The World's Largest Open Access Agricultural & Applied Economics Digital Library

This document is discoverable and free to researchers across the globe due to the work of AgEcon Search.

Help ensure our sustainability.

Give to AgEcon Search

AgEcon Search
http://ageconsearch.umn.edu
aesearch@umn.edu

*Papers downloaded from **AgEcon Search** may be used for non-commercial purposes and personal study only. No other use, including posting to another Internet site, is permitted without permission from the copyright owner (not AgEcon Search), or as allowed under the provisions of Fair Use, U.S. Copyright Act, Title 17 U.S.C.*

No endorsement of AgEcon Search or its fundraising activities by the author(s) of the following work or their employer(s) is intended or implied.

Centre for Agricultural Strategy

Priorities for a new century – agriculture, food and rural policies in the European Union

Edited by B J Marshall & F A Miller

STP
HD1920.5
.Z8
P75x
1995

CAS Paper 31 April 1995

Marshall BJ & Miller FA (Eds)(1995) *Priorities for a new century - agriculture, food and rural policies in the European Union.* CAS Paper 31. Reading: Centre for Agricultural Strategy.

1 Food and agriculture: a global perspective

Jock R Anderson

INTRODUCTION

I really welcome this opportunity to ponder a global perspective for food and agriculture on my favourite planet, not least because it is in line with our decisions to gather here today: we are all inescapably interested in this topic that has such weighty consequences, for not only our own future ken, but for our species and its welfare. Naturally, however, our individual perspectives on the topic vary greatly, reflecting not only its inherent complexity but the diversity in our individual perceptions.

I come to today's topic largely from the experience in and information gleaned from several years in the World Bank's central Agriculture and Natural Resources Department, and a rather lengthy period of active involvement with the International Agricultural Research Centers of the Consultative Group on International Agricultural Research. You will form your own opinion of where I sit in the optimistic-pessimistic alarmist-complacent spectra, but I will strive to be realistic, while alerting you to some critical conditions necessary for underpinning and rationalising whatever optimism you find in my 'realism'.

My approach here is a simple one of sharing with you my own best judgment of the prospects for global food and agriculture, and of trying to present the situation in a form that does not imply an unjustifiable level of precision in projections that extend to a time when I will not be alive to defend them. The field is remarkably controversial, and another approach – one adopted just a month ago by my colleague Alex McCalla in his Crawford Lecture – would be to review critically the diverse positions that have recently been taken, from Mitchell & Ingco (1994) to Brown & Kane (1994), to mention just two rather extreme scenarios. Since McCalla has done this so ably, and as I have neither the time nor space to repeat the exercise, I present my simplified interpretation, comforted that my 'conditionally conventional' view happens to match that of McCalla fairly closely. In so saying, I should also share one of his pithy paragraphs (McCalla, 1994, p. 22):

> 'Of course, no one knows who will be right. Projections thirty years ahead, particularly those by economists, are invariably wrong. This is partly because of questionable assumptions, limited models, and poor information, but also because a dynamic world economy is self-adjusting since it does not tolerate disequilibrium easily.'

SOME DEFINING DIMENSIONS OF REALITY

Time

Naturally a first dimension is time. My temporal horizon is primarily to the next three decades or so, which will take us well into the (for us) most important portion of the 'new century,' and yet be close enough in time to permit me to put aside for the present purpose the many so far unresolvable uncertainties about the food and agricultural implications of the enhanced Greenhouse Effect and of policies that bear on its evolution: themes that doubtless will be taken up in many future conferences (Downing & Parry 1994; Norse, 1994).

Population

Yet this short period does offer challenge enough for contemplation, providing as it does for some impressive if not disturbing increases in global population, mostly in the presently less-developed countries (LDCs), as depicted by the projections summarised in Table 1.1.

Table 1.1
Human population (billion)

Country group	1995 (%)	2025 (%)
LDCs[a]	4.5	7.1
MDCs[b]	1.2	1.4
Total	5.7	8.5

[a] Less-developed countries
[b] More-developed countries
Source: United Nations (1993)

Food needs

Making detailed projections of the aggregate food needs for humanity is a task that involves the deployment of considerable information, much of which is even more speculative and uncertain than the analogous information on population levels to which they are applied. For an overview, however, the situation can be appreciated through constructing simplified scenarios focused on the major sources of food energy, namely, the cereals, and relating consumption patterns for 'average' consumers to plausible changes in average income levels across country groups. Such a process should, if done in a consistent and comprehensive way, also involve the modelling of the formation of market prices of all goods, including food products generally and major sources of food energy specifically, and the corresponding choices by consumers as prices and incomes vary over time. Such comprehensive studies are costly and are subject to inevitable controversy and uncertainty and thus, not surprisingly, are rare. To focus quickly on the Big Picture, I resort to one such simplified scenario assembly in which I have been involved (Crosson & Anderson 1992, 1994). Imagining what a megaton (Mt) of wheat 'looks like' is difficult enough, but the 3300 Mt (about 2.5 km^3) of total cereal needs in 2030 (Table 1.2) is large indeed and, significantly, is nearly double the size of the cereal mountain 'consumed' in any recent year – the quotes reminding us that apparent consumption involves much apparent waste, as highlighted recently by Bender (1994).

Table 1.2
Food on the plate: 1990 and 2030

Country group/crop	Approximate 1990 (Mt)	Projected 2030 (Mt)	Implied average annual growth rate (%)	1980s historic rate (%)
LDCs				
Rice	310	640	1.8	2.6
Wheat	270	770	2.6	3.7
Coarse Grains	300	950	2.9	1.7
LDC total	880	2360	2.5	2.6
MDC total	800	940	0.4	-
World total	1680	3300	1.7	-

Source: Apparent aggregate cereal consumption, rounded and extracted from Crosson & Anderson (1992, p 12).

RESOURCES: DEGRADATION *v* SUSTENANCE

Many of the resources that support agriculture are limited in supply in various ways, such as having a sharply increasing cost per unit beyond some critical level. The critical level may be:

- essentially infinite, as is the case for most atmospheric gases;
- probably rather finite, as for, say, petroleum-based energy;
- slowly approached, as is the case for financial and capital resources;
- fairly clearly delineated, as is the case for agricultural land;
- potentially quite confining, such as water.

The list of resources is long and the constraints that may be associated with them diverse, especially in their local specificities. Generalisations thus run the danger of falsity, especially when applied to particular agricultural niches, but must be made in order to examine the likely form of the Big Picture.

The following sections focus on land, water and knowledge resources, all of which are 'human' resources, in the sense that they serve most productively when the property rights in them are clear, secure and hopefully fair. Depending in part on the nature of such property rights of individual farm managers, the discussion must also recognise the reality that a given resource can vary greatly in quality, over space and over time, often for the worse, in which case the situation may be described generically as resource degradation – encompassing such varied phenomena as desertification, erosion, salinisation, exhaustion, compaction, toxification, and so on.

Degradation is thus a phenomenon that has many manifestations, most of which are resource-specific. Land degradation is one of the most widely recognised forms, especially in its most dramatic form of gully soil erosion, rather less in more subtle forms such as dryland salinity buildup. But every resource is potentially susceptible to degradation and erosion. The knowledge resource itself, to which I return with some passion later, can also be degraded, as its structures of support decline (such as an absence of fresh 'injections' of human capital from cutting-edge post-graduate programmes; libraries and their users losing contact with contemporary thinking through non-renewal of journal subscriptions; an absence of current reference texts and ready international professional contacts; inadequate incentives to add productively to the knowledge store; under extreme conditions, the deliberate distortion of evidence, constituting scientific fraud).

Whether it be land, water or atmosphere, human capital, the knowledge resource or other perhaps even more fragile resources, the reality of degradation must be considered and allowed for in assessments of future resource situations. The possibilities are not always 'well balanced' in terms of symmetry but the obverse of degradation, enhancement of a resource, is in principle possible.

Enhancement sometimes may be costly but if the rewards are adequate, (which may require increased security of tenure in some resources such as land, and even life itself - some contemporary cases in sub-Saharan Africa do spring to mind), happen it will, with the consequent positive outcomes for boosted private returns and productivity.

The land resource

Measuring actual land use at a global level (FAO 1994) has its own subtleties that need not distract us today, but assessing future potential use is a real art form, fortunately tackled regularly by FAO, (see Table 1.3). Taking a stab at actual conversions to cropland by any designated future time goes beyond art and certainly beyond science – involving as it does judgments about many different societies' changing values of both the economic and environmental costs of changed land use – but this is done for the purpose of concreteness in the final column of Table 1.3.

Table 1.3
Cropland overview: recent and for the year 2030 (million ha)

Region	Cropped 1990	Technically arable but uncropped 1990	Guesstimated realistic new cropland to 2030[a]
sub-Saharan Africa	210	800	40
West Asia/ North America	80	10	5
East Asia	210	100	30
South Asia	190	40	20
Latin America/ Caribbean	190	870	50
LDCs	880	1820	145
MDCs	600	80	5
World	1480	1900	150

[a] Given needs for animal pastures and forests, infrastructural limitations, new urban land occupations, tsetse-related impediments to conversion, rising environmental opportunity costs and constraints arising from use of lower quality land.

Source: FAO (1994)

Adding an additional 150 million ha (about 10%) to the world's cropland over 40 years may seem modest enough relative to recent past-decade annual increments of the order of 1%, but even this, I think, will be difficult, infrastructurally demanding, and politically controversial in many (especially 'green') quarters. Whatever may, in fact, prove to be attainable, it seems to me – and here I am rather more pessimistic than is my colleague Pierre Crosson – that this source of meeting the 1.7 % annual growth challenge of Table 1.2 will in itself be minor (ie only about 0.25 %).

These overview remarks about land are simplistically quantitative and crude in that they take no account of qualitative dimensions, such as the diversity of land productivities (both in present and potential cropland), the extent and consequences of the many forms of land degradation and the effective-supply-increasing consequences of various land improvement interventions such as application of organic and inorganic fertilisers, terracing, tied ridging, 'conservation farming' methods such as zero tillage, and of land reclamation endeavours, expensive as these may sometimes be.

Space forbids an analysis of this controversial area here (much of the literature is critically examined by Crosson & Anderson, 1992 and Crosson 1994) but, on balance, and without considerable investment, such land-quality enhancement activities over the four decades may well outpace the new losses to degradation to the tune of another net 10% equivalent increase of the land resource, ie, about another 0.25 % per annum contribution to the needed 1.7 % annual increase in production.

Needless to say, what is actually achieved in the management of land will depend crucially on the policy environment that surrounds this most special of resources. Different cultures differ greatly in the way they approach the land resource, ranging from strong public ownership with little real security of individualised tenure in, say, parts of the former Soviet Union through to unconstrained privately owned and fully alienable land at the other extreme, with many intermediate gradations of ownership and thus of incentive for responsible custodial management. A favourable outcome by way of the enhanced productivity foreshadowed above will thus rely on a progressive evolution of tenurial incentives for individuals to manage their land with greater regard to the rights of future users.

The water resource

The next physical resource with which I must deal, if only briefly, is water, particularly in its role of irrigation for crops, although the scarcity issues to be touched on also link strongly to non-agricultural uses of water, such as the various human-driven imperative urban, industrial and domestic purposes, and less pressing but nonetheless significant recreational purposes.

The global situation for irrigated area can be viewed in a manner parallel to that for the land resource, of which it is of course a part, as is presented in Table 1.4. The numbers in Table 1.4 seem much smaller than those of Table 1.3 for several good reasons, notably that irrigation is quite an expensive practice and is becoming more so in several ways (Yudelman, 1994). First, many of the undeveloped projects have geomorphological and engineering attributes that make them as much as twice as expensive as earlier typical schemes, a situation exacerbated by high transport/transaction costs in more remote sites. Second, there is now growing recognition of the short-sightedness in inadequately dealing with drainage in many early schemes, and attention to this both retrospectively and prospectively 'increases' irrigation costs from their apparent to higher real levels. Third, and most significantly, the social and environmental costs, especially of large schemes in heavily populated possibly 'fragile' areas are being better recognised, more vehemently articulated, and more adequately taken into account. Such considerations explain the pessimism evident in the final-column guesstimates of Table 1.4.

Table 1.4
Irrigated land overview: recent and for 2030 (million ha)

Region	Irrigated[a] 1990	Technically potentially irrigable 1990	Guesstimated realistic new irrigated land
sub-Saharan Africa	4	16	4
West Asia/ North America	8	2	0
East Asia	140	60	20
South Asia	20	6	4
Latin America/ Caribbean	16	24	4
LDCs	188	108	32
MDCs	68	26	2
World	256	134	34

[a] Based on World Bank/UNDP (1990, p 115), rounded to the nearest even number.

The higher land productivity of irrigated agriculture relative to non-irrigated (an average yield factor of 2.5) must be recognised in assessing the guesstimated contribution of new irrigation investment to meeting the demand scenarios. Assuming the new irrigation is on existing cropland, the net increase in the total-productivity-equivalent land resource is some 50 million ha (on top of the 150) to 2030, which contributes only an additional 0.08 % per year.

Analogous to the case of land, however, there are qualitative aspects to consider, along with the sheer magnitudes of areas nominally irrigated. The productivity of this resource depends on several attributes such as timing of delivery relative to needs, requests and intentions, and reliability of supply generally, not to mention the quality (eg, salt, nutrients, silt and pesticide (Farah 1994) burdens) of the water itself. Most of the attributes can best be considered under the general heading of 'management,' a field presently handled inadequately in many irrigation schemes. With greater attention to overcoming wasteful and inefficient management practices through research, training, pricing and incentives, much may be achieved over the coming decades and, accordingly, I feel that progress here could be some 1.5 times as effective as new schemes themselves to the year 2030, bringing the total likely contribution of the water resource to 0.08 + 0.12 = 0.2 % per year.

As is the case for the land resource, policy attitudes adopted towards the water resource will be of great consequence (World Bank, 1993). The ownership and user rights issues in water are, however, even more complicated than those for land and thus the opportunities for enhancing qualitative aspects of the water resource are not so favourable. This is not to say that governments should not address themselves vigorously to clarifying the rights of users of the water resource, especially as it becomes increasingly scarce over coming decades. They **must** address these issues, even though they involve conflicts – intranational and international – that are among the most difficult to resolve (Umali, 1993, Kirmani & Rangeley 1994).

With the important exception taken up in the next section, I feel it is unlikely that other biophysical resources (such as climate and plant and animal genetic resources *per se*) will play much of a role in identifying the production growth equation to the year 2030, so it is time to summarise the assessment thus far. It has been speculated that, of the needed annual average growth of 1.7% per annum, 0.5 will come from the land resource and 0.2 from the water resource, which leaves about 1 % per annum to be found elsewhere. I think this quest should lead us in the general direction of technology and knowledge.

The knowledge resource

The foregoing review of the limited prospects for the major physical resources leads to a direct consideration of the one resource that is not so limited or limiting, but yet requires rather special handling. Agricultural knowledge, as expressed in an efficiently productive agriculture, has many rather special features, which include (Francis 1990) being non-rival in use, readily expandable through appropriate investment, easily transmissible, and productively integrative.

The supply of new knowledge can be conceptualised usefully as being distributed among three major components: human capital, institutional innovation (including policy), and improved technology.

All three are vital and any sensible development strategy must address them all carefully. For brevity and also simplicity, since it is somewhat less difficult to measure, I will here focus on the technology leg of this stool.

To summarise a large and rich literature all too succinctly, investment in agricultural knowledge systems has generally (at least according to some 200 retrospective studies) proved to be highly socially rewarding, with internal rates of return usually in the region of 30% and with seemingly few total failures. This is not to suggest that every ECU (or whatever) invested in agricultural knowledge systems is necessarily well spent – more of this later, when I touch on some of the pressing needs in sub-Saharan Africa – but a socially responsible investment programme must be alert to both opportunities and challenges.

Fortunately, the reality of these diverse situations is increasingly well understood in the development community. Donors and recipients alike are becoming rather more discerning than has often been the case, when the needs perceived may have overwhelmed the realism of judgements that may have been driven more by donor priorities and 'needs' rather than the 'real' concerns of the people in recipient and beneficiary communities.

To return now to the demand scenario that remains unmet by increased land and water resources, can the 'missing' 1% per year be provided by conventional inputs and the knowledge resource? When Crosson & Anderson (1992) looked at this question, we decided it could – subject to the crucial proviso that investment in the new-technology generating systems (largely International Agricultural Research Centers and National Agricultural Research Systems) remains strong, stable and efficient. In the present era of diminished real resources for both international and national research, this too is indeed a further key issue that must remain on the policy agenda. Those concerned with public resource allocation must revisit the lowered priority implicitly assigned to research investment. With re-invigorated research resource commitments, however, significant productivity growth seems achievable, perhaps towards the speculative possibilities for land-productivity growth for some key crops depicted in Table 1.5.

As in the past (Byerlee, 1994), local achievements will vary greatly according to many local circumstances but, with aggregate performances in both (a) varietal improvement and (b) management (including fertiliser use), perhaps each of the order of the 0.8% per year indicated in Table 1.5, the missing 1% per year should be able to be found by 2030 – but with little leeway, and with the growing complication of struggling with issues as intangible as increasing (albeit unpriced) environmental costs of key resources and as difficult as the establishment of property rights in these resources, including plant and animal genetic resources.

Table 1.5
Indicative components of potential annual land productivity growth for major cereals (%) to the year 2030

Crop	Varietal	Irrigation[a]	Fertiliser, Management, etc[b]	Total
Rice	0.7	0.1	0.9	1.7
Wheat	0.6	0.2	1.1	1.9
Maize	1.0	0.5	0.5	2.0

a This component has already been aggregatively 'accounted for' in the above discussion of the water resource, and is included here only to indicate the crop-specific nature of its contribution.

b Fertiliser and its management (often, but not always, more, with better placement, timing, etc), crop management generally, including integrated pest management.

Source: Based on speculations assembled by Crosson & Anderson (1992, pp 91-99).

Lest this 'sanguine finding' seems too easy and perhaps just too convenient, let me re-emphasise some of the conditions that underlie the projections of productivity growth potential reported in Table 1.5. The varietal gains are to come from crop-improvement efforts, aided in novel ways by techniques from modern molecular biology and, at least in the case of maize, a strong involvement of private research organisations that will, in turn, depend on effective protection of the intellectual properties they will produce. There will also need to be an important contribution of private research in some of the fertiliser and management productivity gains, as well as a continuing public contribution from international and (mainly) national research agencies, for what will be increasingly knowledge-intensive input use. Needless to say, farmers will only employ such more-productive inputs to the extent that they are perceived to be profitable and not too risky, which leads us to commodity markets and trade regimes, and their uncertainties over future decades – topics for another occasion.

CONCLUSION

To seek a global perspective on world food and agriculture is thus to step back sufficiently far to look at key resource provisioning in a somewhat detached way – a step that leads one to broad-brush generalities that may not sit comfortably with a steady-as-she-goes philosophy. Those who derive their livelihood from alarmist overstatements of the urgency of many agricultural sub-system interventions may also not wish to agree with this perspective. Realism, as I perceive it, takes one down a rather narrow path where, to stray from the resource commitments that to me seem obligatory, is to risk negative consequences for supply that are hardly conscionable. Our duty – I now conveniently lapse to the European Union as 'our,' but it clearly goes well beyond the present European Union (EU) – is to assist effectively, quickly and in some cases rather urgently, and above all magnanimously (if not altogether altruistically, because the future of Humanity is, after all, at stake). So much better to have to worry about dealing with surplus food stocks than to have to manage scarce supplies among the unfulfilled needy and hungry.

All this leads me to the general topic of 'aid' or, in official parlance, 'official development assistance.' I realise that this is not the focal theme of today's meeting but I hold strongly the view that aid cannot be allowed to slip from the agenda of a conference such as this. European assistance to agricultural development has been 'long and strong' and, it is my fervent Churchillian hope, there must be no 'withdrawal.' One cannot afford to be relaxed about such important matters, especially with so many alternative imperatives beckoning so eagerly. The 'environment' is one of these but, with a few important exceptions, it is mostly compatible with the fostering of greater agricultural productivity. 'Poverty alleviation' is another that is directly attended not only by bolstered agricultural productivity (to the extent that the poor are rural) but also by the consequently reduced prices of food staples for all.

Africa must receive a special mention, however, whether one reads Tiffen & Mortimore (1994) or Kaplan (1994). Many factors contribute to the current problems but one that will assume greater significance is an enlarged shortfall in food supply in sub-Saharan Africa. The global perspective taken thus far does not address the key question of regional distribution. In spite of the relative abundance of potential agricultural land (Table 1.3), sub-Saharan Africa will continue to lag behind other regions in per person food availabilities. Trade and aid will fill important gaps, but African food and fibre production must be boosted through investment in physical and social infrastructure, including most especially institutions, such as National Agricultural Research Systems, that efficiently provide the technology that will generate much of the needed growth in agricultural productivity.

Aid aside, what does all this prognostication mean for agricultural policy in the European Union in the post-1993 GATT era? The need for consistently growing global agricultural production is clear enough, even if the translation of this need into effective demand depends on a vast set of factors, including general economic growth and a strengthening of property rights. The scenario I have sketched suggests that we are going to 'make' it: through socially acceptable conversion of land to cropping, and some additional and refurbished irrigation; judicious but sustained investment in new agricultural knowledge to boost productivity; and an open trading regime that indeed makes a global perspective relevant.

The overview implies increasing resource scarcities and environmental challenges, particularly in heavily populated regions, expanded trade to meet local deficits and more extensively exploited national comparative advantage and, it is hoped, rather more liberalised trading systems. Any increase in protectionism will essentially diminish the global supplies of key resources. Europe, whatever its geographical range by 2030, will be a major agricultural trader, and a growing number of countries will be relying on its food exports, not to mention its industrial output that will be imported by many countries, more- and less-developed, as key agricultural inputs that will drive much of the speculated advances in productivity. How Europe manages its role in the global challenge, (it is not my field but I have read a little Atkin (1993)) as well as wrestles with its own agricultural and environmental responsibilities (Pearce, 1994), will be of great consequence and for me fascinating to observe – which is one of the reasons I am so delighted to be here today to witness part of the process in process.

REFERENCES

Atkin, M (1993) *Snouts in the trough: European farmers, the Common Agricultural Policy and the public purse,* Cambridge: Woodhead.

Bender, W H (1994) An end use analysis of global food requirements, *Food Policy* **19**(4), 381-395.

Brown, R & Kane, H (1994) *Full house: reassessing the earth's population carrying capacity.* Worldwatch Environmental Alert Series. New York: Norton.

Byerlee, D (1994) *Modern varieties, productivity, and sustainability: recent experience and emerging challenges.* Mexico 6 DF: CIMMYT

Crosson, P (1994) Future supplies of land and water for world agriculture. In: Nurul Islam (Ed) *2020 Vision.* Washington: IFPRI. (In Press).

Crosson, P & Anderson, J R (1992) *Resources and global food prospects: supply and demand for cereals to 2030.* World Bank Technical Report No. 184. Washington: World Bank.

Crosson, P & Anderson, J R (1994) Demand and supply: trends in global agriculture. *Food Policy* **19**(2), 105-119.

Downing, T E & Parry, M L (1994) Introduction: climate change and world food security. *Food Policy* **19**(2), 99-104.

FAO (1994) *Agriculture towards 2010.* Rome: FAO. (Revised draft).

Farah, J (1994) *Pesticide policies in developing countries: do they encourage excessive use?* World Bank Discussion Paper Number 238. Washington: World Bank.

Feder, G & Keck, A (In Press) Increasing competition for land and water resources: a global perspective. In: Pingate P (Ed) IRRI Conference Proceedings on *Social Science Methods in Agricultural Systems: Coping with Resource Competition in Asia.* Chiang Mai, Thailand, November 1994. Los Banõs, Phillipines: IRRI.

Francis, C A (1990) The economics of sustainable low-input farming systems. In: Francis, C A, Flora C B, & King, L D (Eds) *Sustainable agriculture in temperate zones.* New York: Wiley.

Kaplan, R D (1994) The coming anarchy. *Atlantic Monthly* **273**(2), 44-76.

Kirmani, S & Rangeley, R (1994) *International inland waters: concepts for a more active World Bank role.* World Bank Technical Paper Number 239. Washington: World Bank.

McCalla, A F (1994) *Agriculture and food needs to 2025: why we should be concerned.* Sir John Crawford Memorial Lecture, Consultative Group on International Agricultural Research, Washington, DC.

Mitchell, D O & Ingco, M D (1994) *Waiting for Malthus: the world food outlook.* Boulder, Colorado: Westview. (In Press).

Norse, D (1994) Multiple threats to regional food production: environment, economy, population? *Food Policy* **19**(2), 133-148.

Pearce, F (1994) Greening the heart of England. *New Scientist* **143** (1944), 30-35.

Tiffen, M & Mortimore, M (1994) Malthus controverted: the role of capital and technology in growth and environment recovery in Kenya. *World Development* **27**(7), 997-1010.

Umali, D L (1993) *Irrigation-induced salinity: a growing problem for development and the environment.* World Bank Technical Paper Number 215. Washington: World Bank.

United Nations (1993) *World population prospects: the 1992 revision.* New York: United Nations.

World Bank (1993) *Water resources management.* Washington: World Bank.

World Bank/UNDP (1990) *Irrigation and drainage research: a proposal.* Washington: Agriculture and Rural Development Department, World Bank.

Yudelman, M (1994) Demand and supply of foodstuffs up to 2050 with special reference to irrigation. *IIMI Review* **8**(1), 4-14.