Application of AI and ML in Reducing Wastage in Agriculture

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Introduction:

Agriculture is one of the most important industries for society and our current conventional farming practices aggravate common problems in our world today. According to Schroders Global[1], 65% of our freshwater is used in the agriculture industry and almost half of it is entirely wasted. Additionally, more than 50% of pesticides are wasted every year in this industry. Making precise assumptions can be extremely important especially in agriculture. ScienceDirect furthers this stating, “An accurate crop yield prediction model can help farmers to decide what to grow and when to grow.” There is an underlying issue here, and it is our current unsustainable farming practices that can threaten our environment and diminish our resources. Artificial intelligence has the potential to entirely revolutionize this field ensuring that resources are saved.

We have tried to suppress the problem of agricultural waste in the past with simple techniques; however, these simple techniques result in complex problems. In a past article from the National Library of Medicine[2], we see that they suggested the idea of educating farmers of sustainable farming practices. However, if farmers were to approach this issue, they would face countless challenges in changing they’re water systems and strategy. In addition, the agriculture industry is very time sensitive, and even a couple days of incorrect watering can alter a crop yield. Another previous work in this field was keeping the soil somewhat watered the whole year allowing for the soil to be ready for season. However, other places in the world like Delhi[3] have chosen to do something different, like burning the land when not in season. By doing this they allow for optimized soil fertility, however face the consequence of severe pollution. Moreover, countless farmers endeavored to reduce pesticide. They mainly did this because pesticides can be harmful since they can cause contamination and cause a huge amount of runoff. Even after farmers tried this, they were still unable to reach the sufficient amount of yield and could not fulfill the necessary demand. This exemplifies the fact that pesticides play a pivotal role in agriculture. According to the National Institutes of Health[2], “Without the use of pesticides, there would be a 78% loss of fruit production, a 54% loss of vegetable production, and a 32% loss of cereal production.”agriculture and even a slight reduction in pesticide use can have significant ramifications for our society.

In China, farmers have adopted a new technique of keeping soil moisturized and keeping yield balanced. According to the Journal of Kadirli Faculty of Applied Sciences[4], farmers use cover crops during rainfall periods which essentially cover the soil to protect it. There are not many downsides to this solution since it protects the soil, future plants, protects plants from pests, and helps a lot with erosion. However, according to USDA Climate Hubs, these cover crops can potentially deplete soil moisture resulting in much less yield. Also, in India droughts are a huge issue and so farmers use techniques like cow dung to retain soil moisture.

Cow dung also offers important nutrients for the soil like phosphorus, nitrogen, potassium, and more. However, cow dung can contain dangerous bacteria and pathogens.

The use of AI within the agriculture industry is best so that we can use optimized techniques to minimize waste but also maximize yield. Through using soil moisture sensors, weather patterns, plant growth patterns, and more, we are able to sufficiently use our resources without using excess, ensuring suitable crop turnouts around the world. To begin, soil moisture sensors can be used to detect whether crops are well watered or not allowing the farmer to make the proper decision for the crops. The sensor can detect the soil tension (calibrated in centibars or kilopascals) to gauge the status of the soil. Additionally, data from resources such as weather reports can be used to detect whether more water is needed during the day. Finally, we can use plant growth patterns to determine how much more fertilizer is necessary.

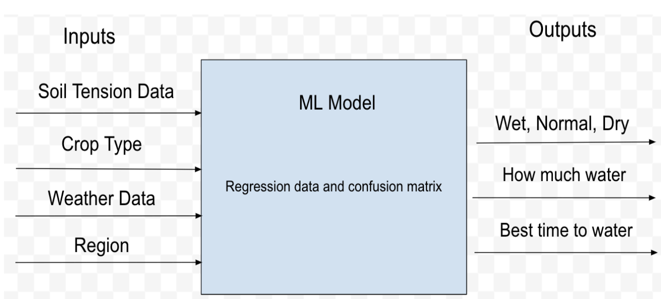
Knowing the main cause of the wastage of these resources, we can now try to figure out the data sets that we would need. First of all, we would have to understand important parameters such as the humidity, rain, etc from the weather forecast along with the soil moisture and tension data. These parameters would be the inputs for this ML model while the outputs would be the decision on how much water or fertilizer is needed and when. The unsupervised data here would be the regional weather. Throughout this research paper, we will identify how the use of different types of learning within ML and AI can be used to properly reduce wastage, detect pests or other harmful insects, and use resources such as weather reports to deliver precise prediction data.

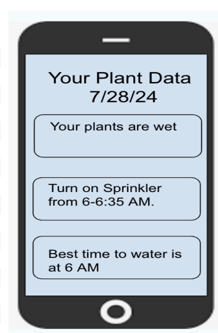
Perspective/Solution:

Now we can start on using both the weather analytics and soil moisture sensors to reduce waste in agriculture. We will have to determine the ideal weather for crop production (depending on the crop) and then the correct soil moisture tension. For weather we would most likely need to determine humidity levels, precipitation, temperature, radiation, and based on the data we receive we can make the decision on more or less water. For the soil moisture sensor we have to find the perfect centibar levels of soil tension and whether it is above or less, we can alter the water. In this case, we are assuming that the sprinkler speed will stay the same but you are keeping the sprinklers on for a longer time.

We will first begin with the soil moisture levels. Soil moisture sensor reading results are located in dataloggers. If the soil readings come out to 0-30 cb then the soil is wet and not ideal for agriculture. If it comes out to 30-60 cb then the soil is proper for irrigation and crop growth. Anything above 60 means that the soil is getting too dry and requires more water. In the end, this would be classified supervised data in which the main output of the situation would be more water or less water. This would be using machine learning here since there is really just analyzing data based on the plant being grown and its soil tension. In this case this would be corresponding to binary classifying data since we have 2 outcomes, dry or wet. The farmer could simply reduce or increase how long the sprinklers would be running. However, farmers have to take into account that different plants require different amounts of water, as corn needs much more water than a lot of other plants. However, lots of other factors remain such as the location in which the sensor is located and the irrigation start range, meaning the type of ground that the farming takes place on. Generally, soil tension levels remain equal throughout a field since they usually face the same conditions meaning that these sensors are only needed to be placed in a couple areas throughout a field. This all depends on the overall topography of the land because if there are even minor hills, there could be less soil tension in certain places.

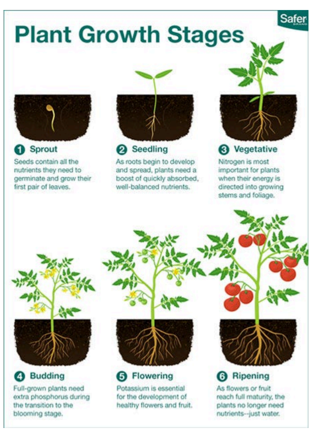
With the information we have received from the soil moisture sensors, we can use a confusion matrix to assess the accuracy of the sensor. This would simply detect the possibilities of the numerous outcomes that result from the sensors. We can see how the results are the same and this shows us the credibility of the outcome. However, this does not play a crucial role with receiving data because we already know that there are really only 2 outcomes that come from this set of data, too wet or dry. Another data-set we can factor into the classification would be the weather. Using data like the humidity and temperature can overall help farmers make the decisive decision of choosing how much water to give. We can also use regression machine learning data for this since the ML can examine the random number data and will use this data to learn from ideal weather temperatures. The ML can come out with the input that more water will be needed due to a heat wave. This is a simple way for farmers to easily make decisions off of this data, rather than making guesses. The simple drawing below depicts the overall inputs and outputs of this computing model. The inputs for the farmer would be the soil tension data, region, and the crop type first. The weather will be an automatic input since the model would use the nearby weather data. After the farmer puts this in, he will receive the message of wet, normal, or dry and will get an accurate estimation of how much more or less water. The final output would be the best time of day to water the plants which will be mostly based on the weather. Additionally, there is another image that demonstrates what the farmer would see based on the outputs of this model.





There are multiple types of sensors that can be applied to agriculture. One of them is called the capacitance sensor which is on the more reliable side. This focuses on the storage of electricity in the soil or the dielectric constant. If the soil moisture would increase, lowering the soil tension, then the dielectric constant would increase, signaling that the plants are properly watered, or watered too much. A tensiometer is another one that is very successful within the agriculture field. This soil moisture sensor has a vacuum gauge below its porcelain head with a lot of the electronics. This is a very simple design and can take in lots of data like the flow of water direction and the water depth. However, the stats received from this sensor all depend on the condition of the soil, meaning that if the soil quality is not up to par, the results will not be as accurate and precise. There are many other sensors like the TDR sensor which is similar to the capacitance sensor, receiving most of the information from the dielectric constant. Most soil moisture sensors end up receiving similar data so the sensor does not matter a lot. One of the most important parts of the soil moisture sensors is the data transmission aspect. An optimal option for this is NB-IoT(Narrowband Iot). Most data transmission devices would have trouble due to the rural and remote land. However, NB-IoT does not have this problem of allowing for fast and effective information transfer. While being very effective specifically for farming, NB-IoT also offers lower power consumption and a very low cost. NB-IoT has up to 10 years of battery life and costs less than a dollar per unit.

Another way to ensure the best possible agricultural outcome is through farmers looking at optimal plant growth patterns and letting that determine proper fertilizer usage. This most likely will require mostly ML but a bit of AI. This would not require much classification since it is much more complex than a simple more or less answer. The ML will first find the best possible growth patterns for the plants based on past results and data. AI will be able to make assumptions based on images. From there farmers will be able to find whether their plants are growing too slow or too fast. The main problem that is trying to be solved here is the fact that over-fertilizing plants can lead to runoff, poisoning, nutrient imbalances, and plant death.



Machine learning has the capability of figuring out when and what these phases will look like so we can properly determine the best amount of fertilizer needed. Usually farmers put the same amount of fertilizer for each plant but some plants can be facing different conditions. This could be due to issues like not retrieving enough sunlight, weather conditions, and more. Due to the countless number of wasted plants every year, the information can detect whether the plants would be infected or are not receiving enough nutrients. Also, the ML learns from previous results so it will be able to detect patterns between plants.

One way to execute this in the best way possible is by creating a software which allows for analyzing images of plants using ML/AI. If machine learning can find all the info regarding the plant stages, then ML can pick the closest image to the phase. Farmers have been growing plants for a long time so they have an idea for the length of a normal harvest. We can apply the idea regarding soil moisture data to this. Combining the 2 ideas would lead to a big database of plant data and can ultimately help farmers the most in just one application.

Discussion:

Although the 2 ideas on soil moisture and plant growth patterns have countless benefits, there are lots of issues that need to be taken into account. Regarding the first idea, it's hard to include all possible plants and techniques used by different farmers. It would not be ideal to make farmers change their farming style to be the same all over the world, so this would not be able to impact the whole agriculture field itself. Also, the soil moisture sensors may confuse the farmers because there may be thousands of plants and some plants may not receive as much water because of overall topography. It would not be efficient to place a moisture sensor for every plant so there will end up being a couple of plants which have a difference in the amount of water they receive. Finally, these soil moisture will cost a good amount of money and will need to be replaced over a couple years. They do also need to be re-charged every couple weeks or so and can bring some inconvenience to farmers. This also entirely depends on the soil moisture sensors because some sensors are entirely underground and some are stationed above ground. The implementation of solar panels could be effective, but then again the cost is a major issue.

There are multiple problems regarding the idea on the plant growth database. Like the other idea, there are way too many plants in many different conditions so the database will be limited to only a selective number of farmers. However, artificial intelligence has the capability of managing an immense amount of data. Another problem is that farmers will have to spot the plants which are growing abnormally which is hard especially for farmers with more land. This should mainly be used for plants that are on an unusual growth pattern because farmers do not have enough time. Then again, some fields have thousands of plants so some farmers may deem it inconvenient to use. At this point it is just weighing the benefits and the issues. The solution may be inconvenient for some, but is ensuring that farmers reduce runoff and maximize yield.

If these 2 ideas can be implemented into agriculture in the next couple of years, we can achieve more efficient agriculture, meaning more crop yield. Additionally, we will be using much less water on our plants, helping us drastically. We will also see a reduced amount of toxic material in ecosystems all around the world due to the reduction of fertilizer runoff. This runoff is now being toxic for our environment and preventing this can save habitats and many species. Overall, the agriculture industry would be more well structured with reducing fertilizer runoff and water, while also increasing crop yields.

In conclusion, the application of AI and ML in agriculture can address the long-standing issues of resource wastage and habitat destruction. Through the use of sensors, data, and modeling, farmers can make data driven choices to optimize resources. Despite challenges such as costs and adaptation across diverse farming practices, the benefits far outweigh the challenges. As these technologies keep changing and integrate into current farming practices, it paves a pathway for a more sustainable future, mitigating countless issues today.

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