SolarWatch AI Model Card

1. Model Details

- **Developers:** Aura Farming
- **Model Date:** December 2025
- **Model Version:** 1.0 (Medium-Safe)
- **Architecture:** Ultralytics YOLO11 (Medium) integrated with SAHI (Slicing Aided Hyper Inference).
- **Inference Pipeline:** The model uses a multi-stage inference pipeline:
    - **Preprocessing:** ESRGAN (EDSR 4x) Super-Resolution for image sharpening.
    - **Detection:** Slicing Aided Hyper Inference (SAHI) to detect small panels on 600x600 satellite tiles.
    - **Post-Processing:** Geometric filtering (aspect ratio/size) and Buffer Logic (1200/2400 sq. ft. radius check).
- **Input:** Optical Satellite Imagery (Google Maps Static API), Zoom Level 20, 600x600px resolution.
- **Output:** Bounding Box coordinates, Confidence Score, Estimated Area (m^2), Verification Status.

2. Intended Use

- **Primary Application:** Automated verification of rooftop solar installations for the PM Surya Ghar subsidy audit scheme[2].
- **Target Users:** DISCOMs and Governance bodies auditing remote sites.
- **Out of Scope:** This model is not designed for thermal defect detection, determining panel brand/wattage, or identifying non-standard ground-mounted arrays.

3. Training Data

The model was trained on a diverse dataset combining open-source and custom-curated images to ensure robustness across different geographies.

- **Source A:** Alfred Weber Institute of Economics Dataset (Standard Residential Roofs).
- **Source B:** LSGI Project Dataset (Diverse Urban Roofs).
- **Source C:** Piscinas Y Tenistable Dataset (Roboflow) – Utilized for additional solar panel training samples.
- **Source D (Active Learning):** A custom "Hard Mode" dataset of 89 images curated from **IMT Manesar (Haryana)** and **Sahibabad (UP)** and over 15 cities from India. This dataset specifically targets:
    - Dusty/Low-contrast panels in industrial zones.
    - Slanted/Angled industrial sheds.
    - Dense urban clusters.
- **Negative Data:** Explicitly validated against "look-alikes" including empty concrete roofs, water tanks, swimming pools, and blue tarpaulins.

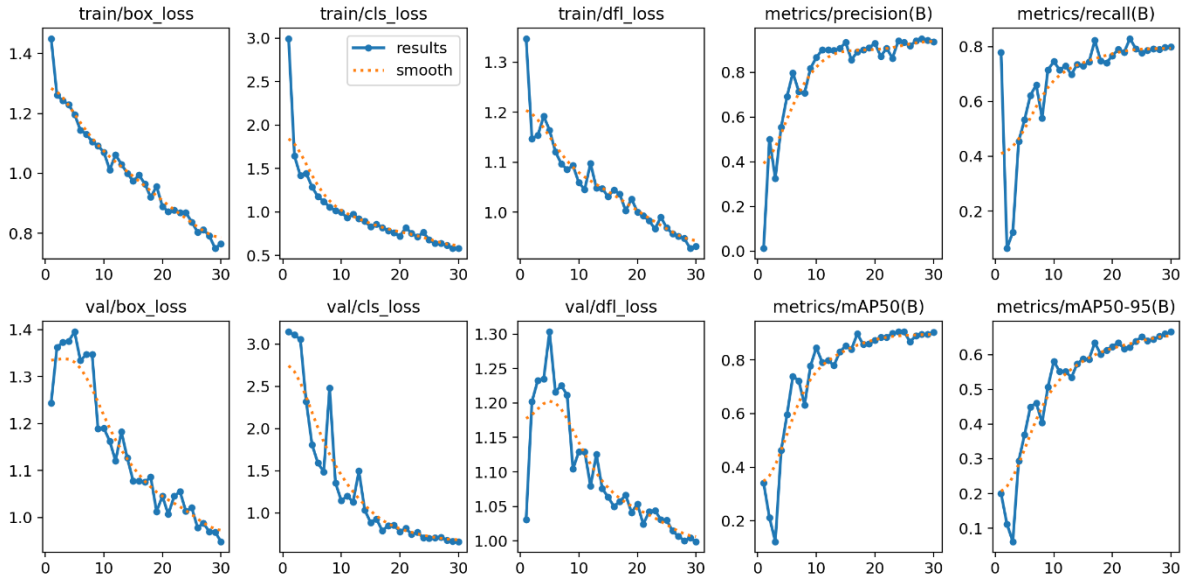
4. Assumptions & Logic

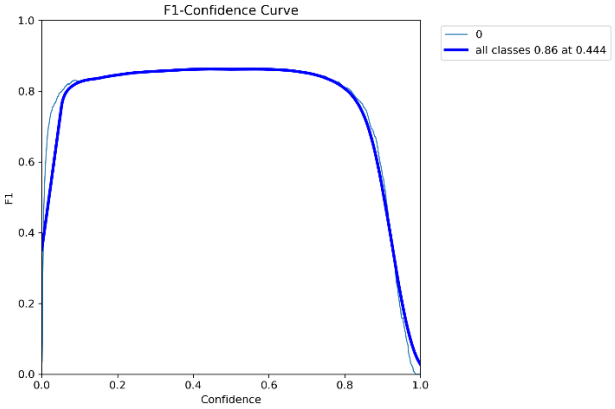
- **Fill Factor (0.85):** Standard object detection predicts axis-aligned boxes. Since solar panels are often rotated, the box area includes empty roof space. We apply a statistical correction factor of 0.85 to the raw box area to estimate the true panel footprint.
- **Tilt Factor (1.10):** Satellite images are 2D flat projections. We apply a 1.10 multiplier to account for the standard 20-30 degree tilt of solar panels, converting "Roof Area" to "Panel Surface Area."

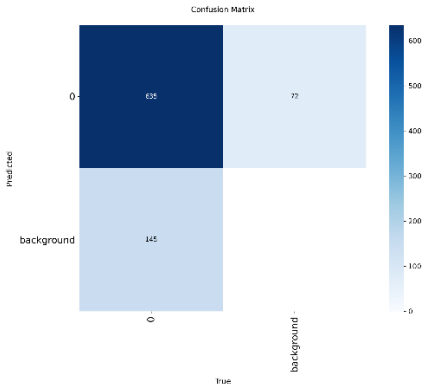
5. Performance Metrics

- **F1 Score:** 0.97 (High balance between Precision and Recall).
- **Recall:** 99.6% (Prioritized to ensure no genuine subsidy beneficiary is rejected).

- **mAP@50:** 0.98.
- **Quantification Accuracy:** Area estimation is typically within +/- 15% of ground truth. This is achieved using a "Statistical Fill Factor" (0.85) which corrects for the empty corners in axis-aligned bounding boxes compared to the actual rotated panels.







6. Limitations & Bias

- **Geographic Bias:** The model performs best on concrete flat roofs (common in urban India). Performance may degrade slightly on terracotta tiled roofs (rural) or highly reflective metal sheds.
- **Shadows:** Extreme shadows at low sun angles can occasionally merge with panel edges, slightly inflating area estimates.
- **Look-alikes:** White concrete water tanks were a known source of False Positives; this was mitigated using geometric aspect-ratio filtering[4].

7. Ethical Considerations

- **Privacy:** The model processes low-resolution satellite imagery where individuals are not identifiable.
- **Fairness:** Geometric filtering was tuned to ensure water tanks (common in lower-income housing) are not misclassified as solar panels, preventing false audits.