agricultural biotechnology is seen by some as a potentially neat solution to this unfolding scenario. But this is far from a universal position. Disputes abound: some disagree with the forecasts and the models; others question the potentials of biotechnology and point to other technological and management solutions to production questions; still others argue that distribution and access remain the key issue. The next section then, explores some of these contrasting positions.

6 Contrasting positions: the agricultural biotechnology and food security debate

So where do the protagonists in the biotechnology debate position themselves with respect to these perspectives on food security issues?[9] This section highlights some of the key axes in the debate and identifies a number of broad positions. This assessment is derived from a broad search of recent statements and reviews made by international organisations, funding bodies, research centres, NGOs, academic researchers and others.[10] A number of major conferences, commissions and assessments have been held over the past few years which have attempted to draw together a range of perspectives on the agricultural biotechnology debate.[11] While food security issues were not the sole focus for the discussions, these have featured prominently.

Picking up on the scenario modelling mentioned above, the starting point for many commentaries is the diagnosis of a future 'food gap', based on projections of population increase, urbanisation and changing food consumption patterns. The IFPRI model data, for example, is regularly quoted as a key justification of the need for more investment in yield growth. Per Pinstrup-Andersen, then the Director General of IFPRI, and colleagues argue:

> About 73 million people will be added to the world's population every year between 1995 and 2020 … Per capita incomes are expected to increase in all major developing regions over this period. Meeting the needs of a growing and urbanising population with rising incomes will have profound implications for the world's agricultural production and trading systems in coming decades.
>
> (Pinstrup-Andersen *et al.* 1999: 5)

In a commentary on the CGIAR position on biotechnology more broadly, an ethical stance is taken on the need to address the 'productivity gap' through technological development:

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9 The biotechnology debate clearly extends far beyond questions of contributions to food security – scientific, ethical, legal dimensions abound. These will not be explored here, although many impinge indirectly.

10 Web based materials were the dominant source. News reports, press statements, conference reports and academic papers are picked up by online fora such as *AgBioForum*, *AgBiotechNet* and *AgBiotechInfoNet*. The *Biotechnology Knowledge Centre* (run by Monsanto) and *AgBioWorld* (sponsored by C.S. Prakash) in particular, disseminate mainly pro-biotech material including statements from influential commentators such as Norman Borlaug, C.S. Prakash, Gordon Conway and others. Other commentary and analysis came from online journals such as *Nature Biotechnology*, the *Electronic Journal of Biotechnology* and *Biotechnology and Development Monitor*. Industry sources included: Monsanto, Dow, Limagrain, Aventis (including archive material from Rhone-Poulenc and Hoechst), Syngenta (Novartis and Astra-Zeneca), DuPont and BASF. NGO sources included RAFI, GRAIN, GeneWatch, Green Alliance, CorporateWatch, Oxfam, the World Development Movement and Christian Aid. Searches of sites of key multilateral organisations (e.g. FAO, World Bank, OECD) were complemented by materials from international research organisations (notably the CGIAR centres, including IFPRI and ISNAR), as well as the Nuffield and Rockefeller Foundations. See reference list for web sources cited.

11 For example: World Bank, (Kendall *et al.* 1997); CGIAR (the CGIAR/National Academy of Science conference, *Ensuring Food Security, Protecting the Environment, Reducing Poverty in Developing Countries: can biotechnology help?*, Washington D.C., 21 - 22 October 1999; Persley and Lantin 2000); OECD (Conference on the Scientific and Health Aspects of Genetically Modified Foods, *GM Food Safety: Facts, Uncertainties, and Assessment.*, Edinburgh, 28 February - 1 March 2000.); Royal Society (the so-called 'Seven Academies Report: Royal Society *et al.* 2000); Nuffield Foundation (Nuffield Council on Bio-ethics 1999).

> If technological development by-passes poor people, opportunities for reducing poverty, food insecurity, child malnutrition and natural resource degradation will be missed, and the productivity gap between developing and developed country agriculture will widen. Such an outcome would be unethical indeed.
>
> (Pinstrup-Andersen and Cohen 2000: 22)

Gordon Conway, the President of the Rockefeller Foundation, a major funder of biotechnology related research, notes:

> [B]y 2020 there will be an extra 2 billion mouths to feed … Biotechnology is going to be an essential partner, if yield ceilings are to be raised, if crops are to be grown without excessive reliance on pesticides, and if farmers on less favoured lands are to be provided with crops that are resistant to drought and salinity, and that can make more efficient use of nitrogen and other nutrients.
>
> (Conway 1999)

And the UN Food and Agriculture Organisation (FAO) in its recent statement on biotechnology observes:

> Agriculture is expected to feed an increasing human population, forecast to reach 8,000 million by 2020, of whom 6,700 million will be in the developing countries. Although the rate of population growth is steadily decreasing, the increase in absolute numbers of people to be fed may be such that the carrying capacity of agricultural lands could soon be reached given current technology. New technologies, such as biotechnologies, if properly focused, offer a responsible way to enhance agricultural productivity for now and the future …
>
> (FAO 2000a: para. 1)

Similar lines of argument are put forward by officials from developing countries, particularly from China and India, where population growth is expected to be largest. For example, Zhang argues for the future role of biotechnology in China in these terms at a major CGIAR conference:

> It is projected that the Chinese population will reach its peak of 1.6 billion by the year 2030. Consequently, demand for food production is also projected to be increased by at least 60 per cent in order to keep up with the pace of population growth. Moreover … vast urbanisation will continuously result in the losses of farmland and other natural resources. Therefore, the only viable approach to increasing food production is to increase the productivity of unit area of farmland. However, statistics show that the total productions of the major grain crops have shown decreased rates of growth in the last decade … There is also a huge demand for quality improvement of food product … [A]lmost all the widely used cultivators and hybrids have very poor cooking and eating qualities … Another major problem is degradation of the environment.
>
> (Zhang 1999: 1)

A number of vocal advocates of biotechnology solutions make use of this style of argument to promote what might be termed an extreme 'techno-optimist' agenda. Norman Borlaug, for example, the Nobel laureate with a passionate belief in the potentials of technological transformation based on his experiences as a breeder in the first Green Revolution, is a firm advocate of the future potentials of agricultural biotechnology:

> Even if current per capita food consumption stays constant, population growth would require that world food production increases by 2.6 billion gross tons – or 57 per cent – between 1990 and 2025. However, if diets improve among the destitute who live in hunger, estimated to be 1 billion people living mainly in Asia and Africa, world food demand could increase by 100 per cent – to above 9 billion gross tons – over this 35 year period … To meet the projected food demands … the average yield of all cereals must be increased by 80 per cent between 1990 and the year 2025 … [G]enetic engineering will permit another 50 per cent increase in yields over the next 35 years.
>
> (Borlaug 1997: 3, 4)

Similarly, C.S. Prakash from Tuskagee University in the US is a bio-technologist originally from India with similarly firm views on the transformatory technological potentials. He initiated a petition of scientists supportive of biotechnology, drafted in the following terms:

> We, the undersigned members of the scientific community, believe that recombinant DNA techniques constitute powerful and safe means for the modification of organisms and can contribute substantially in enhancing quality of life by improving agriculture, health care, and the environment … The responsible genetic modification of plants is neither new nor dangerous … The addition of new or different genes into an organism by recombinant DNA techniques does not inherently pose new or heightened risks relative to the modification of organisms by more traditional methods … The novel genetic tools offer greater flexibility and precision in the modification of crop plants … Through judicious deployment, biotechnology can also address environmental degradation, hunger, and poverty in the developing world by providing improved agricultural productivity and greater nutritional security.
>
> (AgBioWorld 1999)

Industry public relations material very often picks up this line of argument in advocating their position. While Monsanto's grand claims made in newspaper adverts in Europe that biotechnology could 'feed the world' were seen by some as somewhat overblown, a similar rhetoric can be detected in most industry-based commentaries.

> Applications of biotechnology in agriculture are in their infancy … The rapid progress being made in genomics may enhance plant breeding to help secure better and more consistent yields. This would be of great benefit to those farming marginal lands worldwide. Arable land is disappearing and even

> if every acre is maximised using conventional agriculture, we start to come up short if we have to feed 8 billion people in 2025 and beyond …
>
> According to the United Nations, 800 million people worldwide are already chronically malnourished. The UN Food and Agriculture Organisation estimates that two out of five children in the developing world are stunted, one in three is underweight, and one in ten is 'wasted' due to under-nourishment. Biotechnology alone won't solve the problems of hunger and malnutrition, but it can play an important role in alleviating them by making it possible to grow more food with added nutrition on less land and under tough conditions.
>
> (DuPont and William 2000)

There are many, however, who dispute these claims of a technology-based revolution, pointing to the limits of the earlier 'Green Revolution' discussed above. Issues of distribution and access are highlighted in particular by academics, NGOs and other activists. There is enough food to the feed the world, they argue: addressing food insecurity is a matter of tackling inequality.

> While companies claim GM crops will feed the world in fact they are largely irrelevant to ending hunger: around the world they are driven by commercial interests, not a concern to 'feed the world' or raise productivity. The real challenge is poverty eradication; land reform; water conservation; and increasing production by promoting mixed, low chemical-use farming, which favours naturally improved and locally adapted plants … People go hungry because they are poor and cannot afford food or because they do not have land on which to grow it …
>
> (Christian Aid 2000: 1)

Similarly, Peter Rosset, co-Director of the US-based NGO Food First/The Institute for Food and Development Policy and Miguel Altieri, Professor of Environmental Science at the University of California at Berkeley, write:

> Biotechnology companies often claim that genetically modified organisms (GMOs) – specifically genetically altered seeds – are essential scientific breakthroughs needed to feed the world, protect the environment, and reduce poverty in developing countries. This view rests on two critical assumptions, both of which we question. The first is that hunger is due to a gap between food production and human population density or growth rate. The second is that genetic engineering is the only or best way to increase agricultural production and thus meet future food needs … There is no relationship between the prevalence of hunger in a given country and its population … The world today produces more food per inhabitant than ever before … The real causes of hunger are poverty, inequality and lack of access …
>
> (Altieri and Rosset 1999)

Global trade regimes are the subject of critique by some. For example:

> These trade agreements [WTO Agriculture Agreement, APEC free trade zone] impose further constraints on the ability of developing countries to promote food security by way of import restrictions and guaranteed price supports for farmers … Despite the so-called level playing field under the WTO, these developed countries continue to sell subsidised agriculture products onto the world market, thereby depressing prices … With the influx of cheap grains onto the world market and the restrictions imposed on developing countries to protect their domestic producers, the threat to food security is very real and growing.
>
> (BIOTHAI *et al.* 1999: 9–11)

Others point out that addressing international and national distributional issues and the global world order is perhaps an impossible task and, meanwhile, people go hungry. Focusing on production increases is not incompatible with poverty, they argue. Indeed, as Michael Lipton (an influential university-based economist) points out in the Nuffield report:

> Political difficulties of redistribution within, let alone among, countries are huge. Logistical problems and costs of food distribution also militate against sole reliance on redistributing income (i.e. demand for food) to meet present, let alone future, needs arising from increasing populations in less developed countries. Hence we must stress the importance of any new options that will secure higher direct and indirect employment and cheap food in labour-surplus developing countries … What is required is a major increase in support for GM crop research and outreach directed at employment-intensive production of food staples within developing countries.
>
> (Nuffield 1999: 4.8, 4.10)

Gordon Conway draws the same conclusions:

> Some argue that lack of food is simply a problem of unequal distribution. If poor people were not poor they could buy the food they need. This is true, but over-simplistic and not very helpful. There are no signs the world is about to engage in a massive redistribution of wealth. Food aid on the scale required would be costly in both economic and environmental terms for the industrialised countries and would inhibit local farmers from producing for the market. And the practical reality is that the majority of the poor live in rural areas. The only way they can increase their incomes is through agricultural and natural resource development, which means greater productivity.
>
> (Conway 2000)

But, while accepting his broad argument, others question an apparent faith in technological solutions. The Vitamin A enriched 'golden rice' has of late become symbolic of the potentials for a pro-poor biotechnology solution for the developing world, yet others observe that dealing with Vitamin A deficiencies may not best be achieved through the engineering of a yellow rice which consumers may not accept. The NGO Genewatch offers a critique:

> VAD [vitamin A deficiency], IDA [iron deficiency anaemia] and other nutritional deficiencies in developing countries are the result of poverty and its associated problems of inadequate diet, poor hygiene and sanitation. Addressing this root cause must therefore be the main priority for any sustainable solutions. If excitement about the potential for GM crops … diverts resources which would be better spent tackling poverty directly, or from existing intervention strategies … GM crops would have a net detrimental effect.
>
> (Dibb and Mayer 2000: 23)

Others, meanwhile, accept the potential role of biotechnology solutions, but recognise the importance of combining these with other technologies in what Gordon Conway (1997) has dubbed a 'Doubly Green Revolution':

> I believe we need a … Doubly Green Revolution, that repeats the successes of the old but in a manner that is environmentally friendly and much more equitable. This is going to take the application of modern ecology in such areas as integrated pest management and the development of sustainable agricultural systems. It is also going to need much greater participation in the development process by farmers themselves. But I also believe it is going to need the application of modern biotechnology – to help raise yield ceilings, to produce crops resistant to drought, salinity, pests and diseases, and to produce new crop products of greater nutritional value …
>
> (Conway 2000)

MS Swaminathan, former Director General of IRRI and more recently the founder of the MS Swaminathan Foundation in Chennai, India takes a similar line, talking of the 'ever-green revolution':

> Because land and water for agriculture are diminishing resources, there is no option but to produce more food and other agricultural commodities from less arable land and irrigation water. In other words, the need for more food has to be met through higher yields per units of land, water energy and time. We need to examine how science can be mobilised to raise further the biological productivity ceiling without associated harm. Scientific progress on the farms, as an 'ever-green revolution', must emphasise that the productivity advance is sustainable …
>
> (Swaminathan 1999: 37)

He goes on to point out the need to take public concerns into account in the development of public policy, and suggests a range of principles, which should guide future R and D work:

> Unless R and D efforts on GM foods are based on principles of bio-ethics, bio-safety, biodiversity conservation and bio-partnerships, there will be serious public concern in India, as well as many

> other developing countries, about the ultimate nutritional, social, ecological and economic consequences of replacing numerous local varieties with a few new genetically improved crop varieties.
>
> (Swaminathan 1999: 40)

Some critics, though, argue that these are fudged compromises, with the rhetoric of 'sustainability' and 'agro-ecology' being used to mask an underlying commitment to a high-tech biotechnology approach. Instead, they argue, choices have to be made. With limited public funds a commitment to a pro-poor, food security oriented agriculture must start with existing technologies and integrated, agro-ecological solutions:

> [T]he agro-ecological approach … offers several advantages. First, it is an alternative path to agricultural productivity or intensification that relies on local farming knowledge and techniques adjusted to different local conditions, management of diverse on-farm resources and inputs, and incorporation of contemporary scientific understanding of biological principles and resources in farming systems. Second, it offers the only practical way to actually restore agricultural lands that have been degraded by conventional agronomic practices. Third, it offers an environmentally sound and affordable way for smallholders to sustainably intensify production in marginal areas. Finally, it has the potential to reverse the anti-peasant biases inherent in strategies that emphasise purchased inputs and machinery, valuing instead the assets that small farmers already possess, including local knowledge and the low opportunity costs for labour that prevail in the regions where they live. Thus it is an approach that is likely to decrease, rather than exacerbate, inequality, and also enhance sustainability.
>
> (Altieri *et al.* 1998)

Others point to the constraints on a 'biotechnology for the poor' scenario given the structure of the biotechnology industry, the costs of biotechnology R and D, and the limited public research capacity in developing countries. Conway points out:

> More important than the potential hazards, at least to my mind, is the question of who benefits from biotechnology … So far the focus of [the 'big six' multinational life sciences] companies has been on developed country markets where potential sales are large, patents are well protected and the risks are lower. Most of the GM crops being currently grown in the developing countries are cash crops, for example Bt cotton in China. There is less interest in small farmer food crops because the returns are deemed to be low.
>
> (Conway 2000)

This theme is taken up by the Royal Society/National Academies report, which notes that the potentials of biotechnology may not be realised if the status quo is not challenged:

> Current industrial biotechnology is primarily oriented to the needs of large-scale commercial agriculture, rather than to those of the subsistence farmer. Most developing countries lack the financial resources and are limited in the scientific infrastructure needed to develop their own biotechnology programmes for the crops that are important to feed their people. The long-term decline of public agricultural research, the increasing privatisation of GM technologies, and the growing emphasis on the crops and priorities of the industrialised nations do not bode well for feeding the increasing populations of the developing world. As noted previously, without changed incentives for sharing access to GM technologies, the world is unlikely to direct much of its research for improved nutrition and employment-based access to staples for the poor.
>
> (Royal Society *et al.* 1998: ch.7)

The Nuffield report echoes this concern:

> As GM crop research is organised at present, the following worst case scenario is all too likely: slow progress in those GM crops that enable poor countries to be self-sufficient in food; advances directed at crop quality or management rather than drought tolerance or yield enhancement; emphasis on innovations that save labour costs (for example, herbicide tolerance), rather than those which create productive employment; major yield-enhancing progress in developed countries to produce, or substitute for GM crops now imported (in conventional non-GM) form from poor countries.
>
> (Nuffield 1999: 4.23)

The varied positions on the potential contributions of new agricultural biotechnologies therefore reflect in many ways those in the broader food security debate outlined above. Two key strands, mirroring those identified above, can be discerned. There are those who argue that, because of growing populations or the income and labour generating potentials of new technologies, investment in biotechnologies to enhance growth in yield potentials is essential, and should be a major global priority if poverty and food security are to be addressed for the future. On the other hand, there are those who argue that there are other means to the same ends, involving alternative, more conventional technologies and policy and institutional measures to tackle distribution and access, both locally and through challenging the political economy of the global food system more fundamentally.

Most commentators add a series of significant provisos to their positions. Ultimately which line is pursued (and there are many who argue combinations of both) depends on the assumed likelihood of those provisos being met, involving various leaps of faith and political positioning on the part of the different advocates. Those advocating agricultural biotechnologies as a central component of future poverty eradication and food security strategies must, for example, assume that sufficient public resources will be made available, or sufficient incentives for private companies to invest, for the development of biotechnology applications that meet poor people's needs – staple crops, drought resistance, saline tolerance, disease/insect resistance and so on – and that the science is up to the task in the medium term.

They also must assume that a widely accepted and trusted public policy approach to rural development/agriculture is in place to identify the appropriate role for agricultural biotechnology investment in the context of broader rural/livelihood policies; that regulatory frameworks necessary to ensure that such applications meet acceptable bio-safety and environmental standards can be developed and enforced; and that the monopolisation of technology by the private sector does not result in reduced choice and increased vulnerability for the rural poor.

Critics sceptical about the future of agricultural biotechnologies in meeting food security needs regard such qualifications as a tall order. They, in turn, must assume that the development of alternative technologies can result in the necessary returns (in terms of production, risk reduction etc.) to increase food security, over areas far larger than the relatively isolated case examples documented in the literature to date. They must also assume that policies for local, national and international redistribution of food will take place, in contexts where governments are weak and trends towards liberalisation and reduced government intervention are ongoing, and being reinforced by international agreements on trade and conditionalities by donors. Those advocating biotechnology argue in turn that these assumptions too are wildly unrealistic.

A consensus on this issue is therefore far from apparent. Most international agencies offer rather bland 'bit of both' compromises – biotechnology applications have potentials for addressing some elements of food security problems in developing countries, but such potentials can be achieved only with some significant provisos.[12] FAO, for example, in their most recent statement for example argue for 'increased public funding and dialogue between the public and private sectors':

> In view of the potential contribution of biotechnologies for increasing food supply and overcoming food insecurity and vulnerability, FAO considers that efforts should be made to ensure that developing countries in general, and resource-poor farmers, in particular, benefit more from biotechnological research, while continuing to have access to a diversity of sources of genetic material. FAO proposes that this need be addressed through increased public funding and dialogue between the public and private sectors.
>
> (FAO 2000a)

[12] See for example: Brenner (1997); IFPRI (1999); FAO (2000a); Serageldin and Persley (1999); among others.

7 Conclusion

So where does the debate go next? An impasse seems to have developed, and the generalised 'consensus' statements emanating from the international agencies do not get us very far. How can an approach to technology assessment and public policy be developed that allows a fuller debate to occur, where all the provisos and assumptions are examined in depth? A 'one size fits all' policy approach clearly is inappropriate. Agricultural biotechnology applications may be appropriate for some groups of farmers, some types of crops and in some agro-ecological zones and not others. Given the high costs of public investment in biotechnology R and D, some hard choices have to be made. What is the potential (long-term and unknown) public good return of such investments? What are the opportunity costs of following and indeed, not following a biotechnology promotion strategy? What compromises and mixes of investment are most appropriate for different countries and for the publicly funded international agricultural research system as a whole? Unfortunately there are few existing processes to deliberate upon such thorny dilemmas at either national or international levels.

The international debate, with its entrenched positions and generalised narratives, is inevitably limited. The challenge is to move on and identify new ways of engaging with the policy debate from a more local perspective, addressing the wider global issues in ways that are informed by local understandings and practices. A broader set of widely agreed criteria for an appropriate policy framework for 'pro-poor' biotechnology is clearly needed to encourage such a discussion (Cohen 1999; Morris and Hoisington 1999; Spillane 2000; Janssen *et al.* 2000). Elements would perhaps include: the institutionalisation of a precautionary style, which does not foreclose options, encourages a broad and inclusive debate about implications, and develops solutions appropriate to different national and local settings.

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