Case Study 1: Predictive Maintenance in Solar Power Systems

Problem Statement: Solar power plants play a crucial role in the transition toward clean energy. However, maintaining large solar farms is challenging, as breakdowns or inefficiencies can significantly reduce power output and cause financial losses. Traditionally, maintenance schedules are set based on time intervals, which may lead to over-maintenance or under-maintenance of equipment. The introduction of AI-driven predictive maintenance offers a solution that can help identify potential failures before they happen.

Real-Life Example: A solar farm in California experienced frequent inverter failures, leading to a 15% reduction in power output during peak hours. By integrating machine learning algorithms, the company was able to predict inverter failures by analyzing historical data from sensors, weather conditions, and energy output. The predictive model reduced downtime by 30%, increased energy production, and lowered maintenance costs.

Dataset: You are provided with sensor data from solar panels, including temperature, voltage, current, and historical maintenance records.

Questions:

1. What features in the dataset are most important for predicting equipment failures?
2. Develop a machine learning model to predict inverter failure.
3. How would you improve the model's accuracy?
4. What actions should be taken if a failure is predicted?
5. How can predictive maintenance contribute to sustainability and reduce waste?

Case Study 2: Waste Sorting Using Computer Vision

Problem Statement: Waste management is a critical aspect of sustainability. A major problem faced by recycling facilities is the incorrect sorting of waste, which reduces recycling efficiency. Sorting waste manually is labor-intensive and prone to human error. AI and machine learning, particularly computer vision, can automate this process by identifying and classifying waste types.

Real-Life Example: A recycling plant in Sweden implemented a computer vision system that used a convolutional neural network (CNN) to sort recyclable materials such as plastic, glass, and metal from general waste. This AI-based system improved sorting accuracy by 25% and reduced labor costs by 15%. It also increased the overall recycling rate, contributing to Sweden's impressive 99% waste diversion from landfills.

Dataset: You are provided with a dataset containing images of different types of waste (plastic, glass, metal, paper) labeled for classification.

Questions:

1. How can CNNs be applied to classify images of waste accurately?
2. What preprocessing steps are required to enhance the image quality for the model?

3. How can the system be improved to differentiate between different types of plastic (e.g., PET vs. HDPE)?
4. What challenges would you anticipate in scaling this system across multiple recycling centers?
5. Discuss how AI can increase the effectiveness of waste management in urban areas.

Case Study 3: Energy Efficiency in Smart Buildings

Problem Statement: Buildings account for nearly 40% of global energy consumption. Improving energy efficiency in buildings is essential for meeting sustainability targets. AI-powered systems can analyze energy consumption patterns, optimize heating and cooling systems, and provide recommendations for reducing energy use. These solutions are particularly effective in commercial buildings with high energy demands.

Real-Life Example: A smart office building in Singapore implemented an AI-based energy management system to optimize its HVAC (heating, ventilation, and air conditioning) system. By analyzing real-time occupancy data, weather forecasts, and historical energy consumption, the system automatically adjusted temperatures and airflow. This resulted in a 20% reduction in energy consumption and a 10% decrease in operating costs.

Dataset: You are provided with building energy usage data, occupancy data, and weather conditions over a two-year period.

Questions:

1. How can AI be used to identify inefficiencies in energy consumption in smart buildings?
2. Build a model to predict the energy consumption of the building based on occupancy and weather data.
3. Suggest additional features that could be incorporated into the model to improve its accuracy.
4. What steps can building managers take based on the model's predictions to reduce energy consumption?
5. How can AI-driven solutions contribute to achieving net-zero energy buildings?

Case Study 4: Air Quality Prediction in Urban Areas

Problem Statement: Air pollution is a severe challenge in urban areas, impacting public health and the environment. Accurately predicting air quality levels can help city officials take timely actions to reduce emissions or warn the public. Traditional methods of monitoring air quality are limited by the number of sensors and real-time reporting. AI models can fill these gaps by using available sensor data combined with weather and traffic information.

Real-Life Example: In Delhi, one of the most polluted cities in the world, a local environmental agency used AI to predict air quality indices (AQI) with a 24-hour lead time. By analyzing traffic, meteorological data, and pollutant levels, the model helped the city issue

early warnings, allowing citizens to take preventive measures, such as staying indoors or reducing outdoor activities on high-pollution days.

Dataset: You are provided with air quality data (PM2.5, PM10, NO2, CO), traffic data, and weather conditions over three years.

Questions:

1. How can machine learning models be used to predict air quality levels?
2. Which features in the dataset are likely to have the most significant impact on air quality?
3. Build a model to predict AQI for the next 24 hours.
4. How can this model be integrated with a city's traffic management system to reduce pollution?
5. Discuss the role of AI in mitigating air pollution in developing countries.

Case Study 5: Sustainable Agriculture with AI for Crop Yield Prediction

Problem Statement: Agriculture is highly sensitive to environmental conditions such as temperature, rainfall, and soil quality. In the context of climate change, it is vital for farmers to have accurate predictions about crop yields to optimize resource usage and reduce waste. AI can help by analyzing historical data and environmental factors to forecast yields and recommend best practices for sustainable farming.

Real-Life Example: Farmers in rural India collaborated with an AI company to implement crop yield prediction models for wheat and rice. Using historical crop data, soil conditions, and weather patterns, the AI provided yield forecasts and irrigation recommendations. This allowed farmers to plan better, reduce water usage by 15%, and increase crop yields by 10%.

Dataset: You are provided with crop yield data, soil quality data, rainfall, and temperature readings over a 5-year period.

Questions:

1. How can AI help farmers increase crop yields while reducing environmental impact?
2. Develop a model to predict crop yields based on soil and weather data.
3. What steps can farmers take based on the model's predictions to optimize their resources?
4. How can AI solutions like this contribute to global food security?
5. Discuss how AI can be used to promote sustainable agricultural practices in developing countries.