

Sustainability of Agriculture in Miami-Dade County: Considering Water Supply¹

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The term *sustainable agriculture* is used to describe an agricultural production system that is not only economically profitable, but also environmentally friendly. The concept of sustainability has grown out of the desire to leave our environment in a good condition for future generations. Although many different factors influence agricultural sustainability, one major factor is irrigation.

Irrigation is essential to most agricultural production systems and has been shown to significantly increase yield (National Research Council, 1996). Florida agricultural irrigation accounts for more than 3,900 million gallons per day (MGD) or 48% of all ground and surface freshwater withdrawals. This is not surprising because over 1.8 million acres of agricultural land in Florida are irrigated (National Agricultural Statistic Service, 2007).

The relationship between irrigation and agricultural sustainability is both economic and environmental. Irrigation, when implemented properly, can increase yield and reduce agrochemical requirements, ultimately increasing profit. Irrigation

implemented incorrectly may result in overuse of water (Muñoz-Carpena and Dukes, 2005), loss of agrochemicals (Spalding et al., 2001), and possibly decreased yield or harvest quality (Phene and Howell, 1984; Wang et al., 2002; 2005).

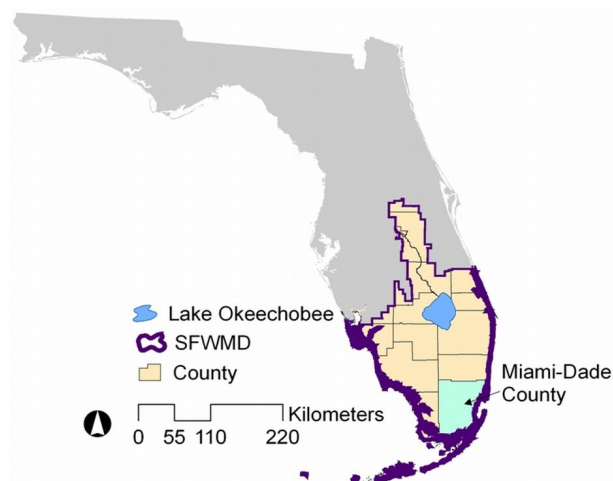


Figure 1. The South Florida Water Management District boundary and Miami-Dade County, FL. Credits: K.W. Migliaccio

Developing sustainable agricultural practices in Miami-Dade County (Figure 1) is important to ensuring the future of its economically significant

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winter vegetable, tropical fruit, and ornamental nursery plant production. This publication discusses water availability, factors that influence water availability, agricultural water use, and irrigation efficiency as they relate to Miami-Dade County.

Water Availability

In order to irrigate, agricultural producers must have a reliable and usable source of water. In Miami-Dade County, the dominant freshwater source is the Biscayne aquifer (Figure 2). Producers rely on this water supply not only for irrigation but also for the protection of crops against freezing when temperatures occasionally drop below freezing in the winter. The Biscayne aquifer is also used as the primary drinking water supply for about 3 million people.

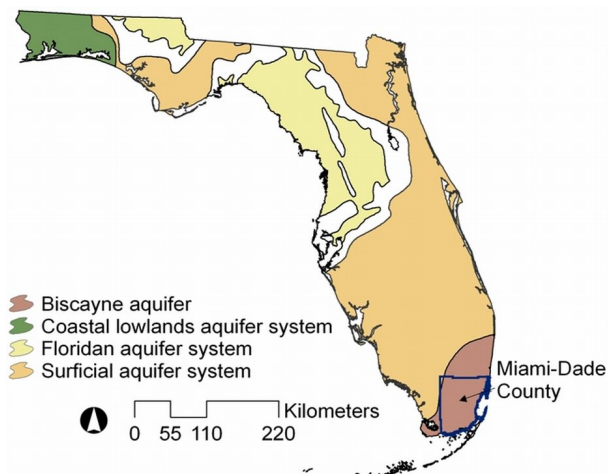


Figure 2. Uppermost principle aquifers for Florida from USGS Water Resources Division, 1998. Credits: K.W. Migliaccio

The Biscayne aquifer is an underground unconfined system of limestone, sandstone, and sand that stores groundwater (Klein and Hull, 1978). It is also fairly shallow, highly permeable, and hydraulically connected to both fresh and salt waters. These three aspects make the protection of the aquifer from salt water intrusion challenging. Protection of the aquifer requires a volume of fresh water (also known as freshwater head) to be maintained; lowering of this freshwater volume results in saltwater intrusion into the aquifer, rendering the

water in the aquifer unfit for drinking and irrigating (Miller, 1990).

Because the surrounding soil and limestone bedrock are highly permeable and the aquifer is close to the ground surface, the Biscayne aquifer is highly susceptible to groundwater contamination. The quality of water in the aquifer can be degraded by various human pollutants including fertilization, septic tanks, chemical spills, and other sources. Pollutants are transported by rainfall or irrigation through the soil profile and into groundwater supplies (Bradner et al., 2004). The importance of high-quality water in the Biscayne aquifer is crucial, as contamination of the aquifer could render it unfit as a drinking water supply (without expensive treatment) and possibly as an irrigation supply.

The Biscayne aquifer has been a dependable source of water supply. The availability of water for irrigation has not historically been a dominant concern for agricultural producers in Miami-Dade County. However, the demands on and variability in our water supplies have intensified tremendously over recent years in response to climate variability, rapid urbanization, and natural system protection goals (such as the Comprehensive Everglades Restoration Plan, or CERP). These factors must be balanced to ensure an adequate water supply for all water uses.

Climate Variability

Climate variability plays an important part in managing our water supplies. For this discussion, climate variability refers to a fluctuation in climate that occurs over a few months or seasons (e.g., annual amount of rainfall, number of tropical storms per year, etc.). The most commonly reported climate variability phenomenon is the El Niño-Southern Oscillation (ENSO) phase (or El Niño and La Niña). These fluctuations in climate influence water supplies through their deviations in temperature and/or precipitation for a period of time. Oftentimes these variabilities result in drought or other extreme events.

Recently, the 2006-2007 drought encompassed much of Florida. The drought was primarily due to record-low rainfalls. Rainfall is the primary source of water for replenishing fresh surface- and groundwater

reservoirs used for water supply in Florida. The 2006-2007 drought resulted in Lake Okeechobee reaching new record lows and the South Florida Water Management District (SFWMD) instating water restrictions to conserve water supplies during the drought period.

The 2006-2007 drought was followed by a 2009-2010 El Niño during the dry season that resulted in wetter than normal averages. Average precipitation (1998-2010) at the Florida Automatic Weather Network (FAWN) in Homestead for November to May dry seasons was 16.3 in (414.8 mm); however, during the 2009-2010 dry season the station recorded 25.7 in (653.3 mm).

Urbanization

As one of the most populated states in the US, Florida faces unique challenges in meeting the rapidly increasing demands of human water needs. In Miami-Dade County, the population has increased from 2.2 million in 2000 to an estimated 2.5 million in 2009, an approximate 14% increase in population (US Census Bureau, 2010). Approximately 138 gallons of water are used per person per day in Miami-Dade County, translating into an increased water demand of over 41.4 million gallons per day due to population change in Miami-Dade County between 2000 and 2009 (Miami-Dade County, 2010).

Urbanization may also influence the water supply recharge (or refilling of the aquifer from infiltrated rainfall) and quality (Foster et al., 1998). As populations continue to grow and human needs for consumable water increase, local authorities and utilities, in conjunction with the SFWMD, will need to find solutions to the competing demands on south Florida water supplies.

One strategy that Miami-Dade County has implemented to conserve water is year-round water restrictions for outdoor watering. The restrictions are:

- Odd-numbered addresses may irrigate lawns and landscapes on Wednesdays and Saturdays from 12 a.m. to 10 a.m. and/or 4 p.m. to 11:59 p.m.

- Even-numbered addresses may irrigate lawns and landscapes on Thursdays and Sundays from 12 a.m. to 10 a.m. and/or 4 p.m. to 11:59 p.m.
- Hand-watering with one hose and an automatic shut-off nozzle is allowed for 10 minutes per day for landscape stress relief and to prevent plant die-off.
- Newly-planted landscapes can be watered every day, except Fridays, for the first 90 days during the hours listed above.

Natural Systems

South Florida is rich in unique ecological systems that are biologically valuable. The Everglades has received much attention and was the world's largest restoration effort at its onset. The CERP plan for the Everglades includes restoring natural flows of water, water quality, and nearly natural seasonal water levels, which have implications for water availability (Kranzer, 2003). Restoration is being directed by the SFWMD and the US Army Corp of Engineers (USACE). Accomplishment of these goals requires a wide assortment of projects that include modifying freshwater flows and implementing Best Management Practices (BMPs) to minimize pollutant loads entering the Everglades.

In addition to the Everglades, the Biscayne Bay and the Florida Bay estuaries are two natural ecosystems in south Florida that are of ecological importance (Figure 3). Biscayne Bay is home to an aquatic preserve, which consists of northern and southern portions of the bay. The aquatic preserve is separated by the Biscayne National Park. Unlike many portions of Florida coastline, the southern portion of the estuary is one of the most pristine areas in coastal south Florida (FDEP, 2007).

Biscayne Bay is the receiving water for much of Miami-Dade County and portions of Broward County, both of which are experiencing rapid development and population growth. This urbanization trend has resulted in several studies regarding the water quality and quantity conditions in

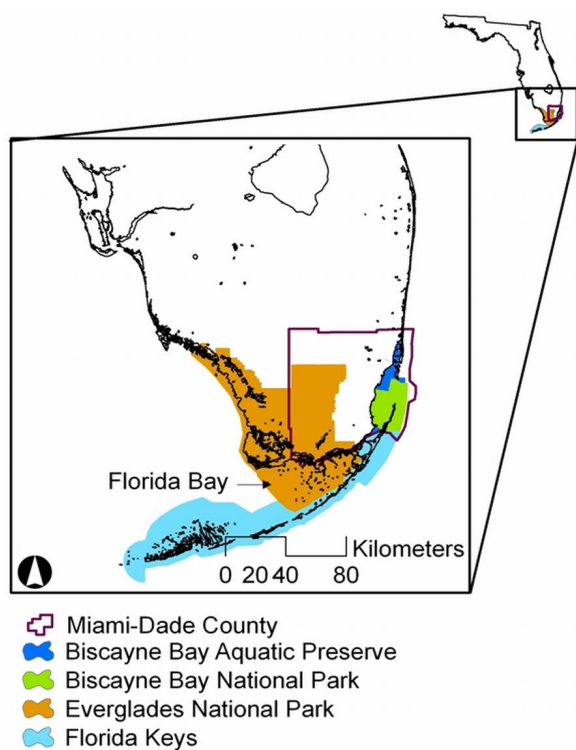


Figure 3. Location of Biscayne Bay and Florida Bay.
Credits: K.W. Migliaccio

Biscayne Bay and protection of its unique and diverse ecosystem. Most notable is the 2007 South Miami-Dade Watershed Study and Plan. The goal of this study was to provide a plan that balances all the water uses in the area, including natural systems and human quality of life.

Similar to Biscayne Bay, Florida Bay also represents a unique estuary system. The majority of Florida Bay, located between Florida mainland and the Florida Keys, is within the Everglades National Park (Figure 3). Florida Bay is an important ecological resource and home to a wide range of marine animals. It also supports substantial shrimp and stone crab industries (Florida Sea Grant, 2007). Florida Bay is the receiving water body for much of the southern Everglades. Hence, the CERP has implications regarding changes in how the bays receive water.

While CERP goals strive to return water quality and quantity to more natural levels, human activities are causing considerable ecosystem stress in the Florida Bay. The delicate ecosystem balance found in the Florida Bay (and Biscayne Bay) was threatened in 2006 as an algal bloom flourished in the normally

clear waters. The preservation of these natural systems depends on many factors, one of which is the quality and quantity of water inflows. The quality and quantity of inflows are influenced by natural processes and human practices. While natural processes are difficult to control, management practices can be implemented to minimize human influences and preserve water quality and quantity inflows into natural systems. Best Management Practices (BMPs) have been identified and are under continual research and development for different applications.

Specifically, BMPs for agriculture have been an active area of research and implementation in Florida. Agricultural BMPs are generally commodity and regionally designated. The agricultural BMPs are designed and implemented with the objective of increasing agricultural sustainability while also protecting water resources. As the interest in preserving natural systems grows and public policies evolve to reflect this, agricultural producers are modifying their production systems to accommodate these additional goals. More information regarding the agricultural BMP program in Florida can be found at the Florida Department of Agricultural and Consumer Services (FDACS), Office of Agricultural Water Policy website

<http://www.floridaagwaterpolicy.com/AtaGlance.html>

Sustainable Agriculture and Irrigation

Conservation practices and efficient water use are imperative to ensuring an adequate water supply for all users. Agricultural producers not only need to protect the water supply to ensure its uninterrupted availability and quality for future irrigation needs, but also need to balance water conservation with the economic viability of their agricultural system (i.e., agricultural sustainability). For agricultural sustainability in Miami-Dade County, it is critical that a balance between water conservation and economic agricultural production be achieved.

Irrigation of agricultural lands requires a water supply (Biscayne aquifer), a water delivery system, and an irrigation schedule. The water delivery system

and the irrigation schedule used by the agricultural producer are two components of the irrigation system that may be optimized for greater agricultural sustainability.

Water Delivery Systems

For Miami-Dade County, water delivery systems are generally not a source of excessive water waste as water is pumped from groundwater at the actual site of irrigation. Some inefficiencies may be present regarding large acreages where water may be piped throughout for irrigation delivery. These types of irrigation system inefficiencies may be easily remedied by conducting regular maintenance of the irrigation system. Regular maintenance consists of turning on the irrigation and observing each component of the irrigation system for proper function. Common problems are leaks around fittings, cracks/disconnects in the line (due to tractor or vehicle damage), holes in drip tape, and broken sprinkler heads. All of these malfunctions are fairly easy to identify and fix; however, they are often overlooked as irrigation timing may not be at a convenient hour for inspection and growers have many other demands on their time.

In Miami-Dade County, agricultural irrigators have the opportunity to contact the Mobile Irrigation Lab (MIL) to assist with irrigation efficiency assessments, particularly those related to the water delivery system. The MIL, historically housed with the South Dade Soil and Water Conservation Service in Florida City, FL, tests irrigation systems and identifies problems that result in wasted water. It provides a valuable service for agricultural producers by improving their irrigation efficiency and reducing wasted water, thereby increasing sustainability.

Irrigation Schedules

While the water delivery system component of an irrigation system should be considered and evaluated when targeting irrigation efficiency, irrigation scheduling is the central component of an irrigation system that can be modified to improve sustainability. Irrigation scheduling refers to the duration and frequency of irrigation events.

Irrigation scheduling is most commonly regulated by manual turn-on and turn-off systems or by automatic timer systems, both of which may result in over-irrigation. Manual irrigation consists of someone deciding that irrigation is needed, turning on the irrigation, and turning off the irrigation once sufficient water has been delivered. The weaknesses of such a system are that someone must be present to turn the irrigation on and off and it is easy to lose track of time or not monitor the irrigation closely and thus over-irrigate. Automatic timers offset some of these limitations by not requiring a person onsite and by providing automatic shutoff. However, using automatic timers to control irrigation has other flaws. The basic concept behind automatic irrigation is that a timer is set to irrigate for a specific duration and frequency, whether or not water is needed. Over-irrigation reduces agricultural sustainability by using increased amounts of water, increasing nutrient leaching, and possibly reducing yields and agronomic profits.

Research conducted at the University of Florida Tropical Research and Education Center (UF-TREC) in Homestead, FL, and UF Gainesville has focused on implementing modified irrigation scheduling methods to increase agricultural sustainability. Research has primarily focused on implementing soil moisture sensors or evapotranspiration (ET)-based technology to initiate irrigation (Muñoz-Carpena et al., 2005; Muñoz-Carpena and Dukes, 2005; Migliaccio et al., 2008; Kisekka et al., 2010; Migliaccio et al., 2010). Soil moisture-based irrigation consists of a soil moisture sensing device that relays information to an automated control on whether or not irrigation is needed. ET-based irrigation uses estimates (real-time or historic) of ET to schedule irrigation.

Four studies (e.g., avocado, carambola, papaya, and palm field nursery) have been completed at UF/IFAS TREC comparing soil moisture-, ET-, and/or set schedule-based irrigation methods. These studies have shown the following:

- Avocado: The soil moisture-based treatment saved 87% of the water volume applied and reduced total phosphorus leached by 66% compared to the set schedule irrigation. The soil moisture-based treatment had greater avocado

fruit production, tree water-use efficiency, and fertilizer-use efficiency than the set schedule treatment.

- Carambola: Results indicated that ET-based irrigation scheduling from either real-time (signal based) or historical weather data applied significantly less quantities of irrigation water compared to a set schedule practice (Kisekka et al., 2010).
- Papaya: Significantly more water was applied in the set schedule irrigation treatment than historic ET- and soil moisture-based treatments with the latter two receiving 31–36% of the water applied in the set schedule treatment (Migliaccio et al., 2010).
- Palm field nursery: Significant differences among treatments were observed for the irrigation water volume applied. Automating the irrigation system to irrigate at soil suction exceeding 5 and 15 cbar (kPa) using switching tensiometers resulted in 75 and 96% less water applied, respectively, than using a set schedule practice (Migliaccio et al., 2008).

All of these studies also indicated no decrease in plant production or yield with the reduced water volumes applied. Results of these studies also indicated two technologies that may be successfully applied in south Florida as a sustainable irrigation practice: automatic switching tensiometers and real-time ET controllers.

Switching tensiometers (Irrometer® Co., Riverside, CA, Figure 4) are devices that can be installed in the field to measure soil tension (or suction). This measurement is then compared to a setting that is adjusted by the user. The switching tensiometer functions as a switch that closes (or allows the solenoid to open and irrigation to occur) when the soil moisture tension is greater than the user-specified setting.

A series of EDIS publications has been developed to describe the use of real-time controllers and other ET-based irrigation methods: Implementing



Figure 4. Switching tensiometer. Credits: H. Trafford

Evapotranspiration-Based Irrigation Scheduling for Agriculture AE458, Evapotranspiration-Based Irrigation Scheduling for Agriculture AE457, Evapotranspiration-Based Irrigation for Agriculture: Crop Coefficients of Some Commercial Crops in Florida AE456, and Evapotranspiration-Based Irrigation for Agriculture: Sources of Evapotranspiration Data for Irrigation Scheduling in Florida AE455.

Research at the UF-TREC on irrigation and sustainability is ongoing. As new technologies become available, they will be integrated into laboratory and field trials to ensure that agricultural producers in Miami-Dade County have the most relevant and up-to-date information. UF Extension specialists and agents are also continually working with agricultural producers to ensure that new technologies and research products are feasible and meet the needs of producers. Continued interaction among Extension faculty, Extension agents, and growers is essential for increasing the sustainability of agriculture in Miami-Dade County.

Summary

An important component of a sustainable agricultural system is irrigation. The ability of agricultural production to successfully continue in Miami-Dade County will depend on the availability of water for irrigation. Due to the increasing demands on water supplies and uncertainties related to climate variability, greater efforts are being made to conserve water by implementing BMPs for agricultural crops. Two promising BMPs that have been shown to conserve considerable amounts of water when

implemented in Miami-Dade County is the use of soil moisture measuring devices and ET-based methods to initiate irrigation. Agricultural sustainability will benefit from continued development of irrigation BMPs to be used in agricultural production.

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