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Sustainable agriculture and rural development

Report of the Secretary-General

Addendum

Linkages between agriculture, land and water*

Contents

		Paragraphs	Page
I.	Introduction	1–4	2
II.	Socio-economic dimensions of agriculture, land and water	5–12	2
III.	Water scarcity and sustainable agricultural development	13–24	3
IV.	Prospects for rain-fed and irrigated agriculture	25–49	5
	A. Rain-fed agriculture	28–41	6
	B. Irrigated agriculture	42–49	8
V.	Priorities for further action	50–54	9

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I. Introduction

1. The relationships among agriculture, land and water are rapidly changing. The more important causes for change include rapid urbanization in developing countries, competition for water among different uses, environmental concerns, degradation of soil and water resources, population pressures, high levels of malnutrition and world market prices of cereals at levels below their long-term trends.

2. Stress on water resources can occur when the current and foreseen demand exceeds the amount of economically exploitable water available from all water sources. The present report highlights the relationship between the limitations of natural water systems and the deficiencies in the whole range of water management policies and services that determine the use and disposal of water.

3. Both rain-fed and irrigated agriculture have the potential to produce more food per unit of land and per unit of water. Future food security must come from increased yields in both types of agriculture. Irrigated agriculture as practised, for example, by large numbers of poor farmers in South Asia suffers, among other things, from poor maintenance of irrigation structures, inadequate drainage, unreliability of irrigation supplies, salinization of the land, outdated institutional arrangements and insufficient investments in other production inputs, such as fertilizers, pest control and good quality seed. Production in rain-fed agriculture as practised by large numbers of resource-poor farmers in Africa is impeded by erratic rainfall, inherently low levels of soil fertility, inadequate in-field soil and water management, and by low investments in other production inputs.

4. Signs of change include far-ranging modifications in public irrigation institutions that are currently being introduced in a large number of countries, and that involve greater representation of water users in the management and maintenance of the systems. Other positive signs include the fairly wide acceptance of improved in-field soil and water management and the introduction of supplementary irrigation by simple systems by small farmers in the rain-fed agriculture of sub-Saharan Africa.

II. Socio-economic dimensions of agriculture, land and water

5. The future will bring opportunities as well as serious challenges. By 2025, approximately 60 per cent of the world's population will live in urban areas (see E/CN.17/2000/7/Add.1). A major concern is to have access to food that is cheap, particularly for urban consumers. In addition, it should be palatable and, preferably, free from health and environmental hazards.

6. In an urbanizing world, the very basis of human livelihood and well-being inevitably continues to depend on how men and women manage their land and water resources. The challenge to feed a rapidly growing world population is not only a matter of producing enough food and other biomass (feed and fibre) but also to make the required food items accessible to all people at all times, that is, to achieve food security. That objective has to be achieved in an increasingly competitive and resource-scarce context. Adequate and timely amounts of water, in particular, but also other essential resources, such as agricultural credit, are often difficult to mobilize. The structural transformation of the agricultural sector will raise questions about the viability of various types of agriculture in different environments. In this regard, it is relevant to consider that agriculture serves not only food production but also environmental sustainability, and has a role in supporting a viable social structure in rural areas.

7. Farming is first and foremost associated with soil and water management for the production of food and other biomass. It is important to assess the situation of farmers and their aspirations. Equally important is to consider the conditions under which farmers' sons and daughters will be living and what kind of livelihood they are seeking for themselves. In all countries, ongoing societal change is affecting people in rural as well as in urban areas.

8. The future is unknown, but the desired future looks different from what characterizes large parts of the world today. Today almost 1,000 million people live in absolute poverty, 70 per cent of whom are rural people, and for many chronic hunger is a reality. Food insecurity is a striking feature also among those who are farmers. Current Food and Agriculture Organization of the United Nations (FAO) data[1] show that the number of undernourished people has declined

by about 5 per cent since 1990/92, but that almost 800 million still go hungry in the developing countries and some 30 million in other countries. Being well nourished is not only a matter of calories but also of eating the right combination of nutrients.

9. It has been estimated by FAO that 44 per cent of the land surface in sub-Saharan Africa is subject to high risk of meteorological droughts. Some 55 per cent of all the world's semi-arid lands with rain-fed farming potential are located in sub-Saharan Africa. The lowest per capita nutrition levels and the highest population growth often go together. The worst affected regions in South Asia and sub-Saharan Africa together will be the home of an additional 400 million people by 2025.

10. The implication of these figures is that an increasing part of food production must take place somewhere else than where it is needed and consumed. A combination of low purchasing power among a large proportion of the world community and lack of opportunities to produce food for one's own consumption makes food security a most difficult task. Apart from the challenges related to poverty, undernutrition and rapid population growth, food production must increasingly be seen in the context of consumer preferences. The fact that certain food items can be produced is no guarantee that they will be demanded or that people can afford to purchase them. Food security is the outcome of a complex set of factors, of which land and water, while crucial, are only two.

11. In addition, a cornerstone in the new approach to rural development that has evolved during the last two decades is the recognition that indigenous knowledge among farmers has intrinsic merits and holds development potential. To build on indigenous knowledge is in sharp contrast to conventional approaches in development and extension that relied on transfer of — often inappropriate — technologies from other hydro-climatic zones and socio-economic cultures. Researchers, advisers, farmers and policy makers need to work together to make available knowledge about promising technologies and farmers' practices to those who would benefit from their adoption. Furthermore, the focus in rural development has generally shifted towards human resource development, farmer participation, farmer management, farmer experimentation, adaptation and dissemination. Assuring real research-extension-farmer linkages is a major concern in current development efforts, especially in efforts to introduce innovative technologies.

12. It is thus increasingly recognized that the focus should be on the management of land and water resources, with due consideration for the context in which farming takes place. Figures on the overall availability or scarcity of natural resources are often quite crude, although necessary as a basis for the analysis. Two strategic questions arise. What can be done to deal with increasing scarcity and threatening resource degradation?[2] And what role do various technologies, extension, credit, market, institutions have in efforts to achieve food security? Management options for improved food security that can be realistically exploited should be identified, including what kinds of agriculture are viable — socially, economically and environmentally.[3]

III. Water scarcity and sustainable agricultural development

13. To arrive at a realistic estimate of the total amount of water that is actually utilized for food production, industry and households, it is necessary to consider the reliance on rainwater. There is a tendency to overlook the fact that the largest share of global food self-sufficiency and security relies on rainwater and not on irrigation supplies. Even irrigated agriculture relies in part on rainwater.

14. The problem is that many countries are approaching water scarcity conditions and few currently have the means to manage the demand for food effectively or import all their food requirements. According to the comprehensive assessment of the freshwater resources of the world (E/CN.17/1997/9), submitted to the Commission on Sustainable Development at its fifth session, in 1997, about one third of the world's population live in countries that are experiencing moderate to high water stress partly resulting from increasing demands from a growing population and human activities. By 2025, it is estimated that as much as two thirds of the world's population (over 5 billion people) could be living in countries under water stress conditions. Given that the number of food deficit countries is also increasing, this raises the questions of where the food (and the water needed to grow it) is to come from and how the transfer

from food surplus to food deficit areas is going to be organized and guaranteed.

15. Irrigated agriculture accounts for the largest part of the water withdrawal, globally about 70 per cent. Only a part of this water is consumed, when it returns to the atmosphere as evaporation from reservoirs and evapotranspiration from the "open landscape" or is incorporated in the crop. In water-scarce tropical countries, the share of withdrawals from run-off flows for irrigation can be as high as 80 to 90 per cent, or even higher in special cases. By contrast, the withdrawals for industry and households are on the order of 20 and 10 per cent, respectively, and the water largely circulates in closed systems where consumptive use is limited but the impact on its quality may be significant.

16. To understand the dimensions of the problem, it is thus crucial to make a clear distinction between two kinds of water scarcity — where agriculture is an important sector of the economy and where it is not. Food self-sufficiency, that is, a sufficient production of food within the national boundaries to meet the food requirements of the population, cannot be realistically achieved in situations where the average water availability is at the benchmark level or below. The situation is quite different if the country can embark on a food security policy, that is, where they have the capacity to import adequate amounts of food for their population.

17. The discussion on water scarcity has substantially broadened during recent years. Although the notions of water stress and scarcity are widely accepted as standard indicators of a growing water challenge, it is also obvious that data on per capita availability does not stipulate the options which society, or the individual water user, may develop and adopt to cope with the changing situation.

18. Generally, water scarcity may be seen as a problem of getting adequate amounts of water of appropriate quality to the right activities and functions at the right place and at the right time at acceptable and affordable cost. Amounts of water which are reaching the crop, but not during critical stages of plant growth, are of no avail. Similarly, if the limited amounts of water available for distribution are allocated to activities which are not in line with socio-economic and environmental objectives of a country or region, it implies inefficient water-resource utilization. This is a reasonable assertion, particularly if other activities that would better serve development objectives are deprived of water. With reference to past indiscriminate water supply policies, a state of relative water scarcity may thus be associated with a process where too much water has been allocated to too few activities with too high a subsidy.

19. With respect to water scarcity, it has been argued that it is not water that is becoming scarce but that the number of people and their wants are becoming too many. Added to this is the fact that human-induced water quality deterioration is further diminishing the quantity of freshwater, that is, the amount of water that can be safely used for various purposes.

20. The most significant question is not whether scarcity exists or not, but what kind of adaptation strategy is feasible when the ratio between people and water increases and how that strategy can be implemented. The kind of adaptation referred to in this context currently differs significantly from the one in the past when technical solutions on the supply side could be applied to address the water shortages. When shortages may no longer be managed through technical fixes alone, the problem needs to be addressed through adaptation in terms of social and institutional adjustments.

21. Social adaptation entails at least two main issues. One concerns the need to gradually produce more output and/or value per unit of water. In many cases, this implies new technologies or better use of existing technologies — not to abstract more water but to make better use of the available water and other scarce resources. Introduction of new technologies and resource management practices often need to be promoted through a combination of incentives and sanctions. Moreover, an adaptation often entails a choice of what kind of products and services should be promoted and what kind of products should not be encouraged. Another major issue in connection with social adaptation refers to mitigation and resolution of conflicts that are likely to evolve as a result of scarcity of the natural resource, particularly of the set of potential adaptive behaviours and institutional reforms for addressing the natural resource scarcity and access to services.

22. An often-debated proposition is that a growing demand for a limited amount of water from various sectors of a society should lead to reallocation of water

from the agricultural sector to urban-industrial sectors. A main argument is that the return in terms of socio-economic benefits per unit of water is relatively lower in agriculture than can be generated in urban-industrial sectors. It is also perceived that the financial expenditure for irrigated agriculture is quite high, while it takes a long time for financial returns to materialize. This argument is often presented in the absence of an assessment of the cost involved in the production of the same amount of food and fodder in rain-fed agriculture, or even without questioning whether the latter is feasible. Urban and industrial programmes may then appear less attractive.

23. For water-short countries, it may be more economically viable to import food products, which are water intensive, from water surplus areas rather than to import large volumes of water that would be required to assure self-sufficiency. Imports of food presume that there is a surplus in other parts of the world and that the importing country has the means and the position required for imports. Today, obviously enough food is being produced in the world to cover the total food requirements, but the purchasing power is weak in many of the food-deficit countries simply because their economies are poorly developed. Moreover, international trade or food relief programmes are hampered by logistical problems, trade barriers and political and social instabilities. Nevertheless, food security can probably not be achieved if trade in food items is not going to be expanded and facilitated. A careful look at "virtual water" strategies[4] is therefore warranted. In view of the rapid rate at which countries are approaching water scarcity conditions, the time a country has for embarking on a policy of food imports as part of the national development policy should be considered.

24. Although a vision for long-term change is useful, development plans and projects must have a much shorter time-frame. With increasing water shortage and/or with increasing demand for water from other sectors, it becomes of prime interest to consider three interrelated questions concerning the state of the agricultural sector, currently and in the future:

(a) What is the possibility of increasing the efficiency of water use in rain-fed and irrigated agriculture? Increasing efficiency presumes a reduction in the volume of water that is utilized to grow a particular crop, and/or that "more crop is produced per drop", that is, an increase in yield per unit water, probably involving intrasectoral reallocation;

(b) How to produce more value per unit of water? This can be achieved either by increased efficiency or by switching to other crops or products which fetch a higher price on the market;

(c) What are the prospects of reducing the amount of water that used to be allocated to the agricultural sector (intersectoral reallocation)?

IV. Prospects for rain-fed and irrigated agriculture

25. On a global scale, great progress has been made over recent decades to make food production keep pace with population growth, assisted by the green revolution and the associated increase in irrigation. The rate of increase of water withdrawals during the twentieth century has at least doubled the rate of population increase. Most of the water withdrawn from streams, lakes and groundwater aquifers is supplied to irrigated agriculture. However, global figures have only limited significance since they disregard differences between countries that have already reached the limits of their available freshwater flows and those that will never do so.

26. Despite the increasing difficulties and cost of mobilizing additional water for irrigation purposes, it is essential both to expand irrigation schemes and to increase productivity from existing irrigated agriculture, especially in developing countries, where irrigated yields are often way below their potential level. In future, both rain-fed and irrigated agriculture have to be utilized to the full to meet the food demands of the world's population. FAO has estimated that two thirds of the additional food supplies will need to come from irrigated agriculture and one third from rain-fed agriculture. Both efforts present major challenges. Timely replacement of reservoirs used as a source for irrigation water that are now slowly silting up may be controversial.

27. In some areas, current low yields result from poor drainage and hence waterlogged conditions of the agricultural land. Drainage improvement measures and land recovery take a long time to implement. Improved management arrangements, for which users' participation is an essential element, cannot be

implemented overnight either. The development of effective legislation for the controlled management of overexploited aquifers, the introduction and acceptance of such laws by water users and the monitoring and enforcement of laws and regulations by effective institutions may also take many years. All of which suggests a need for urgent measures, including research and policy support for institutional development and cost recovery issues. Institutional as well as technical changes are required.

A. Rain-fed agriculture

28. Rain-fed agriculture is currently practised on over 80 per cent of the cultivated land. Obviously, this will continue to be the case in highly productive temperate zones where rain-fed yields of cereals are high and often considerably higher than yields obtained by irrigated agriculture in semi-arid developing countries. In water-scarce tropical regions, rain-fed agriculture also covers more than 95 per cent of the croplands, and will probably remain the predominant source of food. In those countries, productivity increases may be achieved through more widespread use of known soil and water conservation techniques, aided by supplementary irrigation.

29. Most potential cropland is already under cultivation. Possibilities for increasing food production through an expansion of agricultural lands into previously non-cultivated lands are small. Increases in food production will have to come from increased yields, which is a sizeable task in rain-fed agriculture since there are severe problems associated with yield increases.

30. To enhance performance of rain-fed agriculture, it will be necessary to overcome two interrelated deficiencies. A significant proportion of current farmland is losing productivity due to soil degradation and soil fertility depletion, which often limits crop growth more than water scarcity even in drought-prone areas. Studies from Kenya and Ethiopia show that annual soil nutrient losses in 1983 exceeded 80 kilograms (kg) of nitrogen, phosphorus and potassium per cultivated hectare.[5] The average fertilizer use in sub-Saharan Africa is below 10 kg per cultivated hectare. Organic fertilizers produced through animals, composting, mulching and green manuring tend to be insufficient to compensate for the large negative soil nutrient balances now often found.

31. As a result of persistent land degradation in many areas, caused primarily by growing demographic pressure, farmers now experience agricultural drought when there is no meteorological drought; that is, the crops suffer from a scarcity of plant-available soil moisture even when there is abundant rainfall. Rain-fed agriculture will continue to change the hydrological cycle in crop fields and also on a watershed scale since a larger proportion of rainfall will be returned to the atmosphere as transpiration. This requires a combination of proper land and water conservation and utilization.

32. The large proportion of non-productive water flow in the rain-fed crop water balance is an indicator of several problems, related to depletion of soil fertility; physical soil deterioration, especially reduced infiltrability and water-holding capacity as a result of the oxidation of organic matter; and the temporal variability of rainfall distribution. The large proportion of rainfall not used directly for production in upstream rain-fed farming systems — 70 to 95 per cent of rainfall — points to an opportunity to improve and stabilize crop yields.

Promising technologies

Conservation tillage

33. The effects of land mismanagement on crop growth are severe in semi-arid and dry sub-humid tropical landscapes. The resulting low yield levels are due in part to land degradation-induced low infiltration rates of surface soils. In combination with erratic, high-intensity rainfall events, this leads to excessive surface run-off, soil erosion and deficient water for crop growth.

34. A major cause of excessive land degradation in hot tropical regions with high intensity rainfall events is conventional soil preparation by hoe or plough, which together with the removal or burning of crop residues leaves the soil exposed to rain, wind and sun. Conventional tillage, using ox- or tractor-drawn ploughs, which is common in developing countries in the tropics, has in the past been considered an indicator of farm systems modernization. However, it is becoming more and more apparent that the type of ploughing developed in temperate regions with gentle rains and low wind and water erosion can have serious adverse effects on the long-term productivity of easily erodible tropical soils. Major long-term negative side-

effects of conventional ploughing on soil productivity include (a) compaction resulting in impermeable hard-pans; (b) increased oxidation of organic matter due to increased aeration and prolonged exposure of bare soil to solar radiation; (c) increased water and wind erosion; and (d) loss of soil water due to increase of evaporative surfaces.

35. Added to the physical factors directly affecting soil productivity are the high labour and energy requirements of conventional tillage and the difficulty of ensuring correct timing of farming operations. The latter two factors strongly affect poor small-scale farmers, who generally depend on ox-traction for ploughing operations.

36. Research from several countries shows significant improvements in crop yields, reduced soil erosion and reduced labour requirements after the introduction of alternative tillage practices, such as ripping, sub-soiling, tied-ridging, pitting and zero-tillage systems.[6] The key to successful conservation tillage is its integration within the total production system. It is probable (but not proven) that conservation tillage has the largest potential of success on structurally conserved land. The change from inverting the soil with a plough to ripping up planting lines only necessitates changes in most farm operations, such as weeding, fertilization, timing of planting and pest management.

Rainwater harvesting

37. Nonetheless, improved tillage practices are of little or no help to the farmer during dry spells and droughts. The challenge lies in the dry spells, when crops suffer from short periods of water stress (often less than three weeks long). Ongoing research indicates that dry spells in semi-arid savanna regions of Kenya, Burkina Faso and Zimbabwe occur more or less every year. When such dry spells occur during sensitive growth stages, such as flowering or grain filling, yields are likely to be much reduced.

38. An interesting option for such dry spells lies in the combination of soil and water conservation structures (see below), conservation tillage (as mentioned above) and optimal soil fertility management. With appropriate water-harvesting structures and supplementary irrigation, the crop can then survive on available water in the soil provided that soil fertility levels are adequate.

39. Supplementary irrigation is defined as the application of a limited amount of water to a crop when rainfall fails to provide sufficient water for plant growth in order to increase and stabilize yields. The additional amount of water is by itself inadequate for crop production. Hence, the essential characteristic of supplementary irrigation is the supplementary nature of rainfall and irrigation. Marginal lands with annual rainfall of less than 300 millimetres can be cultivated if controlled quantities of additional water are made available. However, past experience with the introduction of supplementary irrigation based on water-harvesting techniques into semi-arid and arid countries has often been disappointing. In many reported cases, the emphasis has been on technical aspects, to the neglect of the socio-economic conditions of the people for whom the water-harvesting and supplementary irrigation were intended. Acceptance of new technologies by water users is believed to depend largely on their early and sustained involvement in the development and implementation of the techniques. The farmers' notions of risk and profitability of water-harvesting and supplementary irrigation are particularly important for acceptance or rejection of the new technologies. A convincing cost-benefit analysis is therefore an essential part of the introduction of these techniques.

Integrated soil and water conservation

40. Sustainable land management is a key to the sustainable management and conservation of water resources. Soil conservation has a fairly long tradition but has often been biased towards physical structures, such as bunds and terraces, with the prime aim of stopping further soil erosion. Currently, it is widely held that conservation must include both soil and water resources, that is, integrated soil and water conservation. A critical component of such conservation is the need to link soil and water conservation technologies with the actual hydro-climatic deficiencies present in a given location.

41. Risk management is crucial in rain-fed agriculture. The higher the risk for crop failure due to droughts and dry spells, the lower the likelihood that farmers will invest in other inputs, such as fertilizers, improved varieties and pest management. In-field soil and water conservation contributes relatively little to reducing risks in rain-fed agriculture. In order to substantially reduce risk of crop failure, supplementary

irrigation needs to be combined with water-harvesting. Technologies that reduce risk generally cost more and are more difficult to construct and manage. In general, adoption among smallholder farmers in, for example, East and Southern Africa, is high for in-field soil and water conservation technologies and low for water-harvesting systems.

B. Irrigated agriculture

42. It has been widely noted that a large part of the required increases in food production for the future world population will come from irrigated agriculture.[7] Resources earmarked for improving agricultural performance tend to be directed to favourable areas rather than to marginal areas. A common argument is that a higher output is anticipated from favourable areas, which include irrigated agriculture, and that this output can be achieved at comparatively lower food prices, which are of course are in the interests of both urban and rural consumers.

43. Irrigation projects are often highly subsidized and environmental costs associated with irrigation schemes are usually not reflected in food prices. If the opportunity cost of irrigation water is taken into account, it is not surprising that the privileged status that irrigated agriculture enjoyed for a long time and still enjoys is now being challenged. However, casual dismissal of the importance of irrigation in future food production would be wrong. For one thing, irrigated agriculture is highly productive in many developed and developing countries.

44. In South Asia, irrigated agriculture provides employment to millions of poor farmers where other opportunities for work are lacking. Nonetheless, yields are often below expectations. The reasons for these low yields are many, including unreliability of water supplies, which keeps farmers from making adequate investments in other production factors, such as fertilizers, pest control and good seed. Poor maintenance of the irrigation structures, the absence of drainage and inadequate institutional arrangements have compounded the problem. Concerted efforts should therefore be made to raise yields to levels closer to those which are currently attained under controlled conditions of experimental fields. Information on how this can be achieved is generally available; the synthesized knowledge, unfortunately, is only too slowly applied. Policy support for institutional development, including for more appropriate cost-recovery mechanisms in irrigated agriculture, should be supplied to support all efforts to raise yield levels.

45. In sub-Saharan Africa, most of the poor farmers, even in the semi-arid regions, are dependent for their agriculture on often erratic rainfall. Performance of irrigated agriculture in sub-Saharan Africa has been disappointing,[8] but there are hopeful signs in the introduction of supplementary irrigation by means of simple low-cost drip irrigation systems supplied with water from small streams and also from water-harvesting systems. Again, much support should be given to all these efforts (including the soil and water conservation measures mentioned earlier) to increase yields and sustain gainful employment in rural areas.

46. Many of the problems in today's irrigated agriculture are the legacy of agricultural policies that evolved in connection with the green revolution of the 1960s and during an era when water resources could still be developed for agricultural use. Structural adjustment programmes carried out over the last decade or so have radically changed many national agricultural development policies. Subsidies on agro-chemicals, fuel, tractors etc. have been withdrawn, sometimes with unforeseen consequences which necessitated reintroduction of the subsidies to ensure that the farmers continued to grow sufficient quantities of some crops. Because of the high cost of construction of irrigation and drainage infrastructure, the rate of increase of irrigation development has slowed down in many countries. As the demand for water from urban and industrial users has increased, integrated water resource management is a necessity to ensure that the water is used in the best possible way.

47. Desalination of seawater to augment water supplies for agriculture is not a viable option in the foreseeable future since although the cost of desalination has gradually come down, it is still too high.

48. Poor people often spend more than half of their income on food, and many are still unable to meet their nutritional demands. For the majority of the population in many developing countries, improvement in living conditions depends on productivity increases in agriculture. Crop varieties that can increase productivity under adverse conditions of drought or salinity, lower risks of crop failure, reduce unit production costs and thus lead to lower food prices,

improve the nutrient content of food and convert nitrogen in the air to plant nutrients are all illustrations of the potential benefits that modern biotechnology could offer to low-income people in developing countries (see E/CN.17/2000/7/Add.2). Biotechnology is considered to have great potential for the development of drought- or salt-tolerant crops.

49. It can thus be concluded that efficiency of water use in rain-fed and irrigated agriculture must be increased to produce more per unit of land and per unit of water. Whether water can be transferred from agriculture to other uses is a complex question, the answer to which depends on socio-economic and political considerations. However, it is likely that such transfers will be necessary to increase overall economic benefits, employment and income and thus meet the continuing challenge of providing sufficient food at an affordable price to a growing world population.

V. Priorities for further action

50. All three subjects covered in the present report — agriculture, land and water — are currently undergoing rapid changes. The challenge for the future is to raise yield levels for food crops, produced under both rain-fed and irrigated conditions, to levels much closer to those attained as best practices in agriculturally developed countries. More widespread use of existing technologies for in-field soil and water management can make substantial differences in yield levels, provided that they are combined with conservation tillage and appropriate levels of all other inputs, such as fertilizers, pest control measures and good quality seed.

51. Food production has been increasing much faster in the developing world than in the developed world. It is expected that by 2020, the developing world will be producing 59 per cent of the world's cereals and 61 per cent of the world's meat.[9] Nevertheless, cereal production in the developing world is unlikely to keep pace with demand, and net cereal imports by developing countries are likely to increase significantly between 1995 and 2020 to fill the gap between production and demand. Hence, many developing countries will no longer be self-sufficient in grain production. World markets respond to demand and not to need, and malnutrition will continue in spite of the fact that enough food can be produced for the growing world population. It has been calculated that in the 1980s, 10 per cent more yield gave rise to 4 per cent more jobs in agriculture; currently, 10 per cent more yield results only in something like 1 per cent more jobs in agriculture.[10] Hence, yields have to grow much faster for employment opportunities to increase in the rural areas of developing countries and for people to be able to purchase their basic food, highlighting the importance of economic growth that results in more jobs in urban and rural areas alike. Support can be given to Governments in prioritizing investment options which are most likely to contribute most to economic growth.

52. The total amount of water on earth remains the same, but people have become far more aware that water is a scarce resource. That awareness is not limited to arid and semi-arid countries but occurs also in the temperate zone. It forces policy makers and informed laypeople to think about the allocation of water to various uses. That agriculture takes the largest share of resources and that much freshwater is flushed through toilets is no longer taken for granted. Rivers cross national boundaries and much more attention is being given to transboundary issues in water allocation. Likewise, concerns are expressed about the quality of waste water as it flows back into a country's rivers, lakes and groundwater after it has served its purpose for industrial, agricultural or domestic users. In some countries, restrictions are imposed on permitted contamination with salt and residues of agrochemicals in drainage water and water percolating to the groundwater from agricultural fields. Such restrictions affect the choice of crops a farmer can grow and also have an effect on farming practices.

53. Food production needs to be increased substantially in both irrigated and rain-fed agriculture, and the basic information to make it possible is available. What is needed is to apply information about best practices as part of an integrated water resource management approach, which considers all uses of water and makes that information available to all stakeholders.

54. Four areas can be identified in which the United Nations system, particularly through FAO, is in a good position to take a leading role:

(a) Provide policy support for Governments in the priority setting of investments in agriculture, such that initiatives likely to lead to higher yields per unit of water or unit of land are being funded;

(b) Collect data and information on best practices in water harvesting, supplementary irrigation, simple and cheap drip irrigation systems, in-field soil and water conservation, and institutional arrangements for privatized irrigation systems, and disseminate that information as synthesized knowledge to water users;

(c) Assess the performance, including cost-benefit analyses, of all measures that are likely to raise yields in farmers' fields. This should be done worldwide according to a common format to facilitate comparison among various measures and locations in order to identify the necessary conditions for successful introduction of the different measures;

(d) Stimulate research in:

(i) Integrated water resource management, with special attention to the management of groundwater and the effect on downstream water users of hydrological changes introduced elsewhere in the watershed;

(ii) The development of crops and crop species that grow well under conditions of limited water supply or saline conditions, by conventional plant breeding methods and through modern biotechnology.

Notes

[1] See J. Lundqvist, "Avert looming hydrocide", *Ambio*, vol. 27, No. 6.

[2] See FAO, *The State of Food Insecurity in the World* (Rome, 1999).

[3] A background document entitled "New dimensions in water security" is expected to be submitted by FAO to the Commission at its eighth session.

[4] See J. A. Allan, *"Virtual Water": A Long-Term Solution for Water-Short Middle Eastern Economies?* (London, 1997).

[5] See J. J. Stoorvogel and E. M. A. Smaling, *Assessment of Soil Nutrient Depletion in sub-Saharan Africa: 1983-2000*, Report No. 28, vol. 1 (Wageningen, the Netherlands, 1990).

[6] See P. G. Kaumbutho and T. E. Simalenga, eds., *Conservation Tillage with Animal Traction: A Resource Book of the Animal Traction Network for Eastern and Southern Africa* (Harare, 1999).

[7] See FAO, "Food production: the critical role of water", technical background document, No. 7, World Food Summit, 13-17 November 1996.

[8] See, for example, J. Kijne, "Water for food for sub-Saharan Africa", paper prepared for an FAO e-mail conference on the theme "Water for food in sub-Saharan Africa", 1999.

[9] See P. Pinstrup-Andersen, R. Pandya-Lorch and M. W. Rosegrant, *World Food Prospects: Critical Issues for the Early Twenty-first Century*, 2020 Food Policy Report (Washington, D.C., International Food Policy Research Institute, 1999).

[10] See Michael Lipton, Crawford Lecture, 28 October 1999 (Washington, D.C., Consultative Group on International Agricultural Research).