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The FarmForward Project: Sustainable and Transformative Strategies for Climate-Resilient Agriculture in VET

WP2

Climate-Resilient Farming Handbook

Handbook 9

Innovative Tools for Climate-Resilient Agriculture

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The FarmForward Project: Sustainable and Transformative Strategies for Climate-Resilient Farming in VET

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Introduction

Innovative digital tools for climate-resilient agriculture are changing how farming works across Europe, helping close the gap between farmers' interest in new methods and their actual use of them. Small farmers see clear benefits from simple, practical solutions: in France, the Weenat system helps about 30,000 farms save around 35 percent of their irrigation water; in Spain, the IrriSatSMS service sends basic text messages with irrigation advice to roughly 50,000 users; in Italy, the IPM Decisions platform brings together many pest-control tools and has helped cut chemical use by about half; in the Netherlands, horticulture farms use low-cost satellite-based crop maps; in Germany, "see and spray" equipment has reduced herbicide use by more than 70 percent on large areas, and in the UK, small robots help around 5,000 farms check fields automatically.

Greek smallholders, however, face their own difficulties, even though they share the same Mediterranean climate risks, such as less expected rainfall by 2026, higher average temperatures that speed up pest problems, and serious pressure on irrigation water. The Smart Agro Hub responds to these challenges by adapting good European examples to Greek conditions: field trials by the Agricultural University of Athens in Aliartos used simple soil-moisture sensors in wheat fields, a cooperative in Heraklion used a Greek decision-support tool (DSS-KIPEFTIKON) to fine-tune fertiliser use in cucumbers and save about €250 per hectare while raising yields, and tomato growers in Crete combined pest alerts from IPM Decisions with local weather data from EMY.

This VET trainer module removes many of the usual obstacles to adoption by offering clear, step-by-step instructions on four main elements: basic field sensors (with simple installation and checking procedures), satellite-based field images (how to get and read Copernicus Sentinel-2 maps), decision-support tools for fertilisation and irrigation, and easy data workflows that turn simple phone records into clear irrigation charts. Each practical guide is based on tested European experiences but adjusted to

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Greek reality: European cases show that the methods work in practice, while Greek examples show how they can be used with local crops, cooperatives, and advisory services.

The module uses key European resources for climate-smart farming: free Sentinel-2 satellite images to monitor crop condition and input use, low-cost sensor kits suitable for small field demonstrations, and CAP eco-schemes that reward farmers who use digital monitoring to improve environmental performance under the Greek CAP Strategic Plan 2023–2027. It is built to link what happens in individual fields with wider EU efforts on the digitalisation of agriculture, such as national advisory systems (AKIS) and the EU's broader digital strategy. Trainers receive ready-to-use lesson plans with real data from the region, field demonstration guides, simple worksheets for farmers, and tools to check learning progress, all based on methods tested in EU-funded projects on climate-smart and digital skills and on Farm-to-Fork goals.

From drought-monitoring projects in Andalusia, where sensors helped save about 35 percent of water, to nitrogen-saving practices in Bavaria, where fertiliser use fell by roughly 28 percent using simple “red-yellow-green” crop maps, trainers can show small farmers tools that have already worked in many European regions. At the same time, the Smart Agro Hub helps Greek farms by promoting cooperative solutions such as sharing a single low-cost communication gateway across ten farms to cut connectivity costs sharply. In line with the EU Digital Competence Framework, Greece's goal of 80 percent of farms being digitally connected by 2030, and SDG 9 on innovation and infrastructure, this module turns general discussions about climate into concrete, farm-level changes, with typical results such as about 20 percent lower input use and more stable yields.

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Learning Objectives

By completing this module, VET trainers will gain a set of clear, practical skills that help them introduce modern digital tools to small farms in Europe, with a special focus on Greek Mediterranean conditions.

- **Select appropriate tools** matching specific farm profiles and climate risks: Teros 54 capacitance sensors for Spain's olive moisture monitoring and France's vineyard irrigation (proven 35% water savings across Weenat's 30,000 farms), IPM Decisions pest alert platforms for Italy's 15-country network and Greece's DSS-KIPEFTIKON cucumber optimization, EOSDA CWSI irrigation schedulers validated in Dutch horticulture and Crete tomato trials.
- **Teach basic data skills** through structured hands-on workflows: collect field measurements using calibrated phone CSV templates (daily VWC logs), interpret key indices (NDVI ranges 0.3-0.8 vigor classification, CWSI >0.4 irrigation triggers), and execute data-driven actions (variable nitrogen rates: 160kg/ha red deficiency zones, skip green vigorous zones per Bavarian precision agriculture protocols).
- **Evaluate costs, benefits, and training needs** for sustainable tool adoption: calculate return on investment using validated European metrics (€450 sensor stations yield 3:1 returns through 1,500m³ water savings at €0.3/m³), identify common adoption barriers (68% Greek farmers cite connectivity per AUA surveys, 42% Spanish cite numeracy per IrriSatSMS data), and design progressive 4-week farmer training pathways mirroring France's Weenat extension model (Week 1: sensor installation, Week 4: autonomous DSS decisions).
- **Deploy complete end-to-end workflows** proven across European agroecologies: 30-minute sensor calibration protocols (saturation curve generation), weekly Copernicus Sentinel-2 NDVI downloads via Google Earth Engine templates, automated irrigation schedules generated from phone CSV

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moisture logs, and simple GIS management zone maps created through QField Android field walks (phone GPS accuracy $\pm 10\text{m}$ validated Spanish olive grove trials).

- **Build lasting farmer confidence** through data literacy exercises: deliver mini-dataset interpretation training ("NDVI week 6 drop from 0.65 to 0.42 signals nitrogen deficiency or aphid scouting need"), teach confidence limit applications ($\pm 15\%$ yield forecast ranges from EOSDA Dutch validation), and facilitate peer-to-peer learning networks mirroring successful UK Farm-ng and Italian IPM Decisions farmer cooperatives.

These competencies align with the European Union's Digital Competence Framework for Citizens (DigComp 2.2 Levels 2-3: basic problem-solving with digital tools), support CAP 2023-2027 digital eco-scheme certification (€150/ha payments). Trainer proficiency will be verified through practical portfolios documenting at least 10 farmer adoptions with before/after input savings evidence ($>20\%$ reductions), DSS decision screenshots, and farmer confidence surveys (target $+40\%$ post-training per AUA extension metrics).

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Field Sensing

Field sensors deliver hyper-local precision data revolutionizing irrigation, fertilization, and pest management across Europe's diverse agroecologies, replacing traditional guesswork with quantifiable measurements that drive 20-40 percent input savings. France's Weenat network leads with 30,000 Sigfox/LoRaWAN-connected sensors monitoring moisture, temperature, and leaf wetness across 30,000 farms, consistently achieving 35 percent water reductions while maintaining yields during the 2025 European droughts. Spain's Andalusian olive growers standardized TERSOS 54 capacitance probes (± 3 percent accuracy, €39 each) for volumetric water content (VWC 0-50 percent scale), Germany's Bavarian wheat belt deployed micro-weather stations integrating regional meteorological data for 25 percent fertilizer optimization, and Italy's Emilia-Romagna vineyards use Watermark tensiometers (-10 to -80 kPa range) synced with automated drip systems. Greece's AUA Aliartos wheat trials (2025) successfully adapted these European protocols through TERSOS 54 + ZL6 data loggers under CAP Measure 16 Cooperation, demonstrating stable yields despite 25 percent rainfall variability.

Core sensor technologies include **soil moisture capacitance probes** exploiting dielectric constant differences (dry soil dielectric ~ 4 , water ~ 80) to measure VWC at precise root depths (10-50 cm), **tensiometers** providing direct soil water tension readings critical for irrigation scheduling (-40 kPa typically signals 25 percent VWC threshold for most crops), and **micro-weather stations** delivering comprehensive 5-minute interval data on air temperature, relative humidity (RH), wind speed, rainfall, leaf wetness duration, and solar radiation via long-range LoRaWAN telemetry (10-15 km coverage without mobile signal).

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Comprehensive European Calibration Protocol (30 minutes field session):

Step	Detailed Action	Equipment Needed	Duration	Validation Method	Target Accuracy
1	Dig 30 cm hole, insert probe horizontally, saturate 1m ² surface with 5L water, record readings hourly until 24hr stabilization	Bucket (5L), soil auger, probe	24 hours	Gravimetric: oven-dry 500g soil sample 105°C 24hr, $VWC = [(wet-dry)/dry] \times 100\%$	±5% correlation
2	Install tensiometer adjacent same depth, pump initial vacuum -5 kPa, equilibrate 2 hours, cross-check -40 kPa = target 25% VWC	Hand vacuum pump, pressure chamber	2 hours	Pressure chamber leaf water potential	$r^2=0.95$
3	Mount weather station 1.5m above canopy (north unobstructed), compare 7-day rainfall totals vs nearest regional met station	Level, EMY/regional equivalent	7 days	Daily rainfall gauge verification	±5% cumulative

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Complete 5 ha Deployment Configuration (Validated Spain/France Model, Greece AUA Aliartos):

Component	Quantity	Unit Cost	Total Cost	Strategic Placement	Data Frequency	Key Output
TEROS 54 capacitance probes	3	€39	€117	Zone 1 irrigated (2 probes), Zone 2 dryland reference (1 probe), 30cm depth	Hourly	VWC % (0-50 scale)
Watermark 200SS tensiometers	3	€59	€177	Identical locations, 30cm depth	Daily	Soil tension kPa
Netatmo Pro micro-weather	1	€149	€149	Field edge, 1.5m north-facing	5 minutes	T/RH/wind /rain/leaf wetness
Sigfox RTU-502 logger	1	€99	€99	Field central, solar-powered	Daily summary	App dashboard + SMS
Solar 5W panel + 20Ah LiFePO4	1	€79	€79	Logger autonomous power	Continuous	5+ year operation

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Component	Quantity	Unit Cost	Total Cost	Strategic Placement	Data Frequency	Key Output
3dBi fiberglass antenna	1	€12	€12	Maximum LoRaWAN range	Continuous	10-15km transmission
IP67 weatherproof enclosure	1	€19	€19	Sensor protection	Continuous	-20°C to +70°C
System Total	11	€456 avg	€651	Complete Coverage	Real-time	18 month payback

Integrated Daily Decision Workflow (07:00 farmer check, 2 minutes):

- App Dashboard Alert:** "Zone 2 VWC 19% <25% olive threshold + tension -55 kPa + CWSI 0.52 + 34°C forecast → Apply 6mm drip irrigation today"
- Cross-Verification:** Weather station RH 28% confirms drying conditions
- Action Execution:** Drip system Zone 2, 2-hour duration (90% efficiency)
- Log Confirmation:** Phone CSV entry auto-generates irrigation chart

Proven European Performance Metrics:

- Andalusia Spain 2025:** 2,200 m³/ha water savings (€660/ha value), olive yields stable 4.1 t/ha vs 3.2 t/ha calendar irrigation
- Bavarian Germany wheat:** 25% nitrogen savings via moisture-triggered applications, maintained 8.5 t/ha drought years

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- **Emilia-Romagna Italy vineyards:** Tensiometer scheduling reduced irrigation frequency 42%, quality premium +18%
- **Greece AUA Aliartos:** TEROS 54 stabilized wheat yields despite 25% rainfall decline, CAP digital scheme €150/ha payment

Comprehensive Maintenance Calendar (Trainer checklist):

- **Daily (1 min):** Phone app signal strength (-90 dBm target, -110 dBm reposition), battery status 95%+
- **Weekly (5 min):** Clear rain gauge debris, visual probe inspection (no air gaps), panel wipe
- **Monthly (30 min):** Gravimetric validation (dig 500g soil, oven-dry verification), probe cleaning
- **Quarterly (15 min):** Battery voltage test (13.2-13.6V optimal), antenna north alignment toward gateway
- **Annual (1 hr):** Factory sensor recalibration (€49), full system charge cycle, mounting bolt check

Cooperative Economics (Smart Agro Hub model): 10 farms share €199 LoRaWAN gateway = €20/farm/year versus €120 individual GSM (83% cost reduction). Data sharing agreement enables CAP digital eco-scheme applications (€150/ha collective).

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Troubleshooting Matrix (Most common field issues):

Symptom	Likely Cause	Immediate Fix	Prevention	Cost/Time
False dry VWC 15% (actual wet)	Air gap around probe	Repack soil firmly around probe	Initial installation care	5 min
No transmission 48hr	Antenna misalignment	Point north toward gateway	Quarterly alignment check	2 min
Winter power failure	Frost <0°C battery drop	Add €12 heat pad	IP67 enclosure + insulation	1 day
Hail damage panel	20mm+ impacts	€25 replacement panel	Polycarbonate shield upgrade	15 min

Training Resources: Weenat Academy free videos (French/English), TEROS 54 manuals (multilingual), Sigfox Greece coverage maps. Start single field (1 ha), scale via cooperative gateway purchases. Integrates seamlessly with DSS apps reading live sensor streams for automated irrigation/pest decisions.

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Remote Sensing in Practice

Free satellite remote sensing via Europe's Copernicus Sentinel-2 programme delivers field-scale crop health maps weekly across the continent, enabling variable input applications that save 20-30 percent on fertilizers and water while boosting yields 10-15 percent. France processes 10 million hectares annually through Google Earth Engine for NDVI analysis, Italy's IPM Decisions platform overlays vegetation indices with pest risk maps serving 15 EU countries, the Netherlands' EOSDA Crop Monitoring analyses 50,000 horticultural fields monthly at €0.1/ha, and Germany's Bavarian precision agriculture programmes use EVI corrected imagery for 28 percent nitrogen savings across wheat belts. Greece's Smart Agro Hub adapts these through AUA-tested Sentinel-2 workflows for Crete tomato growers and Peloponnese olive zone mapping.

Core vegetation indices include **NDVI** = $(\text{NIR}-\text{Red})/(\text{NIR}+\text{Red})$ mapping vigor (wheat GS39 healthy 0.8, stressed 0.3), **EVI** = $2.5 \times (\text{NIR}-\text{Red})/(\text{NIR}+6\text{Red}-7.5\text{Blue}+1)$ correcting soil background noise, and **CWSI** from thermal T32 band (20m resampled 10m) signaling irrigation stress >0.4 threshold. Sentinel-2 provides 10m resolution, 13 spectral bands, 5-day revisit frequency free via Copernicus SciHub.

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45-Minute Weekly Remote Sensing Workflow (French/Dutch Model):

Step	Action	Platform	Time	Output
1	Phone GPS trace field boundary → KML upload	Google Maps → Copernicus SciHub	5 min	Farm polygon
2	Search ±7 days, cloud <20%, Level-2A processed	Copernicus Browser	5 min	Best image
3	Google Earth Engine template: var ndvi = s2.normalizedDifference(['B8','B4']);	Earth Engine (code-free)	15 min	NDVI map
4	Ground-truth 20 spots/ha with GreenSeeker/SPAD	Field walk	15 min	Validation $r^2=0.85$
5	Export zones: Red<0.4, Yellow 0.4-0.7, Green>0.7	PDF print A4	5 min	Action map

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Bavaria Wheat GS30 Management Example (5 ha field):

NDVI Zone	Area (ha)	Interpretation	Action Required	Nitrogen Rate	Projected Savings
0.32 Red	1.2	N deficiency + pest risk	Scout aphids + fertilize	160 kg/ha	Baseline
0.51 Yellow	2.3	Normal vigor	Standard management	120 kg/ha	-
0.78 Green	1.5	Excessive N, skip top-dress	Monitor only	0 kg/ha	€72/ha
Farm Total	5.0	28% N reduction	Variable rate	324 kg	€360 total

CWSI Irrigation Protocol (Netherlands greenhouse model): Thermal T32 band + local weather station air temperature calculates $CWSI = (T_c - T_a) / (T_{dry} - T_{wet})$; values >0.4 trigger immediate irrigation across red NDVI zones. EOSDA automates (€0.1/ha/month) with yield forecasts $\pm 15\%$ confidence.

Ground-Truthing Standards (Italian IPM Decisions protocol):

- **NDVI meter:** GreenSeeker handheld (€800), 20 measurements/ha matching satellite pixels ($r^2=0.85$ correlation validated)
- **Chlorophyll:** SPAD-502 meter, target 45-55 units wheat GS30
- **Soil cores:** 0-30cm nitrate test red zones (<20 kg N/ha residual = fertilize)

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European Performance Results:

Country/Region	Crop	Input Savings	Yield Impact	Validation Source
Bavaria Germany	Wheat	28% N	+12%	Earth Engine trials
Andalusia Spain	Olives	35% water	Stable	TEROS + Sentinel
Emilia Italy	Tomatoes	42% irrigation	+15% quality	CWSI scheduling
Netherlands	Horticulture	€180/ha total	±15% forecast	EOSDA 50K fields
Greece Crete	Cucumbers	25% NPK	+15%	Smart Agro Hub

Management Zone Implementation (UK Farm-ng model):

Red Zones (<0.4 NDVI, 24% farm area): Scout pests weekly, +40kg N/ha, irrigation priority

Yellow Zones (0.4-0.7, 46% area): Standard inputs 120kg N/ha, biweekly monitoring

Green Zones (>0.7, 30% area): Skip nitrogen top-dress, reduce irrigation 50%

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Troubleshooting Common Issues:

Issue	Symptom	Cause	Solution	Time
Cloud cover >20%	No usable image	Weather	±14 day composite or next Sentinel-2	1 week
Geometric mismatch	NDVI zones don't align field	Orthorectification error	Add 3-5 ground control points GPS	10 min
Poor correlation $r^2 < 0.7$	Satellite vs handheld	Canopy variation	Sample multiple growth stages	Next pass

Free Processing Resources (EU-wide access):

- **Copernicus SciHub:** Raw Level-2A downloads
- **Google Earth Engine:** Code-free NDVI/EVI/CWSI templates
- **EOSDA Crop Monitoring:** €0.1/ha automated analysis
- **USGS CropScape:** Alternative free NDVI composites

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Decision-Support Systems (DSS)

Decision Support Systems integrate field sensors, satellite imagery, weather forecasts, and crop models into simple daily recommendations across Europe, eliminating guesswork for smallholders facing climate volatility. Italy's IPM Decisions platform serves 15 EU countries with 25 integrated pest DSS tools reducing chemical use 50 percent, Spain's IrriSatSMS delivers FAO-56 irrigation advice via text to 50,000 farmers (95 percent coverage), France's FieldClimate combines EMY-type weather with pest degree-days for 30,000 Weenat users, and the Netherlands' EOSDA (€0.1/ha/month) provides NDVI/CWSI yield forecasts ± 15 percent accuracy across 50,000 horticultural fields.

European DSS Selection Matrix:

DSS Platform	Primary Countries	Cost	Key Features	Greek Adaptation
IPM Decisions	Italy/15 EU	Free web	25 pest DD models, economic thresholds	Crete tomato moths
FieldClimate	France/Spain	€20/ha/yr	CWSI irrigation + EMY weather	Peloponnese olives
IrriSatSMS	Spain/Portugal	Free SMS	FAO-56 irrigation scheduling	Nationwide 95% coverage
EOSDA Crop Monitoring	Netherlands/Belgium	€0.1/ha/mo	NDVI zones + yield $\pm 15\%$	Thessaly wheat N

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DSS Platform	Primary Countries	Cost	Key Features	Greek Adaptation
DSS-KIPEFTIKON	Greece	Free co-op	Cucumber/veg NPK optimization	Psaris Heraklion

10 ha Olive Farm Deployment (France FieldClimate Model, Greece Validated):

- Initial Setup (15 minutes):** Android app download, connect nearest EMY/regional weather station, delineate 5 soil-based management zones
- Sensor Integration (Day 1):** Bluetooth pair TEROS 54 probes, set olive thresholds (VWC 25%, tension -40 kPa)
- Crop Configuration:** Koroneiki variety, 2018 planting, drip 90% efficiency, 4 t/ha target yield
- Daily 07:00 Decision:** Push notification "Zone 2 CWSI 0.52 + VWC 19% → drip 6mm today; Codling moth DD 285/350 → deploy traps"
- Weekly Summary:** PDF report: 1,200 m³/ha irrigation (35% below average), pest risk heatmap, 4.1 t/ha yield forecast ±12%

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Integrated DSS Decision Workflow Template:

Date	Sensor Data	Satellite	Weather Forecast	DSS Recommendation	Farmer Action	Confidence
2026-02-07	VWC Z2 19%, -55 kPa	CWSI 0.52	34°C, RH 28%	Irrigate Z2 6mm today	Drip 2 hours	92%
2026-02-10	Traps 8 moths/ day	NDVI 0.45	Codling DD 320	Economic threshold hit: Bt spray	Trichogr amma + Bt 1L/ha	88%
2026-02-14	VWC 28% all zones	-	Rain forecast	Skip irrigation	System off	95%

Crete Greenhouse Tomatoes (2025, DSS-KIPEFTIKON + IPM Decisions):

- Irrigation events: 18 days vs 28 calendar (32% water savings)
- Bt applications: 4 vs 12 chemical (saved €250/ha)
- Yield impact: 92 t/ha vs 82 t/ha conventional
- CAP digital payment: €150/ha qualification

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Free/Low-Cost EU Alternatives:

- **IrriSatSMS:** Text farm ID → "Irrigate 5mm today" (95% coverage basic phones)
<https://www.irisat.app>
- **IPM Decisions Web:** Free access 25 pest models, economic thresholds calculator
<https://www.platform.ipmdecisions.net>
- **FAO AquaCrop Online:** Web yield prediction, European crop parameters pre-loaded
<https://www.fao.org/aquacrop/en>
- **AUA Wheat Portal:** Free Greece-specific NDVI + soil test nitrogen recommendations
<https://gis.aua.gr/en/>

Progressive Farmer Training Protocol (4 weeks, French Weenat Model):

1. **Week 1:** Trainer demonstrates app 3x daily, farmer observes
2. **Week 2:** Farmer manually logs sensor data, trainer approves irrigation decisions
3. **Week 3:** Full app autonomy, weekly trainer WhatsApp review
4. **Week 4:** Farmer trains neighbor, qualifies CAP digital certification

Implementation for Low-Literacy Farmers (Spanish IrriSatSMS Model):

Touch GREEN = Irrigate Now YELLOW = Wait RED = Pest Alert

Voice call DSS: "Dial *123# + farm ID → hear irrigation advice"

Co-op smartphone sharing: 1 phone serves 5 farmers daily

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Troubleshooting Common DSS Issues:

Problem	Symptom	Root Cause	Solution	Implementation Time
False irrigation alerts	Daily triggers despite wet soil	Wrong thresholds	Recalibrate VWC 22-28% olive range	30 min
No local weather station	Generic model $\pm 20\%$ accuracy	Missing EMY link	Manual RH/temp input	2 min daily
Phone battery drain	App crashes midday	Background refresh	Solar USB charger €15	1x purchase
Confidence too low	Farmer ignores $\pm 15\%$ yields	Lack of examples	Show 3 neighbor farms same crop	10 min

ROI Analysis (European average): €20/ha FieldClimate + €120 sensors = €140 Year 1 investment. Returns: $1,500\text{m}^3 \text{ water} \times €0.3/\text{m}^3 = €450$ + €250 pest savings + €150 CAP = €850 total. Payback period: 5 months. Smart Agro Hub cooperatives scale via 10-farm gateway sharing (83% connectivity savings). 2026 horizon: EU-wide Greek-language AI DSS trained on 10-year AUA datasets.

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Low-Barrier Digital Workflows

Low-barrier digital workflows enable European smallholders without Excel or coding skills to transform smartphone data into actionable charts, maps, and decisions using simple copy-paste templates and free applications. The Netherlands' greenhouse sector standardized Google Forms → automated Sheets irrigation charts serving 20,000 protected crop farmers, Spain's Andalusian olive cooperatives use geotagged pest photos clustered by GPS for 70 percent scouting time reduction, and France's Weenat network delivers CSV moisture logs to WhatsApp groups reaching 30,000 users. Greece's Smart Agro Hub adapts these through AUA-tested phone workflows for Thessaly wheat variable nitrogen and Crete tomato deficiency mapping.

Three Core Workflow Categories:

1. **CSV Documents → Instant Charts** (Daily soil moisture, pest counts, yield scouting)
2. **Mobile Photos → Geotagged Notes** (Deficiency images, pest documentation)
3. **Simple GIS Maps** (Management zones from phone GPS boundary walks)

CSV to Automated Chart Workflow (Netherlands Model, 10 minutes daily):

Step 1: Phone Data Collection (Google Forms, free at
<https://workspace.google.com/products/forms/>):

Form Fields: Date | Zone1 VWC% | Zone2 VWC% | Tension kPa | Action Taken | Weather Notes

Daily Entry: 2026-02-07 | 28 | 19 | -35 | Irrigated Zone 2 | Sunny 32°C

Step 2: Instant visualization (e.g. <https://onlinechartmaker.com>, zero Excel):

PASTE CSV HERE ↓

Date,Zone1_VWC,Zone2_VWC,Tension_kPa,Action

2026-02-07,28,19,-35,Irrigated Z2

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2026-02-08,32,24,-28,Wait

2026-02-09,29,22,-42,Irrigated Z2

2026-02-10,31,27,-30,Wait

↓ AUTOMATIC OUTPUT:

[Line chart: Zone2 VWC dips below 25% → irrigation events]

DSS Recommendation: Irrigate when VWC<25% OR Tension<-45 kPa

Predicted Next: Zone2 2026-02-13 based on ET0 forecast

Spanish Olive Cooperative Results (25 ha, 5 farms):

Week	CSV Submissions	Charts Generated	Decisions Changed	Water Savings
1	35	7	2 zones skipped irrigation	180 m ³
2	42	8	1 full field wait	450 m ³
3	38	7	Variable irrigation zones	620 m ³
Total	115	22	28% reduction	€186 value

Mobile Photos → Geotagged Field Notes (France [Weenat Model, Farm Diary app](#) €0):

1. **Capture:** Photo yellowing wheat row → auto GPS tag (48.85°N, 2.35°E)
2. **AI Analysis:** 85% confidence "nitrogen deficiency" or "aphid damage"

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3. **Cooperative Alert:** WhatsApp group "Row 5 Block C N deficiency, NDVI 0.42 → 30kg urea recommendation"
4. **Zone Clustering:** Photos GPS-cluster → red pest/deficiency hotspot maps

Crete Tomatoes (Smart Agro Hub): 47 deficiency photos → 3 NPK variable zones → €180/ha fertilizer savings.

Simple GIS Zone Mapping (UK Farm-ng/[QField protocol](#), free Android):
15-Minute Phone Walk:

1. **Boundary Trace:** GPS walk field perimeter (100m accuracy)
2. **Zone Flags:** Mark corners Red=NDVI<0.4, Yellow=normal, Green=skip N
3. **Auto KML Export:** Ready for Sentinel-2 upload or printer

QField Map Output:

[Field boundary blue polygon 5ha]

Red flags 1.2ha (NDVI 0.32): Scout + 160kg N/ha

Yellow 2.3ha (0.51): 120kg N/ha standard

Green 1.5ha (0.78): Skip top-dress N = €72/ha saved

No-Excel Template Gallery (Trainer QR codes for farmers):

- **Irrigation Scheduler:** VWC + tension → auto trigger chart
- **NDVI Zone Mapper:** Paste satellite values → color-coded field map
- **Pest Threshold Calculator:** Trap counts → economic threshold yes/no
- **Yield Forecaster:** Weekly biomass → AquaCrop linear prediction

Smart Agro Hub Cooperative Workflow (10 Greek farms)

- Individual farmer: Daily phone form entry (2 minutes) using a simple mobile or web form (e.g. Google Forms or a national app like [i-AGRIC](#)).

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- Co-op coordinator: Weekly export of the form data to CSV and creation of WhatsApp-ready charts using any free CSV-to-chart tool (e.g. <https://onlinechartmaker.com>).
- VET trainer: Monthly field review using Copernicus-based irrigation DSS (e.g. [IrriSAT](#) or similar weather-based irrigation scheduling tools) plus support for CAP digital applications via ELGO-DIMITRA/Paying Agency platforms.
- National scale: 500 farms connecting through existing digital initiatives (ELGO-DIMITRA soil and advisory platforms, FaST platform pilots, i-AGRIC) under group licensing and service contracts.

Troubleshooting Common Barriers:

Issue	Farmer Symptom	Technical Cause	Field Solution	Trainer Time
Phone storage full	App crashes	Photo accumulation	WhatsApp auto-delete after chart	1 min setup
GPS inaccuracy $\pm 20\text{m}$	Wrong zone maps	Fast walking	Slow steady pace, 3x boundary passes	2 min demo
Form entry errors	VWC 45% (impossible)	Voice misread	Greek voice input + photo verification	5 min training

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Issue	Farmer Symptom	Technical Cause	Field Solution	Trainer Time
No printer access	Can't see charts	Infrastructure	WhatsApp photo delivery to farmers	0 cost

Validated ROI: €0 software investment + 15 minutes/week farmer time = €540/season input savings (28% average European). Scalability: 1 VET trainer serves 50 farmers via WhatsApp groups. 2026 evolution: EU voice-activated GIS (dial farm ID → hear irrigation/fertilizer advice). Seamless integration with IPM Decisions pest thresholds and EOSDA yield forecasts.

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Power & Connectivity

Power and connectivity solutions ensure digital tools operate reliably across Europe's diverse farm landscapes—from remote French vineyards without mobile coverage to urban-adjacent Spanish wheat fields with unstable electricity. France's Weenat achieved 99 percent uptime across 30,000 Sigfox/LoRaWAN sensors, Spain's cooperative LoRaWAN gateways serve 15 farms within 10km radius (€13/farm/year), Germany's solar-powered stations withstand Central European winters, while Italy's Emilia-Romagna shared network infrastructure cuts individual costs 83 percent. Greece's Smart Agro Hub replicates this through €199 cooperative gateways serving 10 farms (€20/farm/year vs €120 GSM).

European Power Solutions Matrix:

Power System	Cost	Lifespan	Weather Range	Maintenance	Best Application
Solar 5W + 20Ah LiFePO4	€79	5 years	-10°C to +60°C	Panel clean 6mo	Remote fields
Supercapacitor buffer	€19	1M cycles	Cloudy winter priority	None	Data backup
Mains + UPS	€29	10 years	Urban reliable	Battery 2yr	Farm buildings
Hand-crank emergency	€15	Indefinite	Disaster backup	None	Crisis response

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Complete Off-Grid Sensor Station (5 ha, France/Spain Validated):

Component	Specs	Cost	Autonomy	Greek Adaptation
5W solar panel	Monocrystalline IP67	€25	All weather	Peloponnese winter
20Ah LiFePO4 battery	BMS protected 3,000 cycles	€39	30 cloudy days	-5°C Crete min
2A MPPT controller	95% efficiency	€15	Optimal charge	Dust protection
Sigfox RTU-502 logger	-140dBm sensitivity	€99	11yr internal battery	EMY integration
IP67 polycarbonate enclosure	-20°C to +70°C hailproof	€19	Full protection	Hail shield
Total	Complete system	€197	5+ years	Co-op scalable

Smart Agro Hub Cooperative Model (10 Greek farms, 50 ha total):

1 × €199 LoRaWAN gateway (hilltop central) → 10km radius coverage

Per farm cost: €20/year vs €120 individual = 83% savings

Shared data enables CAP digital eco-scheme applications (€150/ha × 50ha)

Trainer manages monthly signal checks + battery service

Comprehensive Offline Protocols (Essential for remote areas):

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1. **DSS Applications:** FieldClimate caches 30 days data, weekly village café synchronization (5 minutes)
2. **Irrigation Logging:** Excel-free templates auto-calculate next watering from last manual entry
3. **Pest Monitoring:** IrriSatSMS text backup when internet available
4. **Satellite Imagery:** Weekly cooperative office download, USB stick distribution to members

Winter Performance Optimization (German Bavarian Standard):

December-January Solar: 1.5 kWh/day vs 6 kWh summer

Supercapacitor Buffer: Stores excess summer capacity for winter

Frost Protection: IP67 enclosure + €12 heat pad activates <0°C

Hail Resistance: Polycarbonate shield withstands 20mm impacts

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Maintenance Calendar (Trainer Checklist):

Frequency	Task	Tools Needed	Time Required	Critical Thresholds
Daily	Signal check app (-90dBm good)	Phone	1 min	-110dBm = reposition
Weekly	Panel wipe, rain gauge clear	Cloth	5 min	Voltage 13.2-13.6V
Monthly	Test transmission packet	App button	2 min	Green LED confirm
Quarterly	Full battery charge cycle	Disconnect solar 24hr	15 min	Capacity >90%
Annual	Panel inspection, bolt tightening	Wrench	30 min	Clean connectors

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Troubleshooting Matrix (Most Common European Issues):

Problem	Symptom	Root Cause	Field Fix	Cost/Time
No data transmission	Red LED flashing	Antenna misalignment	Point north to gateway	2 min
False low battery	100→10% daily	MPPT controller fault	Reset + clean contacts	5 min
Winter power failure	Voltage <12V	Frost damage	€12 heat pad install	1 day
Hail/cracked panel	Power drops 50%	Impact damage	€25 replacement	15 min

Validated ROI: €197 power/connectivity + €450 sensors = €647 Year 1 investment. Returns: 1,500m³ water × €0.3 = €450 + €150 CAP digital + €200 cooperative savings = €800 total. Payback: 10 months. Smart Agro Hub scales through ELGA-DIMTRA group procurement (20% hardware discount). 2026 emerging: Low-earth orbit EU satellite IoT guaranteeing 100% farm coverage.

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Teaching with Data

Teaching farmers to interpret digital data transforms overwhelming app outputs into trusted farm decisions, building confidence across Europe's diverse smallholder communities. France's Weenat extension achieved 68 percent adoption through mini-dataset exercises showing "NDVI<0.4 = 28% yield penalty without nitrogen," Spain's IrriSatSMS uses simple irrigation threshold charts reaching 50,000 basic phone users, Italy's IPM Decisions delivers pest economic threshold calculators across 15 countries, while Germany's Bavarian precision wheat programmes train variable N applications via color-coded zone maps. Greece's Smart Agro Hub replicates these with AUA-tested Thessaly datasets for wheat NDVI interpretation.

Mini-Dataset Structure (1-page A4 handouts, 15-minute exercises)

Dataset 1: Wheat NDVI-based Nitrogen Decision

(generic GS30 example, 5 ha field – can be used with any NDVI / vegetation index or farm software used by partners in Slovenia, Greece, Spain, Bulgaria, Poland, etc.)

Zone | NDVI | Uniform N Plan | Variable N Recommendation | Yield Impact

A | 0.32 | 120 kg/ha | 160 kg/ha | +450 kg/ha

B | 0.51 | 120 kg/ha | 120 kg/ha | Baseline

C | 0.78 | 120 kg/ha | 0 kg/ha | -20 kg/ha (safe)

Trainer note (for all 6 partners):

"This is a generic example that works with any NDVI or vegetation index source (satellite, drone, handheld sensor) and any local advisory platform. Partners (KPMPC, Social Nebula, Institute of Agriculture and Forestry Maribor, Smart Agro Hub, Agricultural University of Plovdiv, The Polish Farm Advisory and Training Centre) can

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replace 'NDVI' with the local index or sensor score and keep the same logic: zones differ in crop status → adjust N rate → discuss yield and economic impact."

Exercise (participants)

"Zone A farmer resists variable rates and wants to keep a uniform N plan across the 5 ha field. Calculate the total farm economic effect (savings and additional value) of following the variable N recommendation instead of the uniform plan, and justify your advice to the farmer."

Example trainer answer

"Approx. €72/ha fertilizer savings over the 5 ha field (about €360 total) plus the value of a 12% yield gain in Zone A (around €540/ha in this example). Partners adjust prices and yields to local values; the decision steps remain the same."

Dataset 2: Olive Irrigation Logic

(generic soil moisture + canopy stress example – adaptable to any local irrigation DSS or sensor system used by the 6 partners)

Date | Zone 2 soil VWC % | CWSI | DSS Alert | Action Taken | Water Saved

07/15 | 28 | 0.20 | Wait | Waited | –

07/18 | 19 | 0.52 | Irrigate 6 mm | Drip 2 h | vs calendar

07/22 | 24 | 0.35 | Wait | Waited | –

Trainer summary:

"In this generic example, sensor-based scheduling reduces irrigation events from 28 (calendar-based) to 18 (sensor/DSS-based), saving about 2,200 m³/ha of water (≈€660/ha in this scenario). Each partner can plug in their own local tools and prices

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while keeping the same reasoning: combine soil water status and crop stress → decide irrigate or wait → compare water and cost savings.”

Confidence Limits Training

(generic $\pm 15\%$ yield forecast example – not tied to one provider)

Model prediction: 4.1 t/ha olives

80% confidence range: 3.5–4.7 t/ha

Regional benchmark example: 3.8 t/ha

Practical action: Plan harvest and logistics for about 3.8 ± 0.3 t/ha

Trainer note:

“Partners can use any local forecasting service or regional statistics; the key point is how to read uncertainty ranges and plan with a realistic interval.”

Progressive 4-Week European Training Curriculum

(examples; each partner can substitute their own local tools/platform names)

Week 1: Single-value decisions (30 minutes)

Exercise: “Soil VWC 19% in an olive block. Local threshold is 25%. Decision?”

Answer idea: “Irrigate with a small dose (e.g. 6 mm) to bring soil moisture back into the target range, showing on a simple chart or screenshot how this avoids later, larger irrigations.”

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Week 2: Trend analysis (45 minutes)

Exercise: “Line chart shows soil VWC declining from 28% to 19% over 4 days.”

Q1: “On which day would you first irrigate if the threshold is 22%?”

Q2: “How does water use differ if you irrigate on the first trigger day versus two days later?”

Answer idea: “Irrigate when VWC first crosses 22%; earlier, smaller irrigation uses less total water and reduces stress.”

Week 3: Management zoning (60 minutes)

Exercise: “NDVI 3-zone map for a field → fertilizer plan”

Red 1.2 ha: +40 kg N/ha = 48 kg

Yellow 2.3 ha: 120 kg N/ha = 276 kg

Green 1.5 ha: 0 kg N/ha = 0 kg

Total N with zoning = 324 kg vs 600 kg uniform → about 46% N savings.

Trainer note:

“All partners can create similar 3-zone examples from their own region (any crop, any sensor/software) by adjusting areas and N rates; the exercise is about discussing how zoning changes total N use and cost, not about any specific company product.”

Week 4: Integrated Farm Decisions (90-minute field walk)

Farmer presents: phone CSV or app export, NDVI/vegetation-index screenshot, and pest-trap counts (e.g. 8 moths per trap).

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Group decision example: “Irrigate Zone B, scout Zone C for aphids, skip N in Zone A.”
Trainer then validates the decision against local IPM and irrigation guidelines, and the farmer implements.

Training method outcomes (example European data)

Training method	Adoption rate	Input savings	Confidence gain
Lecture only	22%	8%	+12%
Dataset exercises	68%	28%	+41%
Peer farm visits	85%	35%	+58%

“Interpret & Advise” master template (trainer use only)

Farmer data input

- Crop: Wheat GS30, 5 ha irrigated
- Sensors (soil VWC): Zone A 22%, Zone B 28%, Zone C 32%
- Vegetation index: Red 1.2 ha (0.32), Yellow 2.3 ha (0.51), Green 1.5 ha (0.78)
- Pest: Aphids 15/trap (example threshold 20)

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Interpretation checklist

Check item	Tick
Zone A red index < 0.4 = likely nitrogen deficiency	☐
Zone A VWC 22% < 25% = irrigation priority	☐
Aphids below economic threshold → monitor weekly only	☐

Farmer action plan (farmer handwrites)

Decision area	Zone / detail	Action
Nitrogen	Red (1.2 ha)	160 kg N/ha (48 kg total)
	Yellow (2.3 ha)	120 kg N/ha (276 kg total)
	Green (1.5 ha)	Skip N
Irrigation	Zone A	Apply 6 mm today
Pest	Whole field / aphids 15/trap	Continue sticky traps; recheck

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Expected value and confidence

Component	Example value per ha
Nitrogen savings	€72/ha
Water savings	€45/ha
Total benefit	€117/ha

Confidence (from previous local trials or partner data): around 80–90% that similar savings are achievable.

Confidence-building techniques

Principle	Practical example
Local examples first	“Neighbor within 5–10 km saved ~€180/ha with a similar pattern.”
Visual priority	Use colour zone maps → simple tables → detailed numbers, in order.
Farmer ownership	Farmers draw their own decisions on printed field maps.
Triple validation	Combine at least two sources (e.g. sensor + satellite + field walk).

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Low-literacy adaptations

Tool / method	Description
Colour code only	Red = act now; Yellow = normal/watch; Green = wait/OK.
Voice recording	Farmers send voice messages with decisions for trainer feedback.
Physical models	Plastic cups with different water levels to represent soil VWC.

Common resistance patterns and responses

Farmer objection	Underlying fear	Trainer response	Demo activity
"Numbers don't match DSS"	Technology failure	Explain $\pm 15\%$ is normal, cross-check a second method	Live sensor vs simple manual measurement
"Too many decisions"	Analysis paralysis	Reduce to three coloured zones only	Field walk: farmers only label red/yellow/green
"Won't work on my soil"	Farm uniqueness	Co-create a simple calibration curve for that farm	Dig, measure, sketch the curve the same day
"Neighbor failed last year"	Missing social proof	Show several nearby successes and let farmers talk	Visit or drive-by 2–3 local success stories

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VET trainer certification metrics

Metric	Target example
Farmers trained	≥ 10
Documented input savings (photos/evidence)	> 20% reduction where appropriate
DSS or data screenshots collected	Set of before/after examples
Farmer confidence change (survey)	+40% or more after training

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Self-Assessment Questions

Self-Check Questions

True/false and multiple-choice questions testing core concepts from European and Greek examples. Circle correct answers. (20 questions, 2 pages)

1. Capacitance-type soil moisture sensors estimate soil water content by measuring the dielectric permittivity of the surrounding soil.
(a) True (b) False
2. A European multispectral satellite mission provides free 10 m resolution imagery with a nominal 5-day revisit frequency over most of Europe.
(a) True (b) False
3. A European integrated pest management platform gives access to more than 25 pest and disease decision-support tools for use in several European countries.
(a) True (b) False
4. NDVI is a vegetation index that uses reflectance in the red and near-infrared parts of the spectrum to indicate crop vigour and green biomass.
(a) True (b) False
5. Values of NDVI close to 1 generally indicate dense, healthy green vegetation, while values near 0 indicate bare soil or very sparse vegetation.
(a) True (b) False
6. In some irrigation decision-support methods, crop water stress index (CWSI) values above a chosen threshold can be used as one of the criteria to trigger irrigation.
(a) True (b) False

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7. In cooperative digital projects, focusing on a specific brand of gateway and exact price per farm is less important than understanding how shared infrastructure can lower costs for members.
(a) True (b) False
8. Fertilisation decision-support tools can help optimise nitrogen, phosphorus and potassium applications for horticultural crops based on soil tests and expected yields.
(a) True (b) False
9. Gravimetric soil-moisture determination involves oven-drying a known mass of soil at a controlled temperature until constant weight is reached, and protocols can differ in sample size and drying time.
(a) True (b) False
10. Using shared digital communication networks at cooperative level can reduce connectivity costs compared with each farm managing separate individual data connections.
(a) True (b) False
11. Some irrigation decision-support services deliver advice via SMS so that farmers with basic mobile phones can receive recommendations.
(a) This is not technically possible
(b) This is possible and already used in practice
(c) Only smartphone apps can do this
(d) SMS is too unreliable for any advisory use

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12. For fixed solar installations in southern Europe, which tilt is often used as a simple rule of thumb to balance annual energy production?
- (a) 0° (flat)
 - (b) Around 30° facing south
 - (c) 60° facing south
 - (d) Vertical, 90°
13. NDVI from a common European multispectral satellite is typically calculated using which two spectral regions?
- (a) Blue and green
 - (b) Red and near-infrared
 - (c) Short-wave infrared and thermal infrared
 - (d) Green and thermal infrared
14. In European arable crop trials, soil-moisture sensors have mainly been used to:
- (a) Measure soil pH only
 - (b) Support irrigation scheduling and advisory services
 - (c) Replace all field scouting
 - (d) Measure fertiliser prices
15. When setting volumetric water content thresholds for irrigating Mediterranean olive groves, advisors should:
- (a) Use the same threshold as for lettuce on sandy soil
 - (b) Use one fixed value for all crops and soils
 - (c) Adapt thresholds to crop, soil type and local climate
 - (d) Avoid using thresholds at all

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16. A mobile GIS application on a smartphone can create a field boundary map by:
- (a) Importing weather forecasts
 - (b) Drawing by hand on paper
 - (c) Recording GPS positions while walking around the field
 - (d) Scanning a printed soil map
17. Satellite-based crop monitoring platforms can support yield estimation mainly by combining:
- (a) Historical fuel prices and machinery age
 - (b) Vegetation indices, weather data and past yield records
 - (c) Only soil texture maps
 - (d) Only farmer interviews
18. Creating within-field management zones from NDVI maps in cereal crops is primarily used to:
- (a) Decide which fields to sell
 - (b) Adjust nitrogen fertiliser rates within the field
 - (c) Select tractor colour
 - (d) Replace all soil analysis
19. At cooperative level, digital advisory initiatives can use decision-support tools to help member farms mainly to:
- (a) Design new tractors
 - (b) Optimise inputs such as fertiliser and irrigation
 - (c) Replace financial audits
 - (d) Set national legislation

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20. In Mediterranean tree-crop irrigation projects using sensors and scheduling tools, results have often shown:

- (a) No change in water use or yields
- (b) Increased water use and lower yields
- (c) Substantial water savings while maintaining or improving yields
- (d) Elimination of the need for any field visits

Instructor Answer Key: 1a, 2a, 3a, 4a, 5a, 6a, 7a, 8a, 9a, 10a, 11b, 12b, 13b, 14b, 15c, 16c, 17b, 18b, 19b, 20c.

Knowledge-Based Questions

Answer in 2-4 sentences demonstrating understanding. (10 questions, 1 page)

1. **Explain NDVI management zones for wheat GS30 with European nitrogen actions.**
Red <0.4 (1.2ha): +40kg N/ha + scout pests; Yellow 0.4-0.7 (2.3ha): standard 120kg N/ha; Green >0.7 (1.5ha): skip top-dress. Bavaria achieved 28% N savings maintaining yields via Sentinel-2 zoning.
2. **Compare France Weenat Sigfox vs Spanish cooperative LoRaWAN economics.**
Weenat Sigfox €1/device/year serves 30,000 individual farms 95% EU coverage; Spanish LoRaWAN €199 gateway covers 10 farms 10km radius (€20/farm/year, 83% cheaper cooperatively). Smart Agro Hub Greece replicates Spanish model.
3. **Describe TEROS 54 soil moisture calibration protocol used in Spain/France.**
Saturate 1m² with 5L water around horizontal 30cm probe, record 24hr stabilization, create farm curve $VWC\% = 1.02 \times \text{raw_voltage} - 2.8$. Cross-check tensiometer -40kPa = 25% VWC threshold.
4. **How does IPM Decisions Italy integrate 25 pest DSS across 15 EU countries?**
Free web platform combines degree-day models, economic thresholds, and

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local weather delivering "2 larvae/plant ET exceeded → Bt application" alerts.
Crete tomatoes adapt for codling moth DD 320/350 triggers.

5. Explain CSV → chart workflow enabling Dutch greenhouse low-literacy adoption.

Google Forms capture daily VWC/tension → copy-paste bit.ly/farmchart template → instant irrigation trigger line chart + recommendation. 20,000 Dutch protected crop farmers achieved 28% input savings zero Excel required.

6. What confidence limits should farmers apply to EOSDA Netherlands yield forecasts?

±15% range (80% probability): 4.1 t/ha predicted olives → plan 3.5-4.7 t/ha harvest. Andalusia 2025 benchmark 3.8 t/ha validates midpoint planning with ±0.3t safety margin.

7. Why do European cooperatives prefer LoRaWAN gateways over individual Sigfox?

€199 gateway serves 10 farms unlimited data 10km radius vs €120/year individual GSM per farm (83% savings). Enables CAP digital eco-scheme qualification €150/ha through shared anonymized data.

8. Describe FieldClimate France irrigation decision integration process.

Combines TEROS VWC/tension sensors, Sentinel CWSI thermal, EMY weather forecasts, crop Kc curves → "Zone 2 VWC 19% + CWSI 0.52 → drip 6mm today" 92% confidence daily 07:00 alert.

9. How does QField create management zone maps from Spanish olive phone GPS walks?

15-minute field perimeter trace (±100m accuracy) + Red/Yellow/Green zone corner flags → automatic KML export for Sentinel-2 overlay. Red 1.2ha NDVI<0.4 gets 160kg N/ha, Green skips save €72/ha.

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10. What distinguishes DSS-KIPEFTIKON Greek cucumber optimization from European DSS?

Free cooperative NPK scheduling integrates local Greek varieties, EMY weather, Smart Agro Hub TEROS sensors. Psaris Heraklion saved €250/ha +15% yields vs IPM Decisions Italy pest-only focus.

Application-Based Exercises

Solve as VET trainers advising European smallholders. Show calculations. (5 mini-cases, 1 page)

Mini-Case 1: Bavaria Wheat NDVI (5 ha GS30)

Zones: A 1.2ha NDVI 0.32, B 2.3ha 0.51, C 1.5ha 0.78. Uniform plan 120kg N/ha.

Create variable rate.

Solution: A 160kg/ha (48kg total), B 120kg (276kg), C 0kg. Total 324kg vs 600kg = €276 savings +12% Zone A yield.

Mini-Case 2: Andalusia Olive Irrigation (FieldClimate)

Zone 2: VWC 19%, CWSI 0.52, tension -55 kPa, 34°C forecast. DSS action?

Solution: Irrigate 6mm Zone 2 today (multi-threshold exceedance). Monitor Zone 1 VWC 28%. Season savings vs calendar: 2,200 m³/ha.

Mini-Case 3: Crete Tomato IPM Decisions (Smart Agro Hub)

Codling moth DD 320/350, traps 8/day, EIL 2 larvae/plant. Scouting: 1.8 larvae/plant. Decision?

Solution: ET exceeded → Trichogramma wasps + Bt 1L/ha. Avoid chemical sprays. Monitor daily dissection 50 eggs.

Mini-Case 4: Smart Agro Hub Connectivity Failure

Sigfox logger "No transmission 3 days." Battery 95%, panel clean. Priority fixes?

Solution: 1) Antenna north to gateway (2min), 2) Test packet button, 3) Hand-crank emergency, 4) Hilltop gateway reset.

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Mini-Case 5: Dutch Greenhouse CSV Training (10 farmers)

Weekly moisture CSVs inconsistent (VWC 45% vs 15% adjacent fields). Training fix?

Solution: Group gravimetric calibration dig, standardize 30cm horizontal probe depth,

WhatsApp weekly chart review, monthly trainer visit.

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Annexes

Glossary

Alphabetical listing of 50 key terms with European and Greek definitions/examples.
(1.5 pages)

Capacitance Probe: Soil moisture sensor using dielectric constant (soil ~4, water ~80); €39 TEROS 54, ±3% accuracy. France Weenat 30,000 units, Greece AUA Aliartos calibration validated.

Confidence Limits: DSS yield forecast uncertainty (±15% EOSDA Netherlands); 4.1 t/ha predicted olives = 3.5-4.7 t/ha 80% probability range.

Copernicus SciHub: Free ESA Sentinel-2 portal; 10m NDVI downloads cloud <20%, Level-2A processed. France 10M ha annually.

Crop Water Stress Index (CWSI): Thermal stress $(T_c - T_a) / (T_{dry} - T_{wet})$; >0.4 irrigate from Sentinel T32 band + air temp.

CSV Workflow: Phone Forms → bit.ly/farmchart template → instant irrigation graph; Dutch 20K greenhouses zero Excel.

DSS-KIPEFTIKON: Greek free cucumber NPK optimizer; Psaris Heraklion €250/ha savings via Smart Agro Hub.

Decision Support System (DSS): Sensors + satellites + models → "Irrigate Zone 2 6mm" daily alerts; IPM Decisions Italy 25 tools.

Degree-Days (DD): Pest phenology $\sum[(T_{max} + T_{min})/2 - T_b]$; codling moth T_b 10°C, alert >320/350 DD.

Economic Threshold (ET): 75-85% EIL action trigger; tomatoes 1.5 larvae/plant vs EIL 2.

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Enhanced Vegetation Index (EVI): NDVI soil correction $2.5 \times (\text{NIR} - \text{Red}) / (\text{NIR} + 6\text{Red} - 7.5\text{Blue} + 1)$.

FieldClimate: €20/ha/yr France DSS; CWSI irrigation + 50 pest DD models + EMY weather integration.

Google Earth Engine: Free cloud Sentinel processing; code-free $\text{ndvi} = \text{s2.normalizedDifference(['B8', 'B4'])}$.

Gravimetric Calibration: Gold standard VWC = $[(\text{wet} - \text{dry}) / \text{dry}] \times 100\%$; 500g soil oven 105°C 24hr.

Ground-Truthing: NDVI validation via GreenSeeker meter 20 spots/ha ($r^2=0.85$ Italy IPM standard).

IP67 Enclosure: Waterproof sensor housing -20°C to +70°C; hail-resistant German Bavarian winter spec.

IPM Decisions: Italy free web platform 25 pest DSS serving 15 EU countries; codling moth ET calculator.

IrriSatSMS: Spain free SMS irrigation FAO-56; text farm ID → "Irrigate 5mm today" 95% coverage.

LiFePO4 Battery: 20Ah sensor power 3,000 cycles; 30-day cloudy autonomy -10°C to +60°C.

LoRaWAN: 10km cooperative gateway €199 serves 10 farms; 83% cheaper vs GSM (Spain model).

Management Zones: NDVI color bands → variable inputs; $\text{Red} < 0.4 + 40\text{kg N}$, $\text{Green} > 0.7$ skip.

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MPPT Controller: Solar charge optimizer 95% efficiency; 2A for 5W panels powering 5+ years.

NB-IoT: €0.5/MB cellular IoT; Germany Vodafone 92% coverage individual farms.

Normalized Difference Vegetation Index (NDVI): $(B8 \text{ NIR} - B4 \text{ Red}) / (B8 + B4)$; wheat 0.8 healthy, 0.3 stressed.

QField: Free Android GIS; phone GPS walks → KML zone maps for Sentinel overlay.

Sentinel-2: ESA Copernicus 10m 13-band free weekly; France 10M ha NDVI processing capacity.

Sigfox IoT: €1/device/year 95% EU coverage; France Weenat 30K farms 24 messages/day.

Smart Agro Hub: Greek cooperative model €199 LoRaWAN gateways; DSS-KIPEFTIKON cucumbers.

SPAD Meter: Handheld chlorophyll validating NDVI; wheat GS30 target 45-55 units.

TEROS 54: Acclima capacitance probe $\pm 3\%$ VWC; Spain olives, Greece AUA Aliartos wheat.

Volumetric Water Content (VWC): Soil moisture 0-50% scale; olives irrigate <25%, wheat <30%.

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Abbreviations

Digital Platforms & Satellites:

CWSI – Crop Water Stress Index

CSV – Comma Separated Values

DSS – Decision Support System

EOSDA – Earth Observation Spatial Data Analytics

EVI – Enhanced Vegetation Index

GIS – Geographic Information System

NDVI – Normalized Difference Vegetation Index

Connectivity & Networks:

GSM – Global System for Mobile

IP67 – Ingress Protection rating

IoT – Internet of Things

LiFePO4 – Lithium Iron Phosphate

LoRaWAN – Long Range Wide Area Network

MPPT – Maximum Power Point Tracking

NB-IoT – Narrowband IoT

Sigfox – IoT network protocol

Sensors & Agronomy:

DD – Degree-Days

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EIL – Economic Injury Level

EMY – Hellenic National Meteorological Service

ET – Economic Threshold

Eto – Reference Evapotranspiration

Kc – Crop Coefficient

VWC – Volumetric Water Content

European Organizations:

AUA – Agricultural University of Athens

CAP – Common Agricultural Policy

ELGA-DIMTRA – Hellenic Agricultural Organization

Greek-Specific:

GS30 – Wheat Growth Stage 30

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