Course: AI For Software Engineering.

Author: Luke Mbogo

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Week 6 Assignment:

AI Development Workflow.

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Introduction

As Kenya accelerates its transition to electric mobility, driven by government incentives and the rising cost of fossil fuels, the spotlight is now shifting to a critical but underdeveloped pillar of this ecosystem—**after-sales service and repair infrastructure for electric vehicles (EVs)**. While EV adoption in Kenya is gradually increasing, especially among public transport providers and private fleets, the capacity of local garages and workshops to handle EV-specific diagnostics, battery maintenance, and electric motor repairs remains limited and fragmented.

Problem Statement

The Kenyan automobile industry is historically built around internal combustion engine (ICE) vehicles. As a result, the current garage landscape is primarily tailored for conventional vehicle repairs, leaving a significant skills and infrastructure gap when it comes to servicing EVs. There are **fewer than 70 EV-capable garages** in the country, compared to hundreds servicing ICE vehicles. Moreover, **less than 400 e-car repairs are performed annually**, reflecting both a low EV base and a lack of widespread technical capacity.

This mismatch raises a pressing concern: **Can Kenya's auto-repair sector keep up with the projected surge in EV adoption?** Without sufficient investment in training, tools, and standardization, EV owners may face longer wait times, high servicing costs, and safety risks. There is also limited visibility into the geographic distribution, capabilities, and readiness of garages to transition into EV support hubs.

Therefore, the core problem is the **lack of scalable, accessible, and certified EV repair infrastructure** in Kenya—a gap that must be addressed to ensure a smooth and sustainable electric mobility transition.

Snapshot — EV-repair landscape in Kenya (mid-2025)

Item	**Best-available current estimate**	**How we got there**
Registered EVs (all types)	**≈ 9,047 units** (motor-cycles dominate; only **≈ 320 are cars**)	Latest EPRA & EMAK counts for 2024-2025 (citizen.digital)
Conventional auto-repair garages	**≈ 615** country-wide	Business listings scrape (May 2025) (rentechdigital.com)

Item	Best-available current estimate	How we got there
Electric-motor / EV-capable workshops	**≈ 60–70** (≈ 10 % of all garages)	62 “electric motor repair” shops plus OEM service depots for BasiGo, Roam, Caetano, etc. (rentechdigital.com)
Annual EV-car repair jobs (2024)	**≈ 350–400** services*****	1.2 services/car/year × ≈ 320 e-cars
2030 outlook	▶ **EV fleet ~ 50 k**; **EV-ready garages ≥ 300**	Govt target of 5 % new registrations by 2025 and aggressive charging build-out (automag.co.ke, automag.co.ke)

High-level objectives for deeper research

Map & score EV-ready garages

1. Locations and Key Players

Kenya’s EV ecosystem is centered in **Nairobi** and other major urban centers, where most EV-ready garages and service centers are clustered. Key players include:

- **AA Kenya Service Centre (Embakasi, Nairobi):**
    - Has partnered with Moja EV and Skyworth for specialized EV technician training and now services electric vehicles, including the Skyworth SUV.
- **Knights Energy:**
    - Involved in both EV sales and technician training, and provides hands-on experience with models like the Nissan Leaf.
- **Basigo, Roam, Ampersand, Powerhive, EBEE:**
    - These companies are primarily focused on electric buses, motorcycles, and fleet vehicles, but also support technician training and aftersales service.
- **EVChaja:**
    - While best known for its charging network, it collaborates with garages and fleet operators to support EV maintenance and readiness.

There is no public, centralized map listing all 60+ EV-ready workshops, but the above organizations are at the heart of the sector, and their networks are expanding rapidly, especially in Nairobi and Mombasa.

2. Brands Serviced

- **Nissan Leaf:** Most common EV for technician training and practical sessions.
- **Skyworth SUV:** Serviced at AA Kenya after targeted training.
- **Electric Buses:** Basigo and Roam provide servicing for their own fleets and support partner garages.
- **Electric Motorcycles and Tuk-tuks:** Ampersand, EBEE, and Powerhive focus on two- and three-wheelers, with associated service support.

Workshops associated with these brands are most likely to be EV-ready, with technicians trained on the specific requirements of each vehicle type.

3. Technician Skills and Training

- **AfricaNEV, Advanced Mobility, and EVChaja** have run the first dedicated EV technician training programs in Kenya, focusing on both theoretical and practical skills.
- **AA Kenya Service Centre** has upskilled its staff through partnerships, enabling them to handle diagnostics, repairs, and maintenance for EVs.
- Training covers:
    - EV powertrains and high-voltage systems
    - Use of diagnostic tools and safety equipment
    - Hands-on work with real EVs (notably the Nissan Leaf and Skyworth SUV)
- **Ongoing training** is available through organizations like NobleProg, offering both in-person and online courses for Kenyan technicians.

4. Tools and Equipment Gaps

What's Available:

- Basic diagnostic tools and some EV-specific equipment are present in leading service centers (AA Kenya, Knights Energy).
- PPE and safety equipment for high-voltage work are being introduced as part of technician training programs.

Gaps Identified:

- **Advanced diagnostic software:** Many garages lack proprietary tools for newer or less common EV brands.
- **Specialized equipment:** Not all workshops have full sets of insulated tools, battery analyzers, or high-voltage PPE.
- **Charging infrastructure:** While public charging is expanding (led by EVChaja), not every workshop has on-site charging or battery swapping capabilities.
- **Access to repair codes/manuals:** Some brands (especially Chinese imports) do not provide open access to service information, limiting repair options.

5. Scoring and Readiness

Most EV-ready garages in Kenya:

- Are located in Nairobi and Mombasa.
- Have direct partnerships with OEMs or EV fleet companies.
- Employ technicians who have completed recent, hands-on EV training.
- Possess a basic but growing inventory of EV-specific tools and PPE.
- Still face gaps in advanced diagnostics, brand-specific software, and full charging infrastructure.

Less ready garages:

- Are outside major cities.
- Lack access to ongoing training and advanced equipment.
- May only be able to perform basic maintenance or rely on third-party support for complex repairs.

Quantify near-term demand

Kenya's near-term demand for electric vehicles (EVs) is accelerating rapidly, driven by policy, infrastructure expansion, and market momentum. Quantitative indicators for 2024–2026 are as follows:

Current Market Size and Growth

- **Registered EVs:** As of mid-2025, there are approximately **9,047 EVs** registered in Kenya, up from 2,079 in June 2023 and 3,753 at the end of 2023.

- **Recent Growth Rate:** EV registrations have surged, with **2,694 added in 2023** and **5,294 in 2024** alone—representing a **150% increase in sales year-on-year**.

Projected Short-Term Demand (2025–2027)

- **Annual Sales Trajectory:** If the current growth rate continues, **annual EV registrations could exceed 10,000 per year by 2026**, especially as more affordable models and used imports enter the market.
- **Market Share:** Despite rapid growth, EVs still make up only **0.2% of Kenya's total registered vehicles** (about 5 million).
- **Government Targets:** Kenya aims for **5% of all registered vehicles to be electric by 2025** and **15% of annual vehicle sales to be electric by 2028**.

Segment Breakdown

- **Motorcycles:** The majority of new EVs are motorcycles and three-wheelers, driven by companies like Roam, Ampersand, and Ecobodaa.
- **Cars:** Uptake is rising, especially for models like the Nissan Leaf, BYD Dolphin, and MG4 EV, but remains limited by high upfront costs and import taxes.
- **Public Transport:** Electric buses (BasiGo, Roam) and fleet vehicles are a fast-growing segment, supported by government and donor programs.

Infrastructure and Policy Drivers

- **Charging Infrastructure:** Kenya Power is installing **45 new EV chargers in six counties** in 2025, supplementing private sector efforts.
- **Government Incentives:** Reduced excise duty (from 20% to 10%) and VAT exemptions for EVs are making adoption more attractive.
- **Energy Demand:** EPRA projects that EV uptake will increase Kenya's electricity consumption by **15.465 GWh over the next three years**, with annual increases of 5.155 GWh.

Summary.
Kenya's near-term EV demand is set to double or triple annually, with motorcycles and fleet vehicles leading growth. Policy incentives, new charging infrastructure, and growing consumer awareness are expected to push annual EV sales into five figures by 2026, while the government's 5% electrification target for all vehicles by 2025 remains ambitious but is driving substantial investment and adoption.

Assess capacity-building needs.

Assessing **capacity-building needs for Kenya's EV sector** reveals a clear demand for specialized training, curriculum development, and practical skills enhancement to support the growing EV market. The key points are:

1. Current Training Initiatives

- **Spiro Academy at Technical University of Kenya (TU-K):**
  Launching an 18-month Graduate Tech Training Programme and a One-Year EV Specialisation Course in partnership with Kenya Tech University and Fleming College. This academy aims to develop top EV talent with comprehensive technical training, internships, and industry-based learning.
- **AfricaNEV and Advanced Mobility Programs:**
  Hands-on e-mobility training programs have been conducted, focusing on practical skills such as dismantling and reassembling EVs (e.g., Nissan Leafs), combined with visits to leading EV companies (Basigo, Ampersand, Knights Energy). These programs enhance technician readiness for EV maintenance and repair.
- **NITA Curriculum Validation:**
  The National Industrial Training Authority (NITA), in collaboration with industry partners, is validating an EV Technician curriculum aligned with industry needs to ensure trainees gain relevant knowledge and technical expertise for servicing EVs.
- **Private and Online Courses:**
  Providers like NobleProg and Academy of EV Technology offer short courses (e.g., 14-hour EV maintenance and troubleshooting training) to upskill technicians quickly, both online and onsite.

2. Skills and Knowledge Gaps

- **Technical Expertise:**
  There is a critical need for technicians trained in high-voltage safety, battery management systems, EV powertrains, and advanced diagnostics. Many current technicians lack hands-on experience with EV-specific components and safety protocols.
- **Diagnostic and Repair Skills:**
  Access to proprietary diagnostic software and repair manuals remains limited, necessitating training on generic EV systems and brand-specific modules where possible.
- **Entrepreneurship and Business Skills:**
  Courses that combine technical knowledge with business management, legal

frameworks, and finance (e.g., EVSE business management) are essential to support MSMEs entering the EV service and charging infrastructure market.

3. Infrastructure and Institutional Support Needs

- **Training Facilities:**
  Existing institutions like TU-K have workshops and labs (robotics, PLC, conventional and non-conventional workshops) suitable for EV training but require remodeling and equipment upgrades to fully support EV curricula.
- **Geographic Reach:**
  Capacity-building programs are currently concentrated in Nairobi and major urban centers. There is a need to expand training access to underserved counties (e.g., Isiolo, Meru, Wajir, Garissa) through initiatives like the Kenya National Highways Authority's one-year technical training programs targeting youth.
- **Industry Collaboration:**
  Stronger partnerships between academia, government, and private EV companies are needed to ensure curricula remain relevant, internships are available, and research and innovation in EV technology are fostered.

Conclusion

Kenya's EV capacity-building efforts are progressing with promising initiatives like Spiro Academy at TU-K, AfricaNEV's practical training, and NITA's curriculum validation. However, scaling these programs nationwide, upgrading training infrastructure, expanding access beyond urban centers, and integrating business skills are critical to meet the surging demand for skilled EV technicians and entrepreneurs. Strengthening industry-academia-government partnerships will be key to building a robust, sustainable EV workforce in Kenya.

Two key stakeholders to engage early

- **Garage / service-network owners** (independent shops, dealer networks, fleet-operators like BasiGo & Roam) – they hold the data on actual repair volumes and skills gaps.
- **Government & regulators** (EPRA, NTSA, Ministry of Transport) – set standards, training curriculum, tax incentives, and collect the registration data you need.

Proposed single KPI to track success

EV-Garage Coverage Ratio = Number of EV cars ÷ Number of certified EV-ready garages

- **Baseline (2024):** ≈ 320 cars ÷ 65 garages ≈ **5 cars/garage**
- **Target (end-2027):** ≤ 3 cars/garage

A falling ratio means repair capacity is scaling *faster* than the EV fleet, signalling healthy ecosystem growth and shorter wait-times for owners.

Recommended Model: XGBoost Regressor

Why XGBoost (Extreme Gradient Boosting)?

- It outperforms Random Forest in most real-world structured data problems.
- Handles missing values, multicollinearity, and non-linear relationships very well.
- Ranks features by importance — giving you clear visibility into *what's driving EV garage readiness or performance*.
- Well-supported in Python and scalable even on limited data.

It's widely used in industry for problems like housing price prediction, customer behavior forecasting, and yes — *infrastructure readiness prediction models like this one*.

Data Splitting

You'd stick with:

- 70% Training set
- 15% Validation set
- 15% Test set

But with XGBoost, you can also use its built-in cross-validation (cv) method to avoid overfitting and optimize accuracy further.

Two Key Hyperparameters to Tune in XGBoost

1. learning_rate (a.k.a. eta)
    - Controls how much the model corrects itself at each step.
    - Lower values (like 0.01–0.1) lead to higher accuracy but longer training.
2. n_estimators
    - Number of boosting rounds (i.e. how many trees to build).
    - A higher value increases model capacity, but too high can cause overfitting unless learning_rate is small.

Optional third to tune: max_depth — to control model complexity.

Example Use Case

Let's say you want to predict the number of EV services a garage can do in a month based on:

- Number of technicians
- Location (urban vs rural)
- Type of equipment
- Training level
- Past repair logs

XGBoost Regressor would handle that beautifully — and tell you *which of those features matter most*.

Evaluation Metrics

Let's say you're using **XGBoost Regressor** to predict the number of EV repairs a garage can handle monthly. Two ideal metrics:

a) Mean Absolute Error (MAE)

- **What it does**: Measures the average absolute difference between predicted and actual values.
- **Why it's relevant**: It gives a clear, interpretable value in the same unit (e.g. "The model is off by ~5 repairs on average"). It's robust to outliers.

b) R^2 Score (Coefficient of Determination)

- **What it does**: Measures how well your model explains the variance in the target variable.
- **Why it's relevant**: Tells you how much of the repair volume your features (like techs, equipment, location) are actually explaining. R^2 closer to 1 = better performance.

Concept Drift

What it is:

Concept drift happens when **the underlying patterns in data change over time**, making your trained model less accurate.

For example: If EV technology rapidly evolves or new garage types enter the market, your model may no longer make accurate predictions using old patterns.

How to Monitor It Post-Deployment:

- **Monitor prediction error** over time (e.g. sudden rise in MAE or drop in R^2).
- Use a **drift detection algorithm** (e.g. ADWIN, DDM) to spot shifts in data distributions.
- Regularly compare **live input features** (e.g. avg number of techs, service type distributions) to training set statistics.

Also, retrain the model periodically using fresh data from the growing EV market.

One Technical Challenge: Scalability

The challenge:

As your system gains more users (e.g. hundreds of garages submitting real-time data), you may face:

- Slow model predictions
- Delayed responses for garage insights
- Memory overload during batch retraining

How to solve it:

- Use **model-serving frameworks** like **FastAPI** + **Docker** to containerize and deploy the model efficiently.
- For larger loads, deploy on **cloud infrastructure** (e.g. AWS SageMaker, Azure ML, or Google Vertex AI) which auto-scales with demand.
- Use **batch prediction** for less time-sensitive analytics and **real-time inference** only where needed.

Conclusion

This project demonstrates how machine learning can be applied to real-world healthcare challenges, specifically predicting patient readmission risk within 30 days of discharge. By integrating data preprocessing, model training, and an interactive Streamlit interface, we've built an end-to-end AI system that empowers medical practitioners to make more informed decisions.

The tool provides early warnings for at-risk patients, enabling hospitals to focus follow-up care and reduce unnecessary readmissions — ultimately improving patient outcomes and reducing operational costs. While this is a functional prototype, real-world deployment would require

further clinical validation, integration with hospital systems, and adherence to healthcare data regulations like HIPAA.