Project Notes:

Project Title: Improving Irrigation Water Use Efficiency in High Tunnel Agriculture
Name: Claire Newcom

Note Well: There are NO SHORT-cuts to reading journal articles and taking notes from them. Comprehension is paramount. You will most likely need to read it several times, so set aside enough time in your schedule.

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
What k(-1 cm) k(-1 cm) represents unsaturated hydraulic conductivity, which is the ability of soil to retain water when the spaces between the grains are not saturated with water. It is related to something called Darcy's equation, which is an equation for the flow of water through a porous substance (paraphrased from Darcy's law Definition & Meaning - Merriam-Webster). Permeability, which is the ability of water to pass through the voids between the grains, is also important. Resource used Soil Permeability - Darcy's Law - YouTube	I googled what it was, and then went down a few rabbit holes looking on youtube and online.	Soil Permeability - Darcy's Law - YouTube	10/8/2023
What high tunnels were	Googling what high tunnels were and what purpose they served	 Search what is a high tunnel Patent 2 - sort of	12/1/2023

Literature Search Parameters:

These searches were performed between 8/20/2023 and 2/14/2024.
List of keywords and databases used during this project.

Database/search engine	Keywords	Summary of search
Scopus	dance, dance AND shoes, dance AND shoe’	3 articles out of 165 articles and out of those 3 I chose 1.
Scopus	Drought AND “Water absorption”, limited to “Soil Moisture”	After the search was refined, there were 81 articles left, 9 of those seemed to be of interest. Out of those 9, 1 article was chosen.
Scopus	“Soil Water Repellency” AND drought, limited to Agricultural and Biological Sciences, limited to Soil Moisture AND Soil Water Repellency	After the search was refined, there were 175 articles, out of which 1 was chosen primarily and more were considered.
Bing	hydrochar	I searched hydrochar in the Bing search engine, which populated with articles about hydrochar, and I chose one that looked at both hydrochar and biochar
Scopus	“Soil water content”; "soil water content" AND measuring; "soil water content" AND measuring, limited to Soil Moisture Sensors; "soil water content" AND measuring, limited to Soil Moisture Sensors, limited to the time period 2013-2023, limited to Engineering, limited to Agricultural and Biological Sciences	After the search was refined, there were 122 articles, out of which 1 was chosen primarily and more were considered.
Scopus	“Aquifer depletion”; “aquifer depletion” limited to Agriculture	After the search was refined, there were 30 articles, out of which 1 was chosen.
Bing and google patent search	“Polytunnel”	The search in google patents resulted in 2 patents that were

		considered and then used
Bing	“High tunnels”	I found 1 article that I used

Tags:

Tag Name	
#Brainstorming	#soil
#patents	#water
#summer	#MSEF

Article #1 Notes: Title

Article notes should be on separate sheets

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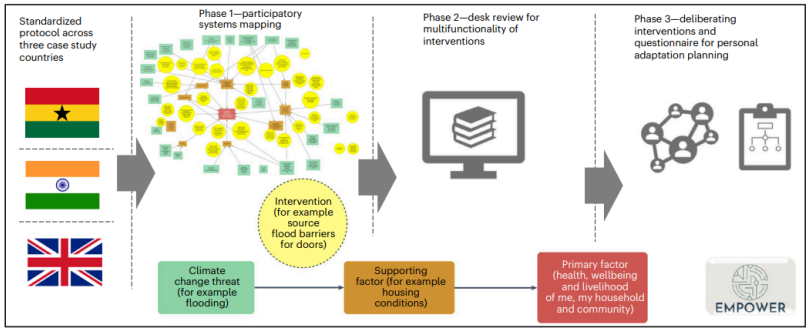
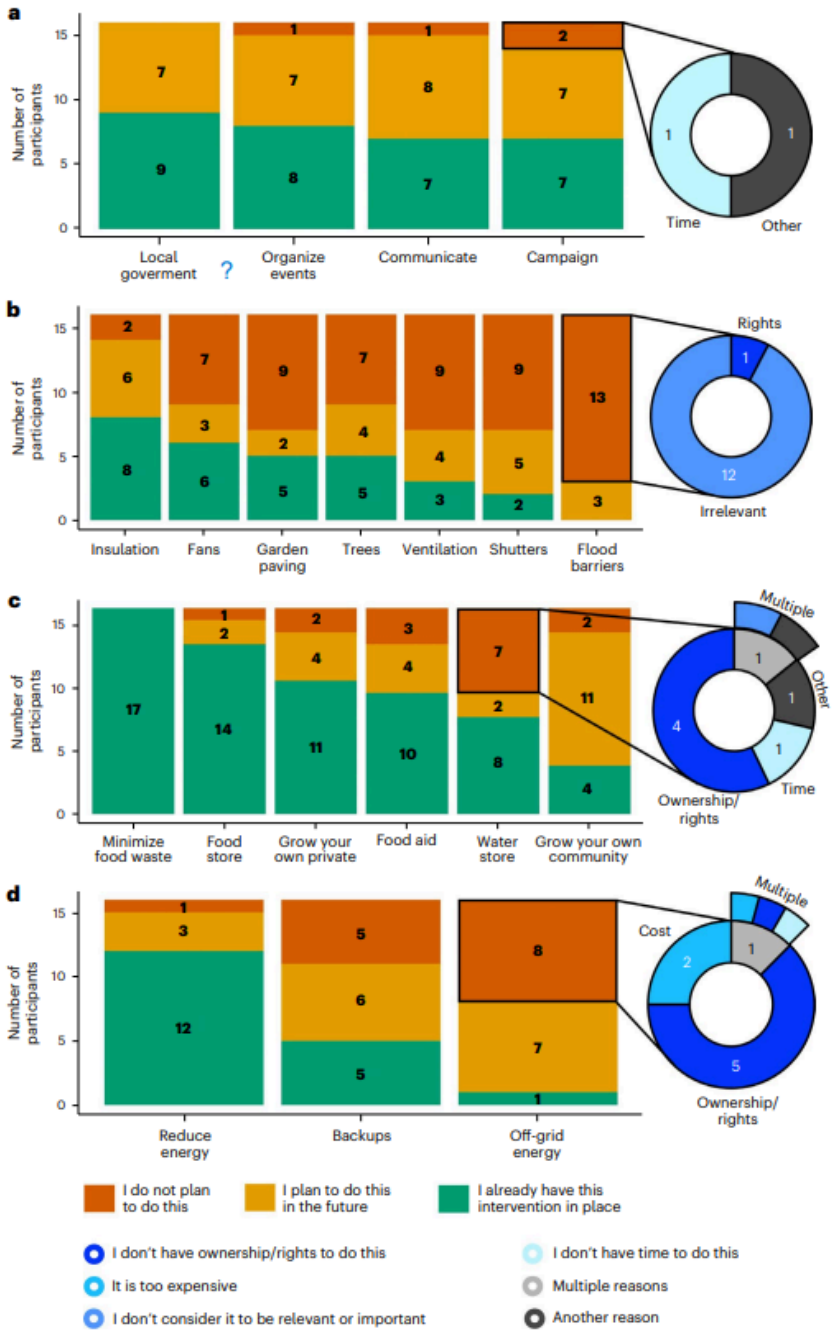
Source Title	
Source citation (APA Format)	
Original URL	
Source type	
Keywords	
#Tags	
Summary of key points + notes (include methodology)	
Research Question/Problem/ Need	
Important Figures	
VOCAB: (w/definition)	
Cited references to follow up on	
Follow up Questions	

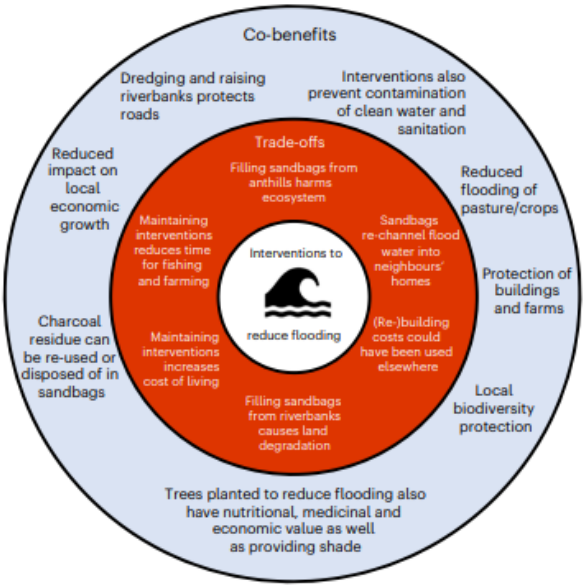
Article #1 Notes: **Empowering citizen-led adaptation to systemic climate change risks**

Source Title	**Empowering citizen-led adaptation to systemic climate change risks**
Source citation (APA Format)	Oliver, T. H., Bazaanah, P., Da Costa, J., Deka, N., Dornelles, A. Z., Greenwell, M. P., Nagarajan, M., Narasimhan, K., Obuobie, E., Osei, M. A., & Gilbert, N. (2023). Empowering citizen-led adaptation to Systemic Climate Change Risks. *Nature Climate Change*, *13*(7), 671–678. https://doi.org/10.1038/s41558-023-01712-6
Original URL	Empowering citizen-led adaptation to systemic climate change risks | Nature Climate Change
Source type	Journal Article
Keywords	Adaptation, Participatory systems mapping, Context dependence, Multifunctionality, Constraints on interventions
#Tags	#Brainstorming
Summary of key points + notes (include methodology)	Adaptation to climate change and its risks is necessary, but often governments and businesses are the most influential in the decision making process, as opposed to the communities that climate change impacts. The study examined a pilot process where multiple factors were identified, such as measures taken to protect houses and communities. The participants in the study found that there was more awareness about climate change, and the study observed some new ideas for citizen-led adaptation.
Research Question/Problem/ Need	What can be done so that communities can be more involved in the process of adaptation to climate change and its impacts?
Important Figures	 This is a visual representation of the phases of the EMPOWER project. The

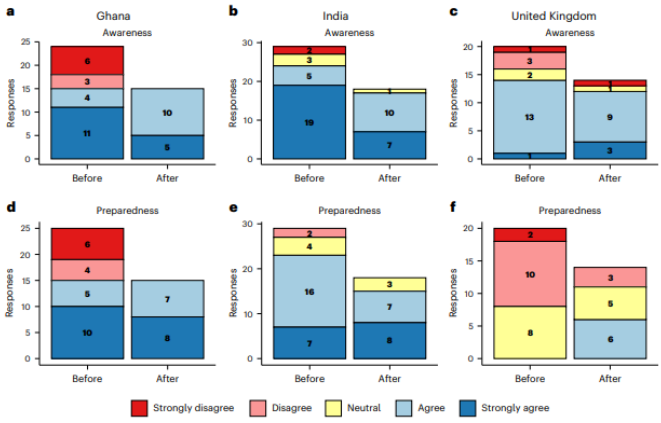
locations of the projects were first found, and then a mind map was made using the ideas the communities came up with. Then the ideas were evaluated to see what other functions there were. These ideas were presented back to the communities to see which ones were viable.



This is a diagrammatic representation of the UK participants' opinions and thoughts on the project. A section is general, b section is housing, c section is food, and d section is energy.



This is a diagram of the benefits and trade-offs of interventions to reduce flooding. This was made using what the Ghanaian participants had identified.



This is a more general representation of the opinions of the participants after the EMPOWER program.

VOCAB: (w/definition)

Adaptation: the action of adapting or changing to better suit new conditions.
Participatory approach: meaning involving stakeholders, and mainly the stakeholders that are going to be affected by whatever is occuring.
Value-action gaps: are when people act in a way that does not represent their values, for various reasons.
Multifunctionality: having multiple functions
Stratification: the act of sorting things into layers or categories based on some criteria.
Hydrological modeling: a smaller model of a real world system that helps with the

	understanding of that system.
Cited references to follow up on	Moser, S. C. & Ekstrom, J. A. A framework to diagnose barriers to climate change adaptation. *Proc. Natl Acad. Sci.* USA **107**, 22026–22031 (2010). Bhave, A. G., Mishra, A. & Raghuwanshi, N. S. A combined bottom-up and top-down approach for assessment of climate change adaptation options. *J. Hydrol.* **518**, 150–161 (2014) Berrang-Ford, L. et al. A systematic global stocktake of evidence on human adaptation to climate change. *Nat. Clim. Change* **11**, 989–1000 (2021). Piggott-McKellar, A. E., McNamara, K. E., Nunn, P. D. & Watson, J. E. M. What are the barriers to successful community-based climate change adaptation? A review of grey literature. *Local Environ.* **24**, 374–390 (2019). *IPCC Climate Change 2022: Impacts, Adaptation and Vulnerability.* Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change (Pörtner, H. O. et al eds) (Cambridge University Press, 2022); https://doi.org/10.1017/9781009325844
Follow up Questions	What would a community adaptation approach entail? Can the community adaptation approaches be scaled up and work for larger populations? Are the adaptation approaches affordable? Would the cost of the interventions outweigh the benefits?

Article #2 Notes: **How climate policy commitments influence energy systems and the economies of US states**

Source Title	**How climate policy commitments influence energy systems and the economies of US states**
Source citation (APA Format)	Bergquist, P., & Warshaw, C. (2023a). How climate policy commitments influence energy systems and the economies of US states. *Nature Communications, 14*(1). https://doi.org/10.1038/s41467-023-40560-y
Original URL	How climate policy commitments influence energy systems and the economies of US states | Nature Communications
Source type	Journal Article
Keywords	Bayesian factor analysis, granular dataset, RPS,
#Tags	#Brainstorming
Summary of key points + notes (include methodology)	In the United States, the state governments are where most of the policy making surrounding climate change occurs, but only looking at a small number of policies makes it difficult to understand what the extent of the impacts are. Greater variation in climate change policies are associated with some reductions in carbon dioxide emissions in both energy systems and the economy. This study found that strict climate policies do not negatively affect states' economies, and that there are benefits associated with state climate policies.
Research Question/Problem/ Need	How does looking at multiple state climate change policies together help us understand the effectiveness of those policies and their impacts on the economy and energy systems?
Important Figures	

Policy	No. states enacting	State(s) adopting by year 1
CA Car Emissions Standard	18	CA
Climate action plan	33	DE, HI, IL
Community Solar	21	MA
Complete Streets Policies	32	FL, OR, RI
Electric decoupling	41	AL, CT, MN, NH, VT
Emissions performance standards	6	OR
Energy efficiency resource standard (continuous)	25	TX, VT
Energy efficiency target	36	FL, TX, VT
Environmental Building Standards	43	MD, OR
Environmental Policy Act	17	CA, CT, DC, GA, HI, IN, MA, MD, MN, MT, NC, NJ, NY, SD, VA, WA, WI
Fuel generation mix disclosure	25	CA, CO, CT, DC, DE, FL, IL, MA, MD, ME, MI, NJ, NY, OH, OR, PA, VA, WA
GHG target	27	NH, RI, VA, VT
Gas decoupling	38	AL, CT, MN, NH, NV, VT
Gas tax	51	
Greenhouse Gas Cap	14	CT, DE, ME, NH, NJ, NY, VT
Greenhouse gas registry/ reporting	42	CA
Low-income energy efficiency programs	44	AK, AR, AZ, CA, CO, CT, DC, DE, FL, IA, ID, IL, IN, KS, KY, MA, MD, ME, MI, MN, MO, MS, MT, NC, NH, NJ, NM, NV, NY, OH, OK, OR, PA, RI, SC, TN, TX, UT, VA, VT, WA, WI
Mandatory green power option	25	IA, MN, WA
On-site renewable generation	45	CA, CT, DC, DE, IA, MD, ME, MN, MT, ND, NH, NJ, NV, NY, OH, OK, OR, VA, VT, WA, WI
PACE authorization	37	HI
Public Benefit Fund	25	CA, CT, DC, DE, IL, MA, ME, MI, MN, MT, NH, NJ, NY, OH, OR, PA, RI, VT, WI
RPS target (binding only)	31	AZ, IA, ME, WI
Renewable Portfolio Standard	39	AZ, CT, IA, MA, ME, NJ, NV, TX, WI
Solar Tax Credit	40	AZ, CA, CT, FL, HI, IA, IN, KS, LA, MA, MD, MN, MT, NC, NH, NJ, NV, NY, OR, RI, SD, TX, VA, VT, WI
State preemption of local gas bans	4	AZ, LA, OK, TN

The table shows the name of each policy, the number of states that have adopted it, and the number of states that had adopted it by the first year for which we have a record of the policy's adoption. Our dataset includes policy data from all 50 states and the District of Columbia. Supplementary Table S3 provides a longer description of each policy.

These are examples of policies to combat climate change from around the United States.

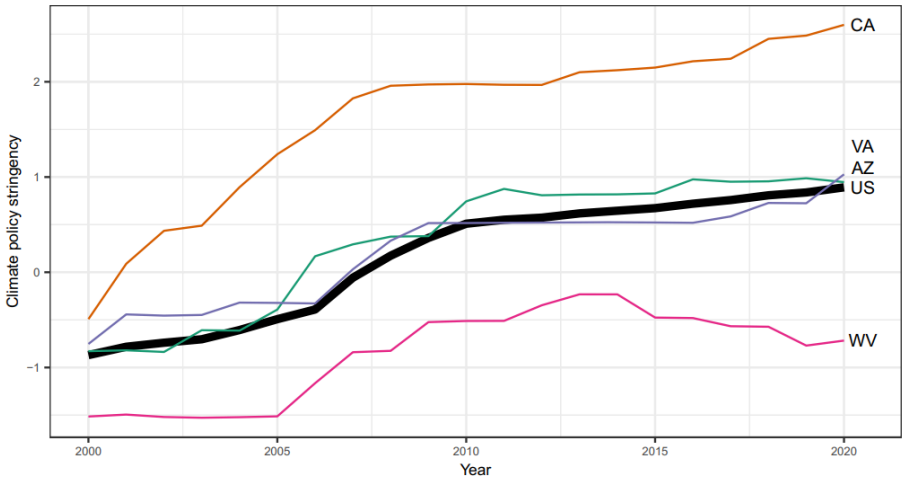


Fig. 1 | Increasing state climate policy commitments over time. Each thin line represents the trajectory of an individual case state, and each of these case states is shown in its own color for clarity. The bold line shows the average of our climate policy stringency index across all the states, with each state weighted equally. Supplementary Fig. S2 shows climate policy stringency for all states.

This graph shows the climate policy stringency of a few states. There is a very big difference between CA and WV.

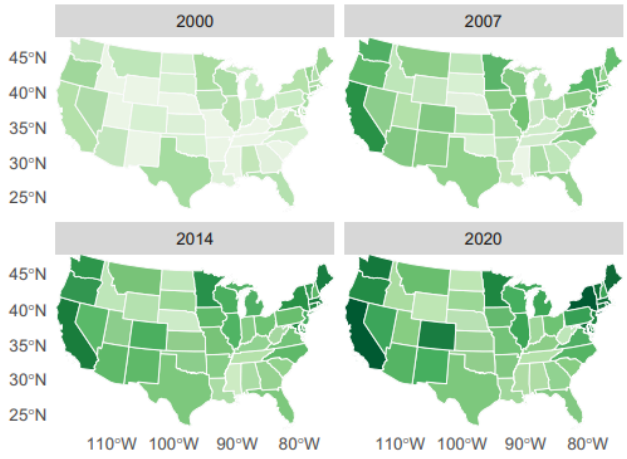


Fig. 2 | State climate policy, 2000–2020. States shaded with darker greens have enacted a higher number of stronger climate policies, and states shaded with lighter greens have enacted fewer, weaker climate policies. The maps were developed using the R package Tigris[58] and based on spatial data provided by the US Census Bureau. Supplementary Fig. S1 includes Alaska and Hawaii, and Supplementary Table S1 shows the estimate for each state in 2020.

Over time, certain states adopted more stringent climate policies, while others were less aggressive in their climate policy adoption.

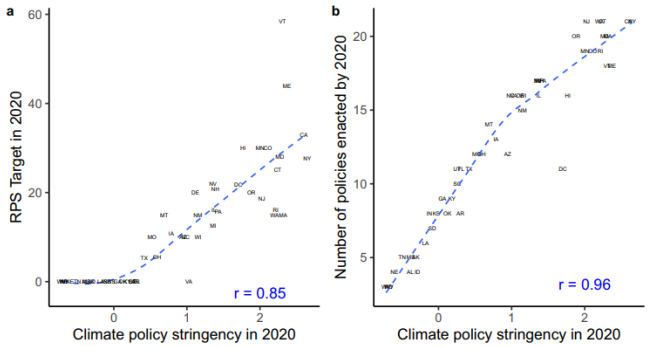


Fig. 3 | Climate policy index compared with simpler measures of climate policy. Panel (**a**) shows the relationship between the aggressiveness of states' RPS targets, defined as the percent of utilities' electricity production that must be generated from renewable sources in 2020, and our climate policy index in 2020. Panel (**b**) shows the number of policies that each state had enacted in 2020 and that state's climate policy in 2020. The figure visualizes the variation that our index captures by incorporating numerous policies, estimating discrimination parameters for each policy type, and accounting for variation across states' versions of the same policy instrument. Both panels include the Pearson's *R* correlation coefficient and locally weighted smoothing (Lowess) line.

Renewable portfolio standards (RPS) for 2020 was plotted against climate policy stringency in 2020. Many states did not have an RPS target, while others have a very high RPS standard. The second graph plotted the number of policies enacted by 2020 against climate policy stringency in 2020. States that had a higher RPS standard vs climate policy stringency seem to be, without very in depth analysis, more likely to have a higher number of policies and were more stringent in the policies.

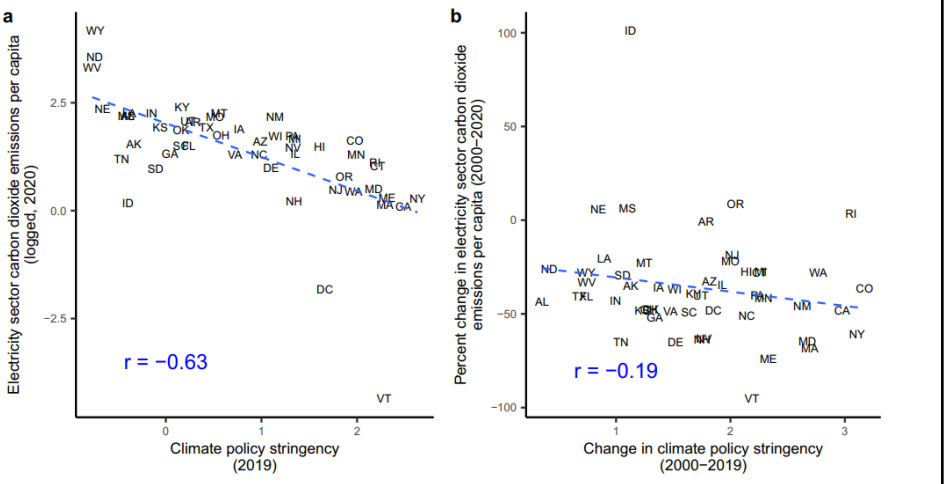


Fig. 4 | Climate policy and CO_2 emissions. Panel (**a**) shows the correlation between each state's climate policy (standard deviation units) in 2019 on the *X*-axis and CO_2 emissions from the electricity sector (per capita, logged) in 2020 on the *Y*-axis. Panel (**b**) shows the change in climate policy (standard deviation units) between 2000 and 2019 on the *X*- axis and the change in logged per capita CO_2 emissions from the electricity sector between 2000 and 2020 on the *Y*-axis. Both panels include the Pearson's *r* correlation coeffient and linear best-fit line. Both panels suggest a strong association between climate policy and CO_2 emissions.

These graphs show the relationship between climate policy stringency and CO2 emissions in the electricity sector. The line of best fits for both of the graphs show that higher policy stringency relates to lower CO2 emissions.

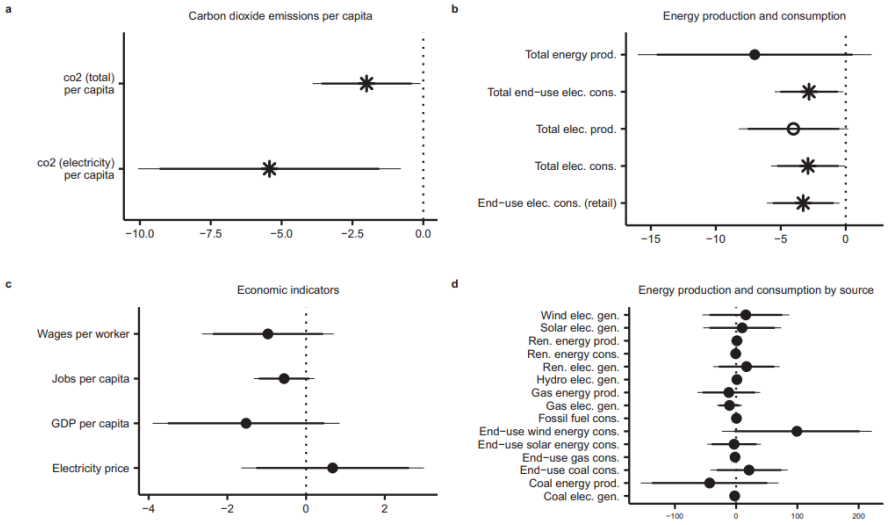


Fig. 5 | Effects of climate policy on carbon dioxide emissions, energy production and consumption, and the economy. The figure shows the effect of the climate policy stringency index (on the *X*-axis) on CO_2 emissions (panel (**a**)), energy production and consumption (panels (**b**) and (**d**)), and economic indicators (panel (**c**)). We estimate the effects of climate policy on each dependent variable using OLS regression models that include state and region-year fixed effects and standard errors clustered by state and region-year. Each regression is estimated for 1071 observations, including 51 geographic units across 21 years, in 4 regions. Regression coefficients, shown as points in the figure, have been corrected for measurement error in our climate policy index[25]. Thick error bars reflect 90% confidence intervals, and thin error bars reflect 95% confidence intervals. Statistical significance is designated with stars ($\alpha = 0.05$) and hollow points ($\alpha = 0.1$). Climate policy is standardized to have mean of zero and standard deviation of one. All dependent variables are logged, and coefficients have been multiplied by 100 so that the figure approximately shows the percent change in these outcomes associated with a standard-deviation increase in climate policy.

These are more in detail graphs about the effects of climate policy stringency of various different variables. The stars and hollow points represent statistical significance.

VOCAB: (w/definition)

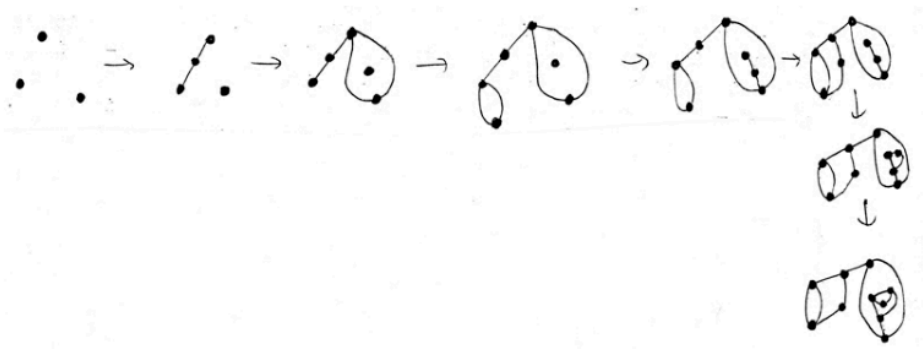
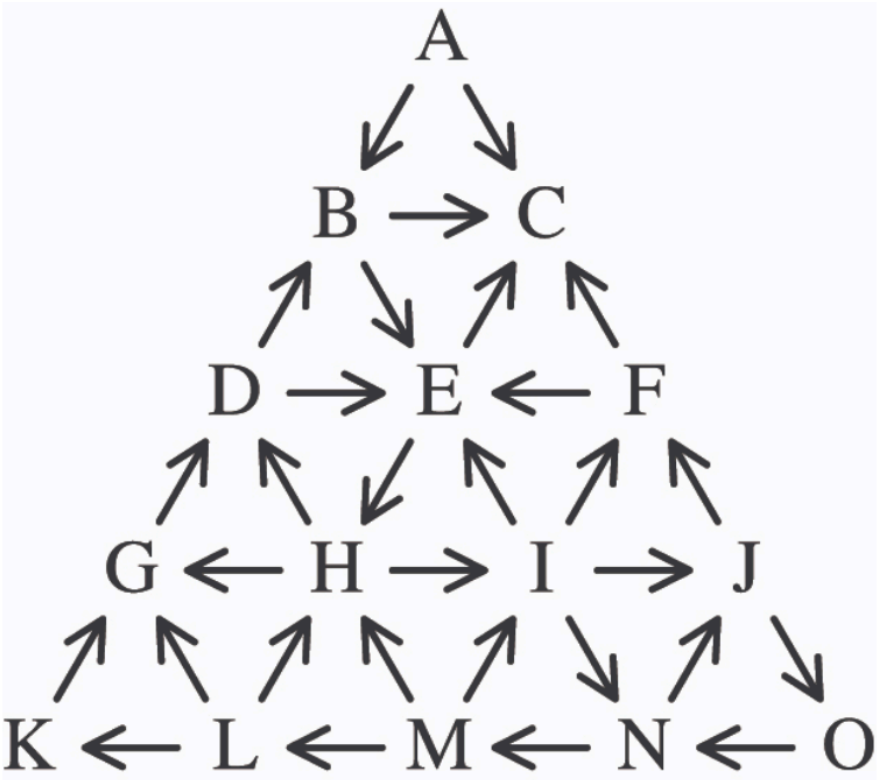
Stringent: strict and precise
Granular dataset: a detailed dataset
RPS: renewable portfolio standards, meaning a certain minimum amount of energy supplied by electric providers must be from renewable sources.

Cited references to follow up on	Stokes, L. C. *Short Circuiting Policy: Interest Groups and the Battle Over Clean Energy and Climate Policy in the American States* (Oxford University Press, 2020). Caughey, D. & Warshaw, C. Policy preferences and policy change: dynamic responsiveness in the American States, 1936–2014. *Am. Political Sci. Rev.* **112**, 249–266 (2018). Caughey, D. & Warshaw, C. The dynamics of state policy liberalism, 1936–2014. *Am. J. Political Sci.* **60**, 899–913 (2016). Doherty, K. L. & Webler, T. N. Social norms and efficacy beliefs drive the alarmed segment's public-sphere climate actions. *Nat. Clim. Change* **6**, 879–884 (2016). Peng, W. et al. The surprisingly inexpensive cost of state-driven emission control strategies. *Nat. Clim. Change* **11**, 738–745 (2021).
Follow up Questions	What impact have newer policies, made in the covid era, had on the economy and energy systems? Can a larger set of individual policies be drawn from and would that show a different effect on the economy and on energy systems? Do the policies of different regions have different impacts?

Article #3 Notes: **A Life in Games**

Article notes should be on separate sheets

Source Title	A Life in Games
Source citation (APA Format)	Roberts, S. (2015, August 28). *A Life in Games*. Quanta Magazine. https://www.quantamagazine.org/john-conways-life-in-games-20150828/
Original URL	A Life in Games | Quanta Magazine
Source type	Web Page Magazine Article
Keywords	Game theory, surreal numbers, Game of Life, symmetry, number theory
#Tags	#Brainstorming #Summer
Summary of key points + notes (include methodology)	This article was about John Horton Conway, and how he used games, which are normally played just for fun, to discover complex theories. He created games of his own, like the Game of Life, and he co-created the game Sprouts, which are both very simple games in terms of their rules, but they can become very complex as they are played. In playing and analyzing games, he also discovered the surreal number system, which, as I understand it, includes all real numbers, and all the infinities between numbers. His creation of games, and his use of games allowed him to create and find new ways of thinking. Here, games were used to do more than what they were originally created for, which was enjoyment, and I find that interesting. I enjoy playing games and doing puzzles, but I do them mainly for enjoyment, but trying to do more than that also seems interesting to me. This article provides an example as to how games can not only be used for enjoyment, but they can also provide insights for STEM and other academic fields. Conway used games to discover the surreal number system, so using games for something other than their intended purpose can lead to advancement. I would be interested in using games in a way that would help people, so possibly for educational purposes, and that is not necessarily what they were intended for.
Research Question/Problem/ Need	How can games be used to model difficult mathematical concepts?

Important Figures	 This is an example of a sprouts game. Conway played sprouts, along with other games, to try and understand more about numbers and math.  This is an example of a logical puzzle game, where four players start at position A, and then they all continue moving until all of them are stuck at position C, where the next person who is supposed to play loses.
VOCAB: (w/definition)	Game Theory: It is the study of the mathematical models of the decisions that can be made between multiple individuals as they try Surreal numbers: A number system that includes all integers and all the infinites between integers. Mathematics: The science of numbers.

Cited references to follow up on	N/A
Follow up Questions	Can games be used to understand other phenomena? What uses do surreal numbers have in the physical world? Could games be used as a supplement for learning or understanding difficult math concepts?

Article #4 Notes: **Scientists can listen to proteins by turning data into music**

Article notes should be on separate sheets

Source Title	Scientists can listen to proteins by turning data into music
Source citation (APA Format)	Elsevier. (n.d.). *Scientists can listen to proteins by turning data into music*. Phys.Org. Retrieved September 19, 2023, from https://phys.org/news/2016-10-scientists-proteins-music.html
Original URL	Scientists can listen to proteins by turning data into music (phys.org)
Source type	News/Magazine Article
Keywords	Anomalies, proteins, sonification, bioinformatics, protein fold assignment
#Tags	#Brainstorming #Summer
Summary of key points + notes (include methodology)	In this article, scientists made music from protein structure data, so that they could listen to the protein. This could help the scientists analyze proteins, and possibly see, or hear, if something is wrong, or different, with a protein's structure. I find this interesting because it is an alternative way to study something that is also very creative, and you are not just looking at data. As said in the article, the musical representation of the proteins might be useful in understanding more about protein folding. From what I have seen, protein folding is hard to predict, the placement of the bonds needs to be considered, as well as the different polarities of different sections of the peptide chain, along with several other factors affecting the function of the folded protein. Music is being used here to help recognize patterns in protein folding, and it is giving me some ideas as to how crochet may be able to be used to possibly do something similar. I think that possibly crocheting something, or making a tactile model of proteins that could be physically manipulated might be able to be used to help visualize protein structure, in a different way than the norm, similar to how using the music was unusual.
Research Question/Problem/ Need	What can protein data sound like? Are there analytical benefits? And can we hear particular elements or anomalies in the data
Important Figures	N/A
VOCAB: (w/definition)	Anomalies: Odd or out of the norm occurrences. Mutation: A change in DNA that can be positive, negative, or neutral. Sonification: The process of converting a data set into sounds that could be

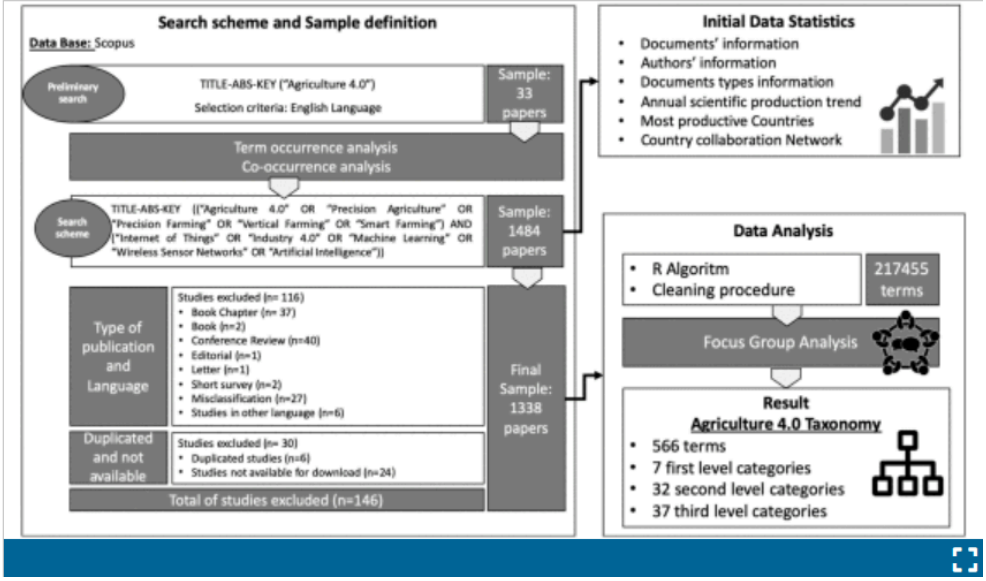
	listened to. Bioinformatics: Visual representations of biological molecules.
Cited references to follow up on	"Melody discrimination and protein fold classification," *Heliyo*n (2016). DOI: 10.1016/j.heliyon.2016.e00175
Follow up Questions	How could the concept of changing how we analyze proteins relate to crochet? How could music and proteins relate to crochet? Could translating data into music be applied to other fields?

Article #5 Notes: **Agriculture 4.0 as Enabler of Sustainable Agri-Food: A Proposed Taxonomy**

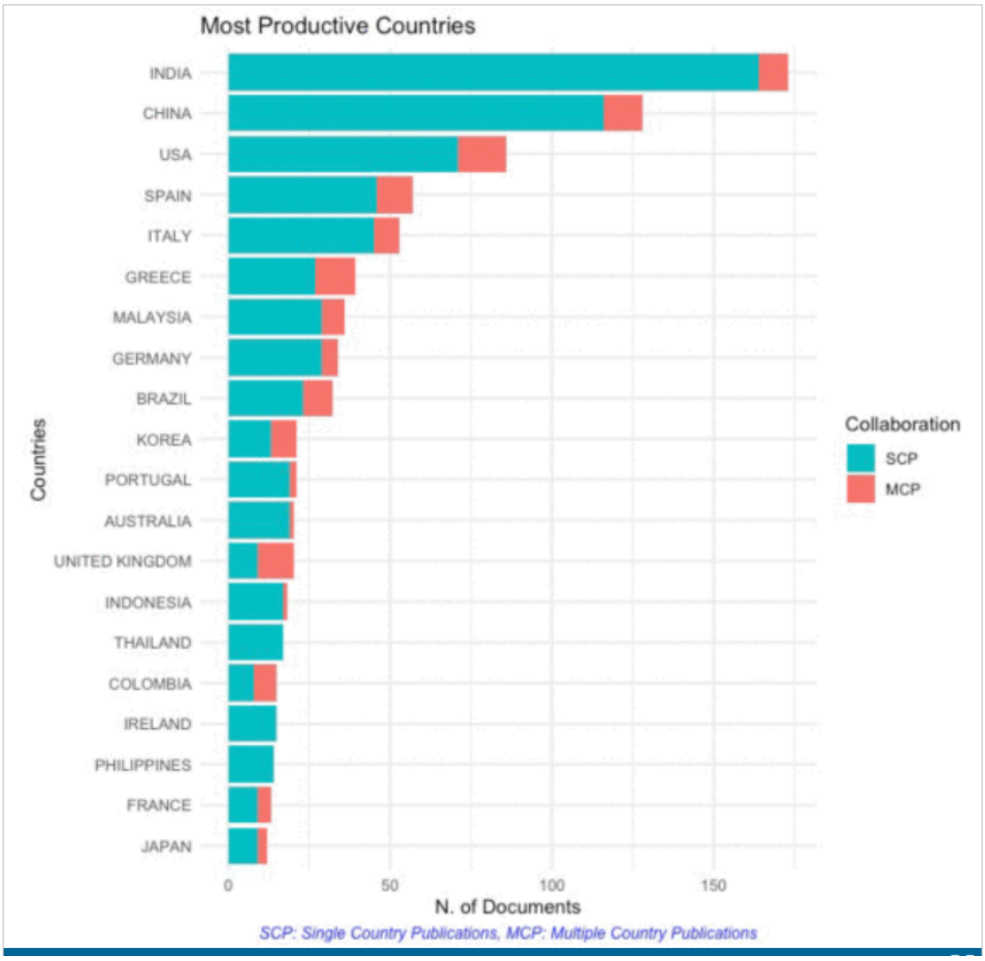
Source Title	Agriculture 4.0 as Enabler of Sustainable Agri-Food: A Proposed Taxonomy
Source citation (APA Format)	Latino, M. E., Corallo, A., Menegoli, M., & Nuzzo, B. (2021). Agriculture 4.0 as Enabler of Sustainable Agri-Food: A Proposed Taxonomy. *IEEE Transactions on Engineering Management*, *70*(10), 3678–3696. https://doi.org/10.1109/TEM.2021.3101548
Original URL	Agriculture 4.0 as Enabler of Sustainable Agri-Food: A Proposed Taxonomy | IEEE Journals & Magazine | IEEE Xplore
Source type	Journal Article
Keywords	Agriculture 4.0, sustainable, sustainability, innovation, agricultural digitalization, agri-food innovation, agri-food sustainability, precision farming, smart farming
#Tags	#brainstorming
Summary of key points + notes (include methodology)	There are many challenges that the agri-food sector is currently facing, and those challenges need to be addressed sustainably, which Agriculture 4.0 can help with; however, there is not an easy way to navigate the information present in Agriculture 4.0, which is why this article exists. The authors used a large sample size of articles on Agriculture 4.0 to create a taxonomy of terms that can be used to better find information on Agriculture 4.0. They found research gaps, as well as possible applications for many parts of the Agriculture 4.0 sector, and then they address what could be done in the future and what limitations exist currently. ● Some issues in agriculture ○ Water waste ○ Land waste ○ Not producing enough food. We also will not have enough food to sustain everyone in the future at the rate we are producing food ○ There are some issue with food safety ○ Greenhouse gas emissions from food production ● Multiple agricultural revolutions ○ 1st: hunter-gatherer's that started farming

	○ 2nd: people started using machines to help them farm (machines were things like the seed drill) ○ 3rd: green innovations ○ 4th: current agricultural revolution that focuses on sustainability and improving both quality and quantity of food produced using a variety of methods. ● Because information is being digitized, more machinery will need to be used. More information, however, can help with the goals of Agriculture 4.0 ● Hunger issues in developing countries are often due to unequal distribution-how can that be changed? A machine? Could working with a nonprofit lead to something? ● Agriculture 4.0 is similar to Industry 4.0 - connections? Things that could be brought over or related? ● Cyber Physical Systems are used in Industry 4.0 and rely on the Internet of Things, Cloud and Fog computing, and Big Data Analytics. These three groups are the main ones that are being used in Agriculture 4.0 ● Some of the theoretical approaches to implementing Agriculture 4.0 seem very specific to their one specific case. Is there a generalization that could be made? ● Agriculture 4.0 is still a theory ● METHODS: ○ They chose a systematic literature review method, and started with a small sample size of articles to select relevant search terms. The authors used the Scopus scientific database to search for relevant articles. Once they had their search terms, they imputed them into Scopus to find related articles. They found common terms, with one word, two words, or three words. They then gathered a focus group, which is a small group of experts on the subject, who analyzed the words and sorted them into the taxonomy. ● There are 7 major search routes they identified: agriculture digitalization process terms, main issues, main aims, agricultural sector features, parameters to monitor/calculate, and technological aspects and data. ● They identify Agriculture 4.0 as being able to address sustainability challenges from multiple perspectives ● This study “presents theoretical applications” ● ● RESEARCH GAPS: ○ No category about business models ○ “concepts related to the application of the principles of the circular economy in the value chain processes are missing.”
Research Question/Problem/ Need	What are the current research routes in agri-food digitalization? How does Agriculture 4.0 is act as an enabler in sustainable agri-food?

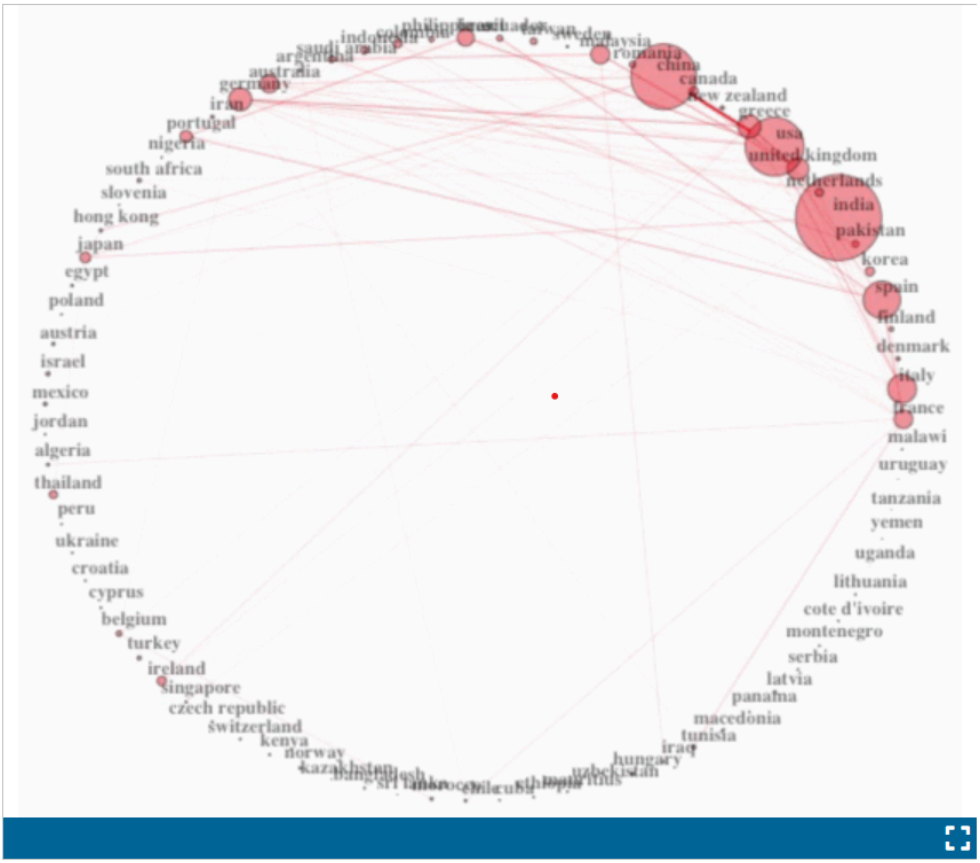
Important Figures



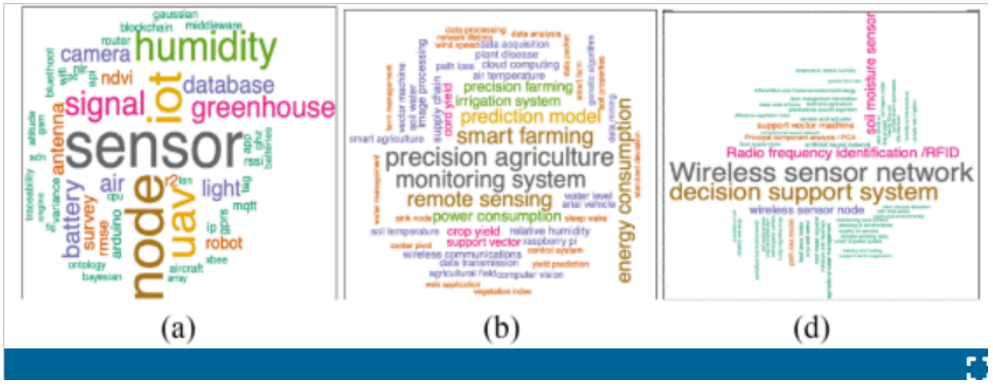
This is a diagrammatic representation of the methodology used for this paper. This shows how they searched Scopus to find the initial amount of articles relating to Agriculture 4.0. It then leads to the results, which was formulated in the taxonomy.



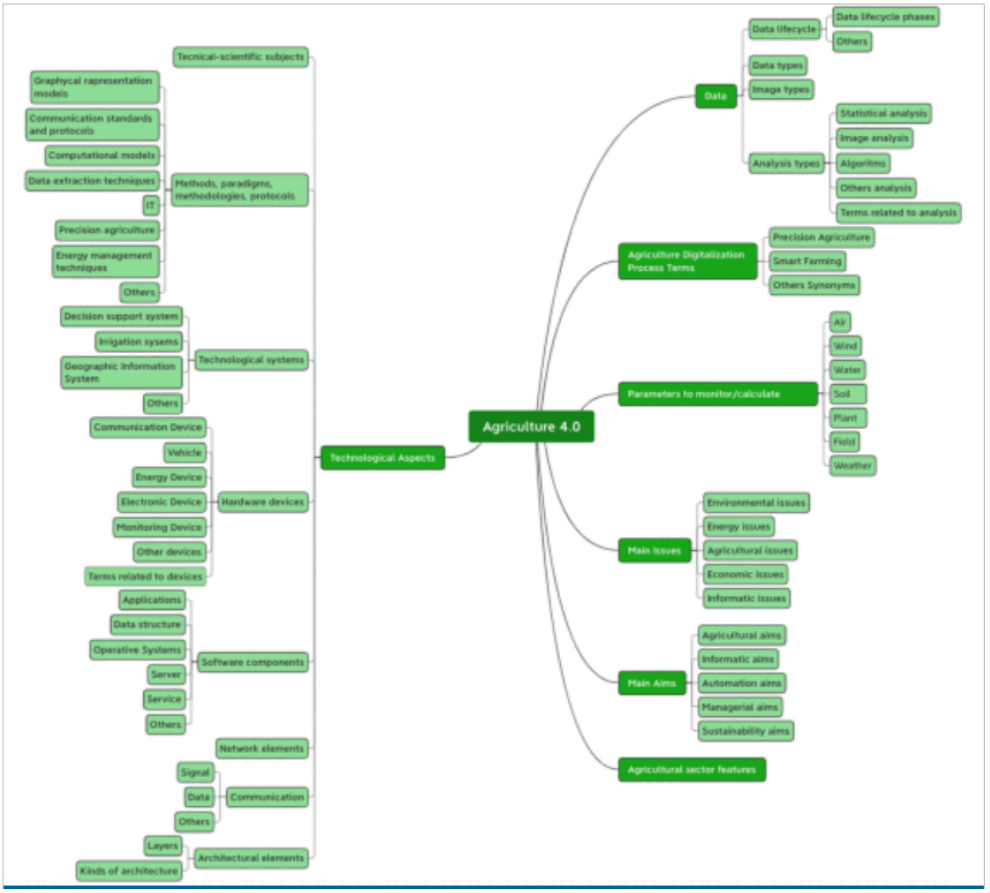
This is a graph of the countries that produced the largest number of articles on Agriculture 4.0. SCP means single country publications, and MCP means multiple country publications.



This is a diagrammatic representation of all the countries that collaborated to write about Agriculture 4.0. Countries with bigger circles and more lines collaborate more with other countries.



These three word clouds represent the most commonly used single word phrases, double word phrases, and three word phrases found in the taxonomy.



This is a diagrammatic representation of the relations the focus group found between some of the more common words and phrases. It starts at Agriculture 4.0, and then extends into various other connections.

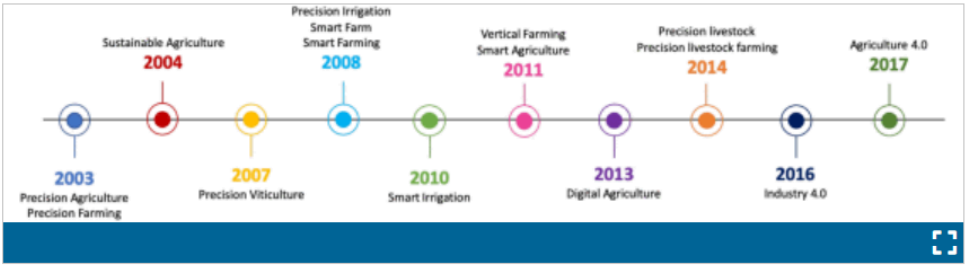


Fig. 10.
Temporal line of synonyms of Agriculture 4.0.

This is a timeline of when synonyms meaning Agriculture 4.0 first appeared.

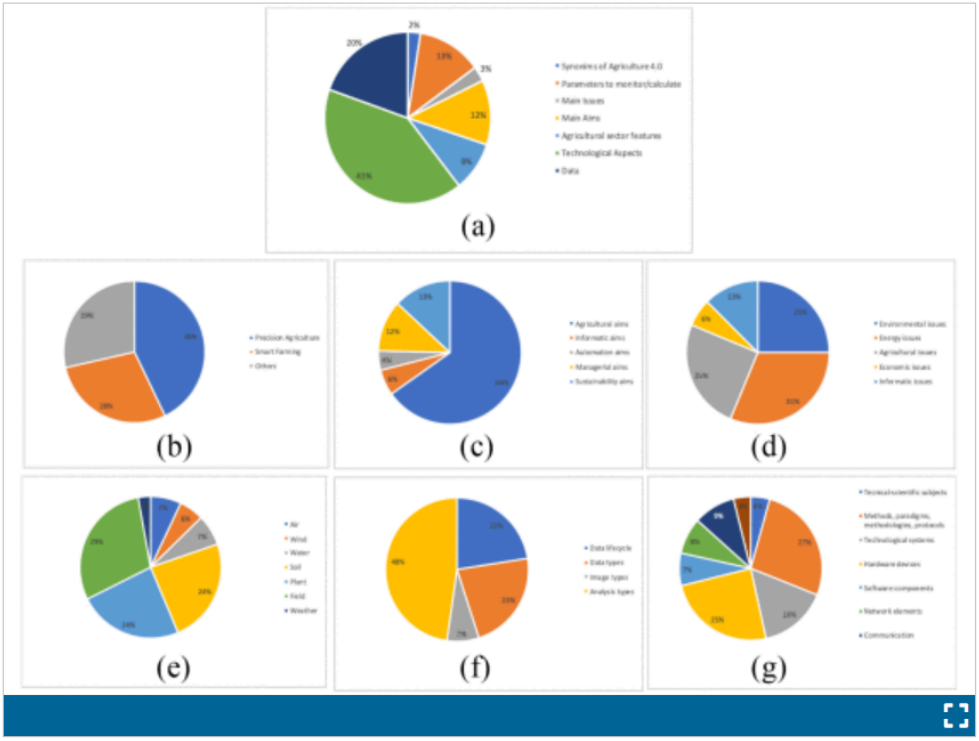
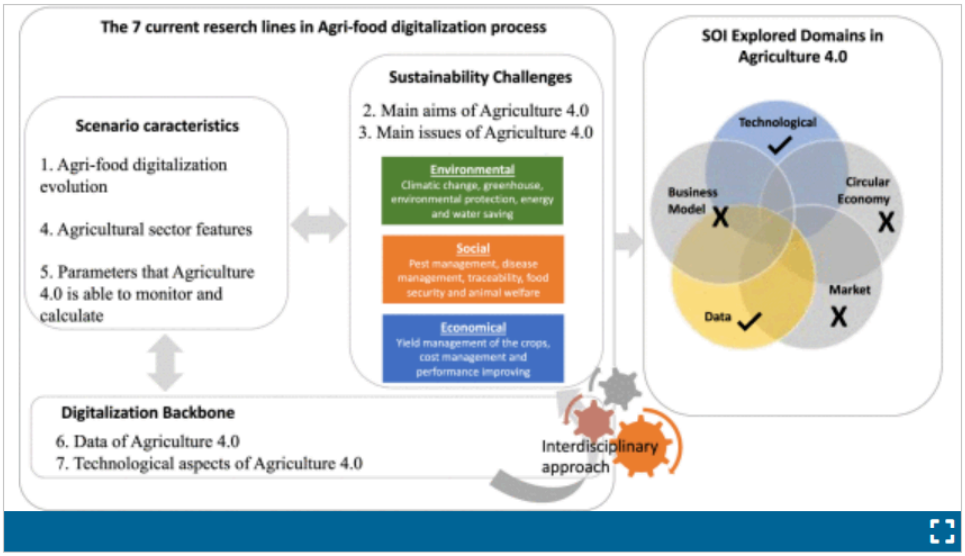


Fig. 11.
Percentage of taxonomy categories.

These pie charts show the percentage of taxonomy categories and the subcategories. (a) represents the 7 main categories, (b) represents *Agriculture Digitalization Process Term*, (c) represents *main aims*, (d) represents the *main issue* category, (e) represents *parameters to monitor/calculate*, (f) represents the Data category, and (g) represents *Technological Aspects*.

	 **Fig. 12.** Main findings of the article. This diagram represents the main findings of the article. It explains the 7 research lines they found, which were separated into three other categories. It also explains what they did and did not look at, meaning their limitations.
VOCAB: (w/definition)	Agriculture 4.0: The fourth agricultural revolution, which aims to increase productivity and sustainability within the agricultural sector, and has the potential to change how the agricultural sector is run. Internet of Things (IoT), which is characterized by the presence of several uniquely addressable cooperating objects, such as mobile phones, sensors, and actuators (Latino, M. E. et al.) Taxonomy: A hierarchy of classification Sustainable: of, relating to, or being a method of harvesting or using a resource so that the resource is not depleted or permanently damaged. (Merriam-Webster) Digitalization process: The process of converting information to a digital format.
Cited references to follow up on	D. Banerjee and L. V. Hysjulien, "Understanding food disasters and food traumas in the global food system: A conceptual framework", *J. Rural Stud.*, vol. 61, pp. 155-161, Jul. 2018. S. J. Vermeulen, B. M. Campbell and J. S. Ingram, "Climate change and food systems", *Annu. Rev. Environ. Res.*, vol. 37, pp. 195-222, 2012. S. Rotz et al., "The politics of digital agricultural technologies: A preliminary review", *Sociologia Ruralis*, vol. 59, no. 2, pp. 203-229, Apr. 2019.

	J. Iqbal, Z. H. Khan and A. Khalid, "Prospects of robotics in food industry", *Food Sci. Technol.*, vol. 37, no. 2, pp. 159-165, May 2017. I. Zonda, D. Xu, M. Jongeling and G. Huisman, "Growkit: Using technology to support people growing food at home", *Proc. CHI Conf. Human Factors Comput. Syst.*, pp. 1-6, May 2019. C. Peano, V. M. Merlino, F. Sottile, D. Borra and S. Massaglia, "Sustainability for food consumers: Which perception?", *Sustainability*, vol. 11, no. 21, Oct. 2019.
Follow up Questions	In what way could this taxonomy be used to better implement Agriculture 4.0 in the real world? How can more concepts within Industry 4.0 be translated to and used in Agriculture 4.0? How can Agriculture 4.0 be implemented and used at a more rapid speed? What effect would Agriculture 4.0 have on climate change and or greenhouse gas emissions?

Article #6 Notes: **Understanding food disasters and food traumas in the global food system: A conceptual framework**

Source Title	Understanding food disasters and food traumas in the global food system: A conceptual framework
Source citation (APA Format)	Banerjee, D., & Hysjulien, L. V. (2018). Understanding food disasters and food traumas in the global food system: A conceptual framework. *Journal of Rural Studies*, *61*, 155–161. https://doi.org/10.1016/j.jrurstud.2018.04.011
Original URL	Understanding food disasters and food traumas in the global food system: A conceptual framework - ScienceDirect
Source type	Journal Article
Keywords	Food trauma, food system, food regime, food disaster-food trauma framework, food disasters, agriculture, conceptual framework, disaster, food supply
#Tags	#Brainstorming
Summary of key points + notes (include methodology)	The current food system, on the surface, appears stable, but there are many underlying issues that still exist, and that could lead to change within the system. The authors propose a conceptual food disaster-food trauma framework that would be used to understand how the issues are able to exist within the system, and if these issues could be used to transform or challenge how the food system is run. The article further describes some issues in the food system, and then how those issues are hidden within the system. ● The developing world is being very negatively affected by rising food prices globally. ● New food regimes, in food regime theory, come from crises that lead to the realization that something is wrong, which then can lead to change. ● There are issues in our current food structures, but the whole of the structure is largely stable, so these issues are less noticeable compared to the past. ● “A stable food system refers to the general stability of the food production system” while the more minor issues are ignored. ● Their paper looks at the concept of whether or not there are issues that could trigger a transformation within the system ● They propose a food disaster-food trauma framework, which is a

conceptual framework, where they would look at the underlying issues of our largely stable food system.

- The first food regime was pre-WWII, and was the result of colonialism in the late 19th century and nation state liberalism. In North America, there was a lot of open land, and immigrants traveled there to farm. Because of this, there was a large surplus of grain, and the results of that surplus were Europeans not being able to make a living off of farming.
- The second food regime was post WWII, where there was a rise in economic relations between countries, which led to agriculture and the food industry becoming more meat focused and producing “durable foods”
- Rapid increases in food prices create devastating conditions for developing countries.
- The third food regime, also called “Food from Nowhere,” was described as “a separation of agricultural practices from our modern life-world.” It is the food regime we are in now.
- Food regime theory does not explain the times when the majority of the system is stable, though it has underlying contradictions.
- The FD-FT framework looks at “normalized crises” which are crises that exist in our current food regime but are masked by the regime.
- Concerns about food safety have been arising, and are a part of the “crisis of controllability”
- An estimated 1 billion people are living in food insecurity, as of 2010 it seems.
- Severe acute malnutrition in children under 5 is not just being hungry at night, it is a lack of food and nutrition that leads the child to be physically stunted and more susceptible to preventable diseases.
- Food disasters in our current food system can be thought of as the compilation of many different issues within the system.
- Recurring droughts in Russia and the Ukraine have led to fluctuations in the prices of the crops grown there, like wheat and corn.
- “Instead, it should be viewed as a conceptual framework that explain how and why food disasters exists within a state of permanent disasters.” What does this mean? Are the permanent disasters outside of the agricultural industry?
- The first step, they said, to a FD-FT framework is to acknowledge that food disasters are continuous and ever-present.
- The concept of food trauma is used to understand how the issues in our food systems are masked by the systems themselves.
- The framework tries to look at the root causes rather than the effects.
- They suggest that the impact of masking the food crisis has led to the false idea that the food system is stable and all is well.
- Symbolic power- essentially the dominant power uses common products to further their interests. Those in power want to stay in power.
- Social structures create a system where food problems become the norm, which then makes the issues worse, and creates a negative feedback loop.
- FD-FT can help with the understanding that it is not the individual's fault

	or simply a result of culture that food insecurity exists, but a result of power differences, class differences, and access to food. ● Severe droughts are a major issue- there is a need for water
Research Question/Problem/ Need	How are the issues within the food system covered by the apparent stability of the food system as a whole, and how can those issues be used to promote change within the system.
Important Figures	**Table 1** Food disaster typology. Food Health Disasters — Concerns over the safety of food as it relates to food-borne illness — (Altekruse et al., 1997; Ghornai et al., 2010; Newell et al., 2010; Wilcock et al., 2004) Ecological Disasters — Two categories: man-made disasters and natural disasters — (Brown et al., 2004; Cribb, 2010; Kloppenburg, 2014) Food Market Disasters — Related to fluctuating costs of foodstuff commodities — (Altieri, 2010; Bello and Baviera, 2010; McMichael, 2010; Tokar, 2010) This table shows 3 different broad classifications of food disasters, which are useful in understanding how our food system works.
VOCAB: (w/definition)	Food trauma: the article defines food trauma as a conceptual tool that can be used to understand how various problems in the food system are masked by the system. Food system: The web of activities that go into the production and then consumption of food. Food regime: A way of theorizing food systems, where new regimes appear after changes in the systems are caused by “moments of crisis.” Conceptual Framework: A framework for a system or algorithm that is still only a concept, and has not yet been made into a reality.
Cited references to follow up on	Collier, P., 2008. The politics of hunger: how illusion and greed fan the food crisis. Foreign Aff. 87 (6), 67–80. Mohanty, B.B., 2005. We are like the living dead’: farmer suicides in Maharashtra, western India. J. Peasant Stud. 32 (2), 243–276. Carolan, M.S., 2012. The food and human security index: rethinking food security and growth. Int. J. Sociol. Agric. Food 19 (2), 176–200
Follow up Questions	What can be done to try and bring some of the issues in the food system to light? How can food regime theory be used to change how our food systems are run today? Is there something that could be used along with food regime theory that could lead to a change in our food systems? What can be done to ease the impact of vastly fluctuating markets on developing nations?

Article #7 Notes: **In your shoes: A qualitative study on the perspectives of professional dancers and staff regarding dance injury and its prevention**

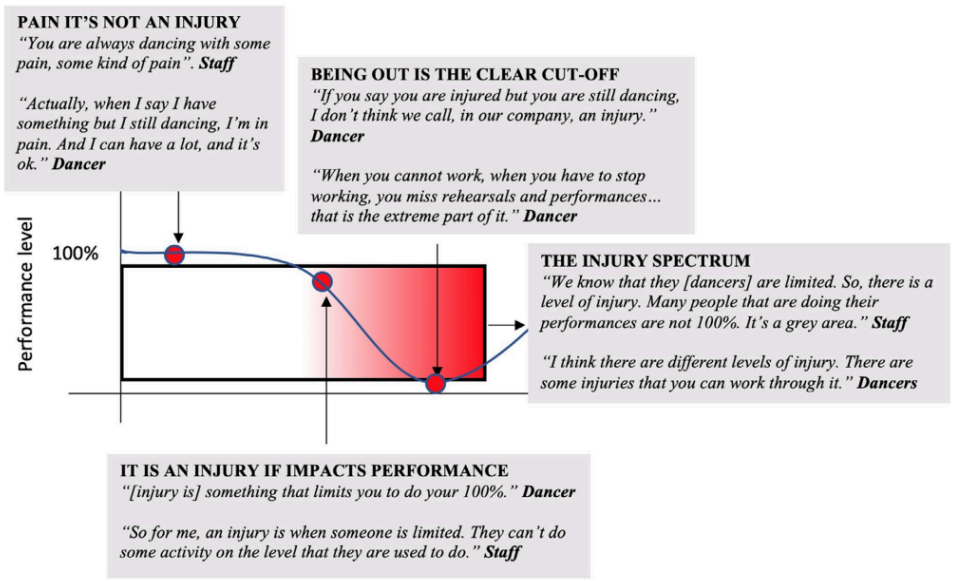
Source Title	In your shoes: A qualitative study on the perspectives of professional dancers and staff regarding dance injury and its prevention
Source citation (APA Format)	Bolling, C., Van Rijn, R. M., Pasman, H. R., Van Mechelen, W., & Stubbe, J. H. (2021). In your shoes: A qualitative study on the perspectives of professional dancers and staff regarding dance injury and its prevention. *Translational Sports Medicine*, *4*(3), 386–394. https://doi.org/10.1002/tsm2.226
Original URL	In your shoes: A qualitative study on the perspectives of professional dancers and staff regarding dance injury and its prevention - Bolling - 2021 - TRANSLATIONAL SPORTS MEDICINE - Wiley Online Library
Source type	Journal Article
Keywords	dance injuries; injuries; performing arts; prevention; qualitative research; sports injuries
#Tags	#Brainstorming
Summary of key points + notes (include methodology)	Summary: In this study, professional dancers and staff of the Dutch National Ballet were asked for their perspectives and opinions on injuries related to dance. Their viewpoints were analyzed to find patterns for what dancers and staff think injuries look like, what causes injuries, and what can be done to prevent dance related injuries. The researchers found that there is not a clear definition as to what an injury is, however, many dancers expressed that missing dance and how long they were forced to miss class due to an injury reflected how severe the injury was. The researchers also found that a higher workload and the transition between workloads was a major cause of injuries, and the ability to prevent injury was based on managing load and open communication between the dancers and the staff. Notes: ● There are divergent results relating to dance injury, which standard injury definition would help with in terms of data collection. ● Sports and dance injuries are complex ● There is a normalization of pain and injuries in dance

	● MATERIALS AND METHODS: ○ Two focus groups were gathered ○ The groups were formed to be heterogeneous based on the whole cast so the diversity of the cast could be represented properly. ○ The interviews taken were audio recorded, transcribed and then analyzed. ○ The two analyzers independently analyzed the information, then met up together and discussed until they agreed. ● Majority interviewed were female. ● Staff and Dancers had different definitions as to what constituted an injury, though there were overlaps. ● Both said limiting the dancers ability to dance at their fullest, either in time or effort, was important in determining how severe an injury was. ● Workload is something that majorly affects a dancer and how likely they are to get injured. The transition between a lighter workload and a heavier one also has an impact on the likelihood. ● Load capacity is different in every dancer ● Preparation for a heavy workload was described as being important for injury prevention. ● Communication between the staff and the dancer where both sides trust one another is important for injury prevention and making sure the injury does not progress too far. ● Young dancers need to be guided in injury prevention as they are not experienced and they should not need to learn through getting a severe injury. ● Injuries are underreported because they are so normalized within the industry. ● More collaboration and teamwork is needed between the dancers and the staff for injury prevention. ● Dancers say that it is mainly their responsibility to prevent injuries, but a lot of factors that cause injuries are out of their control. -paraphrased ●
Research Question/Problem/ Need	What are the experiences and opinions of professional dancers and staff in regards to injury classification, causes of injuries, and injury prevention in relation to dance?

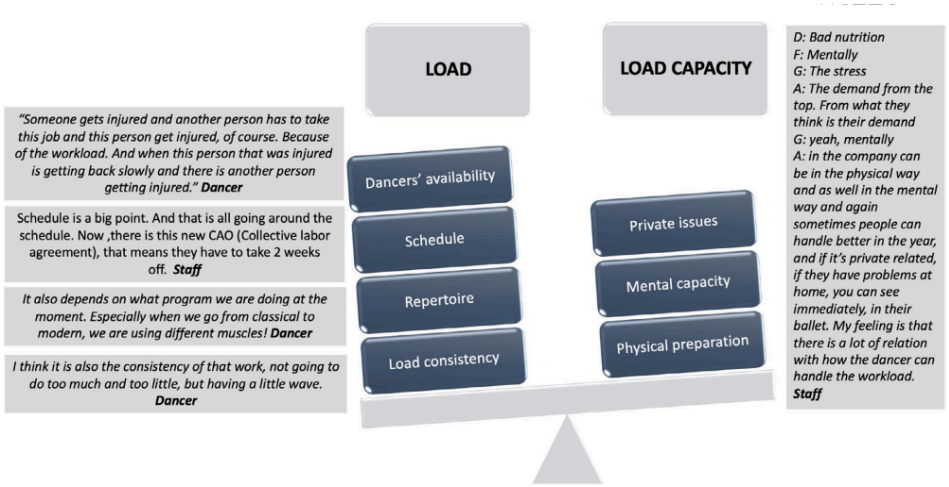
Important Figures

Interview guide	
Injury definition	What do you consider as an injury?
	How do you define an injury?
Factors influencing injury occurrence	Which factors influence the occurrence of an injury?
	How do these factors influence the injury occurrence?
Injury prevention measures	Who is responsible for the prevention of injuries?
	Which injury prevention strategies do you apply and why?
	How do you choose your injury prevention strategies?
	Which factors in your daily routine support injury prevention? Which factors make injury prevention more difficult?

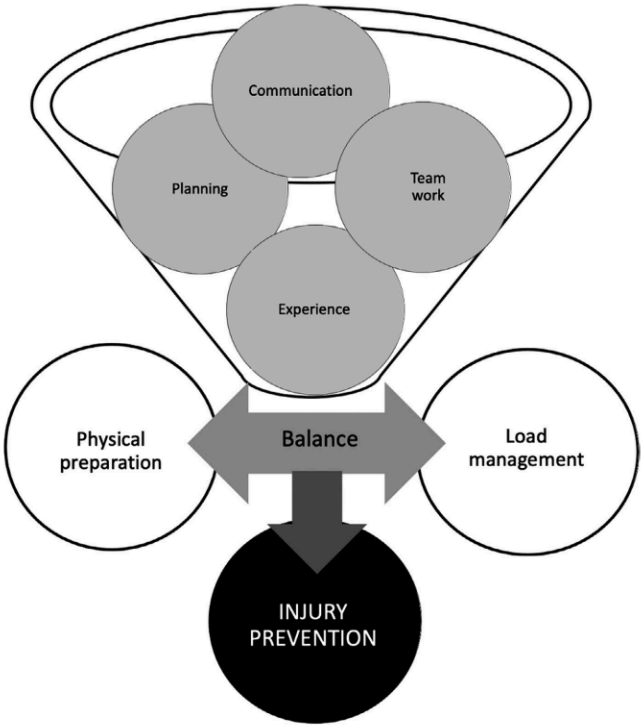
This is a table of the questions asked in the interviews with the dancers and staff.



This is a diagram of what dancers and staff thought an injury was defined as. The path of the graph is supported by the quotes of the dancers and staff as they were responding to the interview questions.



This is a diagram of how the workload of a dancer is a compilation of many factors, and the load capacity is also a compilation of factors. If the load of a dancer exceeds their load capacity, throwing the scales off balance, then that dancer is at a higher risk of injuring themselves.



This diagram is about how balance between physical preparation, injury prevention, and load management is influenced by the 4 factors in gray. The information to create this chart was obtained via the interviews.

VOCAB: (w/definition)

Epidemiological: Relating to the branch of medicine that studies and deals with diseases. (Paraphrased from Oxford Dictionary's definition)

Grounded Theory: A theory where new ideas are created based on data, not

	existing ideas. Heterogenous: Being diverse Triangulation: Using or measuring a series of triangles in order to understand connections and relative points. (Paraphrased from Oxford Dictionary's definition)
Cited references to follow up on	Moita JP, Nunes A, Esteves J, Oliveira R, Xarez L. The relationship between muscular strength and dance injuries: a systematic review. *Med Probl Perform Art*. 2017; 32(1): 40-50. https://doi.org/10.21091/mppa.2017.1002 Wainwright SP, Williams C, Turner BS. Fractured identities: injury and the balletic body. *Health (Irvine Calif)*. 2005; 9(1): 49-66. https://doi.org/10.1177/1363459305048097 McEwen K, Young K. Ballet and pain: reflections on a risk-dance culture. *Qual Res Sport Exerc Heal*. 2011; 3(2): 152-173. https://doi.org/10.1080/2159676X.2011.572181 Verhagen E, Mellette J, Konin J, Scott R, Brito J, McCall A. Taking the lead towards healthy performance: the requirement of leadership to elevate the health and performance teams in elite sports. *BMJ Open Sport Exerc Med*. 2020; 6(1):e000834. https://doi.org/10.1136/bmjsem-2020-000834
Follow up Questions	Could changing the way the shoes of a dancer are made help to increase their load capacity? Are there other reasons besides workload that have an impact on the likelihood of injury in a dancer? Are there other factors that could increase injury prevention besides managing work? Would a better dance shoe help dancers in their training and then in injury prevention?

Article #8 Notes: **Socioeconomic impacts of marine heatwaves: Global issues and opportunities**

Source Title	Socioeconomic impacts of marine heatwaves: Global issues and opportunities
Source citation (APA Format)	Smith, K. E., Burrows, M. T., Hobday, A. J., Sen Gupta, A., Moore, P. J., Thomsen,

	M., Wernberg, T., & Smale, D. A. (2021). Socioeconomic impacts of marine heatwaves: Global issues and opportunities. *Science*, *374*(6566), eabj3593. https://doi.org/10.1126/science.abj3593
Original URL	Socioeconomic impacts of marine heatwaves: Global issues and opportunities | Science
Source type	Journal Article
Keywords	Anthropogenic, Marine Heatwaves (MHW's), Adaptation, Mitigation, Ecosystem services, Species range shifts, ecosystem reconfiguration, socioeconomic
#Tags	#Brainstorming #Summer
Summary of key points + notes (include methodology)	This article was about the effects of marine heatwaves on economics and human society. As I understand it, marine heatwaves are instances when sections of the oceans have their temperatures raised above the norm for extended periods of time, similar to heatwaves on land. The purpose of this study was to attempt to understand more about how marine heatwaves affect ecosystems globally and what impacts those affected ecosystems have on human society and the global economy. Some of those impacts were negative, and included major losses of money, the shutdown of fisheries, and the destruction of parts of kelp forests which, in one case, resulted in indigenous tribes in New Zealand having difficulty in continuing important traditions, and many more factors. Other impacts were more positive, for example, some rare aquarium species were more abundant, and there was a greater quantity of whale sightings which increased tourism and money. However, looking at the tables specifically, there seem to currently be more negative impacts associated with marine heatwaves than positive impacts, meaning that the negatives outweigh the positives. The authors also continuously express how they believe that more strategies for adaptation to, and mitigation of, marine heatwaves are necessary to try and decrease the negative effects of marine heatwaves. I personally found this article interesting because I want to help with the many issues that climate change has created, and in order to help with those issues I need to know what they are and what is currently being done. This article specifically talks about what the impacts of marine heatwaves currently are globally and socioeconomically, and how mitigation and adaptation to these are necessary; furthermore some of the ideas given for how to do this could be built off of. I am thinking that more involvement and advocacy from the public would be a good step to trying to get change to occur in those that do not want to change.
Research Question/Problem/ Need	What are the effects of extreme climatic events, specifically marine heatwaves, on ecosystems globally, and what are the socioeconomic impacts of these MHW's?

Important Figures

Table 1. Examples of direct economic outcomes of MHWs.

Location	Year(s)	Socioeconomic impact	Location of impact	Value/loss/gain	Primary industry affected	Affected TEEB ecosystem service	Reference(s)
Gulf of Alaska	2014–2019	Population decline and low recruitment affects Gulf of Alaska commercial Pacific cod fishery catch limits	Alaska, USA	Fishery valued at US$103 million per annum; loss unknown; funding relief: In 2018, Congress appropriated US$24.4 million in federal disaster relief funding.*	Commercial fisheries	Provisioning and habitat services	(29)
	2020	Population decline and low recruitment closes Gulf of Alaska commercial Pacific cod fishery for the season	Alaska, USA	Fishery valued at US$103 million per annum; comparative loss likely; federal disaster relief funding requested (pending as of 5 May 2021)*	Commercial fisheries	Provisioning and habitat services	(29, 48)
Northeast Pacific Ocean	2015	Harmful algal blooms cause closure of recreational razor clamming	Washington, USA	US$40 million loss in tourist spending	Tourism and recreational fisheries	Regulating and cultural	(49, 66)
	2015–2016	Harmful algal blooms cause closure of commercial Dungeness crab fisheries	West Coast, USA	US$97.5 million loss; funding relief: Congress to appropriate US$27.3 million in federal disaster relief funding including US$1.5 million to the native American Quileute Tribe*	Commercial fisheries	Provisioning and regulating	(67, 103)
	2015–present	Population decline of red sea urchin due to kelp loss causes closure of commercial fishery	California, USA	Fishery valued at US$3 million per annum; funding relief: Congress appropriated US$3.3 million in federal disaster relief funding for 2016 and 2017*	Commercial fisheries	Provisioning, regulating, habitat, and cultural	(14)
	2018–present	Population decline of abalone due to kelp loss causes closure of recreational fishery	California, USA	US$44 million loss per annum	Tourism and recreational fishing	Provisioning, regulating, habitat, and cultural	(14)
Southeast Pacific Ocean	2016–2017	Mass mortality of farmed salmon due to harmful algal blooms	Southern Chile	Export loss of US$800 million	Aquaculture	Provisioning and regulating	(38)
Coral Sea	2016,, 2018	Bleaching and mass mortalities of corals	Great Barrier Reef, Australia	The Great Barrier Reef is valued at US$4.2 billion annually, with a total value estimated at US$41 billion; loss related to bleaching unknown; gains related to "last chance tourism" also unknown	Tourism	Habitat and cultural	(69)

continued on next page

Location	Year(s)	Socioeconomic impact	Location of impact	Value/loss/gain	Primary industry affected	Affected TEEB ecosystem service	Reference(s)
Tasman Sea	2016	Pacific oyster mortality syndrome closed hatcheries and decimated juvenile stocks	East coast of Tasmania, Australia	Aquaculture valued at US$19 million; loss unknown	Aquaculture	Provisioning and habitat	(104)
	2016	Poor performance of salmon limited production	East coast of Tasmania, Australia	Aquaculture valued at US$545 million; loss unknown	Aquaculture	Provisioning and habitat	(104)
	2016	Mortality of wild caught abalone led to smaller catch and reduced quotas	South/southeast coast of Tasmania, Australia	Wild caught fishery valued at US$62 million; loss unknown	Fisheries	Provisioning and habitat	(104)
Southeast Asia seas	2010	Bleaching and mass mortalities of corals	Indonesia, Malaysia, Thailand	US$49 to 74 million loss	Tourism	Habitat and cultural	(73)
Southeast Indian Ocean	2011 present	Closure of abalone fishery due to mass mortality event	West Coast, Australia	Estimated loss per annum ~US$0.16 million	Commercial and recreational fisheries	Provisioning, habitat, and cultural	(51)
	2011 2013	Closure of commercial swimmer crab fishery for 18 months to protect breeding stock after low catch rates	Shark Bay, Australia	US$3.1 million loss	Commercial fisheries	Provisioning and habitat	(105)
	2011 2016	Closure of commercial scallop fishery for 3 years (Shark Bay) or 5 years (Abrolhos Islands and Midwest) due to low recruitment	West Coast, Australia	Estimated losses per annum: Shark Bay ~US$8.2 million†; Abrolhos Islands and Midwest ~US$3 million‡	Commercial fisheries	Provisioning and habitat	(51)
	2011	Loss of carbon storage and other ecosystem services provided by seagrass	Shark Bay, Western Australia, Australia	US$3.1 billion loss per annum for multiple consecutive years	Multiple ecosystem services	Provisioning, regulating, habitat, and cultural	(21)
Gulf of Maine	2012	Early lobster migration led to record landings and drop in lobster value	Gulf of Maine, USA	US$38 million loss	Commercial fisheries	Provisioning and habitat	(77)
	2016	Proactive management of lobster fishery after 2012 MHW led to economic gains	Gulf of Maine, USA	US$108 million gain	Commercial fisheries	Provisioning and habitat	(77)

*Funding relief values in the United States are from the National Oceanic and Atmospheric Administration (NOAA; https://www.fisheries.noaa.gov/national/funding-and-financial-services/fishery-disaster-determinations). †Values estimated from the Government of Western Australia State of the fisheries annual reports (https://www.fish.wa.gov.au/About-Us/Publications/Pages/State-of-the-Fisheries-report.aspx).

This is a table containing some of the information about mainly the economic effects of MHW's.

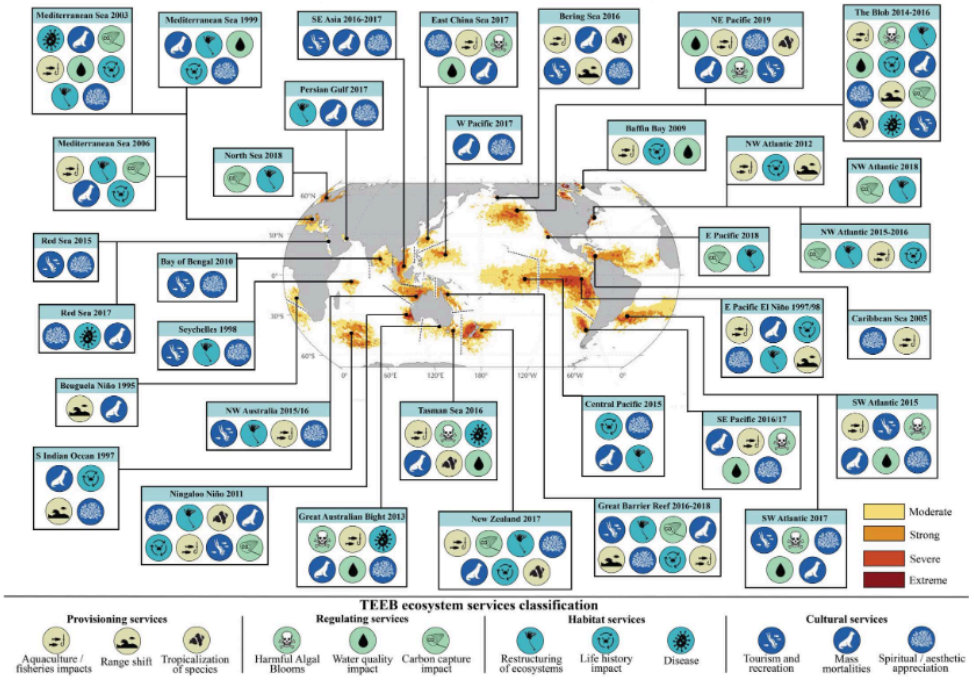
Table 2. Reported impacts of MHW events. Responses in **bold** indicate positive socioeconomic consequences, those in *italics* are negative consequences, and those in roman are both negative and positive.

Location	Year(s)	Recorded response variable	Reference(s)
Southeast Atlantic (Benguela Niño)	1995	*Mass mortalities of fish, southward displacement of fish species*	(*22*)
South Indian Ocean	1997	*Mortality and reproductive failure in king penguins, range shift in prey species*	(*106, 107*)
East Pacific El Niño	1997–1998	Shift in fisheries species, *mass mortalities and reproductive failure of Galapagos sea lions, decline in kelp forests, low zooplankton abundance, coral bleaching, ecosystem disruption*	(*26, 27, 43, 108, 109*)
West Indian Ocean	1998	*Coral bleaching, restructuring of ecosystems*	(*61, 110*)
Red Sea	1998, 2007, 2010, 2012, 2015,	*Coral bleaching*	(*111*)
	2017	*Mass mortalities of coral reef fish, fish disease*	(*112*)
Mediterranean Sea	1999	*Mass mortalities of benthic organisms, habitat loss, reduced growth and reproduction, coral bleaching*	(*19, 24, 113, 114*)
Mediterranean Sea	2003	*Mortalities in mollusk fisheries (multiple life stages), mass mortalities of benthic organisms, coral bleaching, seagrass flowering and shoot mortality, reduced growth and reproduction, disease*	(*24, 44, 45, 114–116*)
Caribbean Sea	2005	*Coral bleaching, loss of fisheries*	(*16, 117, 118*)
Mediterranean Sea	2006	*Mortalities in mollusk fisheries (multiple life stages), mass mortalities of benthic organisms, shoot mortality in seagrass*	(*24, 44, 45*)
Canadian Arctic	2009	Earlier sea ice breakup, decreased sea ice, **increased productivity**, **increased cod reproduction**	(*32, 33*)
Bay of Bengal	2010	*Coral bleaching*	(*16, 17*)
Southeast Indian Ocean (Ningaloo Niño)	2011	*Loss of seagrass and kelp, coral bleaching, fisheries closures, reduced fisheries quotas,* shifts in recruitment, **range expansion of tropical fish**	(*15, 31, 36, 50, 51, 119–121*)
Northwest Atlantic	2012	Spring boom in lobster landings, range shift of a range of commercially valuable fisheries species (e.g., squid, cod, flounder, hake)	(*35, 39, 77, 84*)
Great Australian Bight	2013	*Mass mortalities of fish and abalone, harmful algal blooms, disease*	(*122*)
Northeast Pacific (The Blob)	2014–2016	*Mass mortalities of California sea lions, seals, seabirds, and marine invertebrates; sea star wasting disease;* range shifts in a variety of species; *harmful algal blooms; fisheries disruptions and closures; shifts in kelp forest ecosystems;* **increase in orca births**; *coral bleaching;* **increased abundance of tuna**; **unusual sightings of warm water species**; increases and decreases in fisheries recruitment; **increased observations of whales**; *increased whale entanglement*	(*25, 28, 38, 123–125*)
Northwest Atlantic	2015–2016	*Loss of seagrass,* **early migration of lobsters**	(*58, 77*)
Southwest Atlantic	2015	*Harmful algal blooms, mass fish mortalities, closure of fisheries, flags flown on beaches to indicate potential health risks*	(*126*)
Central Pacific	2015–2016	*Mass coral bleaching and mortality, shift from coral to encrusting macroalgae and crustose coralline algae, decreased fish biomass, reduction in seabirds and seabird breeding*	(*61, 127, 128*)

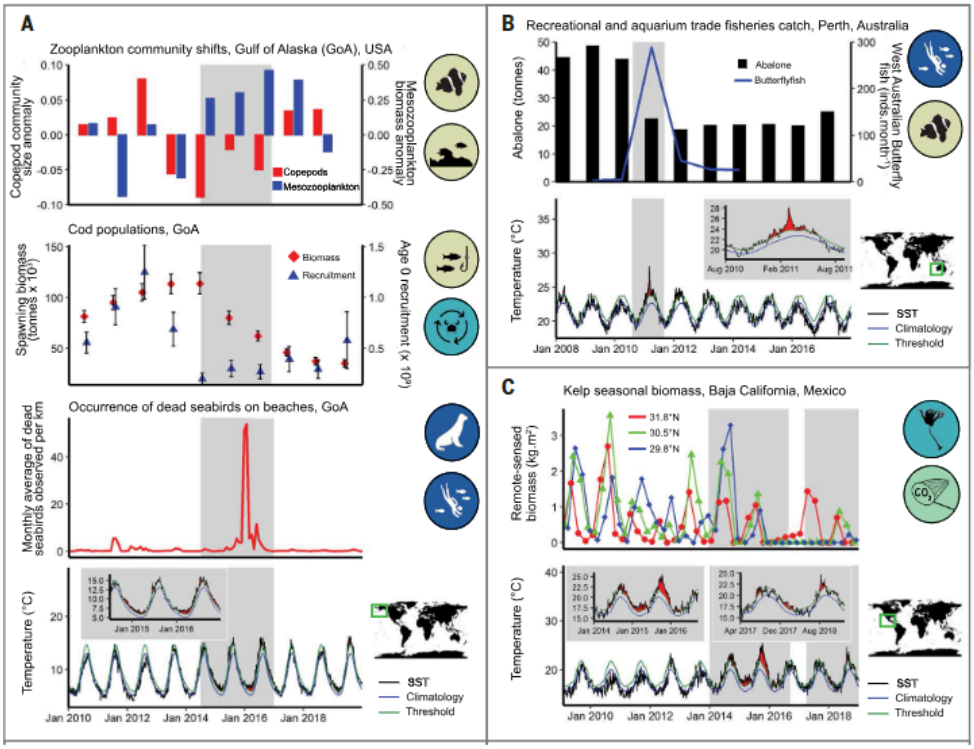
continued on next page

Location	Year(s)	Recorded response variable	Reference(s)
Southeast Indian Ocean	2015 2016	Coral bleaching	(121, 129)
Tasman Sea	2015 2016	Loss of fisheries, loss of kelp, POMS, mortality of abalone, fish species noted outside of their range	(74, 130)
Bering Sea	2016	Range expansion of bowhead whales, mass mortality of puffins, low sea ice, reduced ice based fishing, low snow and unsafe river ice making winter transportation difficult, tropicalization of copepods	(131)
Southern Ocean	2016	Decreased sea ice	(132)
Southeast Pacific	2016 2017	Mass mortalities of farmed salmon, harmful algal blooms	(38, 65)
Southeast Asia seas	2016 2017	Mass coral bleaching, reefs closed to tourism	(132)
Coral Sea	2016 2018	Mass coral bleaching, mass coral mortalities, failed coral recruitment, species range shifts, loss of seagrass, poor reproductive effort in seagrass, increased abundance and biomass of coral trout	(37, 53, 121, 133 138)
Tasman Sea	2017	Loss of kelp, range shift of fish and jellyfish, early spawning in snapper, salmon mortalities in fish farms	(13, 139)
East China Sea	2017	Harmful algal blooms, coral bleaching, mass mortalities of farmed fish	(140 142)
Southwest Atlantic	2017	Harmful algal blooms, mass mortalities of fish, closure of recreational beaches	(143, 144)
West Pacific	2017	Mass mortality of coral after successive bleaching events in 2013, 2014, 2016, and 2017	(61, 145)
Persian Gulf	2017	Mass coral bleaching, coral mortality, increase in turf algae	(146)
Northeast Pacific	2018	Loss of kelp	(12)
Northwest Atlantic	2018	Loss of kelp forest	(55)
North and Baltic Seas	2018	Loss of kelp forest	(55)
Northeast Pacific	2019 2021	Harmful algal blooms, Dungeness crab fisheries closures, recreational razor clam fisheries closures, fish mortalities at fish farms, olive Ridley sea turtles observed off British Colombia, coral bleaching	(38, 147 150)

This is a table containing information about where MHW's have previously occurred, and what the ecological effects were.



This is a diagram representing how strong the MHW's were, and what the impacts

	of those MHW's were on the ecosystem and economically.  These are some more specific impacts of MHW's on ecosystem services
VOCAB: (w/definition)	Anthropogenic: A change in the environment caused by humans Marine Heatwaves: Short-term periods of the ocean warming above the normal expectations. Adaptation: A change so something can be better suited for situations Mitigation: Minimizing the negative effects of an event
Cited references to follow up on	M. W. Fraser, G. A. Kendrick, J. Statton, R. K. Hovey, A. Zavala-Perez, D. I. Walker, Extreme climate events lower resilience of foundation seagrass at edge of biogeographical range. *J. Ecol.* **102**, 1528–1536 (2014). D. A. Smale, T. Wernberg, E. C. J. Oliver, M. Thomsen, B. P. Harvey, S. C. Straub, M. T. Burrows, L. V. Alexander, J. A. Benthuysen, M. G. Donat, M. Feng, A. J. Hobday, N. J. Holbrook, S. E. Perkins-Kirkpatrick, H. A. Scannell, A. Sen Gupta, B. L. Payne, P. J. Moore, Marine heatwaves threaten global biodiversity and the provision of ecosystem services. *Nat. Clim. Chang.* **9**, 306–312 (2019). A. Himes-Cornell, L. Pendleton, P. Atiyah, Valuing ecosystem services from blue forests: A systematic review of the valuation of salt marshes, sea grass beds and mangrove forests. *Ecosyst. Serv.* **30**, 36–48 (2018).

Follow up Questions	Do marine heatwaves have effects on land agriculture? Could last chance tourism be used to help revitalize certain agricultural areas? How could marine heatwaves be utilized by humans to create food sources? How far reaching are the socioeconomic impacts of marine heatwaves?

Article #9 Notes: **Hydrophysical characteristics in water-repellent tropical Eucalyptus, Pine, and Casuarina plantation forest soils**

Source Title	Hydrophysical characteristics in water-repellent tropical Eucalyptus, Pine, and Casuarina plantation forest soils
Source citation (APA Format)	Leelamanie, D. A. L., Piyaruwan, H. I. G. S., Jayasinghe, P. K. S. C., & Senevirathne, P. A. N. R. (2021). Hydrophysical characteristics in water-repellent tropical Eucalyptus, Pine, and Casuarina plantation forest soils. *Journal of Hydrology and Hydromechanics*, *69*(4), 447–455. https://doi.org/10.2478/johh-2021-0027
Original URL	Hydrophysical characteristics in water-repellent tropical Eucalyptus, Pine, and Casuarina plantation forest soils (sciendo.com)
Source type	Journal Article
Keywords	Casuarina equisetifolia, Eucalyptus grandis, Hydrophysical characteristics, Pinus caribaea, Water repellency
#Tags	#soil
Summary of key points + notes (include methodology)	This article looked at the Soil Water Repellency in 3 types of soils where trees with high levels of hydrophobic compounds were grown, and how the SWR differed between the wet and dry seasons of the areas. The researchers aimed to look at how the three trees studied impacted the hydrophysical characteristics of the soils in which they were grown. It was found that the SWR did in fact hinder the ability of water to travel in the soils, and that higher water entry values in the dry season predicted a higher likelihood of soil runoff and erosion. The researchers concluded that more research into the structure of the soil itself and soil biology will be needed to better understand how water flow is hindered. NOTES: Abstract ● Some areas have higher Soil Water Repellency (SWR), meaning that “the rate of wetting in dry soils” is reduced. Essentially, it takes longer for soils to absorb water. ● Higher SWR was observed in the dry season by all three soils (Eucalyptus, Pine, and Casuarina). ● Water entry into soils and flow of water in soils was clearly hindered by

SWR

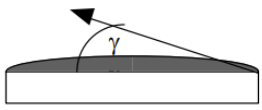
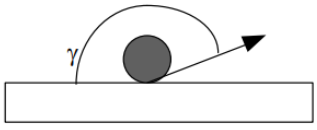
- Higher water entry in dry season indicated higher likelihood for runoff and topsoil erosion (paraphrased)

Introduction

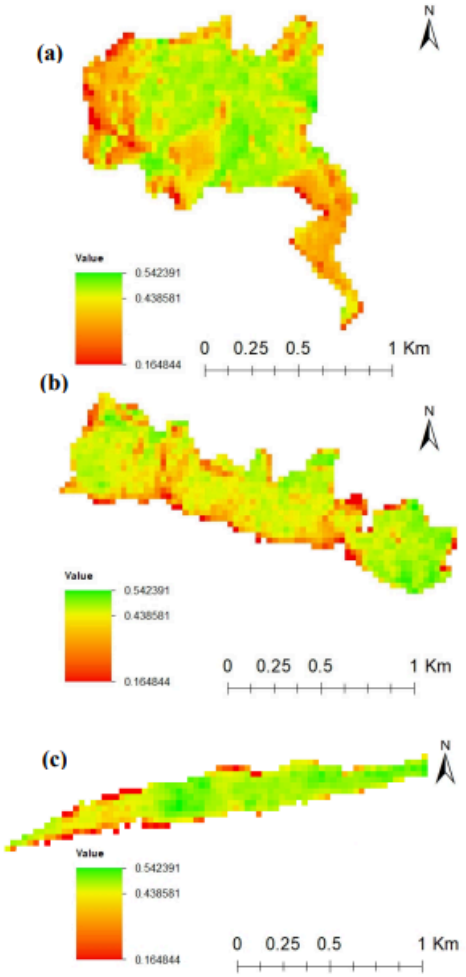
- SWR is caused by the mixing of organic substances into soil or a hydrophobic organic coating on the minerals in the soil (paraphrased)
- SWR leads to other problems like water flow patterns that are uneven and unstable, which can also lead to spots of high and low water concentration, which can lead to preferential flow patterns
- SWR has been considered a widespread challenge for a long time
- Plants higher in hydrophobic resins and waxes cause higher SWR in soils
- The causes for SWR observed here were considered natural causes, as opposed to unnatural causes like forest fires
- SWR varies spatially, but forests that have it have different hydraulic properties. After long wet periods it goes away, but heavy rainfall events directly after long dry periods tend to intensify soil runoff and erosion (paraphrased)
- Both wet and dry seasons were considered during this study (paraphrased)

Methods

- 3 sites were looked at, all were water repellent experimental sites
- The Eucalyptus forest was first looked at. The mean annual rainfall was 1600-1700 mm (about 63 inches, which is greater than MA avg annual rainfall)
- In the dry season, less than 10% of the average rainfall is received
- Dense layer of litter(leaves and such) (3-4cm) was on the surface of the ground
- Avg moisture content was 12% to 8% in wet and dry seasons respectively (paraphrased)
- Next was Pine. Mean annual rainfall was 1700-1900 mm of rainfall
- Dry season also received less than 10% of avg rainfall
- 3-12 cm thick layer of litter (mostly pine needles)
- Avg moisture content was 17% to 14% in wet and dry seasons respectively (paraphrased)
- Casuarina had a mean annual rainfall of 900 mm
- Dry season received less than 20% of mean annual rainfall
- 3-10 cm thickness of litter
- Avg moisture content was 5-7% to 0.5-1.5% in wet and dry seasons respectively (paraphrased)
- During wet season, decomposition rates were greater and level of litter decreased
- Soil samples were taken at 0–5, 5–10, and 10–15 cm
- To measure the properties of the soils they were first air dried, then sifted, and then experimented on using various procedures. The results are in table 1
- Water repellency was measured by measuring the time it took for a drop of water to be absorbed into the soil (water drop penetration time), and the angle at which it was absorbed.

	Results and Discussion ● Casuarina soil showed highest SWR in the dry season, while Eucalyptus soil showed highest SWR in the wet season (paraphrased) ● Low SWR in the wet season corresponded with the thickness of the litter; because the layer was less thick in the wet season, it was lower. ● In the Eucalyptus and Pine soils, in the dry season, there were areas that had higher infiltration levels, which indicated preferential paths. This could cause issues because some areas may get more water than others, and could lead to higher levels of erosion. ● The study found that it was clear that SWR decelerates water infiltration into the soil. Conclusions ● There were clear differences between all three in the water repellency between wet and dry seasons ● Water entry into soils as well as the subsurface water flow was hindered by the SWR. (direct quote) Extra research: ● k(-1 cm) represents unsaturated hydraulic conductivity, which is the ability of soil to retain water when the spaces between the grains are not saturated with water. It is related to something called Darcy's equation, which is an equation for the flow of water through a porous substance (paraphrased from Darcy's law Definition & Meaning - Merriam-Webster). Permeability, which is the ability of water to pass through the voids between the grains, is also important. Resource used Soil Permeability - Darcy's Law - YouTube ● Contact angle is a common way to measure the wettability of soil. The Sessile drop method is a common way of determining contact angle, where a drop of liquid(usually water), with a known surface area, is placed on the surface of the material, and the angle is found by looking through a goniometer. Sources : 3.3: Contact Angles - Chemistry LibreTexts and chapter2-00 (ucdavis.edu)  Small contact angle, < 90° Liquid wets the solid **Hydrophilic surface**  Large contact angle, > 90° Liquid repelled by solid **Hydrophobic surface**
Research Question/Problem/ Need	How does Soil Water Repellency in soils limit the flow of water within soils?

Important Figures



This is a thematic map of the Normalized Difference Vegetation Index, which is a measure of the state of plant health. (a) represents Eucalyptus, (b) represents Pine, and (c) represents Casuarina. These are maps of the plantations that the researchers looked at.

Table 1. The basic properties of the plantation forest soils (mean ± standard deviation).

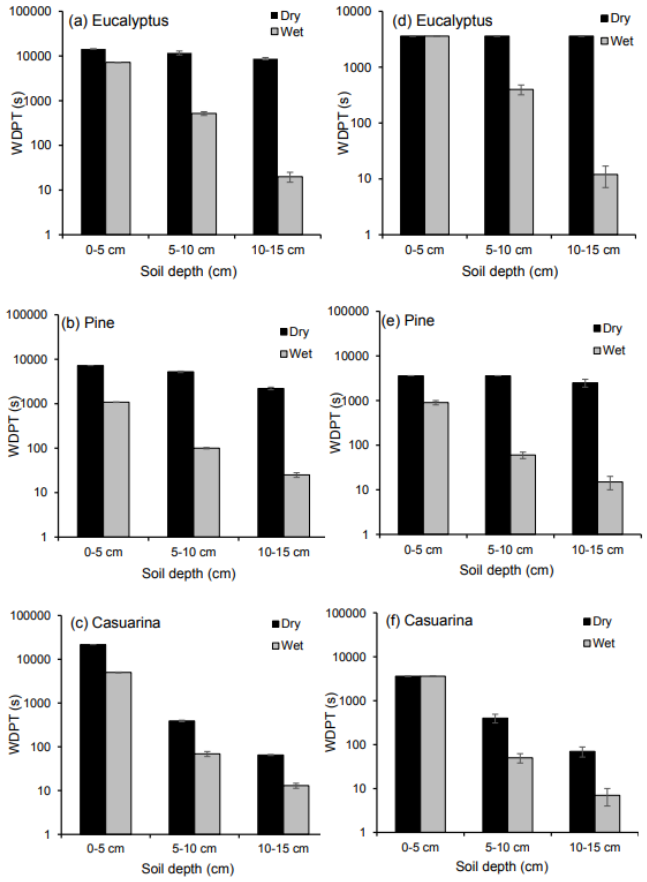
Soil property		Eucalyptus			Pine			Casuarina		
		0–5 cm	5–10 cm	10–15 cm	0–5 cm	5–10 cm	10–15 cm	0–5 cm	5–10 cm	10–15 cm
Bulk density (g cm^{-3})		1.02±0.10	1.10 ±0.05	1.18 ±0.02	0.96±0.16	1.07±0.07	1.12±0.10	1.98 ±0.04	2.12 ±0.09	2.19 ±0.08
Particle density (g cm^{-3})		2.30±0.25	2.30 ±0.26	2.55 ±0.22	2.56±0.16	2.68±0.07	2.58±0.25	2.80 ±0.03	2.81 ±0.12	2.80 ±0.08
Porosity (%)		55.5 ±6.0	52.1±5.6	53.8±4.2	62.5±5.6	60.0±1.8	56.7±5.0	29.3±2.5	24.5±2.8	21.8±2.4
Sand %		80.4 ±1.8	74.8 ±2.1	79.5 ±0.1	73.7±3.9	72.6±2.3	72.6±3.2	96.7±2.1	96.9 ±4.1	97.0 ±2.9
Silt %		5.8±1.5	6.4±1.5	6.3±1.5	10.4±0.6	8.2±1.6	9.2±1.5	3.2±0.5	2.9±0.3	2.5±0.3
Clay %		13.8±4.2	17.8 ±4.4	14.2 ±2.4	15.9±3.7	19.3±3.4	18.2±1.9	0.1±0.05	0.2±0.3	0.5±0.2
Texture		Loamy sand	Sandy loam	Sandy loam	Sandy loam	Sandy loam	Sandy loam	Sand	Sand	Sand
Organic matter (%)	Wet	9.94±0.14	7.05 ±0.04	6.92 ±0.06	15.4±4.0	12.4±2.8	10.6±1.7	1.82 ±0.15	1.29 ±0.08	0.56 ±0.04
	Dry	13.2 ±1.1	9.83 ±0.72	7.95 ±0.74	19.1±1.6	15.5±1.1	12.4±0.4	2.04 ±0.06	1.64 ±0.03	1.17 ±0.03

This is a table of the results the researchers found when they looked at the properties of the soils from each of the plantations at different depths

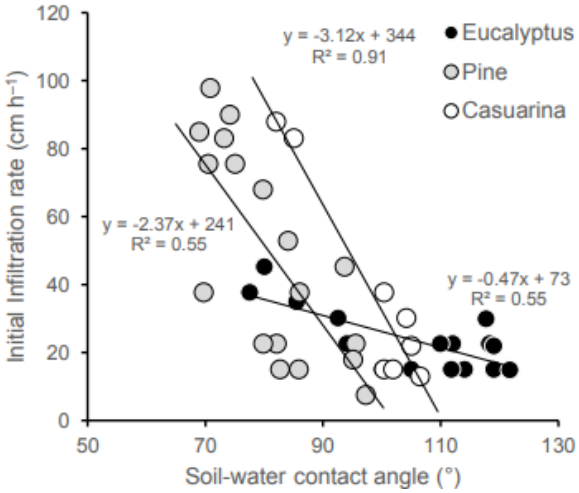
Table 2. Unsaturated hydraulic conductivity (k), water sorptivity (S_W), contact angle, and water entry value (h_{we}) of the tested forest soils in wet and dry seasons.

	k(−1 cm) (cm h^{-1})		S_W (cm s$^{-1/2}$)		Contact angle (°)		h_{we} (cm)	
	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry
Eucalyptus								
Minimum	1.23	0.01	0.028	0.062	119	124	3.8	6.3
Maximum	6.97	4.45	0.130	0.133	78	110	3.3	4.0
Mean	2.46	1.83	0.082	0.080	103	115	3.6	4.9
S.D.	1.63	1.35	0.025	0.018	13	4	0.3	0.9
Pine								
Minimum	0.47	0.02	0.021	0.019	97	107	3.4	4.4
Maximum	2.89	5.86	0.168	0.164	67	69	1.3	1.4
Mean	2.33	2.11	0.148	0.143	83	83	2.4	2.8
S.D.	0.76	1.98	0.019	0.050	10	14	1.4	1.2
Casuarina								
Minimum	1.66	–	0.035	–	106	119	5.3	8.2
Maximum	44.83	–	0.259	–	85	104	3.8	5.4
Mean	23.39	–	0.127	–	100	111	4.8	6.8
S.D.	17.60	–	0.095	–	7	6	0.4	0.9

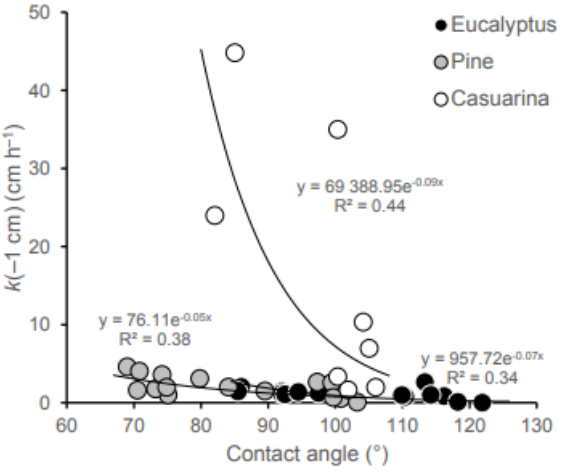
This is a table of information about the unsaturated hydraulic conductivity (k)(meaning how much water passes through an area), water sorptivity (S_W) (transport of water into porous substances(paraphrased)), contact angle, and water entry value of the soils in both the wet and dry seasons.



These are graphs of the potential water repellency (a,b,c), and the actual water repellency (d,e,f).



This is a graph relating the soil water contact angle (meaning soil water repellency) and how that relates to initial infiltration rate.



This is a graph relating the contact angle and unsaturated hydraulic conductivity.

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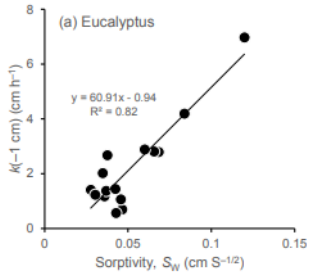
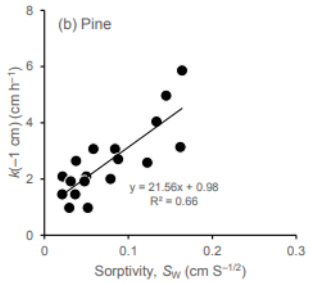
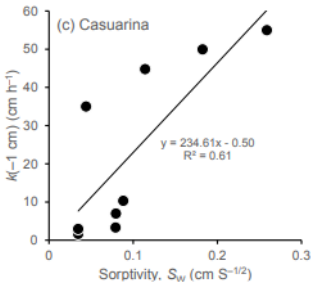
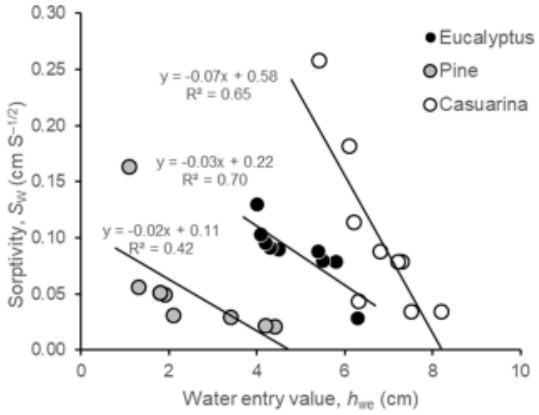






These three graphs relate the individual Sorptivity of the soils to the individual unsaturated hydraulic conductivity.


This is a graph relating water entry value and Sorptivity.
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<tr>
<td>VOCAB: (w/definition)</td>
<td>Sorptivity: the ability of a medium to absorb liquid (paraphrased from Sorptivity of Soils | SpringerLink)
Hydrophysical characteristics: The characteristics of soil, for example, particle size, sorptivity, and water holding capacity.
Unsaturated Hydraulic Conductivity (k): the mass of water passing through an area in time. (paraphrased from</td>
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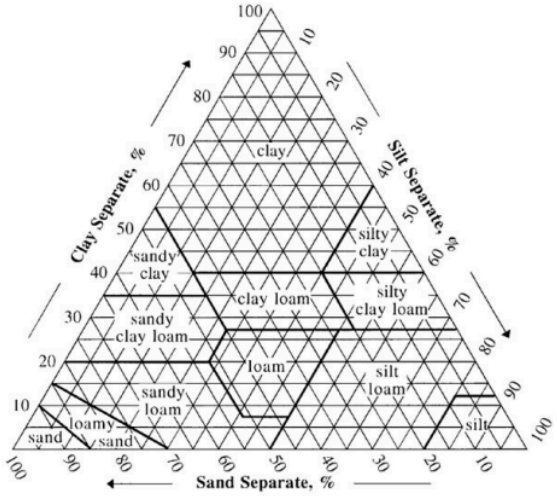
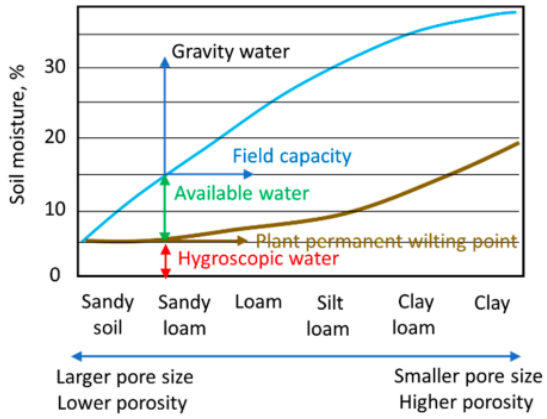
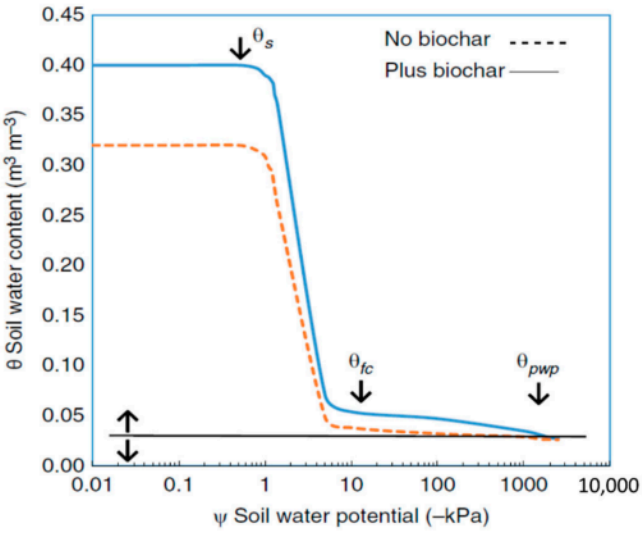
	https://www.bing.com/search?pglt=41&q=Unsaturated+Hydraulic+Conductivity+(k)&cvid=751e5def2c384d678d3a4cd28e45a3bd&aqs=edge..69i57j69i11004.495j0j1&FORM=ANNAB1&PC=LCTS) Casuarina equisetifolia: (CE) meaning casuarina. Eucalyptus grandis: (EU) meaning eucalyptus. Pinus caribaea: (PC) meaning pine.
Cited references to follow up on	Chenu, C., Le Bissonnais, Y., Arrouays, D., 2000. Organic matter influence on clay wettability and soil aggregate stability. Soil Science Society of America Journal, 64, 4, 1479–1486. https://doi.org/10.2136/sssaj2000.6441479x10.2136/sssaj2000.6441479x Lichner, Ľ., Capuliak, J., Zhukova, N., Holko, L., Czachor, H., Kollár, J., 2013. Pines influence hydrophysical parameters and water flow in a sandy soil. Biologia, 68, 6, 1104–1108. https://doi.org/10.2478/s11756-013-0254-710.2478/s11756-013-0254-7 Moody, J.A., Kinner, D.A., Úbeda, X., 2009. Linking hydraulic properties of fire-affected soils to infiltration and water repellency. Journal of Hydrology, 379, 3–4, 291–303. https://doi.org/10.1016/j.jhydrol.2009.10.01510.1016/j.jhydrol.2009.10.015
Follow up Questions	Do droughts cause higher SWR in soils? What is the effect of high SWR in soils on droughts? Does SWR affect the intensity of droughts? Does having more water in soils decrease SWR?

Article #10 Notes: **Role of Biochar in Improving Sandy Soil Water Retention and Resilience to Drought**

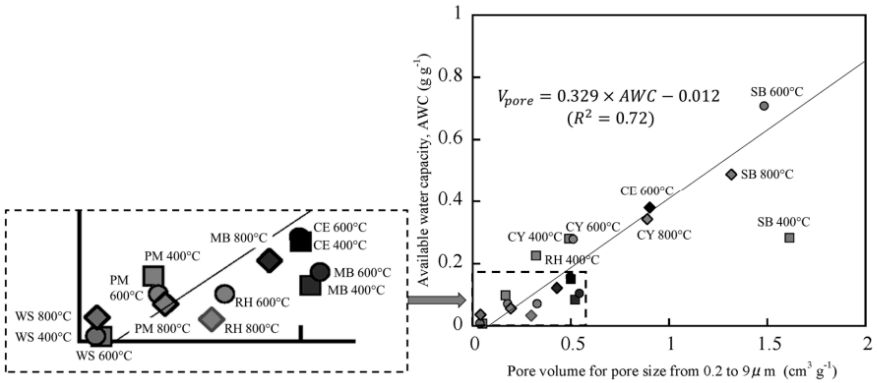
Source Title	Role of Biochar in Improving Sandy Soil Water Retention and Resilience to Drought
Source citation (APA Format)	Li, L., Zhang, Y.-J., Novak, A., Yang, Y., & Wang, J. (2021). Role of Biochar in Improving Sandy Soil Water Retention and Resilience to Drought. *Water*, *13*(4), 407. https://doi.org/10.3390/w13040407
Original URL	Water | Free Full-Text | Role of Biochar in Improving Sandy Soil Water Retention and Resilience to Drought (mdpi.com)
Source type	Journal Article
Keywords	biochar; drought; porosity; sandy soil; water retention
#Tags	#soil
Summary of key points + notes (include methodology)	Biochar is a charcoal-like substance that is made by burning organic materials in low oxygen environments. This article looked at how biochar is applied to soils and what effect it has on elevating water retention in sandy soils. They compiled data from many other articles and condensed it into this research review paper. The authors found that, in sandy soil, biochar increased the surface area of the soil particles and helped increase water retention. Notes: ● Due to climate change, many regions in the world may experience an increase in the frequency and severity of droughts, which could lead to an increase in variability of precipitation and greater water loss (almost a direct quote). ● When they talk about pores, they are talking about the spaces between the grains, not actual pores on the grains (if those do exist they contribute to the spaces) - this may be wrong, they may actually be talking about the pores ● Biochar is hydrophobic, which, contradictory to what the other article said, can be good sometimes it seems. It can be treated to make it less hydrophobic though. ● (µm means micrometer, 1/1000 of a millimeter) ● **Sandy soils have low water retention (seems to be common knowledge). Low buffer capacity for rainfall. More likely to have nutrients washed away.** ● This article looked at how biochar is used as a solution for mitigating

	drought effects on crops, however they did also bring up how growing cover crops is another solution. ● **Sandy soil contains at least 85% sand** ● **Cations that hold nutrient anions increase with increased surface area (good). (paraphrased)** ● Adding biochar to sandy soil would increase the total surface area of the soil. ● **Water volume in soil can be measured gravimetrically (θg, g water/g soil) or volumetrically (θv, cm3 water/cm3 soil).** ● **Biochar from different types of organic matter has different pore sizes, and biochar produced at different temperatures and for different amounts of time also have different pore sizes.** ● Slow pyrolysis process means, essentially, where the molecules are heated up and broken down without being exposed to oxygen. It is how biochar is produced. ● **The porosity of a few samples of biochar was measured by mercury intrusion(was spelt as instruction) porosimetry, which is when mercury is forced at high temperatures into the pores of the material, and a porosimeter is what does this. The pressure needed determines the pore size. (paraphrased from a Bing search of how does mercury instruction porosimetry work)** ● The results from the paper they found showed that the optimal pore size for capillary-rise of water was from 0.2 μm to 9 μm in (paraphrased) This seems to be quite a big range. This was based on a large number of types of biochar. ● molarity-of-ethanol-droplet (MED) testing method was used to measure hydrophobicity. This method is done by mixing different concentrations of ethanol in water and dropping them on the dry soil, then seeing which ones can sink in 5 seconds. The lowest ethanol concentration relates to water repellency ● Low temps, higher hydrophobicity ● Chemical ways of changing hydrophobicity, also can age it to make it more hydrophilic ● **One article found that adding biochar increased gravity drained water content, and increased water holding capacity** ● **Usually biochar is applied by mixing it with fertilizer and spreading that over the field** ● **Studies have presented lab results that adding biochar can increase moisture contents , which can have knock-on effects like better nutrient and water retention, specifically in sandy or gravelly soils. (paraphrased)** ● However temperate soils need to be researched more, as does the relationship between biochar addition and soil water retention, plant water consumption, and water use efficiency. (paraphrased) ● Biochar can be made from Fast pyrolysis and gasification cost effectively, however, biochar made from wastes need to be modified through post treatment methods (paraphrased) ● Biochar does not provide more than a few trace nutrients

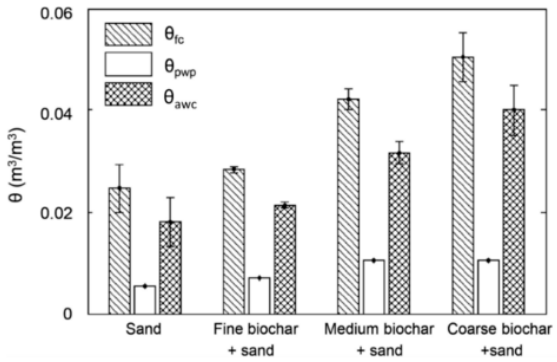
	• Can be used for improving soil, managing waste (pollution), mitigate climate change, and provide energy • Hydrophobicity could be a major factor limiting its ability to enhance soil water retention. (paraphrased)
Research Question/Problem/ Need	What is currently known about biochar and its relation to increasing water retention in sandy soils?
Important Figures	 **Figure 1.** USDA soil textural triangle [36]. This is a representation of the many different soil types that occur. The arrows travel clockwise, are labeled sand separate %, clay separate %, and silt separate %. The corners of the triangle correspond to the sides they are closest to, meaning the corner between sand and clay has all sand, little clay, and little silt.  This is a graph relating soil types to the % amount of moisture they hold. The space above the blue line represents the water that has drained from the soil due to gravity, the space beneath the blue line and above the brown line represents the available water in the soil. The brown line represents the plant wilting point, or the minimum amount of water a plant needs to not wilt.



This graph relates water volumetric content (θ) and soil water potential (φ) for soil without biochar and with biochar. Water volumetric content is the measure of the volume of water per unit volume of soil (paraphrased off of Bing search of volumetric water content). Soil water potential is a measure of the amount of energy needed to extract water from the soil (paraphrased from Bing search of what is soil water potential).



This is a graphical plot of the pore sizes from biochar that was created from different sources and temperatures. This was from a chart they got off of reference 44.

	 This is a bar graph where field capacity is represented by (θfc), permanent wilting point is represented by (θpwp), and plant available water content is represented by (θawc). The reference study looked at the effects of 3 different types of biochar on these three variables. (paraphrased)
VOCAB: (w/definition)	Biochar: Biochar is a charcoal-like substance that is made by burning organic materials in low oxygen environments. Different organic substances and different levels of heat at which they are burned change their pore sizes. Micropore: a very narrow pore, especially in a material. (quoted from Bing dictionary) 5 µm to 30 µm in diameter Macropore: larger than a micropore, (>80 µm in diameter) Mesopore: between macro and micropore, 30 µm to 80 µm in diameter Ultra-micropores: smaller than a micropore, 0.1 µm to 5 µm in diameter Cryptopore: <0.1 µm in diameter Physicochemical properties: Physical and chemical properties Gravimetrically: measuring using gravity (in this context I believe) Volumetrically: measuring using volume (in this context I believe) Field capacity: FC (θfc) is the maximum water content held in the soil after the drainage has stopped. (direct quote from article) Plant permanent wilting point: PWP (θpwp) is the minimum water content at the state when the plant dies. (direct quote from article) Plant available water content: AWC (θawc) is the difference between the field capacity and the permanent wilting point. (direct quote from article) Hydrophobicity: tendency to not mix with or repel water
Cited references to follow up on	Ren, X.; Weitzel, M.; O'Neill, B.C. Avoided economic impacts of climate change on agriculture: Integrating a land surface model (CLM) with a global economic model (iPETS). *Clim. Chang.* **2018**, *46*, 517–531.

	Fernandez, I.F.; Schmitt, C.V.; Birkel, S.D.; Stancioff, E.; Pershing, A.J.; Kelley, J.T.; Runge, J.A.; Jacobson, G.L.; Mayewski, P.A. *Maine's Climate Future*; University of Maine: Orono, ME, USA, 2015. [**Google Scholar**] Dokoohaki, H.; Miguez, F.E.; Laird, D.A.; Horton, R.; Basso, A.S. Assessing the Biochar Effects on Selected Physical Properties of a Sandy Soil: An Analytical Approach. *Commun. Soil Sci. Plant Anal.* **2017**, *48*, 1387–1398. [**Google Scholar**] [**CrossRef**] Jahan, S.; Iqbal, S.; Jabeen, K. Structural characterization of soil biochar amendments and their comparative performance under moisture deficit regimes. *Arab. J. Geosci.* **2019**, *12*, 203. [**Google Scholar**] [**CrossRef**] Basso, A.S.; Miguez, F.E.; Laird, D.A.; Horton, R.; Westgate, M. Assessing potential of biochar for increasing water-holding capacity of sandy soils. *Glob. Chang. Biol. Bioenergy* **2012**, *5*, 132–143. [**Google Scholar**] [**CrossRef**][**Green Version**] USDA British Society of Soil Science
Follow up Questions	Could biochar be used as a way to long term reduce water loss and reduce the effects of droughts? How could biochar be incorporated into a machine? What are sustainable ways of creating useful biochar? Is there anything that acts like biochar? Or plays a similar role?

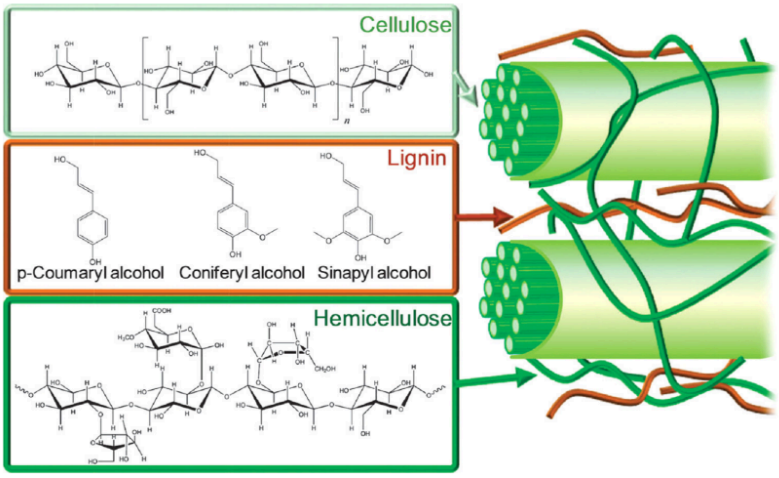
Article #11 Notes: **A comparative review of biochar and hydrochar in terms of production, physico-chemical properties and applications**

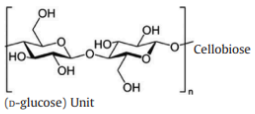
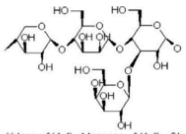
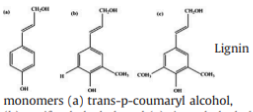
Source Title	A comparative review of biochar and hydrochar in terms of production, physico-chemical properties and applications
Source citation (APA Format)	Kambo, H. S., & Dutta, A. (2015). A comparative review of biochar and hydrochar in terms of production, physico-chemical properties and applications. *Renewable and Sustainable Energy Reviews*, *45*, 359–378. https://doi.org/10.1016/j.rser.2015.01.050
Original URL	A comparative review of biochar and hydrochar in terms of production, physico-chemical properties and applications - ScienceDirect
Source type	Journal Article
Keywords	Biochar, Hydrochar, Hydrothermal, Carbonization, Pyrolysis
#Tags	#soil
Summary of key points + notes (include methodology)	Summary: This article was about the similarities, differences, and uses of hydrochar and biochar. Hydrochar is made from submerging biomass in subcritical water to carbonize it, and biochar is made from the slow pyrolysis of dry biomass. At the time of creation of this article, not much was known about hydrochar and its uses, but it seemed to be most useful in creating renewable biofuel. Hydrochar and biochar differ in how they are made and how they are used, however some potential uses are carbon sequestration, soil amelioration, bioenergy production, and wastewater pollution remediation. Based on what I have read so far, I am no longer sure that biochar or hydrochar would be useful in my project, however, if it becomes necessary, I will have this information. It would also likely be expensive to source, which is not ideal. Notes: ● Hydrochar Uses sub-critical water (define this) to carbonize the biomass, compared to the drying of the biomass needed for pyrolysis. This produces hydrochar, which is different from biochar. ● The chars produced from pyrolysis and hydrothermal carbonization have different properties from one another that make them better suited for

different tasks, though these tasks can occasionally overlap.

- Hydrochar (HTC char) is better than biochar in certain ways, but biochar still has its uses.
- Biomass is something that is produced constantly and can create renewable fuel, not really useful to me but interesting
- This article focuses more on the fuel properties of biochar and hydrochar, but useful for background info.
- Biochar has many uses, including sequestering carbon and bettering soil, and it could be used for sustainable energy production
- The origin of biochar is associated with the soils of Amazon region, often referred to as “Terra-Preta” soils. (direct quote, page 3)
- biochar is a relatively new term
- Biochar and hydrochar differ in how they are made, biochar is made from pyrolysis, while hydrochar is produced via hydrothermal carbonization and results in a slurry. biochar-dry hydrochar-wet
- need to know if the biomass is wet or dry to determine which method for creating char is better. Wet or dry categorization depends on initial moisture content. above 30% is wet, below 30% is dry (at time of harvesting). wet can be dried, but that takes extra time and energy and money
- Some biomass is grown with the purpose of becoming energy producers, while others are just waste. waste is reasonable because it does not take extra agricultural land away from food growing. Some examples of waste are agro-forestry waste, animal manure waste, organic-food wastes, sewage sludge, and MSW (municipal solid waste)
- how biochar is created - heat the biomass at high temps with a lack of oxygen - how do they get rid of the oxygen?
- slow pyrolysis is better for biochar production because there is a higher solid yield
- Dry torrefaction aka mild pyrolysis is when the biomass is heated to roughly 200-300 degrees C for 30 min to a couple of hours. Less mass loss, however it is not biochar because there are still some volatile organic compounds within the resulting mass. references 70-79 can help me learn more
- gasification mainly produces gasses, though there is a small amount of biochar that is produced. the biochar produced has many more toxic compounds than other biochar
- Hydrothermal carbonization (HTC), aka wet torrefaction, converts organic material into a high carbon rich solid product (paraphrased). The biomass is submerged in water and heated to 180-260 degrees celsius, the pressure is not regulated, and it is called subcritical water.(paraphrased)
- Because the biomass in water for HTC, water content of the material does not matter, which eliminates the need for pre drying. The HTC process creates 3 main products, the solids (hydrochar), liquids (bio-oil mixed with water), and a small amount of gas (mainly CO2). The mass yield is about 40%-70%, which is higher than the amount produced by torrefaction.
- Hydrochar seems to mainly be used for fuel purposes, and to do that it

	needs to be dried, as it exits the HTC process in a slurry. Compressing the hydrochar can result in a moisture content of less than 50% (which is good-requires less energy), and then it is thermal dried, which takes less time and energy because a lot of the water is already gone. ● The presence of oxygen containing groups on the surface makes it more hydrophilic - may be useful ● Liquid water, below the critical point, is referred to as subcritical water and above as supercritical water. (direct quote, page 6) ● HTC pre-treatment takes place in subcritical water because the water at that point exhibits both basic and acidic characteristics, which helps dissolve the organic compounds. Supercritical water also has some unique characteristics, as it acts similarly to both a liquid and a gas. ● For HTC more water is needed than biomass, which can be expensive and at an industrial scale may not be worth it. ● Different treatments create products with different physical and chemical characteristics (paraphrased). Meaning biochar and hydrochar will have different properties within their own groups, and compared to the other. ● Solid yield depends partially on how much lignin is present in the biomass. Section 4.1 was not very useful to me, however if I want to learn more about solid yield and chemical composition characterization of biochar and hydrochar, I can look there ● For biochar, the structure is composed of graphite-like layers where the surface area increases with temperature increases. For hydrochar, the structure mainly has spherically shaped carbonaceous nanoparticles on the surface (partially directly quoted and partially paraphrased, page 8). ● The differences in the structures are mostly due to the differences in how the chars are created. They create different reaction pathways. (paraphrased) ● Section 4 is more useful if I were to be creating hydrochar or biochar, which I do not intend to do. ● To make the chars an absorbent material, it needs to be chemically and or physically altered, like subjecting it to high temps and blowing co2 over it or using potassium hydroxide ● biochar does not usually need to be activated, but hydrochar does because they generally have low surface area (paraphrased) ● Hydrochar would probably be better for energy production ● Biochar does not break down as easily as hydrochar, and can be used for carbon sequestration, however, hydrochar is more efficient to produce, I think, so it should be researched how it could be better used for carbon sequestration ● Biochar may not be beneficial to all types of soils, it is better if it is in degraded or infertile soils, tropical soils, in combination with fertilizers, or when the chars were sources of nutrients. The structure of biochar improves soil aeration and can benefit soil organisms. Biochar usually starts out as hydrophobic, but as it is exposed to water and oxygen it becomes more hydrophilic (like the other article said I think). hydrochar has not been tested much as a soil amendment

	• activated biochar can be used to absorb water pollutants, less is known about how hydrochar could be used for water cleaning purposes, more research is needed. • Many factors influence the final characteristics of biochar and hydrochar. Hydrochar could replace coal at power plants, but currently it is in-efficient to produce at an industrial scale. The HTC process eliminates the need for pre drying that pyrolysis requires. Not enough is really known if biochar is super toxic, and at the rate it is used now in soils, it would be impossible to remove completely if it was toxic.
Research Question/Problem/ Need	What is currently known about biochar and hydrochar, and what are the currently known differences between the two?
Important Figures	 This is a diagrammatic representation of the structure of lignocellulosic biomass. Lignin does not break down as easily as cellulose and hemicellulose, and makes up the majority of the matter in biochar and hydrochar.

Compound	Cellulose	Hemicellulose	Lignin
Chemical structure	 Cellobiose (D-glucose) Unit	 - Xylose - ß(1,4) - Mannose - ß(1,4) - Glucose - - alpha(1,3) - Galactose	 Lignin monomers (a) trans-p-coumaryl alcohol, (b) coniferyl alcohol, and (c) sinapyl alcohol
Molecular formula	$(C_6H_{10}O_5)_n$	$C_5H_{10}O_5$	(a) $C_9H_{10}O_2$, (b)$C_{10}H_{12}O_3$, and (c) $C_{11}H_{14}O_4$
Typical composition in biomass	(i) Hardwood: 39–54% (ii) Softwood: 41–50% (iii) Agricultural: 24–50%	(i) Hardwood: 15–36% (ii) Softwood: 11–27% (iii) Agricultural :22–35%	(i) Hardwood:17–29% (ii) Softwood:27–30% (iii) Agricultural:7–29%
Structural formation	A homopolymer of D-glucose subunits. Cellulose is linked by β-1,4 glycosidic bonds forming long chains.	A hetropolymer of Xylose, Mannose, Glucose, and Galactose. Xylan, the dominating component in hemicellulose, is linked by β-(1→4)-glycosidic or α-(1→2)-bonded 4-O-methylglucoronic acids. Also may contain acetyl group attached to it.	A hetropolymer built up of three different phenyl-propane monomers groups: p-coumaryl, coniferyl and sinapyl alcohol. This complex polymer is oriented by a different degree of methoxylation of above-mentioned monomers forming a large molecular structure(s).
Hydrophobicity	Medium	Low	High
Calorific value	17–18 MJ/kg	17–18 MJ/kg	23.3–26.6 MJ/Kg
Thermal stability and solubility in water	Cellulose is non-soluble in water under standard conditions. It can be hydrolyzed in subcritical water around 180 °C and around 300–400 °C in standard conditions.	Owing to its amorphous structure, thermal breakdown of hemicellulose is relatively easier. It can be hydrolyzed in water around 160 °C and around 200–300 °C under standard conditions.	Lignin is the most thermo-chemically stable component in wood and highly insoluble in water. Its degradation/hydrolysis starts in near or supercritical water or around 600 °C in ambient conditions.
Applications	Paper manufacturing, textiles, biofuels, chromatography, binding/composite materials, etc.	Mainly includes animal feed, food packaging, health care and bio-refinery industry.	Manufacturing of adhesive compounds and bioenergy.

This is a table of some of the physical and chemical properties of cellulose, hemicellulose, and lignin.

Pre-treatment	Operating temperature (°C)	Residence time	Heating rate	Typical product yield (%)		
				Solid	Liquid	Gases
Slow pyrolysis	300–650	5 min–12 h	10–30 °C/min	25–35	20–30	25–35
Gasification[a]	600–900	10–20 s	50–100 °C/s	< 10	< 5	> 85
Dry-torrefaction[a]	200–300	30 min–4 h	10–15 °C/min	60–80	–	20–40
HTC	180–260	5 min–12 h	5–10 °C/min	45–70	5–25	2–5

[a] Generally solid product from these technologies is not regarded as Biochar, because either the solid yield is very low or the solid does not have the same properties as those of biochar.

This is a table of different ways biomass is treated

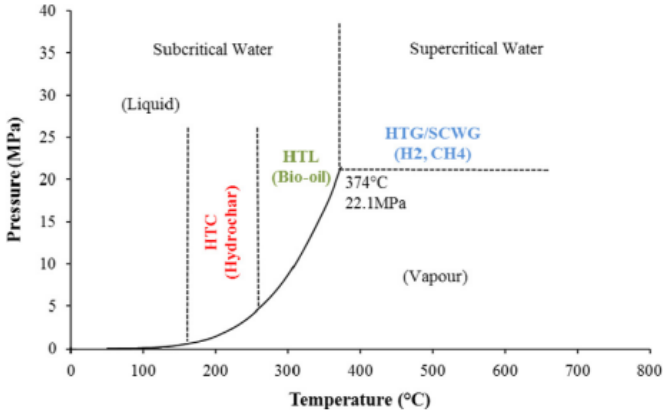


Fig. 2. Classification of hydrothermal processing of biomass with reference to the pressure–temperature phase diagram of water.

An example of a phase diagram of water, with the solid phase not shown (temperatures are too high for it to show). This shows subcritical and supercritical water.

Table 3
Factor affecting physicochemical properties of char via pyrolysis and HTC, adapted from [15,42,157].

Parameter	BET-surface area and porosity		Solid mass yield (%)		Degree of de-hydration and de-carboxylation or C/H–C/O ratios	
	Pyrolysis	HTC	Pyrolysis	HTC	Pyrolysis	HTC
Highest reaction temperature (HRT)	Increases up to 500 °C, further increase negatively influence the properties	Typically increases up to 230 °C, further increase shows negative response	Decreases	Decreases	Increase	Increase
High heating rate (HHR)	Generally increases from 5–100 °C/min, further increase destroys the porous structure	–	Decreases	–	Increase	–
Reaction residence time (RRT)	Increases	Increases	Decreases	Decreases	Increase	Increase (highly complex reaction mechanism)
Pressure (P)	Decreases	Decreases (usually not controlled)	Increase	Increase	–	–
Catalyst (sub-or/to-supercritical H_2O, CO_2, N_2, air, salts, acids, etc.)	Increases	Increases	Decreases	Decreases	Increase	Increase
Reactor (shape, orientation, stirrer)	–	–	–	–	Homogenize the reactions	Homogenize the reactions
Moisture content of feedstock	Supplement energy is required for drying and negatively affects the properties	Not affected (therefore is best suitable for wet biomass)	Decrease	Not affected (the process itself required water)	–	The process itself requires water and is thus initiated by hydrolysis reaction
Pre-processing (particle size)	Increases with reduction in size	The effect is relatively much less than pyrolysis	Decreases with reduction in size	Decreases (but the effect is insignificant)	Increases	–
Solid load (ratio of reaction medium to feedstock)	–	Decreases	–	Decreases (high ratios, > 10:1 are typically used for bio-oil production)	–	Decreases
Post-processing (grinding, physical and chemical activation)	Generally not required if performed above 400 °C	Hydrochar has very poor surface areas and therefore is required.	Activation causes volatilization of material and thus would reduce the mass yield	Activation causes volatilization of material and thus would reduce the mass yield	Activated chars have high C-content	Activated chars have high C-content

	This is a table of the factors that affect the properties of biochar and hydrochar.
VOCAB: (w/definition)	Sub-critical water: water at high temperatures and pressures, but is not supercritical Amelioration: the act of making something better; improvement. (direct quote from oxford dictionary) Lignocellulosic: plant matter that is dry, see important figures for more info as to what it is. Biochar: biochar is a solid material obtained from the thermochemical conversion of biomass in an oxygen-limited environment. (direct quote, page 3) CCS: Carbon capture and storage Pyrolysis: Pyrolysis is a thermochemical decomposition process during which biomass is heated at elevated temperature (300–650 1C) in the absence of oxygen. (direct quote, page 4) Klinker formation: lumps or nodes? No definite definition could be found for Klinker at a simple search
Cited references to follow up on	[15] Lehmann J, Joseph S. Biochar for environmental management: science and technology. Routledge-Earthscan; 2009. [35] Libra JA, Ro KS, Kammann C, Funke A, Berge ND, Neubauer Y, et al. Table A1 Hydrothermal carbonization of biomass residuals: a comparative review of the chemistry, processes and applications of wet and dry pyrolysis. Biofuels 2011;2:71–106. [44] Fuertes A, Arbestain MC, Sevilla M, Maciá-Agulló J, Fiol S, López R, et al. Chemical and structural properties of carbonaceous products obtained by pyrolysis and hydrothermal carbonisation of corn stover. Soil Res 2010;48:618–26. [45] Wiedner K, Rumpel C, Steiner C, Pozzi A, Maas R, Glaser B. Chemical evaluation of chars produced by thermochemical conversion (gasification, pyrolysis and hydrothermal carbonization) of agro-industrial biomass on a commercial scale. Biomass Bioenergy 2013;59:264–78.
Follow up Questions	Would biochar, or hydrochar, actually be useful as a way to absorb and sequester water in a machine? Would biochar, or hydrochar, be a useful additive to a soil to assist a machine that aims to sequester water? From a sustainability standpoint, is biochar, or hydrochar, better than other absorption materials? From an economical standpoint, is biochar, or hydrochar, better than other absorption materials?

Article #12 Notes: **Embeddable Soil Moisture Content Sensor Based on Open-End Microwave Coaxial Cable Resonator**

Source Title	Embeddable Soil Moisture Content Sensor Based on Open-End Microwave Coaxial Cable Resonator
Source citation (APA Format)	Guo, J., Tang, Y., Wu, Y., Zhu, C., & Huang, J. (2023). Embeddable Soil Moisture Content Sensor Based on Open-End Microwave Coaxial Cable Resonator. *IEEE Sensors Journal*, *23*(12), 13575–13584. https://doi.org/10.1109/JSEN.2023.3266665
Original URL	Embeddable Soil Moisture Content Sensor Based on Open-End Microwave Coaxial Cable Resonator | IEEE Journals & Magazine | IEEE Xplore
Source type	Journal Article
Keywords	Microwave resonator, open-end coaxial cable, soil moisture, sensors
#Tags	#water #soils
Summary of key points + notes (include methodology)	SUMMARY: In this article, the authors sought to make a more precise, durable and cost effective way to measure soil moisture. They used a modified open ended coaxial cable with a metal bar and a PVA film that served as reflectors and measured frequencies, which allowed for sensitive measurements of soil moisture. MY THOUGHTS: I think this article would be used as a next steps piece, where the machine could sense moisture levels and then respond accordingly, it may not be the easiest to integrate at the start. The device also does not look fully complete yet, so it may be worthwhile to see if the authors followed up with more about this device NOTES: ● I think that because this sensor can be made cheaply, this could be used as a part of a soil water retention and distribution machine ● Knowing more about the soil moisture content can provide insight and information about a variety of topics, including geophysical fields, agricultural production, soil remediation engineering, and groundwater contaminant removal engineering. (half direct quote, page 1, half paraphrased).

	● Examples of soil water content sensors besides the one presented in this article include the traditional gravimetric method, gamma-ray transmission, neutron scattering, capacitance, seismic waves, and dielectric methods. There are likely patents out there for these ● The gravimetric method takes too long and takes too much work and is not cost effective for real time monitoring. It is done by measuring the difference in mass between wet and dry soil (paraphrased) - not really useful to me anyway ● the cosmic gamma-ray method involves the emission of gamma rays that travel through the soil, and the energy transmitted indicates the moisture content, however there is the issue of radiation and safety and costs - also not useful to me ● The capacitance method measures the microwave frequencies and how it varies based on the soil's water content. two antenna sensors are used, but it is easily corroded - maybe something I could use, but not the best ● The neutron probe method involves inserting neutrons, which emit low level radiation, into the ground, and then measuring how many neutrons are scattered back to the device, with more scattering meaning a higher water content. has high accuracy but is expensive and requires gov. registration (paraphrased) - no ● seismic waves have different velocities depending on many factors, which can be measured and the water content can be found. not economical for small-scale soil site investigations. (paraphrased) - I do not really understand this one ● none of the methods are cost effective, easy to make, very sensitive, or last for a long time, which is why the author included them, makes their idea look stronger ● soils dielectric properties are affected by water content and this can be used to measure water content (half direct quote page 2, half paraphrased) ● Some types of sensors that use dielectric properties to measure water content are time-domain reflectometry (TDR), frequency domain reflectometry (FDR), coaxial probes, and microwave ring resonators. I will not be going into detail about these because they are not useful to me ● The author's sensor is designed to be resistive to corrosion, have real-time measurement, and be useful for on site monitoring. The embeddable open-end microwave coaxial cable resonator (EOE-MCCR) is cheap to make. a polyvinyl alcohol PVA diaphragm -assisted planar is used to make it a moisture sensor device. it is robust and stable ● water, soil, and air, along with many other things, have dielectric constants, with water's being 80, dry soil's being 4, and air's as 1. As the moisture levels in the soils change, so to do their dielectric permittivity, which is related to the dielectric constants, so moisture can be measured ● The authors chose to use a coaxial cable for their design because it is durable and can transmit signals long distances. ● A PVA film was chosen because it can readily absorb water and release it, and it quickly establishes equilibrium; it also does not corrode easily.

	● The metal pole in the sensor serves as the first reflector, and the PVA film serves as the second reflector. The first reflector stays constant, while the dielectric constant of the second changes, and using a couple of complicated equations these can be connected and it can function as a soil moisture sensor ● If I want to know more about how it was built and how they used simulations to confirm their model would work, look at parts B and C in section III ● to test their EOE-MCCR concept, they made a sensor from a custom-made hollow coaxial cable and tested it. ● They set up the experiment by using a plexiglass cylinder with fixed dimensions and using dry soil that they injected a known amount of water into the soil and were left to rest in a stable temperature environment for 24 hours, and then each sample was measured for 1 hour to obtain stable data. (both paraphrased and partially a direct quote). ● Their sensor has high resolution and could be modified to better detect changes in moisture. They added water to the samples in 1 mL increments, with a total water volume of 11 mL. This translates to a 4% to 24% soil moisture change in 2% steps for the amount of soil they used. These changes in percentages can be seen in how the frequencies change. - I think, the math stuff is a bit confusing ● The authors think that the sensor could also have uses in contaminated soil remediation and groundwater pollution protection, as well as other applications ● Their conclusions are that an open-end coaxial cable soil sensor would be a more precise, non invasive and cost-effective way to measure soil moisture. The implementation of the PVA film makes it possible for more sensitive measurements to be taken. the sensor could be further developed for other applications (paraphrased)
Research Question/Problem/ Need	Could a more durable and accurate sensor be made to measure soil water content?

Important Figures

TABLE I
COMPARISON OF COMMON USE SOIL MOISTURE SENSOR TECHNIQUES

Measurement Principle	Application requirements, range(m)	Measured parameter	Response time	Cost (USD)	Resolution	Sensitivity	Operation Frequency	Advantage	Disadvantage
Gravimetric Technique [6, 13]	Lab required, any depth	Soil water content	24 h	~ 400	0.01%	NA	NA	Easy to implement, accurate results	Time consuming, destructive test
Neutron probe [15, 18-20]	In-situ, 0.1–0.3 m	Neutron scattering	1-2min	~10,000	±1%	0.703-1.085 m/m θ	NA	Fast response Nondestructive	Health risk, high cost
Capacitive technique/FDR [21-23]	In situ, Lab, <1m, operating frequency up to 1GHz	Dielectric constant	30s	100-4000	±1 to ± 3%	0.02-0.03m^3/m^3 θ	~MHz	Fast response, non-destructive	Not good response in high saline soils
Resistive sensor [21-23]	In-situ, Lab, 0.1-0.3m	Electrical resistance	2-3h	5-30	±1 to 2%	0.02-0.09 ohm θ	~KHz	Cost effective	Time consuming
Commercial sensor (Campbell,CS616) [24]	In situ, Lab, <0.3m, operating frequency up to 1GHz	Dielectric constant	30s	~200	0.1%	Not Reported	Not Reported	Fast response, non-destructive	Not good at deep range measurement
Proposed method	In situ, Lab, 0.365m, operating frequency 1.0-1.06GHz	Dielectric constant	30s	~50	±1.51*10^{-4}%	1.44MHz/%	1.04-1.09GHzz	Non-corrosion, high resolution, high stability, low cost	Single point method

Note: NA-Not Applicable; θ- Soil Moisture Content

This table compares the common soil moisture sensor techniques that are already present and already exist.

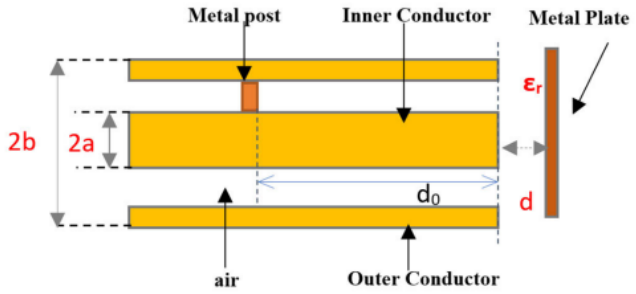


Fig. 1. Schematic of EOE-MCCR terminated by a metal plate with a medium gap distance (d) from the open end of the coaxial line. The inner and outer conductor diameters are 2a and 2b, respectively. The metal post serves as the first reflector, and the open end serves as the second reflector. ε_r represents the relative permittivity of the medium in the gap.

This diagram shows a diagram of the EOE-MCCR model. The model uses dielectric properties and measures frequencies to figure out the moisture content of the soil

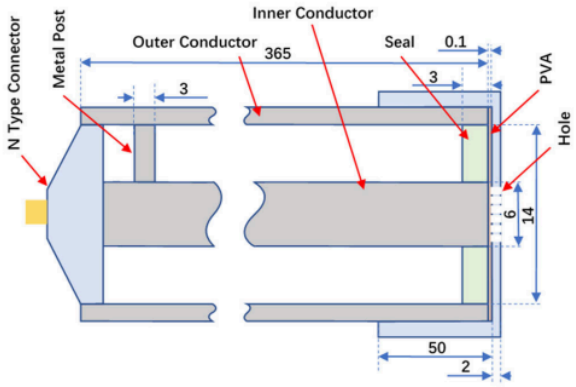


Fig. 2. Cross-sectional schematic of the EOE-MCCR, with inner and outer conductor diameters of 6 and 14 mm, respectively. The metal post is 35 mm away from the input end. A PVA film is inserted into the gap as a soil moisture element. Unit: mm.

This is a more detailed diagram of the EOE-MCCR model. The PVA film serves as the second reflector and a moisture sensor. The metal pole in the sensor serves as the first reflector, and the PVA film serves as the second reflector. The first reflector stays constant, while the dielectric constant of the second changes, and together they create a microwave cavity resonator.

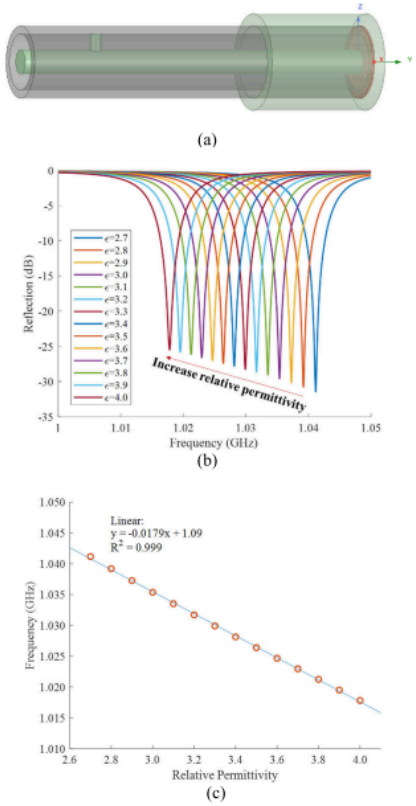


Fig. 3. Investigation of the proposed moisture sensor using full-wave simulations. (a) Full-wave simulation schematic. (b) Evolution of the reflection spectrum as the relative permittivity increases. (c) Calculated resonance frequency of the sensor as a function of applied relative permittivity.

These diagrams represent what the authors simulated and expected to happen

with their sensor

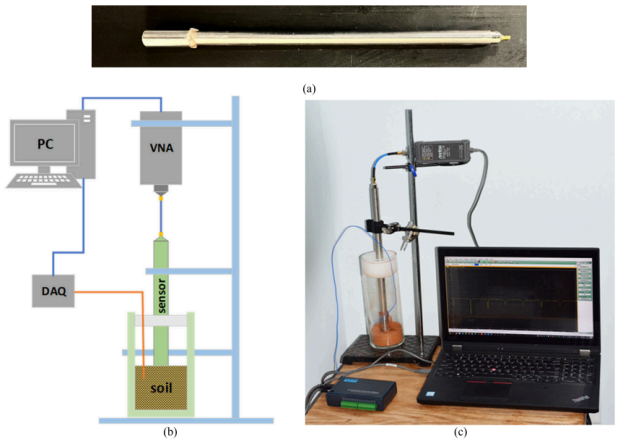


Fig. 4. (a) Photograph of the prototype device. (b) Experimental setup used to test the soil moisture response of the EOE-MCCR. (c) Actual experimental setup.

In this figure, (a) is the actual prototype sensor they tested, (b) is a diagram of the experimental setup, and (c) is the actual setup they used.

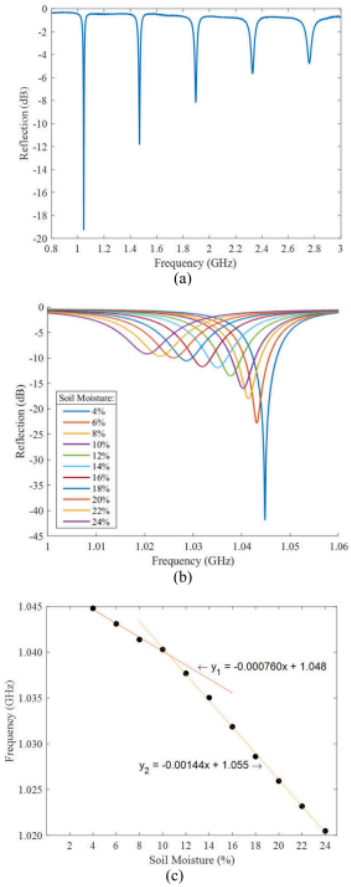
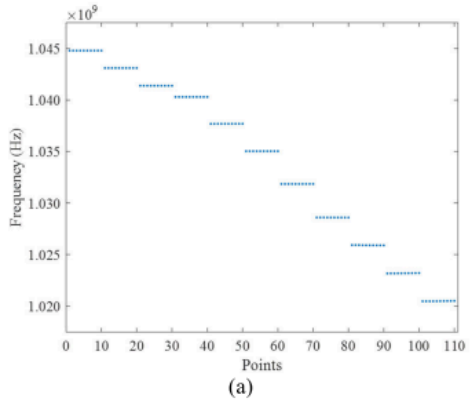


Figure 5(a) shows the amplitude reflection spectrum. The peaks, I think, represent resonance of multiple frequencies, and multiple frequencies are visible. The downward trend of the spectrum was because of the high transmission loss of the cable. Figure 5(b) shows the measured response of the sensor to water content variations. It is the recorded reflection spectra during increasing soil moisture

(heavily quoted, but also paraphrased). Figure 5c shows the resonance frequencies plotted against the soil moisture percentages with a linear curve fit model.



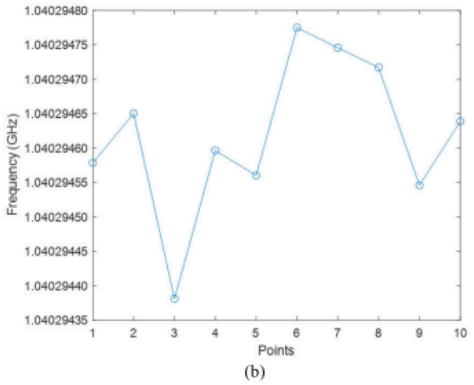


Fig. 6. Sensitivity and response of the prototype soil moisture sensor. (a) Sensor's response to small variations of soil moisture, where ten measurements were recorded for each soil moisture setting. (b) Maximum variability of 114.9 Hz was observed for ten measurements of the resonance frequency obtained from measurement points 30–40, indicating the high precision of the proposed sensor.

These graphs show the frequency measured by the sensor for each soil moisture setting at 10 different points. On the first graph, due to the zoomed out frequencies, the results look very consistent. In the second graph, the authors only looked at the variability for points 30-40, where the maximum variability was 114.9 Hz.

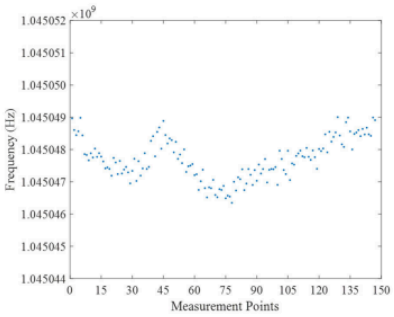


Fig. 7. Stability test of the proposed PVA-film-assisted soil moisture sensor. The sensor was placed in a temperature-controlled container at 25 °C for 150 min to eliminate environmental interferences. The frequency uncertainty was found to be 640 Hz, indicating excellent stability of the sensor.

This graph shows the frequency against the number of measurement points taken, where each dot is 1 measurement point. They conducted a stability test and found that the frequency uncertainty was 640 Hz. (I do not know why they are including Hz, I am confused)

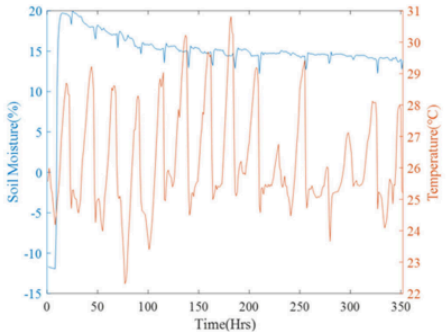


Fig. 8. Long-term observation of soil moisture changes in response to water injection. A total of 20 mL of water was added to 125 g of soil, resulting in a gradual increase in soil moisture content that stabilized at approximately 16%.

In this graph the measured soil moisture is plotted against time, and temperature is plotted against time to see how it stabilizes.

VOCAB: (w/definition)

Coaxial cable: a transmission line that consists of a tube of electrically conducting material surrounding a central conductor held in place by insulators and that is used to transmit telegraph, telephone, television, and Internet signals. Taken from Coaxial cable Definition & Meaning - Merriam-Webster

Vadose Zones: The vadose zone is the Earth's terrestrial subsurface that extends from the surface to the regional groundwater table. Taken from Vadose Zone - an overview | ScienceDirect Topics

Capacitance: the ability of a system to store an electric charge.

- the ratio of the change in an electric charge in a system to the corresponding change in its electric potential.

Taken from oxford dictionary and Bing search - capacitance definition

	Dielectric: adjective : having the property of transmitting electric force without conduction; insulating. - taken from oxford dictionary and Bing search - Dielectric definition
Cited references to follow up on	L. Yu et al., “Review of research progress on soil moisture sensor technology,” Int. J. Agricult. Biol. Eng., vol. 14, pp. 32–42, Jan. 2021. K. Sharma, S. Irmak, M. S. Kukal, M. C. Vuran, A. J. Jhala, and X. Qiao, “Evaluation of soil moisture sensing technologies in silt loam and loamy sand soils: Assessment of performance, temperature sensitivity, and siteand sensor-specific calibration functions,” Trans. ASABE, vol. 64, no. 4, pp. 1123–1139, 2021. K. Y. You et al., “Precise moisture monitoring for various soil types using handheld microwave-sensor meter,” IEEE Sensors J., vol. 13, no. 7, pp. 2563–2570, Jul. 2013. M. Hardie, “Review of novel and emerging proximal soil moisture sensors for use in agriculture,” Sensors, vol. 20, no. 23, p. 6934, Dec. 2020.
Follow up Questions	Could a coaxial probe sensor be connected to a larger machine? Does the coaxial probe sensor exist as a commercial product? If not, have the authors made any advancements on it? Can the coaxial sensor be completely buried and still work? Would the coaxial sensor be a viable option to assist in regulating amounts of water in soil?

Article #13 Notes: **California's epic rain year boosted groundwater levels, but not enough to recoup losses**

Source Title	California's epic rain year boosted groundwater levels, but not enough to recoup losses
Source citation (APA Format)	James, I. (2023, October 16). *California's epic rain year boosted groundwater levels, but not enough to recoup losses*. Phys.org. https://phys.org/news/2023-10-california-epic-year-boosted-groundwater.html
Original URL	California's epic rain year boosted groundwater levels, but not enough to recoup losses (phys.org)
Source type	Scientific News Article
Keywords	Groundwater; drought; aquifer; percolation; subsidence
#Tags	#MSEF, #soil, #water
Summary of key points + notes (include methodology)	Summary: The last year in California was very wet, and provided relief from years of droughts, which have led to the depletion of groundwater resources. Even though the year was very rainy, the water that was soaked into the ground was not enough to replenish the aquifers, and more rainy years are needed, along with the implementation of other strategies to return the groundwater supplies to acceptable levels. Notes: ● California had a very wet year in 2023, but even though a lot of rain came and soaked into the ground, it was not enough to fully replenish the groundwater supplies. (paraphrased) ● Water levels rose in 34% of wells, and decreased in 9% of wells, others had little change (paraphrased). -How does this compare to other years? ● Last three years have been extreme drought years, but this much rain does not help as much as needed because there have been decades of overuse. ● Several more wet years are needed, along with the deployment of other strategies to reverse the depletion of underground water. ● Water takes a lot of time to accumulate underground. ● Recovery has occurred in shallow aquifers, deeper aquifers have not risen as much, and those deeper ones are usually the ones agricultural wells tap into. ● Heavy pumping of aquifers, usually done by agricultural districts who are watering their plants, has led to the drainage of the aquifers and the

	subsequent collapse of some clay layers, leaving less room for water in the future. However, some strategies, like using water from canals to water crops has lessened the heavy pumping. (heavily paraphrased) ● The ground can rise as a result of having more water added to it, such as near the 5 Freeway in the Westlands Water District, which had sunk 3 inches over the past decade and rose nearly an inch. ● Some agencies in the San Joaquin Valley have been over pumping and leading to the continued subsidence of the land, which has warranted them a warning from California state water regulators. ● Some parts of Tulare Lake basin have sunk up to 6 feet since 2015, which have sent floodwaters to areas that previously did not experience these floods, and has resulted in the raising of levies. ● Due to the greater amount of rain, Tulare Lake has reappeared. It had dried out and become farming grounds for tomatoes and cotton. The reappearance does not solve groundwater problems though. ● Repeated droughts and the effect of climate change over the years has resulted in an accumulated precipitation deficit. ● In dry years, more water needs to be pumped from the ground ● Last year, about 1500 California household wells dried up, this year was less, at more than 400 wells
Research Question/Problem/ Need	Though there has been more rainwater in California over the past year, the rain that has come is not enough to restore the depleted reserves in aquifers.
Important Figures	None
VOCAB: (w/definition)	Subsidence: the gradual caving in or sinking of an area of land (taken from Oxford Languages) Aquifer: An underground layer of water. Percolate: filter gradually through a porous surface or substance (taken from Oxford Languages) Water extraction: Using pumps to extract water from underground water sources
Cited references to follow up on	No references were given.
Follow up Questions	What are other ways of storing water or obtaining water that do not damage aquifers? What are the farmers doing to irrigate their fields? What caused the wetter year this year? What are the long term effects of subsidence due to droughts?

Article #14 Notes: **New design cuts costs, energy needs for drip irrigation, bringing the systems within reach for more farmers**

Source Title	New design cuts costs, energy needs for drip irrigation, bringing the systems within reach for more farmers
Source citation (APA Format)	Chu, J., & Technology, M. I. of. (2017, April 20). *New design cuts costs, energy needs for drip irrigation, bringing the systems within reach for more farmers*. Phys.Org. https://phys.org/news/2017-04-energy-needsfor-irrigation-systemswithin-farmers.html
Original URL	https://phys.org/news/2017-04-energy-needsfor-irrigation-systemswithin-farmers.html
Source type	Scientific News Article
Keywords	Drip irrigation; water use; efficiency
#Tags	#MSEF, #soil, #water
Summary of key points + notes (include methodology)	Summary: Researchers from MIT wanted to make drip irrigation systems more energy efficient and cheaper so farmers in developing countries can have better water efficiency and make more money. A drip irrigation system is a series of tubes with holes that drip water directly onto the plant's roots. The researchers used algorithms to design more energy efficient systems. Notes: ● Drip irrigation is widely used as a method to save water when watering crops in the US. ● Water is trickled directly onto a plant's base, giving only as much water as the farmer wants. ● Can reduce water consumption by as much as 60% and increase crop yield by as much as 90% (almost direct quote) ● Are expensive, so engineers at MIT wanted to see if they could make them less expensive by optimizing the drippers, therefore reducing energy needs ● Did this by modifying the drippers dimensions to reduce the pressure needed to release the same amount of water.

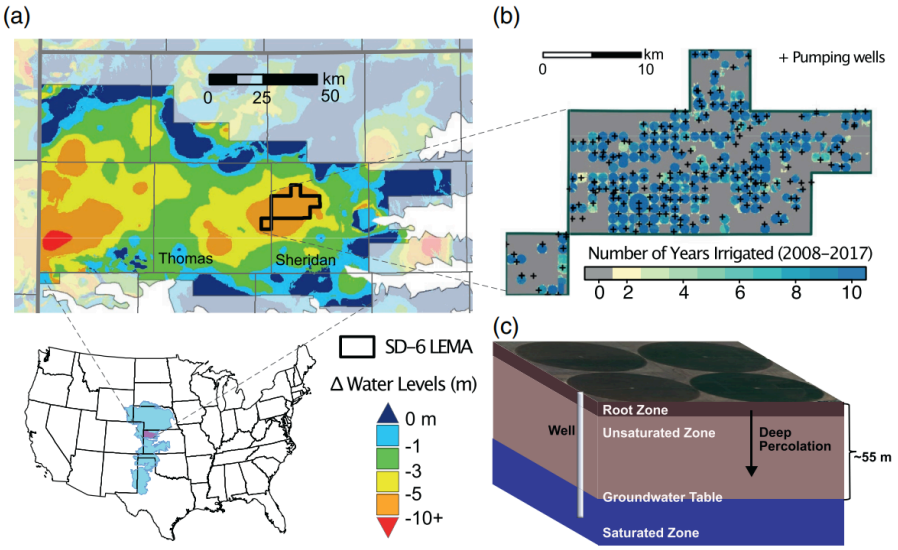
	● Makes drippers more affordable to people in developing nations ● In India, as well as other parts of the world, flood irrigation is used to water crops cheaply. Flood irrigation is when the fields are flooded via redirecting river or groundwater sources. This is cheap, but inefficient and it is difficult for the farmers to control. Most of the excess water not absorbed by the plants is evaporated or drained away. ● The driver and pump system of drip irrigation systems are the main cost. ● The researchers wanted to make it cheaper by focusing on pressure compensating drippers, which maintain constant flow rate regardless of initial water pressure ● They used algorithms to find what models may work the best. ● Push for more drip irrigation systems, can get people out of poverty because they can grow more high value crops, there is also less water loss. ● There is a push to get this tech out to more people, because it could really help them and give them the push they need.
Research Question/Problem/ Need	How can drip irrigation systems be made more efficient?
Important Figures	none
VOCAB: (w/definition)	Drip irrigation: A method of irrigation where the water is applied directly to the roots of the plant out of pressurized tubes. Drippers: The pieces in the tubes of the drip irrigation systems that release water. Flood irrigation: A type of irrigation where water from underground sources or rivers is redirected to flood the fields. Bar: unit of pressure equivalent to 100 kPa.
Cited references to follow up on	Pulkit Shamshery et al. Modeling the future of irrigation: A parametric description of pressure compensating drip irrigation emitter performance, PLOS ONE (2017). DOI: 10.1371/journal.pone.0175241
Follow up Questions	Are there any other downsides to drip irrigation systems? What is the effect on the soil that is not receiving water? Would this low cost, low pressure drip irrigation system work vertically? What other methods of irrigation exist?

Article #15 Notes: **Combining Remote Sensing and Crop Models to Assess the Sustainability of Stakeholder-Driven Groundwater Management in the US High Plains Aquifer**

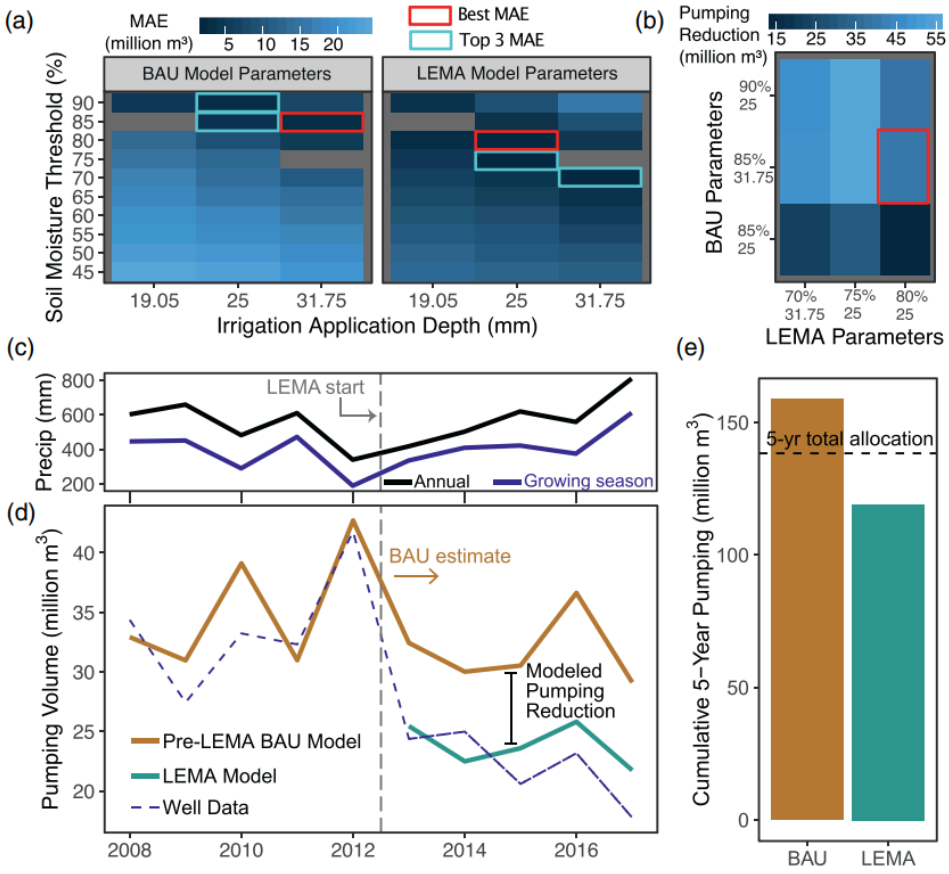
Source Title	Combining Remote Sensing and Crop Models to Assess the Sustainability of Stakeholder-Driven Groundwater Management in the US High Plains Aquifer
Source citation (APA Format)	Deines, J. M., Kendall, A. D., Butler, J. J., Basso, B., & Hyndman, D. W. (2021). Combining Remote Sensing and Crop Models to Assess the Sustainability of Stakeholder-Driven Groundwater Management in the US High Plains Aquifer. *Water Resources Research*, *57*(3), e2020WR027756. https://doi.org/10.1029/2020WR027756
Original URL	https://agupubs-onlinelibrary-wiley-com.ezpv7-web-p-u01.wpi.edu/doi/10.1029/2020WR027756
Source type	Journal Article
Keywords	Groundwater management; simulation; reducing water usage
#Tags	#MSEF, #soil, #water
Summary of key points + notes (include methodology)	Summary: There is too much groundwater that is being used for agricultural purposes, and this has led to the creation of a program called LEMA that helps farmers reduce water consumption through efficient agriculture. The LEMA program was found to reduce groundwater extraction, and lowered energy costs for farmers. Notes: ● Too much groundwater is being used, and it is often used by irrigation land, and groundwater usage exceeds the restoration rate of aquifers. ● Laws in the past have disincentivised using groundwater resources in order to allow for the restoration of. ● The LEMA program (Local Enhanced Management Area) was created by Kansas legislation in 2012 as a stakeholder program to conserve

	groundwater resources ● One LEMA program, implemented in an area with high underground water usage and low above ground water levels, was successful, and exceeded the pumping reduction expectations. ● Need: quantify effects of the LEMA program so other such programs can be implemented better ● Little irrigation water used during the LEMA program makes it back to the aquifer ● Measuring changes in crop income is difficult, and complicates the task of quantifiably assessing the LEMA program ● They used a System Approach to Land Use Sustainability (SALUS) crop model to simulate the water use changes from the LEMA program. ● They simulated water savings that occurred during the LEMA program and a BAU program ● Efficiently irrigating is one way farmers can reduce water use ● They estimated that for this LEMA, ~72% of water use efficiency came from improved irrigation. ● Their model found that when water was applied at 85% soil moisture, that best matched the groundwater usage in the BAU scenario. ● They found that the LEMA program reduced total 5-year groundwater extraction by 25% to 119 million m3 compared to BAU estimates of 159 million m3 (direct quote) ● Improvements in irrigation efficiency reduce water use ● The LEMA scenario was better than the BAU scenario for all years. ● There is an irrigation paradox when using more efficient irrigation systems as systems like drip irrigation provide only the necessary amounts of water to plants, resulting in less water that percolates back into the underground reserves. ● When the LEMA program was used, there were minimal yield penalties ● Compared to the BAU scenario pumping costs, the LEMA saved a total of $2.85 million over 2013–2017, a 25% reduction in energy costs for the 5 years, scaling linearly from the reduced water volume due to our uniform application of energy intensity (direct quote) ● Net water balance only increased by 8.6 million m3, meaning that only 22% of the pumping reductions translated into water conservation. ● Overall, net profits during the LEMA program were increased ● Extending the aquifer's lifespan could help mitigate the effects of droughts in the future ● Aquifer sustainability may be difficult to achieve under drought conditions
Research Question/Problem/ Need	What was the effect of the LEMA program on the net water balance, considering changes in both groundwater extraction and irrigation return flows? and (2) How did the LEMA program affect crop yields and net profits, incorporating both yield penalties and reduced energy costs associated with reduced pumping?

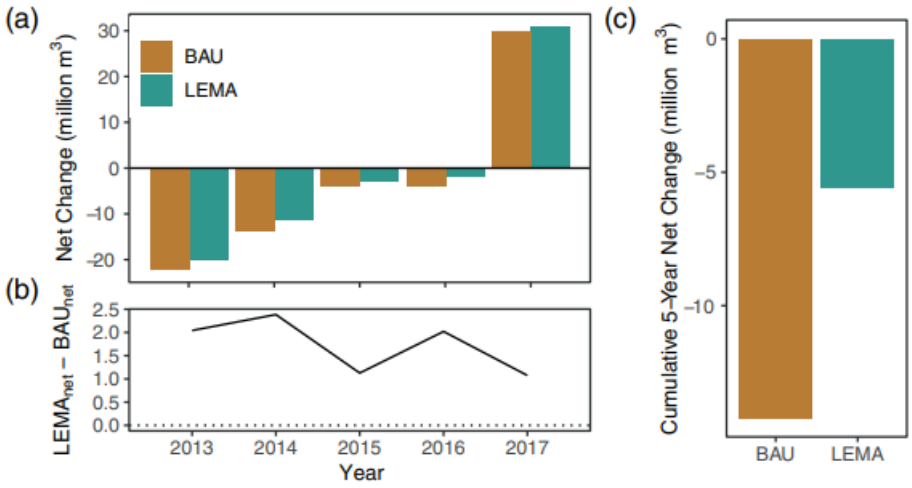
Important Figures



This shows the area that was looked at. This is where the SD-6 LEMA program was run.



These graphs show comparisons between the BAU model and the LEMA model, and how the LEMA model shows a lower amount of water needed for irrigation purposes.

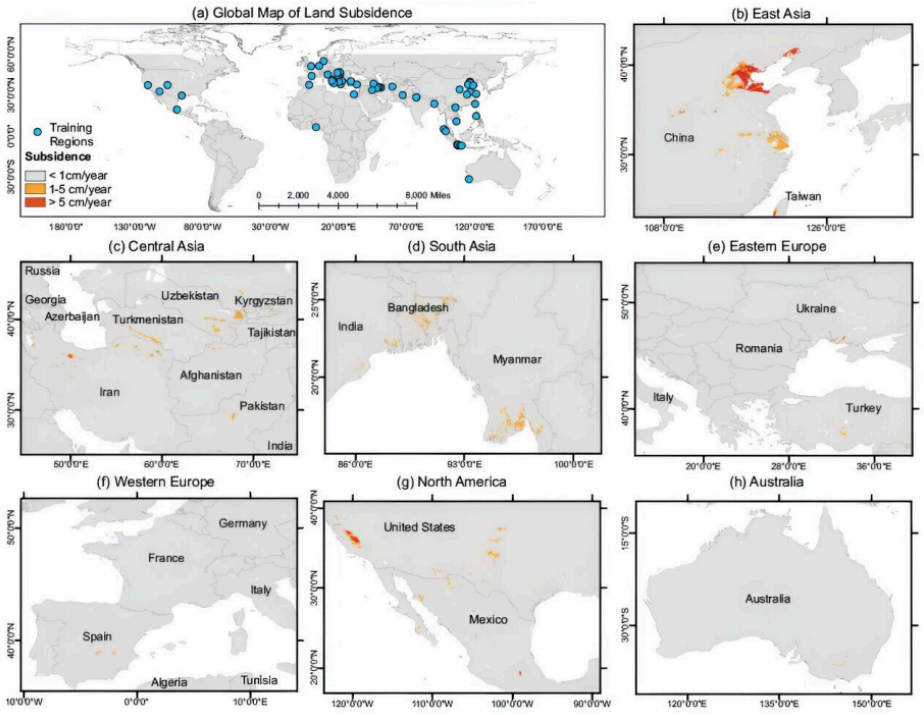
	 These graphs show the net groundwater estimation savings. Over the years the estimated savings get bigger and bigger, however, with the LEMA program, the net change is smaller.
VOCAB: (w/definition)	Aggregate: a material or structure formed from a loosely compacted mass of fragments or particles. (From Oxford Languages). Litigations: The process of taking legal action. (From Oxford Languages) Recharge: The replenishment of an aquifer by the absorption of water (From Oxford Languages) Hydrologic: adjective form of hydrology. Hydrology: the branch of science concerned with the properties of the earth's water, and especially its movement in relation to land (From Oxford Languages)
Cited references to follow up on	Basso, B., Kendall, A. D., & Hyndman, D. W. (2013). The future of agriculture over the Ogallala Aquifer: Solutions to grow crops more efficiently with limited water. Earth's Future, 1, 39–41. https://doi.org/10.1002/2013EF000107 Boryan, C., Yang, Z., Mueller, R., & Craig, M. (2011). Monitoring US agriculture: The US Department of Agriculture, National Agricultural Statistics Service, Cropland Data Layer program. Geocarto International, 26(5), 341–358. https://doi.org/10.1080/10106049.2011.562309 Butler, J. J., Whittemore, D. O., Wilson, B. B., & Bohling, G. C. (2016). A new approach for assessing the future of aquifers supporting irrigated agriculture. Geophysical Research Letters, 43, 2004–2010. https://doi.org/10.1002/2016GL067879

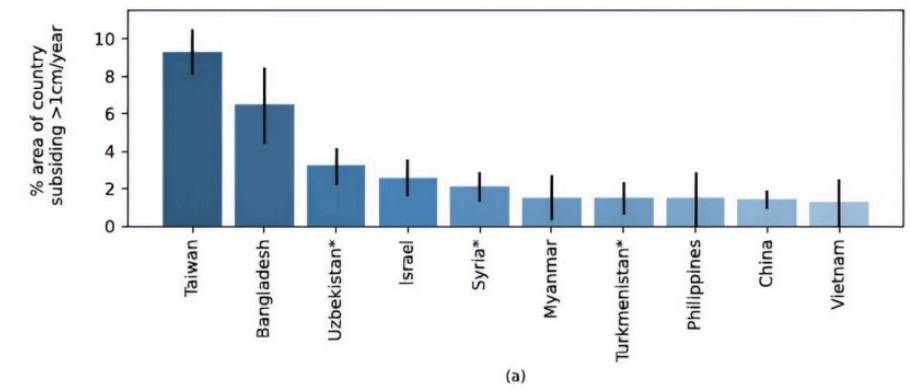
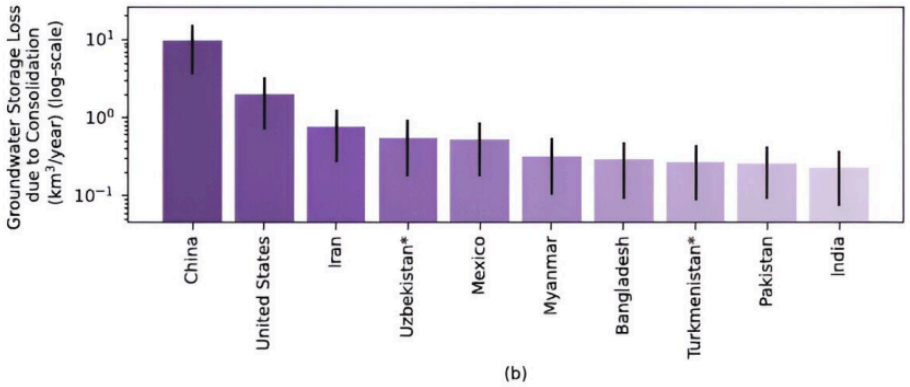
	Foster, T., Brozović, N., & Butler, A. P. (2017). Effects of initial aquifer conditions on economic benefits from groundwater conservation. Water Resources Research, 53, 744–762. https://doi.org/10.1002/2016WR019365
Follow up Questions	What can be done to make aquifer recharge more efficient? How can water usage be decreased even more? Are there any other water usage models? What types of irrigation are used to decrease aquifer depletion?

Article #16 Notes: **Combining Remote Sensing and Crop Models to Assess the Sustainability of Stakeholder-Driven Groundwater Management in the US High Plains Aquifer**

Source Title	Combining Remote Sensing and Crop Models to Assess the Sustainability of Stakeholder-Driven Groundwater Management in the US High Plains Aquifer
Source citation (APA Format)	Institute, D. R. (2023, November 6). *Scientists map loss of groundwater storage around the world*. Phys.Org. https://phys.org/news/2023-11-scientists-loss-groundwater-storage-world.html
Original URL	https://phys.org/news/2023-11-scientists-loss-groundwater-storage-world.html
Source type	Scientific News Article
Keywords	Global; water resources; aquifer depletion; subsidence
#Tags	#MSEF, #soil, #water
Summary of key points + notes (include methodology)	Summary: The researchers developed a machine learning model that maps approximate subsidization around the world. Subsidization occurs all around the world, and is not limited to arid regions. Notes:

	● As the world's population grows, there is a greater reliance on groundwater resources (paraphrased) ● Pumping groundwater resources leads to the ground sinking, and this study shows a mapping system of groundwater depletion over the whole world. ● Study was originally published in the journal *Nature Communications* in October. They looked at how groundwater extraction was leading to the ground sinking and aquifers collapsing. ● They found global aquifer storage capacity is disappearing at a rate of approximately 17 km3 per year (about the size of 7,000 Great Pyramids of Giza). (direct quote) ● Subsidence was found to usually be occurring over cropland and urban regions, about 75% (almost direct quote) ● There are areas where there is no data on how the land is subsidizing, so they used advanced machine learning techniques (paraphrased) ● Compiled all the publicly available info from federal and state agencies and scientific articles (almost direct quote) ● Used this data to build a computer model that can use risk factors for land subsidence and predicted ground subsidence for other regions. (almost direct quote) ● Tested model on areas where the subsidence was already known ● Found U.S., China, and Iran account for most of the global underground water storage loss (quote-ish) with some regions experiencing more than 5cm/year of land subsidence. (quote) ● Predicts high subsidence rates in Afghanistan, Uzbekistan, Azerbaijan, and Syria, which have never been measured ● Most of Europe is experiencing low levels of subsidence (less than 1cm/year), but this can still have an impact on infrastructure. ● Subsidization can also cause arsenic contamination and saltwater intrusion, which impact groundwater quality. ● Problem is not limited to arid regions, Bangladesh, India, and Vietnam have humid climates and subsidence ● Hope is that the data could be used to help water managers understand the groundwater impact in their regions.
Research Question/Problem/ Need	How can subsidization be measured globally?

Important Figures	 This is a map that the model developed for land subsidence. Most of the world is gray, meaning that in a year, the land subsidizes less than a cm. The blue dots on the global map show training regions for the model.

	 (a)  (b) Here are two graphs. a) shows the % area of some countries that are subsidizing at greater than 1% each year. b) shows groundwater storage loss due to consolidation for some countries. Some of the countries overlap, such as Uzbekistan, Myanmar, and Turkmenistan.
VOCAB: (w/definition)	Arid: very dry Groundwater: Water held underground, such as in aquifers, in soil, or in rocks Land subsidence: the gradual sinking of land, can be caused by both natural and human means. Hydrologic: the branch of science that studies water resources on earth.
Cited references to follow up on	Md Fahim Hasan et al, Global land subsidence mapping reveals widespread loss of aquifer storage capacity, *Nature Communications* (2023). DOI: 10.1038/s41467-023-41933-z
Follow up Questions	Does a higher rate of subsidence relate to higher water usage? Does a higher rate of subsidence relate to areas with higher agricultural land usage? To what degree of accuracy is this model at?

	Does subsidence have an affect on agriculture?

Article #17 Notes: **Soil and plants lose more water under drought**

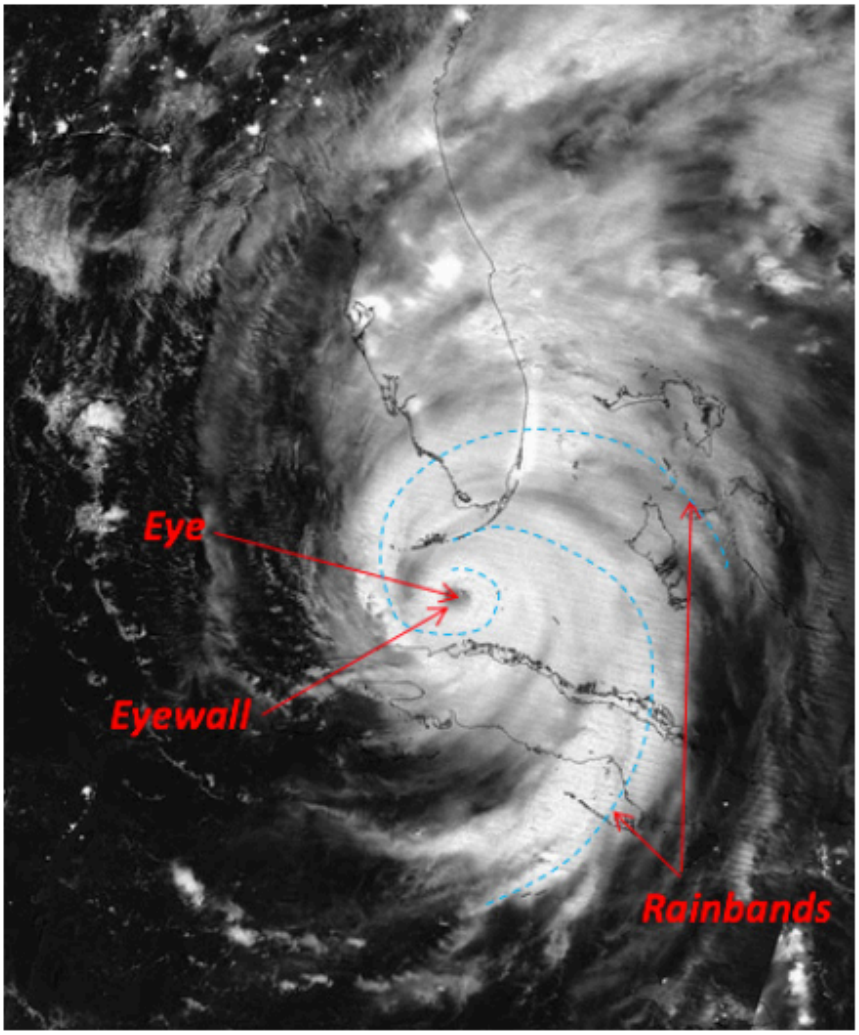
Source Title	Soil and plants lose more water under drought
Source citation (APA Format)	Pascolini-Campbell, M. (2022). Soil and plants lose more water under drought. *Nature Climate Change*, *12*(11), 969–970. https://doi.org/10.1038/s41558-022-01510-6
Original URL	https://www.nature.com/articles/s41558-022-01510-6
Source type	Scientific news article
Keywords	Drought; water loss; evapotranspiration; anomalies
#Tags	#MSEF, #soil, #water
Summary of key points + notes (include methodology)	Summary: Evapotranspiration is the movement of water from the soil and from plants to the air. During droughts there is less water in the air and the ground, but because there is less water in the air, the air draws up the little water that is left in the soil and in the plants and worsens drought conditions. This article describes a study that attempted to model evapotranspiration during droughts. Notes: ● Droughts decrease the amount of available water in the nature system ● One study shows that there is an increase of land to air water transfer during droughts (water leaves soil more in droughts) ● More droughts now than in the past ● During droughts, there is less water for evapotranspiration, but there is also a greater want of the atmosphere for more water, which draws more water from the ground and plants, leading to drier conditions for the plants ● Hard to determine how this process works, so Zhao et al. used a water balance approach to estimate global evapotranspiration in the drought months between 2003 to 2020 (paraphrased, almost direct quote). ● They calculated evapotranspiration by finding the residual from the inputs and outputs, which were precipitation, and river discharge and water storage changes ● They found that evapotranspiration anomalies increase during droughts ● Enhanced water loss from plants and soil can lead to flash droughts, with potentially devastating impacts on both agricultural and natural ecosystems (paraphrased, almost direct quote).

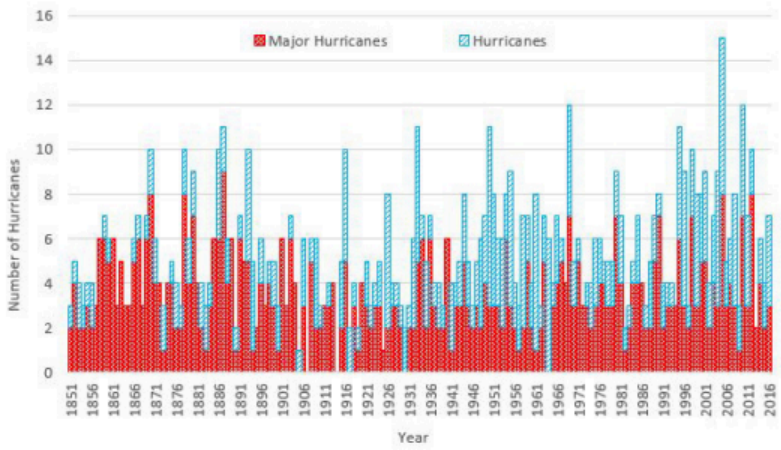
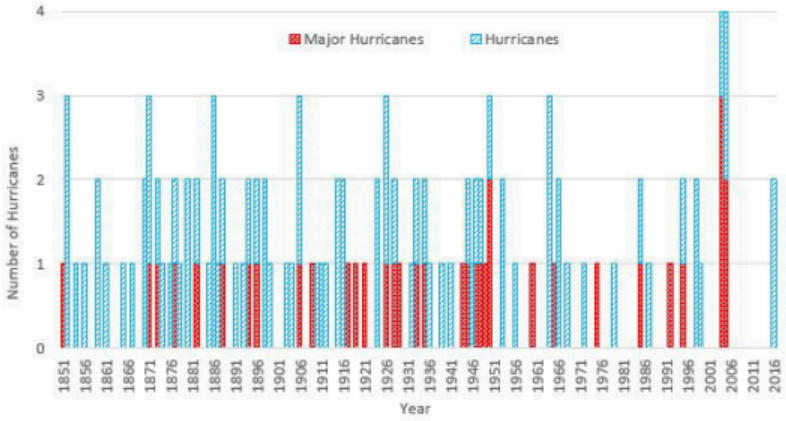
	• They compared their model with other models, and found those other models to be underestimating the relationship between droughts and evapotranspiration anomalies, which could make current drought predictions less accurate.
Research Question/Problem/ Need	How can the effect of evapotranspiration during droughts be measured?
Important Figures	N/A
VOCAB: (w/definition)	Evapotranspiration: the process by which water is transferred from the land to the atmosphere by evaporation from the soil and other surfaces and by transpiration from plants. (from Oxford Languages) Famine: extreme scarcity of food (from Oxford Languages) Anomalies: something that deviates from what is standard, normal, or expected. (from Oxford Languages) Atmosphere: the envelope of gases surrounding the earth or another planet. (from Oxford Langauges)
Cited references to follow up on	Zhao, M., A. G., Liu, Y. & Konings, A. G. *Nat. Clim. Change* https://doi.org/10.1038/s41558- 022-01505-3 (2022) Ellerbeck, S. Droughts are getting worse around the world, here's why and what needs to be done. *World Economic Forum* (12 August 2002); https://go.nature.com/3rfqkJF Drought in the Horn of Africa: FAO appeals for $172 million to help avert famine and humanitarian catastrophe. *FAO* (27 June 2022); https://go.nature.com/3rih6MH Rodell, M. et al. Geophys. Res. Lett. https://doi.org/10.1029/2004GL020873 (2004).
Follow up Questions	Can evapotranspiration be slowed? What are evapotranspiration rates within high tunnels? Are evapotranspiration rates within high tunnels higher or lower than outside of high tunnels? Approximately how inaccurate are current drought predictions?

Article #18 Notes: Hurricane Impacts on Florida's Agriculture and Natural Resources

Source Title	Hurricane Impacts on Florida's Agriculture and Natural Resources
Source citation (APA Format)	Fletcher, P., Smyth, A., Gu Her, Y., Bassil, E., Stingl, U., Brym, Z., & Qui, J. (2018, November 5). *AE528/AE528: Hurricane Impacts on Florida's Agriculture and Natural Resources*. UF : IFAS Extension. https://edis.ifas.ufl.edu/publication/AE528
Original URL	https://edis.ifas.ufl.edu/publication/AE528
Source type	Journal Article
Keywords	Hurricanes; Agriculture; Florida;
#Tags	#MSEF, #water
Summary of key points + notes (include methodology)	Summary: The effects of hurricanes on surrounding ecosystems are far reaching and often severe. Hurricanes can affect natural ecosystems as well as agricultural ecosystems, with humans and aquatic ecosystems also being affected. Notes: ● Hurricanes have many effects on both inland and coastal areas, and we need to understand these effects to start preparing for them ● This article focuses mainly on the effects of hurricanes on Florida, and how hurricanes can affect the natural and agricultural resources. ● Hurricanes are large storms that swirl and start in the Atlantic Ocean closer to the equator, and then move up and eventually northwest. The scientific name for hurricanes is a tropical cyclone. ● Latent heat, or water that has warmed and evaporated in the ocean, fuels tropical cyclone ● Categorized by sustained wind speeds ● Consist of eye, eyewall, and rainbands ● Hurricanes are given names that repeat every 6 years, though the most severe are retired - names are used mainly for the benefit of the public and communication to the public ● Number of hurricanes have increased slightly, and a lot of the ones that affect the us affect Florida ● Lots of money has gone into recovering from damage caused by

	hurricanes ● **IMPACTS ON ECOSYSTEMS:** ● forests , swamps, and many other natural areas can be severely impacted by hurricanes, severe damage is common ● Loss of these habitat creators releases CO2 into the air and can lead to the deaths of a lot of wildlife ● **Impacts on Agroecosystems:** ● A UF/IFAS survey reported Hurricane Irma damaged more than half of the agricultural and horticulture crops in seven Florida counties (direct quote) ● Loss of harvestable goods was included in the damages ● Because of how agricultural land is run, it may be more prone to damage from hurricanes- this means diversity is important and may help ● **Impacts on Crops:** ● Damage to orchards is more persistent than damage to annual crops ● Pruning trees can help mitigate or reduce the effects of flooding and hurricanes ● Areas near the coast often experience sea surges and higher salinity, which adds to the plants environmental stress ● Too high salinity levels can kill plants ● **Impacts on Freshwater Bodies:** ● In Florida, the limestone soils absorb water well, but urban areas are more often flooded because the concrete is impervious ● Heavy rainfall can contribute to water contamination, with runoff soils getting into fresh water bodies ● Stormwater surge can contaminate freshwater resources with salt water ● **Impacts on Coral Reefs, Seagrasses, and Wetlands:** ● The hurricanes can shift the coastline structure a bit, exposing sea life and leading to the death of certain sea life. ● Restoration of wetlands can help protect against hurricanes in the future, as wetlands absorb water ● **Impacts on Microbial Communities:** ● Previous studies have shown the potential impact of hurricanes, including increased concentrations of human and animal pathogens and/or potentially toxic phytoplankton blooms (direct quote) ● Harmful microbes can increase in number after the disturbance caused by hurricanes ● **Conclusions:** ● The effects of hurricanes are far reaching and incredibly impactful
Research Question/Problem/ Need	What are the currently known effects of hurricanes on Florida ecosystems, agroecosystems, economy, and other things?

Important Figures	 This figure shows the different parts of the hurricane. The eye is in the very center, the eyewall surrounds the eye and has the highest winds. The rainbands are the outer parts where rains fall.

	 Figure 3. The number of hurricanes formed in the Atlantic Ocean in the past. Credits: NOAA  Figure 4. The number of hurricanes that affected Florida in the past. Credits: NOAA These graphs show the number of hurricanes that have formed in the Atlantic since 1851, and that have had an effect on florida. There is a lot of overlap between the two graphs, though fewer of the major hurricanes have affected Florida.
VOCAB: (w/definition)	Agroecosystems: an ecosystem on agricultural land (from Oxford Languages) Microbe: a microorganism, especially a bacterium causing disease or fermentation. (from Oxford Languages) Turbidity: the quality of being cloudy, opaque, or thick with suspended matter (from Oxford Languages) Levees: an embankment built to prevent the overflow of a river (from Oxford Languages)
Cited references to follow up on	Altieri, M. A. 1999. “The ecological role of biodiversity in agroecosystems.”

	Agriculture, Ecosystems & Environment 74: 19–31. Buma, B. and C. A. Wessman. 2011. “Disturbance interactions can impact resilience mechanisms of forests.” Ecosphere 2(5): 64. Miami-Dade County. 2018b. “Flood zones.” Miami-Dade County. Accessed on February 1, 2023. https:// mdc.maps.arcgis.com/apps/webappviewer/index.html?id=685a1c5e03c947d9a786df7b4ddb79d3 NewScientist. 2017. “Thousands likely to be killed by Hurricane Irma’s deadly legacy.” NewScientist. Accessed on October 7, 2018. https://www.newscientist.com/article/2147860-thousands-likely-to-be-killed-byhurricane-irmas-deadly-legacy/
Follow up Questions	How do hurricanes affect other parts of the United States? How do hurricanes affect California and the west coast? What policies are in place to help farmers when hurricanes come? What do farmers do to help save their crops from hurricanes?

Article #19 Notes: **Modeling capillary wick irrigation system for greenhouse crop production**

Source Title	Modeling capillary wick irrigation system for greenhouse crop production
Source citation (APA Format)	Roonjho, S. J., Kamal, R. M., & Roonjho, A. R. (2022). Modeling capillary wick irrigation system for greenhouse crop production. *Agricultural Water Management*, *274*, 107927. https://doi.org/10.1016/j.agwat.2022.107927
Original URL	Modeling capillary wick irrigation system for greenhouse crop production - ScienceDirect
Source type	Journal article
Keywords	Microirrigation; Capillary wick irrigation; Hanging wick; Buried wick; Greenhouse potted crops
#Tags	#MSEF, #water
Summary of key points + notes (include methodology)	Summary: Common micro irrigation systems, such as drip irrigation systems, are expensive, so the authors wanted to develop a different micro irrigation system that would still conserve water. The authors developed a wick irrigation system, and focused mainly on the wick material and how the wick was positioned, along with a few other factors. Notes: ● There is a very limited supply of freshwater available, and the agricultural industry accounts for the majority of water usage globally ● Drip irrigation has been used to reduce the amount of water used in agriculture, as have other micro irrigation techniques, however, these are often costly. ● Wick irrigation is considered a promising method to help with this issue ● Provides water through capillary movement ● Increases the efficiency of root water and nutrient uptake, with a reported increase and yield and water saving ● Wick irrigation has been found to be significantly efficient over conventional irrigation ● There has not been enough attention from researchers on wick irrigation, with this study being created to develop a wick design for a systematic capillary wick irrigation system (hanging and buried) for greenhouse crop production (half paraphrased, half direct quote) ● They used three different materials for the wick

	● They determined water holding capacity of the wicks ● Capillary rise was also tested by drying out the wicks and inserted into a water filled beaker ● Water was absorbed from the PVC pipe and discharged to a beaker or potted substrate through gravity ● For a buried wick, peat moss was used as the growing media, and the water was still supplied from the pipe. ● They mathematically estimated the amount of water that would discharge from the wick ● They used a local variety of tomatoes for the greenhouse experiments. ● Greenhouse experiments were conducted to measure the discharge of a buried wick, and the effects of evapotranspiration on the discharge of the wick ● Two pots were randomly chosen for the measurement of the water discharge ● Evapotranspiration was measured using gravimetric methods ● The absorption levels of the wicks differed greatly ($P > 0.05$). Cotton boden non woven exhibited highest absorption, with lowest capillary action recorded in cotton ● Evapotranspiration affected the discharge of the buried wick ● An increase in evapotranspiration resulted in an increase in discharge from the buried wick ● The wick discharge linear curve (Fig. 7) was developed based on the results obtained from the greenhouse experiment (direct quote) ● A single emitter can work for many different types of plants in one greenhouse, such as strawberries, cabbage, cauliflower and more. ● The wick material is the most important factor of a capillary wick irrigation system, with the water holding capacity and maximum capillary action are important in determining the best material ● Wick length and initial moisture had an impact on how much discharge there was ● Pot size has an impact on discharge estimates ● The cotton-bonded non-woven wick material has higher maximum capillary and water holding capacity (direct quote) ● The discharge of selected wick material (CNW) in buried and hanging wick were linearly affected by wick length inside pipe and water level inside the pipe. (direct quote)
Research Question/Problem/ Need	The need the authors were addressing was the need for a cheaper, but still water efficient micro irrigation system for greenhouses. They developed a wick irrigation system.

Important Figures

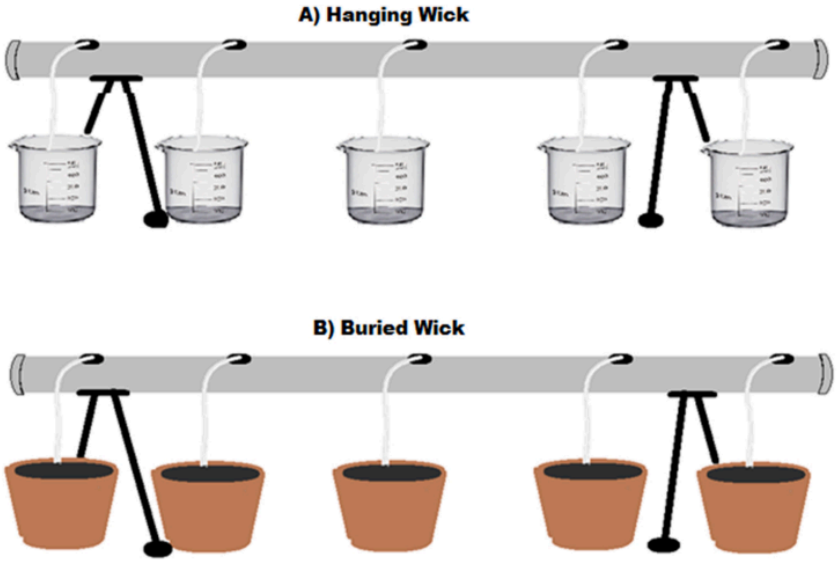


Fig. 1. : Layout of the experimental setup under laboratory.

This is the layout of how they tested the hanging and buried wicks in a lab setting. The medium in the pots was peat moss.

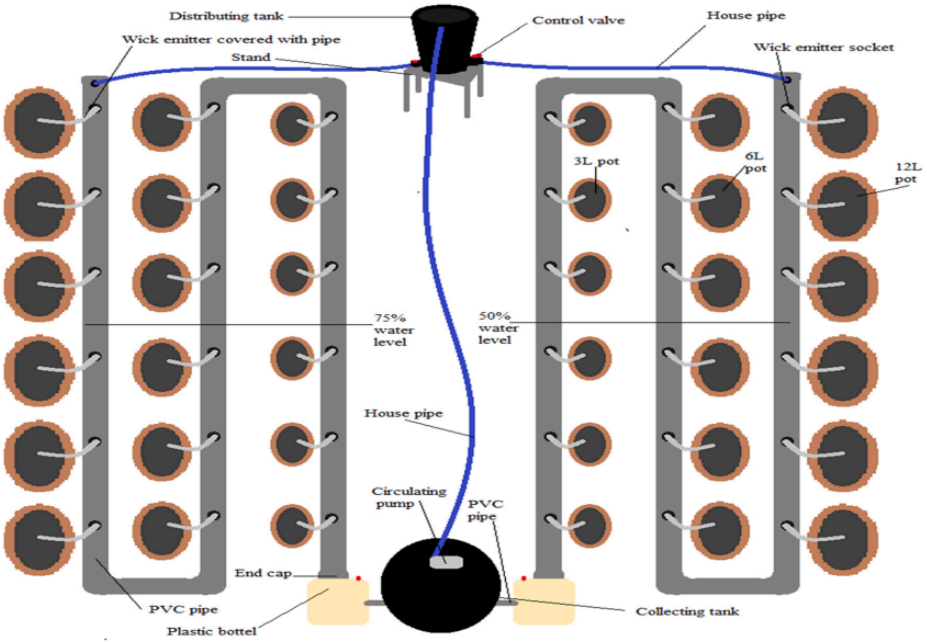
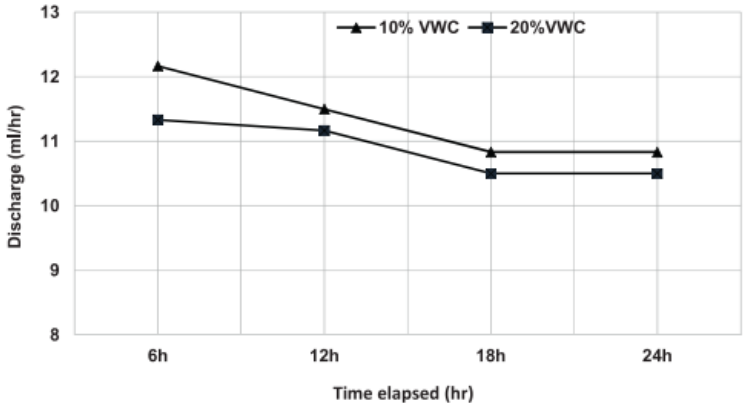


Fig. 2. : Layout of the experimental setup in greenhouse.

This is the experimental setup of the wick irrigation system in a greenhouse.

	 **Fig. 4. :** Effects of initial water contents on the discharge of buried wick. This graph shows the effects of initial water amounts in the soil on how much the wick discharged. With a higher amount of water in the soil, there was a decrease in discharge rate.
VOCAB: (w/definition)	Capillary: involving, held by, or resulting from surface tension (from Merriam Webster Dictionary https://www.merriam-webster.com/dictionary/capillary) Saturation: the state or process that occurs when no more of something can be absorbed, combined with, or added (from Oxford Languages) Volumetric: relating to the measurement of volume (from Oxford Languages) Discharge: allow (a liquid, gas, or other substance) to flow out from where it has been confined (from Oxford Languages)
Cited references to follow up on	Bhatt, N.J., Kanzariya, B.R., 2017. Experimental investigations on wick Irrigation: An indigenous irrigation technique to suit small-land holders. Int. J. Adv. Eng. Res. Dev. 4 (8), 138–144. https://doi.org/10.21090/IJAERD.22713. Gallegos, J., Alvaro, J., Urrestarazu, M., 2020. Container design affects shoot and root growth of vegetable plants. Hort. Sci. 55 (6), 787–794. Masuda, M., 2008. Innovative cultivation method using capillary wick covered with water permeable root-barrier material. Agric. Hortic. 83, 8–12 Semananda, N., Ward, J., Myers, B., 2018. A semi-systematic review of capillary irrigation: the benefits, limitations, and opportunities. Horticulturae 4 (3), 23. https://doi.org/10.3390/horticulturae4030023.
Follow up Questions	Can wick irrigation systems be used in high tunnels? How exactly do wick irrigation systems compare to drip irrigation systems?

	What is the feasibility of using a wick irrigation system on a large scale? What major limitations do wick irrigation systems have?

Article #20 Notes: **New models provide clarity around climate change and its impacts**

Source Title	New models provide clarity around climate change and its impacts
Source citation (APA Format)	Ashby, S., & Pacific Northwest National Laboratory. (2023, November 24). *New models provide clarity around climate change and its impacts*. Phys.Org. https://phys.org/news/2023-11-clarity-climate-impacts.html
Original URL	https://phys.org/news/2023-11-clarity-climate-impacts.html
Source type	Scientific news article
Keywords	Economic systems; global warming; climate change; model
#Tags	#MSEF
Summary of key points + notes (include methodology)	Summary: Notes: ● Understanding climate change is both important and incredibly challenging, as there are many factors that influence and are influenced by it ● Identifying solutions, and the future reaching impacts of these solutions is also hard ● Researchers have created a map of the earth that shows the many changes that occur ● They want to understand the impacts of climate change, and aim to inform decisions made that can be used to mitigate the severe effects of climatic disasters ● Global warming needs to make it to under 2 degrees C soon, with 1.5 degrees being even more beneficial to humans such as reducing the likelihood of wildfires ● They identified 3 steps that countries can take to get there: ○ Increase carbon dioxide removal ○ Reduce emissions of other greenhouse gases, such as methane ○ Reverse deforestation (direct quote) ● This and similar research will be used as taking points for the 28th United Nations Climate Change Conference ● They will talk about how climate change can be mitigated and slowed ● A similar model, the Global Change Analysis Model, is used already to study how different major changes around the world can affect the Earth

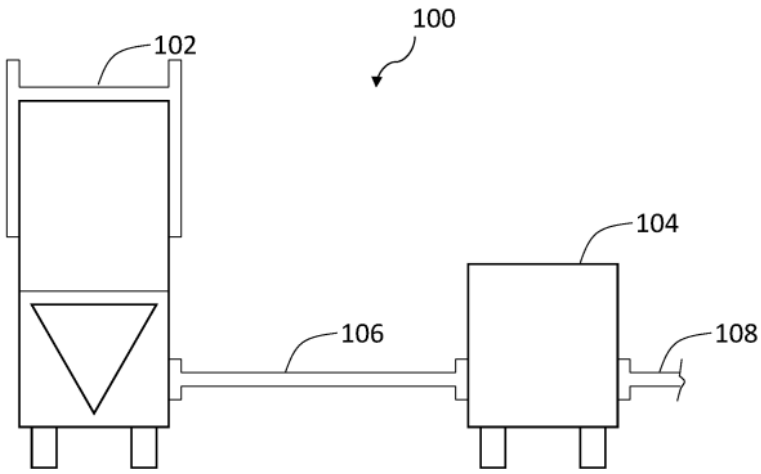
	• This model (the JGCRI one) is available freely and is being updated with new technologies • This model is optimized for use on super powerful computers, has been used to predict the Earth's climate for a year in a single day • Understanding climatic conditions in the future can help inform long term resources management (water management being one of them) among other things.
Research Question/Problem/ Need	Understanding climate change is difficult, so how can climate change be modeled?
Important Figures	N/A
VOCAB: (w/definition)	Emissions: the production and discharge of something, especially gas or radiation (from Oxford Languages) Greenhouse gasses: a gas that contributes to the greenhouse effect by absorbing infrared radiation, e.g., carbon dioxide and chlorofluorocarbons. (from Oxford Languages) Deforestation: the action of clearing a wide area of trees (from Oxford Languages) Socio-economic: relating to or concerned with the interaction of social and economic factors (from Oxford Languages).
Cited references to follow up on	N/A
Follow up Questions	How can this model be used in predictions for farmers? How accurate is this model? In what quantity has this model been used previously? Does the model itself provide suggestions?

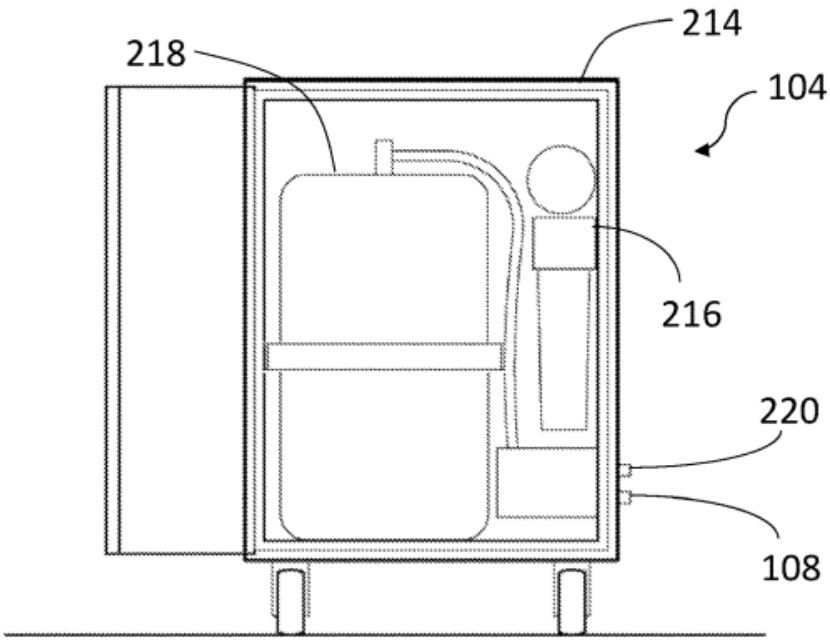
Patent #1 Notes: **Atmospheric water generation and remote operation**

Source Title	Atmospheric water generation and remote operation
Source citation (APA Format)	Mayer, R. A. (2021). *Atmospheric water generation and remote operation.* (US Patent No. 11,045,743). U.S. Patent and Trademark Office. https://patents.google.com/patent/US11045743B1/en?q=(%22ATMOSPHERIC+WATER+GENERATION+AND+REMOTE+OPERATION%22)&oq=%22ATMOSPHERIC+WATER+GENERATION+AND+REMOTE+OPERATION%22
Original URL	https://patents.google.com/patent/US11045743B1/en?q=(%22ATMOSPHERIC+WATER+GENERATION+AND+REMOTE+OPERATION%22)&oq=%22ATMOSPHERIC+WATER+GENERATION+AND+REMOTE+OPERATION%22
Source type	Patent
Keywords	Atmospheric; water generator; wireless communications device
#Tags	#patents

Summary of key points + notes (include methodology)	Summary: This device takes in water from the atmosphere, and then condenses, collects and stores filtered water. There is a wireless communications device that can be used to change the settings of the atmospheric water generator.
	
	Notes:
	● What their device does: collects atmospheric water and converts it to drinking water.
	● Their claims:
	
	- 1. Atmospheric water generator that includes multiple subsystems
	  - Subsystem 1 is located outside, and includes a cooling element and a water collector that takes in air
	  - Also includes a tube attached to the water collector
	  - Subsystem 2 is inside, also attached to the tube, and filters the water.
	  - This subsystem includes a water storage bladder, a membrane filter, and a tap connected to the water storage bladder. The bladder is pressurized.

	- A remote wireless communications device - An updatable database of information - Operating instructions received by the wireless communication devices - 2. Sort of extension on claim 1, mostly defines a specific portion of the claim 1 section - A display on the wireless communications device, where the display shows at least one outdoor temperature, humidity, water level, indoor temp, indoor humidity, and a dew point. - 3. Extension on claim 1 (same sort of deal as 2) - Displaying energy consumption in days, weeks, months, or annual on the wireless communications device - 4. (same as 2) - Part of the remote wireless sensor device. The device is able to set a cooling temp below the dew point - 5. (same as 2) - Remote wireless communications device shows a calculated cost associated with water collected and power needed to collect that water - 6. (same as 2) - Remote wireless communications device communicates with and shows the status of the atmospheric water generator - 7. Everything is the exact same as 1, except 1 thing is added to the end - Remote wireless communications device communicates with and shows the status of the atmospheric water generator - 8. Sort of extension on claim 7, mostly defines a specific portion of the claim 7 section - Exact same as 2 - 9. (same as 8) - Exact same as 3 - 10. (same as 8) - Sets a cooling temp for the atmospheric water generators cooling coil from remote wireless sensor - 11. Refers to 10 - Cooling temp can be set below dew point - 12. (same as 8) - Remote wireless communications device shows a calculated cost associated with water collected over a period of time and power needed to collect that water over same period of time - 13. - Claim for generating water from the atmosphere - Displays status of atmospheric water generator, where the processor that is in charge of displaying the information has memory storage(?) - Two subsystems, one located indoors, one located outdoors. Outdoor system collects water, indoor system filters and stores it - Operating instructions inputted into the processor

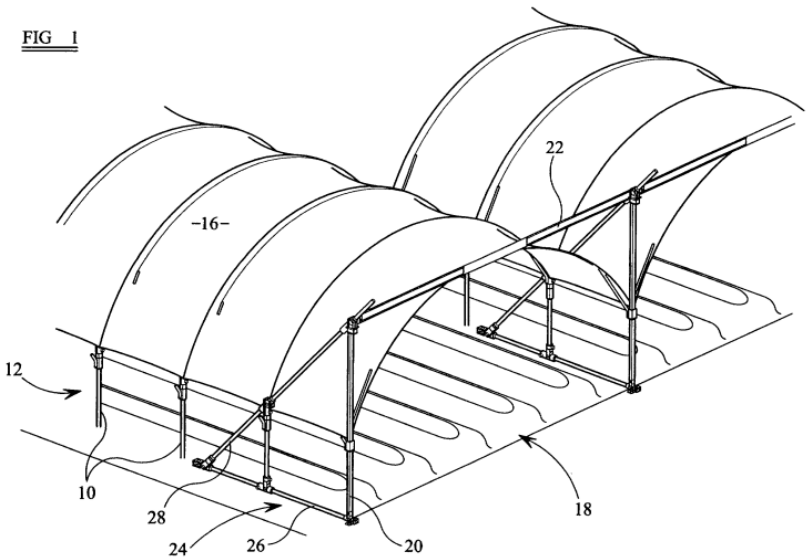
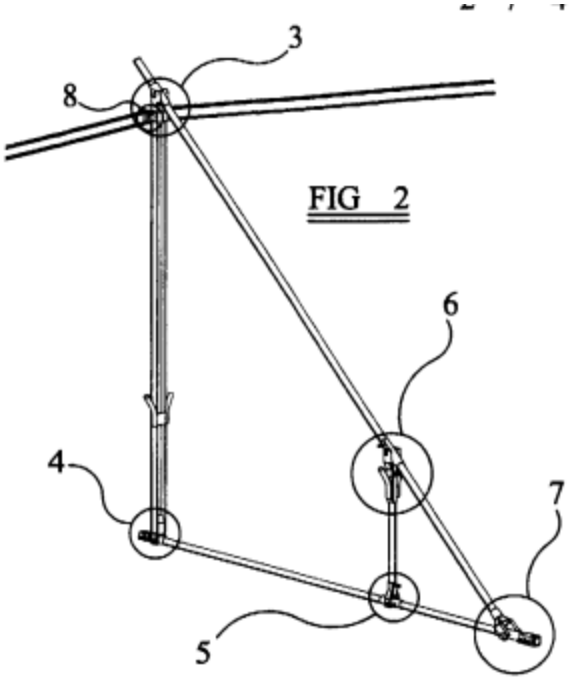
	- Operating instruction relayed from processor to generator - Operating instructions that turn the device on and off - Receiving outdoor air at ambient temperature - Pressurizing - 14. Sort of extension on claim 13, mostly defines a specific portion of the claim 13 section - Same as 2 and 8 - 15 (same as 14) - Same as 3 and 9 - 16 (same as 14) - Similar to 10, processor can set cooling element temperature - 17 (refers to 16) - Cooling element temp can be set below the dew point - 18 (same as 14) - Similar to 12 and 5, processor does calculations - 19 (same as 14) - Processor displays status information - 20, 21, and 22, say the same thing, referring to 1, 7 and 13 and how the stored energy device comprises of a spring
Research Question/Problem/ Need	Devising a device that can generate water from the atmosphere.
Important Figures	 Figure 1 Shows the whole atmospheric water generation system, represented by 100. 102

	is the first subsystem, and 104 is the second subsystem. 106 represents the water tube connecting the two. 102 can be located outside, and 104 can be located inside. 108 shows how the collected water could be tapped for drinking. Water is collected from the atmosphere by 102, and then sent to 104 to be filtered and stored.  Figure 7 Shows cross-sectional view of the second subsystem. 108 shows where the tap could go to distribute water. 220 shows a place for a water inlet. 216 shows a pathogen neutralizing module. 214 shows a second housing for subsystem 2. 218 shows the water storage container.
VOCAB: (w/definition)	Atmospheric: relating to the atmosphere of the earth (from Oxford Languages) Pneumatic: containing or operated by air or gas under pressure (from Oxford Languages) Ambient: relating to the immediate surroundings of something (from Oxford Languages) Microns: a unit of length equal to one millionth of a meter; a micrometer. (from Oxford Languages)
Cited references to follow up on	2006/0112711 A1 * 6/2006 Yoon BO1D 5/0006 62/285 https://patentimages.storage.googleapis.com/ae/ab/a4/1a6f45b1cc4f8d/US20060112711A1.pdf

	2008/0314062 A1 12/2008 Ritchey https://patentimages.storage.googleapis.com/45/75/0c/4e0b9549dff896/US20080314062A1.pdf 2012/0085927 Al 4/2012 Maeng et al. https://patentimages.storage.googleapis.com/e7/7c/19/f7fd94f62ea787/US20120085927A1.pdf 2013/0255280 A1 * 10/2013 Murphy E03B 3/28 62 / 3.4 https://www.freepatentsonline.com/y2013/0255280.html
Follow up Questions	Can this water be used for plants? How much energy does the dehumidifier use or save? How efficient is the system? What amount of water absorption and storage would make this economically viable?

Patent #2 Notes: **Support structure for a poly tunnel**

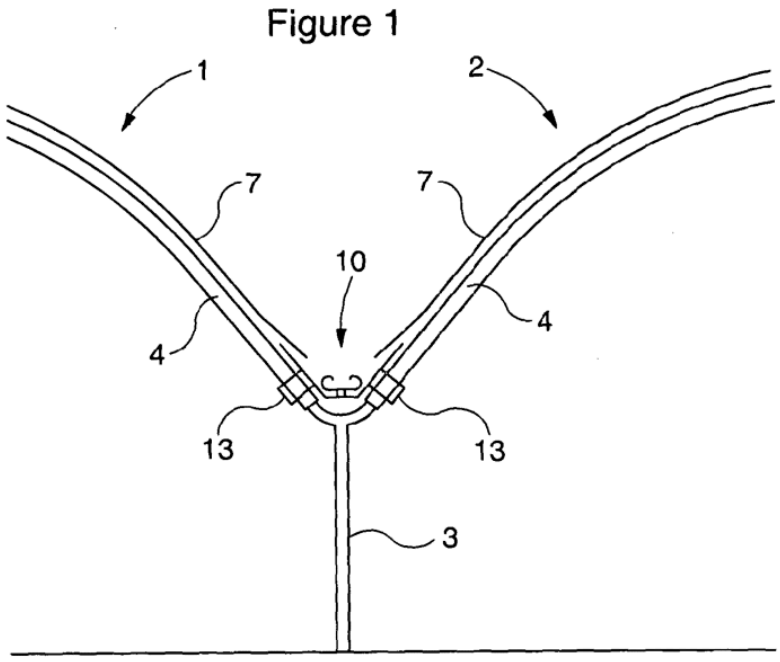
Source Title	Support structure for a poly tunnel
Source citation (APA Format)	Corbett, T. R. (2005). *Support structure for a poly tunnel* (UK Patent No. 2388127). The Intellectual Property Office. https://patents.google.com/patent/GB2388127A/en?q=(%22poly+tunnel%22)&oq=%22poly+tunnel%22
Original URL	https://patents.google.com/patent/GB2388127A/en?q=(%22poly+tunnel%22)&oq=%22poly+tunnel%22
Source type	Patent
Keywords	Poly tunnel; support systems
#Tags	#patents
Summary of key points + notes (include methodology)	Summary: In this patent, a support system for polytunnels to make the movement of large machinery into the polytunnels and the movement of polytunnel itself easier. Notes: ● This patent describes a support system that could be used to support the frame of a poly tunnel. ● Poly tunnels generally consist of hoops that are anchored into the ground and covered with a plastic covering to protect plants against rain and cold. ● Their claims include: ○ A support system with an endframe that has a diagonal strut ○ The system which further includes a hoop support leg connected to the base and diagonal strut ○ The system which further includes a hoop support leg attached to the upright ○ An adjustable bracket that connects the diagonal, the upright, and the cross member ○ A drive shaft adjacent to the cross member at at least 1 part ○ A second end frame ○ A poly tunnel that is the support system, where the support system holds up the cover ○ Multiple support systems, where each has its own individual drive shaft, though when they become interconnected, they can be moved as 1
Research Question/Problem/ Need	Creating a poly tunnel support system.

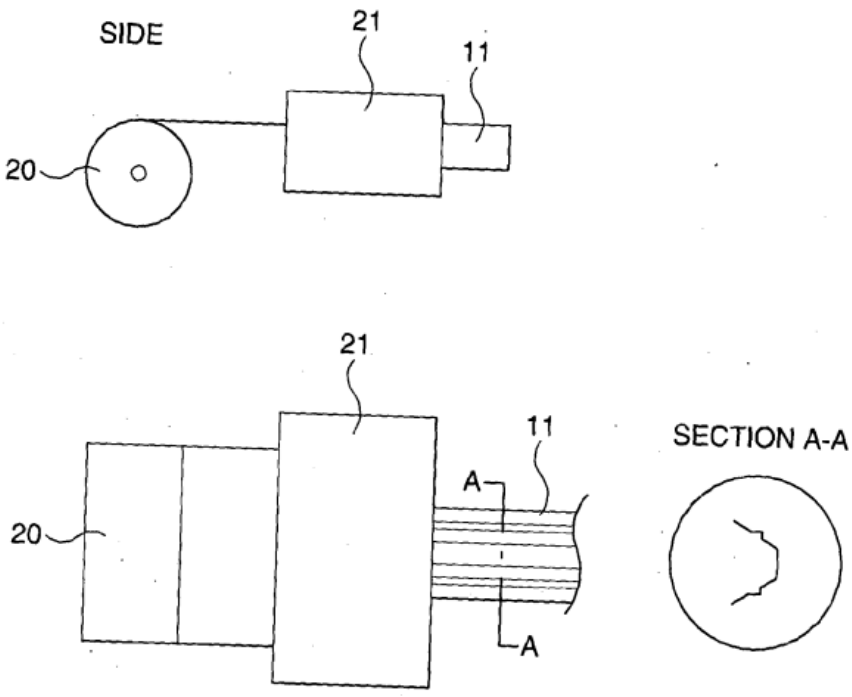
Important Figures	 This is a diagram of the support system, with the two end frames and the beams that connect them.  This diagram shows a more in depth diagram of one of the end frames.
VOCAB: (w/definition)	Polytunnel: an elongated polythene-covered frame under which seedlings or other plants are grown outdoors. (from Oxford Languages) Plurality: the fact or state of being plural: (from Oxford Languages)

	Hereinbefore: before this point in this document (from Oxford Languages) Telescopic: having or consisting of concentric tubular sections designed to slide into one another (from Oxford Languages)
Cited references to follow up on	GB770209A https://patents.google.com/patent/GB770209A/en GB2222429A * 1988-09-01 1990-03-07 Michael Joseph Corbett Mobile scaffold for building or construction work ES2009583A6 * 1988-03-29 1989-10-01 Martin Calvo Manuel Structure for greenhouses. (Machine-translation by Google Translate, not legally binding) WO2002049417A1 * 2000-12-20 2002-06-27 Trefilarbed Bissen S.A. Lightweight construction
Follow up Questions	How great of a need is there for this invention? Does this work for all tunnel shapes? How would this be manufactured? Is this an economical design?

Patent #3 Notes: **A method of making a polytunnel gutter using a coil of sheet metal**

Source Title	A method of making a polytunnel gutter using a coil of sheet metal
Source citation (APA Format)	Whatton, R. (2017). *A method of making a polytunnel gutter using a coil of sheet metal*. (United Kingdom Patent No. 2497941) Intellectual Property Office. https://patents.google.com/patent/GB2497941A/en?q=(Polytunnel)&oq=Polytunnel
Original URL	https://patents.google.com/patent/GB2497941A/en?q=(Polytunnel)&oq=Polytunnel
Source type	Patent
Keywords	Polytunnel; gutter; brackets
#Tags	#patents
Summary of key points + notes (include methodology)	Summary: This patent describes a way of distributing gutters easily onto a poly tunnel or high tunnel. The gutters are distributed in one long section. Notes: ● Polytunnels are made up of hoops with a plastic covering, and the same supporting legs can support multiple tunnels ● There is a gutter system that utilizes the impermeability of the plastic cover to collect rainwater ● Their claims include: ○ Their method for constructing and installing a gutter system where they form a continuous gutter that is supported by a structural framework. ○ This structural framework is comprised of a pair of row legs ○ The gutter extends along at least 1 of the rows of legs ○ This will work for polytunnels that are side by side ○ For polytunnels that are side by side, there is a Y piece that the gutter is supported by ○ There is the additional step of attaching brackets to the gutter where ropes for the cover could be secured ○ The formation of the gutter comprises of rolling completed by a mobile rolling machine ○ The gutter is extended onto the polytunnel as it is formed ○ The gutter is supported by the polytunnel as it is extended ○ The mobile rolling machine can extend the gutters between 2 adjacent tunnels ○ The gutter is cut to length using a guillotine

	○ The gutter extends the full length of the poly tunnel without any joins ○ Coil is made of steel or aluminum
Research Question/Problem/ Need	Intention is to create an improved method for making and installing gutters on high tunnels
Important Figures	 This figure shows how the gutter would be placed in between two polytunnels. There is the actual gutter, the supports, and the plastic covering that leads into the cover

	 Figure 3 This shows a schematic of the mobile roller
VOCAB: (w/definition)	Electro-conductivity: Electrical conductivity is a measure of how readily a material transmits an electrical current. (from ThoughtCo. https://www.thoughtco.com/definition-of-electrical-conductivity-605064#:~:text=Electrical%20conductivity%20is%20a%20measure%20of%20how%20readily,carry%20or%20it%27s%20ability%20to%20carry%20a%20current.) Guillotine: a machine with a heavy blade sliding vertically in grooves, used for beheading people. (from Oxford Languages) Channel: a length of water wider than a strait, joining two larger areas of water, especially two seas (from Oxford Languages) Galvanized: coated with a protective layer of zinc (from Oxford Languages)
Cited references to follow up on	US5356164A * 1993-05-20 1994-10-18 Miller Chase E Seamless gutter rolling support JPS58170950U * 1982-05-08 1983-11-15 恵和商工株式会社 Toy for multi-building house JPH0252557U * 1988-10-05 1990-04-16

	WO2000025571A1 * 1998-10-30 2000-05-11 Rovero Systems B.V. Building having joists and a gutter, and a gutter and joist for use therein
Follow up Questions	Why was this design for gutters chosen? Is there anything special about the gutters? How do they make sure all of the water falls into the gutters? Is the distribution of the gutters optimized?