Climate Change AI

Shaping Your AI-for-Climate Project in Practice

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Agenda

1. Assessing AI fit and Technology Readiness
2. Data Pipelines and Deployment Pathways
3. Impact Assessment and Metrics
4. Stakeholders, Power & Sustainability

Ice breaker

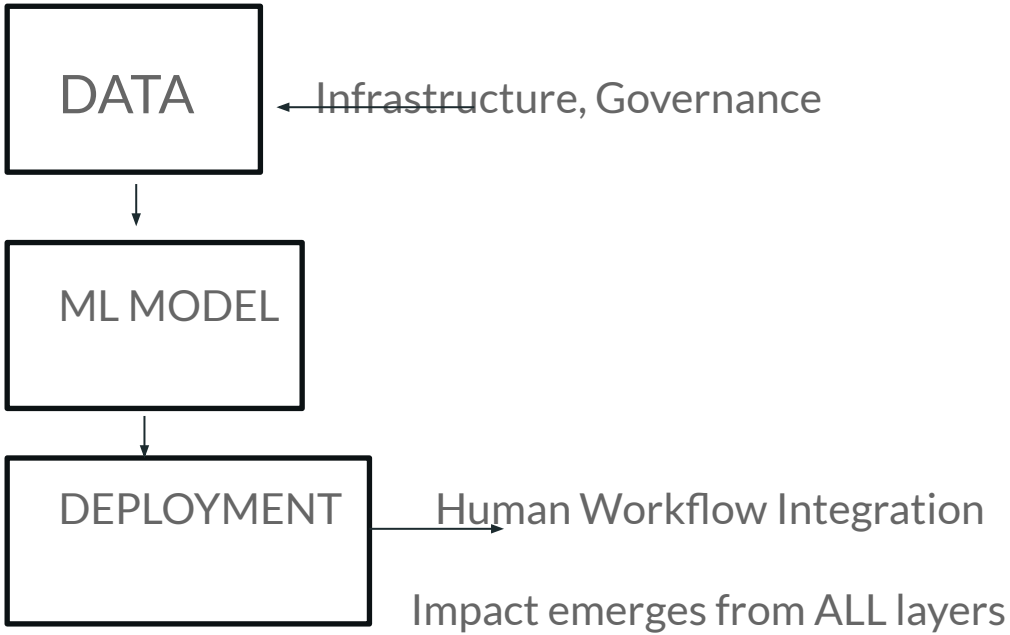
- Identify climate challenges where you think AI could help

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Key Concepts

- Machine Learning is Only One component



Assessing AI Fit & Technology Readiness

Is AI the Right Tool?

- Questions Before Choosing AI:
  - Do we have sufficient quality data available?
  - Are operational constraints compatible with AI workflows?
  - Will stakeholders accept algorithmic recommendations?
  - Could simpler methods achieve comparable outcomes?

Is AI the Right Tool?

- When AI adds value:
  - Complexity patterns, high dimensionality
  - Scalability demands, human-like speed augmentation path
  - Real-time inference required
- When simpler solutions suffice
  - Simple rule-based decisions
  - Limited data
  - High-stakes without explainability

Technology Readiness Levels in Climate Context

- What's deployable now vs. requires further innovation
- Risk of promising capabilities that don't exist yet
- Balancing ambition with feasibility

Technology Readiness Levels in Climate Context

DOABLE NOW

- Satellite-based deforestation monitoring
- Energy demand load prediction
- Carbon stock estimation
- Crop yield regional modeling
- Emission inventory automation

Technology Readiness Levels

REQUIRES INNOVATION

- Hyper-local microclimate forecasting
- Grid-scale renewable balancing agents
- Fully autonomous wildfire suppression
- Precision soil health diagnostics
- Cross-sectoral optimization cascades

Choosing an AI Approach

Task Type	Methods	Trade-offs
Regression/Forecasting	Random Forest, XGBoost	Speed vs Interpretability
Classification (binary/multi)	Logistic Regression, CNNs	Accuracy vs Complexity
Spatial analysis	GANs, Autoencoders	Resolution vs Compute
Anomaly detection	VAEs	Sensitivity vs False positives
Reinforcement learning	PPO, DQN	Flexibility vs Training stability

Choosing an AI Approach

Consideration checklist:

- Team expertise availability
- Latency requirements
- Model update frequency
- Hardware/software budget
- Regulatory/compliance needs

Case Study – Coffee Farming in Tanzania

- 4th largest producer in Africa
- 150,000 tones annually
- Revenue $100m to $135m annually
- Produced by 450,000 small family operations
- Farmers organized in Agriculture Marketing Co-operative Societies



TCB (2021), Tanzanian Coffee Industry Development Strategy 2020-2025, *Tanzania Coffee Board. https://shorturl.at/yNHMZ*

- Export markets for Tanzania coffee
- EU countries 40%
  - Germany, Belgium, Italy, Sweden and Poland
- Other markets 60%
  - USA
  - Japan, South Korea, China, India



EU Commission (2023), Regulation (EU) 2023/1115 on deforestation-free products. https://shorturl.at/ETo3z

- 90% of coffee export
  - Produced by smallholder farmers
  - No traceability information
  - Farmers geo-mapping is at 70% in two regions
  - Government owned central registry of coffee farmers
- 10% is direct export
  - Large estates
  - Traceability information available



TCB (2021), Tanzanian Coffee Industry Development Strategy 2020-2025, *Tanzania Coffee Board*

- Farmers Central registry
  - Costly for Government
  - Geo-mapping of farms is continuous exercise
  - Updating information (farm and farmers)
  - Sustainability of the platform not clear
- Risk of losing the EU market
- Evidence from Ethiopia: coffee farmers have switched to other crops



Sorokin, S. (2024), How are EUDR requirements implemented in companies' supply networks? *The case of Ethiopian Coffee sourcing*, *IIIEE Master Thesis*, Lund University.

Checkpoint 1

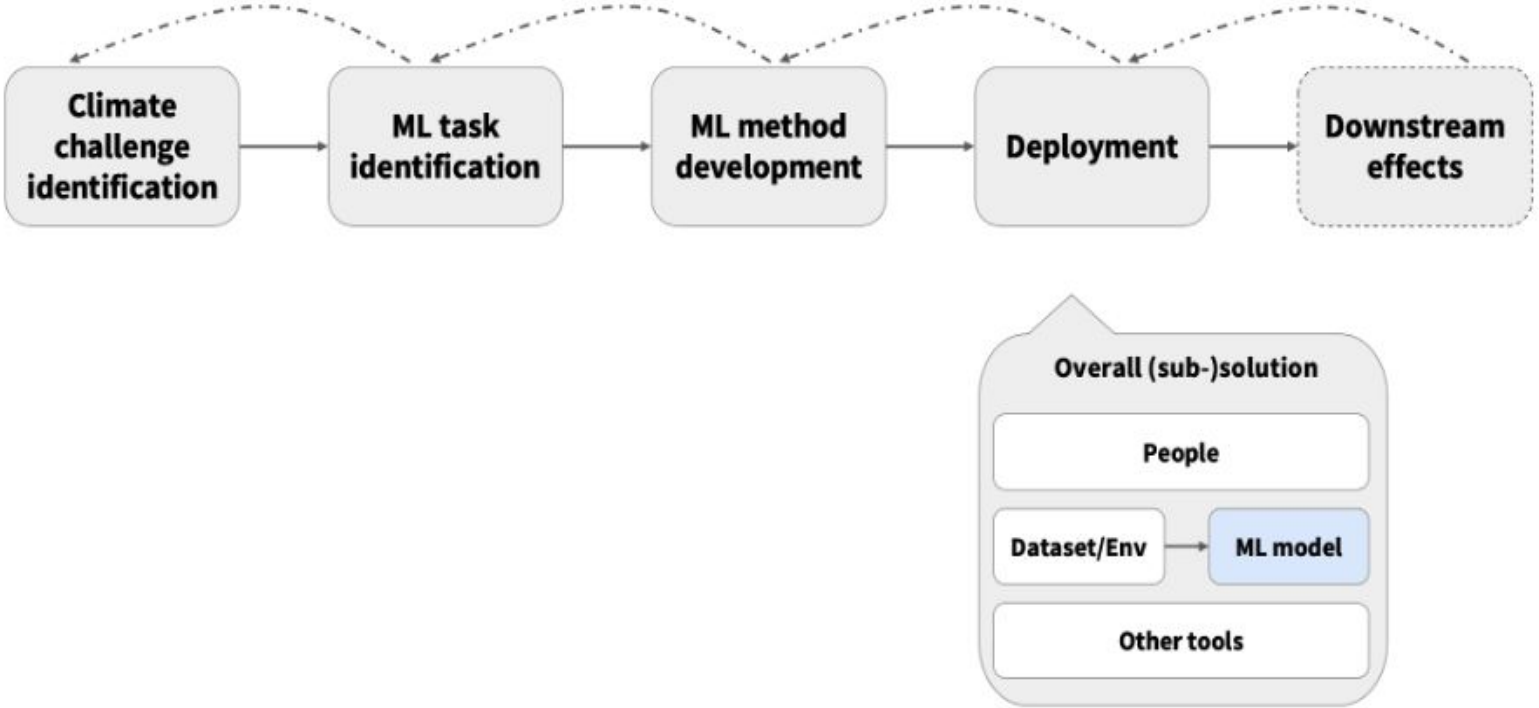
- Evaluate the proposed AI solutions for coffee farmers.
    - Select the “AI appropriate” use cases

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Data Pipelines & Deployment Pathways

Lifecycle of an ML-for-climate project



1. Stages of the Deployment Pipeline: Climate Challenge

Climate challenge identification

- Problem definition & stakeholder needs assessment

Case Study Integration: Coffee Farmers

- **Current System**: National coffee farmer registry for EUDR compliance (traceability)
- **Gap**: Registration alone doesn't help farmers adapt to climate change
- Smallholder farmers: the most vulnerable group to climate change.
- Challenge for farmers: Lack of information – experiencing and responding to climate change.

Mbwambo, S. et al (2021), Climate Change Perceptions by Smallholder Coffee Farmers in Northern and Southern Highlands of Tanzania, *Climate*; 9, 90. https://doi.org/ 10.3390/cli9060090

2. Stages of the Deployment Pipeline : AI Opportunities

ML Task definition

- Translate problem into formal prediction/classification/optimal control

Problem	Traditional Approach	AI Solution	Value Add
Climate risk assessment	Historical averages	ML weather forecasting	Farm-level predictions
Deforestation verification	Manual field visits	Satellite + computer vision	Real-time monitoring
Crop yield prediction	Expert experience	Ensemble models	Precision timing

3. Stages of the Deployment Pipeline: Modeling

ML Method development

- Model training, validation, iteration cycles
- Data availability vs. data adequacy (quality > quantity)
- Feature engineering for climate data (temporal, spatial, environmental)
- Model selection framework: interpretability vs. accuracy trade-offs
- Validation challenges in climate contexts (non-stationary environments)

3. Stages of the Deployment Pipeline: Modeling

ML model development for Coffee Farmers

- Computer Vision: Deforestation detection (ChangeNet / U-Net)
- Time-series: Yield forecasting (LSTM / Prophet)
- Classification: Disease risk scoring (Random Forest / XGBoost)
- Recommendation: Optimal harvest windows (RL-based optimization)

4. Stages of the Deployment Pipeline: Deployment

Deployment

- Full production with infrastructure and support

Output for Coffee farmers (ideal)

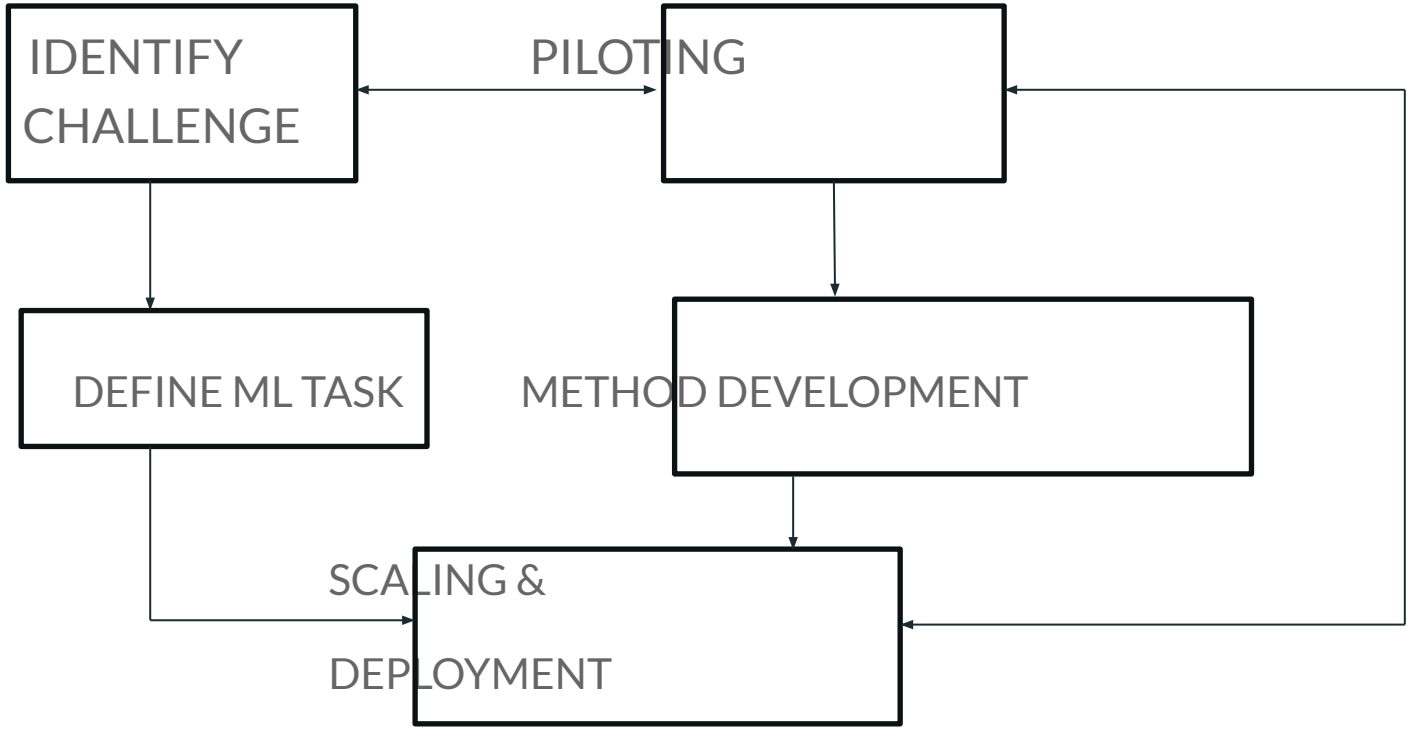
- EUDR compliance reports (automated)
- Climate risk alerts (SMS/USSD)
- Advisory recommendations (local language)
- Carbon credit eligibility

Stages of the Deployment Pipeline: Summary

1. Climate challenge identification -> Problem definition & stakeholder needs assessment
2. ML Task definition -> Translate problem into formal prediction/classification/optimal control
3. Method development -> model training, validation, iteration cycles
4. Pilot/ testing -> limited rollout measuring usability + early signals
5. Scaling/ deployment -> full production with infrastructure and support
6. Monitoring / maintenance -> performance tracking, drift correction, updates

Feedback Loop

- Every arrow represents opportunity to discover misalignment earlier



Feedback Loops Between Stages

- Iteration is necessary – not linear
- Early deployments inform model refinement
- Real-world performance data reshapes initial assumptions

ML as One Component

- Infrastructure dependencies (connectivity, hardware)
- Human-in-the-loop requirements
- Integration with existing workflows and decision systems

Checkpoint 2

- You’re leading an AI-for-climate project that predicts wildfire risk using satellite imagery and weather data. Your team is designing the deployment pathway.

Question:

- Which statement BEST reflects sound pipeline design for this project?

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Impact Assessing & Metrics

From Impact to Metrics

Process:

- Define desired outcome first,
- Identify measurable proxies
- Validate causal chain

Easy indicators ≠ Meaningful indicators

From Impact to Metrics

Desired Outcome	**Indicators**
Reduced greenhouse gas emissions	Fuel consumption ↓, kWh usage↓
Adaptation resilience improvement success	Crop loss severity ↓, evacuation success↑
Conservation effectiveness	Species population stability↑
Equity enhancement	Marginalized household participation↑

What Can and Cannot be Measured

- Direct measurables vs proxies
- Latent variables requiring inference
- Time lags between intervention and observable effects

Measurement Limitations

Directly Measured	Requires Inference / Modeling
Grid electricity consumption	Household appliance efficiency
Satellite vegetation indices	Below-canopy biodiversity
Export commodity volumes	Farmer income distributions
Building occupancy sensors	Occupant comfort perception
Traffic flow counts	Commuter air exposure levels

Unmeasured variables accumulate bias over time unless addressed explicitly

Short-Term vs Long-Term Metrics

Dimension	Short-term	Long-term
Examples	Adoption rate, model accuracy	Emission reduction, resilience improvements
Measurement frequency	Continuous/weekly	Annual/biennial
Attribution difficulty	Low-Medium	High
Intervention levers	Product design, UX	Policy, infrastructure investment

Checkpoint 3

- Your team is working on an AI-for-climate project that uses satellite imagery to detect illegal deforestation in protected rainforest areas. Your team is designing the impact assessment framework for funders and stakeholders.

Question:
Which metric framework BEST captures real climate impact while avoiding common measurement pitfalls?

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Stakeholders, Power & Sustainability

Stakeholder Mapping

Category	Characteristics	Engagement Needs
Shapers	Regulators, funders, policymakers	Formal consultations, transparency reports
Users	Operators, frontline workers, communities	Co-design workshops, training
Affected parties	Communities indirectly impacted	Accountability mechanisms, grievance channels
Opponents	Groups bearing concentrated losses	Mitigation offers, alternative benefit-sharing

Power awareness exercise: Who has voice currently? Who lacks representation?

Arnstein's Ladder of Citizen Participation

Rungs of Empowerment

- LEVEL 3: TOKENISM
  - Consultation (opinions solicited, not guaranteed incorporation)
  - Placation (minor advisory roles, limited influence capacity)
  - Informing (one-way communication, feedback optional)
- LEVEL 2: POWER TRANSFER
  - Partnership (shared governance responsibilities negotiated)
  - Delegated Power (community holds veto/approval authority)
  - Citizen Control (local autonomy dominates decisions)

Power Dynamics Awareness

CONTROL QUESTIONS

- Who owns raw dataset sovereignty?
- Who accesses trained model weights independently?
- Who controls computational infrastructure provisioning?
- Who decides priority feature roadmap developments?

Power Dynamics

BENEFIT DISTRIBUTION

- Primary financial gains accrue where exactly?
- Employment opportunities created internally versus externally?
- Knowledge transfer enabling local self-sufficiency?

COST ALLOCATION:

- Connectivity expenses borne by whom primarily?
- Maintenance labor obligations assigned appropriately?
- Risk exposures proportionately shared responsibly?

Scoring Guide: Majority affirmative = equitable alignment trending positively

Sustainability Framework

- Economic viability beyond pilot funding
- Institutional ownership and maintenance capacity
- Community buy-in and local expertise development
- Exit strategies that preserve value

Case Study Deep Dive

Coffee Farmers

- **Challenge**: New EU Deforestation Regulation (EUDR) requires traceable coffee supply chains.
- **Current infrastructure**: National central registry under development registering farmers, geo-mapping farms, storing farm-level data accessible to suppliers before export.
- **Stakeholders**: Smallholder farmers, cooperatives, coffee board (regulator and certification body), national coffee research institute, export companies, EU importers.

Proposed AI Climate Data Products for Farmers

Product Description	Problem Addressed	Implementation Consideration
Yield Prediction Model	Uncertainty planning, market timing	Requires historical yield data, satellite imagery integration
Frost/Disease Early Warning	Loss prevention	Mobile alert system; needs ground-truth validation
Optimal Harvest Window Advisor	Quality consistency, price maximization	Weather pattern analysis + cherry maturity modeling
Carbon Sequestration Estimator	Potential carbon credit eligibility	Soil modeling, agroforestry tracking
Price forecasting dashboard	Bargaining power improvement	Market intelligence aggregation; risk of information asymmetry

Critical Questions

1. **Data Governance:** Who owns farmer geo-location and production data? Could this become exploitative if supplier access prioritized over farmer privacy/benefits?
2. **Equity Concerns:** Will tech-enabled farmers gain competitive advantages while marginalized producers lose market position?
3. **Infrastructure Dependence:** Connectivity gaps—can offline-first tools prevent exclusion?
4. **Capacity Building:** Does registration process empower farmers with actionable insights, or merely extract data for compliance purposes?
5. **Power Redistribution Mechanisms:** Cooperative-owned analytics platforms versus centralized government/extractor-controlled systems.

Participatory Design

- Farmers as co-developers, not just data sources
- Build feedback loops where model outputs improve farmer decisions visibly.
- Regulatory compliance doesn’t overshadow developmental outcomes.

Reading List

CEIMIA. (2025). State of AI in climate action in Sub-Saharan Africa. International Center of Expertise in Montreal on Artificial Intelligence. https://shorturl.at/STDyd

Mienye, I. D., Sun, Y., & Ileberi, E. (2024). Artificial intelligence and sustainable development in Africa: A comprehensive review. *Machine Learning with Applications*, *18*, 100591. https://doi.org/10.1016/j.mlwa.2024.100591

Nhemachena, C., et al. (2024). Using artificial intelligence in support of climate change adaptation Africa: Potentials and risks. Humanities and Social Sciences Communications, 11(4223). https://doi.org/10.1057/s41599-024-04223-7

UNFCCC & UNIDO (2025). Artificial Intelligence for Climate Action: Advancing Mitigation and Adaptation in Developing Countries. TEC Technical Paper. https://shorturl.at/flofg



Thank You