

## Homerton Design Challenge: A viable mitigation of plant diseases in the global race to reach food security



P. Infestans lesions on a plant<sup>[1]</sup>

**Problem:** A persistent epidemic of plant pathogens is collapsing the full solidarity of global food security; one of the greatest issues in the modern world stems from the lack of food security. Although the issue is multi-faceted, being impacted widely by conflict and climate change, we can mitigate the volatility of food security



Rice Blast (*M. Oryzae*) [2]

by improving the efficiency of large scale agriculture, yielding better results faster.



East African Cassava Mosaic Virus [3]

Losses from disease can be as severe as -21.5% for staples such as wheat, destroying the community upon which it depends.<sup>[2]</sup> If we can fix the debilitating issue of crop loss due to disease, our global food production would increase and help steady food security, aiding in the resolution of the 2nd UN sustainability goal<sup>[1]</sup>. The most significant plant pathogens upon this destructive rampage include *P. Infestans*, *H. Vastatrix*, *M. Oryzae*, and East African Cassava Mosaic Virus. As shown below the diseases can cause severe damage to produce, reducing yield, economic output, and production of food for the global market.



Coffee Leaf Rust (*H. Vastatrix*) [4]

### Ideas:

With a focus on the long-standing issue of food security, which has already seen millions of pounds spent to mitigate its effects but to no significant change, we felt that it was essential to come up with a practical solution that could help ameliorate food security across the world. From genetic engineering to mitigating the effects of climate change, these ideas had already been thoroughly researched and explored, not leaving a huge scope for innovation. Additionally, in order to make our solution globally accessible and therefore have the biggest potential impact, we had to ensure that minimal specialist equipment and knowledge were required. Very quickly into developing our ideas it became clear that technological innovation would be the most effective and viable solution to this problem.

### Selection:

We took inspiration from the recent surge in the usage of AI to incorporate AI and camera software into a groundbreaking new drone. LiDAR sensors and cameras are used to identify lesions on plant leaves in fields of crops and then matched against a database of images of known pathogens (compiled with images already on the internet such as the ones above), whilst maintaining spatial awareness and avoiding obstacles. This software already exists and can be easily adapted for this purpose.

We selected coloured corn starch to be our colour marker, allowing the farmer themselves to be able to visibly see the infected and damaged crops and cull the necessary sections of these to prevent further spread, after a small amount is sprayed on the selected areas from the reservoir inside the drone. Corn starch is non-toxic, cheap and easy to source material, and will not damage the crop.

When the drone has finished its reconnaissance, it will land on a wireless charging pad with a large surface area and wireless charging coils to maximise charging efficiency. This pad will also have a low energy consumption thus reducing negative environmental impacts significantly, in line with the project as a whole.

We strongly believe this technology is more advantageous than some of our other ideas, including genetic engineering, education and infrastructure, climate change mitigation and sustainable farming because it provides a cheap, efficient and environmentally sustainable solution to this crisis. Alongside these other areas of concern, this device will flourish, notably due to the minimal training required and ease of usage, as well as having an immediate impact and is not restricted by the actions of the human population, some features which unfortunately our other ideas do not possess.

Feasibility has been one of our main objectives, and so we calculated the minimum value of solar irradiance required in order for the drone to have the ability to charge normally via solely the solar panel<sup>[6][8][9]</sup>:

## Power

The following calculation uses the Ecoway 400W Solar Panel as an example:

$$P = \eta \times A \times I$$

where:  $P$  = Power (W)

$\eta$  = Efficiency of solar panel

$A$  = Area of solar panel ( $m^2$ )

$I$  = Solar irradiance. ( $W/m^2$ )

As the efficiency and area of the solar panel remain constant, we can calculate  $I_{min}$  to provide the required 50W to charge the drone:

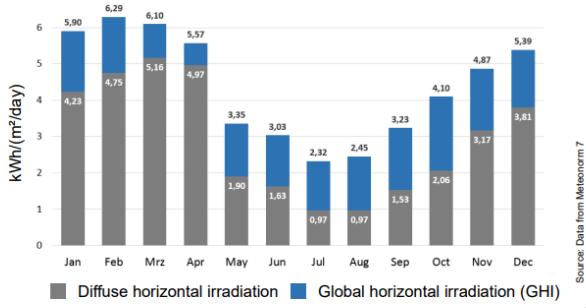
$$0.50 = 0.23 \times 1.058 \times 2.365 \times I_{min}$$

$$I_{min} = 0.87 W/m^2$$

This is a very low value of solar irradiance, which suggests that the drone can fly and charge during almost all daylight hours.



### Solar irradiation – Lima, Peru



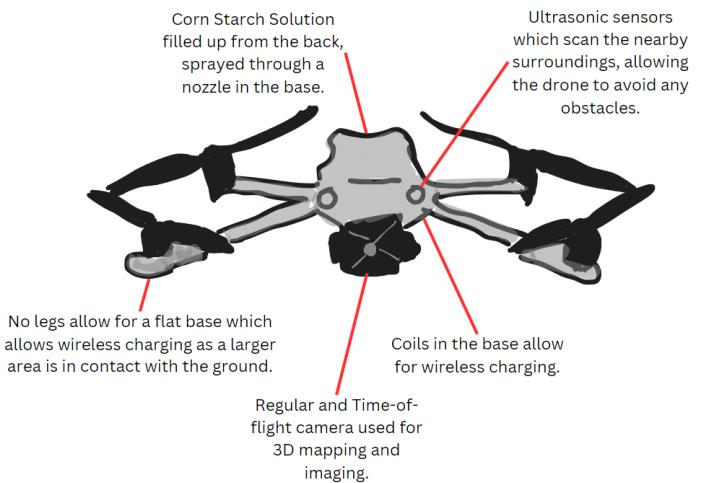
As shown by the graph,<sup>[6]</sup> the average solar insolation throughout the year is at an average of 4.4 kWh/m<sup>2</sup>/day, which is an average solar irradiation of 4,400 W/m<sup>2</sup> every hour. This is evidently more than sufficient to power the drones during the farming season in impoverished countries like Peru, where food security is a pressing issue.

<b>Concern</b>	<b>Solution</b>
The solar panels cannot deliver enough power for the drone.	A 2.5m <sup>2</sup> solar panel can provide enough energy for 30 minutes of flight every 4 hours as suggested by the calculations above.
The drone cannot land accurately on the charging base.	The combination of 3D mapping and the radio waves allow the drone to accurately land, unlike GPS.
The camera does not have enough resolution to see lesions on leaves.	Our camera will be high-resolution and the drone will be able to fly close (due to obstacle avoidance) allowing for a clear image.
The drone will not work on a wet day.	The drone will not work, however the base can be kept under shelter permanently, as the drone can exit the shelter with its sensors, preventing it from getting wet and having permanent damage.
The drone can't cover an entire field with its flight time.	The drone will be able to fly between 1-1.5 hours each day. This will allow it to cover 1.4 km <sup>2</sup> fields every day at a speed of 2 km/h. This is much above the average Peruvian farm which is 0.3 km <sup>2</sup> .
The colour marker is dispersed in the wind.	Our drone will be able to fly close to plants safely due to its collision avoidance system. By getting close less of the marker will get lost in the wind. The corn starch is small enough to notably stay on the plant despite the impact of wind, and the farmer can check the map for the intended location.

### **Implementation:**

In terms of the cost to produce one of these, the exemplar solar panel used costs us a total of £600 to purchase<sup>[7]</sup>. The rest of the charging terminal would cost about £200: £50 for the wireless charger, £50 for the Raspberry Pi running the AI and £100 to add folding solar panels and the rest of the case. Additionally, the drone would cost about £1000. A similar drone without our customisations costs £900<sup>[10]</sup>. The total cost is around £2000.

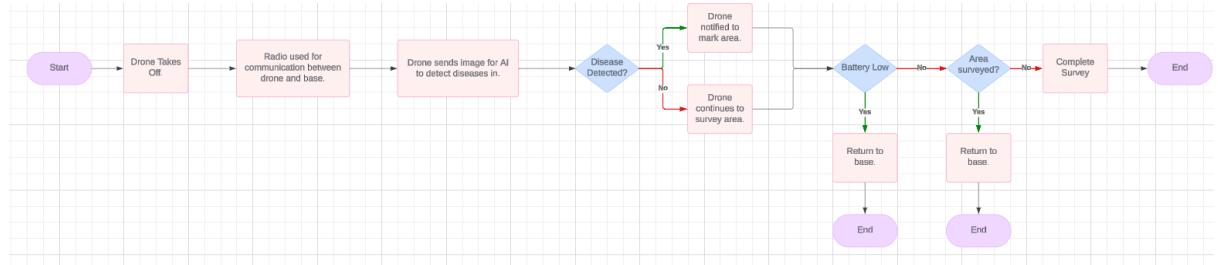
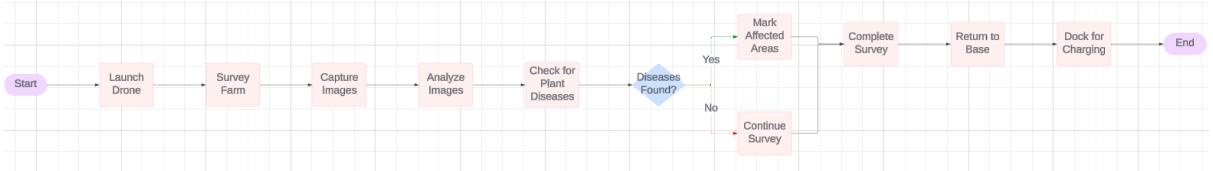
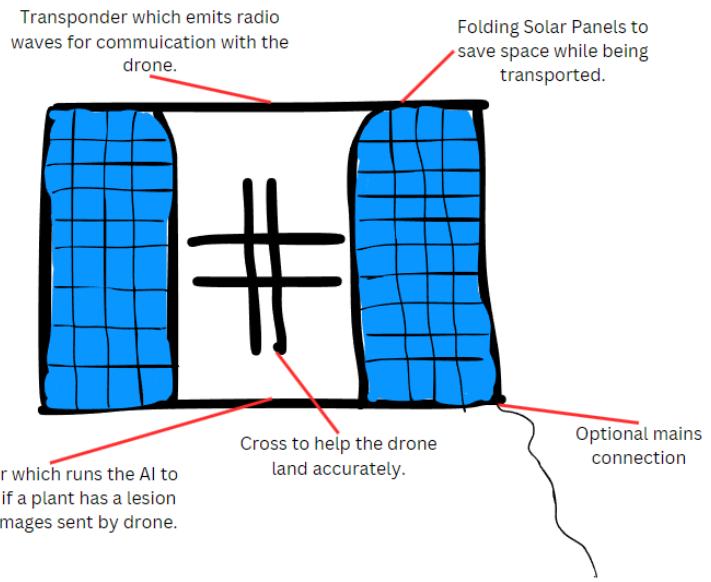
Our drone utilises 2 cameras in conjunction: a regular and time-of-flight camera. This allows it to map a 3D image of the farm while being able to display any locations on a map readable by humans. An AI model run in the base can then be used to analyse the information to flag any plants that it deems infected. It can then spray a small coloured corn starch



solution to mark any areas that need to be checked, eliminating the need for farmers to be able to understand maps. The drone will have to fly at an intermediate height to allow the video resolution to be high enough to accurately identify the plants. Ultrasonic sensors on all 6 faces will monitor nearby objects to prevent the drone from hitting obstacles.

After reconnaissance, the drone

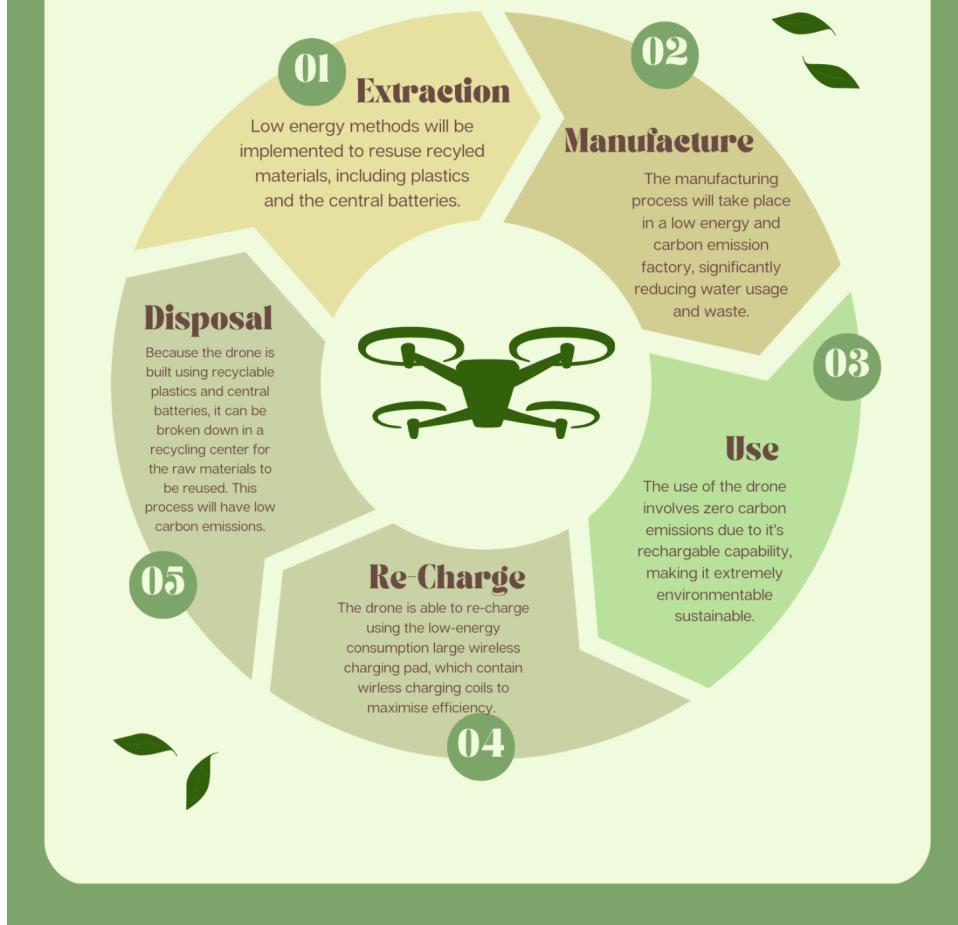
automatically returns to its charging terminal. The base is powered through solar panels and constantly emits radio signals (which also transfer data for the AI model). This allows the drone to accurately land on the base along with its LiDAR cameras. The base then charges the drone through coils. By landing on a base, we do not require legs, allowing us to maximise the surface area for wireless charging. The base will also utilise folding solar panels for easy transport.



## **Life Cycle Assessment:**

# **Life Cycle Assessment of our Drone**

The life cycle of our drone starts from the extraction of raw materials, which must be extracted through different methods. These will then be used to build the device and ensure our goals of sustainability are reached, notably through the re-charging capability of the product. Following this, the drone can be used limitlessly, before it needs to be disposed of.



## **Conclusion:**

In conclusion, we utilised a holistic approach to determine a viable solution to the issue of plant diseases disrupting food security, a major problem in the modern forefront of considering the availability of food taking into account the oncoming astronomical increase in population. We isolated an easy solution for farmers, creating a method by which the impact of plant diseases is incredibly subdued due to quick and effective management enabled by the information provided by the drone.



### References:

- [10] DronesDirect. (n.d.). *DJI Air 3 RC-N2 with Free Extra DJI Air 3 Intelligent Flight Battery*|DronesDirect.[online] Available At:  
[https://www.dronesdirect.co.uk/p/buncp.ma.00000691.04-89918/dji-air-3-rc-n2-with-free-extra-dji-air-3-intelligent-flight-battery?utm\\_campaign=73258\\_Idealo+internet+GmbH+-+UK&utm\\_medium=affiliate&refsource=awin&sv1=affiliate&sv\\_campaign\\_id=73258&awc=74736\\_1721205498\\_44736c84549bef8dcd0649129557814](https://www.dronesdirect.co.uk/p/buncp.ma.00000691.04-89918/dji-air-3-rc-n2-with-free-extra-dji-air-3-intelligent-flight-battery?utm_campaign=73258_Idealo+internet+GmbH+-+UK&utm_medium=affiliate&refsource=awin&sv1=affiliate&sv_campaign_id=73258&awc=74736_1721205498_44736c84549bef8dcd0649129557814) [Accessed 17 Jul. 2024].
- [7] EcoFlow UK. (n.d.). *Buy EcoFlow 400W Solar Panel — EcoFlow UK.* [online] Available at:  
[https://uk.ecoflow.com/products/400w-portable-solar-panel?utm\\_source=bing&utm\\_medium=cpc&utm\\_campaign=summer\\_sale&utm\\_content=uk\\_shopping&msclkid=74e39393901316cbd0c7f5055ee10157&utm\\_term=4587506118486259](https://uk.ecoflow.com/products/400w-portable-solar-panel?utm_source=bing&utm_medium=cpc&utm_campaign=summer_sale&utm_content=uk_shopping&msclkid=74e39393901316cbd0c7f5055ee10157&utm_term=4587506118486259) [Accessed 17 Jul. 2024].
- [3] Phytophthora Infestans (Phytophthora blight). (2022). *CABI Compendium*, CABI Compendium. doi:<https://doi.org/10.1079/cabicompendium.40970>.
- [2] Ristaino, J.B., Anderson, P.K., Bebber, D.P., Brauman, K.A., Cunniffe, N.J., Fedoroff, N.V., Finegold, C., Garrett, K.A., Gilligan, C.A., Jones, C.M., Martin, M.D., MacDonald, G.K., Neenan, P., Records, A., Schmale, D.G., Tateosian, L. and Wei, Q. (2021). The Persistent Threat of Emerging Plant Disease Pandemics to Global Food Security. *Proceedings of the National Academy of Sciences*, [online] 118(23), p.e2022239118. doi:<https://doi.org/10.1073/pnas.2022239118>.
- [6] Session 3: Solar Power Spatial Planning Techniques IRENA Global Atlas Spatial Planning Techniques 2-day Seminar. (n.d.). Available at:  
[https://www.irena.org/-/media/Files/IRENA/Agency/Events/2014/Jul/15/11\\_Solar\\_power\\_spatial\\_planning\\_techniques\\_Lima\\_Peru\\_EN.pdf?la=en&hash=F9374A0F5F1F539CF08B0BE9FFBA6A9C29929E1D](https://www.irena.org/-/media/Files/IRENA/Agency/Events/2014/Jul/15/11_Solar_power_spatial_planning_techniques_Lima_Peru_EN.pdf?la=en&hash=F9374A0F5F1F539CF08B0BE9FFBA6A9C29929E1D) [Accessed 17 Jul. 2024].
- [1] United Nations (2015). *The 17 Sustainable Development Goals.* [online] United Nations. Available at: <https://sdgs.un.org/goals>.
- [9] Worlddata.info. (n.d.). *This Is How Long the Sun Shines in Peru! up to 12:50 Hours of Daylight a day.* [online] Available at:  
<https://www.worlddata.info/america/peru/sunset.php>.

[8] worldpopulationreview.com. (n.d.). *Cost of Electricity by Country 2022*. [online] Available at: <https://worldpopulationreview.com/country-rankings/cost-of-electricity-by-country>.

[5] www.infonet-biovision.org. (n.d.). *African Cassava Mosaic Virus (ACMV) | Infonet Biovision Home*. [online] Available at: <https://www.infonet-biovision.org/PlantHealth/MinorPests/african-cassava-mosaic-virus-acmv-0> [Accessed 17 Jul. 2024].

[4] www.isa.ulisboa.pt. (n.d.). *Coffee - H. Vastatrix Interaction | Instituto Superior De Agronomia*. [online] Available at: <https://www.isa.ulisboa.pt/en/cifc/research/coffee-immunity-fungal-effectors/coffee-h-vastatrix-interaction> [Accessed 17 Jul. 2024].