Detailed Roadmap for AI-Based Leopard Management and Conservation

Phase 1 Feasibility Study & Data Collection
Phase 2 AI Model Development
Phase 3 IoT & Camera Trap Integration
Phase 4 Predictive Modeling & Poaching Detection
Phase 5 Community Apps & Awareness Systems
Phase 6 Deployment & Field Testing
Phase 7 Final Optimization & Scale-Up

📌 Phase 1: Feasibility Study & Data Collection (2 Months)

Objectives:

- Understand the **current challenges** in leopard conservation.
- Collect **real-world data** (images, sounds, tracking logs).
- Identify **hardware/software requirements** for AI model training.

Key Tasks:

✅ Conduct field research with **forest departments and NGOs**
✅ Gather **leopard images** from existing camera traps
✅ Collect **audio samples of leopard calls** from wildlife recordings
✅ Identify suitable **drone models & IoT sensors** for monitoring
✅ Assess **network connectivity options** (4G/5G/Satellite/LoRaWAN)
✅ Define **regulatory and ethical considerations**

dataset	links
[LILA BC] # Leopard ID 2022	https://lila.science/datasets/leopard-id-2022/
# Seattle(ish) Camera Traps	https://lila.science/datasets/seattleish-camera-traps/

📌 Phase 2: AI Model Development (3 Months)

Objective:
This phase focuses on building and training **AI models** for detecting leopards, analyzing their activity patterns, identifying leopard sounds, and integrating drone-based surveillance. The AI models will be developed using deep learning frameworks and optimized for real-time processing.

🛠️ 1.1 Camera Traps with AI-Driven Image Recognition

Goal: Develop an **AI model** that can automatically recognize leopards in images from camera traps and send alerts in real time.

Tasks:

✅ **Dataset Preparation:**

- Collect **thousands of leopard images** from existing camera traps.
- Label images manually to **train object detection models**.
- Use **datasets from wildlife research organizations** (e.g., Snapshot Safari, LILA BC).

✅ **Model Selection & Training:**

- Train an **object detection model (YOLOv7, Faster R-CNN, SSD)**.
- Optimize model for **low-light and nighttime detection**.
- Implement **image augmentation** (rotation, brightness adjustments) to improve accuracy.

✅ **Edge Computing Optimization:**

- Deploy model on **Jetson Nano / Raspberry Pi** for on-site processing.
- Test **AWS Rekognition & Google Vision API** for cloud-based identification.
- Set up **real-time alert system** via cloud notifications.

Tech Stack:

✓ **AI Model:** TensorFlow, PyTorch, YOLOv7
✓ **Dataset:** COCO Dataset, Custom Leopard Dataset
✓ **Cloud:** AWS Rekognition, Google Vision API
✓ **Hardware:** Jetson Nano, Raspberry Pi
✓ **Alert System:** Firebase Push Notifications, Twilio SMS

🛠 1.2 Population Estimation & Activity Patterns

Goal: Use AI to analyze **leopard movement patterns** and estimate their population based on collected image timestamps.

Tasks:

✅ **Motion Tracking Algorithm:**

- Use **LSTM (Long Short-Term Memory) models** for time-series analysis.
- Process timestamps and location metadata from camera traps.
- Detect **leopard movement patterns** (day/night activity, seasonal movement).

✅ **Density Estimation:**

- Train AI to **estimate population density** using images and geolocation data.
- Use **statistical models (Poisson Distribution, Kernel Density Estimation)** to predict leopard concentration areas.
- Compare **leopard density before & after conservation interventions**.

✅ **Dashboard Development:**

- Create an **interactive dashboard (Tableau, Dash, Power BI)** for researchers.
- Enable **real-time analytics & filtering by date/location**.
- Integrate with **GIS (Geographic Information System) for mapping** leopard activity.

Tech Stack:

✓ **AI Model:** LSTM (Time-Series Analysis), OpenCV
✓ **Database:** PostgreSQL, MongoDB
✓ **Visualization:** Tableau, Dash, Power BI
✓ **GIS Integration:** QGIS, ArcGIS

🛠 1.3 Acoustic Monitoring & AI-Based Sound Analysis

Goal: Develop **AI-powered audio recognition models** to detect leopard roars, growls, and distress calls in forests.

Tasks:

✅ **Sound Dataset Collection:**

- Gather **recordings of leopard calls** from conservation sources.
- Label audio clips for **training AI to distinguish between leopard sounds & background noise**.

✅ **AI Model Training:**

- Train a **CNN (Convolutional Neural Network) model** to classify sounds.
- Use **Mel Spectrograms & MFCC (Mel-Frequency Cepstral Coefficients)** to analyze sound features.
- Fine-tune model for **low-frequency and distant leopard calls**.

✅ **Real-Time Monitoring & Alerts:**

- Deploy **IoT-based sound sensors** in leopard habitats.
- Implement **automated triangulation** of sound sources to **estimate leopard locations**.
- Develop **mobile alerts** for rangers when a leopard sound is detected.

Tech Stack:

✓ **AI Model:** CNN, TensorFlow Audio, Librosa
✓ **Sound Processing:** Mel Spectrograms, MFCC
✓ **IoT Devices:** Raspberry Pi with Microphone Array
✓ **Cloud Processing:** AWS Lambda, Google AutoML
✓ **Alert System:** Twilio SMS, Firebase Notifications

Overall, model which is best.

Model	Speed (FPS)	Accuracy	Best For	Best Deployment
YOLOv7	✅ ✅ ✅	✅ ✅	Real-time leopard detection	Edge AI (Jetson, Raspberry Pi)
EfficientDet	✅ ✅	✅ ✅ ✅	Small leopard detection, low-power devices	Mobile & Cloud
CenterNet	✅ ✅	✅ ✅ ✅	Camouflaged leopards in dense forests	Edge & Cloud
Faster R-CNN	✅	✅ ✅ ✅	High-resolution leopard images	Cloud-based AI

Model	Speed (FPS)	Accuracy	Best For	Best Deployment
Cascade R-CNN	✅	✅ ✅ ✅ ✅	Occluded & hard-to-detect leopards	Cloud & High-end GPU
RetinaNet	✅ ✅	✅ ✅ ✅	Reducing false positives, night-time detection	Server AI
DETR (Transformer)	✅	✅ ✅ ✅ ✅	Complex background & jungle analysis	Research & Cloud AI
Swin Transformer	✅	✅ ✅ ✅ ✅	Thermal imaging & night vision	Cloud AI