United States Department of Agriculture

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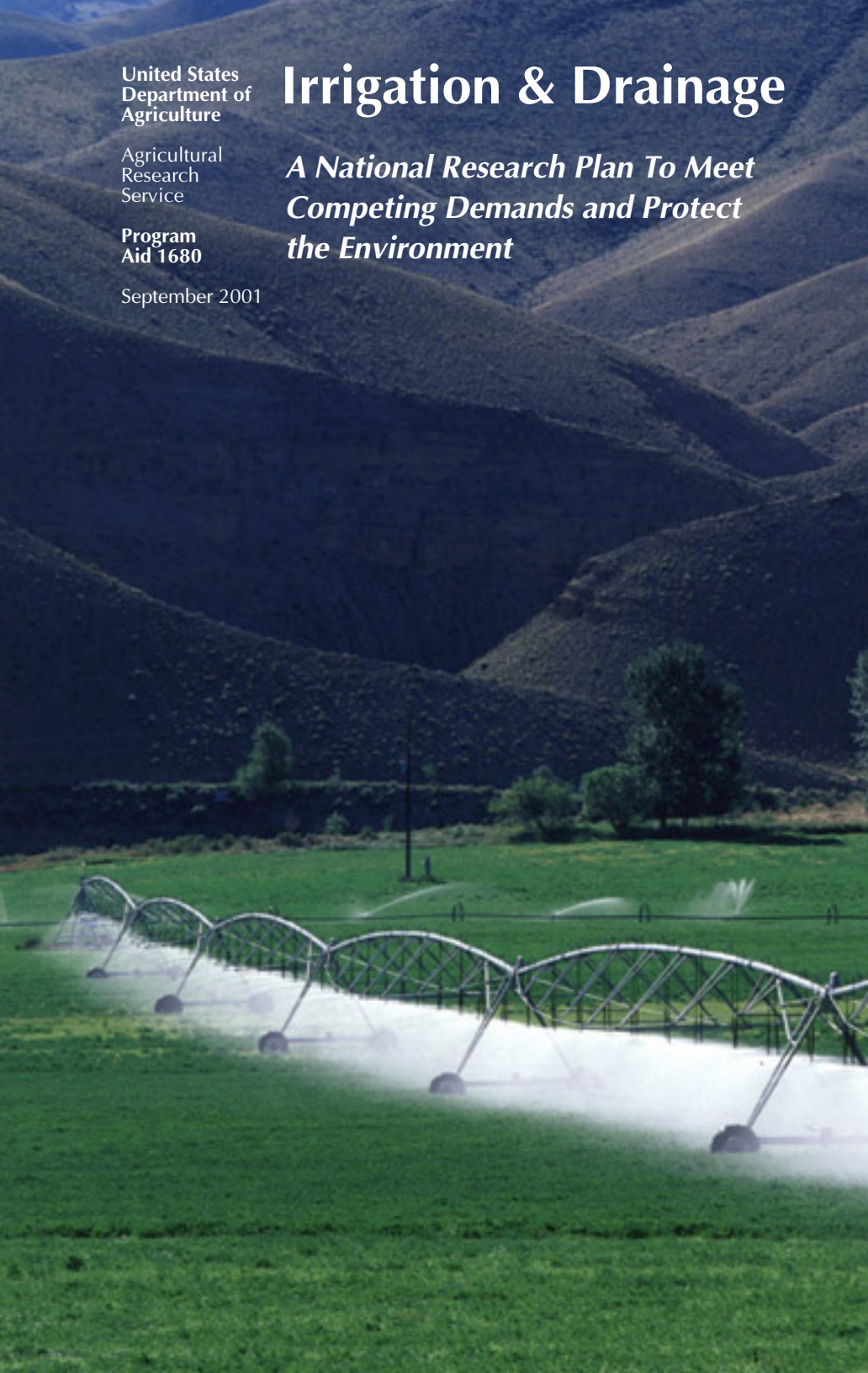
Irrigation & Drainage

A National Research Plan To Meet Competing Demands and Protect the Environment



Irrigation and drainage have played central roles in the remarkable success of American agriculture. Settlement of the American West was tied closely to irrigation, and drainage in humid regions makes possible the high production of food and fiber we know today.

Irrigation is also vital to crop production throughout the Midwest, into the South, and in many Eastern States, especially Florida. Urban irrigation now comprises a large component of the irrigation market—for landscaping, golf courses, athletic fields, and other recreational uses.

Irrigation continues to expand nationally, although acreages have declined in some states due to competing demands. As a heavy water user, irrigated agriculture is but one of many needs for water, energy, and land resources. At the same time, the growing global economy and world population are placing greater demands on irrigated agriculture to provide food and fiber.

Conditions such as these inevitably mean changes in public policy and programs that manage and allocate water. Policymakers at all levels face increasing demands for water—for food and fiber, urban and environmental purposes, and Native American claims, as well as for retaining U.S. global competitiveness in agriculture.

Improvements in irrigation and drainage technology are helping the Nation cope with these challenges. We are using our natural resources more efficiently and paying closer attention to safeguarding and improving the environment.

Researchers are developing sophisticated systems that producers need to remain competitive in today's global markets. As farmers strive to adopt more efficient, effective irrigation and drainage practices, more research will be essential for solving both existing and emerging problems.

The Agricultural Research Service (ARS) is the agency within the U.S. Department of Agriculture responsible for developing and improving irrigation and drainage technologies and management practices. With advice from many users, ARS has identified the following high-priority problem areas in irrigation and drainage:

Crop Production Systems
- **irrigated crop production**
- **precision irrigation**

Water Quantity Technologies
- **water conservation**
- **energy conservation**
- **irrigation in humid areas**
- **drainage systems**

Water Quality & Environmental Impact
- **salinity and trace elements**
- **waste water reuse**
- **the environment**
- **erosion**

Facts About Irrigation

- Irrigation made it possible for 16 percent of U.S. cropland to produce 48 percent of harvested crop sales in 1997. That corresponds to about 280,000 farms irrigating 55 million acres of crop and grazing land.

- The average value of crops produced per acre was $317 in 1997. That same year, sales from irrigated cropland totaled more than $950 per acre, compared with sales of less than $200 per acre from nonirrigated cropland.

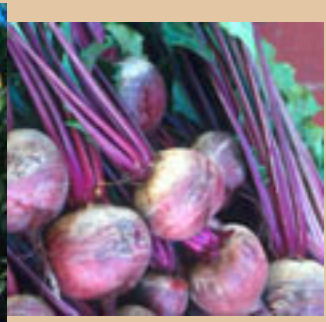
- In the West, sales averaged about $850 per acre in 1997 on the 38 million acres of irrigated cropland, accounting for one-third of all crop sales in the Nation.

- Irrigation in the East covers less than 12 million acres, but crop sales are valued at more than $1,250 an acre, the highest in the Nation.

- The major irrigated crops included corn, hay, pasture, cotton, soybeans, and wheat in 1997.

- About 60 percent of irrigated crop sales were from orchards, vegetables, and horticultural crops. These crops make up about 15 percent of the acres irrigated and represent 72 percent of the acres in orchard, vegetable, and horticultural crops.

ARS has drawn up a plan of action to guide research on irrigation and drainage. Forming the core of the plan are environmental and economic issues. The pages that follow offer a sketch of each of the nine problem areas, the national research goals, and the hoped-for long-term effects.



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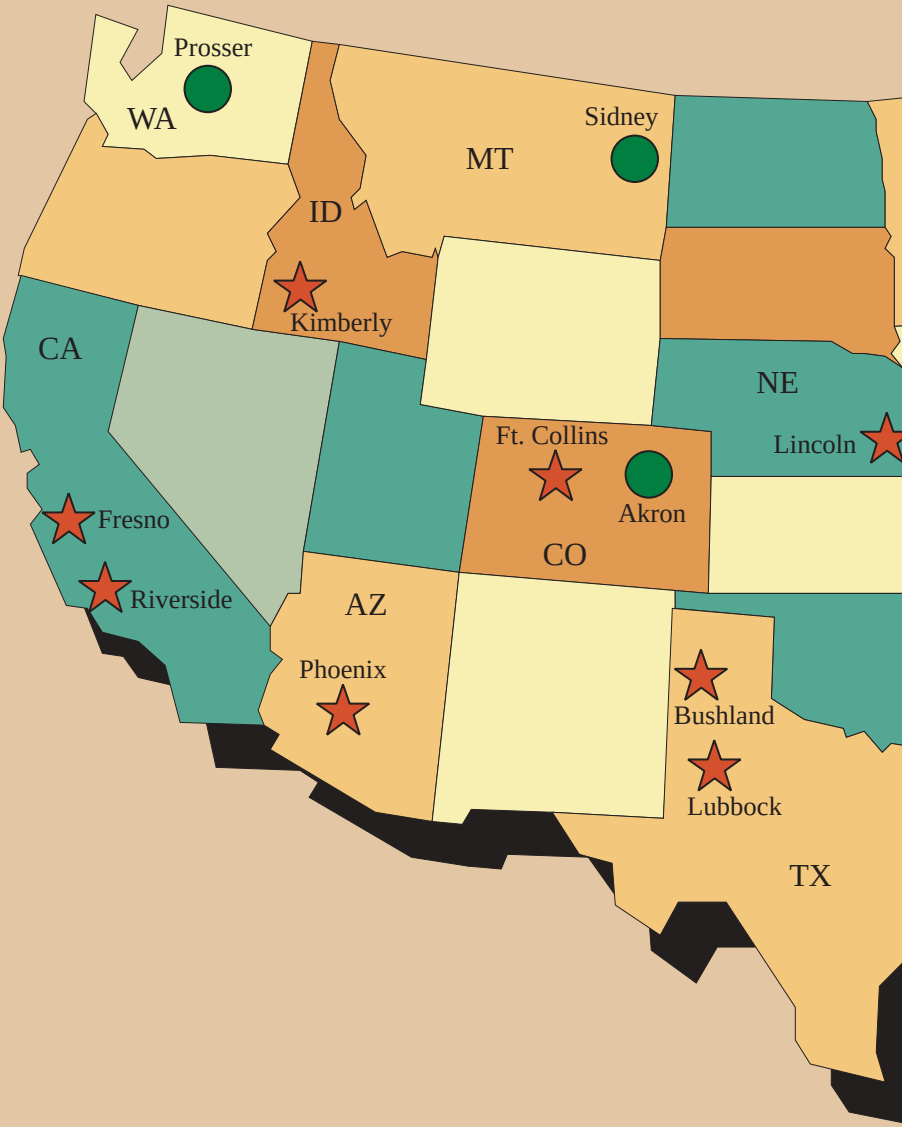

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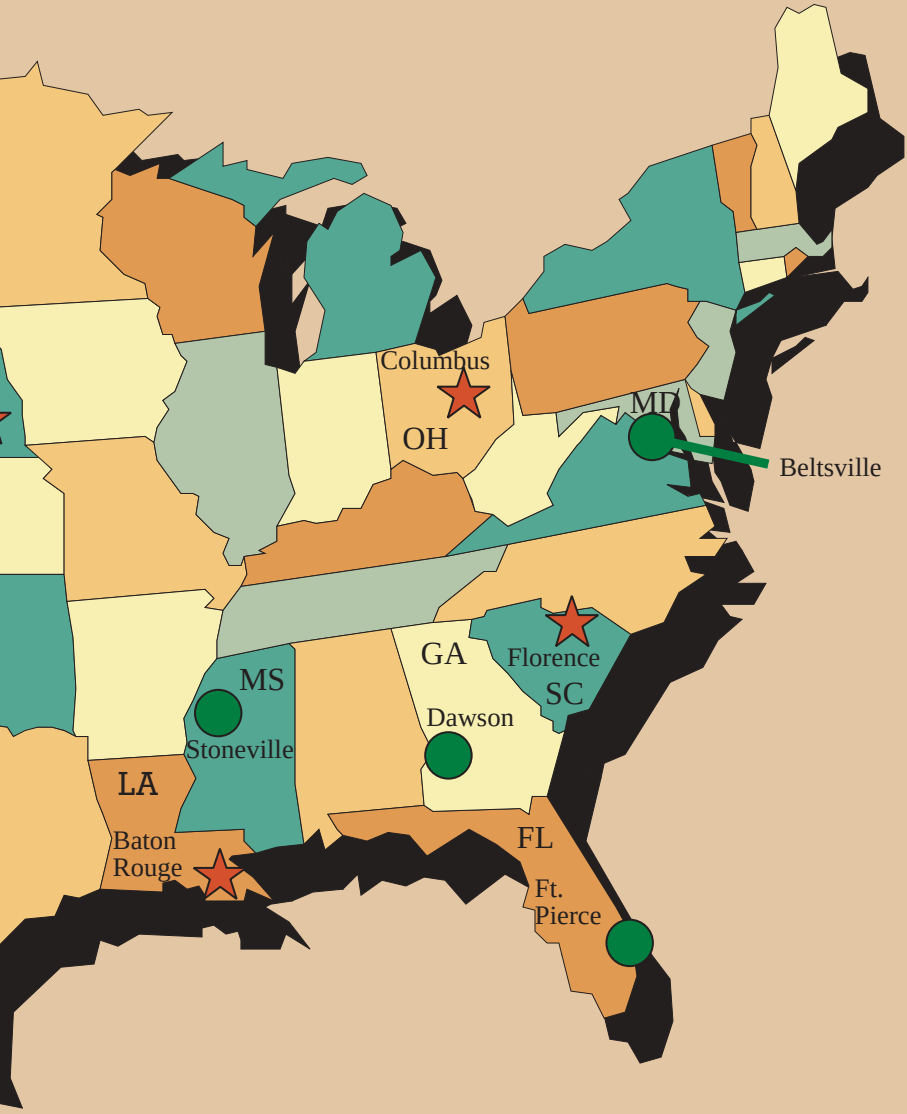


Crop Production Systems

Irrigated Crop Production

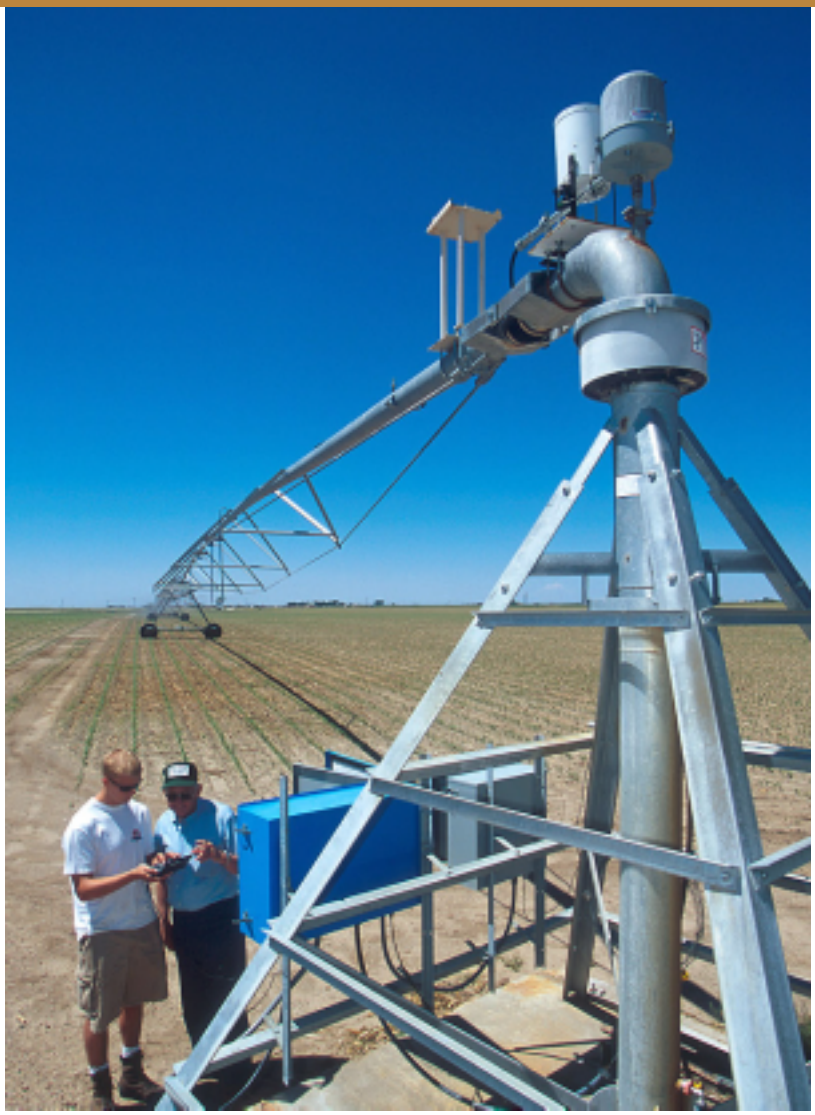
The purpose of irrigation is to produce crops that have economic and social value. The continued productivity of irrigated agriculture will be critical as national and world populations grow and demand more food and fiber.

Properly managed irrigation can increase crop yields, reduce risks commonly associated with agriculture, increase product quality, reduce pest pressures, and precisely deliver and manage nutrients. Because irrigation management is specific to each crop, irrigation research must be crop-specific, meaning that cropping systems must be understood, including those involving high-value specialty crops with particular needs.

Research goal—To develop ecologically sound water, pest, and nutrient management practices and technologies for rotational cropping systems that maximize the economic benefits of irrigated agriculture.

Long-term effect—Irrigated agriculture that is highly competitive in the global economy.

Precision Irrigation



Precision irrigation applies water and agricultural chemicals precisely where they are needed. By using site-specific management and variable-rate technology, precision irrigation enhances yields and reduces applications of nutrients and chemicals such as herbicides, pesticides, nematicides, and fungicides.

For precision irrigation to achieve its potential, we need to better understand a cropping system's responses to existing practices and recommended changes. This understanding must encompass the proper management of all variable additions or inputs, including one of the most important—water.

Research goal—To develop precision irrigation systems and technologies for site-specific management of high-value crops.

Long-term effect—Irrigation that makes effective use of precision technologies, thereby enhancing productivity.

Water Quantity Technologies

Water Conservation

Water conservation is one of the primary ways that irrigation helps society meet competing demands for water.

We are not likely to satisfy increased water demands with new water sources. The costs and environmental effects of development would be prohibitive. As the largest water user in the United States, irrigation—of agriculture, turf, and landscapes—must seek ways to conserve. This will require a variety of technologies.

Research goals—

- To develop technology that quantifies and controls a broad range of water supplies and uses.
- To develop cultural and management practices for agriculture, turf, and landscapes that maximize returns from the water used.
- To develop improved practices and systems that mitigate the adverse effects of irrigation on water quality and the environment.

Long-term effect—A national water supply that meets the needs of irrigated agriculture and the public.

Energy Conservation

Energy conservation must work hand in glove with the use of alternative energy sources and water conservation.

While water is ultimately a renewable resource, energy is not—at least in the present state of technology. Like water conservation, however, energy conservation has implications for society and the environment. So the development and use of irrigation technology must incorporate the same concern for conserving energy as it does for conserving water.

Research goals—

- To develop irrigation technology and cultural and management practices for agriculture, turf, and landscapes that maximize returns from the energy used.
- To find ways to use renewable, efficient, and environmentally friendly energy sources—such as wind, solar, and biofuels—in irrigation systems.

Long-term effect—Dependable and sustainable energy for the Nation's irrigation needs.

Humid Areas

With consistent planning and operation of water management systems, irrigation and drainage can be sustained in humid areas with minimal environmental impacts, while enhancing the Nation's agricultural productivity.

The profitability of irrigation and drainage in humid areas depends on seasonal rainfall, adequate economic returns from crops, and irrigation and drainage expenses. To boost profitability and reduce risks, we need better methods for determining when and how much to irrigate. And we need new ways to design and operate drainage systems.

Research goal—To develop the knowledge, techniques, systems, and models to design and operate sustainable agricultural irrigation and drainage systems in humid areas, with minimal environmental impacts and efficient use of water resources, including waste water.

Long-term effect—Environmentally and economically sustainable irrigation and drainage systems in humid areas.

Drainage Systems

Managing surface and subsurface drainage systems to control contamination of surface runoff and shallow groundwater, as well as the depth of the water table, evolved first in humid areas and later in arid areas. In humid areas, controlled drainage has reduced nitrate in subsurface drainage discharge.

Many questions remain about the best drainage practices for improving crop production and the quality of runoff and subsurface drainage discharge in humid, semiarid, and arid areas. We need different drainage systems to ensure efficient, environmentally sound crop production in all of these areas.

Research goals—

- To develop drainage practices that enable crops to use shallow groundwater efficiently, while reducing the use of agricultural chemicals.
- To use controlled drainage systems in semiarid and arid areas that reduce the environmental effects of salts and trace elements carried in drainage discharge.
- To use controlled drainage or water-table management systems in humid areas that reduce flood flows and the environmental effects of nutrients carried in drainage discharge.

Long-term effect—Drainage systems that improve crop production while working in harmony with the environment.

Water Quality & Environmental Impact

Salinity and Trace Elements

Use of crop irrigation on some lands is threatened by its effects on soils, groundwater, and surface water. Crops extract nearly pure water, leaving soluble salts and toxic trace elements behind to accumulate around the roots. Managing this accumulation is a continuous challenge. To preserve the land's productivity, more water must be added to remove the salts and trace elements from the root zone. Often, drainage systems are needed to facilitate this process.

Research goals—

- To develop methods for managing salts and trace elements in irrigation and drainage waters that would eliminate their harmful effects on soils, groundwater, and crop productivity.
- To dispose of the concentrated salts and toxic elements in waste products and reduce the associated hazards.
- To develop instruments that measure salinity and models that predict the effects of salinity on crops, soils, watersheds, and aquifers.

Long-term effect—No loss of irrigated land or productivity due to salinity and trace elements.

Waste Water Reuse

Irrigation is a primary—and desirable—way to use waste water from agriculture, industry, and municipalities.

Water is limited in many parts of the United States. One solution to shortages is use of agricultural, industrial, and municipal waste waters for agriculture, municipal parks and recreational areas, and other green spaces. These uses would offset the demand for drinkable water. And they are permissible, provided they do not degrade surface and groundwater, cause soil salinization and deterioration, or result in real or perceived threats to public health.

Research goals—

- To identify best management practices for irrigation using waste water.
- To overcome specific climatic and soil limitations that prevent applying waste waters on agricultural lands and urban landscapes.

Long-term effect—Irrigation systems that reuse waste waters without compromising the public's health or the environment.

The Environment

Irrigation and drainage can improve or degrade ecosystems and the environment. Problems associated with irrigated agriculture include erosion, sedimentation of surface waters, chemical and nutrient contamination of water supplies, and salinization. Too, water and chemical inputs for urban and recreational irrigation are often far higher than necessary.

We need to understand how irrigation and drainage affect the movement of sediment and chemicals into water supplies. New, improved practices and strategies could enhance the health of ecosystems and the quality of the environment.

Research goals—

- To determine the effects of irrigation and drainage practices on the movement of pesticides, nutrients, sediment, biological agents, salts, and trace elements into surface water and groundwater.
- To predict and validate the effect of irrigation and drainage practices in fields, farms, watersheds, and river basins.

Long-term effect—Irrigated agriculture that is environmentally compatible.

Erosion

Irrigation enables farmers to use less than half the land area they would otherwise need for the same yields. Unfortunately, irrigation often increases erosion. Because erosion theory and models and conservation practices are derived largely from situations involving rain, they do not perform well when applied to irrigated lands. Poor irrigation practices also cause runoff and erosion, which contribute to surface-water contamination.

Research goals—

- To develop methods and a computer model for accurately predicting infiltration, runoff, and erosion from irrigation.
- To develop new conservation management and irrigation practices that enhance infiltration, reduce runoff, and improve water quality on a wide range of irrigated soils.

Long-term effect—Irrigated agriculture that maintains soil resources for future generations.

Frequent Questions About Irrigation

- Is irrigation a good idea for small farms?

For small farms, getting access to water for irrigation is less of a problem than stretching the supply of available water. Use of irrigation systems is increasing on small- and medium-sized farms and in greenhouse operations.

- Which countries lead in irrigated agriculture?

Four countries—India, China, the U.S., and Pakistan—account for more than half of the world's irrigated land. Many nations, including China, Egypt, India, Indonesia, and Pakistan, rely on irrigated land for more than half of their domestic food production.

- Can we win the salt and drainage battles, or is irrigation doomed to decline?

In theory, most salt problems can be solved, but in reality, most remain unsolved. Engineers have devised many techniques to control waterlogging and the accompanying salt buildup, but practically speaking, we have just started to manage waterlogging, salinity, and drainage.

- Will the increasing water requirements of our urban areas affect the availability of water for agricultural irrigation?

Without a doubt, cities will continue to require more water, leaving less for agriculture. Unknown, however, is the amount of water that ultimately will be reallocated and the effect of that reallocation on food production, farmers, and small communities.

- Can agriculture continue to irrigate?

In large part, the answer lies in agriculture's ability to do more with less water and energy. As water becomes increasingly scarce, getting more benefit from every drop will be the key.

For additional information

go to Water Quality and Management under the ARS National Program web site **http://www.nps.ars.usda.gov**

For specific questions on related research projects or to obtain single copies of this publication (free, while supplies last), contact Dale A. Bucks, National Program Leader for Water Quality and Management, at **dab@ars.usda.gov,** or write him at USDA–ARS, G.W. Carver Center, 5601 Sunnyside Ave., Mail Stop 5140, Beltsville, MD 20705–5140.

ARS Mission

As the principal in-house research arm of the U.S. Department of Agriculture, ARS conducts research to develop and transfer solutions to agricultural problems of high national priority and provides information access and dissemination to—ensure high-quality, safe food and other agricultural products, assess the nutritional needs of Americans, sustain a competitive agricultural economy, enhance the natural resource base and the environment, and provide economic opportunities for rural citizens, communities, and society as a whole. For more information about ARS, visit the web site at **http://www.ars.usda.gov/**