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UAV-BASED THERMAL AND MULTISPECTRAL MONITORING OF POTENTIAL IRRIGATION-RELATED ANOMALIES IN SURFACE AND SUBSURFACE DRIP-IRRIGATED POTATO

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A ABSTRACT | STUDY PURPOSE & APPROACH

Drip-emitter clogging can create uneven water availability and localized crop responses. This study assesses whether repeated UAV thermal and multispectral imagery can map spatial anomalies potentially associated with irrigation-related water deficits in surface- and subsurface-drip potato. The planned monitoring covers 1,500 m² of surface drip and 2,000 m² of subsurface drip, using a DJI Matrice 300 RTK with Zenmuse H30T thermal and CHNSpec FS-500 multispectral sensors. Thermal patterns and NDVI, NDRE and GNDVI will be compared through time to identify persistent, spatially coincident anomalies. Airborne observations are treated as a non-invasive screening layer—not proof of emitter clogging or its cause.

KEYWORDS UAV • multispectral imagery • thermal mapping • drip irrigation • emitter clogging • potato cultivation

01 1 | RESEARCH PROBLEM & OBJECTIVE

- **Why emitter reliability matters.** Physical sediment, soil intrusion, chemical precipitation, fertigation deposits and biological growth can restrict discharge and produce non-uniform wetting.
- **Why UAV monitoring.** Hydraulic checks (pressure, emitter discharge and distribution uniformity) provide direct evidence, but may require substantial field work and may not quickly show the spatial extent of emerging anomalies.
- **Study objective.** Evaluate the feasibility of thermal + multispectral UAV screening to prioritize areas for subsequent irrigation-system inspection in both irrigation configurations.

02 2 | STUDY AREA & EXPERIMENTAL DESIGN

PLANNED PARAMETER	SURFACE DRIP	SUBSURFACE DRIP
Monitored area	1,500 m²	2,000 m²
Irrigation layout	Laterals at soil surface	Laterals buried below surface
Nominal depth / interval	45 mm / 7 days	45 mm / 7 days
UAV survey / flight	Weekly • 50 m AGL	Weekly • 50 m AGL
Ground validation	Not planned	Not planned

Potato (Solanum tuberosum L.): Bellarosa, Carrera, Redsec and Brașovia. One principal plot per configuration; comparison is descriptive, not a replicated test.

03 3 | UAV PLATFORM & SENSOR PAYLOADS

DJI MATRICE 300 RTK • RTK georeferencing • H30T and FS-500 flown separately, as close together as practicable

ZENMUSE H30T | THERMAL

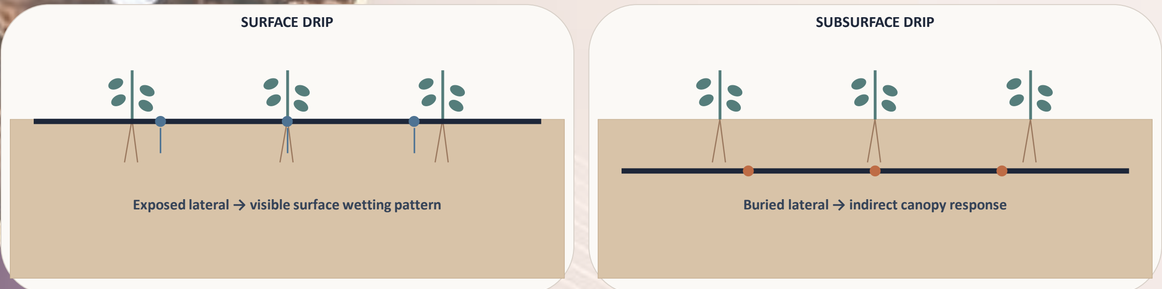
- 8–14 µm uncooled VOx microbolometer
- 1280 × 1024 radiometric JPEG (R-JPEG)
- High Gain mode for temperature extraction
- Apparent soil / canopy temperature

CHNSPEC FS-500 | MULTISPECTRAL

- 16-bit TIFF imagery
- Green 555 nm; Red 660 nm
- Red-edge 720 nm; NIR 840 nm
- NDVI, NDRE and GNDVI

ZENMUSE P1 RGB (SUPPLEMENTARY) • crop-row delineation, canopy gaps and visible surface features. No ground-control points are planned; RTK supports repeat-date alignment.

04 4 | WHY SURFACE AND SUBSURFACE SIGNALS DIFFER



SURFACE DRIP: when soil is exposed, local cooling / wetting and evaporation may be visible directly. SUBSURFACE DRIP: the buried lateral is not visible; surface signals are indirect, mediated by soil heat transfer and plant water status. As canopy closes, observations increasingly represent vegetation rather than soil.

05 5 | FLIGHT PROTOCOL, PROCESSING & INDICES

- **Acquisition.** Weekly surveys through the growing season; 50 m AGL; initial overlap 80% forward / 70% side; ideally ~24 h before the next irrigation (about six days after the previous event). Avoid wet canopy and flights immediately after rainfall.
- **Thermal processing.** Extract radiometric temperature from original R-JPEG (DTAT3 or equivalent); keep emissivity, target distance and atmospheric settings consistent. High-Resolution mode is not used for quantitative temperature.

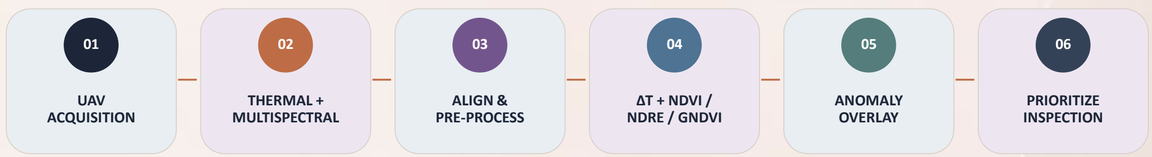
$$NDVI = (NIR - Red)/(NIR + Red) \quad \bullet \quad NDRE = (NIR - RedEdge)/(NIR + RedEdge) \quad \bullet \quad GNDVI = (NIR - Green)/(NIR + Green)$$

- **Multispectral processing.** Align 16-bit bands and apply the manufacturer workflow consistently. Without a confirmed independent reflectance panel, emphasize within-date spatial patterns and relative temporal change—not absolute reflectance comparability.
- **Spatial analysis.** Provisionally use 1 × 1 m cells (subject to GSD / row geometry); compare local anomalies using median and MAD. A ~2 robust-SD threshold is exploratory, not a validated diagnostic limit.

IMAGE-DERIVED INDICATORS

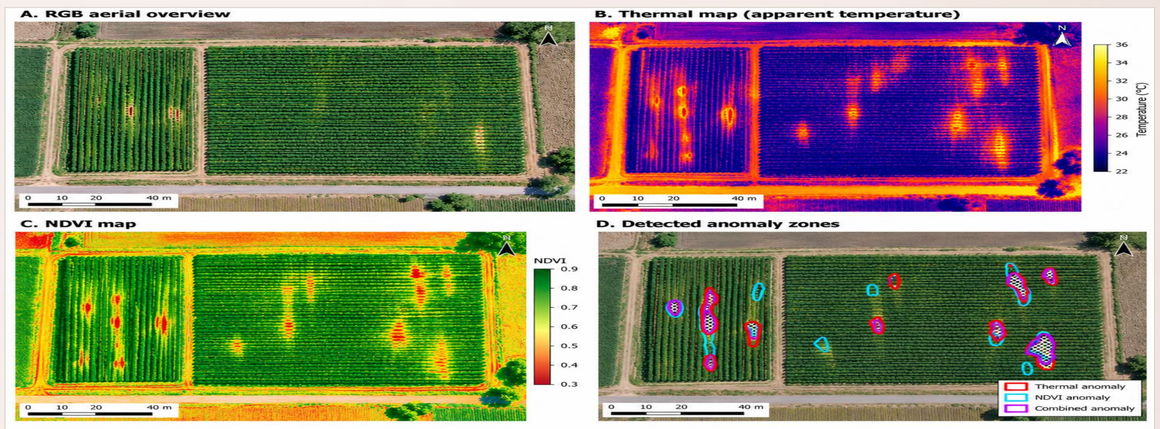
ΔT and ΔVI (candidate vs. local reference) • anomalous area (%) • temporal persistence (%) • thermal–spectral overlap (IoU). These quantify image contrast and repeatability—not diagnostic accuracy.

06 6 | MULTISENSOR WORKFLOW



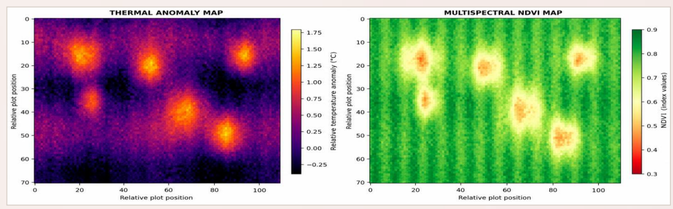
OUTPUT: georeferenced maps • thermal-only / spectral-only / coincident zones • area, persistence and cross-sensor agreement

07 7 | UAV IMAGE PRODUCTS — SOURCE FIGURE 2



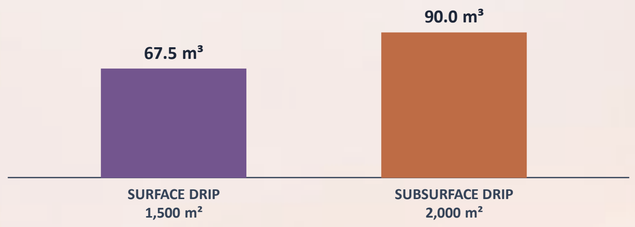
A RGB aerial overview • B thermal apparent-temperature map • C NDVI map • D candidate anomaly zones. Thermal and spectral layers are complementary; mapped zones indicate locations for review, not confirmed emitter defects.

08 8 | EXAMPLE OF THERMAL–SPECTRAL SPATIAL COMPARISON



Thermal anomaly and NDVI example raster (source Figure 3). Used to demonstrate co-registration and candidate-zone comparison; the manuscript describes this as an example, not a validated diagnosis.

09 9 | PLANNED IRRIGATION VOLUME PER EVENT



COMBINED NOMINAL VOLUME

157.5 m³

Calculation: area × 0.045 m (45 mm). 67.5 + 90.0 = 157.5 m³ per event. Theoretical planned volumes—not measured discharge or evidence of uniform application.

10 10 | INTERPRETING ANOMALIES: SIGNAL ≠ DIAGNOSIS

OBSERVED PATTERN	POSSIBLE INTERPRETATION	ALTERNATIVE EXPLANATIONS
Warm canopy + lower NDVI/NDRE; persistent	Possible water-deficit candidate	Disease, nutrition, soil, cultivar or phenology
Warm exposed-soil patch; no canopy signal	Wetness / evaporation contrast	Texture, shade, rainfall, solar exposure
Low vegetation index; no thermal anomaly	Canopy condition / development change	Plant gaps, disease, nutrients, senescence
Cool soil patch; no canopy response	Recent wetting / surface-energy difference	Shade, drainage, emissivity
Pattern follows a row / suspected lateral	Prioritize field inspection	Row geometry or planting variability; not proof

11 11 | CONCLUSION & VALIDATION PRIORITY

- **Core conclusion.** Thermal and multispectral imagery can provide complementary, non-invasive spatial screening for candidate irrigation-related anomalies in both drip configurations.
- **Validation required.** Without soil-moisture, emitter-discharge, pressure and distribution-uniformity measurements, the study cannot confirm malfunctions or report sensitivity, specificity or diagnostic accuracy. Future field checks are essential.

STUDY CONTEXT: Timișoara, Western Romania • Potato plots under surface and subsurface drip irrigation • Exploratory UAV screening; hydraulic and soil-moisture validation remains [illegible]