Improved Water Policies and New Technology will Promote Greater Food and Cellulosic Biomass Production and Reduce Competition for Water**

Alvin Smucker, Ph.D.
Professor of Soil Biophysics; Director, Michigan State University Subsurface Water Retention Technology Program, Michigan State University, East Lansing, Michigan, United States

Summary
Growing world populations, increased transport costs, and associated greenhouse gas (GHG) contamination, combined with changing climates demand the establishment of national and multinational water policies, designed for adoption by local regions and landscapes. Newly established region-specific policies need to be coupled with water pricing, best plant/soil management practices, and temporary subsidy support to those who adopt new water-saving science and technologies. Policies are needed for enforcing graded reductions in water use among domestic and industrial sectors in urban and surrounding rural regions during prolonged reductions in annual precipitation. Graduated water pricing increases, based on essential and aesthetic water volume use, need to be coupled with reported water conservation practices by domestic, industrial (including agricultural), and city government users located across urban centers and rural regions. Historically, many urban centers and farmlands were located along or near rivers, primarily for access to water sources and transportation. Therefore, new policies are required to address how rivers are used in metropolitan, industrial, and agricultural areas to minmize the contamination of these resources. Unlimited water use by agricultural communities also requires expanded environmental water use policies. In the United States, competing federal agencies need to develop a national water policy that establishes guidelines focused on maximum water-use efficiency and minimum water pollution, which include improved guidelines of the Clean Water Act. Historic regional water policies need to be replaced by community based policies developed and implemented by local authorities. This approach should be designed to incorporate systems approaches that consider local/regional, social, political, economic, environmental, and agroecological practices that ultimately lead to the policy adoption. Individual, corporate, municipal, and state organizations adopting these new community-based policies should receive government funding as they incorporate new technological tools that lead to annual water conservation. The world anxiously awaits technological solutions that overcome or at least diminish these more frequent droughty conditions associated with changing climates.

Current realities

Historic approaches for resolving agricultural water deficits have included the global expenditure of hundreds of billions of dollars, invested in hydroelectric and irrigation water reservoirs with the goal of distributing surface water through networks of canals. Dozens of billions of dollars have been spent developing bioengineered plants to improve drought tolerance. There has been a rapid expansion in the agricultural and horticultural irrigation industries, using competitive and often unsustainable quantities of surface and groundwater sources. Often, large quantities of irrigation water are applied to soils unable to retain adequate quantities of water for the plant to achieve maximum production of food and fiber. We are rapidly approaching limits of food production, where many of these historic policies and approaches need to be improved by using new technologies to retain more water where it falls.

Agricultural irrigation practices are often in competition with urban and industrial water needs. Surface water accumulations in reservoirs are expensive, are breeding grounds for disease-carrying insects and animals, and place surface water vulnerable to maximum evaporation. Additionally, 10% to 40% of this surface water evaporates during storage and transport in open channels before it reaches the droughty soil and is absorbed by plant root systems. Nearly all fertile soils requiring little to no supplemental irrigation for sustainable agricultural production are

already farmed. Therefore, options for expanding food production in the U.S. and most countries require better management of soil water in the root zones of plants, especially those growing on marginal lands. Increasing food production by 60% to 70% to meet the food needs for a human population approaching 9 billion by 2050, with current limited water resources, requires more efficient soil water storage. Increasing irrigation of sands and other marginal lands, mandates new technologies to increase soil water-holding capacities. Such efforts will transform these areas into sustainable agricultural production in closer proximity to urban centers.

As new sustainable water conservation technologies emerge, current water use for maximum food production paradigms require policy changes that better manage fresh water losses to the oceans from many of our large fresh water lakes. Some of these retained water volumes could be used for supplemental irrigation of food crops. This will sustainably produce more food and fiber, sequester more carbon, protect the environment, and provide more nutritious sustainable food value chains to large urban centers. This paper offers new and revised policies that could resolve many of the current restraints for maximizing food value chains with less water.

Scientific opportunities and challenges

Current water policies in the U.S. and most countries do not permit, nor do they enable, satisfactory solutions to the growing human competition for our most valuable natural resource: **nonsaline fresh water.** Since agriculture uses approximately 70% of this valued natural resource, soil scientists, hydrologists, plant scientists, and engineers need to discover and develop new water-conservation technologies that increase water-use efficiency. New subsurface water retention technology (SWRT) has been developed to convert billions of sandy soil acres into sustainable agricultural production systems that double grain and biomass production with less water.

Greater population, combined with improved diets containing more protein, will require up to 70% more food production. Prescription irrigation that includes greater soil water and nutrient retention in plant root zones, when combined with new policies, offers new approaches for producing more crop per drop of water. We have proposed a trilogy of integrated low-cost technologies that address weaknesses in current farming practices, which require less irrigation when coupled with the best integration of these technologies. These new technologies can be installed with little maintenance for continuous operation in a manner that transforms agriculture and elevates domestic income. Overcoming short- and long-term water deficits for agricultural crops is a key step toward maximizing newly developed hybrids, associated pest management, and protection of harvested produce. Although estimates of food insecurity vary it has been suggested that feeding this many people requires incremental changes in both water technology and water policy.

Policy Issues

- National water policies need to include just and uniformly useful water laws that supersede the plethora of state and regional laws and practices.

- The U.S. Environmental Protection Agency (EPA), Department of Interior (DOI), Department of Energy (DOE), Department of Agriculture-Natural Resources Conservation Service (USDA-NRCS), as well as other federal and state agencies need to formulate national water policies that establish guidelines focused on maximum water-use efficiency and minimum water pollution. These new policies must include rewards through tax incentives and temporary subsidies for those who lead, as well as taxing irrigation food production systems, industries, corporations, and individual dwellings that are inefficient and unsustainable.

- These new federal and state water policies need to be coupled with community-based policy development, implementation, and litigating boards. Only highly efficient irrigation systems of lawns, gardens, parks, sports areas, and agricultural crops should be permitted to operate. Community-established policies that adjust to wet and dry seasons should tax inefficient water use by industries, municipalities, and all irrigation sources.

- Governments must identify the most strategic locations for best irrigated dryland agricultural production and develop permits for the use of public surface waters and renewable deep water reservoirs.

- State and regional governments need to establish seasonal water consumption parameters for households, industries, and agricultural needs in specific regions that pollute rivers, lakes, and streams.

- Government and crop insurance companies must support farm crop losses only when the most water use-efficient irrigation systems are coupled with drought-tolerant cultivars planted on farm lands located in arid and semiarid regions.

- Limit major river flow to oceans by establishing more accurate controls of water levels in the five Great Lakes and other large water storage bodies resulting in available water for on-farm irrigation of grain crops.

- General population support of the best water use for food production should include certification of food production that includes most water-use efficiency (WUE) rankings and food transport distances on food labels.

- Federal and entrepreneurial initiatives are needed for balancing shipping traffic, electrical energy production, and fresh water irrigation using water from rivers in the U.S. and globally.

- Reduce conflicts and current water wars by establishing free to low-cost water-use policies with surrounding countries that parallel and complement current free-trade policies.

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