Carbon Offset Estimation Service Documentation

## 🌍 Problem Statement

Agricultural activities contribute to both greenhouse gas emissions and carbon sequestration. This service aims to calculate the estimated net carbon offset (in tCO2e) and potential carbon credit value for a given farm setup using user inputs, machine learning predictions, and known carbon factors.

## ⚙️ Tech Stack

- Backend: Java 17 + Spring Boot 3  
- ML Model: PMML (Predictive Model Markup Language)  
- Data Format: JSON request/response  
- Integration: RESTful API + ML model embedded with JPMML

## 🔧 API Endpoint

POST /api/v1/estimate-carbon-offset  
  
Request Body:  
{  
 "areaHa": 1.5,  
 "cropType": "wheat",  
 "fertilizerNkgPerHa": 50,  
 "irrigationType": "flood",  
 "dieselLitres": 10,  
 "manureApplied": true,  
 "noTill": true,  
 "treesPlanted": 15,  
 "biocharTons": 0.3,  
 "durationMonths": 6,  
 "location": {"lat": 19.07, "lon": 72.88}  
}

## 📊 Carbon Estimation Logic

1. Emissions (kg CO2e):  
 - Fertilizer = N\_kg/ha \* area \* emission\_factor \* gwpN2O  
 - Diesel = litres \* fuel\_emission\_factor  
 - Irrigation = area \* factor based on type (flood/other)  
 - Optional boost for manure  
 - Reduction for noTill = true  
  
2. Sequestration (kg CO2e):  
 - Trees = treesPlanted \* factor  
 - Biochar = biocharTons \* factor  
 - ML Prediction = additional offset via PMML  
  
3. Adjustments:  
 - Leakage = 10% of emissions  
 - Uncertainty = 20% of emissions  
 - Scale all by durationMonths / 12.0  
  
4. Final Offset & Credit:  
 totalOffset = sequestrationTotal - (emissions + leakage + uncertainty)  
 estimatedCreditValue = totalOffset \* pricePerTonne

## 📈 Sample Output Explanation

{  
 "estimatedOffsetTCO2e": 1.32,  
 "estimatedCreditValue": 26.45,  
 "currency": "₹",  
 "emissions": {  
 "irrigation": 0.0004,  
 "fuel": 0.0134,  
 "fertilizer": 0.1368  
 },  
 "sequestration": {  
 "biochar": 0.201,  
 "mlPrediction": 1.12,  
 "trees": 0.1875  
 },  
 "leakage": 0.0143,  
 "uncertaintyBuffer": 0.0286  
}  
  
📌 Interpretation:  
- Total Emissions = 0.1506 tCO₂e  
- Leakage = 0.0143, Uncertainty = 0.0286  
- Sequestration = 1.5085 tCO₂e  
- Net Offset = 1.5085 - (0.1506 + 0.0143 + 0.0286) ≈ 1.32 tCO₂e  
- Credit Value = 1.32 × ₹20 = ₹26.45

## 🎓 Notes on Configuration

application.yml:  
carbon:  
 factor:  
 fertilizer: 0.01  
 fuel: 2.68  
 irrigationFlood: 0.5  
 irrigationOther: 0.2  
 trees: 0.025  
 biochar: 1.34  
 gwpN2o: 298  
 pricePerTonne: 20  
 currency: ₹

## 🔧 Future Enhancements

- Accept geotagged images to extract lat/lon  
- ONNX integration for deep learning  
- Soil/weather API enrichment  
- React + Tailwind UI integration  
- Carbon credit PDF certificates

## 📍 Contact

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