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Chapter 1 - Introduction

One of the primary objectives of agriculture is to provide the food and fibre needs of human beings. These needs increase as the population increases. The world population was 2.5 thousand million in 1950; 4.9 thousand million in 1985, and 5.3 thousand million in 1990. It is expected to be 6.3 thousand million in 2000, and 8.5 thousand million in 2025 (UN 1991). The population of the developing countries, which is presently over three-quarters of the worlds total, is projected to increase by about 2.0 percent per year during the last decade of this century and to account for about 90 percent of the expected increase in global population (World Bank 1988). These growth rates will require an increase in agricultural production of about 40 to 50 percent over the next thirty to forty years, in order to maintain the present level of food intake; a 20 and 60 percent increase for developed and developing countries, respectively.

Growth in crop production can come from increases in arable land, cropping intensity and yield per unit area of cropped land. Nearly two-thirds of the increase in crop production needed in the developing countries in the next decade must come from increases in average yields, a fifth from increases in arable lands, and the balance from increases in cropping intensity (FAO 1988). About two-thirds of the increase in arable lands is expected to come from the expansion of irrigation. Thus it is concluded that the needed increases in food production in developing countries must come primarily from existing cropland, mostly irrigated land.

Irrigation has already played a major role in increasing food production over the past fifty years. The world's irrigated land was 8 million hectares in 1800, 48 million hectares in 1900, 94 million hectares in 1950 198 million hectares in 1970, and about 220 million hectares in 1990 (Jensen *et al.* 1990). About three-quarters of the irrigated land is presently in the developing countries. In these countries, almost 60 percent of the production of major cereals (primarily rice and wheat) is derived from irrigation. Irrigated land presently accounts for 15 percent of the cultivated land but produces 36 percent of the world's food (FAO 1988).

Expansion in irrigation needs to be 2.25 percent per year in order to meet food needs by the year 2000 (FAO 1988). However, the present rate of expansion in irrigation has recently slowed to less than 1 percent per year (CAST 1988). The reasons for this slowing down in expansion rate are many. Among them are the high costs of irrigation development and the fact that much of the suitable land and water supplies available for irrigation have already been developed; progressively more expensive and socio-economically less favourable areas are left for further expansion. Water is the limiting constraint for almost 600 million hectares of potentially suitable arable land (FAO 1988). Also, the overall performance of many irrigation projects has been less than expected due to inadequate operation, maintenance and inefficient management (FAO 1990). It is not unusual to find that less than 60 percent of the water diverted or pumped for irrigation is actually used in crop transpiration. Furthermore, improper irrigation causes environmental and ecological problems.

Agricultural production systems are limited by the capacity of the associated ecosystems to sustain their natural properties, even though advances in agricultural technology (including use of irrigation, plant breeding, fertilizers and pesticides) have reduced our dependency somewhat in this regard. The relationship between sustainable agriculture and the environment is one of complimentarity and interdependence. In many locations around the world, strains upon the environment are occurring increasingly and concern is mounting about the sustainability of irrigated agriculture with respect to waterlogging, salinization, erosion, desertification, loss of biological diversity, water-borne diseases, adverse effects of potentially toxic agricultural chemicals upon human health and the biota of associated eco-systems (World Commission on Environment and Development 1987).

Overall, the use of sophisticated agricultural practices has had, so far, a net beneficial effect upon agricultural production, human welfare, nutrition and health. But mismanagement and overuse have the potential to overwhelm the ability of natural processes to "absorb" these practices. A critical challenge facing most countries is to halt and reverse the present extent of environmental degradation resulting from excessive exploitation of natural resources, especially those manifested in desertification, soil erosion, waterlogging, and soil and water salinization, in order to ensure the needs of future generations. Presently, 5 to 7 million hectares of arable land (0.3 - 0.5 percent) are being lost every year through soil degradation. The projected loss by the year 2000 is 10 million hectares annually (0.7 percent of the area presently cultivated). By the year 2000, productivity of about one-third of the world's arable land may be severely impaired by excessive erosion (UNEP 1982). The future expansion of food production will be increasingly dependent upon sound irrigation and water management and upon the concurrent maintenance of the present agricultural resource base and the environment - two of the most challenging tasks facing mankind today (FAO 1988).

From the facts and projections cited above it is concluded that:

- global food needs are increasing while soil and water resources are becoming more limited and diminished in quality;

- the need to conserve water, to utilize it more efficiently and to protect its quality, and simultaneously to protect soil resources is increasing; and

- world agriculture must both expand its base of production and produce more with presently developed resources.

Because higher yields are obtained with irrigated agriculture and because it is less dependent on the vagaries of weather, it assumes special importance in this regard. Expansion of irrigated agriculture could contribute significantly towards achieving and stabilizing food and fibre needs. However, new water supplies for such expansion are limited. Irrigated agriculture is already the largest consumer of developed water resources. At the same time, drainage return from irrigated lands is one of the major causes of waterlogging (usually in lower lying regions) and of water pollution (with respect to salts, nitrates, agricultural chemicals and certain natural, potentially toxic trace elements).

Water availability for irrigation could be enhanced through judicious and proper use of saline water and the recycling of drainage waters for irrigation.

Considerable amounts of such water are available in various places in the world, including Australia, Egypt, India, Israel, Pakistan, the USA, and the former USSR. Waters generally classified as unsuitable for irrigation can, in fact, be used successfully to grow crops without long-term hazardous consequences to crops or soils, with the use of improved farming and management practices. The development of crops with increased salt tolerance and the adoption of new crop and water management strategies will further enhance and facilitate the use of saline waters for irrigation and crop production, while keeping soil salinity from becoming excessive. The reuse of drainage waters for irrigation will also help to conserve water and to minimize the hazardous effects of irrigation on the environment and ecology.

The development of appropriate practices for the use of saline waters for irrigation requires an adequate understanding of how salts affect waters, soils and plants. But, the sustainability of a viable, permanent irrigated agriculture, especially with the use of saline irrigation waters, requires much more. It requires the implementation of appropriate management practices to control salinity, not only within the irrigated fields, but also within irrigation projects and geohydrologic systems. It is important to remember that most waterlogging and salinity problems presently existing in major irrigation projects throughout the world have resulted with the use of "good quality" irrigation waters. Hence, it may be argued that the major causes of salinity problems presently being generally encountered in typical irrigation projects must first be avoided, if more saline than normal waters are to be used successfully for irrigation, since such use may increase the likelihood of salinity problems in a given field. On the other hand, reuse of drainage waters for irrigation can help reduce overall the drainage, waterlogging and salt-loading problems that occur, especially at the project or river basin scales and, hence, can result in a net decrease in the totality of irrigation-induced and salinity-related problems, including environmental pollution. In any case, it is imperative that management practices for the control of soil and water salinity at such scales be considered an essential part of the management requirements for using saline waters for irrigation. This requires the following:

- that the seriousness of salinity-related environmental problems and the vulnerability of irrigated lands to waterlogging and salination be sufficiently recognized;

- that the processes contributing to these problems and the effects of salts on soils and plants be understood;

- that the salinity conditions and trends of the irrigated lands and associated water resources be routinely assessed using appropriate measurement and monitoring techniques that provide meaningful and timely information;

- that salinity-related problems be properly diagnosed using appropriate criteria and standards;

- that future conditions of soil and water salinity be adequately predicted using appropriate prognostic techniques; and

- that the viability of the irrigated agriculture and associated water resources be sustained by implementing effective long-term control measures.