General Applications of AI

AI in Climate & Sustainability

Focus: weather, water, and waste

Outline

- Introduction

- AI Applications

    - Weather & Climate Prediction

    - Water Resource Management

    - Waste Management

- Google AI for Earth

- Challenges & Ethical Concerns

Introduction

Climate & Sustainability Challenges

- Rising global temperatures, sea-levels, and extreme weather events.

- Stress on natural resources: freshwater, soil, clean air.

- Growing urbanization, waste generation, and food-water-energy insecurity.

- Biodiversity collapse and ecosystem fragility

- Traditional monitoring & response systems are slow, reactive, and localized.

Temperature

Resources

Urbanization

Biodiversity

Slow Response
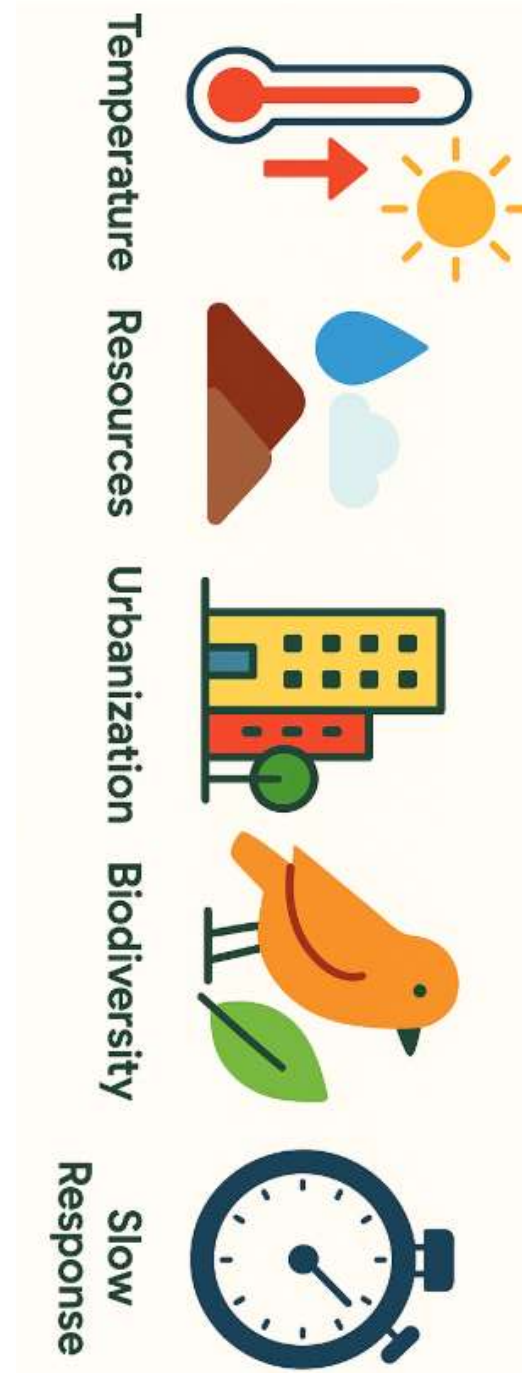
Introduction

**Role of AI in Environmental Intelligence**

- AI helps tackle sustainability challenges by:
    - Processing massive volumes of data (e.g., satellite, sensor, weather)
    - Predicting extreme events before they happen
    - Optimizing use of resources (water, energy, food)
    - Automating monitoring via remote sensing, drones, and smart sensors
- AI = Augmented Insight
  AI doesn't replace climate science — it enhances its speed, scale, and precision

DATA

PREDICTION

OPTIMIZATION

AI

AUTOMATION
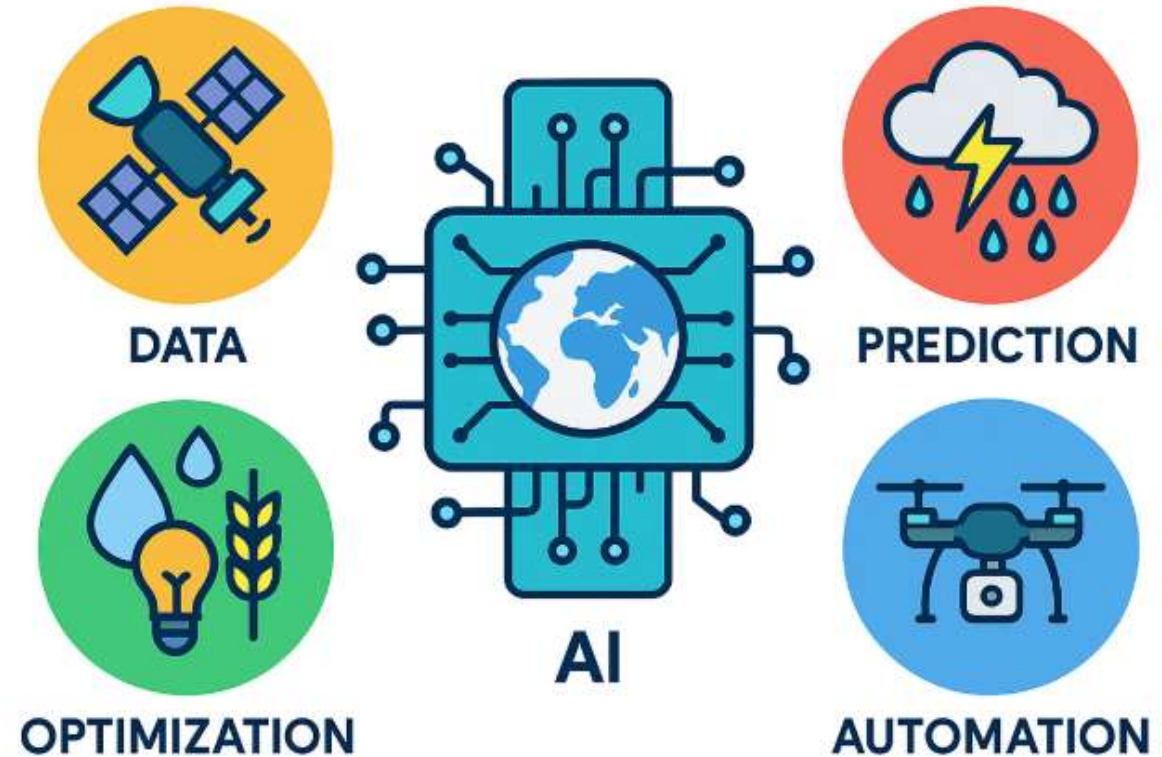
Introduction

Motivation

- "Data + AI can save drops and lives."
  — (Framing sustainability as a real-time data-driven problem)
- Every drop of water, every unit of energy, every degraded forest pixel… can now be monitored in near-real-time.
- AI transforms this environmental data flood into climate action.
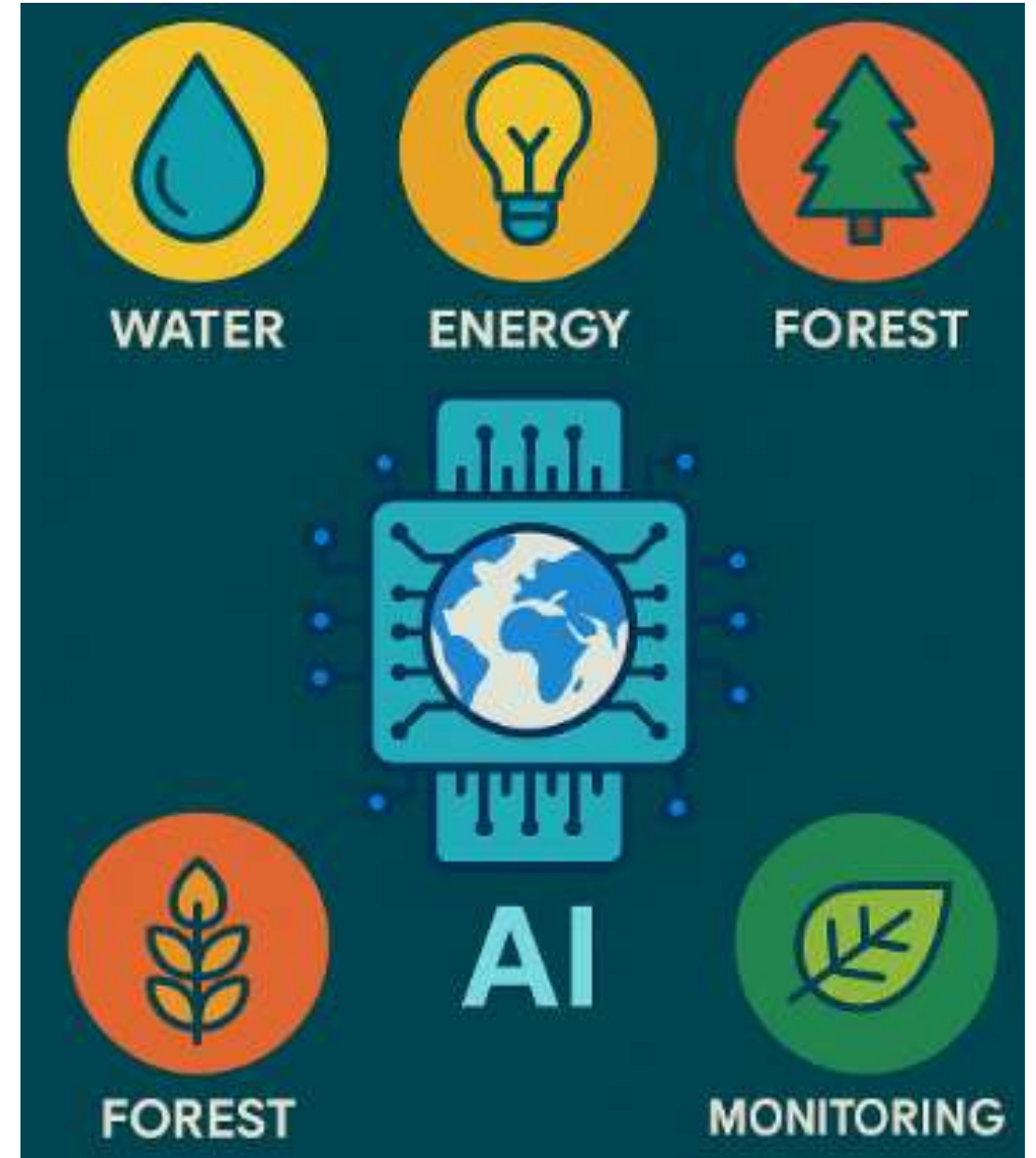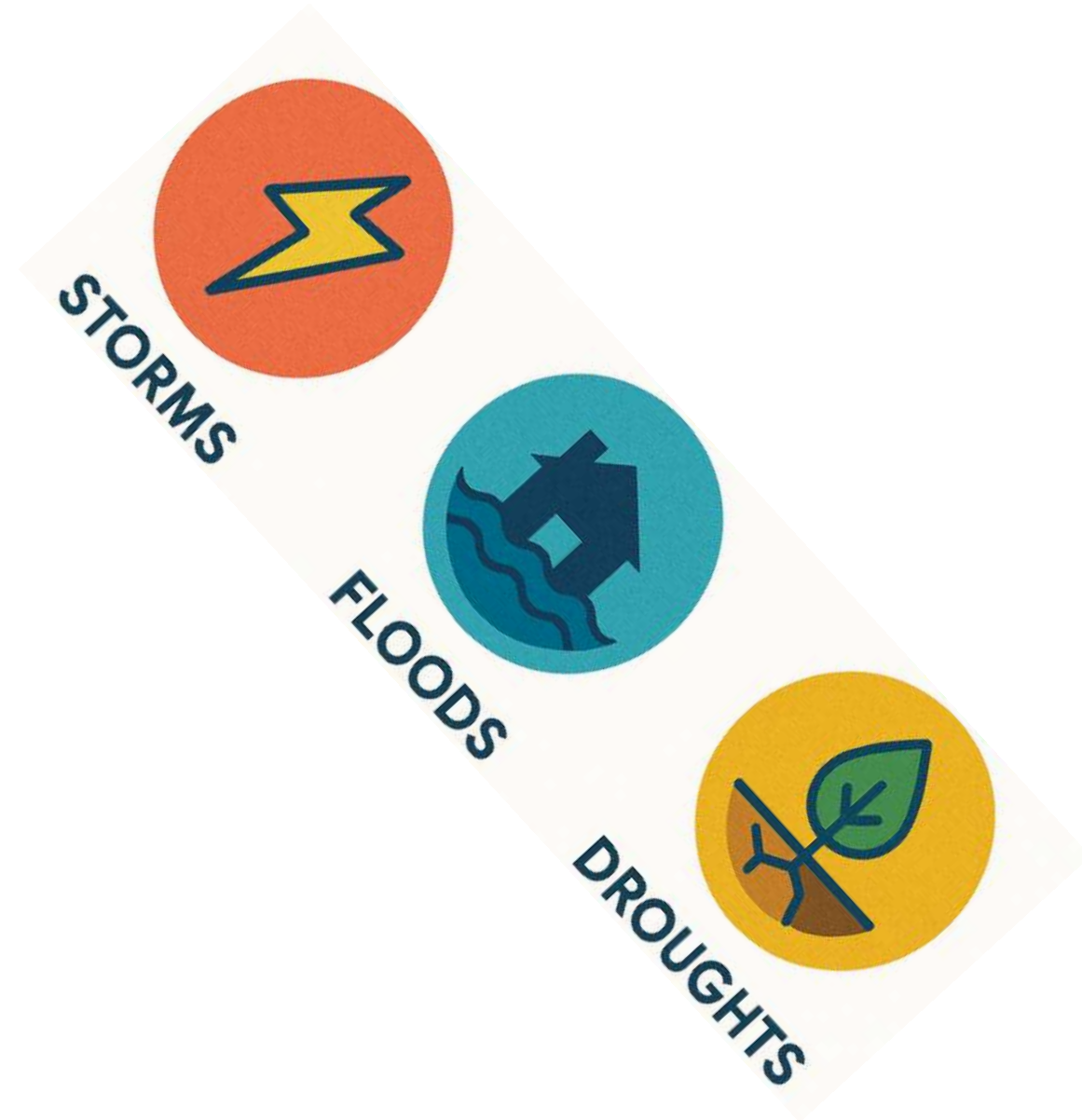
Core Applications of AI

Applications of AI

- Weather & Climate Prediction
- Waste Management
- Water Resource Management
- Precision Agriculture

Core Applications of AI

**Weather & Climate Prediction:** AI in Extreme Event Forecasting

- Traditional numerical weather prediction (NWP) models are physics-based, slow, and computationally intensive.

- AI/ML offers faster and often more localized predictions for:
  - Storms (cyclones, hurricanes)
  - Floods (urban and riverine)
  - Droughts (rainfall deficit, soil moisture depletion)

STORMS

FLOODS

DROUGHTS

Core Applications of AI

Weather & Climate Prediction: Flood & Storm Resilience

- AI-Powered Flood Forecasting Systems
- Use satellite + sensor + rainfall + river data with ML models to predict flood intensity and path (e.g., Google Flood Forecasting Initiative).
- Real-time alerts delivered via SMS, apps, and maps.
- Urban Flood Simulation Models
- Deep learning with GIS and LiDAR data to simulate drainage and runoff patterns.
- Used for infrastructure planning and smart drainage system design.

FORECASTING

SIMULATION
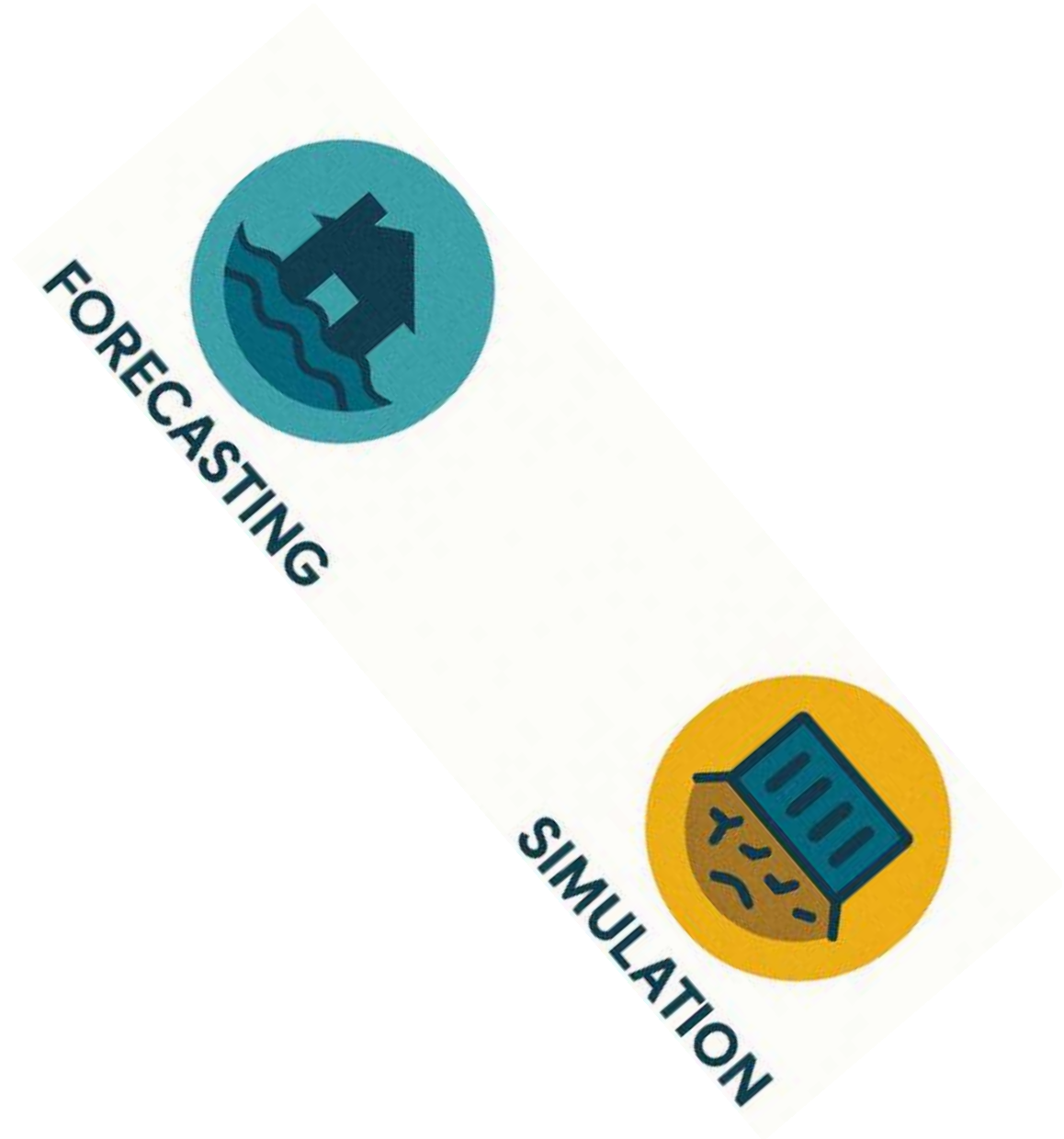
Core Applications of AI

Weather & Climate Prediction: Wildfire Early Warning & Control

- AI for Fire Risk Prediction

- Predict wildfire outbreaks using temperature, humidity, wind, vegetation index, and satellite imagery.

- CNN + time-series models detect ignition hotspots and fire spread.

- Autonomous Drone Surveillance

- AI-powered drones monitor vulnerable forests for early fire signs (thermal cameras + anomaly detection).

AI for Fire Risk Prediction

Autonomous Drone Surveillance
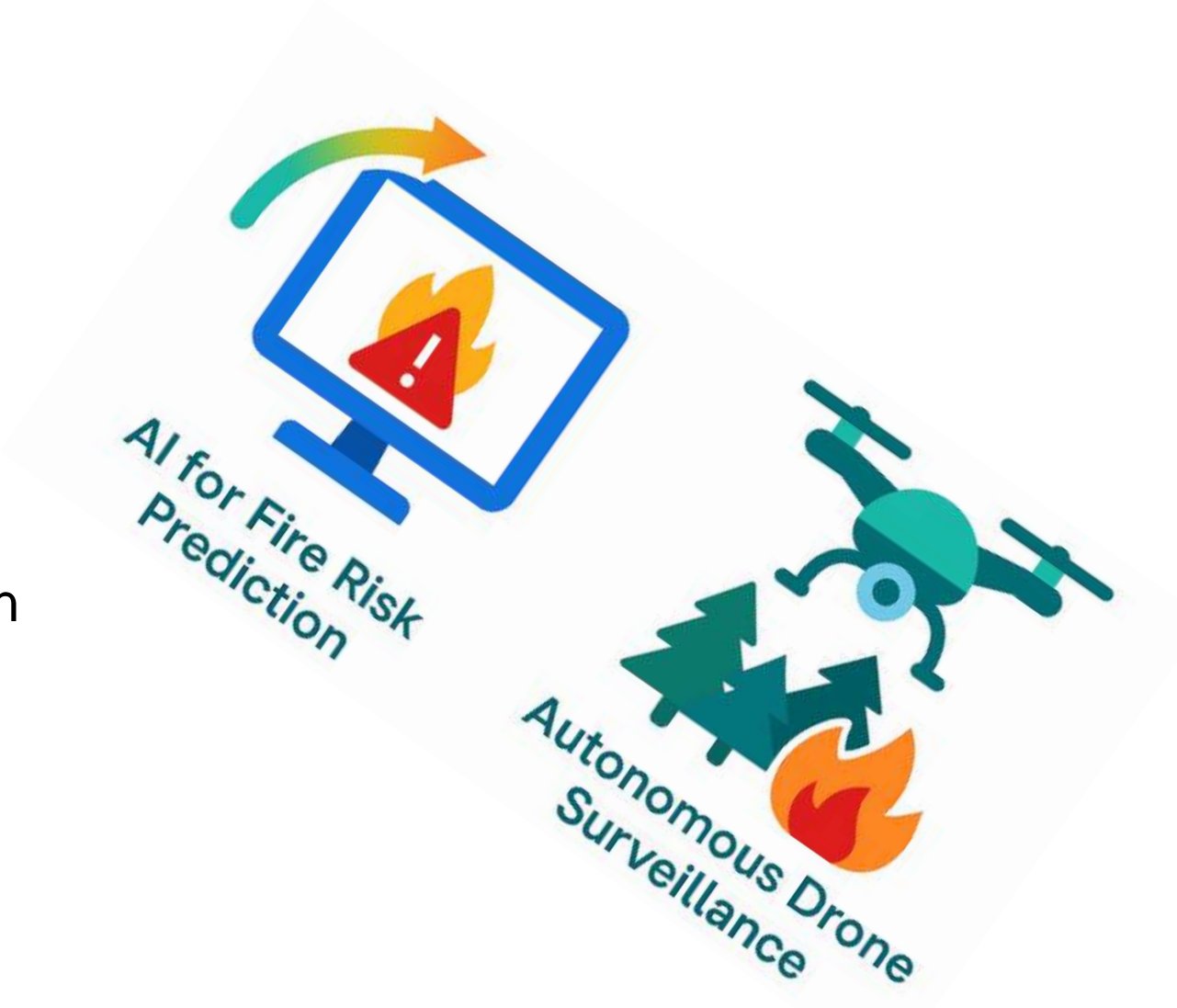
Core Applications of AI

Weather & Climate Prediction: Water Stress & Drought Management

- Drought Forecasting with ML

- Combine weather models, vegetation index (NDVI), and historical patterns.

- Early intervention in irrigation planning and crop insurance schemes.

- Smart Irrigation Systems

- AI + IoT sensors optimize irrigation schedules based on evapotranspiration, soil moisture, and weather forecast.

Drought Forecasting with ML

Smart Irrigation Systems

Core Applications of AI

Weather & Climate Prediction: Agricultural Resilience

- Crop Health Monitoring

- AI models (e.g., CNNs on drone/satellite images) detect crop diseases early.

- Helps prevent large-scale crop failure under changing climate conditions.

- Climate-Aware Yield Prediction

- Predict crop output under various climate change scenarios to inform policy and food supply chains.

Crop Health Monitoring

Climate-Aware Yield Prediction

Core Applications of AI

Weather & Climate Prediction: Urban Heat & Infrastructure Planning

- AI for Urban Heat Island (UHI) Detection
- Satellite imagery + ML to detect heat-prone zones.
- Guides city-level tree plantation, green roof, and waterbody restoration planning.
- Climate-Resilient Infrastructure Design
- AI simulations of storm impact, material fatigue, and failure points under extreme weather.
- Used in planning roads, bridges, water tanks, etc

AI for Urban Heat Detection

Climate-Resilient Infrastructure Design

Core Applications of AI

Weather & Climate Prediction: Biodiversity & Ecosystem Monitoring

- AI-Enabled Camera Trap Analysis

- CV models to detect and classify wildlife movement changes due to habitat stress or migration.

- Predictive Modelling of Ecosystem Shifts

- AI forecasts changes in species range, vegetation, and water cycles under future climate conditions.

Camera Traps

Ecosystems

Core Applications of AI

Weather & Climate Prediction: Climate Risk Maps Using AI

- Integrates socio-economic + climate + geospatial data to highlight vulnerable populations and assets.

- AI Chatbots for Farmer & Community Guidance

- Delivers crop, weather, and disaster advisories in local languages using NLP.

Core Applications of AI

Weather & Climate Prediction: Real-Time Nowcasting

- Short-term, high-resolution prediction (e.g., next 2–6 hours)
- Used for rain, lightning, hail, and wind predictions
- Example: Google DeepMind's Nowcasting system:
  - Trained on radar data
  - Predicts rainfalls at a street-level resolution
  - Used by UK Met Office

Google DeepMind's Nowcasting system:

Trained on radar data

Predicts rainfall at a street-level resolution

Met Office

Used by UK Met Office

Core Applications of AI

**Waste Management:** AI-Powered Waste Segregation & Recycling

- Computer Vision (CV) with CNNs for identifying waste types:
    - Plastic, paper, metal, glass, organic
- Used in smart recycling stations and automated MRFs (Material Recovery Facilities)
- Robotic arms guided by AI sort waste in real-time
- Example: AMP Robotics (USA) — 80+% accuracy in material classification
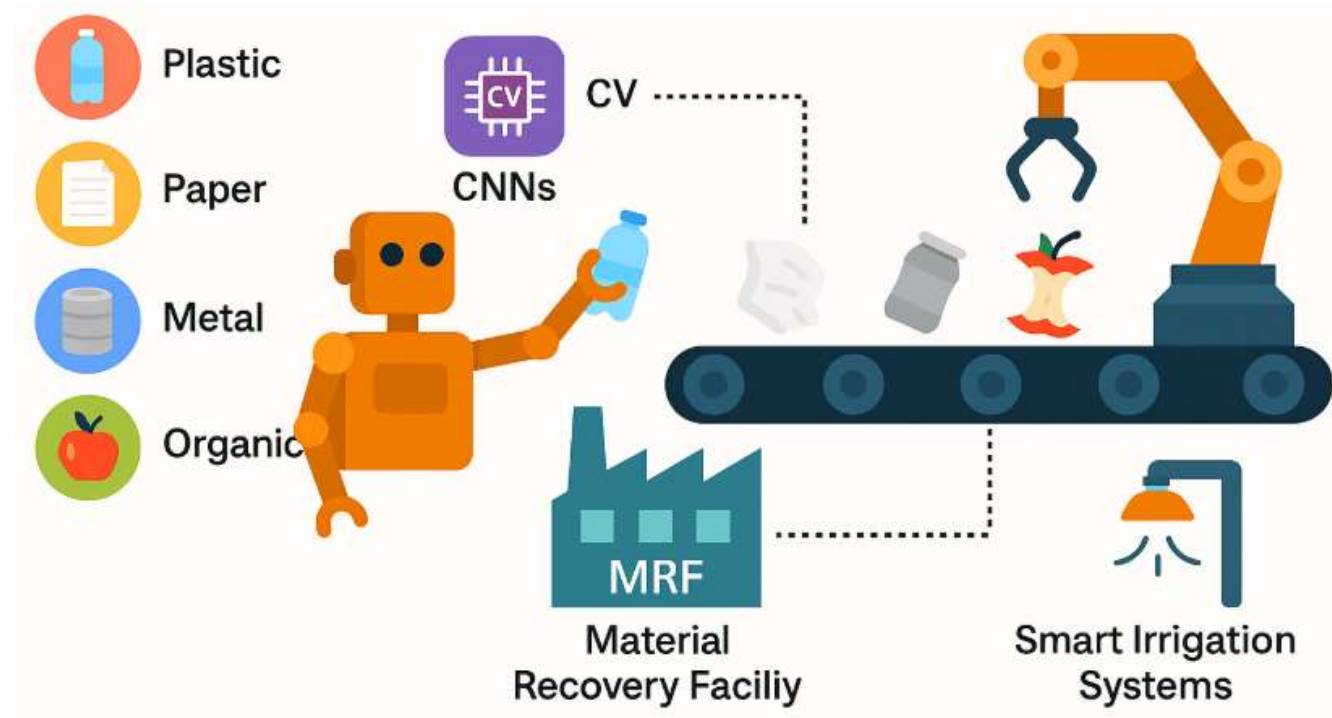
Core Applications of AI

Waste Management: Food Waste Prediction & Supply Chain Optimization

- AI models predict food demand vs. supply using:
  - Past sales data, holidays, weather, expiry patterns
- Helps grocery chains and restaurants reduce overstocking
- Optimizes routing & storage to extend shelf life
- Example: *Wasteless AI* — real-time dynamic pricing to reduce expired food

Demand → AI → Shelf Life

Food Waste Prediction
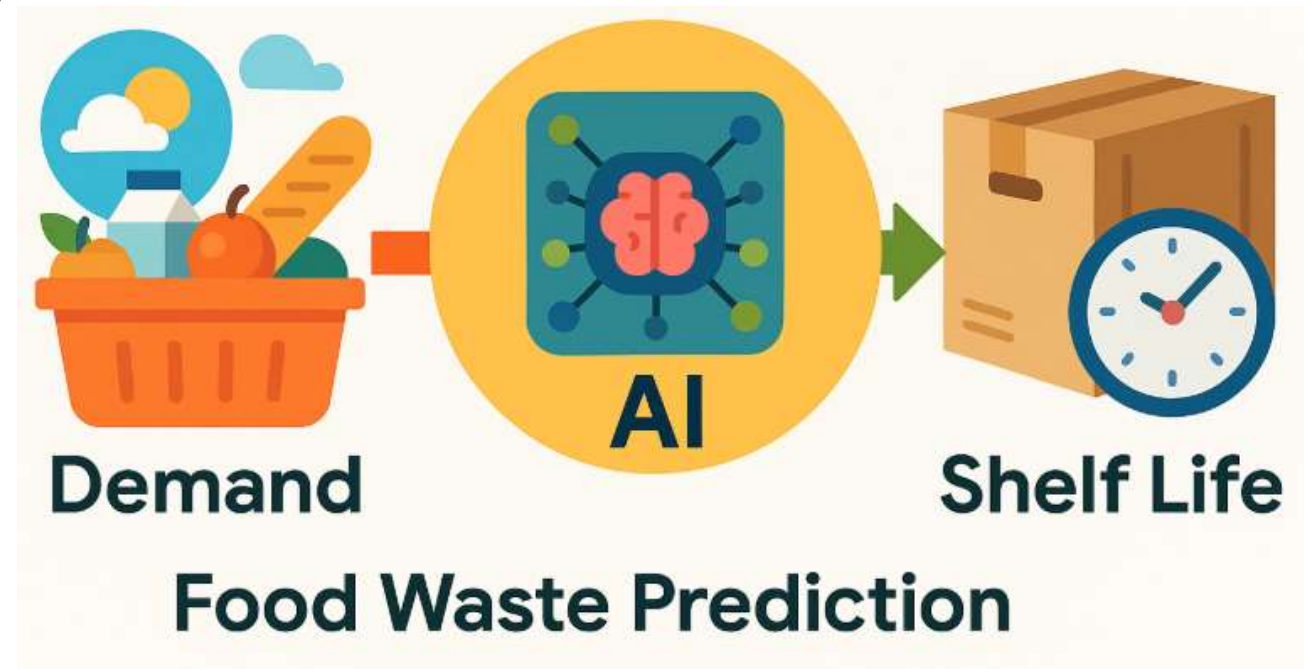
Core Applications of AI

Waste Management: Real Use Cases

Area	AI Contribution
Urban recycling	CV-based segregation in bins and recycling plants
Food supply chains	ML to forecast perishables demand, adjust procurement
Smart cities	IoT + AI bins that notify fill levels and detect anomalies

Core Applications of AI

Water Resource Management: Predicting Droughts

- Use of satellite data (e.g., NASA GRACE) + AI/ML to estimate:
    - Soil moisture
    - Groundwater depletion
    - Rainfall anomalies
- ML Models detect drought patterns earlier than traditional methods
- Example: NASA GRACE + Random Forest for drought risk prediction in India & Africa
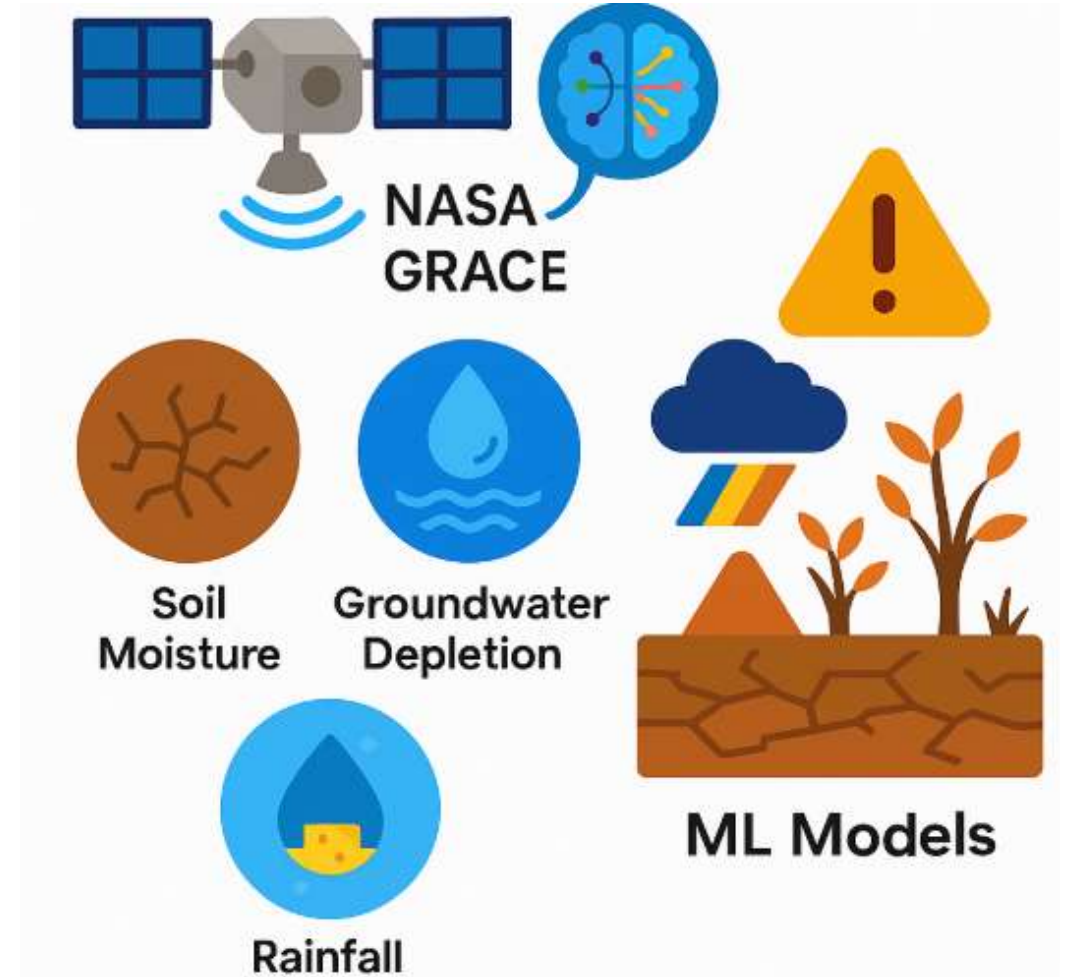
Core Applications of AI

Water Resource Management: Leak Detection
in Water Supply

- Smart sensors installed along pipelines monitor:
    - Pressure, flow, vibration, and acoustic signals
- AI-based anomaly detection algorithms spot leaks or bursts in real-time
- Benefits: Saves billions of liters annually in urban water systems

Core Applications of AI

Water Resource Management: AI for Smart Irrigation & Groundwater Monitoring

- AI + IoT for:
  - Soil moisture prediction
  - Weather-aware irrigation scheduling
  - Evapotranspiration rate modelling
- Example: CropX, Arable Labs using ML + sensors for water-efficient farming

Core Applications of AI

Water Resource Management: Flood Prediction and Early Warning

- Google Flood Forecasting Initiative:
  - Uses hydrological models + AI
  - Sends real-time flood warnings via Maps, Search, SMS
  - Operational in India, Bangladesh, and parts of Africa
- Combines satellite, river flow, rainfall, and elevation data

Core Applications of AI

Water Resource Management: Benefits of AI in Water Management

Area	AI Role
Drought Prediction	Early alerts via ML on satellite + ground data
Urban Water Systems	Leak detection, predictive maintenance
Agriculture	Optimized irrigation and water use
Disaster Management	Flood nowcasting + early alerts

Google AI for Earth

Google AI for Earth: Overview of the Initiative

- Launched by: Google in 2017

- Mission: Empower global researchers with AI + geospatial tools to tackle climate and sustainability challenges

- Support Provided:
  - Funding, tools (e.g., Google Earth Engine, AutoML)
  - Cloud credits for researchers and NGOs
  - Access to satellite + remote sensing data
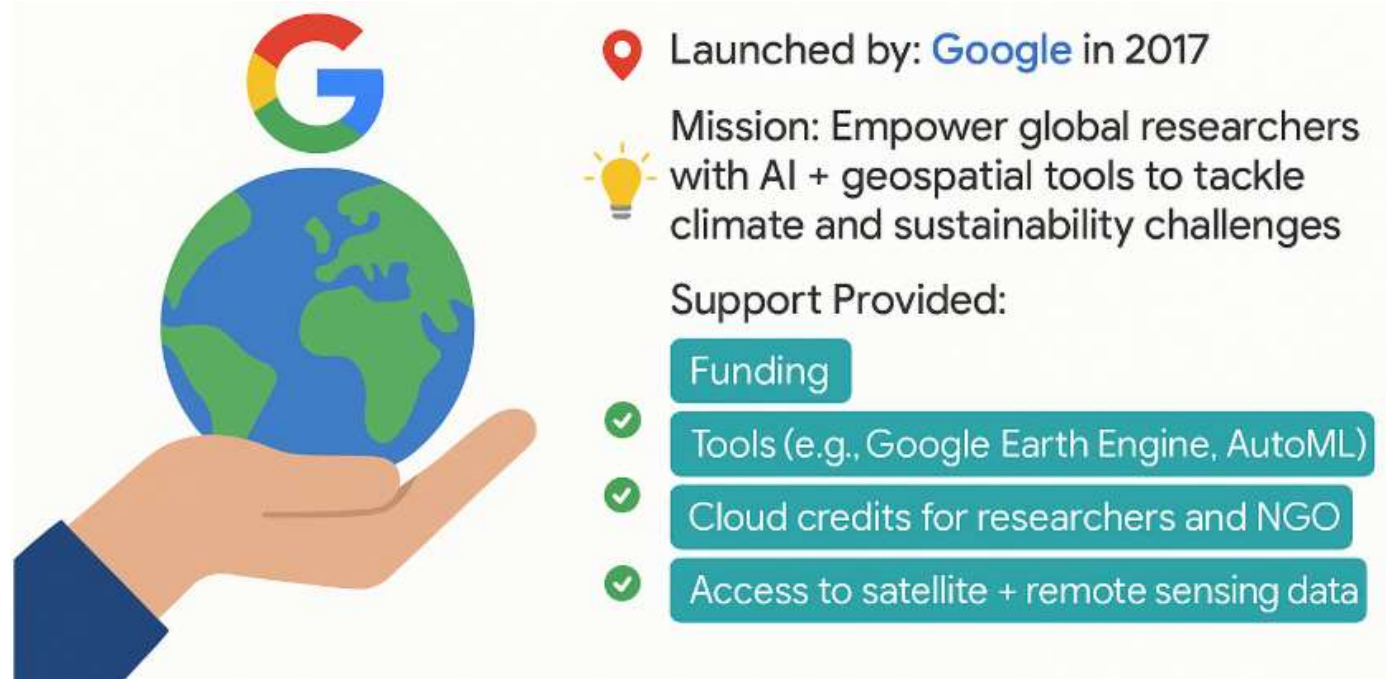
Google AI for Earth

Google AI for Earth

- Surface Water Mapping

- Uses Earth Engine + ML to detect presence of water bodies across years

- Tracks seasonal water shrinkage, reservoir depletion, and river course changes

- Dataset: JRC Global Surface Water

Google AI for Earth

Google AI for Earth

- Flood Prediction in India

- Combines hydrological models + AI

- Predicts flood risk zones in real time using:
    - River levels
    - Elevation models
    - Rainfall forecasts

- Outputs: Maps, SMS alerts, Google Search banners

- Impact: Over 360 million people now covered by warnings (as of 2023)

Google AI for Earth

Google AI for Earth

- Land Cover Classification

- AI models classify terrain into forest, cropland, water, urban, etc.

- Trained on satellite imagery + human-verified labels

- Useful for:
    - Urban planning
    - Deforestation monitoring
    - Agricultural mapping

Google AI for Earth

Google AI for Earth

- Biodiversity Monitoring

- AI + camera traps + satellite data

- Tracks endangered species movement and habitats

- Detects illegal logging or mining via pattern changes

- Example: Wildlife Insights uses CV to identify species from photos

Challenges

- **Other Challenges:**

- **Lack of Transparency and Explainability:** Complex AI models, particularly deep learning models, can be "black boxes," making it difficult to understand how they arrive at decisions, which can be problematic when dealing with climate-related issues.

- **Accountability and Responsibility:** Determining who is responsible when AI systems make errors or cause harm in climate-related contexts is a complex ethical challenge.

- **Job Displacement:** AI-driven automation could lead to job losses in certain sectors, potentially exacerbating social inequalities.

Challenges

- **Environmental Impact:**

- **High Energy Consumption:** AI models, especially large language models, require significant computational power and energy, leading to increased greenhouse gas emissions and strain on energy grids.

- **E-waste:** The rapid pace of AI hardware development creates substantial electronic waste, with improper disposal posing environmental risks.

- **Resource Utilization:** AI development and deployment can consume vast amounts of water and other resources, potentially competing with other essential needs.

- **Data-Related Issues:**

- **Data Availability and Quality:** AI relies on large datasets, and the lack of reliable and accessible environmental data in many regions can hinder the effectiveness of AI-driven solutions.

- **Data Privacy and Security:** Climate-related AI applications often require access to sensitive personal data, raising concerns about privacy breaches and unauthorized access.

- **Bias in Data:** AI models trained on biased datasets can perpetuate and amplify existing inequalities, leading to unfair or discriminatory outcomes.

Ethical Issues

- **Bias and Fairness:**

- AI systems should be designed and deployed in a way that ensures fairness and does not discriminate against any particular group or region.

- **Data Privacy and Security:**

- Robust measures must be in place to protect sensitive data used by AI systems, especially in climate-related applications.

- **Transparency and Explainability:**

- AI systems should be transparent and explainable, particularly when making decisions that affect people's lives and the environment.

- **Accountability and Responsibility:**

- Establishing clear lines of accountability for AI systems is crucial to address any negative impacts or unintended consequences.

Ethical Issues

- **Access and Equity:**

- The benefits of AI-driven climate solutions should be accessible to all, regardless of their location or socioeconomic status.

- **Environmental Impact:**

- The environmental footprint of AI development and operation needs to be carefully considered and minimized, with a focus on sustainable practices and resource management.

- **Human-AI Collaboration:**

- Ensuring responsible human-AI collaboration is essential to harness the potential of AI while mitigating potential risks and ethical concerns.

- **Misinformation and Manipulation:**

- AI can be used to spread misinformation or manipulate public opinion on climate change, undermining efforts to address the crisis.

THANK YOU