Project Notes:

Project Title: Reducing Freshwater Waste on Farms Through Automatic Irrigation
Name:Noah Proctor

Contents:

Knowledge Gaps:

This list provides a brief overview of the major knowledge gaps for this project, how they were resolved and where to find the information.

Knowledge Gap	Resolved By	Information is located	Date resolved
Under Ground irrigation	Reading Articles	Article 5	9-10
How to interpret weather data to predict rain?	Reading Articles	Article 6	9-15
How to get data from digital sensors	Reading code examples and working hands on	In my GitHub	10-7
How to integrate control theory	Reading Articles	Article 11	10-8
How do hills affect irrigation	Reading Blogs and Articles	Article 21	12-01

Literature Search Parameters:

These searches were performed between (8/07/24) and XX/XX/2019.
List of keywords and databases used during this project.

Database/search engine	Keywords	Summary of search
Google Scholar	Auto irrigation	Lots of articles with complex systems, I was able to find some smaller systems that are similar to my goals
Google Scholar	Underground irrigation	A really interesting article on the benefits of conserving water when the irrigation is conducted underground.
Google Scholar	How to predict weather?	Lots of articles on intense algorithms and equations, I am still on the hunt for a simple and clear method.
Google Scholar	How to predict rain?	Lots of articles on ponding and how to product flooding and puddles from forming when it is going to rain. Some useful equation on determining the amount of water that could be necessary.
Gordon Library	Automatic Irrigation	A lot of articles similar to prior read as well as a fascinating one on control theory
Google Patents	Irrigation	Many patents on irrigation and different types and styles of systems

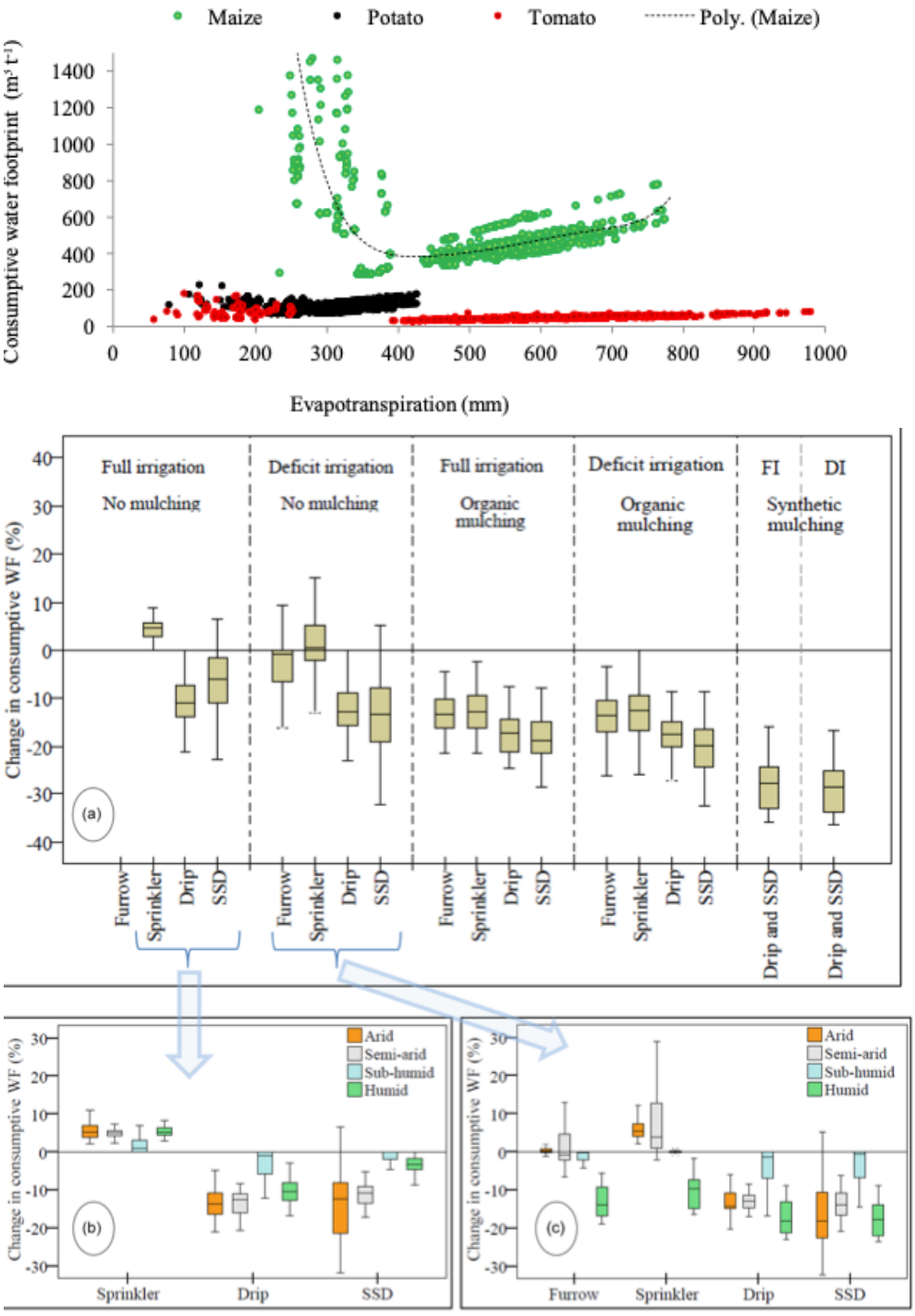
Tags:

Tag Name	
#drip	#goodresoruces
#dripnotgood	#newirrigation
#humid	#flooding
#birds	#WaterContamination
#autoirrigation	#underground
#introduction	#similar
#algorithim	#multisensor
#weatherprediction	#reducewater
#rain	

Article #1 Notes: Green and blue water footprint reduction in irrigated agriculture: effect of irrigation techniques, irrigation strategies and mulching

Article notes should be on separate sheets

Source Title	Green and blue water footprint reduction in irrigated agriculture: effect of irrigation techniques, irrigation strategies and mulching
Source citation (APA Format)	Chukalla, A. D., Krol, M. S., & Hoekstra, A. Y. (2015a). Green and blue water footprint reduction in irrigated agriculture: Effect of irrigation techniques, irrigation strategies and mulching. *Hydrology and Earth System Sciences*, *19*(12), 4877–4891. https://doi.org/10.5194/hess-19-4877-2015
Original URL	https://hess.copernicus.org/articles/19/4877/2015/hess-19-4877-2015.pdf
Source type	Journal Entry
Keywords	Drip irrigation, mulch, reduced water
#Tags	#drip #goodresources
Summary of key points + notes (include methodology)	This article explores the possibilities of different styles of irrigation as well as the reduction of freshwater use. They additionally explored the impact that mulch would have on moisture retention. The main different irrigation types they explored were full, deficit, supplementary, and no irrigation.
Research Question/Problem/ Need	Is plant yield affected by irrigation style and water amount?

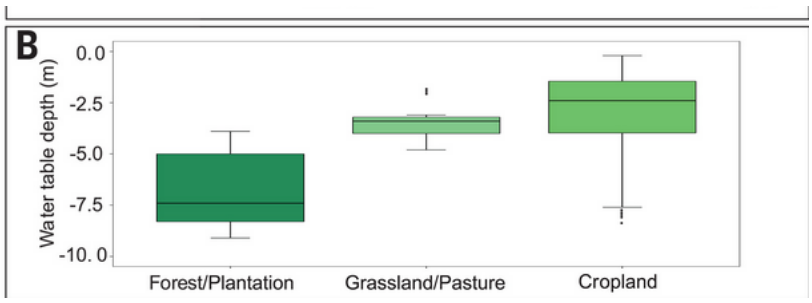
Important Figures	 Graphs of water consumption
VOCAB: (w/definition)	Green water - water held in soil for plants Blue Water - Surface water or groundwater that is used for irrigation and other human needs.

Cited references to follow up on	Al-Said, F. A., Ashfaq, M., Al-Barhi, M., Hanjra, M. A., and Khan, I. A.: Water productivity of vegetables under modern irrigation methods in Oman, Irrig. Drain., 61, 477–489, 2012. Ali, M. H.: Water Application Methods, in: Practices of Irrigation & On-farm Water Management, Springer, New York, USA, 35–63, 2011.
Follow up Questions	Would the research have been better if they were to use moisture sensors? Would the research results have been different if it had been conducted in the US? Would the research results have been different if different plants were used?

Article #2 Notes: Agricultural expansion raises groundwater and increases flooding in the South American plains

Article notes should be on separate sheets

Source Title	Science.com
Source citation (APA Format)	Houspanossian, J., Giménez, R., Whitworth-Hulse, J. I., Nosetto, M. D., Tych, W., Atkinson, P. M., Rufino, M. C., & Jobbágy, E. G. (2023). Agricultural expansion raises groundwater and increases flooding in the South American plains. *Science*, *380*(6652), 1344–1348. https://doi.org/10.1126/science.add5462
Original URL	https://www.science.org/doi/10.1126/science.add5462
Source type	Journal Article
Keywords	Humidity, wet bulb, temperature
#Tags	#humid #flooding #newirrigation
Summary of key points + notes (include methodology)	With rising food needs more and more countries are trying to figure out a way to capitalize on the agricultural industry. Many countries especially in Southern America have gotten into agriculture building large-scale farms. They are tearing out native plants and replacing them with annual crops. These annual crops require much more water than the native plants causing farmers to have to irrigate their fields frequently. With the increased irrigation, the water table continues to rise above its natural levels. This causes large issues when natural rainstorms come in the soil gets overwhelmed and results in flooding. Studies have shown that areas that have annual crops that require lots of irrigation more likely to be susceptible to flooding than those who have natural plants. Removing natural plants can also cause other issues to the soil and its natural balance. Annual crops can use vital nutrients at a faster rate than native crops severely damaging the soil and further damaging the environment.
Research Question/Problem/ Need	More farming is resulting in higher water tables.

Important Figures	 The crop land has the most varied difference in water table. The one with the second most is the Grass Land/Plantation. This could be affected because of the deforestation efforts and other human tampering.
VOCAB: (w/definition)	Hydrological-circulation of water
Cited references to follow up on	Y. Fan, H. Li, G. Miguez-Macho, Global patterns of groundwater table depth. *Science***339**, 940–943 (2013).
Follow up Questions	Would these flooding difference patterns be similar in the United States?

Article #3 Notes: Canada Goose Ecology and Impacts in New Jersey

Article notes should be on separate sheets

Source Title	Rutger.edu
Source citation (APA Format)	Maslo, B., & Lewis, C. (n.d.). *Canada Goose Ecology and Impacts in New Jersey (Rutgers NJAES)*. Retrieved February 10, 2025, from https://njaes.rutgers.edu/fs1214/
Original URL	https://njaes.rutgers.edu/fs1214/#:~:text=Canada%20geese%20are%20carriers%20of,the%20fecal%20coliform%2C%20Escherichia%20coli
Source type	Scientific News
Keywords	Water contamination, fecal matter, geese
#Tags	#Birds #WaterContamination
Summary of key points + notes (include methodology)	Waterfowl feces play a large impact in the cleanliness of our water sources with year after year more and more lakes and ponds having to close because of E. coli numbers. This plays a larger role than just a limited place to cool off in the summer, it can destroy our ecosystems and damage drinking water. Recently the geese and other waterfowl populations are increasing which causes lots of issues, more than just with their feces. Geese are causing issues in farmlands, airports, and other residential areas. In recent years there have been more and more goose-aircraft accidents which can be deadly for both the animals and the passengers onboard the aircraft. They not only get in the way but also leave behind some pretty messy feces. Their feces can carry many other illnesses that can cause major effects on both humans and livestock animals. water can act as a breeding pool for this bacterium allowing for it to quickly grow and reproduce. The bacteria are causing detrimental damage to every aspect of our world from our waterways to our farm fields.
Research Question/Problem/ Need	Bird feces destroying water sources

Important Figures	N/A
VOCAB: (w/definition)	*Branta canadensis*-Species name for Canada Goose
Cited references to follow up on	Clark, L. 2003. A review of pathogens of agricultural and human health interest found in Canada geese. USDA National Wildlife Health Center — Staff Publications. Paper 205.A
Follow up Questions	How can we deter the geese?

Article #4 Notes: Is Earth really getting too hot for people to survive? Article notes should be on separate sheets

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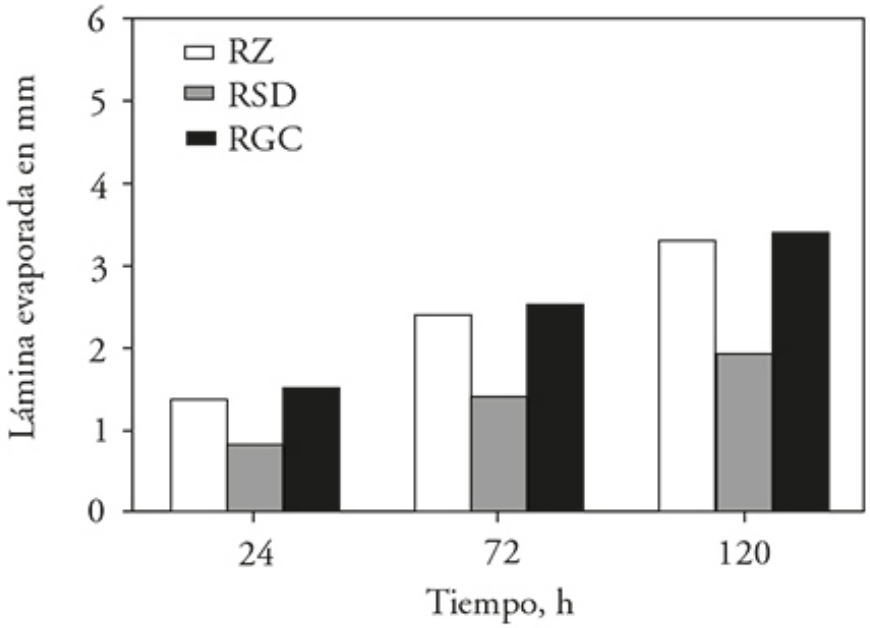
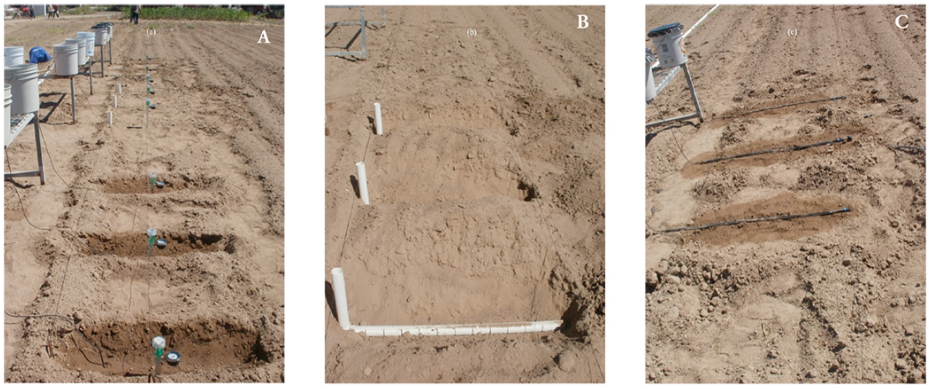
Source Title	LiveScience.com
Source citation (APA Format)	Denning, S. (2024, June 19). *Is Earth really getting too hot for people to survive?*. LiveScience. https://www.livescience.com/planet-earth/climate-change/is-earth-really-getting-too-hot-for-people-to-survive
Original URL	https://www.livescience.com/planet-earth/climate-change/is-earth-really-getting-too-hot-for-people-to-survive
Source type	Scientific News
Keywords	Humidity, irrigation by sky
#Tags	#humidity #irrigation
Summary of key points + notes (include methodology)	Seemingly every summer, the temperatures continue to rise, setting new record temperatures. A large factor in the increasing heat is the constant increase of CO2 in the environment. Every time we consume any type of fossil fuel whether it is coal, gasoline, or oil, the surface temperature of the earth increases. Humidity also has a strong impact on the perceived temperature because the body has a harder time cooling off when it is humid. The human body has adapted over time to cope with the heat by sweating. However, in high-humidity areas, sweat becomes less effective. When sweat loses its effectiveness, the body can no longer regulate its temperature, leading to overheating. The overheating can be detrimental to the body causing serious and even fatal injuries. Rising temperatures and humidity are serious issues and threaten our world. Rising temperatures have detrimental effects on the icebergs causing rising sea levels. Another cause of the increasing humidity is crop irrigation, especially in the southern US. They utilize a form of spray irrigation where water is sprayed down on the crops. Throughout the day some of the water gets absorbed into the soil and later by the plant but the remainder gets evaporated into the environment increasing the humidity. This adds to the perceived temperature making it seem incredibly hot.

Research Question/Problem/ Need	Increasing humidity due to irrigation
Important Figures	NA
VOCAB: (w/definition)	Wet Bulb-temperature from a thermometer that has been covered in a wet cloth to get a more accurate reading of temperature and humidity
Cited references to follow up on	NA
Follow up Questions	Would bans on residential irrigation contribute?

Article #5 Notes: **Design of an underground irrigation system to decrease soil evaporation, as compared with two conventional methods**

Article notes should be on separate sheets

Source Title	scielo.org
Source citation (APA Format)	Lucero-Vega, G., Troyo-Diéguez, E., Murillo-Amador, B., Nieto-Garibay, A., Ruíz-Espinoza, F. H., Beltrán-Morañes, F. A., & Zamora-Salgado, S. (2016). Design of an underground irrigation system to decrease soil evaporation, as compared with two conventional methods. *Agrociencia*, *51*(5).
Original URL	https://www.scielo.org.mx/scielo.php?pid=S1405-31952017000500487&script=sci_arttext&tlng=en
Source type	Research Paper
Keywords	Underground irrigation

#Tags	#dripnotgood #underground #reducewaste
Summary of key points + notes (include methodology)	The underground diffusers were the most efficient over many systems of irrigation including drip irrigation and irrigation in ditches. This was proven by conducting moisture tests by taking soil samples in the different areas of irrigation and then weighing them before and after being baked in an oven at 105 C for 24 hours. Then they were able to calculate the moisture levels. The underground diffusers held the most moisture at all depth levels but performed especially well from 0-10 cm.
Research Question/Problem/ Need	What type of irrigation is the most effect?
Important Figures	 RSD had the least lost water 

	RSD Can be seen in the middle RZ on the left and RGC on right
VOCAB: (w/definition)	RZ (irrigation in ditches) RSD (Irrigation underground by diffusers) RGC (Drip irrigation) RGS (underground drip irrigation)
Cited references to follow up on	Ayars, J.E., A. Fulton, and B. Taylor. 2015. Subsurface drip irrigation in California - Here to stay?. Agric. Water Manage . 157: 39-47. [Links] Dos Santos, L.N., E.E. Matsura, I.Z. Goncalves, E.A.A.Barbosa , A.A.Nazário , N.F.Tuta, M.C.L.Elaiuy, D.R.C.Feitosa, and A.C.M. deSousa. 2016. Water storage in the soil profile under subsurface drip irrigation: Evaluating two installation depths of emitters and two water qualities. Agric. Water Manage . 170: 91-98. [Links]
Follow up Questions	How would a traditional sprinkler irrigation compare to this? If irrigation were to just be piped down in smaller pipes how much clogging could that cause?

Article #6 Notes: Weather Forecast Prediction: An Integrated Approach for Analyzing and Measuring Weather Data

Article notes should be on separate sheets

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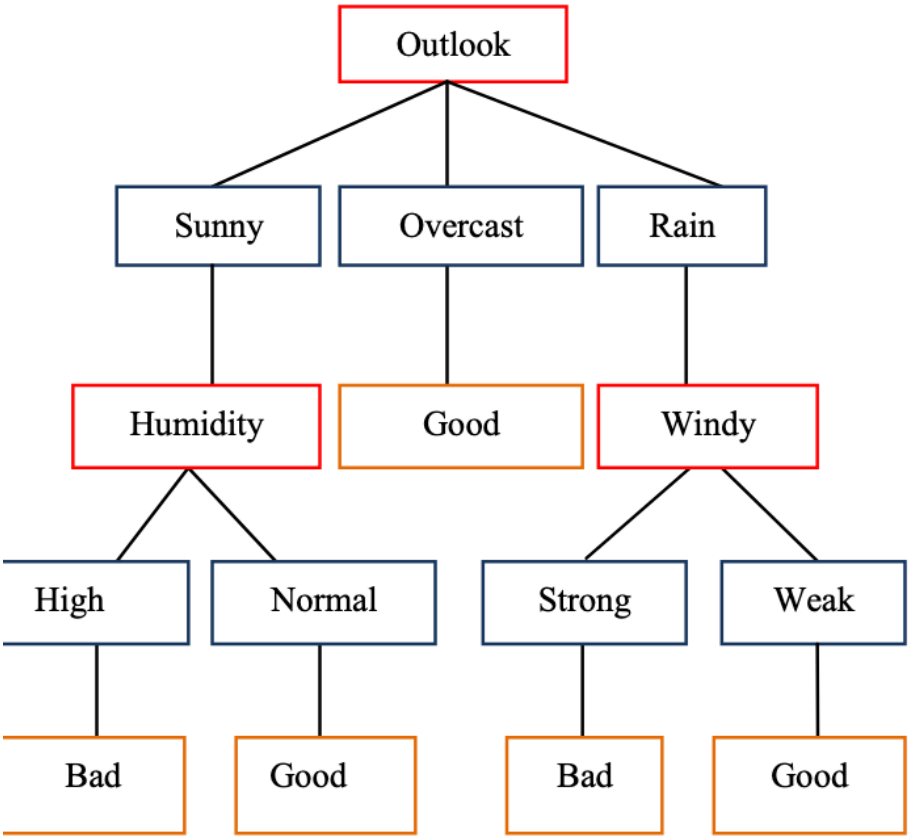
Source Title	Researchgate.net
Source citation (APA Format)	Biswas, M., Dhoom, T., & Barua, S. (2018). Weather Forecast Prediction: An Integrated Approach for Analyzing and Measuring Weather Data. *International Journal of Computer Applications*, *182*, 20–24. https://doi.org/10.5120/ijca2018918265
Original URL	https://d1wqtxts1xzle7.cloudfront.net/63281808/Sayantanu-2018-ijca-91826520200512-40956-1h7izq5-libre.pdf?1589274704=&response-content-disposition=inline%3B+filename%3DWeather_Forecast_Prediction.pdf&Expires=1726096686&Signature=HKdcO-olJAAHmWx6bvSkNB0~uNstj5uE-zpjiLwc~6FxbWCY1gIPE6VHK0SsV9Zq3S8hyn47wr5bmI6q0j5TyxacG8Fd1FrbmIUHmHi43guLwva560u~jfLq~k1sMcGlz5e0DFEbcQ9H1V6WRQMnV8W3ArY8bo7Jw9-XCy7iReIo4zXllQgZHoNH4P3COs~W1AdPbfqLzlIf1CO54gDret8evo-bIgdYfyFP5NwvY8O-CQQn57rZ3qcOusf9MzLhcUNGMcJB2-DVlEKjD38Tv5p6svR6GjNCvrrZfC5uO3AA7vEA7PGfP4PfKOzEvyOx3NqKxVfZhhHuAOjrzA5y0A__&Key-Pair-Id=APKAJLOHF5GGSLRBV4ZA
Source type	Research Paper

Keywords	Chi square, Classification, Naïve Bayes, Prediction, Weather Forecasting
#Tags	#weatherprediction #rain
Summary of key points + notes (include methodology)	This model uses both Naïve Bayes and Chi Square to attempt to predict the statical significance of weather conditions calculated based off of the temperature, sunlight level, humidity, and wind speeds. It uses a data set of these conditions and their outcome weather to determine the significance level and then Notes: Might be hard to run on Arduino
Research Question/Problem/ Need	Could they improve accuracies of weather data using predictive analysis?
Important Figures	 Tree that is followed by the system to determine if the weather is “good” (sunny) or “bad” (rainy).
VOCAB: (w/definition)	Naïve Bayes- Machine Learning Algorithm used for text classification

Cited references to follow up on	Mehrnoosh Torabi, Sattar Hashemi, “A Data Mining Paradigm to Forecast Weather”, The 16th CSI International Symposium on Artificial Intelligence and Signal Processing (AISP 2012),IEEE, pp 579-584. Mr. Sunil Navadia, Mr. Jobin Thomas, Mr. Pintukumar Yadav, Ms. Shakila Shaikh, “Weather Prediction: A novel approach for measuring and analyzing weather data”, International conference on I-SMAC (IoT in Social, Mobile, Analytics and Cloud), (I-SMAC 2017), IEEE, pp 414-41
Follow up Questions	Can I just find values for “if” statements?

Article #7 Notes: Automatic Irrigation System using Arduino UNO

Article notes should be on separate sheets

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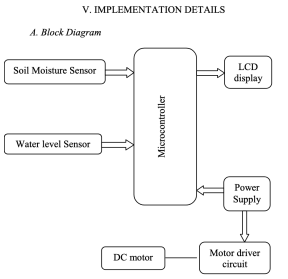
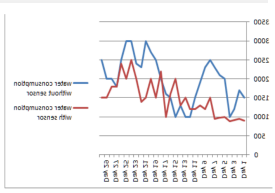
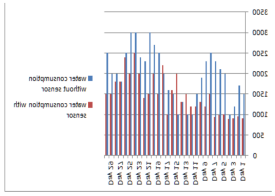
Source Title	IEEE Xplore
Source citation (APA Format)	Taneja, K., & Bhatia, S. (2017, June). Automatic irrigation system using Arduino UNO. *2017 International Conference on Intelligent Computing and Control Systems (ICICCS)*. http://dx.doi.org/10.1109/iccons.2017.8250693
Original URL	http://dx.doi.org/10.1109/iccons.2017.8250693
Source type	Scientific Paper
Keywords	Auto irrigation with Arduino
#Tags	#introduction #similar
Summary of key points + notes (include methodology)	What is the central question? **Is there a way to reduce the amount of water used in agriculture?** Why is this question important? **Agriculture is reasonable for 85% of fresh water consumption.** What data is needed to answer the question? **How much water is used under normal circumstances verses water used when water is being controlled based on moisture.** What methods are used to get the data? **Moisture sensors and water meters.** What analysis must be applied for the data to answer the question? **Different statistical tests to determine if the difference in water used was statistically significant.** What data were obtained? **Amount of water used by both systems** What were the results of the analysis **Water usage when the system had a sensor was a lot less.** How did the analysis answer the central question? **Auto irrigation systems are more water efficient.** What does this answer tell us about the broader field? **It does work and we should do more research into it to learn how to maximize efficiencies.**
Research Question/Problem/	How to reduce the amount of water that is used in agriculture to water plants?

Need	
Important Figures	 Fig.3 Block Diagram of Automated Irrigation System Diagram of the flow of data   Final findings of the efficiencies and which one uses more water
VOCAB: (w/definition)	ATMega328- Chip for data processing and motor control
Cited references to follow up on	S.M Najrul Howlader, Biman Barua, M. Mesbahuddin Sarker, M. Shamim Kaiser, Md Whaiduzzaman, "Automatic Yard Monitoring and Humidity Controlling System Based on IoT", *2023 International Conference on Advanced Computing & Communication Technologies (ICACCTech)*, pp.397-403, 2023.\ Kaniskaa MS, Madanagopal C, Deepa M, Hariprasath K, "Water Level Controller with Weather Forecasting Using 8051 Microcontroller", *2023 7th International Conference on Electronics, Communication and Aerospace Technology (ICECA)*, pp.329-333, 2023.
Follow up Questions	How could analyzing weather data affect this?

Article #8 Notes: A simple accurate method to predict time of ponding under variable intensity rainfall

Article notes should be on separate sheets

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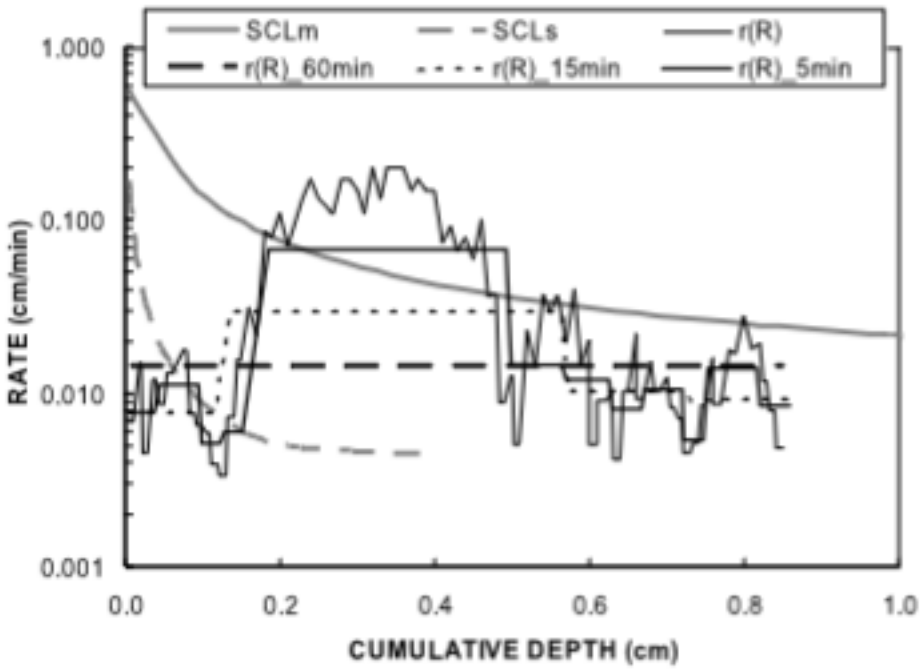
Source Title	Agu pubs
Source citation (APA Format)	| Assouline, S., Selker, J. S., & Parlange, J.-Y. (2007). A simple accurate method to predict time of ponding under variable intensity rainfall. *Water Resources Research*, *43*(3). https://doi.org/10.1029/2006WR005138
Original URL	https://agupubs.onlinelibrary.wiley.com/doi/10.1029/2006WR005138
Source type	Scientific Paper
Keywords	Ponding
#Tags	#algorithim
Summary of key points + notes (include methodology)	They used a lot of equations but most prominently Richard's equation to determine the "ponding" rate of different rain amounts in different soil conditions. They determined this by observing the amount of water that passed through the soil into deeper areas and the amount of water that got stuck towards the top.
Research Question/Problem/ Need	Could they accurately predict flooding based on rain fall and the absorption rate of the soil

Important Figures	 This graph shows the significance of the rate at which the water drops through the soil. It shows the infiltration verse the cumulative infiltration for different soils. It also shows the different time intervals.
VOCAB: (w/definition)	Richard's equation-the way of calculating movement of water in unsaturated soil Hydraulic conductivity, water's ability to pass through pores areas
Cited references to follow up on	Chu, X., and M. A. Marino (2005), Determination of ponding condition and infiltration into layered soils under unsteady conditions, J. Hydrol., 313, 195 – 207
Follow up Questions	Should we change the amount of water that is given to crops based on this?

Article #9 Notes: Patent 1

Article notes should be on separate sheets

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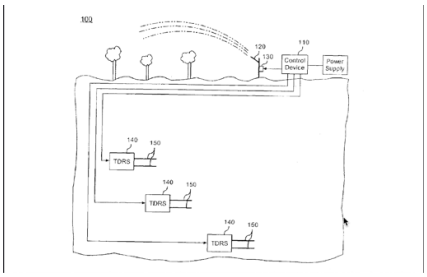
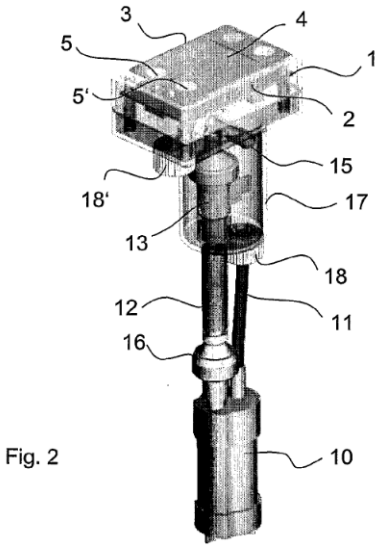
Source Title	Google Patents
Source citation (APA Format)	Dukes, M., Nogueira, L., Cornejo, C., Miller, L., Haman, D., & Scholberg, J. (2005). *Automatic control method and system for irrigation* (U.S. Patent No. 6,978,794 B2). *U.S. Patent and Trademark Office.* https://patentimages.storage.googleapis.com/34/e4/3a/3c12c0d76f7d3b/US6978794.pdf
Original URL	https://patents.google.com/patent/US6978794B2/en
Source type	Patents
Keywords	Irrigation, solenoids, sensors
#Tags	#autoirrigation #multisensor
Summary of key points + notes (include methodology)	An automatic irrigation system that utilizes a solenoid to control the water flow. There are multiple sensors placed a varying soil depth to attempt to get a fairer evolution of the water content. Irrigation can be controlled by a sprinkler
Research Question/Problem/ Need	Is there a way to reduce the freshwater usage on farms and orchards?
Important Figures	
VOCAB: (w/definition)	TDRS – time domain reflectometry sensor
Cited references to follow up on	Roy, K.C. 1998. Irrigation Scheduling of Wheat Using a Computer Program-A Case Study in Bangladesh. In: Inter national Conference on Computers in Agriculture, 7, Orlando, Florida. Proceedings . . . ASAE.

Follow up Questions	What is the benefit of gathering data at multiple depths?

Article #10 Notes: Patent 2

Article notes should be on separate sheets

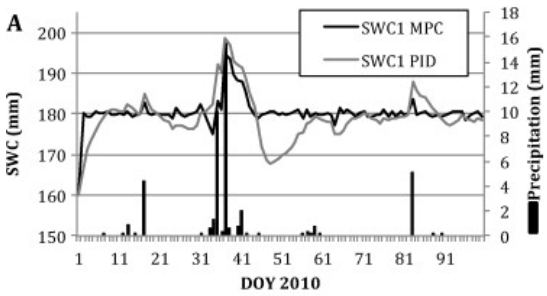
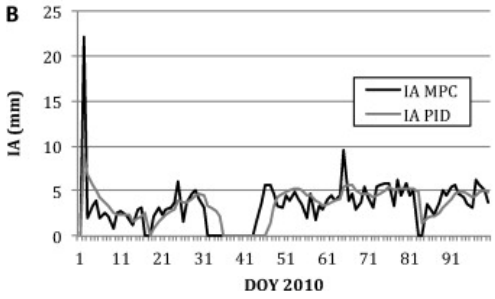
Source Title	Google patents
Source citation (APA Format)	Schmidt, W. (2008). *Watering system for watering plants* (U.S. Patent No. 2008/0302002 A1). *U.S. Patent and Trademark Office.* https://patentimages.storage.googleapis.com/d9/cc/58/b132909a037c88/US20080302002A1.pdf
Original URL	https://patents.google.com/patent/US20080302002A1/en?q=(automatic+irrigation)&country=US
Source type	Patent
Keywords	Plant,watering,automation
#Tags	#autoirrigation
Summary of key points + notes (include methodology)	They wanted to develop a system that could water plants that are meant to be left on balconies. With longer periods of little rain, it becomes a necessity to have a system to automatically water these plants as often they are inconvenient water. They devolved a system that uses the soil moisture as well as humidity in the air to water the plants when it was deemed necessary. Traditional auto watering systems would not work due to the lack of hose spigot.
Research Question/Problem/ Need	Develop a system that could automatically water plants that are in a balcony setting.

Important Figures	 Fig. 2 Gives is a strong insight on how the item works with the water tank located on top and the support structure as well as the cables running up for the data.
VOCAB: (w/definition)	**Tensiometer-used to measure water pressure of soil** **Calcifies-calcium forms and hardens the surface, creating a rock like substance**
Cited references to follow up on	NA
Follow up Questions	How did they determine optimal time of the day to water?

Article #11 Notes: Research on automatic irrigation control: State of the art and recent results. Article notes should be on separate sheets

Source Title	Science Direct

Source citation (APA Format)	Romero, R., Muriel, J. L., García, I., & Muñoz De La Peña, D. (2012). Research on automatic irrigation control: State of the art and recent results. *Agricultural Water Management*, *114*, 59–66. https://doi.org/10.1016/j.agwat.2012.06.026
Original URL	https://www.sciencedirect.com/science/article/pii/S0378377412001746?via%3Dihub
Source type	Scientific Paper
Keywords	Water use efficiency Water productivity Automatic irrigation Control theory Feedback
#Tags	#intro #autoirrigation
Summary of key points + notes (include methodology)	The authors wanted to determine the effectiveness of different automatic irrigation systems. To achieve this they discussed the different types of systems and their benefits. The main two overarching types are closed and open loop systems. Closed loop systems use feedback from prior instances to calculate for next instances while open loop systems are usually hard programed to compensate for mistakes. They were able to find that no matter what style of irrigation was used that there was a significant reduction in the amount of water consumed. They found these by using 4 different styles of algorithms that all yielded similar results.
Research Question/Problem/ Need	Could they integrate an algorithm to reduce the amount of water waste on farms?

Important Figures	  Both graphs show how there was a reduction in the water amount used when there was an increase in both soil moisture and irrigation.
VOCAB: (w/definition)	**Proportional integral derivatives-** It uses measurements of the output variable to determine how much action is needed. It uses the error between the variable and set point, the integral of recent errors, and the rate at which error has been changing. Fuzzy Control Systems- Analyzes analog about that takes a value between 0 and 1, handles situations that aren't always binary Neural Network- Able to capture and represent complex input and outputs. Capable of graphic and determine relationship of nonlinear functions. Aimed to make the decisions that a real human would make Genetic Algorithms- Inspired by Charles Darwin's theory of natural selection. Can be used to construct numerical optimization techniques. Model Predictive Control- Predict the evolution of the system.

Article #12 Notes: Plant nutrition and growth: Basic principles

Article notes should be on separate sheets

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Source Title	Jstor.org

Source citation (APA Format)	Ingestad, T., & Ågren, G. I. (1995). Plant nutrition and growth: Basic principles. *Plant and Soil*, *168–169*(1), 15–20. https://doi.org/10.1007/BF00029309
Original URL	https://www-jstor-org.ezpv7-web-p-u01.wpi.edu/stable/42939838?sid=primo
Source type	Scientific Article
Keywords	growth, nutrition, reference values, relative addition/uptake/growth rate, steady-
#Tags	#plantgrowth #controls
Summary of key points + notes (include methodology)	It discuses the importance of keeping control variables controlled and keeping it in an experimental setting. There are also important values such as the leaf size, plant mass and plant height. It is also important to look at the ratio. Most importantly it is more than essential to make sure that they are all getting the same amount of everything besides what your changing. The sunlight, water, and everything should remain constant throughout.
Research Question/Problem/ Need	What are the important factors to consider when evaluating plants?
Important Figures	NA
VOCAB: (w/definition)	Steady sate -where all the variables are staying the same Mass transport-the movement of nutrients within a plant Nutrient productivity- growth rate per unit of nutrient Modulator-factors that impact growth and nutrient consumption
Cited references to follow up on	Hewitt E J 1966 Sand and Water Culture Methods Used in the Study of Plant Nutrition. 2nd revised ed. Farnham Royal, Common-wealth Agricultural Bureau. 547 p
Follow up Questions	How long does it take to conduct an experiment involving plants and plant growth?

Article #13 Notes: Mobile weather station based on ATmega2560 microprocessor

Article notes should be on separate sheets

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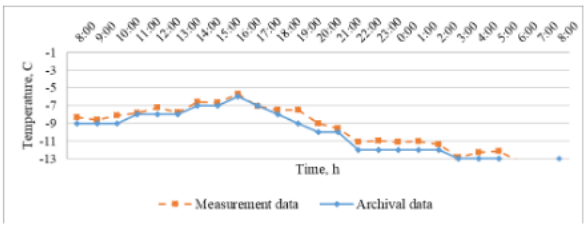
Source Title	IOP Science
Source citation (APA Format)	Semenov, E. S., Ivanchenko, G. S., Kharchenko, A. V., & Kolobanov, R. V. (2019). Mobile weather station based on ATmega2560 microprocessor. *IOP Conference Series: Materials Science and Engineering*, *537*(3), 032086. https://doi.org/10.1088/1757-899X/537/3/032086
Original URL	https://iopscience.iop.org/article/10.1088/1757-899X/537/3/032086/meta
Source type	Journal Article
Keywords	Weather, Pressure, Zambretti
#Tags	#weatherprediction
Summary of key points + notes (include methodology)	Using many different sensors including but not limited to atmospheric pressure, temperature, humidity, and wind speed they were able to predict the weather using the Zanbretti algorithm. They did not specify the logic they used with the algorithm however they did present the results showing the precision of the algorithm and the sensors. The sensors were able to accurately gather data and using the algorithm they could predict weather and use it to send a text message to a phone to warn of the coming weather.
Research Question/Problem/ Need	Could they modernize the Zambetti algorithm to send a text of the weather?

Important Figures	 **Figure 2**. Temperature measurement chart from DS18B20 sensor in comparison with archived data.  Both of these graphs present the accuracies of the sensors that they are using. The slight variability could be that the archive data was from the entire city where this data was from a specific location.
VOCAB: (w/definition)	GSM (Global System for Mobile Communications): A standard for mobile telephony that allows for communication and data transmission over mobile networks. Anemometer: An instrument used to measure wind speed.
Cited references to follow up on	Saini H, Thakur A, Ahuja S and Sabharwal N 2016 3rd Int. Conf. on Signal Processing and Integrated Networks (SPIN) (Noida: Amity University) pp 605-9
Follow up Questions	What was the logic used with the algorithm?

Article #14 Notes Short-term Forecasting Algorithms of Meteorological Data Collection and Processing in Systems

Article notes should be on separate sheets

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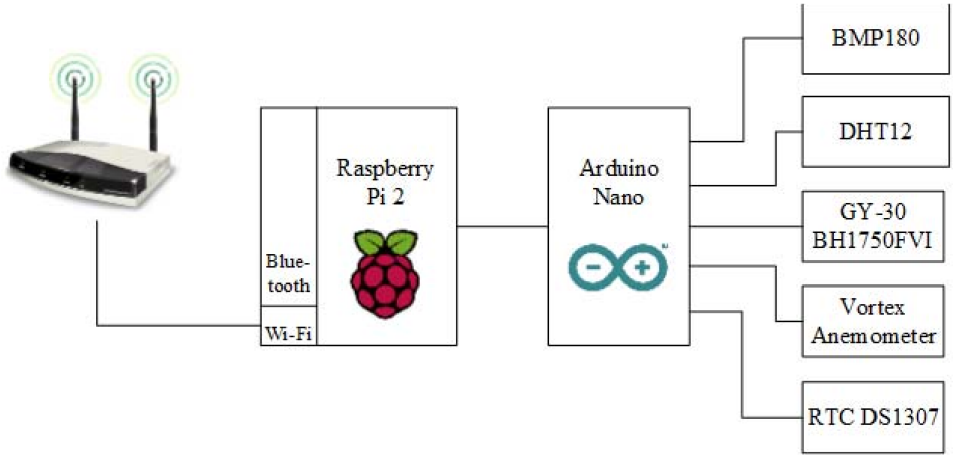
Source Title	IEEE Xplore
Source citation (APA Format)	Babaev, S. I., Potapova, V. Y., Tarasov, A. S., & Stepanov, M. A. (2018). *Short-term forecasting algorithms of meteorological data collection and processing in systems.* In *2018 7th Mediterranean Conference on Embedded Computing (MECO)* (pp. 1–4). IEEE. https://doi.org/10.1109/MECO.2018.8406070
Original URL	https://ieeexplore.ieee.org/abstract/document/8406070?casa_token=IfdM9_m09c8AAAAA:FwOWZ7dK5O0DllWoC4w-FuTkpwJVGz0FwZR8BNFmhTKxOn6rdcH0qY7G1hOEUwaXUOta5VAPZg
Source type	Scientific Paper
Keywords	Raspberry; weather; Wi-Fi; WLAN; meteorological station; IoT; forecasting.
#Tags	#Zambretti
Summary of key points + notes (include methodology)	The authors wanted to write a system and algorithm that was cable of monitoring weather datapoints and creating a forecast that then could be uploaded to the internet. They used an Arduino nano for the data gathering and then sent it to a Raspberry Pi because it was more capable of doing intensive calculations and uploading it to the internet. The authors believed

	that it could have been possible to do everything just using an Arduino however it would have been more complex, especially with the internet side. The explement was mainly focused on attempting to predict nightly frosts and it was relatively successful.
Research Question/Problem/ Need	Could they predict nightly frost and build a mobile weather station?
Important Figures	as a real time clock.  shows the flow chart of how the information was communicated from the sensors to the internet
VOCAB: (w/definition)	
Cited references to follow up on	Osczevski, Randall; Bluestein, Maurice (2005). "The new wind chill equivalent temperature chart". Bulletin of the American Meteorological Society.
Follow up Questions	How did they determine what different things corresponded to?

Article #15 Notes: A Data-Driven Approach for Accurate Rainfall Prediction

Article notes should be on separate sheets

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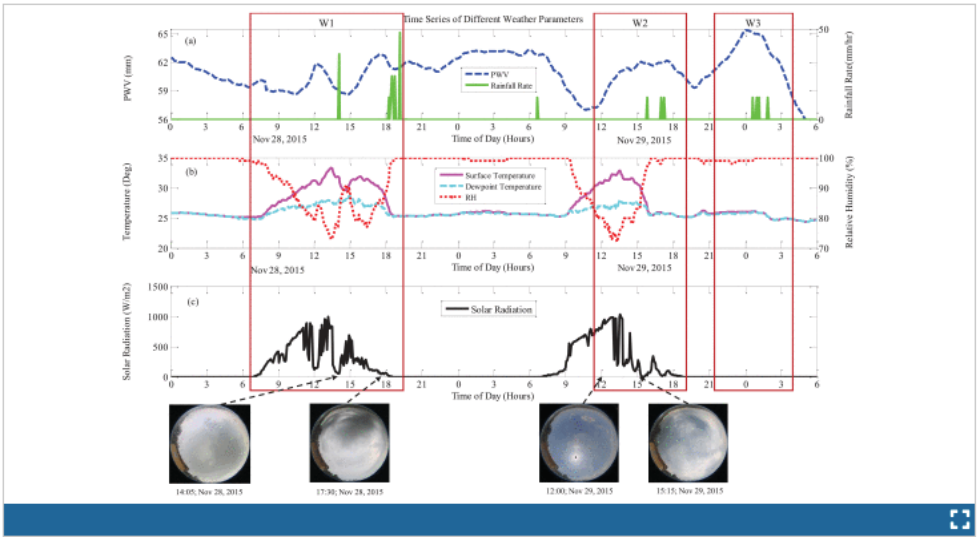
Source Title	IEEE

Source citation (APA Format)	Manandhar, S., Dev, S., Lee, Y. H., Meng, Y. S., & Winkler, S. (2019). A data-driven approach for accurate rainfall prediction. *IEEE Transactions on Geoscience and Remote Sensing, 57*(11), 9323–9331. https://doi.org/10.1109/TGRS.2019.2926110
Original URL	https://ieeexplore.ieee.org/abstract/document/8789447?casa_token=hZMLnlPR8KQAAAAA:FMvUYNaHrllH9Th-YIokBECsF5PpbY7DW2V2MeCDnzBxfwbzeymxR6CLDVNmhFMr0Gd559Mg-g
Source type	Journal
Keywords	Weather, Prediction
#Tags	#Weather
Summary of key points + notes (include methodology)	The authors discussed the difficulties with current weather prediction and how the precipitable water vapor is calculated via GPC might be inaccurate. They developed a ground-based weather system that can accurately` predict if it was going to rain. They used light temperature and relative humidity sensors. Also interestingly they determined that the time of day and day of the year mattered.
1	Models are inaccurate at predicting rain
Important Figures	Shows actual rain vs their models prediction and its input 

VOCAB: (w/definition)	precipitable water vapor-water vapor in the air that can turn finto rain zenith total delay-signal delay in GPS
Cited references to follow up on	Y. Yao, L. Shan and Q. Zhao, "Establishing a method of short-term rainfall forecasting based on GNSS-derived PWV and its application", *Sci. Rep.*, vol. 7, Sep. 2017.
Follow up Questions	What brand sensors were used and where did they get them?

Article #16 Notes: Improving productivity and water use efficiency: A case study of farms in England

Article notes should be on separate sheets

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Source Title	Science Direct
Source citation (APA Format)	Gadanakis, Y., Bennett, R., Park, J., & Areal, F. J. (2015). Improving productivity and water use efficiency: A case study of farms in England. *Agricultural Water Management*, *160*, 22–32. https://doi.org/10.1016/j.agwat.2015.06.020
Original URL	https://www.sciencedirect.com/science/article/pii/S037837741530038X?ref=pdf_download&fr=RR-2&rr=8e6ab895abbf9015
Source type	Scientific Article
Keywords	Data envelopment analysis, Water use efficiency, Technical efficiency Scale efficiency, Benchmarking, England
#Tags	#efficent farms
Summary of key points + notes (include methodology)	The authors wanted to take a deep dive onto the water efficiencies on farms in England including things such as livestock and plant washing as well as the typical watering. They used many mathematical equations to determine the efficiencies and the overwatering that was occurring on farms. They yielded responses that suggested that many farms across England were overusing their water and not being efficient with it. With this they were able to make suggestions to British legislation to employ new laws that can help reduce the water waste.
Research Question/Problem/ Need	Could they analyze and determine the amount of excess water usage on farms in England.

Important Figures	**Table 1** Descriptive statistics of the inputs and the outputs used in the DEA linear programming model. This figure shows us the mean and standard deviation of what they put into their model.
VOCAB: (w/definition)	sub-vector efficiency- efficiency test for one variable
Cited references to follow up on	Knox, J., Weatherhead, K., Díaz, J.R., Kay, M., 2009. Developing a strategy to improve irrigation efficiency in a temperate climate: a case study in England. Outlook Agric. 38 (4), 303–309, http://dx.doi.org/10.5367/000000009790422160
Follow up Questions	Could this be different in different countries?

Inputs and outputs for the DEA model	Irrigating Horticulture Farms	
	Mean	St. Deviation
Area farmed (ha)	7.172	12.17
Total agricultural costs (£/ha)	18,564	36,440
Water use (m^3/ha)	2,709	3,713
Energy cost (£/ha)	1,715	2,400
Total labour (hours/ha)	2,340	3,505
Other agricultural costs (£/ha)	10,117	18,629
Gross Margin (£/ha)	41,583	60,607

Article #17 Notes: Adapting weather conditions based IoT enabled smart irrigation technique in precision agriculture mechanisms

Article notes should be on separate sheets

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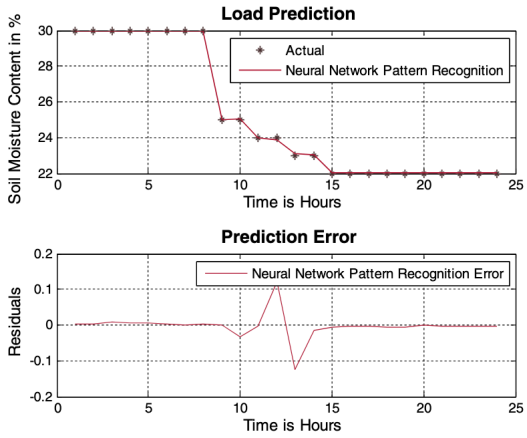
Source Title	Springer Nature
Source citation (APA Format)	Keswani, B., Mohapatra, A. G., Mohanty, A., Khanna, A., Rodrigues, J. J. P. C., Gupta, D., & De Albuquerque, V. H. C. (2019). Adapting weather conditions based IoT enabled smart irrigation technique in precision agriculture mechanisms. *Neural Computing and Applications*, *31*(S1), 277–292. https://doi.org/10.1007/s00521-018-3737-1
Original URL	https://link.springer.com/article/10.1007/s00521-018-3737-1
Source type	Journal
Keywords	Soil moisture content Wireless sensor network Internet of things Variable learning rate gradient descent Gradient descent Structural similarity index (SSIM) Interpolation Fuzzy logic
#Tags	#fuzzylogic
Summary of key points + notes (include methodology)	They developed an IoT-enabled wireless sensor network for precision agriculture with 9 sensors/ The system uses neural networks to predict to soil moisture content 1 hour in advance and generates a map of the soil moisture prediction.
Research Question/Problem/ Need	Excessive Water consumption on farms.

Important Figures	 **Fig. 7** Actual soil moisture content and predicted soil moisture content versus time in hours. Error graph plotted between residuals and time in hours [gradient descent optimization-based neural network pattern classification] Shoes the accuracy of their model and how it was consistently able to predict the soil moisture content throughout the time.
VOCAB: (w/definition)	Fuzzy Logic: A logic system handling approximations rather than absolute truths, often applied in systems needing to process uncertainty or imprecision (e.g., control systems and AI). Interpolation: A technique to estimate unknown values within the bounds of known data, commonly used to create smooth transitions or continuous data from discrete points. Structural Similarity Index (SSIM): A metric comparing structural content between two images or datasets, crucial in evaluating image quality in terms of human visual perception.
Cited references to follow up on	Go´mez-Melendez D, Lopez-Lambrantilde A, Herrera-Ruiz G, Fuentes C, Rico-Garcia E, Olvera-Olvera C, Alaniz-Lumbrerasc D, Teobaldis MF, Verlinden S (2011) Fuzzy irrigation green- house control system based on a field programmable gate array. Afr J Agric Res 6(11):2544–255
Follow up Questions	Could a non machine learning algorithm be implemented to do the same

	thing

Article #18 Notes: A detailed survey on Auto Irrigation system

Article notes should be on separate sheets

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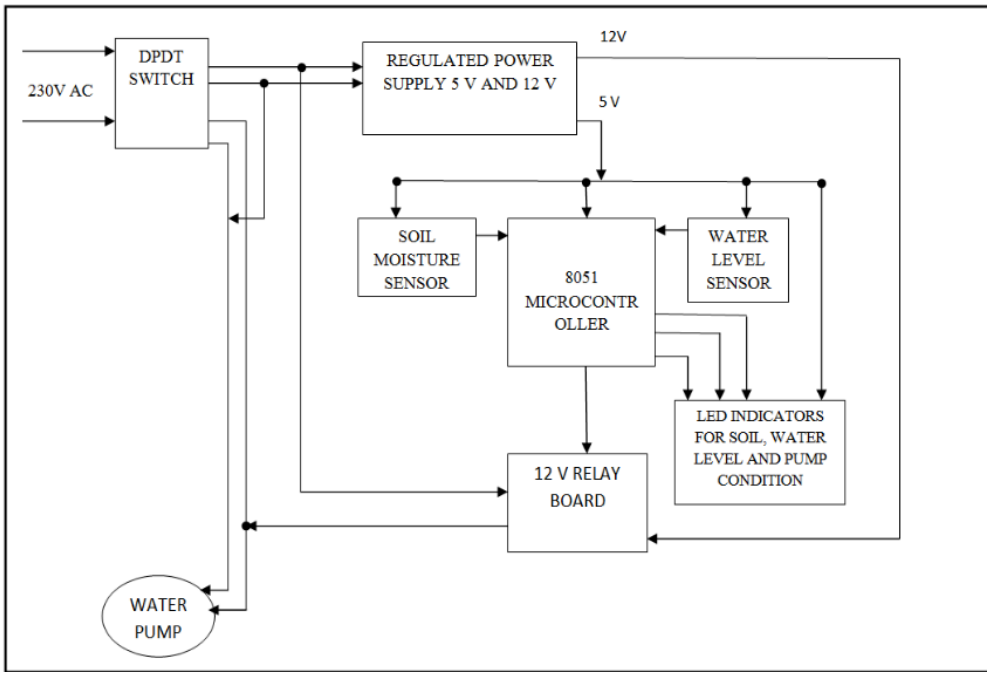
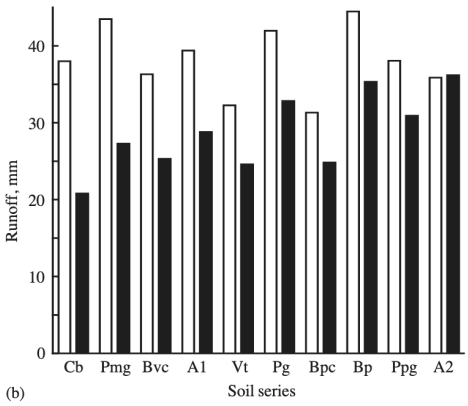
Source Title	IEEE
Source citation (APA Format)	Joshi, A., & Ali, L. (2017). A detailed survey on auto irrigation system. *2017 Conference on Emerging Devices and Smart Systems (ICEDSS)*, 90–95. https://doi.org/10.1109/ICEDSS.2017.8073665
Original URL	https://ieeexplore.ieee.org/abstract/document/8073665
Source type	Journal Article
Keywords	Keywords— Agriculture; Irrigation; Automation.
#Tags	#auto
Summary of key points + notes (include methodology)	The methodology of the survey paper consists of a review of automated irrigation systems. Six types were discussed, Time Based, Volume Based, Open Loop, Closed Loop, Real Time Feedback, and Computer Based Irrigation Control Systems. They analyzed each type's components and functionalities, focusing on technological advancements such as microcontrollers, sensors, and wireless communication. This systematic approach allows for a comprehensive understanding of the current state of auto irrigation technologies and their applications in agriculture. Agricultural takes up 60% of worlds economy
Research Question/Problem/ Need	Automatic irrigation to automate irrigation

Important Figures	 Flow Diagram of how electrical flow runs through the program and powers the connected devices.
VOCAB: (w/definition)	Fertigation- fertilizer through irrigation systems Urbanization-increase of urbanized areas
Cited references to follow up on	Manish Giri and Dnyaneshwar Natha Wavhal “Automated Intelligent Wireless Drip Irrigation Using Linear Programming”, in International Journal of Advanced Research in Computer Engineering & Technology, Vol. 2, No. 1, 2013, pp. 1-5
Follow up Questions	How did they choose their microcontroller.

Article #19 Notes: Comparative Assessment of Infiltration, Runoff and Erosion of Sprinkler Irrigated Soils

Article notes should be on separate sheets

Source Title	Science Direct
Source citation (APA Format)	Santos, F. L., Reis, J. L., Martins, O. C., Castanheira, N. L., & Serralheiro, R. P. (2003). Comparative Assessment of Infiltration, Runoff and Erosion of

	Sprinkler Irrigated Soils. *Biosystems Engineering*, *86*(3), 355–364. https://doi.org/10.1016/S1537-5110(03)00135-1
Original URL	https://www.sciencedirect.com/science/article/pii/S1537511003001351?casa_token=wdw6Zu8PwS4AAAAA:L2FICFI4ieqG33jCksB8mnNFui-dJhQp54MccdjDQFDP5Yevb-ZXI2ef8C1Z_xwh2XTLNU4gVw
Source type	Journal Entry
Keywords	Sprinkler Irrigation Soil Infiltration Runoff and Erosion Polyacrylamide (PAM) Soil Series Assessment
#Tags	#runoff
Summary of key points + notes (include methodology)	This study looks at the effects that sprinkler irrigation can have on runoff in different soil types. It found that low permeability soils have worse impacts with run off. They tried to add some thickening agents tor decrease soil rujn off which had some positive affects. They were able to reduce the run off on slopes.
Research Question/Problem/ Need	Investigating how run off is affected on different slopes and hills.
Important Figures	 Shows the amount of run off compared to the type of soil.
VOCAB: (w/definition)	Infiltration: The process by which water enters the soil, crucial for understanding water absorption and runoff dynamics. Runoff: Water flow that occurs when soil is saturated and cannot absorb

	any more water, leading to surface water movement. Sediment Loss: The removal of soil particles from the land surface due to water movement, which can lead to erosion and degradation of soil quality. Polyacrylamide (PAM): A synthetic polymer used to improve soil stability and reduce erosion by enhancing aggregate stability and infiltration rates. Permeability: The ability of soil to transmit water, a key factor affecting irrigation efficiency and runoff potential.
Cited references to follow up on	Santos F L; Martins O C; Castanheira N S; Figueiredo C (2001). Center pivot sprinkler irrigation, runoff and erosion control in a Mediterranean soil with polyacrylamide. ASAE Paper No. 01 2155
Follow up Questions	Would this be different if tested on different soil types.

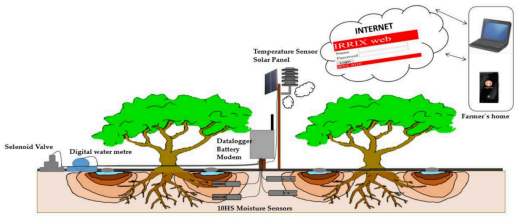
Article #21 Notes: Dealing with Slope Irrigation Article notes should be on separate sheets

Source Title	Rain Bird
Source citation (APA Format)	*Dealing with Slope Irrigation | Rain Bird*. (n.d.). Retrieved December 17, 2024, from https://www.rainbird.com/professionals/dealing-slope-irrigation
Original URL	https://www.rainbird.com/professionals/dealing-slope-irrigation
Source type	Article
Keywords	Slope Irrigation, Dripline, Pressure Regulation, Water Efficiency, Erosion Control
#Tags	#slope
Summary of key points + notes (include methodology)	Freshwater irrigation can cause significant issues on hillsides, such as erosion, run-off, and water waste. To prevent freshwater waste, you can implement various technologies, including drip irrigation systems, which deliver water directly to the roots of plants, minimizing excess water. Additionally, technologies like advanced irrigation timers, pressure-

	regulating devices, check valves to prevent drainage, and matched precipitation rate nozzles ensure precise water application and reduce environmental impact.
Research Question/Problem/ Need	Run off irrigation down a hill.
Important Figures	NA
VOCAB: (w/definition)	Run-off: The flow of excess water over land that cannot be absorbed by the soil. Erosion: The gradual wearing away of soil or land due to water, wind, or other natural forces. Dripline: A type of irrigation system that delivers water directly to plant roots in a controlled manner.
Cited references to follow up on	NA
Follow up Questions	Is this the same on a terrace garden?

Article #22 Notes: Using Soil Moisture Sensors for Automated Irrigation Scheduling in a Plum Crop

Source Title	Using Soil Moisture Sensors for Automated Irrigation Scheduling in a Plum Crop
Source citation (APA Format)	Millán, S., Casadesús, J., Campillo, C., Moñino, M. J., & Prieto, M. H. (2019). Using Soil Moisture Sensors for Automated Irrigation Scheduling in a Plum Crop. *Water*, *11*(10), Article 10. https://doi.org/10.3390/w11102061
Original URL	https://www.mdpi.com/2073-4441/11/10/2061
Source type	Scientific Journal Entry
Keywords	feedback; water management; precision irrigation; crop efficient; drip irrigation
#Tags	#auto
Summary of key points + notes (include methodology)	This study developed an automatic irrigation system for regulated deficit irrigation. This function through the use of 15 moisture sensor sensors that could moisture the soul to optimize irrigation without human involvement. The system tried to calculate how much water was being used and provide that water to the plants. The system ended up being effective and showed a reduction in water used.
Research Question/Problem/ Need	How could they reduce the freshwater waste through the use of automatic irrigation.

Important Figures	 **Figure 1.** Components of the automatic system. Shows how all of the components were connected and how they all played into each other.
VOCAB: (w/definition)	RDI- water management strategy where water is provided based on growth cycle of a plant.
Cited references to follow up on	Miranda, F.; Yoder, R.; Wilkerson, J.; Odhiambo, L. An Autonomous Controller for Site-Specific Management of Fixed Irrigation Systems. Comput. Electron. Agric. 2005, 48, 183–197. [CrossRef]
Follow up Questions	How would the algorithm differ for faster growing plants?

Article #23 Notes: Prehistoric Irrigation in Arizona

Source Title	JSTOR
Source citation (APA Format)	Hodge, F. W. (1893). Prehistoric Irrigation in Arizona. *American Anthropologist*, *6*(3), 323–330.
Original URL	https://www.jstor.org/stable/658315?seq=1
Source type	Article
Keywords	Irrigation, canals, reservoirs
#Tags	#differentstyles #trench
Summary of key points + notes (include methodology)	The ancient pueblos their natural resources to irrigate their crops through different styles of irrigation mainly trench irrigation. They would dig trenches and then fill them with water to provide it where it was needed. These canals could stretch as long as 41 miles and were made of hardened clay to prevent the water from flowing out and leaking into the environment. Then the water was provided to small scale fields to irrigate them as necessary.
Research Question/Problem/ Need	What types of irrigation was used in ancient Arizona?
Important Figures	NA
VOCAB: (w/definition)	**Acequia** – community operated source of water meant for irrigation. **Indurated-** hard surface. **Concretions** – compact minerals in soil
Cited references to follow up on	NA
Follow up Questions	What caused these practices to be stopped?