Graduation Project

Submitted to:

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1 Drones in Business

1.1 Introduction

Drones are taking off across all business sectors.according to pwc [1], it is estimated that the total addressable value of drone powered solutions in all applicable industries is estimated at over $127bn. The industry with the best prospects for drone applications is infrastructure, with total addressable value of just over $45bn.

	2015
Infrastructure	45.2
Transport	13.0
Insurance	6.8
Media & Ent.	8.8
Telecommunication	6.3
Agriculture	32.4
Security	10.5
Mining	4.3
Total	**127.3**

Table 1.1: pwc' Survey results[1]

[1] pwc is a multinational professional services network corporation,which focuses on audit and assurance, tax and consulting services. they help resolve complex issues and identify opportunities.

1.2 Applicable Applications in Egypt

1.2.1 Using drones in Percision Agriculture

1.2.1.1 Introduction

Agricultural drones have been changing the face of farming and cultivation heavily the past 3-5 years, and completely changing the way that many farmers and other entities go about their business. This drones have the ability to check storm damage, monitor crop progress, and make sure that both crops and herds are healthy.

Precision agriculture is a farming management concept that uses drones for agriculture to measure, observe, and respond to variability found in crops.

When you implement all of the new technology that is available out there including drones in agriculture, you can apply resources (even if limited), to make sure that the farm has a very maximum yield.

Figure 1.1: Fertilizers spreading drone

1.2.1.2 Applications

Crop Health It is no secret that there is a strong need for increased agricultural production given the increase expected in population around the globe. There are finite agriculture resources and growers are expected to produce more with less. The need for improved management practices is acute. In order to implement improved practices reliable, timely, and actionable data is required. Enter in-season on-demand aerial imagery.

Aerial imagery is used by consultants (CCAs, scouts, agronomists), cooperatives, and agriculture service providers to assist in calculating the economic differences between the "good" and "bad" crop condition zones enabling improved management decisions. Often times, determining crop health without the "bird's eye view" from aerial imagery is difficult.

One of the main image types to determine crop health is the Near Infrared (NIR) image. The NIR is most effective to determine the vegetative health of the crop as the other imagery bands (Red, Blue, Green) are "absorbed" by the plant to create food.

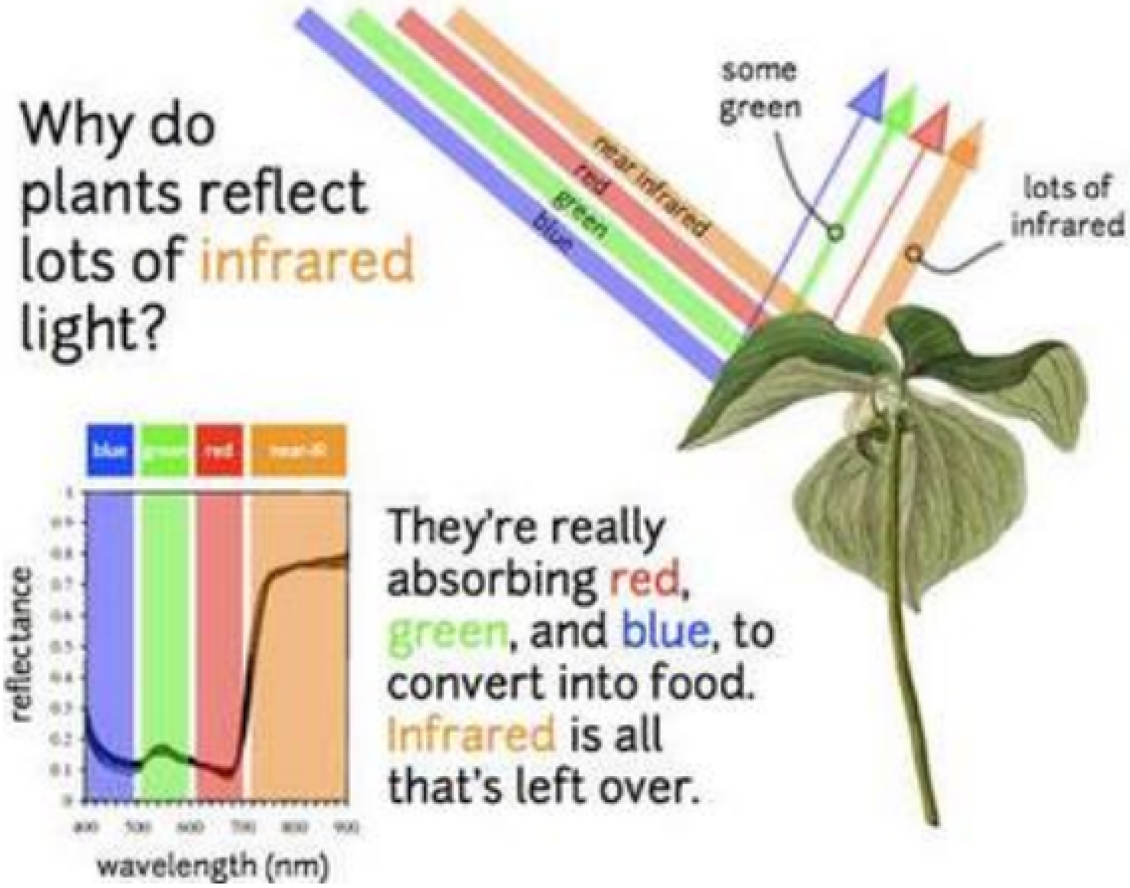


Figure 1.2: Reflection of light on plant

The NIR band used in conjunction with the red band is utilized to create a vegetation index commonly called a Normalized Difference Vegetation Index (NDVI).

The NDVI provides quantitative information on the health of the crop in the field. The green colored zones have the most robust and volume of vegetation while the yellow and red zones represent less vegetation. This information can be used to make management decisions on the application of inputs like fertilizer and fungicide.

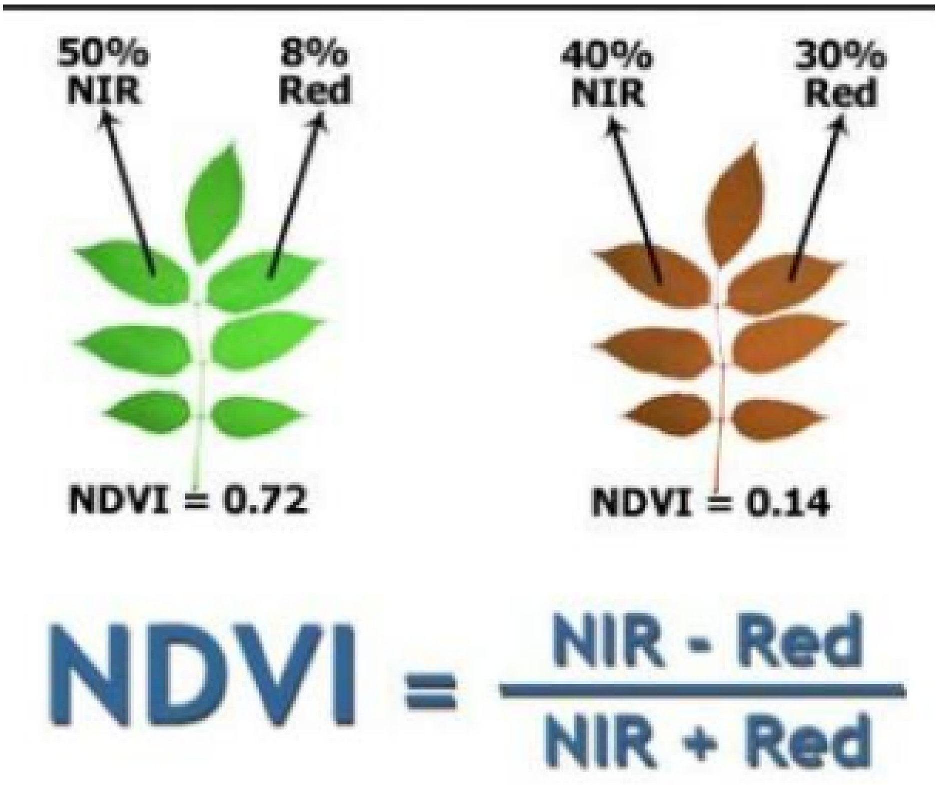


Figure 1.3: NDVI formula

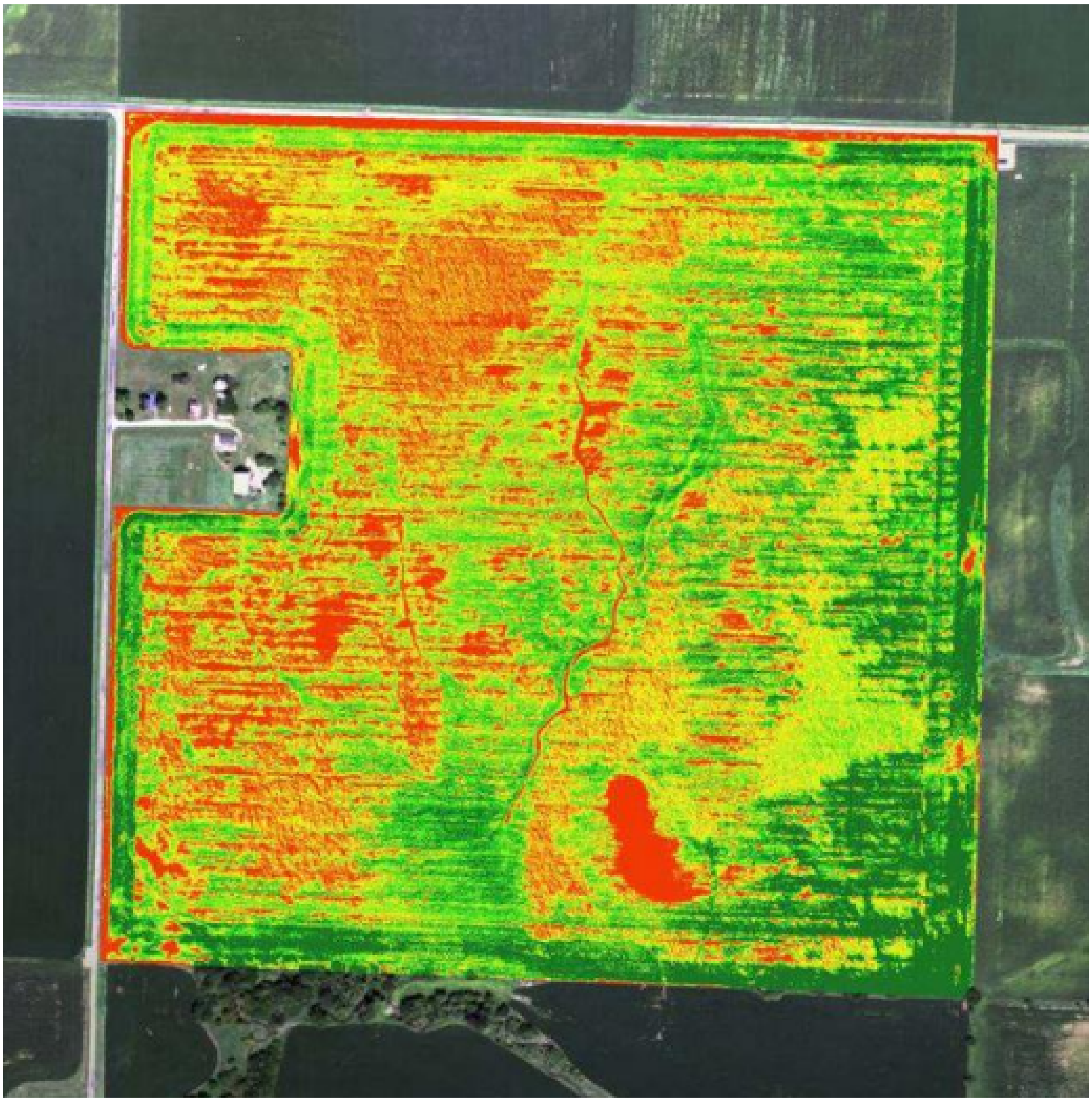


Figure 1.4: NDVI image example

Compaction The term "soil compaction" refers to a change in state of the soil that increases its bulk density. Soil compaction is becoming more and more important due to the fact that:

- Equipment is larger
- Uncontrolled traffic

- Earlier field operations
- Operating on wet soils

Identifying compacted areas within a field with the naked eye is difficult and compaction is a difficult variable to measure from the ground without equipment (eg soil penetrometer) and high labor costs.

If a soil is over-compacted there is significant risk of yield reductions as compacted soils affect both soil and plant growth alike:

Effects On Soil	Effects on Plant Growth
Porosity	Root growt
Aeration	Nutrient uptake
Structure	Water Infiltration/Utilization

Aerial imagery shows subtle patterns of soil compaction that are almost impossible to see from the ground. By comparing patterns of traffic and irregular crop growth, problem areas due to compaction are easily identifiable. In Figure 1 above, the red areas on the north side of the field showed yield losses of 45-65 bushels per acre while the red strip on the east side showed yield losses of 20-30 bushels per acre

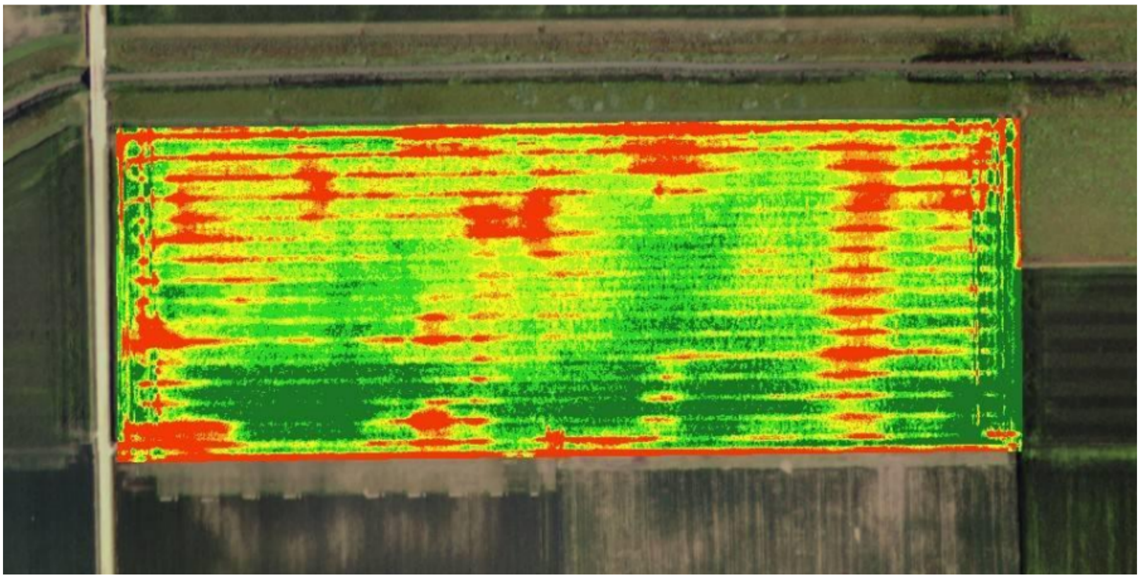


Figure 1.5: NDVI showing effects of compaction

Variable rate application Variable rate application (VRA) is the method of applying varying rates of inputs in the appropriate zones within an individual field. The ultimate goals of VRA are:

- Maximize farm profitability
- Increase efficiencies in the application of crop inputs
- Ensure environmental safety and sustainability

The management of in-season nitrogen application(s) is a critical component to land management. Mismanagement can result in yield loss and negative impacts to the environment. Given this importance, companies and individuals alike are turning toward aerial imagery as a means to develop nitrogen management zones and the corresponding VRA. The economical nitrogen rate can vary substantially within individual fields. It is difficult to assess these differences in a timely manner without the use of remote sensing. An aerial image, when analyzed appropriately, can provide the agronomist with key insights on the crop. For example, the near-infrared (NIR) light reflecting off a nitrogen stressed corn crop is quite less than a non-nitrogen stressed crop.

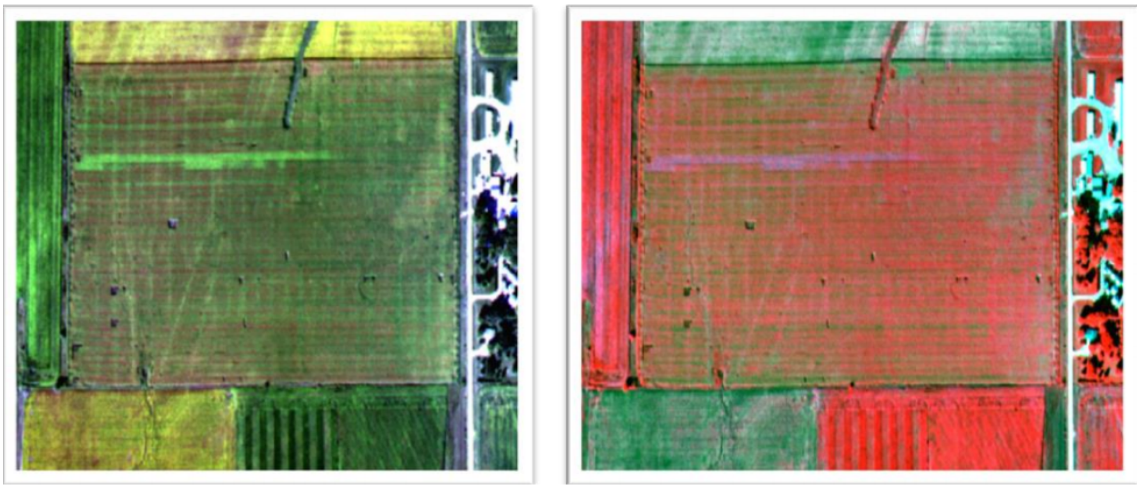


Figure 1.6: True color and NIR showing nitrogen stress

Once aerial images have been utilized to target scouting efforts, a VRA fertilization file can be created using precision agriculture software (ie Mapshots, SST, AgFleet, etc...) Another application of aerial imagery for VRA is using the bare soil image to create zones to apply soil nutrients and/or amendments. Whether you are looking at VR seeding, VRA for fertilization, or VRA for herbicide/fungicide and aerial image is the data layer to use to enable better management decisions and increase profitability.

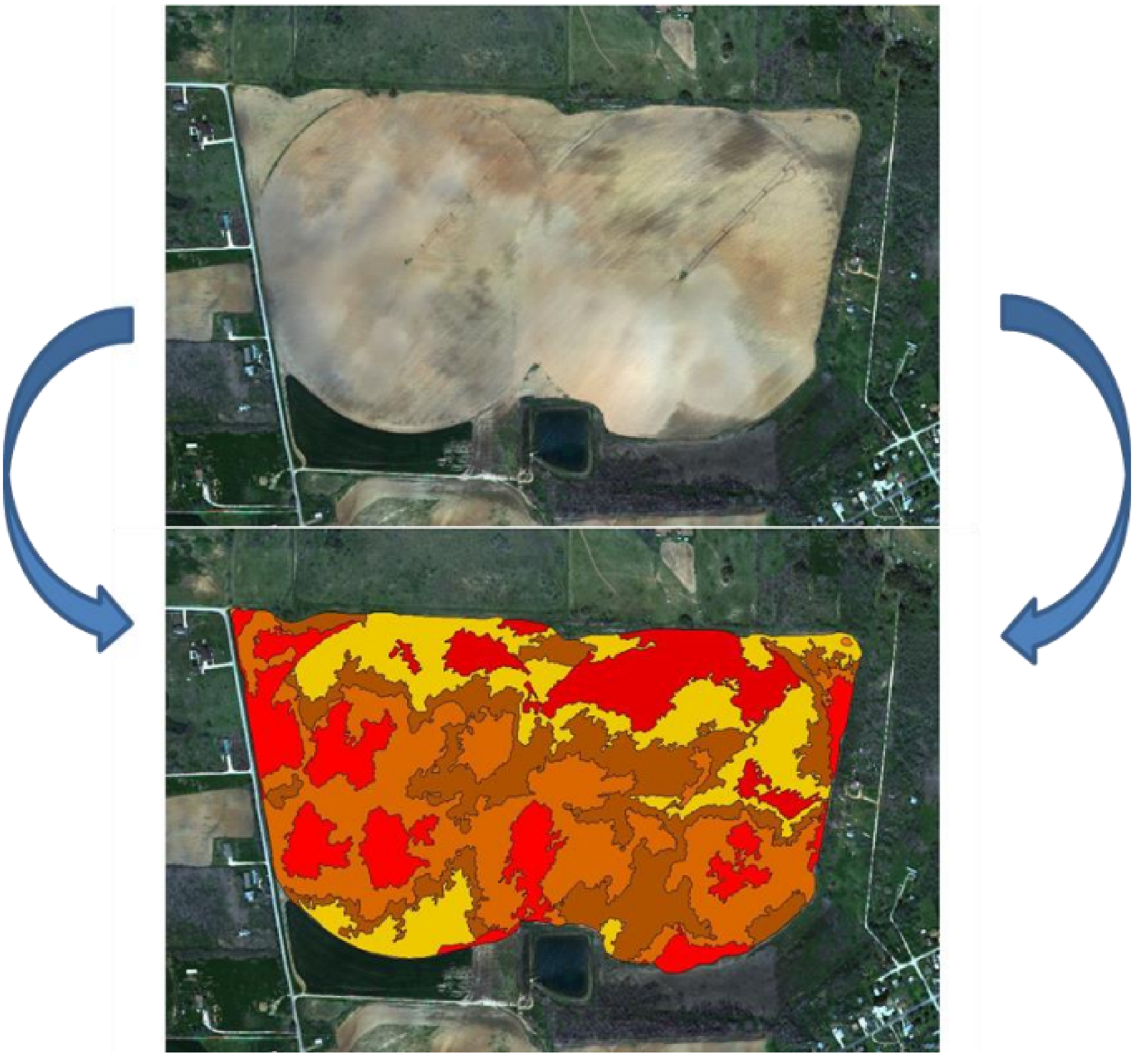


Figure 1.7: VRA image

1.2.1.3 Case Studies

Cotton

Situation Farmers apply herbicides uniformly across fields before planting to ensure good field conditions for planting

Action Use NDVI imagery to identify weeded areas, Apply herbicide only in weeded areas or intensify herbicide applications in heavily weeded areas.

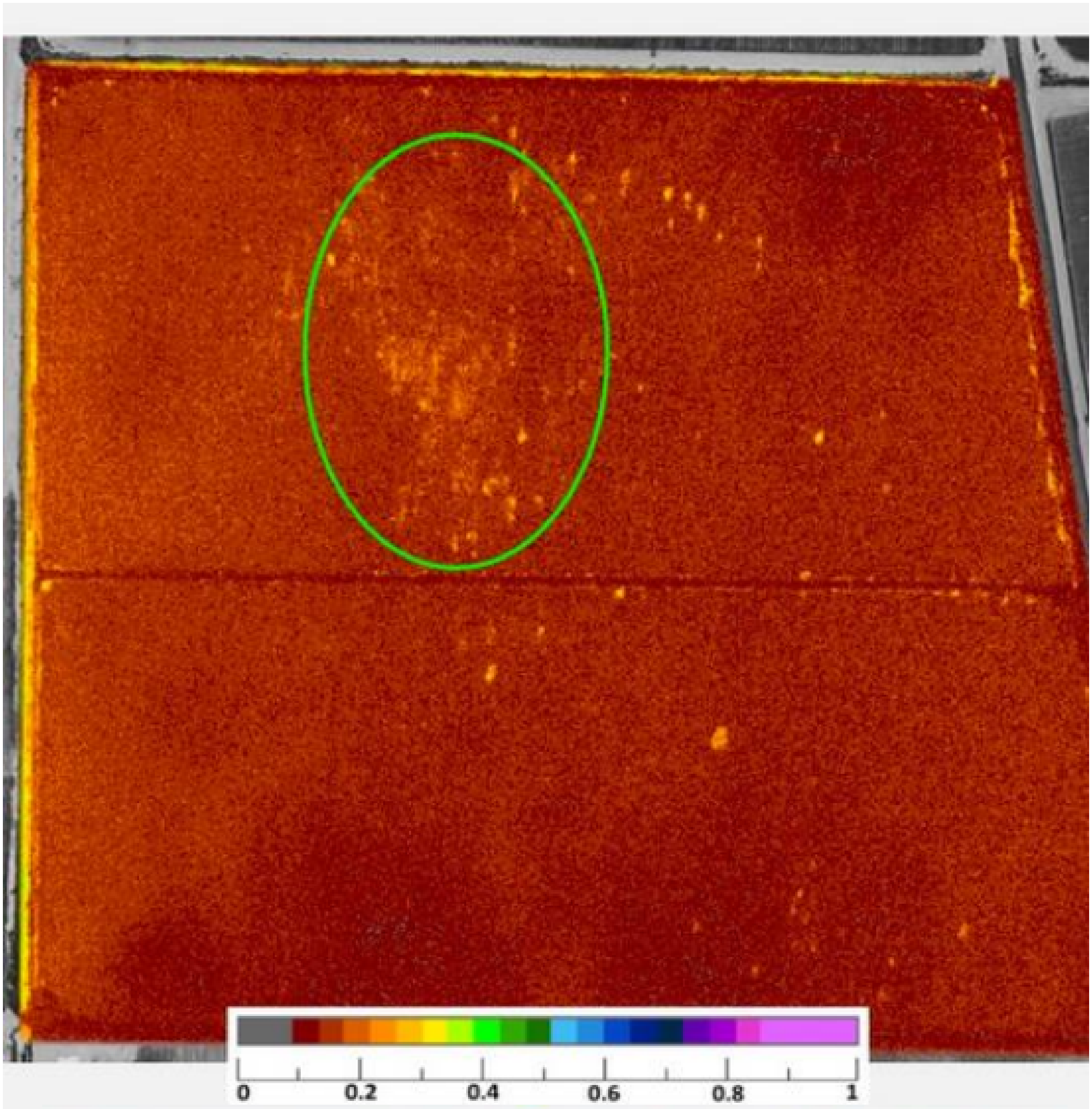


Figure 1.8: Weeded areas

Planter malfunction

Situation Malfunctioning planter can cause 100% loss in nonplanted areas, but such areas can be difficult to locate and quantify.

Action Use imagery to Identify areas to re-plant

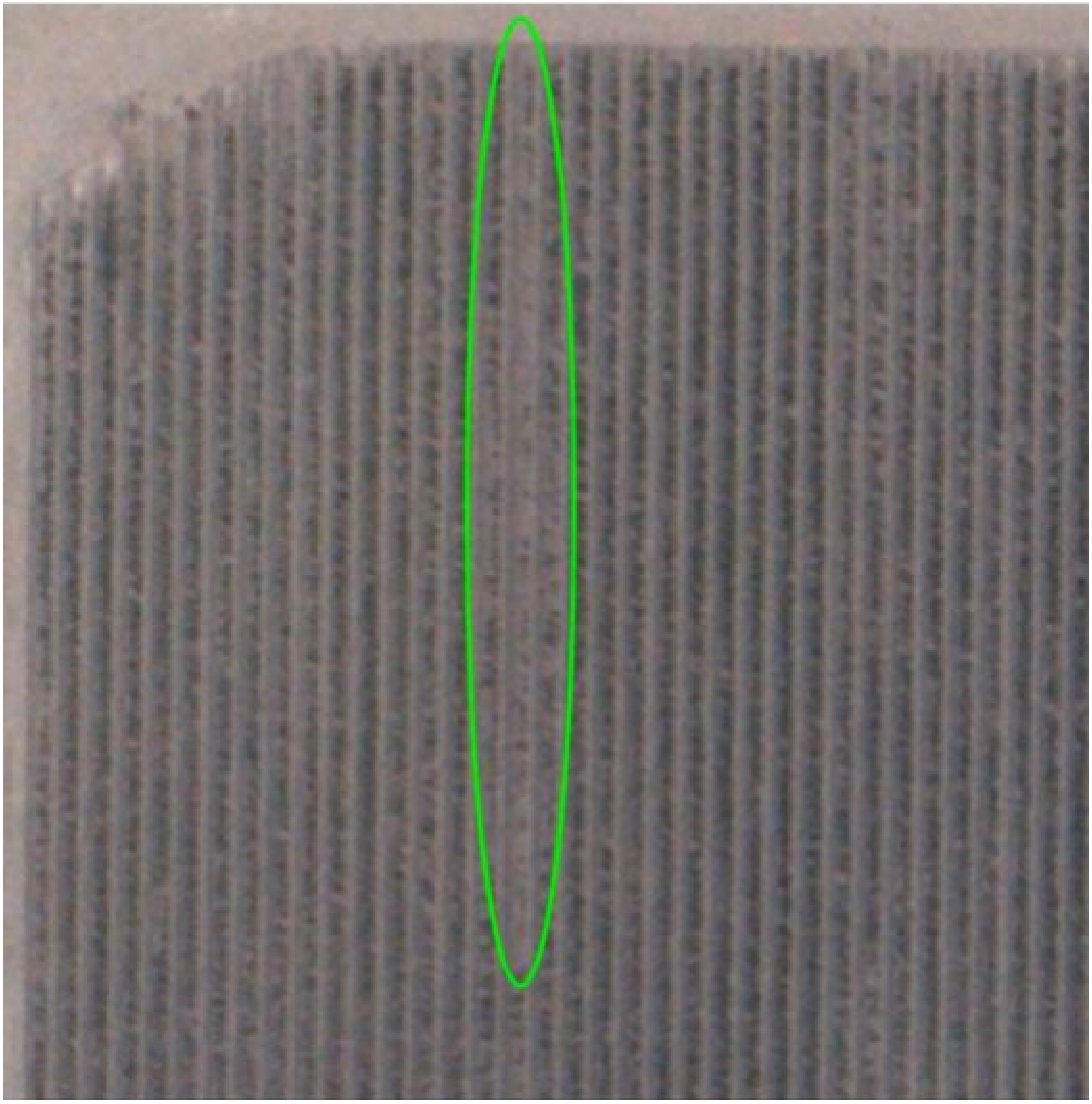


Figure 1.9: Nonplanted areas

Targeted insecticide applications(plant bugs)

Situation Farmers generally apply insecticides uniformly, although early stage plant bugs generally only attack high vigor areas

Action Use NDVI imagery to identify high vigor areas, thus applying insecticide where needed

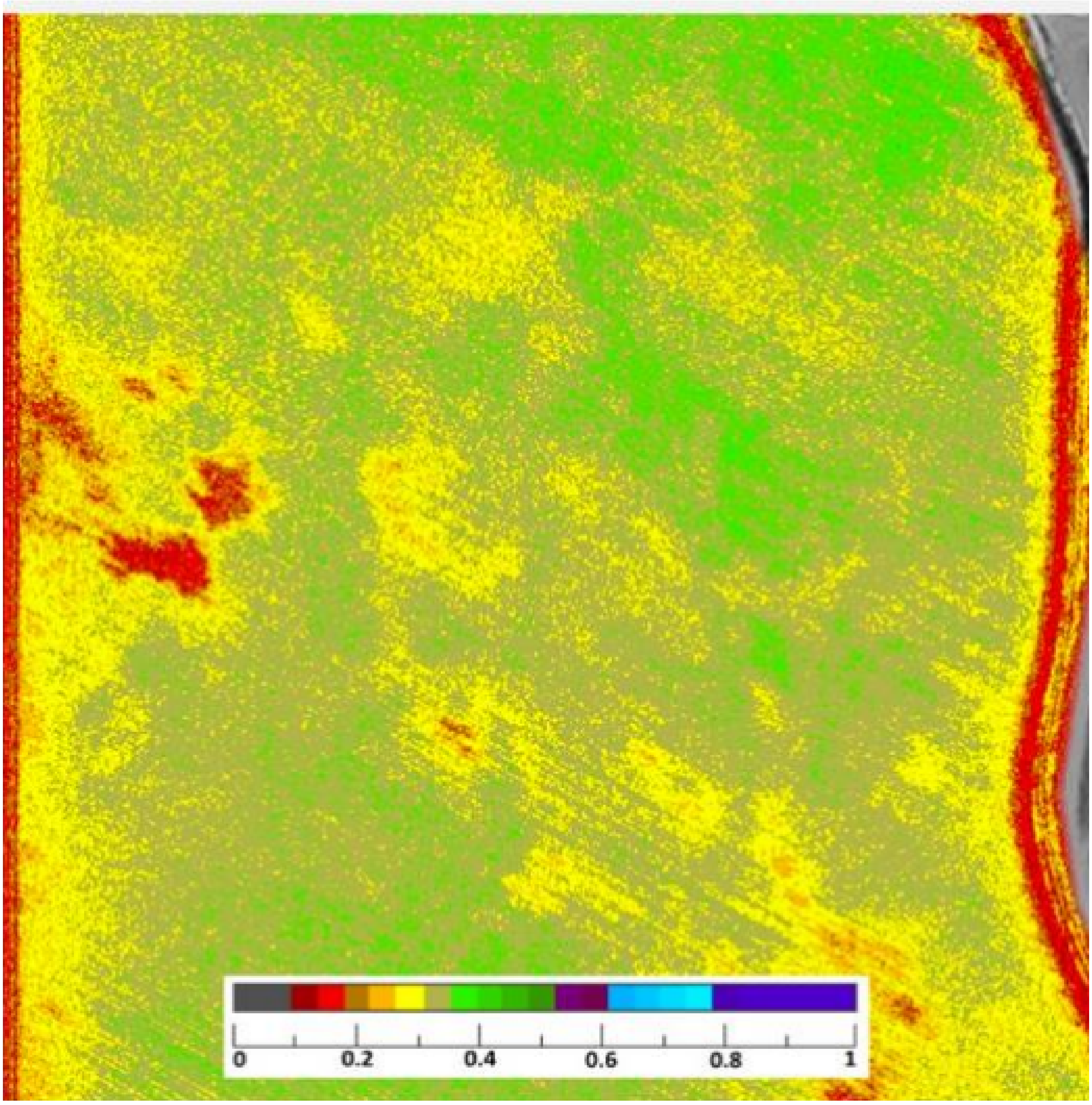
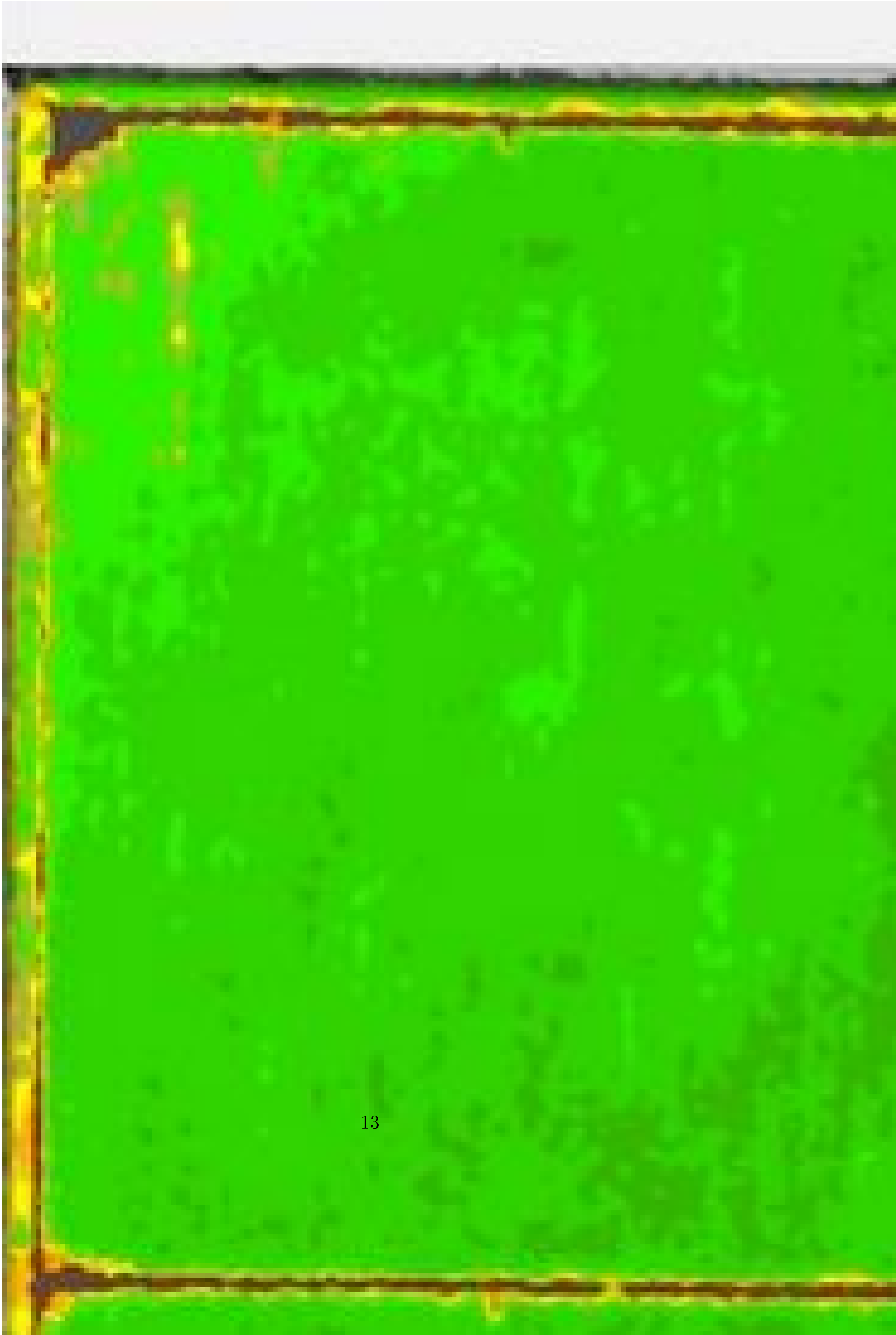


Figure 1.10: High vigor areas

Fertilizer second application

Situation Farmers generally make second nitrogen application uniformly or based on soil maps, where NDVI imagery may provide better representation of nitrogen needs

Action Use NDVI imagery to provide accurate assessment of relative vigor in field to develop fertilizer zones



Center pivot emitter failure

Situation Plugged center pivot emitters not visible by visual inspection, but revealed through NDVI and Thermal Imagery

Action Repair plugged sprinklers

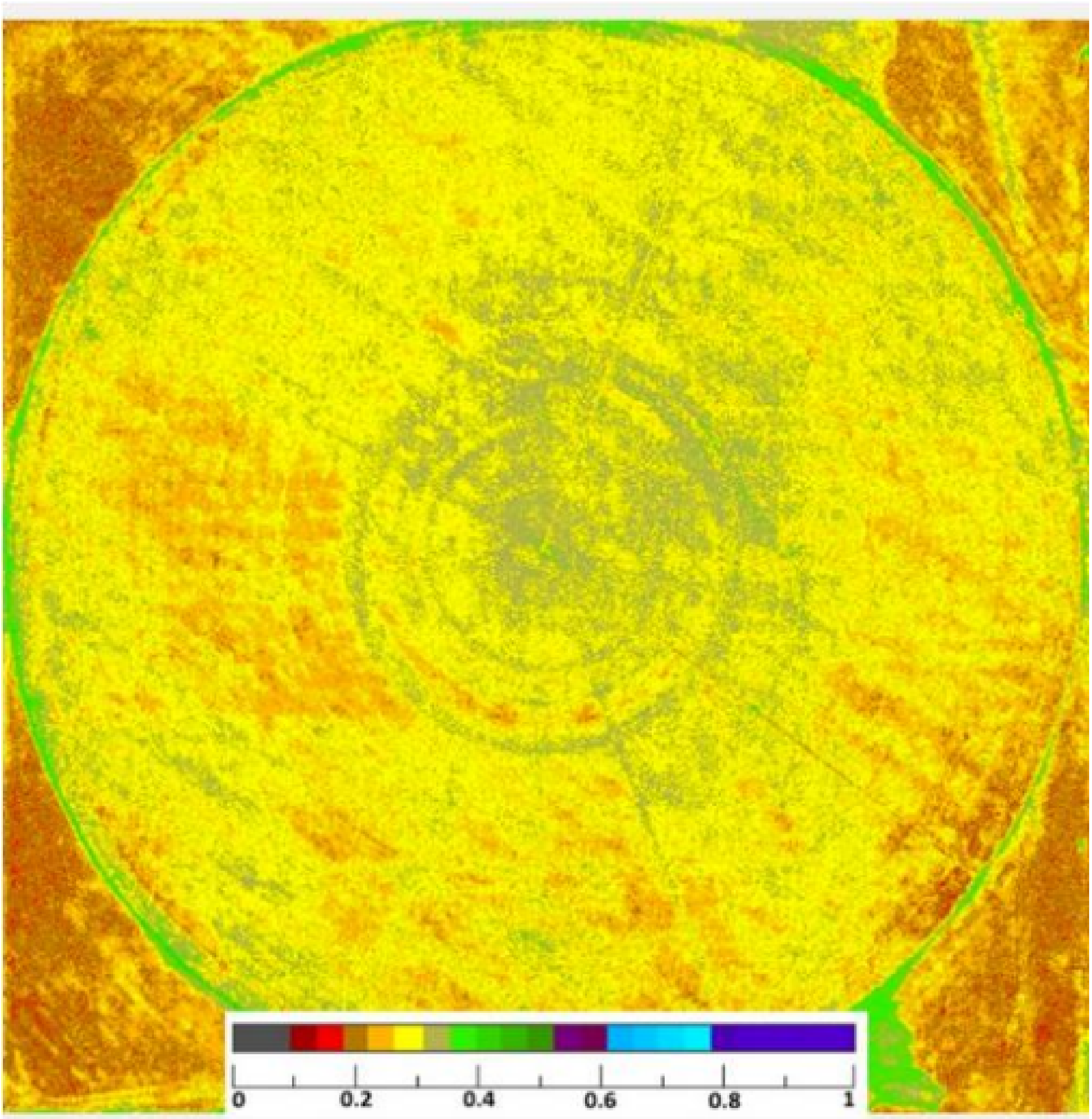


Figure 1.12: Plugged center pivot emitters zones

Inefficient furrow irrigation

Situation Furrows do not flow efficiently, resulting in uneven application of irrigation water. Difficult to assess from the ground with naked eye, but thermal and NDVI imagery enable problem areas to be identified and repaired

Action Repair furrow irrigation efficiencies

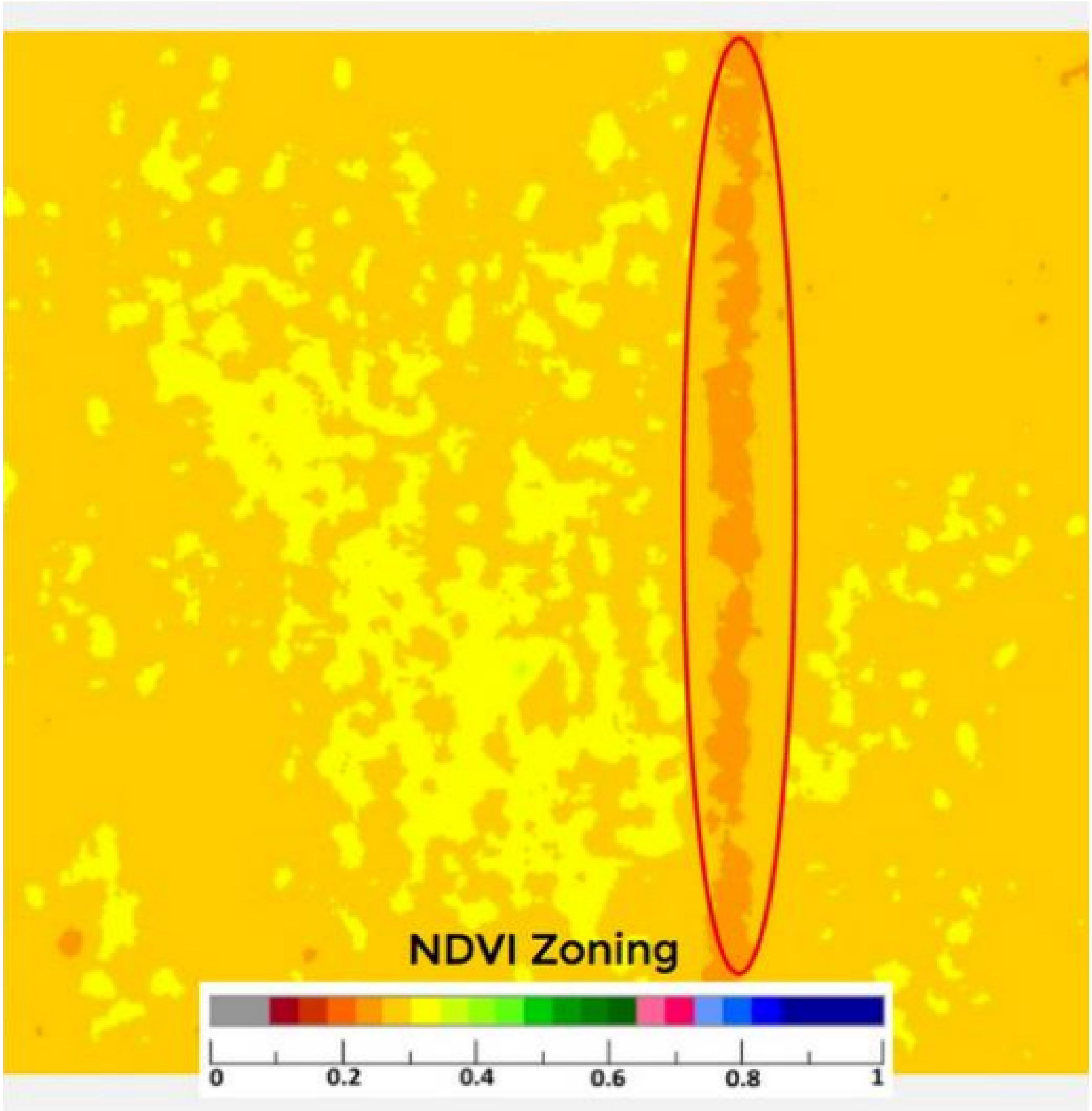


Figure 1.13: Inefficient furrow irrigation zones

Targeted insecticide application (spider mites)

Situation Farmers generally do not apply insecticides, unless scouting identifies a problem, NDVI imagery enable problem areas to be identified and sprayed

Action Use NDVI imagery to identify infested areas, thus applying insecticide when needed

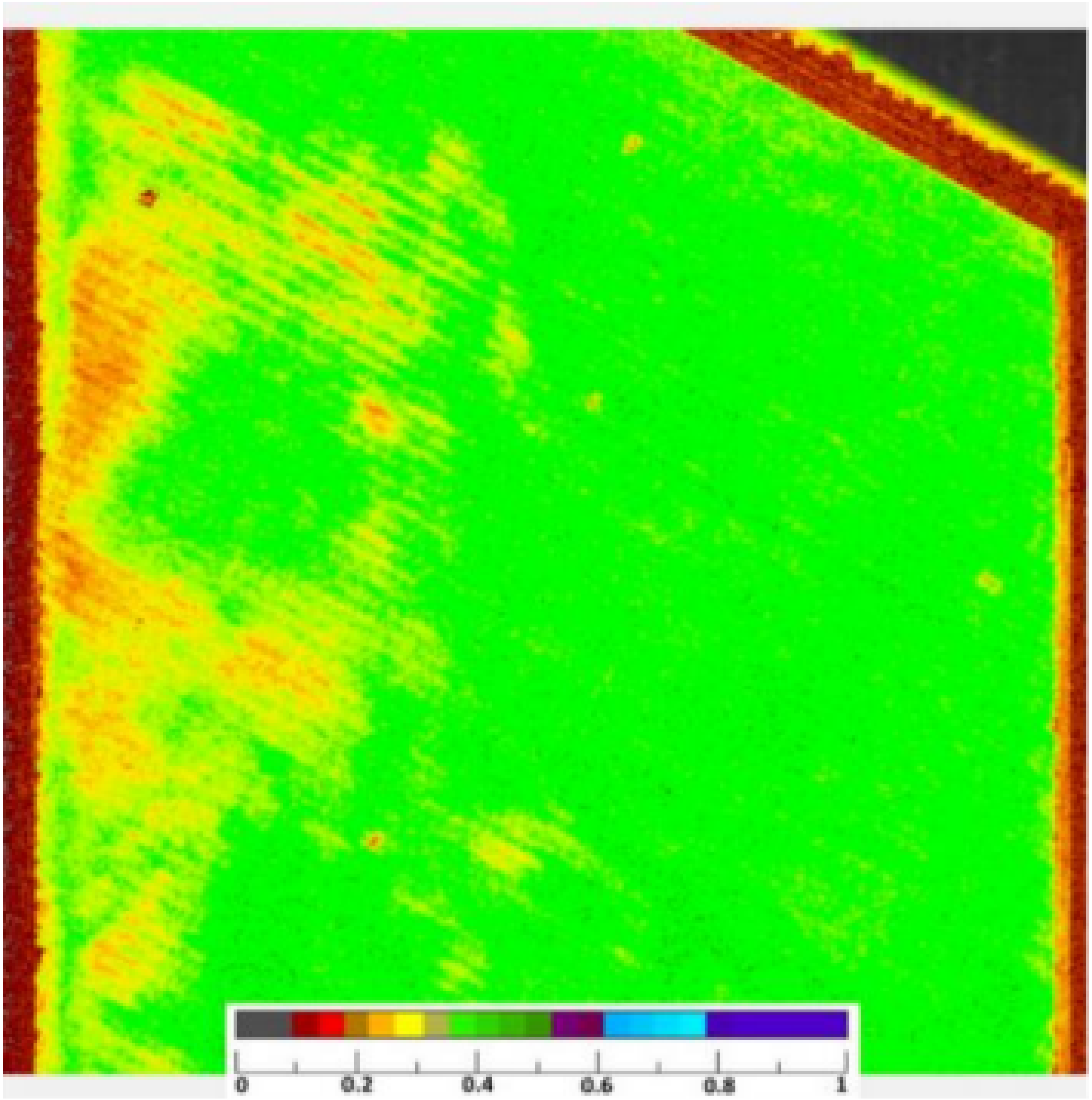


Figure 1.14: Spider mites zones

Targeted weed control

Situation Scouts currently sample the field randomly to discover potential issues or to assess crops. Aerial imagery allows for targeted scouting.

Action Identify areas for scout to visit to discover issues or accurately assess crop, allowing for targeted pest and weed applications

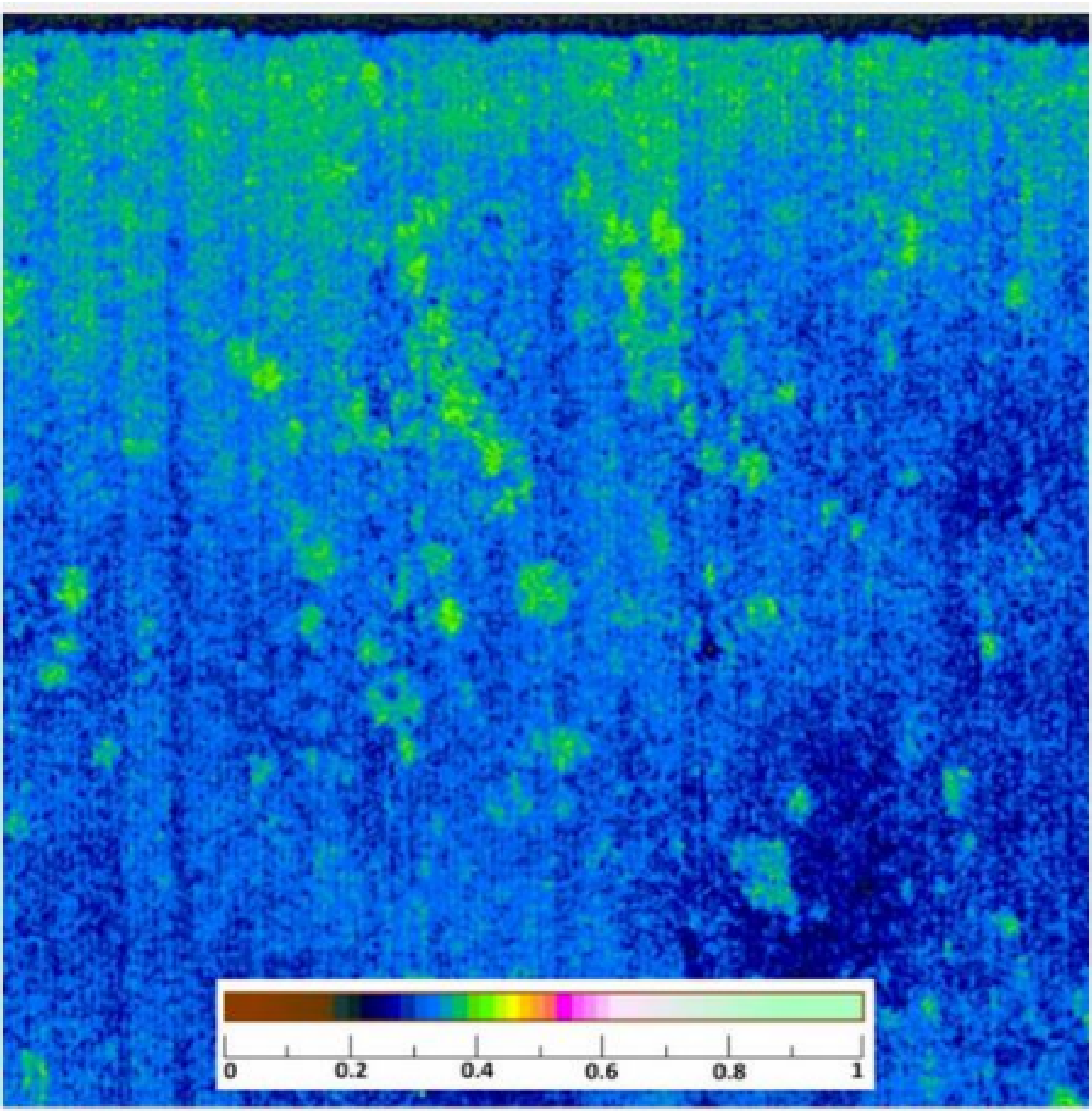


Figure 1.15: Targeted weed zone

Plant growth regulator

Situation Field grows unevenly, necessitating variable applications of PGRs in different areas of field

Action Identify PGR application zones, Apply different rates of PGR in different zonested pest and weed applications

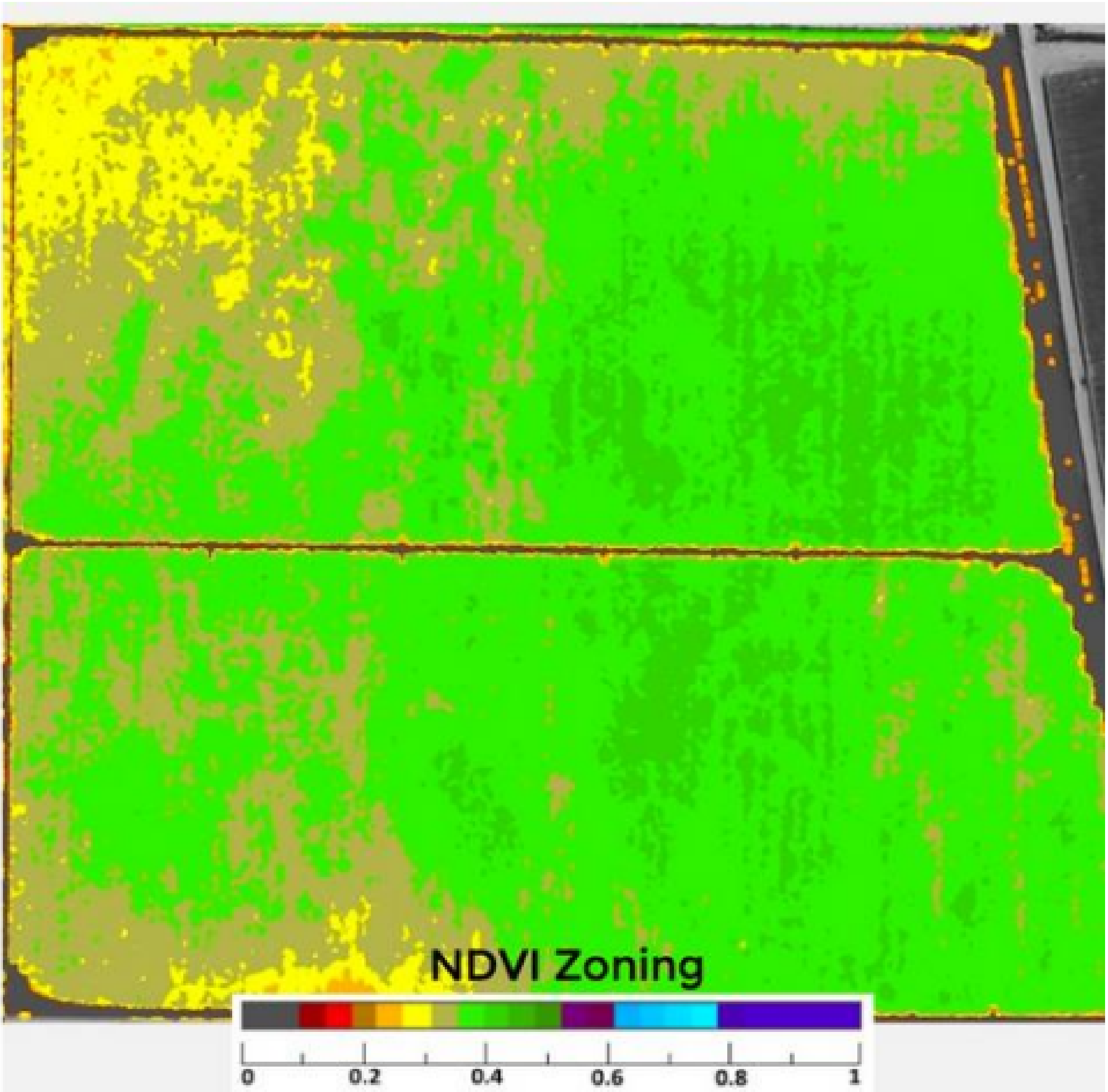


Figure 1.16: Unevenly planted zones

Defoliant application

Situation Field matures unevenly, resulting in difficult balance between defoliant efficacy, yield levels, and harvest requirements

Action Time defoliant application to achieve maximum efficacy to achieve optimal yields and lint quality

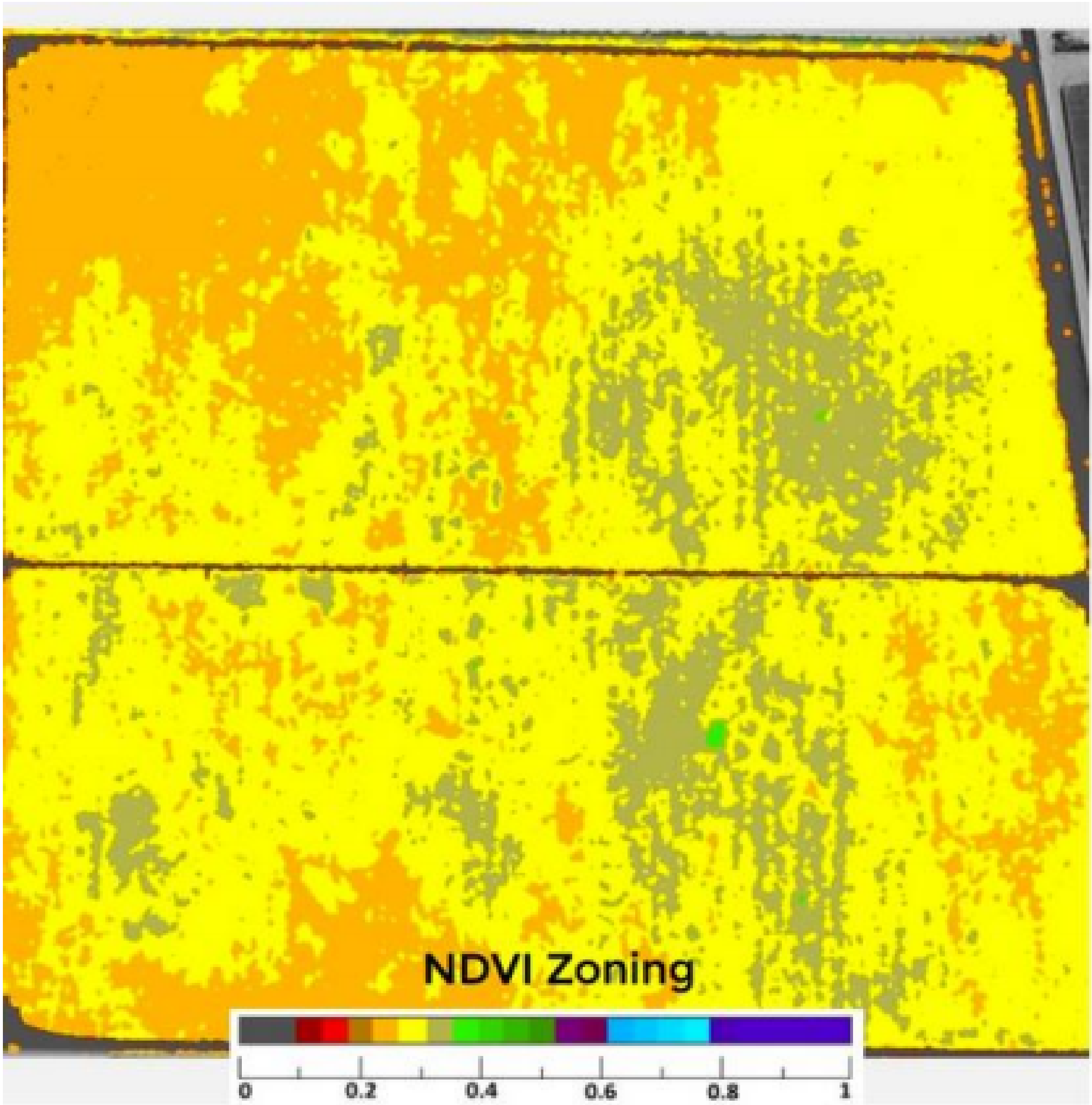


Figure 1.17: Unevenly matured zones

Soil amendments

Situation Soils greatly affect yield and value, but it is very difficult to discern geospatial distribution of soils without aerial imagery

Action Infrared and NDVI imagery highlights differing soil types, allowing for targeted soil amendments

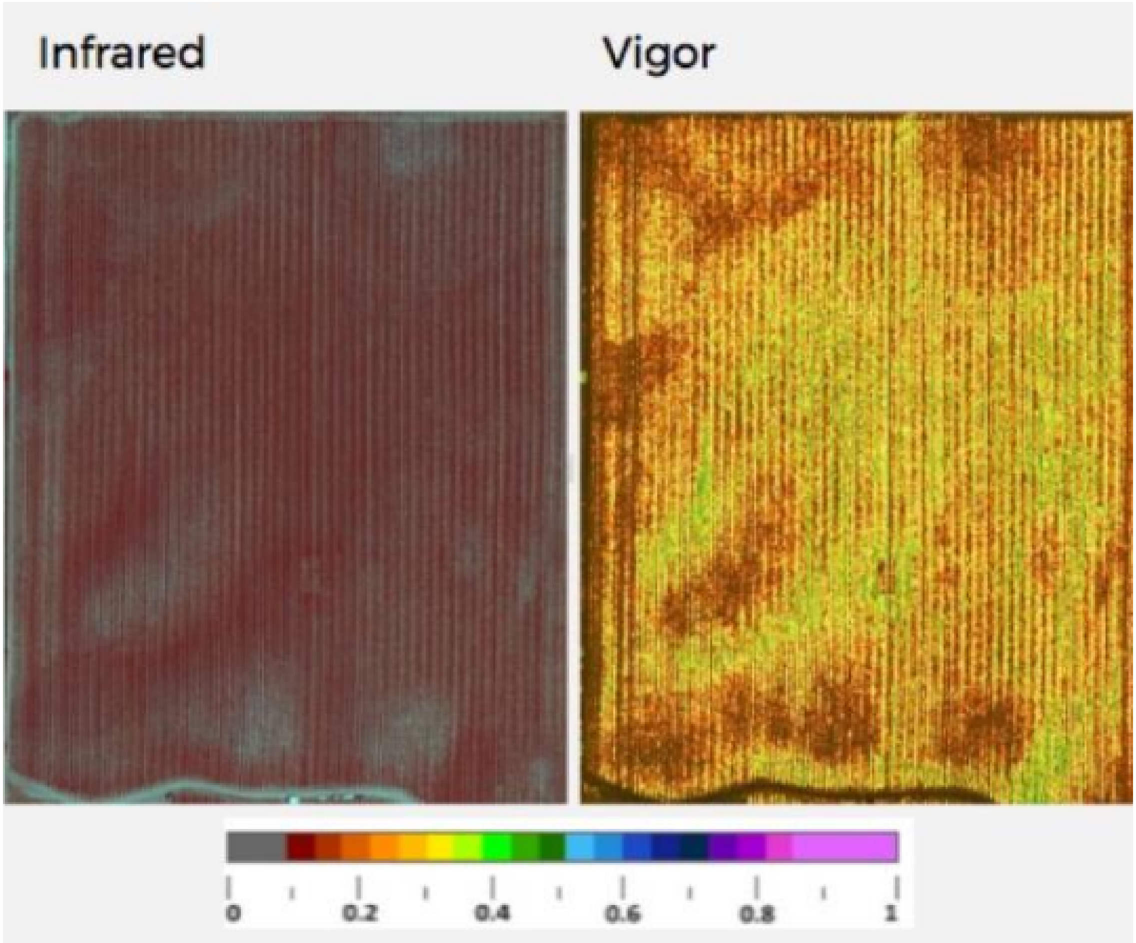


Figure 1.18: Differing soil types zones

powdery mildew

Situation Scouts randomly scout the vineyard for powdery mildew colonies throughout the season

Action NDVI imagery highlights high-vigor areas that are susceptible to powdery mildew, enabling targeted scouting, treatments or thinning.

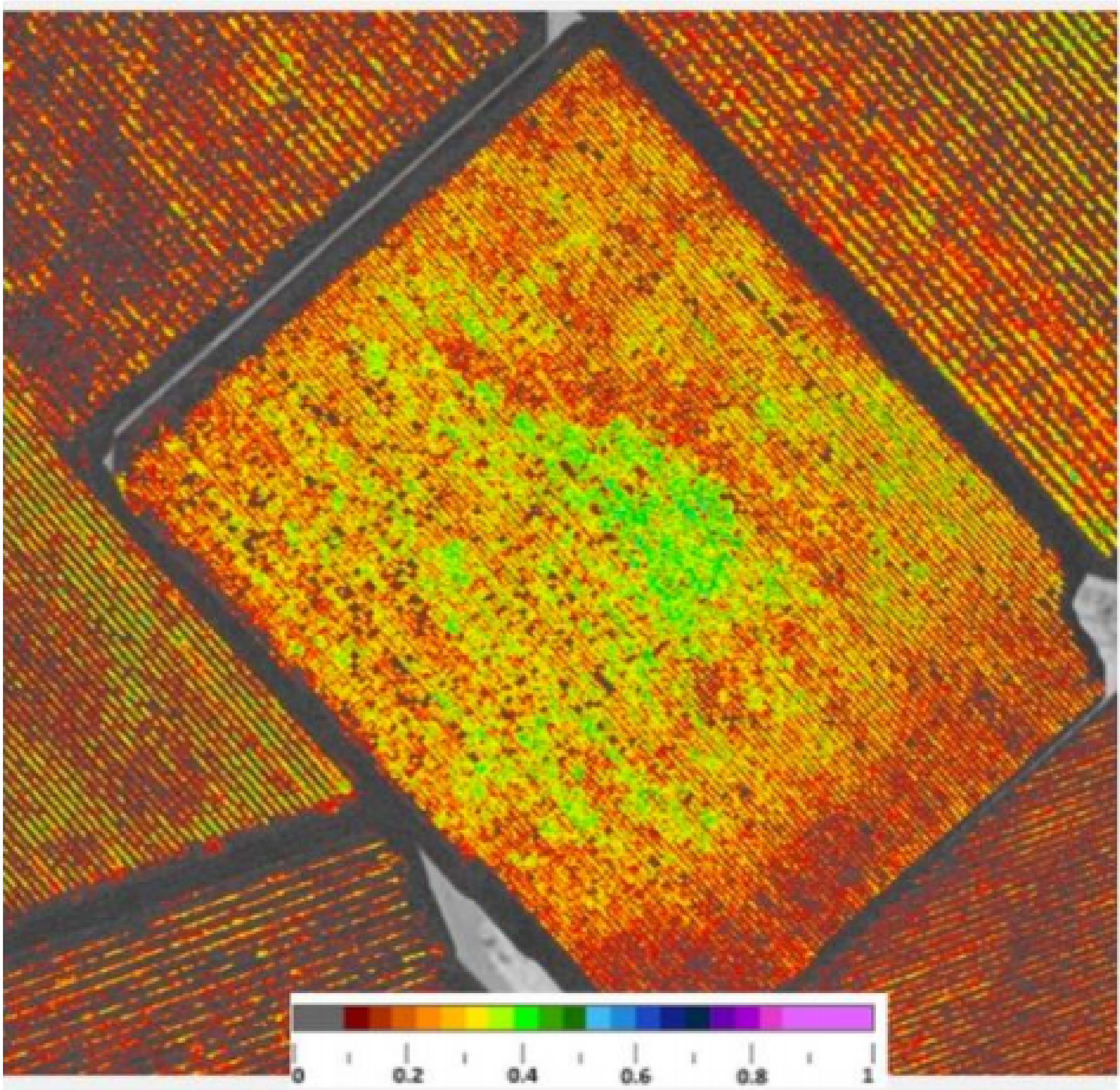


Figure 1.19: Infected powdery mildew zones

Diseases control

Situation Diseases can adversely affect yield, but diseased areas can be be difficult to identify

Action Use NDVI imagery to identify infected areas, thus applying fungicide when and where needed

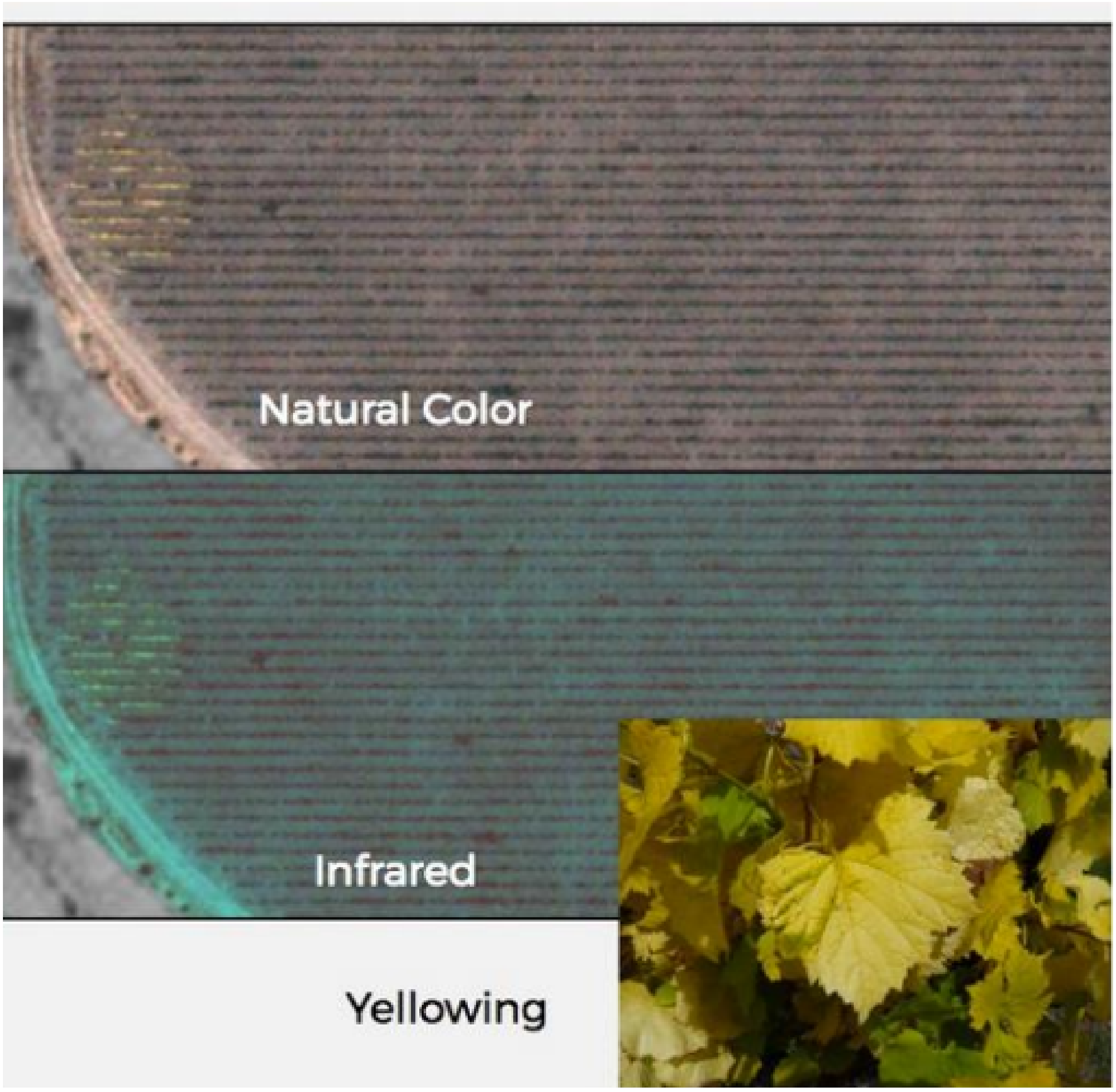


Figure 1.20: Infected zones

Weed control

Situation Weeds can adversely affect yield, but weedy areas can be be difficult to locate and target

Action Use NDVI imagery to identify weedy areas, thus applying herbicides when and where needed

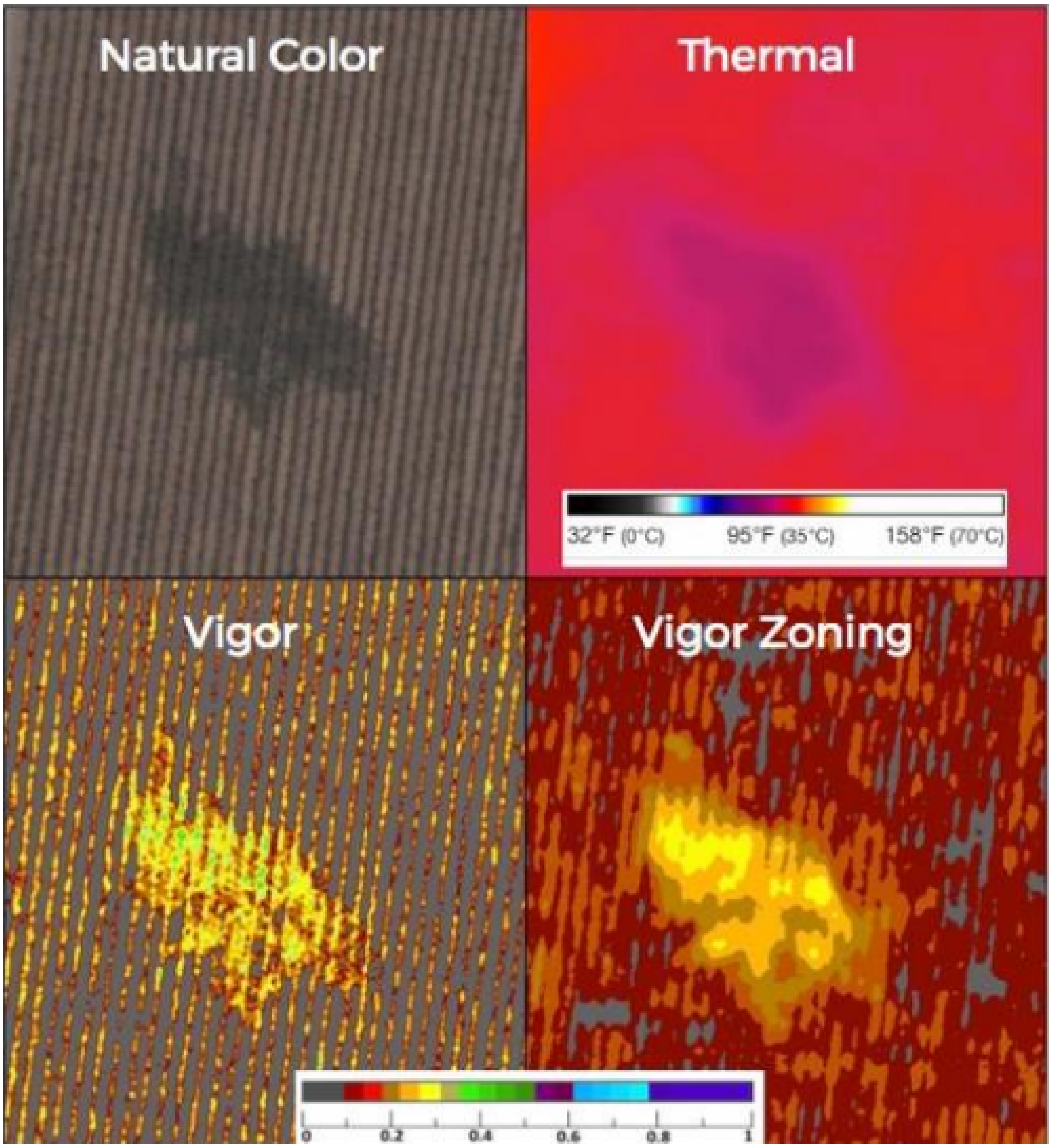


Figure 1.21: Weedy zones

Irrigation leaks

Situation Irrigation systems leak, causing excess vine vigor which diminishes grape quality and thus adversely affects price. Irrigation leaks are difficult to identify without aerial imagery.

Action Use thermal and NDVI imagery to identify irrigation leaks to be repaired, resulting in higher grape quality across vineyard

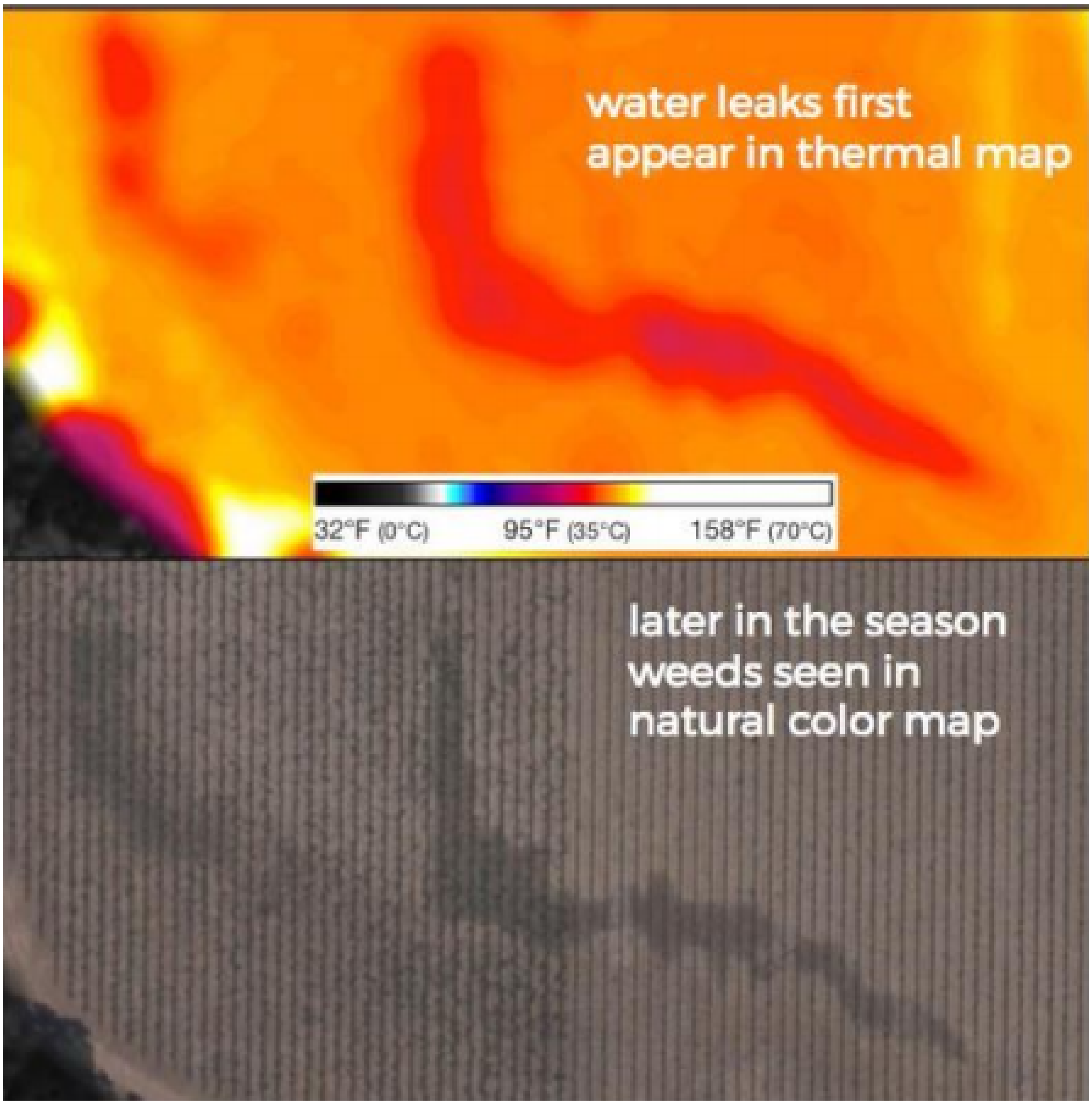


Figure 1.22: Irrigation systems leak zones

Irrigation optimization

Situation Uneven field vigor results in sub-optimal irrigation deliveries (i.e., some parts of vineyard get too much water, other parts get too little)

Action Use NDVI to create irrigation zones, enabling differential irrigation to ensure appropriate irrigation applications in each part of vineyard.

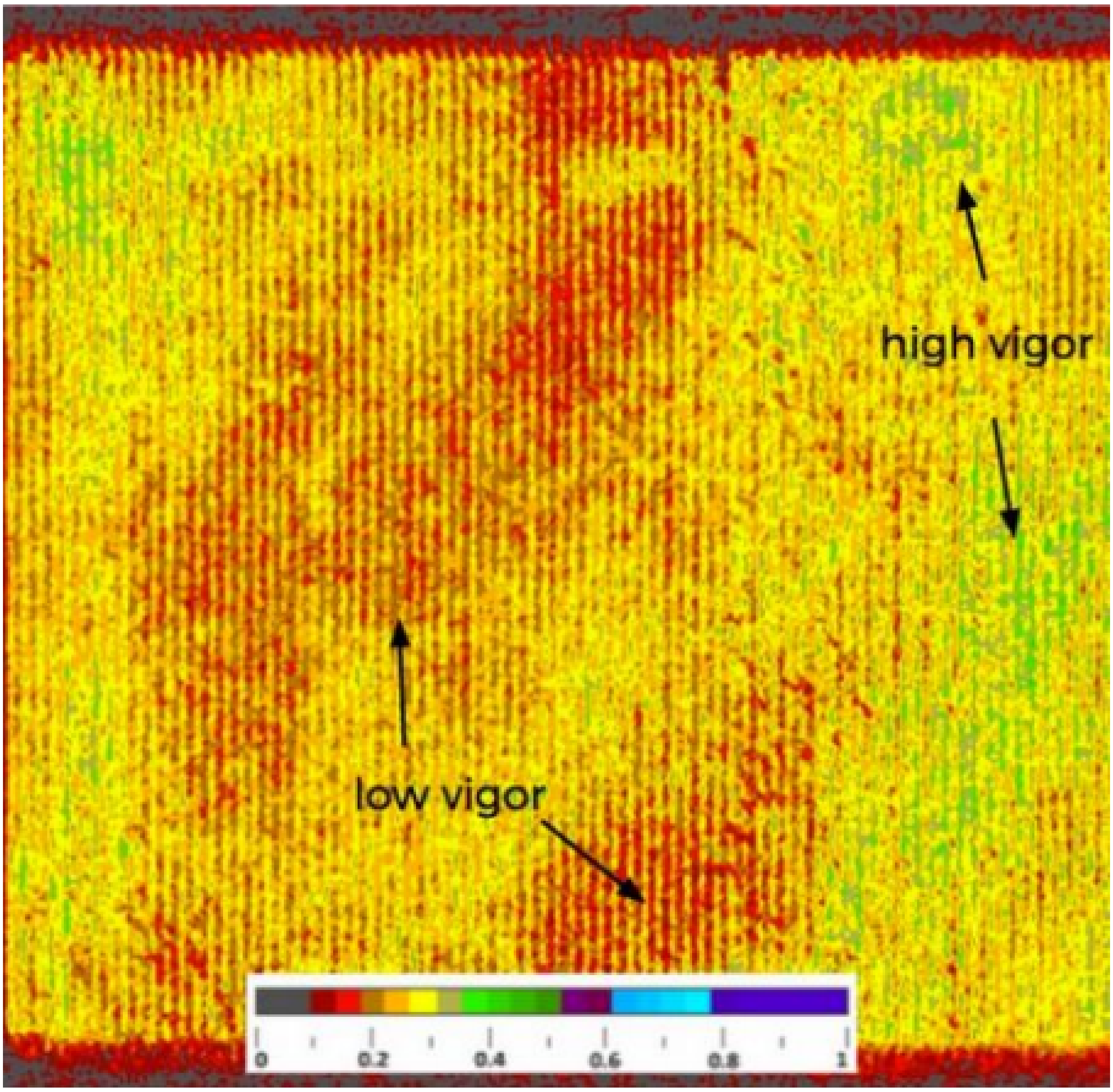


Figure 1.23: Uneven field vigor zone #1

Harvest zones

Situation Uneven field vigor results in mixed quality grape harvest.

Action Use NDVI to create harvest zones, enabling differential harvesting to avoid mixing high and low quality grapes.

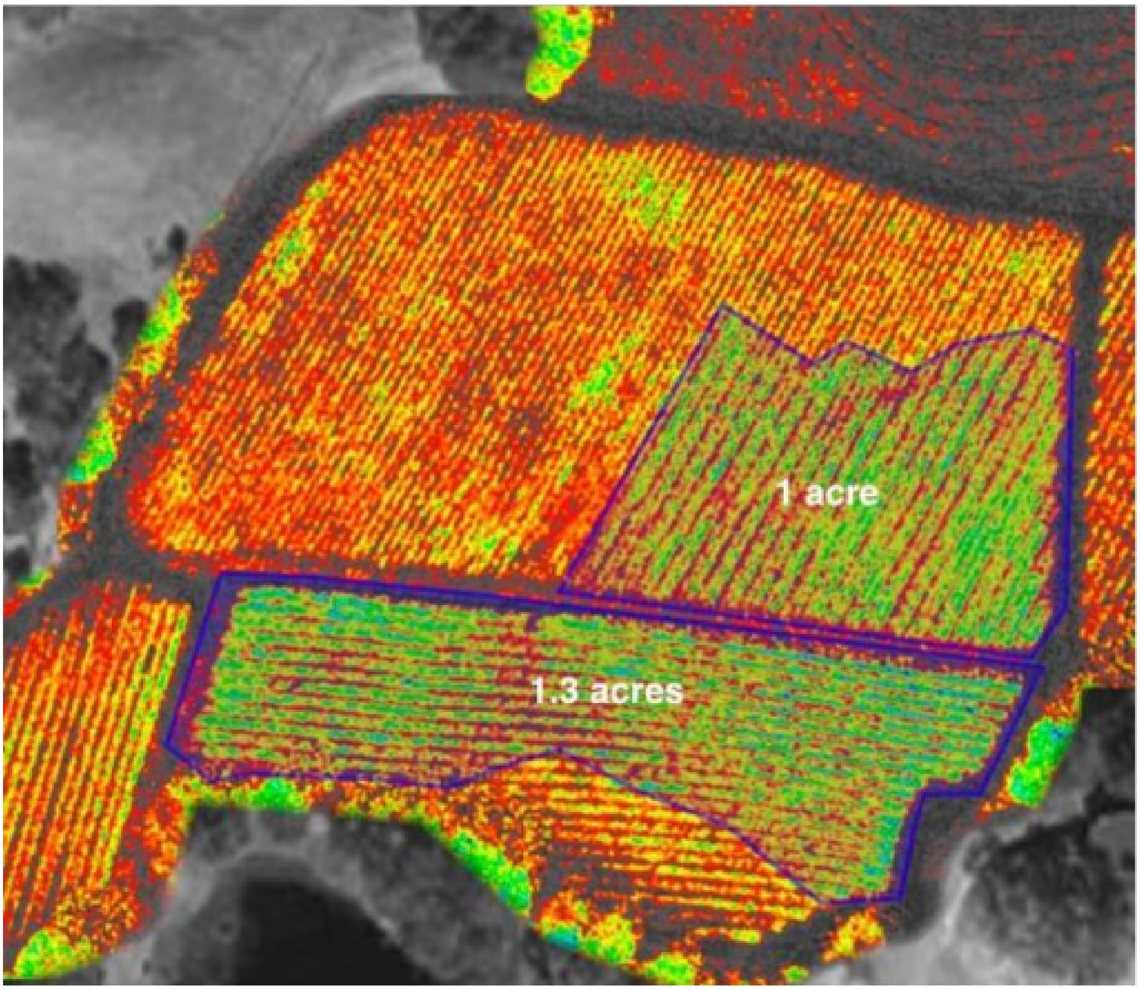


Figure 1.24: Uneven field vigor zone #2

Cover crops

Situation Uneven vineyard vigor results in sub-optimal cover crop planting decisions (i.e., cover crop based upon average vineyard needs as opposed to cover crops matching particular areas)

Action Create in-season vigor zones to inform off-season cover crop decisions

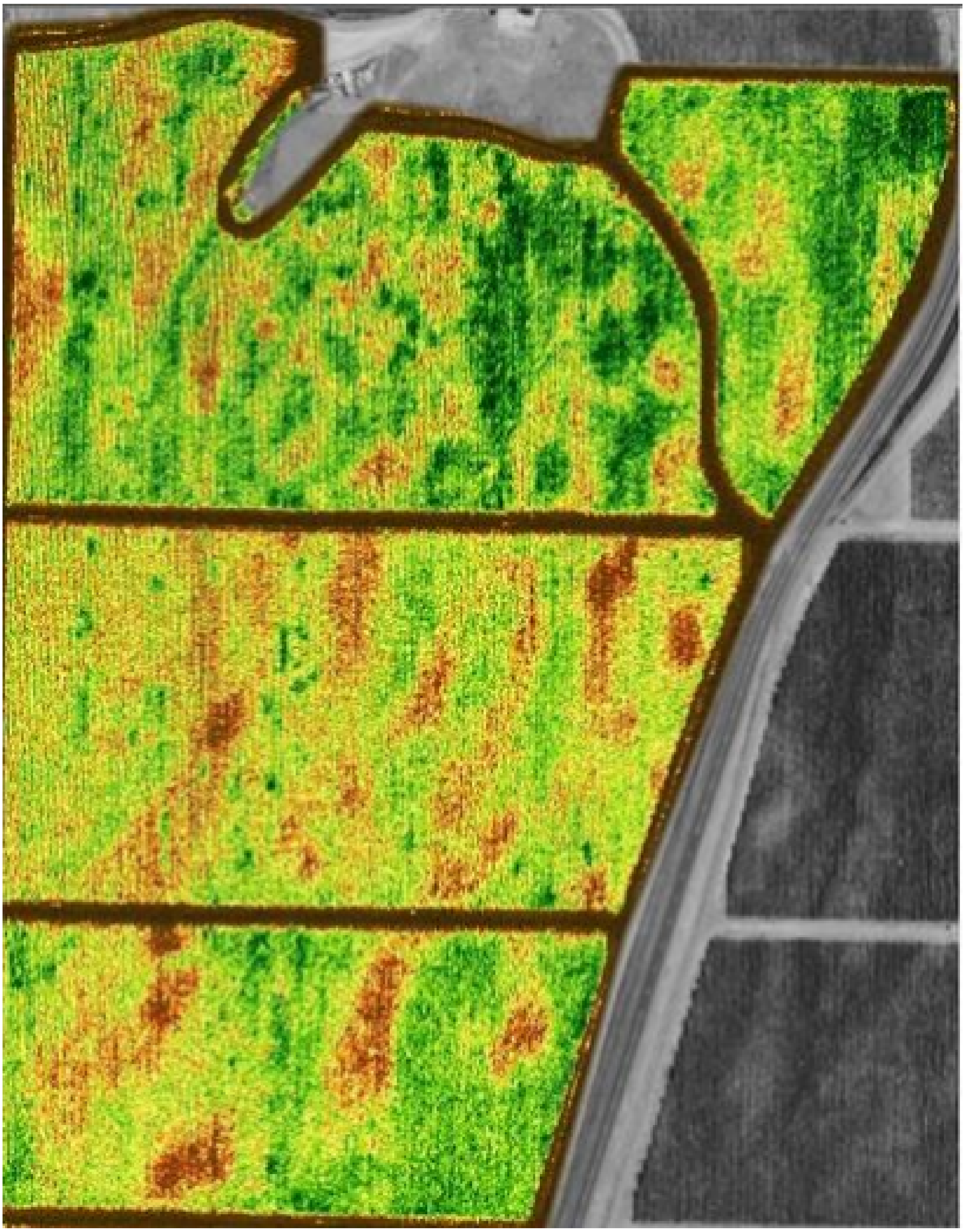


Figure 1.25: Uneven vineyard vigor zone

1.2.2 Using drones in Media and Entertainment

1.2.2.1 Aerial photography

In 2016 , An Egyptian company called "IFLY EGYPT" [2], started up which is specialized in developing UAVs used in aerial photography.they used drones in applications such as

- Football matches

Figure 1.26: Football match image taken by a drone

- Tourism industry

Figure 1.27: Cairo tower image taken by a drone

- Road traffic

Figure 1.28: Road traffic image taken by a drone

Challenges they have faced:

- permissions for using RC devices
- Exporting a lot of advanced equipment
- Maintenance of these equipment Local
- Developing for some equipment to meet the requirements

1.2.2.2 Advertising

Intel used the squadron of drones to advertise its logo

Figure 1.29: Intel image #1

Figure 1.30: Intel image #2

1.2.3 Using drones in Search and Rescue

1.2.3.1 Introduction

Drones aren't always mentioned in the same breath as saving lives, but a new report from one drone manufacturer says they should be.

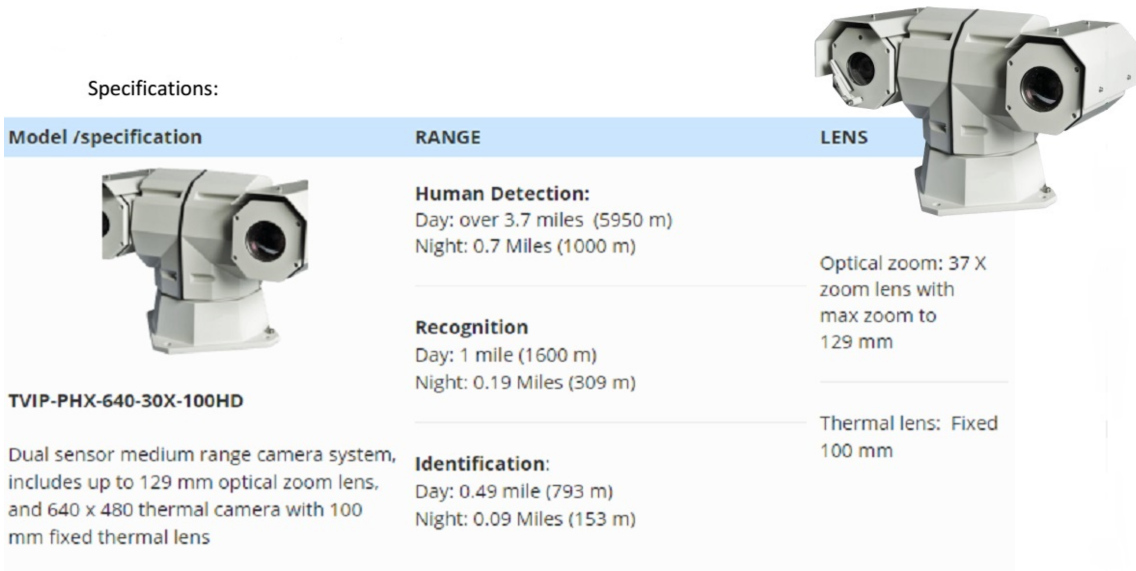
Civilian drones have been used to save at least 59 people in 18 different incidents around the world since 2013, DJI, a China-based company that manufacturers popular civilian drones, said in a statement on Tuesday. The company added that 38 of those individuals were saved within in the last 10 months thanks to rescue teams and civilians employing their unmanned aerial vehicles (UAV) to aid people facing life-threatening emergencies.

Now, DJI says a drone is saving nearly one person's life a week on average.

1.2.3.2 Saving and Rescue UAS

The mission The initial design is a fixed wing UAS with an IR camera for night vision. The UAS surfs the ocean and the Mediterranean Sea in order to search for any people stuck in the middle of the sea and rescue them. This can be done by installing the following devices:

- Long Range IR PTZ system



Specifications:

Model /specification	RANGE	LENS
TVIP-PHX-640-30X-100HD Dual sensor medium range camera system, includes up to 129 mm optical zoom lens, and 640 x 480 thermal camera with 100 mm fixed thermal lens	**Human Detection:** Day: over 3.7 miles (5950 m) Night: 0.7 Miles (1000 m) **Recognition** Day: 1 mile (1600 m) Night: 0.19 Miles (309 m) **Identification**: Day: 0.49 mile (793 m) Night: 0.09 Miles (153 m)	Optical zoom: 37 X zoom lens with max zoom to 129 mm Thermal lens: Fixed 100 mm

Figure 1.31: TVIP-PHX-640-100HD camera specifications

- AXIS Q8641-E PT Thermal Network Camera

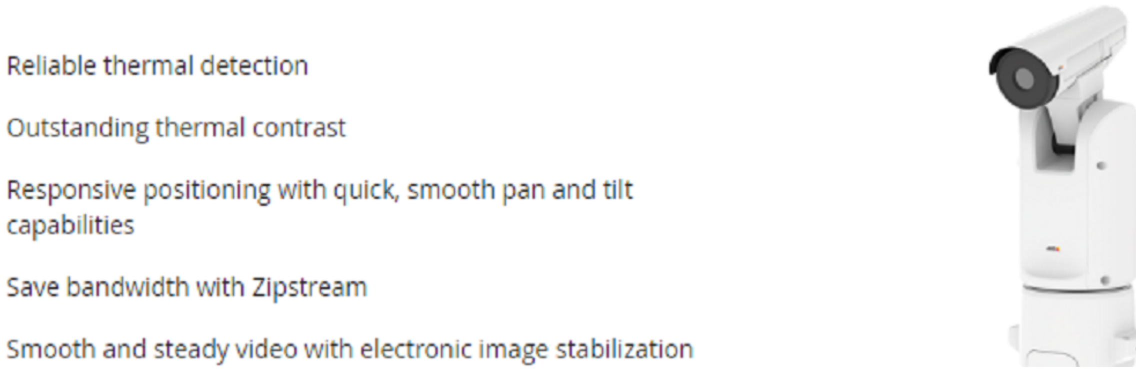


Figure 1.32: AXIS Q8641-E PT camera specifications

- AXIS Q8641-E lets operators choose between really slow or super-fast pan (from 0.05 to 120 degrees per second) and tilt movement (from 0.05 to 65 degrees per second). So they get smooth and jerk-free panoramic viewing when they need it and can respond quickly to events. The camera can be column-mounted, on poles or walls for a 360° panoramic view and a ground-to-sky view from -90° to +45°. It can withstand high winds when it's in motion of up to 47-meter per second (106 mph).

– Detection Ranges

	Focal length	Viewing angle	Detection			
	mm	Horizontal	Human: 1.8 x 0.5 m		Vehicle: 4 x 1.5 m	
			m	yards	m	yards
Detection (1.5 pixels on target)	35	10.7°	1028	1124	3153	3448
Recognition (6 pixels on target)	35	10.7°	257	281	788	862
Identification (12 pixels on target)	35	10.7°	129	141	394	431

Table 1.2: AXIS Q8641-E detection ranges

– This camera can be a better option as it has a local seller in Egypt. As the camera belongs to Axis communications and has a seller "Quantum Digital Technologies, Cairo", "HitekNofal Solutions, Cairo" and "C&CC, Cairo".

Types of UAS that can be used in search and rescue

Fixed Wing UAS The first trial maybe a fixed wing UAS able to carry the payload of the camera system, compatible with the battery and having a GPS system to detect the one drowning in the sea and send its location to The responsible Authority for saving him.

Multi-Rotor Drone This design can be taken into consideration as it's easy to manufacture. This option is a better one.

Another Function may be added to this Multi-Rotor Drone which is dropping life vests and ropes to people stuck in the sea like in the following picture.

Figure 1.33: Dropping life vests drone

1.2.3.3 Firefighting Drones

In search and rescue operations, drones allow greater coverage of a search area – and thermography allows rescue teams to work through the night, significantly increasing the potential for success. Thermal imaging cameras give teams the power to "see in total darkness," says FLIR, the global leader in thermo-graphic imaging sensors. Added to that is the ability to discern figures difficult to find with traditional cameras even in daylight- like one stranded hiker lost against the backdrop of a snowy field. This capacity is one of several reasons that law enforcement organizations around the world are using drones. Firefighting may provide one of the most compelling applications for drones equipped with thermal imaging equipment. From New York City's famous FDNY to volunteer departments in small towns around the country, fire departments are utilizing drone technology to save structures and victims, and minimize risk to firefighters. The aerial perspective through a thermal imaging camera allows teams to pinpoint hotspots, identify victims on the scene, and quickly establish a plan of attack. It provides a level of visibility in the midst of a fire that is impossible with the naked eye or traditional cameras. (You can see how a fire looks through the lens of one of these thermo-graphic tools here – experiencing a firefighters view through dark and smoke.) Drones not only make firefighters more effective – they keep them safe.

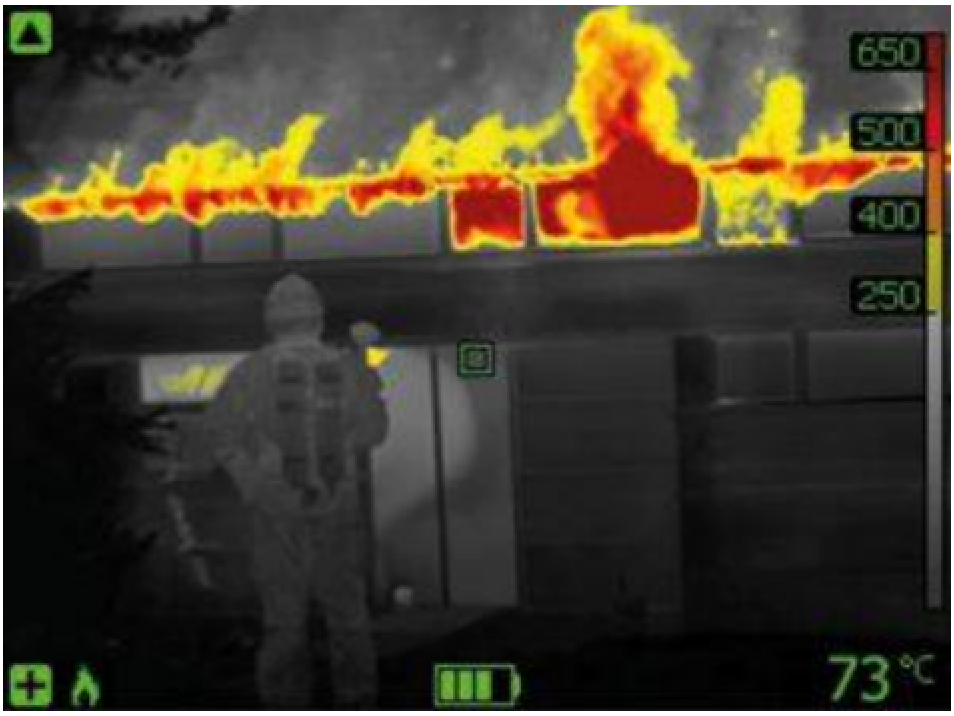


Figure 1.34: Thermal image taken by a Drone

Main components Drones may have the same cameras mentioned above or more accurate thermal cameras for optimizing its missions. But it may be designed to be Multi-Rotor Drone in order to be more flexible to fly above the burnt areas.

1.2.4 Using drones in Disaster Relief and Emergency Response

1.2.4.1 Introduction

Aerial drones are one of the most promising and powerful new technologies to improve disaster response and relief operations. Drones naturally complement traditional manned relief operations by helping to ensure that operations can be conducted safer, faster, and more efficiently.

When a disaster occurs, drones may be used to provide relief workers with better situational awareness, locate survivors amidst the rubble, perform structural analysis of damaged infrastructure, deliver needed supplies and equipment, evacuate casualties, and help extinguish fires among many other potential applications.

In advance of an emergency, drones are able to assist with risk assessment, mapping, and planning [3]. When individuals, businesses, and communities are able to understand and manage risks and plan effectively, they reduce overall damage and losses. Rebuilding and recovery are then able to begin more quickly and ultimately strengthening the resiliency of communities.

Drones have long been described as optimally suited to perform the "3-D" missions, often described as dirty, dull, and dangerous. They can provide needed aerial data in areas considered too hazardous for people on the ground or for manned aircraft operation, such as sites with nuclear radiation contamination or in close proximity to wildfires. Drones can also deliver needed supplies and relay Wi-Fi and cellular phone service when communications are needed the most.

Disaster relief and emergency response (DRER) efforts are inclusive of all actions by first responders and subsequent aid efforts during and immediately following a catastrophic event which threatens human life.The primary purpose of DRER efforts is to save human lives. Secondary purposes of DRER efforts are to preserve and maintain the environment, protect property, keep the peace, and uphold governmental authority.

UAV systems have the potential to improve the effectiveness of DRER efforts by enhancing first responder.

Modern manned DRER systems include ground vehicles, conventional aircraft, and rotorcraft capabilities and providing advanced predictive capabilities and early warning. A wide variety of system types of all sizes with varying capabilities already exist with even more under development.

Disasters or emergencies for which DRER UAV systems could be implemented include: severe storms, tornados, hurricanes, wild fires, tsunamis, floods, earthquakes, avalanches, civil disturbances, oil or chemical spills, and urban disasters.

Civil unmanned aerial vehicle systems have potential to augment disaster relief and emergency response efforts. Optimal design of aerial systems for such applications will lead to unmanned vehicles which provide maximum potentiality for relief and emergency response while accounting for public safety concerns and regulatory requirements.

1.2.4.2 Major Usage

Reconnaissance and Mapping The need for regular mapping of disaster-prone areas cannot be overstated. Flood maps help coordinate disaster response eff orts after events like the Superstorm Sandy storm surge; 3D topographical mapping can help identify areas prone to mudslide; high-resolution visual imaging can help first responders flag critical infrastructure that needs to be secured immediately after a disaster; and advances in remote sensing technology have opened new possibilities in developing early warning signs for potential disasters. For example, British researchers operating in Malaysia have used drones to map patterns of deforestation that have been correlated with increased incidences of malaria.

Maps constructed quickly in the wake of a disaster are also useful tools for identifying and assessing damage, especially when combined with images of the area before a disaster. For this to be most efficacious in assisting relief operations, "before" maps must be very recent, while "after" maps must be created as swiftly as possible.

Unfortunately, in the aftermath of a disaster, mapping may take too long using satellites or traditional manned aircraft. Satellite imaging technology cannot currently penetrate cloud cover, often leading to delays in image capture after extreme weather events.

Structural Integrity Assessment Natural disasters such as earthquakes, hurricanes, tornadoes, tsunamis, and floods, as well as man-made disasters such as explosions and arson, can all cause immense damage to the structural integrity of buildings and infrastructure. Even small-scale events can cause serious damage. For example, the 2011 Virginia Earthquake, though measuring only 5.8 on the Richter scale, caused significant structural damage to such famous landmarks as the Washington Monument and the National Cathedral.

Assessing structural damage after a disaster comes with many potential risks. Assessors may have to enter buildings in danger of collapse or access hard-to-reach places like the undersides of bridges. Drones have proven their usefulness in assessing structural damage over a wide area, locally, and even in building interiors.

Chemical, Biological, Radiological, Nuclear, or Explosive (CBRNE) Events Heavy industry and power generation relies on hazardous chemicals and fuels, including fi ssile material to create nuclear power. Malfunctions in factories or power plants, accidents while transporting hazardous materials, terrorism and criminal sabotage all have the potential to create unexpected chemical, biological or nuclear disasters. These devastating events require fast and eff ective disaster response and relief eff orts, but by their nature are extremely unsafe for relief workers. Characteristics of CBRNE events are: •Toxic / radioactive / explosive environments.

- Toxic / radioactive / explosive environments.
- Unprepared / disrupted surfaces.
- Rapidly changing environmental situations.
- Lack of information and data on the extent of the disaster.

Drones significantly reduce human exposure to unsafe environments while providing continuous monitoring and data validation in the most extreme conditions. Sending drones into a CBRNE area can help rescue workers quickly and safely locate sources of contamination/danger and the scope of the damage, providing invaluable situational awareness. Drones can also be used to repair damage, quickly deliver needed equipment to disaster teams, and apply chemical retardants or dispersants. Additionally, most drones can be deployed from unimproved locations, ensuring that even if airfields are not present or are unusable, aircraft can still be deployed to the area.

While drones have been used primarily in post-CBRNE disaster damage assessment and establishing situational awareness, the uses of drones in these environments are nearly endless.

For example, drones could have been used to distribute goods to the family of Thomas Duncan, the man infected with the Ebola virus in Liberia, who returned to Dallas, Texas, in fall 2014.

Drones have many uses in the preparedness and prevention stages of disaster, as well. For instance, drones fitted with methane sniff ers could detect a gas leak in a storage tank before it ignited.

Search and Rescue Operations Many dynamic tactical challenges accompany search and rescue operations [4]. Searching for people or wreckage over vast areas like deserts, oceans, rugged mountainous and forested terrain can be very time consuming and difficult. This can lead to crew fatigue, decreasing their effectiveness in searching and increasing the likelihood of pilot error. Furthermore, once survivors are located, many rescue / evacuation operations must be carried out in hazardous environments (CBRNE, low visibility, rugged terrain, etc.). The use of unmanned systems in these situations allows operations to be conducted without exposing a flight crew to unnecessary danger. Search and rescue operations often embody the "3-D" model (Dull, Dirty, Dangerous) of missions best suited to drones.

Insurance Claims Response and Risk Assessment Insurance companies play an invaluable role in assisting disaster relief efforts. When people lose their homes and possessions and when businesses stuff er property damage and business interruption, insurance companies are there to provide them with the material support they need to begin the rebuilding process. Insurance coverage can help disaster-stricken areas recover much more quickly and comprehensively than would have been possible otherwise. For these reasons, it is imperative that insurance companies act as eff actively and efficiently as possible in the wake of a disaster. Insurance companies could use drones to fly over an affected area, assessing damage to insured property, developing situational awareness for deploying additional claims adjusters on the ground, and supporting the claims response process. Using drones will also reduce the inherent dangers of inspecting damaged properties. Drones provide more options to review properties, which otherwise would be inaccessible due to safety concerns.

Logistics Support The damage to infrastructure that occurs after major disasters is often one of the most signifi cant obstacles to effi cient disaster relief. Blocked roads, damaged rail, and destroyed sea and airports can severely curtail disaster recovery by delaying delivery of needed supplies and equipment.

Drones provide an alternative for logistical support after a disaster. Drones can fly above destroyed infrastructure, and many, particularly rotary-wing craft, do not require runways for takeoff.

Drone logistics support will also help disaster responders directly. Any extra time that disaster responders can devote to actively mitigating a disaster or searching for and rescuing survivors will save lives and reduce costs. Many rescue workers currently devote substantial time to establishing logistical support for other responders, ferrying equipment and essential supplies like food and water. Drones can help speed up this process.

1.2.4.3 Advantages in Disaster Relief and Emergency Response:

- Drone technology can reduce disaster worker exposure to unnecessary danger:
  - Drones function in environments that are unsafe for humans.
- Drones enhance the effectiveness of responders
  - In addition to relieving disaster responders from some of their most dangerous duties, drones can perform dull and dirty tasks to allow responders to focus on more important matters.
- Drones provide unique viewing angles at low altitudes not possible from manned aircraft
  - For example, a team from several European universities, called NIFTi, used two small rotary-wing drones to assess damage to cathedrals in Mirandola, Italy, after an earthquake in 2012. Such an assessment is impossible with manned systems.
- Drone technology is highly deployable
  - Drones, particularly small models, can be launched in a variety of environments without the need for a runway.
- Drone technology is cost-efficient
  - While a robust drone system can require significant upfront capital cost, drones are still often cheaper than manned aircraft to purchase and operate. Furthermore, by developing relationships with drone service companies, emergency response organizations can pay only for the tools that they need before and after disasters, lowering costs.

1.2.5 Using drones in Wind Turbine Inspection

Wind Turbine Inspections involve identification of defects such as: Dents, Cracks, Delamination, Gel-coat degradation, Paint peel-off, Lightning Strike damage, Lightning Receptor damage, Vortex Generator damage, Fiber Wrinkles, Manufacturing anomalies, installation damage, etc.

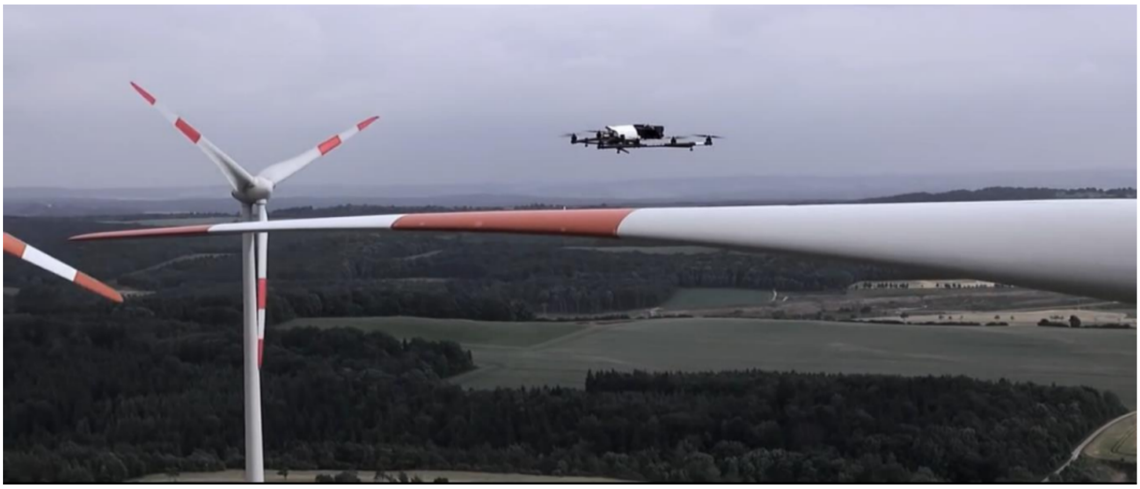


Figure 1.35: Wind Turbine inspection

1.2.6 Using drones in Other Applications

- Meteorological Monitoring (Humidity – Wind – Pressure – Temperature - .....) in various locations to get a Meteorological map
- Police or Military reconnaissance Especially in mountainous areas
- Industrial roof inspections
- Surveying & Mapping
- Solar panels inspections
- Civil inspection
- Pipeline and power line inspections

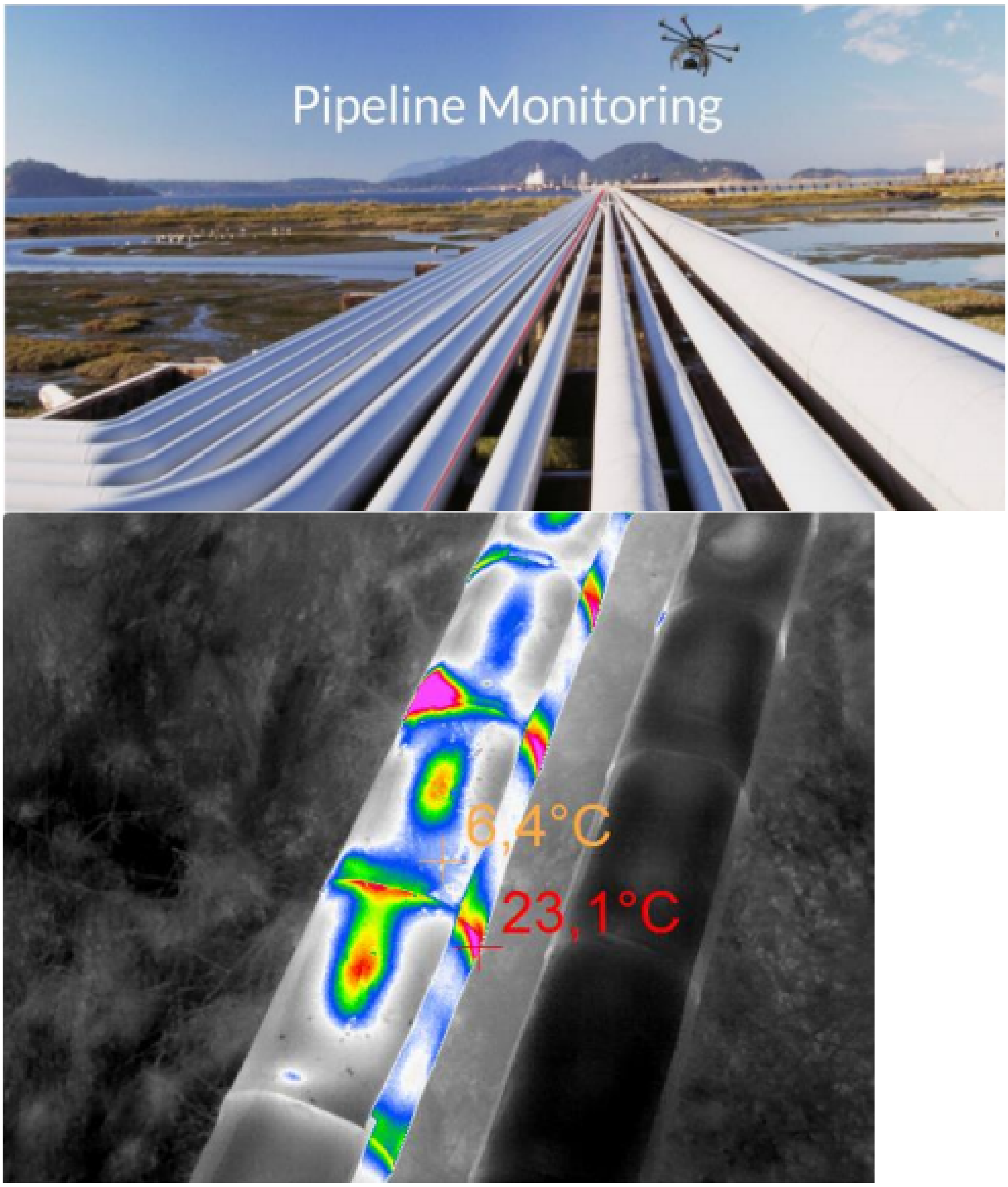


Figure 1.36: Pipeline inspections

- Tunnels inspections Especially narrow ones
- Racing Besides it can be integrated with VR (virtual reality)

- Internet access(Google project)

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