Executive summary

The primary objective of these guidelines is to facilitate the safe use of saline waters for crop production, while promoting water conservation and environmental protection. A secondary objective is to create an awareness of the degradational and pollutional consequences that result from prevalent irrigation practices and the potential to minimize these problems through the interception, isolation and reuse of drainage water for irrigation employing appropriate strategies and practices. In this publication "saline waters" refers to natural salt-affected waters as well as those resulting from human activities, such as irrigation with drainage waters and shallow groundwaters, that fall in the range of 1500 to 7000 mg/l total dissolved solids and which are not widely used for irrigation. Cropping considerations will generally require that appropriate management practices be employed to use such waters effectively over time for crop production.

These guidelines are addressed primarily to those involved with irrigated agriculture, soil and water conservation, and environmental protection. Emphasis is on the avoidance of waterlogging and secondary salinization problems (both in soils and water supplies) associated with irrigation. The basis for these guidelines is presented in terms of the principal effects of salts and irrigation practices on soils, waters and crops.

SCOPE

Chapter 1 discusses the potential to use saline waters, especially drainage waters, to increase crop production (particularly in those countries which are limited by available water supplies) while simultaneously helping to overcome environmental pollution problems associated with irrigation and drainage. Quality characteristics, sources and availability of saline waters potentially suitable for irrigation are described in Chapter 2. Examples of the successful use of various saline waters for irrigation under widely varying situations around the world are given in Chapter 3 to lend credibility to the Guidelines recommendations for such use. In Chapter 4, criteria, standards, methods and models to assess the suitabilities of saline waters for irrigation are discussed. The nature and causes of waterlogging and soil salinization, water pollution, eco-system disturbance and water-borne diseases associated with irrigation are reviewed in Chapter 5. Management principles and practices for safe use of saline waters for crop production and environmental protection are discussed in Chapter 6.

SALINE WATERS AS A RESOURCE

There is ample evidence to illustrate the widespread availability of saline waters and a wide range of experience exists around the world with respect to using them for irrigation under different conditions. This evidence and experience demonstrates that waters of much higher salinities than those customarily

classified as "unsuitable for irrigation" can, in fact, be used effectively for the production of selected crops under the right conditions.

EFFECTS OF SALTS ON CROP PRODUCTION

Salts exert both general and specific effects on plants which directly influence crop growth and yield. Salts also affect certain soil physico-chemical properties which, in turn, affect the suitability of the soil as a medium for plant growth. Excess sodium and very high pH, such as might occur with the use of saline-sodic waters for irrigation, promote the slaking of aggregates and the swelling and dispersion of clays which lead to soil crusting, loss of porosity and reduced permeabilities, especially when rapid desalinization occurs following rainfall or the subsequent use of low-salinity waters for irrigation. The major general effect of salts on plants is to reduce plant stand and growth rate. Chloride, sodium and boron may exert specific toxicity effects on susceptible crops, especially woody perennials. Plants vary in their tolerances to salts and many are sufficiently tolerant, especially after seedling establishment, to produce well when irrigated with saline waters, especially typical drainage waters, provided appropriate cultural management practices are followed.

ASSESSING THE SUITABILITY OF SALINE WATER FOR CROP PRODUCTION

The suitability of a water for irrigation should be evaluated on the basis of criteria indicative of its potential to create soil conditions hazardous to crop growth and subsequently to animals or humans consuming those crops. Relevant criteria for judging irrigation water quality in terms of potential hazards to crop growth are primarily:

- **Permeability and tilth**
- **Salinity**
- **Toxicity and nutritional imbalance**

Permeability and crusting hazards are evaluated by electrical conductivity (EC_{iw},) and the sodium adsorption ratio predicted to occur in the topsoil after irrigation (SAR_{sw}) with reference to threshold tolerances (permissible combinations of EC_{iw} and SAR_{sw}) established for the specific soil in question or, in the absence of specific information, an appropriate general relation. SAR_{sw} is predicted using a computer model (such as Watsuit, which is used in this publication) or, in the absence of a computer, using the SAR value of the irrigation water (SAR_{iw}).

Salinity, toxicity and nutritional problems are evaluated by comparing levels of soil water salinity, concentrations of toxic ions and ratios of Ca/Mg predicted (with Watsuit) to result in the rootzone of the soil after irrigation with reference to acceptable values of salinity, toxic-ion concentrations and Ca/Mg ratios for the specific crop (s) in question. Tables of acceptable levels of salt and toxic-ion concentrations are provided for many crops and plants. Predictions of soil salinity resulting from irrigation with a given saline water can also be made without benefit of a computer by ignoring salt precipitation and dissolution reactions.

Tables and figures are provided to make such predictions along with examples of their use for assessing saline water suitability for irrigation. Uncertainties in the model predictions and insufficient knowledge of soil and crop responses to salts and toxic ions limit the exactness and quantitativeness of the assessment

procedure.

ENVIRONMENTAL ASPECTS OF IRRIGATION

In a number of countries, irrigated agriculture has resulted in major environmental disturbances such as waterlogging and salinization, depletion and pollution of water supplies, especially groundwaters, and increased health risks. The recreational, aesthetic and habitat values of many water systems and agricultural landscapes have also been degraded by improper irrigation development and practices.

Most of the problems of waterlogging and secondary salinization prevalent in irrigated lands and of associated water pollution have resulted from the excessive use of water for irrigation as a consequence of inefficient irrigation distribution systems and poor on-farm management practices, inappropriate drainage management, and the discharge of "spent" drainage water into good-quality water supplies. These problems have occurred even where low salinity waters have been used for irrigation. This might lead one to conclude that the use of saline waters for irrigation can only increase these problems. However, this is not necessarily the case.

The use of saline waters of the levels advocated herein for irrigation will not result in excessively saline soils *per se* nor cause waterlogging with proper management. In fact, the interception of drainage waters percolating below rootzones and their reuse for irrigation will reduce the soil degradational processes associated with excessive deep percolation, salt mobilization, waterlogging and secondary salinization that typically occur in irrigated lands and the water pollution problems associated with their discharge to good-quality water supplies.

In considering the use of a saline water for irrigation and in selecting appropriate management to protect water quality, it is important to recognize that the total volume of a saline water supply cannot be beneficially consumed for irrigation and crop production; and the greater its salinity, the less it can be consumed before the salt concentration becomes limiting. The practice of blending or diluting excessively saline waters with good quality water supplies should only be undertaken after consideration is given to how this affects the volumes of consumable water in the combined and separate supplies. Blending or diluting drainage waters with good quality waters in order to increase water supplies or to meet discharge standards may be inappropriate under certain situations. More crop production can usually be achieved from the total water supply by keeping the water components separated. Serious consideration should be given to keeping saline drainage waters separate from the "good quality" water supplies, especially when the latter waters are to be used for irrigation of salt-sensitive crops. The saline drainage waters can be used more effectively by substituting them for "good quality" water to irrigate certain crops grown in the rotation after seedling establishment.

MANAGEMENT PRINCIPLES AND PRACTICES TO CONTROL SALINITY

An integrated, holistic approach is needed to conserve water and prevent soil salinization and waterlogging while protecting the environment and ecology. Firstly, source control through the implementation of more efficient irrigation systems and practices should be undertaken to minimize water application and reduce deep percolation. Unavoidable drainage waters should be intercepted, isolated and reused to irrigate a succession of crops of increasing salt tolerance, possibly including eucalyptus and halophyte species, so as to reduce drainage water volumes further and to conserve water and minimize pollution,

while producing useful biomass. Conjunctive use of saline groundwater and surface water should also be undertaken to aid in lowering water table elevations, hence to reduce the need for drainage and its disposal, and to conserve water. Various means should be used to reclaim or to dispose of the ultimate unusable final drainage effluent.

To achieve these goals, new technologies and management practices must be developed and implemented. Efficiency of irrigation must be increased by the adoption of appropriate management strategies, systems and practices and through education and training. Such measures must be chosen with recognition of the natural processes operative in irrigated, geohydrologic systems, not just those on-farm, and with an understanding of how they affect the quality of soil and water resources, not just crop production. Some practices can be used to control salinity within the crop rootzone, while other practices can be used to control salinity within larger units of management, such as irrigation projects and river basins. Additional practices can be used to protect offsite environment and ecological systems -including the associated surface and groundwater resources.

There is usually no single way to achieve salinity control in irrigated lands and associated waters. Many different approaches and practices can be combined into satisfactory control systems; the appropriate combination depends upon economic, climatic, social, as well as edaphic and hydrogeologic situations. Thus, no procedures are given for selecting "the" appropriate set of control practices for different situations. They are too numerous. Rather, some important goals, principles and strategies of salinity management, at both on-farm and project levels, that should be considered in the selection and implementation of control practices are reviewed and discussed.