IS THERE REALLY SPARE LAND? A CRITIQUE OF ESTIMATES OF AVAILABLE CULTIVABLE LAND IN DEVELOPING COUNTRIES

ANTHONY YOUNG
School of Environmental Sciences, University of East Anglia, Norwich, NR4 7TJ, UK
(e-mail: anthony.young@land-resources.com; fax: +44 1603 455461)

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" 'No room, no room' they cried . . .
'There's plenty *of room!' said Alice."*
(Lewis Carroll, Alice's Adventures in Wonderland*)*

Abstract. Five assessments covering less-developed countries have identified a 'land balance', available for future cultivation, using the approach of inventory and difference: assessment of the area cultivable, and subtraction of the area presently cultivated. All arrive at a balance of 1600–1900 Mha, about twice the present cultivated area. The supposed existence of this spare land is widely quoted in forecasts of capacity to meet the food requirements for future population increase. It is argued here that these estimates greatly exaggerate the land available, by over-estimating cultivable land, under-estimating present cultivation, and failing to take sufficient account of other essential uses for land. Personal observation suggests that the true remaining balance of cultivable land is very much smaller, in some regions virtually zero. An order-of-magnitude estimate reaches the conclusion that in a representative area with an estimated 'land balance' of 50%, the realistic area is some 3–25% of the cultivable land. This speculation could be tested by directly attempting to find such land in areas where it is supposed to exist. The impression given by current estimates, that a reserve of spare land exists, is misleading to world leaders and policy-makers.

Key words: cultivable land, cultivated land, land balance

1. Introduction and hypothesis

Current UN population projections predict that the population of developing countries will rise to about 8 billion by 2025 and 9 billion by 2050, an increase of some 50% and 80%, respectively, over the present number.[1] It is widely recognized that massive agricultural development will be needed to feed this added population. However, a serious food shortage already exists over substantial parts of the developing world. Public attention is drawn to this by the recurrent and increasingly frequent famines, generally set off by natural disasters, political mismanagement or civil war.

More cogent evidence is provided by statistics for the number of chronically under-nourished, with effects particularly on death rates and restricted growth among children. The 1996 World Food Summit resolved to reduce the number of under-nourished, estimated as 920 million, to half this level by 2015 (FAO, 1996a; 1996b). The number of malnourished, those with dietary imbalance or specific deficiencies, is considerably higher, more than half the world population (WHO, 1996). Furthermore, the present food needs of developing

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countries are maintained by an annual import of some 80 Mt of cereals, nearly all from the temperate zone. In seeking to reduce future hunger, we start from a considerable deficit position.

Contributions to meeting these food needs are expected to come from three sources: an increase of cultivable land, higher crop yields, and reduction in post-harvest losses. In historical perspective, 1960 was a watershed year. Before that time, the major contribution to increasing food supplies came from taking more land into cultivation; since then, it has been predominantly achieved by raising crop yields (Evans, 1998). For the next 25–50 years, it is agreed that raising crop yields must form the major contribution, but all estimates look towards a contribution from an increased land area, raising this every ten years by some 25 Mha for cereal harvested area, or 42 Mha for total cultivated land.[2]

This proposition has been given support by a series of estimates of land, food, the potential to feed future populations. I have recently discussed 14 of the most authoritative of these (Young, 1998) and will not repeat this analysis. For present purposes, it is sufficient to record that all of them assume the existence of substantial areas of land available for future cultivation, in some cases double the present area. This assumption continues to appear in the most recent discussions (Fischer and Heilig, 1998; Greenland et al., 1998a; Evans, 1998), although in one instance with the recognition that 'Much [of the spare land] is already allocated for other use' (Greenland et al., 1998b).

The impression which the assumption of spare land creates tends to downgrade the seriousness with which the land–food–people situation is regarded, both by development professionals and laymen. The hypothesis advanced here is that these estimates are grossly misleading, and that the area of land which can still be taken under cultivation, with sustainable management, is considerably smaller than they indicate. It is argued that the impression created by these estimates is misleading to the world's leaders and policy-makers.

The following two sections of this discussion rest on evidence of contrasting kinds. Section 2 gives the principal estimates of the land balance available for cultivation, based on maps, statistics and analysis by authoritative organizations. Section 3, which questions these estimates, rests on evidence of a quite different nature: personal observations by the author, working and travelling in developing countries. It reaches conclusions which are at variance with the estimates. Section 4 seeks reasons for this discrepancy. Section 5 makes a speculative adjustment to such estimates, and suggests how the true situation could be put to test.

Throughout this article the arguments refer to developing countries only. There is certainly spare land available for cultivation in the developed world, but this is not where it is needed to alleviate food shortage.

2. The estimates

2.1. SOURCES

Estimates of the amount of land available for future expansion of cultivation have been obtained by what will be called the approach of inventory and difference: assessment of the potentially cultivable area, and subtraction from it of the area recorded as presently cultivated. All studies use the same data source for present cultivation: the value for 'arable land and permanent crops' given in the *FAO Production Yearbook* (FAO, annual), now available as the statistical data base FAOSTAT (FAO, ongoing).

The foundations for estimates of cultivable land are the successive studies by FAO and associated organizations, dating from the 1970s onward: the *Soil Map of the World* (FAO, 1970–80), the climatic inventory carried out for the agro-ecological zones project (FAO, 1978–81), and the comparison of crop growth requirements with environmental conditions carried out as part of the population-carrying capacity project (FAO, 1983; 1984). These data sources were brought together, in what is essentially a form of land evaluation carried out at world scale, to give estimates of cultivable land. The five estimates, listed under the abbreviations by which they are referred to in this article, are as follows:

AT 2000: *Agriculture: Toward 2000* (FAO, 1981). This cites the following study (LFP) as its source for estimates of cultivable land, although the data given are not identical.

LFP: *Land, Food and People* (FAO, 1984). This was the first systematic attempt to assess the food production capacity of the developing world.

AT 2010: *World Agriculture: Towards 2010* (Alexandratos, 1995). Although employing a similar approach to LFP, this estimate was largely carried out afresh, with the aid of improved computer analysis techniques including digitized mapping.

FAO/IIASA: AT 2010 was revised and updated in an interim estimate (Fischer and Heilig, 1998).

AB-DLO: *Sustainable World Food Production and Environment* (Luyten, 1995). A separate estimate was made by a Netherlands organization, AB-DLO. This employed a grid cell technique in place of the digitized mapping units of the FAO studies.

The first four studies are successive modifications of the same basic FAO method. The fifth was carried out independently and largely *ab initio*, although the *Soil Map of the World* is one of its ultimate sources. The first three studies cover the developing world excluding China, the FAO/IIASA study adds China, whilst the AB-DLO study covers both developing and developed countries.

Space does not permit a comparison or critical analysis of the methods employed in these estimates. It should be noted, however, that they are far more than mere comparisons of climate, soil, slope, and crop requirements. Factors taken into consideration in some or all of them include, for example, rest periods (fallows, etc.) necessary to maintain soil fertility, the contribution from irrigation of arid lands, soil conservation requirements, and land needed for non-agricultural purposes, including nature conservation and urban expansion. Some studies recognize that much of the remaining cultivable land is under rain forest, which current world opinion considers should be preserved. The FAO/IIASA study suggests that forests and wetlands should not be cleared, only land in the savanna zone being considered as available for cultivation. All the estimates are based on sustainable land use, with avoidance of further land degradation.

2.2. RESULTS

Table I gives the estimates of cultivable and cultivated land given by the five studies, for the developing world as a whole and for its three major continental regions. The definitions of these regions are not identical, and some differences are undoubtedly caused by inclusion, exclusion, or 'trans-continental transfer' of countries which are regionally intermediate or marginally developing. There are two important differences. First, China is excluded from the first three estimates but included in the last two. Secondly, the values for land 'presently' cultivated refer to 1975 for the first two estimates, but to c.1990 for the later ones.

Taking these differences into account, there is fairly good agreement between the estimates. If only the three more recent studies are considered, the cultivable lands of Asia are 67–80% already under cultivation, with a gross difference, cultivable minus cultivated, of 120–200 Mha. In Africa the proportion cultivated is 18–26% and the gross difference close to 820 Mha, and in South and Central America 17–20% cultivated with a gross difference of 730–870 Mha. Allowing for the exclusion of China and the different date for cultivated land data, the two earlier studies are not greatly out of line with the later ones. The relative

TABLE I. Estimates of cultivable and cultivated land in developing countries

Source[a]	Million hectares			Percent cultivated
	Cultivable	Cultivated[b]	Gross difference	
Asia				
AT 2000	474	353	122	74
LFP	345	343	2	99
AT 2010	412	278	134	67
FAO/IIASA	630	456	174	72
AB-DLO	571	453	118	79
Africa				
AT 2000	676	203	473	30
LFP	789	168	621	21
AT 2010	1101	289	812	26
FAO/IIASA	1071	253	818	24
AB-DLO	1011	187	824	18
America				
AT 2000	693	173	520	25
LFP	893	160	733	18
AT 2010	1059	190	869	18
FAO/IIASA	1058	190	868	18
AB-DLO	907	180	727	20
Developing countries				
AT 2000	1843	737	1106	40
LFP	2027	671	1356	33
AT 2010	2572	757	1816	29
FAO/IIASA	2776	900	1876	32
AB-DLO	2489	820	1669	33

[a] For sources see text; data for the first three exclude China.
[b] Land use for the first two sources refers to 1975, for the remainder c. 1990.

contrasts are in agreement with general observation of rural population densities in the respective continents, although the Africa/America difference is less than might have been expected.

For the developing world as a whole, these estimates, based on the approach of inventory and difference, suggest that only 29–33% of the cultivable land is cultivated, and that there is a gross difference between cultivable and cultivated areas of 1670–1900 Mha. For these areas, the neutral term ‘gross difference’ is used here, meaning simply the result of subtracting one figure from another. However, in the source estimates it is variously called the ‘land reserve’, ‘available land’, or ‘land balance’.

These names, coupled with the large areas involved, have given rise to a sense of reassurance. It is commonly believed that, even after allowing for non-agricultural uses of land, considerable areas remain which could be taken into production of food crops.

2.3. LOSS BY LAND DEGRADATION

One further aspect, the loss of land due to degradation, is acknowledged in most of the above estimates. Slight to moderate degrees of degradation leading to the lowering of productive capacity due to reversible degradation, e.g. through soil fertility decline, is very widespread, but bears only indirectly on the present discussion. What is most relevant is the total loss of land, for most practical purposes irreversible, through severe degradation: soil erosion, salinization, and soil pollution.

The most widespread cause of such loss is severe soil erosion. Some estimates of the extent of land lost to erosion are certainly exaggerated. The least unreliable is the semi-quantitative *Global Assessment of Soil Degradation (GLASOD)* (Oldeman et al., 1990). Based largely on this source, the best evidence is that up to the present day, about 300 Mha, or 5% of the formerly usable land in developing countries, has been lost by severe soil degradation; and that the current rate of loss is not less than 5 Mha per year (Young, 1998). If such a rate continues, it would lead to a loss of a further 125 Mha over the next 25 years, or 0.3% of the usable land; the true figure could be double this. Whilst locally of far greater severity, this rate of loss does not impact greatly on total land availability.

3. Reasons to question the estimates

3.1. GENERAL

Contrary to normal scientific practice, some passages in this paragraph are written in the first person, since the reasons for questioning these findings arise from my own field experience. The estimates are the result of work based on methods of natural resource inventory and land evaluation, carried out by international organizations of the highest scientific quality. As a former soil surveyor, a consultant to the *Land, Food and People* study, and a lifetime advocate of soil survey and land evaluation, the decision to challenge them is a painful one! However, qualitative field observations showed that in many regions of the tropics, all land which can be cultivated sustainably is already in use. In some areas this has been the case for 10, 20 or more years. I became convinced that, despite the scientific validity and thoroughness with which the estimates had been made, the results gave a fundamentally incorrect picture of the true situation.

In general terms, not specific to any country, the following observations conflict with the notion that there is abundant spare land:

– Cultivation has been extended onto steep slopes, frequently without adequate soil conservation and thus unsustainably (e.g. Jamaica, Malawi).
– Cultivation has become common in semi-arid zones with a high drought risk, often in conflict with former pastoral use (e.g. Kenya, the sahel zone of West Africa).
– Large regions, both in Asia and Africa, are being cropped continuously, with no fallows or other soil rest periods, in some cases under cereal monoculture. This has resulted in declines in crop yields, and yield response to fertilizer (e.g. Bangladesh (Pagiola, 1995)).
– Nutrient cycling studies show chronic negative balances, removal in harvest exceeding natural inputs and fertilizers (Stoorvogel and Smaling, 1990).
– More generally, land degradation is widely attributed to unsustainable land use, often initiated by a cycle of land shortage, poverty and degradation (Young, 1994; 1998).
– Average farm size in some areas has fallen substantially below one hectare (e.g. Malawi).
– Illegal cultivation of forest reserves, national parks and other protected areas is found (e.g. the Philippines).
– Independently of famines caused by natural disasters or civil conflict, chronic undernutrition is widespread (FAO, 1996b).

Certainly there are explanations other than land shortage for some of these features, for example, socially inequitable land distribution. However, if the former solution to farming problems, to take in more land, had been available, the above phenomena would not have been so widely observed.

3.2. SPECIFIC COUNTRIES

Focus is given to these observations by examining the ‘land balances’ assessed for individual countries. For this purpose, the *AT 2010* study is taken as the basis. However, since the regional findings in the other studies are similar, the observations apply to all five estimates.

Table II shows the ‘land balance’, cultivable minus cultivated land, for sample countries. Since the basis of the present analysis is field observation, with one exception the countries selected are those of which I have personal experience.[3] They are arranged in order of assessed land balance. Two reciprocal figures are given, the percentage of land assessed as cultivable which are already under cultivation, and the percentage which forms the ‘balance’.

It is reassuring that some densely-settled countries are assessed as having negative land balances, that is, the land presently cultivated exceeds that assessed as sustainably cultivable. The four listed all experience food shortage. Seven countries in all have negative balances in this assessment, falling into two groups: dry countries dependent on irrigation

TABLE II. Estimates of the 'land balance' for selected countries, based on the *AT 2010* study. [Breaks in the listing correspond to groups discussed in the text.]

Country	Land cultivated 1988/90 as percent of land cultivable	
	Cultivated (%)	Balance (%)
Rwanda	131	negative
Haiti	108	negative
Pakistan	102	negative
Bangladesh	100.3	negative
Afghanistan	99	1
Niger	95	5
India	82	18
Thailand	72	28
Philippines	71	29
Sri Lanka	61	39
Vietnam	56	44
Malaysia	53	47
Jamaica	51	49
Nigeria	50	50
Kenya	50	50
Malawi	45	55
Ethiopia	43	57
Burkina Faso	37	63
Tanzania	20	80
Sudan	18	82
Brazil	15	85
Madagascar	10	90
Zambia	9	91
Venezuela	9	91

(Pakistan, Tunisia and Yemen), and crowded humid countries (Bangladesh, Haiti, Rwanda and Mauritius).

Seven out of nine countries listed in the assessment as having 80–99% of cultivable land cultivated are in the arid, irrigated group, again in accordance with expectation. India and Burundi are the only humid countries in this group. The assessment for India is of particular interest. Most observers (and farmers) would say that virtually every small corner of India that could be cultivated is already in use, and in many regions has been for many years. Soil fertility decline through continuous cultivation is recognized as widespread (Sehgal and Abrol, 1992). This suggests that a value of anything up to 20% land balance in the assessment means that the true land availability is effectively zero.

The next group of countries in Table II have land balances of 25–50%. It is here that direct observation begins to throw doubt on the reality of the estimates. If there is really a 29% land balance in the Philippines, why is there so much encroachment into forest reserves and national parks? In Vietnam, if there is a balance approaching half the cultivable land, why have protected forests been so extensively encroached upon, and steep slopes cultivated? In Jamaica, unequal land distribution is a factor, estates on the coastal fringes forcing smallholders to cultivate very steeply sloping land in the interior. National policy, far from favouring further clearance, seeks to reduce such non-sustainable cultivation. In Kenya's two humid nodes, the central (Mount Kenya) and western lake regions, farms are becoming too small to support a family and cultivation has been expanding into semi-arid zones.

Malaysia (and, lower on the list, Brazil and Venezuela), represents a different situation. There is indeed cultivable land remaining, which is under rain forest, some of it primary. In the 1960s there were a series of development projects in Malaysia, funded by international loans, the objective of which was to cut down this forest and replace it with oil palm, rubber and other perennial crops. Attitudes have greatly changed since then, and international opinion strongly opposes further clearance. The *AT 2010* survey itself points out that 72% of the land balance is found in only 15 countries, 7 of which have large areas of rain forest; Brazil alone has 27% of the balance. If these areas are not to be cleared (although in practice some of them will be) this eliminates a considerable part of the balance.

It is the next two countries in Table II, Malawi and Ethiopia, which most severely strain this author's credibility. In 1958–62 I carried out soil surveys throughout Malawi, and examined the entire country on air photographs. The more fertile regions, such as the Lilongwe Plain, were already 100% cultivated, for the most part continuously. On the poorer soils, some land remained under rotational fallows. The population was then 3 million. By 1973, with a population of 5 million, all the sustainably usable land was taken up, and cultivation had extended up the hill slopes and down onto the scarplands of the Rift Valley. Today, with a population exceeding 10 million, the country is by any plausible criteria overpopulated. To say, as in the assessment, that more than half the cultivable land remains available is grossly in contradiction with the observable reality. Field observation confirms that spare land is virtually absent from Southern and Central Regions, and almost all recently-cleared land in Northern Region is on steep slopes (Young, in press). In Ethiopia, there is widespread cultivation of steep slopes with concomitant severe erosion; and in some regions, such as Wollo, famine recurs every year that the rainfall is substantially below average. These phenomena would not happen if a land balance of over 50% existed.

Field observation also conflicts with the very large land balances in the last group of Table II. The savannas of Tanzania, southern Sudan and Zambia certainly had spare land before the 1960s, although as shown in the classic description, *The African Husbandman* (Allan, 1965), much of this was needed as long fallows to recuperate fertility. There are still limited areas of available land, but estimates that only 10–20% of the cultivable areas have been taken up are far from credible. Madagascar is experiencing the greatest difficulty in preventing clearance of its protected areas. At the time of writing, southern Sudan is experiencing appalling famine, set off by civil conflict but indicative of a clear inability of the population to feed itself, a situation which would not have occurred if spare land had been available.

Readers are invited to compare their personal field knowledge with country estimates of land balance. If their experience differs from that described above, then the situation will need to be further clarified. A summary of any such observations will be made available on the World Wide Web site *www.land-resources.com* (Young, ongoing).

4. Reasons for the discrepancy

4.1. INTRODUCTION

Qualitative observation, based on personal experience, thus leads to the conclusion that estimates of the ‘land balance’, obtained by the approach of inventory and difference, grossly overestimate the amount of land which is truly available to be taken into cultivation. Reasons for this discrepancy must logically lie in one or all of the following:

– overestimation of cultivable land;
– underestimation of land already cultivated;
– insufficient attention to demands on land for purposes other than cultivation.

4.2. OVERESTIMATION OF CULTIVABLE LAND

Many types of terrain contain inclusions of uncultivable land amidst more fertile soils: hills, scarps, rock outcrops, minor water bodies and swamps. Soil surveyors are not very interested in these. Initially they draw lines around them on air photographs, and in detailed surveys (c. 1 : 20 000) these will be transferred to the map. But even in semi-detailed surveys (c. 1 : 50 000–1 : 100 000) the smaller inclusions would lead to an unacceptable complexity. Recourse is therefore made to soil associations, groups of two or three distinct soil types which for mapping purposes are combined as a single unit. It is not often that the percentage of these inclusions is specified, but 10–20% is common and 30% not unknown. Thus, even on the most detailed maps published, some of the uncultivable inclusions become ‘lost’.

This loss is greatly magnified when the maps are reduced to small scales. This happens first, in reduction to the level of national soil maps, and secondly, in generalization to the 1 : 5 000 000 scale of the *Soil Map of the World*. In some inventories there may have been a third stage of loss, where for simplification, only the dominant soil of a mapped association is taken into account. Stony soils are only mapped as dominant in extremely mountainous or arid zones.

Hence, at all stages of scale reduction, there is a systematic loss of the minor inclusions of non-cultivable land. An average area of 10–15% is suggested for this loss. Its magnitude could be tested by sample studies of detailed soil maps, direct observation of air photographs and satellite imagery, and the representation of corresponding areas on the *Soil map of the world*.

4.3. UNDERESTIMATION OF LAND ALREADY CULTIVATED

Statistics on current land use are derived from Table I of the *FAO Production Yearbook* (FAO, annual), or its equivalent in the statistical database FAOSTAT (FAO, ongoing). Since perennial crops are considered in the estimates as cultivated, the relevant figures are for ‘arable and permanent crops’, a summation of ‘arable land’ and ‘land under permanent crops’. The former is defined to include temporary fallows (up to 5 years) but not ‘abandoned land resulting from shifting cultivation’.

TABLE III. 'Adjustments' of the *AT 2010* study to the reported totals for cropland

	Cropland 1988/90, Mha		
	Original	Adjusted	Percentage adjustment
Sub-Saharan Africa	140	212	51
Latin America and the Caribbean	150	189	26

Data on land use are among the least reliable of international statistics. In developing countries they are generally derived from agricultural censuses, held about every 10 years, sometimes kept constant between census data, sometimes extrapolated on the basis of preceding change. Thus Kenya's arable land is currently given as 3.5 Mha from 1961–74, 3.8 Mha from 1975–84, and 4.0 Mha since 1985.[4] I have elsewhere drawn attention to the questionable nature of land use statistics (Young, 1998). The authoritative international compilation *World Resources* comments that 'FAO often adjusts the definitions of land use categories and sometimes substantially revised earlier data [consequently] apparent trends should be interpreted with caution' (World Resources Institute et al., 1996). One of the most revealing facts is that the *AT 2010* study, finding inconsistencies between the summation of harvested areas for individual crops and the reported totals for cropland, made 'adjustments' to the latter (Table III). A need for international data to be 'adjusted' by 25–50% speaks for itself.

I believe, although cannot prove, that national statistics substantially underestimate present cultivation. The explicit recognition that longer fallows, practised to maintain soil fertility, are excluded may contribute, but the main reason lies elsewhere. It is that governments do not recognize, or report, cultivation which is not supposed to exist: illegal incursion of forest reserves and other protected areas, and possibly also cultivation of steep slopes. An independent survey of forest clearance reached the same conclusion from the opposite direction: that the true area of forest cover was overestimated through failure to recognize illegal clearance for agriculture (Myers, 1980). It is hard to put an average figure on this overestimation, but it could be as high as 10–20%.

4.4. INSUFFICIENT ATTENTION TO DEMANDS ON LAND FOR PURPOSES OTHER THAN CULTIVATION

All the estimates recognize that land is needed for purposes other than cultivation, and that not all these other uses can be restricted to uncultivable areas. The estimates for developing countries are given in Table IV. There are three classes of non-agricultural use: protected areas, human settlements, and forest.

Protected areas are primarily those legally designated for biodiversity conservation purposes; they serve other uses such as water supply and protection against sedimentation. The assumption made in the estimates is that these will neither expand nor contract compared

TABLE IV. Estimates of land under non-agricultural uses, developing countries. The first two estimates exclude China.

		Land in non-agricultural uses, Mha		
		Settlement	Protected	Forest
LFP		180		—
AT 2010	Total	94	385	1690
	On land balance	51	201	>774
FAO/IIASA	Total	—	—	1612
	On land balance	63	201	1056

with their present extent. Some 200 Mha are believed to be found on cultivable land, or 12% of the land balance.

In all the estimates, data on land needed for human settlement purposes (including transport, recreation, etc.) is not available directly but calculated on a per capita basis, derived from a few sample studies. On this basis the area occupied is relatively small, some 3% of the land balance. It is regionally more significant in South–Central and East Asia, at 7.6%.

Forest presents more difficulties, since its degree of overlap with cultivable areas is unknown. By indirect reasoning, two studies estimate that 45% and 65% of the land balance is occupied, respectively, by forest, or by forest and wetlands.

Thanks to the efforts of conservation organizations, data on protected areas is far more reliable than on other kinds of land use. The principal source of error has been noted above, that substantial parts of legally-protected areas are in fact under cultivation.

It is surprising that the extent of human settlements, at least the larger urban agglomerations, is not reported. The reason given is that data are available for so few countries: 17 developed and no developing. The *AT 2010* estimate is introduced by the phrase, ‘As far as some speculative estimates could be made, perhaps some 94 Mha . . . are occupied by human settlements and infrastructures . . . these estimates are tentative and subject to large margins of error’ (Alexandratos, 1995). It employs a baseline figure of 33 ha per 1000 people. One clear fact is that urbanization is increasing, and will almost certainly continue to do so. It has been estimated that between 10 and 25 Mha are lost annually due to urbanization, some half of which is agricultural land (Döös, 1994). The lower extreme of this range extrapolates to a loss of 125 Mha of agricultural land over the next 25 years, a figure of the same order of magnitude as the probable loss to land degradation.

In the light of these reservations, it is not unreasonable to express the opinion that these are substantial underestimates. Land occupied by human settlements is very much more than that directly covered by housing, industry, mining, and transport infrastructure. It includes also areas for recreation (parks, sports fields), waste disposal and filtering, military purposes, the cultural heritage (monuments, historic sites), not to mention the areas of derelict land which are inseparable from urban development. In practice, most urban and other settlement-related development takes place on cultivable land. The gross differences in urban density make a subjective estimate difficult, but with further urbanization over coming years inevitable, possibly 50–65 ha per 1000 people will become a more realistic figure, not for housing alone but for all settlement-related uses of land. This would have the effect of increasing the above estimates of land requirements for settlement from 3% to 4.5–6% of cultivable land.

It would not be difficult to make sample studies, since settlement shows up so clearly on multispectral satellite imagery. Digital image processing would underestimate such cover, by exclusion of 'green' urban areas. 'Eyeballing', that is, drawing lines around urban areas, rural settlements, lines of transport, and other land which is clearly not available for agricultural purposes, would be preferable.

The situation with respect to forests presents difficulties. FAO studies explicitly assume that further clearance is undesirable. This would have the effect of reducing the 'available' part of the land balance by some 50–65%. Set against this view, which is supported by international opinion, is the fact that recent studies show few signs of any check in the rate of forest clearance, currently some 15 Mha, or 0.8% of the remaining forest area, per year. Efforts linked to the Tropical Forestry Action Plan have yet to have an observed effect, notwithstanding the perceived adverse environmental consequences of clearance. Unless and until there is a radical change, this is where a substantial part of added cultivable land in the near future is likely to come from.

5. A provisional adjustment and how it should be verified

5.1. A PROVISIONAL ADJUSTMENT

All of the above discussion is based on qualitative observations, and hence the magnitudes of the adjustments suggested are speculative. To combine highly uncertain data runs the risk of magnifying errors. Nevertheless, since the purpose of this article is to draw attention to the need for improved data, an attempt is made to do so. This is referred to as a provisional adjustment. It should be regarded as an hypothesis, to be compared with the former estimates, as a basis for verification.

Table V takes a representative country or region assessed, by the approach of inventory and difference, as having a cultivable area of 1000 ha, of which 500 ha are cultivated. The gross land balance is 500 ha or 50% of cultivable land. After allowing 12% of the latter for protected areas and 3% for human settlements, the net balance is 42% of cultivable land, from which must be subtracted whatever is considered should, or is likely to, remain under forest. Loss of land by degradation is not included in the table as it is so variable in its spatial distribution; for countries where it is relatively severe, this could further reduce the land balance by an amount of the order of 1–2%.

The adjustment is based on the orders of magnitude suggested above: a reduction of cultivable land by 10–15%, and increase of existing cultivation by 10–20%, with protected land remaining at 12% and settlement occupying 4.5–6.0% of the revised estimate of cultivable land. The effect is to reduce the gross balance from 50% to 28–41% of cultivable land, and the net balance to 23–35%; a figure for desired or expected forest should be further subtracted from this.

TABLE V. A provisional adjustment to an estimated land balance of 50%. For explanation see text.

	Million hectares						Percent of cultivable	
	Cultivable	Cultivated	Gross balance	Protected	Settlement	Net balance	Gross balance	Net balance
Original estimate	1000	500	500	60	15	425	50	42
Speculative adjustment	850–900	550–600	250–350	30–42	11–21	210–294	28–41	23–35

If the figure for forest on cultivable land is taken to be 10–20%, then *an original gross land balance of 50% is reduced to a realistic area of between 3% and 25% of the cultivable land.* Applying an adjustment of this order of magnitude to the country land balances in Table II, the effects are far more in accord with the observed situation in these countries. This conclusion is not intended as a criticism of the assessments, nor how they were conducted. It was right that an attempt to assess the remaining cultivable land should have been made, and it was conducted with much effort and scientific thoroughness. What emerges, on comparing the results with field observation, is that satisfactory data for making such assessments at the national and world level do not exist. Small-scale soil maps systematically misrepresent the cultivable area, national land use statistics are unreliable, and few data exist for land under settlement. For sample areas, it would be possible to follow the same procedures at a detailed scale, 1 : 50 000 or larger, using air photographs, satellite imagery and field observation, and achieve reliable results. It is not realistic to do this at national level.

5.2. VERIFICATION BY DIRECT ASSESSMENT OF THE REMAINING CULTIVABLE LAND

For purposes of national and international policy, it is highly important to assess the amount of land that remains available for cultivation. Reliable assessments of this are an essential basis to national land use planning, research policy, and also in the wider context of the relations with population policy (Young, 1998). A recent review of the world's food-production capacity reaches the conclusion that 'If all resources are harnessed, and adequate measures taken to minimize soil degradation, sufficient food to feed the population in 2020 can be produced, *and probably sufficient for a few billion more*' (Greenland et al., 1998a). The inadequacy of current knowledge on land resources could not be better illustrated by the fact that undernutrition and recurrent famines for many millions of the world's poor rests on estimates as precise as the phrase here italicized.

However, there is a better way to make such assessments than by repeating the approach of inventory and difference. This is directly to observe, and if possible map, where such land is to be found.

The procedure in outline would be as follows. At the first stage, taking the national assessment which suggests that spare cultivable land exists, the executive team ascertains, from local knowledge, in which regions of the country this might be found. It will widely be known that some parts are fully settled, with virtually no spare land.

The second stage is to visit the regions the less fully occupied land. The team either asks to be shown exactly where such spare land is to be found, or provisionally identifies it on air photographs and visits these areas in the field. Either the mapping of sample areas or a method of transects could be employed. For all such areas, three observations must then be made:

1. Is the land in fact cultivable?
2. Is it in reality not yet cultivated, nor under fallow needed to maintain fertility?
3. Is it already in use for necessary purposes?

The third question would cover the full spectrum of uses, for example, land required to maintain the livelihood of migratory pastoralists, production forestry (needed for timber and fuelwood requirements), water catchment areas, nature conservation, areas set aside for indigenous peoples, or land employed for military training. Diplomacy would be required where the last-named use was identified, or on finding areas held empty by influential land speculators. By such direct observation, a much more reliable estimate could be made of order of magnitude of land which is cultivable, not presently cultivated, and not required for other necessary purposes. The approximate estimates could be followed up by precise surveys of areas identified for expansion of cultivation (as was commonly done in the era of land settlement schemes, c. 1950–70).

An added advantage of direct observation would be to record whether the land found available for future use lies near the limits of cultivability. Almost all land of high production capacity has long since been taken up, and current expansion of settlement is nearly always found in marginal areas. It is here suggested that a very high proportion of genuinely available land would be found to have severe limitations of climate, slope, or soil fertility.

Three types of observer, or observation team, could conduct such observations. They could be done on a sample basis by university research scientists, seeking to confirm the hypothesis put forward here. At national level, they could be undertaken by consultants to international organizations. The responsibility for activities related to stewardship of land resources, coupled with advice to international organizations, lies primarily with FAO.

It would be most satisfactory, however, if such work was carried out by national soil surveys or land use planning organizations, acting on the instructions of their own governments. The same is true for observations of land degradation and soil monitoring (Young, 1991). For this to happen would require a radical change in the attitudes of governments of developing countries towards their national heritage of land resources (Young, 1998). Such a change is hard to bring about, but in the present era of decreased funding to international organizations, lasting solutions to problems of population, land, food and development can only come from the governments of developing countries themselves.

6. Conclusions and policy implications

It should again be made clear that the conclusions on which this paper are based rest on personal observations in some 30 developing countries. Where I have conducted soil surveys or land evaluation studies there has been a quantitative basis to the observations, but elsewhere they have been qualitative. Hence, the arguments advanced should be regarded as hypotheses, which should be tested by direct, quantitative, observation.

It is concluded that the major assessments by international bodies and research organizations, although conducted with integrity, without presuppositions, and with the greatest thoroughness, greatly over-estimate the extent of spare land: that is, land available for cultivation but presently uncultivated. Reasons are:

– an over-estimation of the extent of cultivable land, through ‘loss’ of hills and other uncultivable areas, individually small but of substantial total extent, when detailed surveys are reduced to small scales;
– an under-estimation of land already cultivated, statistics for which are demonstrably of great unreliability;
– failure to take sufficient notice of the considerable, and necessary, requirements of other land uses, notably water supply, nature conservation, human settlements, and forest.

Making speculative adjustments to allow for each of these causes, a supposed land balance of 50% is reduced to one of between 3% and 25% of the present cultivable land. If this is correct, as an order of magnitude, then estimates of the total spare land in the developing world, and those for individual countries, should be reduced to *half or less* the values given by current estimates.

Each of the contributory factors to this discrepancy, as well as its total magnitude, can and should be tested. The best way to do this is not by further studies based on the approach of inventory and difference, but by attempts directly to identify, locate and map such land. Particular attention should be given to land requirements of non-agricultural purposes, and their importance to local populations.

Continued reliance on the standard estimates misleads world leaders and policy-makers. By giving the impression of a ‘reserve of spare land’, it reduces the urgency of efforts to reduce present food insecurity and to meet the needs of future populations. The consensus of current opinion is that hunger during the first half of the 21st century can be reduced, or at least held to its present level, but only by greatly increased agricultural research, investment in the rural sector, and efforts to reduce population growth. Hunger can no longer be appreciably reduced by relying on the existence of spare land.

Notes

[1] These values are for the medium variant projection, which in the past has proved fairly accurate. The high and low variants add or subtract, respectively, between 0.5 and 1.5 billion people. The most recent revised projections show a small reductions in the rate of increase.

[2] The relation between these values has remained constant over time, cereal harvested area forming 60% of arable land; the former statistic is probably somewhat less unreliable than the latter.

[3] The exception is Bangladesh, for which I rely on published accounts.

[4] The phrase ‘is currently given’ is necessary, since adjustments to data for earlier years are often made retrospectively.

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