Memorandum

MIAMI-DADE COUNTY

Date: March 11, 2021

Agenda Item No. 2(B)(6)
April 20, 2021

To: Honorable Chairman Jose "Pepe" Diaz
and Members, Board of County Commissioners

From: Daniella Levine Cava
Mayor

Daniella Levine Cava

Subject: Report regarding Sea Level Rise Impacts on the Agricultural Community in Miami-Dade - File No. 192627

As part of my operation to catch up on the backlog of items, we are bringing you reports that were pending from the previous administration. The attached report responds to Resolution No. R-1333-19, approved by the Board of County Commissioners (Board) on December 3, 2019. Resolution No. R-1333-19 directed the County Mayor or County Mayor's designee to conduct a study regarding the impacts of sea level rise on the agricultural community in Miami-Dade County, and to prepare a report on how best to protect that community and its agricultural products from such impacts. The research for this report was conducted primarily from January 2020 to March 2020. It involved direct engagement with members of the agricultural community, analysis of documents referenced within the report, and the support of county employees, including Miami-Dade County's Agricultural Manager.

The report summarizes the contributions and achievements of Miami-Dade's agricultural community, the science of sea level rise in South Florida, and the water management challenges in the agricultural areas of the County. It provides an overview of how sea level rise may impact the agricultural community in Miami-Dade County over the next 20+ years, based on the Southeast Florida Regional Climate Change Compact's Unified Sea Level Rise Projection for Southeast Florida. Current and potential future impacts of sea level rise on agriculture in the County are described, and three recommendations are made to support Miami-Dade's agriculture community as it adapts in response to sea level rise and climate change.

In accordance with Ordinance No. 14-65, this report will be placed on the next available Board meeting agenda.

If you have questions concerning the above, please contact James F. Murley, Chief Resilience Officer, Department of Regulatory and Economic Resources, at 305-375-5593 or at James.Murley@miamidade.gov.

Attachment

c: Geri Bonzon-Keenan, County Attorney
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Sea Level Rise Impacts on the Agricultural Community in Miami-Dade County

September 2020

Final Report Resolution No. R-1333-19

Contents

Executive Summary

On December 3, 2019, the Miami-Dade Board of County Commissioners passed resolution no. R-1333-19 directing the Mayor or Mayor's designee to:

"conduct a study regarding the impacts of sea level rise on the agricultural community in Miami-Dade County, and to prepare a report on how best to protect that community and its agricultural products from such impacts."

The following report provides an overview of how sea level rise may impact the agricultural community in Miami-Dade County over the next 20+ years. Agriculture has and continues to play a unique role in the County. Operation of the regional water management system is critical for the success of agriculture in the County. Because of this, the people who farm here will have to respond to sea level rise as it impacts local and regional water management. The report begins with a summary of the contributions and achievements of Miami-Dade's agricultural community, followed by a description of the science of sea level rise in South Florida and the water management challenges in the agricultural areas of the County. Finally, current and potential future impacts of sea level rise on agriculture in the County are also described. The report uses the most recent Southeast Florida Regional Climate Change Compact's Unified Sea Level Rise Projection for Southeast Florida, updated every 5 years, for planning guidance and it draws on research by the South Florida Water Management District, U.S. Geological Survey, Miami-Dade County Water and Sewer Department, local academics, and the experience of the agricultural community.

Key findings of this report are that sea level rise will compromise the function of canals and flood control structures across Miami-Dade County. New infrastructure will be needed and management practices are likely to change, based on a future Central & Southern Florida Flood Resilience Study. As a consequence the annual seasonal drawdown that lowers groundwater to facilitate planting in October for farms east of U.S. 1 may become less effective. These farms may also experience salt water intrusion and rising groundwater levels, negatively affecting the root zone. Farms further from the coast, including in the Redland area of southwest Miami-Dade, can also expect to experience rising groundwater and a loss of root zone capacity. Adaptation will be necessary. Fortunately, Miami-Dade's agricultural community is creative and has continued to thrive over the past century by adapting to shocks and stresses including disease, storms, market forces, and development pressure.

In order to provide the data and tools that will allow Miami-Dade's agriculture community to succesfully adjust to changing conditions, including climate change and sea level rise, we recommended the following:

1) Support the South Florida Water Management District's effort to prepare its water management structures and operations for sea level rise by conducting the Central & Southern Florida Flood Resiliency Study with the US Army Corps of Engineers. The study should be utilized to guide future infrastructure investment and direct explicit attention to limiting salt water intrusion and maintaining historic groundwater levels to minimize adverse impacts on Miami-Dade's agricultural areas.

2) Continue to support cost-effective adaptation and innovation through continued groundwater and salt front modeling and monitoring performed in partnership with the USGS, as well as economic modeling and applied research into climate resilient crops by working with agencies and stakeholders including the University of Florida Institute of Food and Agricultural Sciences Extension (UF/IFAS) Tropical Research and Education Center (TREC) and Extension in Miami-Dade County.

3) Ensure stakeholders in the agricultural community participate in the County's planning and regulatory response to sea level rise through the County's Agricultural Practices Advisory Board (APAB), the County Agricultural Manager, and the Comprehensive Development Master Plan with the technical support of the Regulatory & Economic Resources Department (RER) and the Miami-Dade Water and Sewer Department (WASD).

Legislative direction

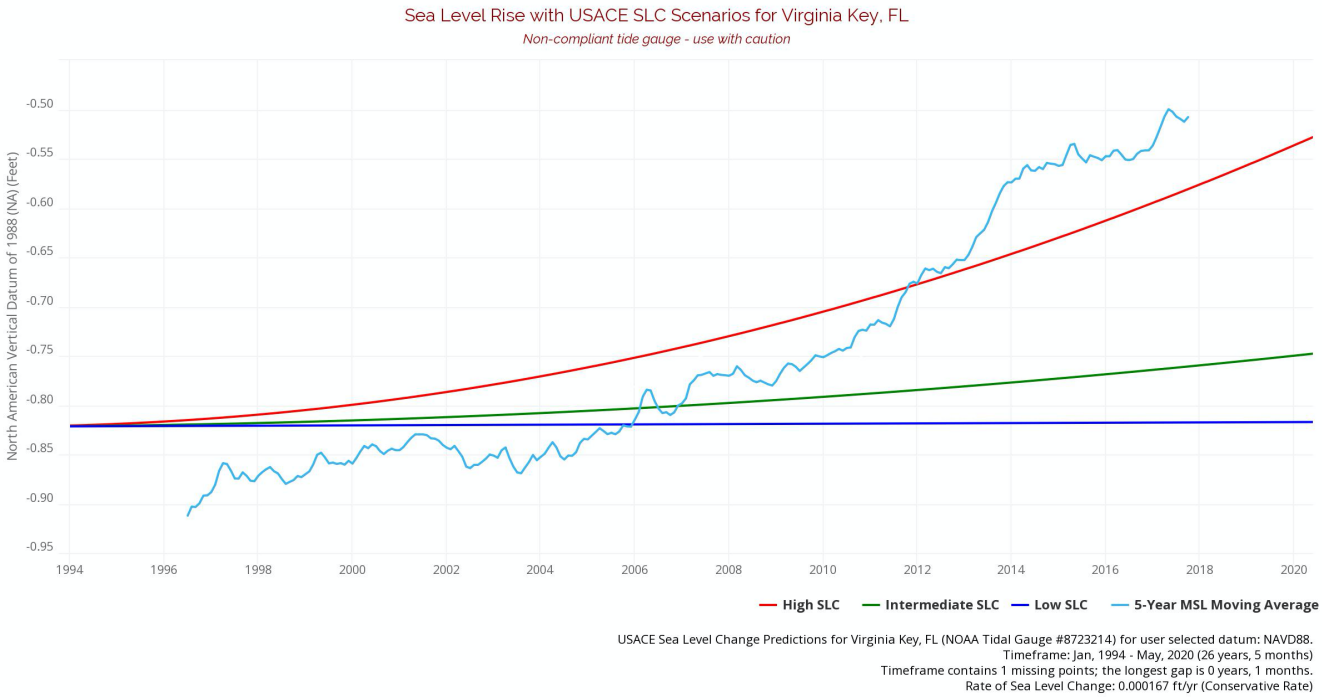
On December 3, 2019, the Miami-Dade Board of County Commissioners passed resolution no. R-1333-19 directing the Mayor or Mayor's designee to:

"conduct a study regarding the impacts of sea level rise on the agricultural community in Miami-Dade County, and to prepare a report on how best to protect that community and its agricultural products from such impacts."

Scope

This study assesses the current and potential future impacts of sea level rise in the agricultural areas, which are concentrated in South Miami-Dade County outside of the urban development boundary (UDB). It evaluates the effect of sea level rise on salt water intrusion, groundwater levels, and to a limited degree, changes in storm surge risk. It focuses on sea level rise impacts through 2040 in order to align with Miami-Dade County's Comprehensive Development Master Plan (CDMP) and the limited assumptions that can be made about future canal management practices. For planning, Miami-Dade County relies on observations and modeling. The tide gauge on Virginia Key has recorded an increase of more than 4 inches in average sea level since 1994[1]. The *Unified Sea Level Rise Projection for Southeast Florida* developed by the Southeast Florida Regional Climate Change Compact[2] is updated every five years, last in 2019, by a panel of scientists to reflect the current best available data and models. The latest science indicates that mean sea levels will likely be between 10 to 17 inches higher than 1992 levels (the compact's reference year) by 2040 and 21 to 40 inches higher by 2070 (Figure 2).

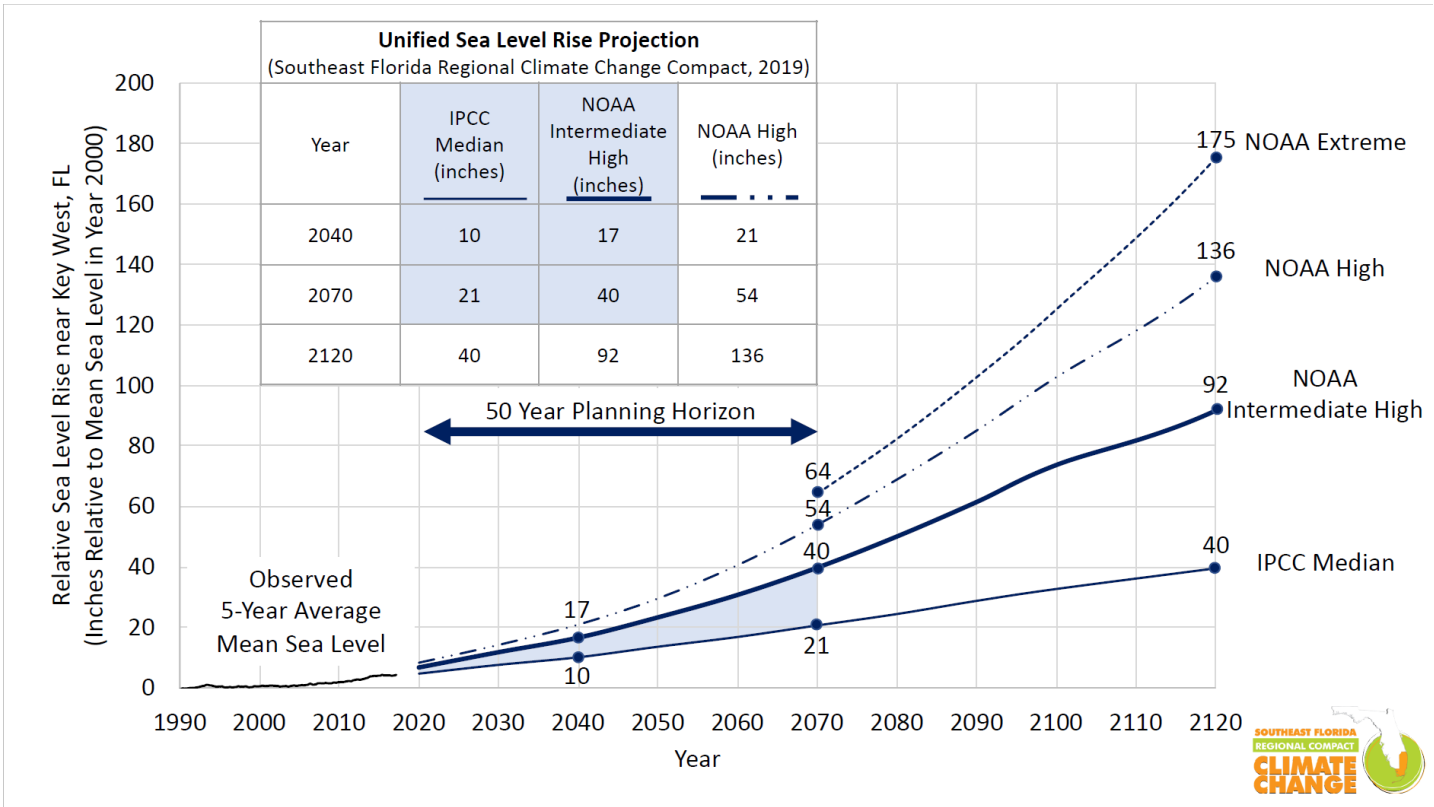
Figure 1: Sea Level Rise observations at Virginia Key



[1] This increase is based on the calculated sea levels at the Virginia Key tide gauge from 1994 through September 2018. Data available at https://climate.sec.usace.army.mil/slr_app/

[2] Southeast Florida Regional Climate Change Compact Sea Level Rise Work Group (Compact). February 2020. A document prepared for the Southeast Florida Regional Climate Change Compact Climate Leadership Committee. 36p.

Figure 2: Unified sea level rise projection for Southeast Florida



Methods

The research for this report was conducted from January to March 2020 by the Office of Resilience in the Department of Regulatory and Economic Resources. It involved direct engagement with members of the agricultural community, analysis of documents referenced within the report, and the support of numerous county employees.

Acknowledgements

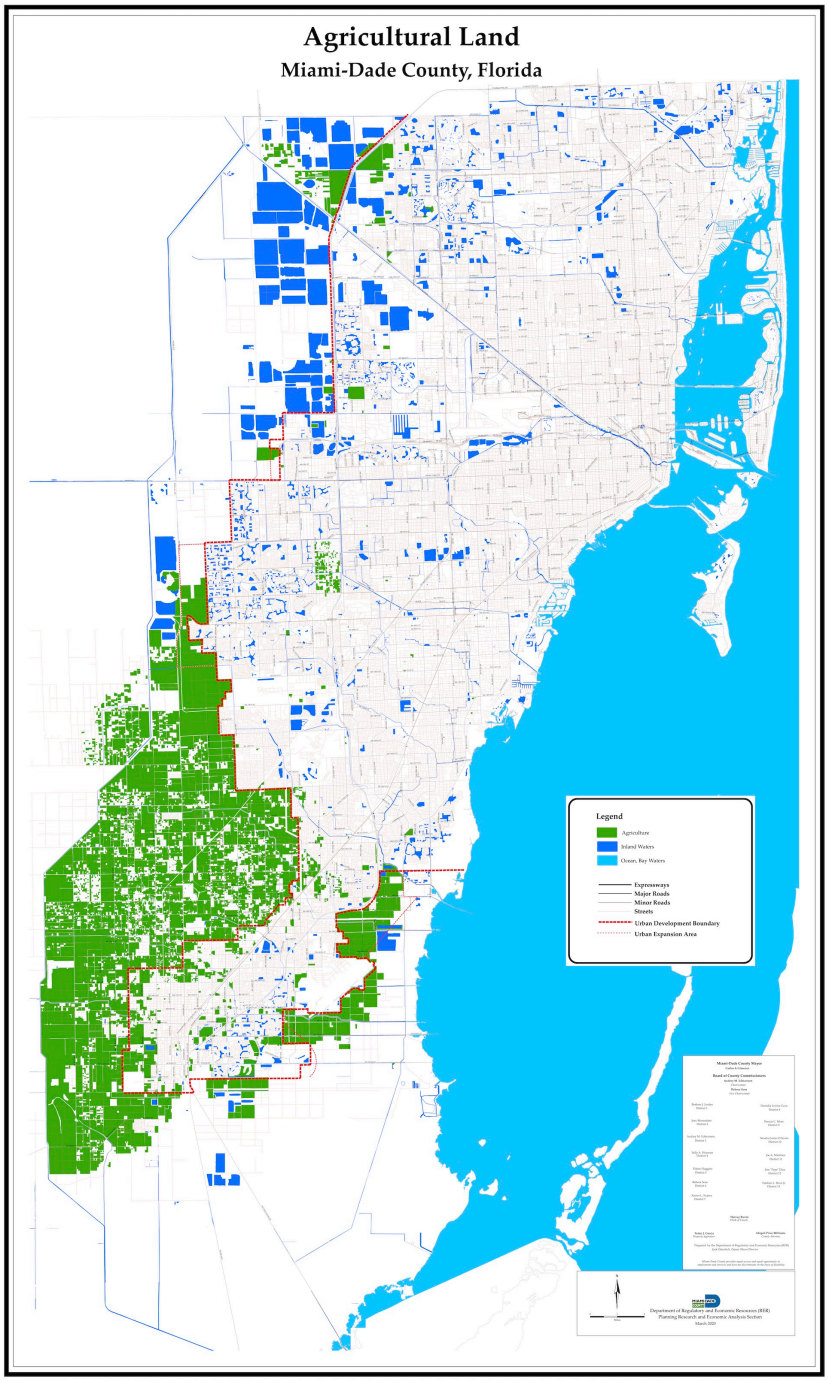
We would like to thank the members of the Miami-Dade Agricultural Practices Advisory Board, Teresa Olczyk and the University of Florida Institute of Food and Agricultural Sciences (UF/IFAS) Extension Miami-Dade County faculty and staff who host the annual Farm Tour and luncheon, Dr. 'Gilly' Evans and the Tropical Research and Education Center (TREC) staff, Akin Owosina, Brenda Mills, and Dr. Carolina Maran of the South Florida Water Management District, Tyra Phillips, Mick Gnaegy, Jonathan Fried, Levis Tores, Jacquelyn St. Jacques, Miami-Dade County Agricultural Manager Charles LaPradd and everyone in the agricultural community who shared their expertise with us.

Agriculture in Miami-Dade County

100+ years of farming

Agriculture has been part of Miami-Dade County since it was founded. The 2002 Miami-Dade County Agricultural Land Retention Study called it the "crown jewel" of Florida's farmland[3]. The subtropical climate, water, and convergence of farmers and entrepreneurs from around the world has created a truly diverse agricultural community. In the late 19th and early 20th century, farms in the County supplied traditional vegetables and citrus to the rest of the country during winter months. These were grown in the rich marl soils in pot holes and glades extending from the Everglades beyond the ridge east to the coast[4]. In the 1950s, rock-plowing and other mechanized farming techniques enabled agriculture to expand to the higher rocklands areas, 5-20 feet above sea level[5]. Tropical fruit production, which began in the early 1900s, flourished as farmers experimented with avocados, mangos, limes, and the development of markets for less well known 'exotic' species, influenced by migrants from other tropical areas. Entrepreneurial farmers also developed niche markets in aquaculture, including exotic fish. The end of the 20th century was marked by a rise in plant nurseries as international trade agreements, rising labor prices, and other market pressures diminished South Florida's competitive advantage in winter vegetables and tropical fruits.

Figure 3: Map of Agricultural Land in Miami-Dade County – Green indicates agricultural land and red dashed line is the Urban Development Boundary.



Farming today

Agriculture and related industries support 270,000 (15%) jobs in Miami-Dade County and contribute $18 billion (12%) to gross regional product[6]. Direct farm sales are $838 million per year, the 2nd highest grossing county and 11% of all

[3] Degner, R., Stevens, T., and Morgan, K. 2002. Miami-Dade County Agricultural Land Retention Study. University of Florida Institute of Food and Agricultural Sciences.
[4] Kotun, K., & Renshaw, A. 2014. Taylor Slough hydrology. *Wetlands*, *34*(1), 9-22.
[5] Li, Y. 2018. SL 183: Calcareous Soils In Miami-Dade County. UF/IFAS. https://edis.ifas.ufl.edu/tr004
[6] UF/IFAS 2019 Annual Report. https://ifas.ufl.edu/media/ifasufledu/ifas-dark-blue/docs/miami-dade.pdf

agricultural production in Florida, led by the nursery business which produces $697 million in sales annually[7]. In addition, the county produces winter vegetables ($86 million) and tropical fruits like avocados, mangos, and lychee ($44 million). Substantial agricultural investments are underway in the County, including Atlantic Sapphire Salmon Farm which aims to invest up to $340 million[8], shade houses that produce high-end nursery plants, and exotic fruits for Asian markets across North America. Agricultural activity is concentrated in Southern and Southwestern areas of the county, outside the urban development boundary (see Figure 3).

The agricultural community is diverse and vibrant. It includes farmers, service providers, distributors, technical experts and farm workers. Farmers are led by prominent farm families with generations of history in the County, and the average farmer is in their late 50s. Farm workers are younger, average age 31, primarily immigrants from Guatemala, Mexico, and El Salvador, are 62% female, and 37% indigenous[9].

Agriculture in the County is supported by technical experts and educators. The Miami-Dade County Agricultural Manager provides technical support and assistance to growers. The University of Florida Institute of Food and Agricultural Sciences (UF/IFAS) Extension in Miami-Dade County[10] and Tropical Research and Education Center (TREC) support agriculture through research and education. UF/IFAS Extension is the liason between the researchers and the local agricultural community. Extension staff provide essential education and technical support on a wide variety of topics and coordinate an annual farm tour. TREC provides research tailored to South Florida on tropical and subtropical crops, management practices, climate change – including sea level rise, and agricultural economics. This unique research facility has been supported by the local agricultural community for decades and is not as well known by the wider community. It is a major reason the agricultural community is as diverse and entrepreneurial as it is. TREC already produces science that can support the agricultural community's response to sea level rise. For example, a study of the C-111 basin by UF/IFAS TREC researchers demonstrated that damaging groundwater levels in the winter growing season are primarily driven by canal management, rather than rain events. In summer when canal levels are higher, rain drives root zone saturation and crop damage[11].

In addition, Miami-Dade Public School's Career and Technical Education (CTE) Agriculture, Food, and Natural Resources career pathway provides hands-on training in agriculture, horticulture, and veterinary science to hundreds of students[12], the future generation of South Florida farmers.

The agricultural community faces multiple challenges that are more immediate than sea level rise. For producers, these include changing markets for produce and landscaping plants, diseases including Laurel Wilt which has hurt avocado production[13], high labor costs relative to foreign competitors, an aging generation of farm operators, development pressure, farmland ownership patterns including short-term leases, and external shocks including COVID-19. Challenges for farm workers include low wages, lack of affordable housing, language and cultural barriers, and health risks including extreme heat[14].

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[7] USDA National Agricultural Statistics Service. 2017 Census of Agriculture. County Profile: Miami-Dade County. https://www.nass.usda.gov/Publications/AgCensus/2017/Online_Resources/County_Profiles/Florida/cp12086.pdf

[8] Board of County Commissioners citizen's presentation by Jose Prado regarding Atlantic Sapphire Salmon Farm. December 17, 2019.

[9] We County. (2018). The Human Landscape: Wages and working conditions of plan nursery workers in south Miami-Dade County. https://www.we-count.org/uploads/Documents/The%20Human%20Landscape%20FINAL.pdf

[10] UF/IFAS Extension in Miami-Dade County is partially funded by Miami-Dade County and is housed within the Department of Parks Recration and Open Space. Extension agents are both University of Florida and County employees.

[11] Zhang, M., Migliaccio, K. W., Her, Y. G., & Schaffer, B. 2019. A simulation model for estimating root zone saturation indices of agricultural crops in a shallow aquifer and canal system. *Agricultural water management*, *220*, 36-49.

[12] https://www.ctemiami.net/agriculture-food-natural-resources-3/

[13] https://sfyl.ifas.ufl.edu/miami-dade/agriculture/laurel-wilt---a-disease-impacting-avocados/

[14] We County. 2018. The Human Landscape: Wages and working conditions of plant nursery workers in south Miami-Dade County. Homestead, FL.

Regional water management

Water management is essential for successful farming in Miami-Dade County's porous limestone soils and low elevations. Besides agriculture, limited freshwater is also need to meet demands public water supply, industrial use, recreation, power generation, and ecosystem health. Water managers and the agricultural community are in ongoing communication about the construction and operation of water management infrastructure that serves as well as protection against flooding and salt water intrusion. Sea level rise is expected to make balancing these competing interests more difficult and require new operational decisions[15].

Canal projects, built for drainage and transportation in the first half of the 20th century, and prolonged drought in the 1930s, caused inward movement of salt water into South Florida's freshwater aquifers. This was mitigated and managed through installation of salinity control structures as part of the Central and Southern Florida Flood Control Project (C&SF Project), a massive regional water management effort that transformed South Florida[16]. Farming on agricultural lands east of US1, in the "East Glade" is supported by the seasonal drawdown, an annual water management practice that has been conducted for over forty years by South Florida Water Management District (SFWMD) staff in consultation with local farmers. With this process, gates at coastal control structures in South Miami-Dade are opened at a lower level in order to increase the root zone depth and facilitate planting in October, after which it opens in a mid-range to support agricultural practices during the winter dry season[17]. SFWMD is currently working with the U.S. Army Corps of Engineers (USACE) to identify funding to update the C&SF Project through the Central & Southern Florida Flood Resilience Study. This study would assess vulnerability of the existing, aging system to climate change, including sea level rise, and identify a phased approach to reducing existing and future flood risk[18].

The primary water management challenge for agricultural land west of the US 1 corridor, including the Redland area in Southwest Miami-Dade, is surface and root zone flooding from groundwater and rainfall. Because the land is extremely porous and drains quickly, flooding only occurs when the water table reaches the surface or high enough into the root zone to damage plants. Over the past twenty years, the Comprehensive Everglades Restoration Project (CERP) has increased the flow of water to the neighboring Everglades[19]. Members of the agricultural community perceive that this has led to relatively higher groundwater levels in South Miami-Dade agricultural areas. In 2016, SFWMD met extensively with agricultural stakeholders and identified possible solutions including a curtain wall seepage barrier and management changes[20]. Multiple management changes have been implemented and construction of a seepage barrier is under review by SFWMD. Groundwater flooding continues to regularly damage crops, including vegetables and fruit trees. Vegetable crops like green beans, tomatoes, and squash can survive for a limited time with as little as eight inches of unsaturated soil, while trees like avocadoes require up to twenty-four inches of unsaturated root zones to avoid damage[21].

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[15] National Academies of Sciences, Engineering, and Medicine. 2018. *Progress Toward Restoring the Everglades: The Seventh Biennial Review - 2018*. Washington, DC: The National Academies Press. https://doi.org/10.17226/25198.

[16] Resources on the history of water management in South Florida are available from SFWMD https://www.sfwmd.gov/who-we-are/history and the USACE https://www.saj.usace.army.mil/About/Congressional-Fact-Sheets-2019/C-SF-Project-C/

[17] A full description of the seasonal drawdown is available in: Hall, C.A. July 2010. Operations Report of the South Miami-Dade Seasonal Operations For October 2009 through April 2010. South Florida Water Management District. 18 p.

[18] https://apps.sfwmd.gov/webapps/publicMeetings/viewFile/25437

[19] For current details on CERP efforts see https://www.evergladesrestoration.gov

[20] For information on the South Dade Study including presentations, videos, and proposed actions see https://www.sfwmd.gov/our-work/south-dade-study

[21] See references in Zhang, et al. 2019. A simulation model for estimating root zone saturation indices of agricultural crops in a shallow aquifer and canal system. *Agricultural water management*, *220*, 36-49.

Sea Level Rise in Miami-Dade County

Sea level rise has been rising for the last century and accelerating over the last 20 years according to global satellite data[22] and tide gauges from Key West up the east coast of the U.S.[23]. Since 1994, measurements at the local tide gauge on Virginia Key have recorded an increase of more than four inches in average sea levels (Figure 1)[24]. It is important to continue monitoring changes and refining the projections, and it is essential the County and the agricultural community recognize the risk of sea level rise and invest strategically.

Multiple studies have been provided to the Board of County Commissioners on sea level rise and its impacts on salt water intrusion, roads, septic systems, sanitary sewer and stormwater infrastructure, and County buildings, among other topics[25]. Building on that work, this study provides a basic overview of the impacts that are relevant to agriculture and the water management practices that support it.

Impact on water management

Sea level rise is expected to make the County and SFWMD's task of balancing flood risk, water supply, and salt water intrusion more difficult over time. Sea level rise is already compromising the ability of SFWMD to use its canals, salt water control structures, and pumps to maintain current flood protection and facilitate the hydrostatic pressure necessary to miminize salt water intrusion. The agricultural lands in Miami-Dade County are at the southern end of a complex system that drains the land south of Lake Okechobee. Multiple studies and operational changes have aimed to minimize adverse impacts on agriculture from high groundwater levels and salt water intrusion. Ultimately, to address these issues the County and stakeholders will have to work with SFWMD to assess options for how to upgrade aging coastal control structures to cope with rising sea levels. These upgrades are critical for the County and the agricultural community to make strategic and cost-effective decisions about the future.

SFWMD staff and leadership have requested that the US Army Corps of Engineers conduct an updated Central and Southern Florida Flood Resiliency Study[26]. Until this assessment is complete and plans for infrastructure investments have been made, it will remain difficult to determine how water management practices will change in response to sea level rise and how agricultural land might be impacted in Miami-Dade.

Impact on groundwater

As sea level rises, groundwater levels will rise and flood risk will increase. Groundwater will rise more along the coast, decreasing the groundwater gradient inland and the ability of canals to drain surface water[27]. A detailed discussion of groundwater models in future sea level rise scenarios through 2040 is available in the February 2020 Miami-Dade report titled, "Vulnerability of Sanitary Sewer and Stormwater Infrastructure to Sea Level Rise". Rising groundwater level is a problem for agriculture because it decreases soil storage capacity and decreases the available root zone. Figures 4a-d provide a simplified depiction of how groundwater is likely to rise in future

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[22] Nerem, R. S., Beckley, B. D., Fasullo, J. T., Hamlington, B. D., Masters, D., & Mitchum, G. T. (2018). Climate-change–driven accelerated sea-level rise detected in the altimeter era. Proceedings of the National Academy of Sciences, 115(9), 2022-2025.

[23] Boon, J. D., Mitchell, M., Loftis, J. D., & Malmquist, D. M. (2018) Anthropocene Sea Level Change: A History of Recent Trends Observed in the U.S. East, Gulf, and West Coast Regions. Special Report in Applied Marine Science and Ocean Engineering (SRAMSOE) No. 467. Virginia Institute of Marine Science, William & Mary. https://doi.org/10.21220/V5T17T. Details of tidal records used in this report are available at https://www.vims.edu/research/products/slrc/compare/index.php

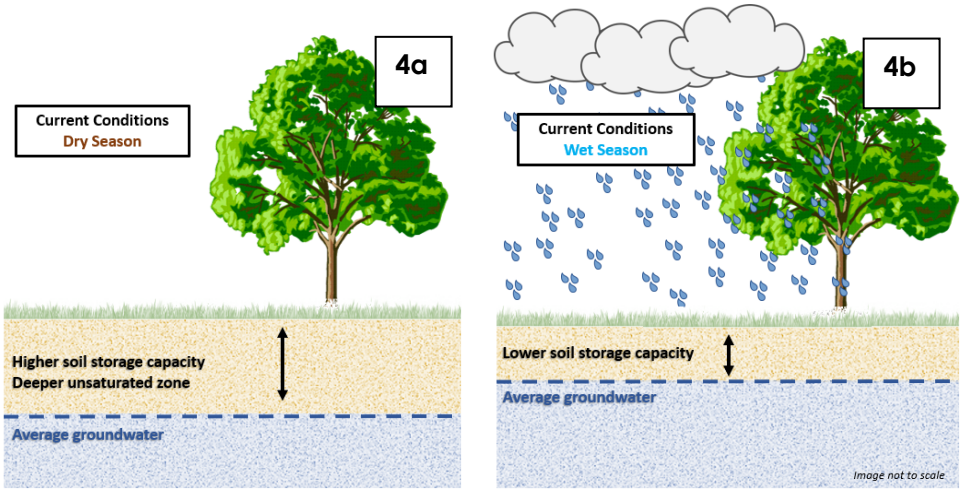
[24] This increased is based on the calculated in sea levels at the Virginia Key tide gauge from 1994 through September 2018. Data available at https://climate.sec.usace.army.mil/slr_app/

[25] These and other reports on sea level rise are available on the Office of Resilience website: https://www.miamidade.gov/global/economy/resilience/sea-level-rise-flooding.page

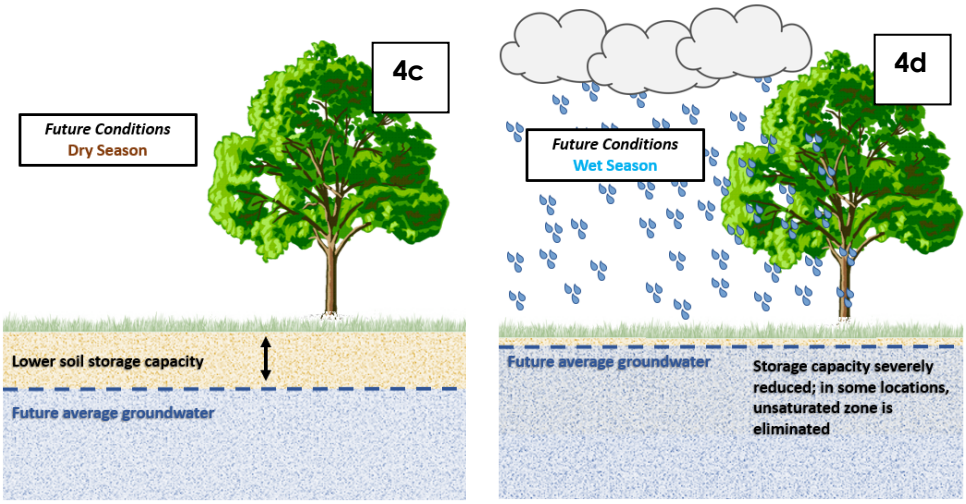
[26] Flood control challenges are summarized in a presentation to the SFWMD Governing Board by Dr. Carolina Maran on March 12, 2020. https://apps.sfwmd.gov/webapps/publicMeetings/viewFile/25445

[27] For a detailed discussion of future scenarios see pg. 95-100 of Hughes, J.D., and White, J.T. (2016). Hydrologic conditions in urban Miami-Dade County, Florida, and the effect of groundwater pumpage and increased sea level on canal leakage and regional groundwater flow (ver. 1.2, July 2016): U.S. Geological Survey Scientific Investigations Report 2014–5162, 175 p. http://dx.doi.org/10.3133/sir20145162.

conditions, making dry season water levels more comparable to wet season conditions, which could potentially lead to more rainfall-driven crop damage during the dry season[28]. Actual impacts in any given location will depend on local conditions including existing drainage infrastructure, soil, and canal management. Detailed modeling on these changes is available in previous sea level rise reports.



Figures 4a and 4b: Average groundwater levels under current conditions in the dry and wet seasons



Figures 4c and 4d: Average groundwater levels under future conditions in the dry and wet seasons

Impact on salt water intrusion

Salt water intrusion already negatively impacts the Biscayne Aquifer, our primary source of drinking water and a source of irrigation for agriculture[29]. The United States Geological Survey (USGS,) in partnership with the Miami-Dade Water and Sewer Department (WASD), has conducted detailed modeling of current (Figure 5) and future salt water intrusion into the Biscayne Aquifer. These models demonstrate that if canals continue to be managed to provide their current level of flood protection and drainage, the salt water intrusion line can be held and public water supply maintained for 25 years or an equivalent of 1.4 feet of sea level rise. However, higher water levels will decrease the canal system's ability to drain urban and agricultural areas, particulary in the southeast.

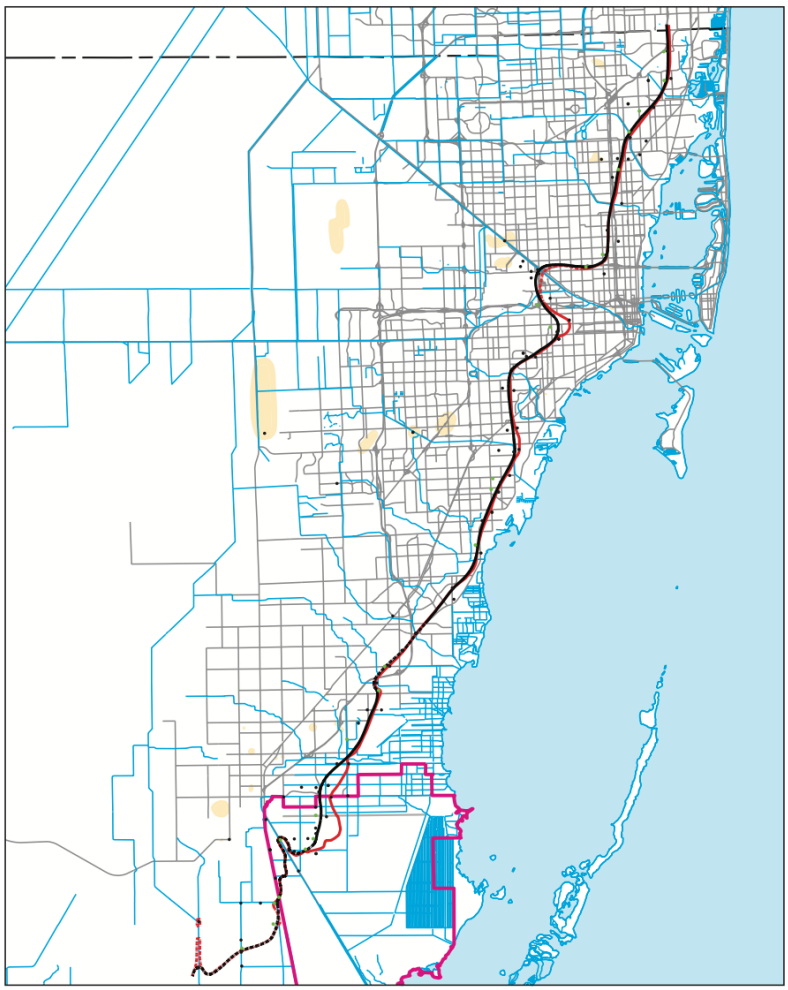
[28] Zhang, M., Migliaccio, K. W., Her, Y. G., & Schaffer, B. 2019. A simulation model for estimating root zone saturation indices of agricultural crops in a shallow aquifer and canal system. *Agricultural water management*, *220*, 36-49.
[29] For an in-depth discussion see Miami-Dade County Report on Flooding and Salt Water Intrusion. 2016.

Additionally groundwater levels are expected to increase 0.1-0.5 feet[30]. Salt water can negatively impact soil and water health by unlocking legacy fertilizer and through sulfidation leading to the accumulation of toxic hydrogen sulfide[31].

Impact on storm surge

South Miami-Dade is exposed to storm surge, however impacts depend on the path of a given storm. Agricultural land east of US 1 is vulnerable to storm surge from a Category 2 or greater hurricane, and much of the agricultural land west of US 1 could be inundated by storm surge from a Category 4 or 5 hurricane[32]. Storm surge levels and associated damage are likely to increase as sea level rises. Existing models contain a great deal of uncertainty, however they are used by insurance companies to set rates paid by the agricultural community. New modeling by Arcadis for the South Florida Water Management District (SFWMD) found that three simulated storms, produced 5-8 ft. of storm surge in Biscayne Bay and flooded southern portions of the County. In this model storm surge would move dramatically further inland into agricultural areas around Homestead under 1, 2, and 3 foot sea level rise scenarios[33].

Figure 5: Map of the Approximate Inland Extent of Saltwater in 2018, black line, and 2011, red line, at the Base of the Biscayne Aquifer in Miami-Dade County, Florida. Tan areas are well fields and the pink line indicates the approximate boundary of the Model Land Area.



Source: USGS

[30] Hughes, J.D., and White, J.T.. 2016. Hydrologic conditions in urban Miami-Dade County, Florida, and the effect of groundwater pumpage and increased sea level on canal leakage and regional groundwater flow (ver. 1.2, July 2016): U.S. Geological Survey Scientific Investigations Report 2014–5162, 175 p., http://dx.doi.org/10.3133/sir20145162.

[31] Tully, K., Gedan, K., Epanchin-Niell, R., Strong, A., Bernhardt, E.S., BenDor, T., Mitchell, M., Kominoski, J., Jordan, T.E., Neubauer, S.C. and Weston, N.B., 2019. The invisible flood: The chemistry, ecology, and social implications of coastal saltwater intrusion. *BioScience*, 69(5), pp.368-378.

Tully, K.L., Weissman, D., Wyner, W.J., Miller, J. and Jordan, T., 2019. Soils in transition: saltwater intrusion alters soil chemistry in agricultural fields. *Biogeochemistry*, 142(3), pp.339-356.

[32] http://frances-a.cs.fiu.edu/gic/

[33] Personal communication with SFWMD staff.

Consequences of Sea Level Rise for the Agricultural Areas of Miami-Dade County

Seasonal drawdown is likely to be compromised

The seasonal drawdown will be increasingly difficult to implement as sea levels rise and King Tides prevent flood gates from opening or risk salt water intruding further inland. Salt water intrusion could damage salt intolerant crops, compromise irrigation sources, and negatively impact soil productivity and water quality east of U.S. 1.

Loss of root zone due to rising groundwater will require adaptation

Rising groundwater will decrease the rootzone and threaten crops. As sea level rise continues to compromise the canal system's level of service the ability to maintain the existing root zone will also be compromised. These impacts will be felt first along the coast and in areas where groundwater is currently closest to the surface.

Costs may rise and land value may fall

Modeling storm surge in South Miami-Dade is particularly difficult[34]. However, higher storm surge associated with sea level rise is likely to expose more agricultural land and buildings to damage. The increased risk associated with this exposure could lead to higher insurance costs and potentially the loss of USDA crop insurance coverage. Even though many farmers in Miami-Dade County self insure against hurricane damages, this would increase the overall cost of business for farmers. It would also limit their ability to secure financing for new ventures. Additionally, agricultural land values in some areas may be negatively impacted by sea level rise.

Septic systems may be compromised and could impact drinking water wells

Much of the agricultural community relies on private wells for drinking water and septic systems to treat their wastewater. As groundwater levels rise septic system operation will be increasingly compromised[35]. Like loss of root zone, these impacts will be felt first in areas where the groundwater is currently closest to the surface. This will necessitate added expenses for repairing or replacing septic systems and may pose health risks including possible drinking well contamination.

Ongoing Adaptation and Proposed Solutions

The agricultural community is already adapting to changing conditions in ways that will help it respond to sea level rise impacts. For example, farmers are using raised beds and additional soil to increase the root zone. They are also investing in high groundwater and salt water tolerant crops, hydroponics, container farming, and aquaculture[36]. To adapt to increased salinity, some producers east of US 1 have shifted production towards species like palm trees that can tolerate higher salinity and groundwater. This year, the Board of County Commissioners adopted amendments to the County's CDMP that include updates on existing conditions, modeled future conditions, and recommendations for future growth and development that increase Miami-Dade County's resilience to sea level rise and other hazards, with specific attention to agricultural areas. In addition, the Miami-Dade Water and Sewer Department has begun to research a new use of targeted pumping and aquifer recharge as a tool to prevent salt water intrusion and maintain a viable root zone for agriculture as sea level rise compromises the drainage system or forces operational changes to current water management.

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[34] SFWMD has recently developed new storm surge models for South Miami-Dade with the support of ARCADIS that will enable more detailed examination of inundation under future sea level rise conditions.

[35] For detailed analysis of impacts of sea level rise on septic system see Miami-Dade County report on Septic System Vulnerability to Sea Level Rise. 2018.

[36] Personal communication and The City Water Resilience Approach. 2019. City Characterization Report: Miami. https://www.arup.com/perspectives/publications/research/section/city-characterisation-report-miami

Conclusions

As the County implements strategies to respond to sea level rise along with the Strategic Plan for Economic Development in South Miami-Dade[37], it is important to remember that the agricultural community is an integral part of what makes Miami-Dade County resilient. Farmers have helped build our prosperity through creativity and experimentation. They provide locally-grown food, economic diversity, jobs, and a sense of place. Rising sea levels are expected to increase groundwater tables, impact our freshwater supply, exaserbate flood risk, increase storm surge, and complicate water management.

Sea level rise is a stress that complicates the challenges farmers in Miami-Dade County face today. The agricultural community is entrepreneurial and can adapt to changing conditions, however they will need the support of the entire county to successfully transition crops and markets as sea levels rise. Miami-Dade County can support this transition in multiple ways. It can continue to fund successful programs like the Purchase of Development Rights Program[38] ~~and the Environmentally Endangered Lands Program~~; support SFWMD efforts to reduce the impact on Miami-Dade farmers from higher water levels in the Everglades; pursue collaborative sollutions such as WASD's targeted aquifer storage and recharge system for lowering groundwater levels; continue work with stakeholders and agencies to model and study ongoing challenges in order to support cost-effective solutions that reduce risk; and work to support continued farming through planning and regulations that acknowledge the unique challenges farmers face in Miami-Dade.

The United States Department of Agriculture has identified climate change – including sea level rise – as a major challenge for farmers[39]. It will expose farm workers to intense heat, introduce new diseases, alter when and where crops can be grown, and introduce new uncertainty into the system. In South Florida, hurricanes and more intense rainfall could increase crop damage in the future[40].

However, farmers are also expected to play an active role in addressing climate change through regenerative practices that build soil health and sequester carbon, develop new more resilient crops, and create innovative solutions like co-locating solar and agriculture on the same land[41]. Florida farmers, including many in Miami-Dade, are actively investigating new revenue streams that can help adapt to climate change and reduce emissions[42]. With the support of the Board of County Commissioners and the community as a whole the agricultural community in Miami-Dade County will continue to innovate in response to climate change.

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[37] To be completed in fall 2020. For more information: https://www.southdadeedc.com/strategic-plan/
[38] Purchase of Development Right Program, R-1036-07
[39] United States Department of Agriculture. 2020. USDA Science Blueprint. Washington, D.C.
[40] Her, Y.G., 2018. [AE528] Hurricane Impacts on Florida's Agriculture and Natural Resources. *EDIS*, *2018*(5).
Rosenzweig, C., Tubiello, F.N., Goldberg, R., Mills, E. and Bloomfield, J., 2002. Increased crop damage in the US from excess precipitation under climate change. *Global Environmental Change*, *12*(3), pp.197-202.
[41] Research has shown agrivoltaic farming can decrease water consumption and increase fruit production. https://www.nrel.gov/news/features/2019/beneath-solar-panels-the-seeds-of-opportunity-sprout.html
[42] Harris, A. (2019). As climate change hits Florida agriculture, could the future be 'carbon farming'? *Miami Herald*. August 19. Access here: https://www.miamiherald.com/news/local/environment/article234030662.html

Recommendations

The following recommendations aim to fulfill the Board of County Commissioners' request for strategies to protect the agricultural community and its products from sea level rise. They were identified through engagement with members of Miami-Dade's agricultural community. In order to provide the data and tools that will allow Miami-Dade's agriculture community to succesfully adjust to changing conditions, including climate change and sea level rise, we recommended the following:

1) Support the South Florida Water Management District's effort to prepare its water management structures and operations for sea level rise by conducting the Central & Southern Florida Flood Resiliency Study with the US Army Corps of Engineers. The study should be utilized to guide future infrastructure investment and direct explicit attention to limiting salt water intrusion and maintaining historic groundwater levels to minimize adverse impacts on Miami-Dade's agricultural areas.

2) Continue to support cost-effective adaptation and innovation through continued groundwater and salt front modeling and monitoring performed in partnership with the USGS, as well as economic modeling and applied research into climate resilient crops by working with agencies and stakeholders including the University of Florida Institute of Food and Agricultural Sciences Extension (UF/IFAS) Tropical Research and Education Center (TREC) and Extension in Miami-Dade County.

3) Ensure stakeholders in the agricultural community participate in the County's planning and regulatory response to sea level rise through the County's Agricultural Practices Advisory Board (APAB), the Agricultural Manager, and the Comprehensive Development Master Plan with the technical support of the Regulatory & Economic Resources Department (RER) and the Miami-Dade Water and Sewer Department (WASD).

Bibliography

Boon, J. D., Mitchell, M., Loftis, J. D., & Malmquist, D. M. (2018). Anthropocene Sea Level Change: A History of Recent Trends Observed in the U.S. East, Gulf, and West Coast Regions. Special Report in Applied Marine Science and Ocean Engineering (SRAMSOE) No. 467. Virginia Institute of Marine Science, William & Mary. https://doi.org/10.21220/V5T17T.

City Water Resilience Approach. (2019). City Characterization Report: Miami. London, UK. https://www.arup.com/perspectives/publications/research/section/city-characterisation-report-miami

Degner, R., Stevens, T., and Morgan, K. (2002). Miami-Dade County Agricultural Land Retention Study. University of Florida Institute of Food and Agricultural Sciences.

Hall, C.A. July 2010. Operations Report of the South Miami-Dade Seasonal Operations For October 2009 through April 2010. South Florida Water Management District. 18 p.

Her, Y.G., 2018. [AE528] Hurricane Impacts on Florida's Agriculture and Natural Resources. *EDIS*, *2018*(5).

Hughes, J.D., and White, J.T. (2016). Hydrologic conditions in urban Miami-Dade County, Florida, and the effect of groundwater pumpage and increased sea level on canal leakage and regional groundwater flow (ver. 1.2, July 2016): U.S. Geological Survey Scientific Investigations Report 2014–5162, 175 p. http://dx.doi.org/10.3133/sir20145162.

Kotun, K., & Renshaw, A. (2014). Taylor Slough hydrology. *Wetlands*, *34*(1), 9-22.

Li, Y. 2018. SL 183: Calcareous Soils In Miami-Dade County. UF/IFAS. https://edis.ifas.ufl.edu/tr004

Nerem, R. S., Beckley, B. D., Fasullo, J. T., Hamlington, B. D., Masters, D., & Mitchum, G. T. (2018). Climate-change–driven accelerated sea-level rise detected in the altimeter era. Proceedings of the National Academy of Sciences, 115(9), 2022-2025.

Rosenzweig, C., Tubiello, F.N., Goldberg, R., Mills, E. and Bloomfield, J., 2002. Increased crop damage in the US from excess precipitation under climate change. *Global Environmental Change*, *12*(3), pp.197-202.

Southeast Florida Regional Climate Change Compact Sea Level Rise Work Group (Compact). February 2020. A document prepared for the Southeast Florida Regional Climate Change Compact Climate Leadership Committee. 36 p. https://southeastfloridaclimatecompact.org/unified-sea-level-rise-projections/

Tully, K., Gedan, K., Epanchin-Niell, R., Strong, A., Bernhardt, E.S., BenDor, T., Mitchell, M., Kominoski, J., Jordan, T.E., Neubauer, S.C. and Weston, N.B., 2019. The invisible flood: The chemistry, ecology, and social implications of coastal saltwater intrusion. *BioScience*, *69*(5), pp.368-378.

Tully, K.L., Weissman, D., Wyner, W.J., Miller, J. and Jordan, T., 2019. Soils in transition: saltwater intrusion alters soil chemistry in agricultural fields. *Biogeochemistry*, 142(3), pp.339-356.

UF/IFAS 2019 Annual Report. https://ifas.ufl.edu/media/ifasufledu/ifas-dark-blue/docs/miami-dade.pdf

US Department of Agriculture. (2020). USDA Science Blueprint. Washington, D.C.

US Department of Agriculture National Agricultural Statistics Service. 2017 Census of Agriculture. County Profile: Miami-Dade County.

We County. (2018). The Human Landscape: Wages and working conditions of plant nursery workers in south Miami-Dade County. Homestead, FL.

Zhang, M., Migliaccio, K. W., Her, Y. G., & Schaffer, B. (2019). A simulation model for estimating root zone saturation indices of agricultural crops in a shallow aquifer and canal system. *Agricultural water management*, *220*, 36-49.