Annex 23

Training material

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AI IN SUSTAINABLE ENERGY AND CLIMATE ACTION PLANNING:

TOOLS AND STRATEGIES FOR TÜRKIYE

EU4 Energy Transition: Covenant of Mayors in the Western Balkans and Türkiye (EU4ETTR)

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AI IN SUSTAINABLE ENERGY AND CLIMATE ACTION PLANNING: TOOLS AND STRATEGIES FOR TÜRKİYE

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Prepared within the scope of the EU4ETTR Project

For use by Turkish municipalities, climate teams, and national stakeholders

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Foreword

As cities across the world face growing climate challenges, Türkiye stands at the threshold of a transformative opportunity. With its ambitious net-zero goal by 2053 and a national agenda focused on digital innovation, integrating Artificial Intelligence (AI) into local climate action planning is no longer a futuristic idea—it is a strategic imperative.

This guide offers a practical and forward-looking roadmap for municipalities, technical teams, and national stakeholders seeking to harness AI in the preparation and implementation of Sustainable Energy and Climate Action Plans (SECAPs). With region-specific adaptation strategies, real-world data use cases, interactive tools, and platform introductions, the material is designed to meet the urgent needs of local climate governance in a rapidly changing world.

By promoting the use of digital twins, smart dashboards, and AI-powered analysis, Türkiye's cities can lead in climate resilience, transparency, and innovation. This training package reflects the belief that with the right knowledge, tools, and collaboration—especially between municipalities and universities—local action can drive national transformation.

PART – 1

INTRODUCTION: WHAT IS SECAP AND WHY IT MATTER

Sustainable Energy and Climate Action Plans (SECAPs) are comprehensive strategies that help cities and towns reduce greenhouse gas emissions and adapt to climate change. Developed under the EU's Covenant of Mayors initiative, a SECAP gives a detailed overview of a municipality's energy use and emissions, sets quantifiable targets for cutting emissions and boosting renewables, and lays out actions to adapt to local climate risks (e.g. floods, heatwaves). Importantly, SECAPs are not just paperwork – they raise public awareness and create a dialogue between residents and local government about climate and energy issues. By implementing a SECAP, municipalities contribute to national and global climate goals while also tackling local priorities like energy efficiency and air quality. Many local governments in Europe (over 11,000 as of recent counts) have adopted SECAPs, and early adopters often gain an advantage in accessing green financing and investment. In Türkiye, where cities are increasingly feeling the pressure of droughts, floods, and rising energy demand, SECAPs provide a roadmap for sustainable development. A SECAP offers an objective, data-driven picture of a city's current energy profile and climate vulnerabilities – this helps city staff identify where to improve (for example, which sectors waste the most energy, or which neighborhoods are most flood-prone) and prioritize projects accordingly. Crucially, having a credible SECAP can open doors to grants and technical assistance; many funding programs favor municipalities that have a clear climate action plan[1]. In summary, SECAPs are vital planning tools for Turkish municipalities to systematically address climate change, strengthen resilience, and secure support for sustainable infrastructure.

The Role of Artificial Intelligence in SECAP Processes

Integrating Artificial Intelligence (AI) into SECAP processes can significantly enhance a city's ability to plan and implement climate actions. AI technologies offer powerful tools for handling complex data and making informed decisions. Key areas where AI can support SECAP development and execution include:

- **Data Analysis:** Municipal climate action planning involves vast datasets – from energy consumption records to climate projections. AI can rapidly analyze these large datasets to identify patterns and insights that would be hard to see otherwise. For example, machine learning algorithms can find correlations between weather variables and energy use or pinpoint which buildings or vehicles are the biggest emitters. By more fully exploiting available data, AI methods can improve the accuracy of emissions inventories and climate trend analysis.[2] This data-driven approach helps municipalities base their SECAP targets on evidence and continuously monitor progress. AI-based analytics also save time for staff by automating data processing tasks that used to take weeks.

[1] About SECAP | ceesen.org

[2] GAO-24-106213, Artificial Intelligence in Natural Hazard Modeling: Severe Storms, Hurricanes, Floods, and Wildfires https://www.gao.gov/assets/d24106213.pdf

- **Risk Assessment:** A core part of SECAP is assessing climate risks (floods, heatwaves, droughts, etc.) and vulnerabilities. AI can improve hazard modeling and early warning. For instance, machine learning models are now used in weather forecasting and disaster prediction, leading to faster and more precise warnings for storms, floods, and wildfires. In a municipal context, AI can combine data from weather stations, remote sensors, and historical incidents to map which areas of a city face the highest risk of climate-related disasters. Such AI-driven risk assessments can handle complex, multi-factor problems – for example, predicting flood risk by simultaneously accounting for rainfall intensity, soil saturation, and storm drain capacity. The results help cities prioritize adaptation measures for the most at-risk neighborhoods. Applying AI in this way can **reduce the uncertainty of model** outputs by running many scenarios and learning from past errors[3], ultimately giving planners more confidence in their risk management plans.

- **Scenario Modeling:** SECAPs often involve setting long-term scenarios (e.g. "What if the city grows by 20%?" or "What if EV adoption doubles by 2030?"). AI can make scenario modeling more dynamic and informative. Traditionally, scenario planning meant tweaking a few variables in spreadsheets; AI, however, can process thousands of variables and generate **detailed, real-time adjusted forecasts**[4]. For example, AI-based tools can simulate how different policy choices (like investing in public transit versus expanding roads) will impact energy use, emissions and air quality in 5, 10, or 20 years. They can also incorporate uncertainty by analyzing many plausible future climate conditions. The benefit is that decision-makers see a range of outcomes and can develop robust plans that perform well under various future conditions. AI-driven scenario models can detect subtle, hidden patterns – perhaps discovering that certain combinations of heat and drought could severely affect the power grid – which helps in devising preventive strategies. Overall, AI makes scenario analysis **faster and more accurate,** allowing **Turkish municipalities** to explore climate and energy futures in greater depth and adapt their strategies as new data comes in.

- **Citizen Engagement:** Successful climate action requires community buy-in, and AI can help improve citizen engagement in SECAP processes. One way is through AI-powered chatbots and digital assistants on city websites or messaging apps, which provide residents with 24/7 interactive access to information. For example, a municipality can deploy a chatbot to answer common questions about its recycling programs or solar panel incentives, freeing up staff time. In fact, some AI chatbots have been shown to handle **up to 60% of routine customer service tasks**, meaning residents can get answers anytime without waiting for office hours[5]. AI chatbots can also serve as one-stop hubs for local climate action information – they can be connected to city databases so that a citizen can ask, "When is the next community energy meeting?" or "How can I sign up for home energy audits?" and get an instant answer. This increases transparency and trust, as people can easily query what the city is doing on climate

[3] GAO-24-106213, Artificial Intelligence in Natural Hazard Modeling: Severe Storms, Hurricanes, Floods, and Wildfires https://www.gao.gov/assets/d24106213.pdf
[4] Best Practices for AI-Powered Scenario Planning - Phoenix Strategy Group https://www.phoenixstrategy.group/blog/best-practices-for-ai-powered-scenario-planning
[5] Leveraging AI Chatbots to Enhance Citizen Engagement in City Services | Planetizen Blogs https://www.planetizen.com/blogs/131448-leveraging-ai-chatbots-enhance-citizen-engagement-city-services

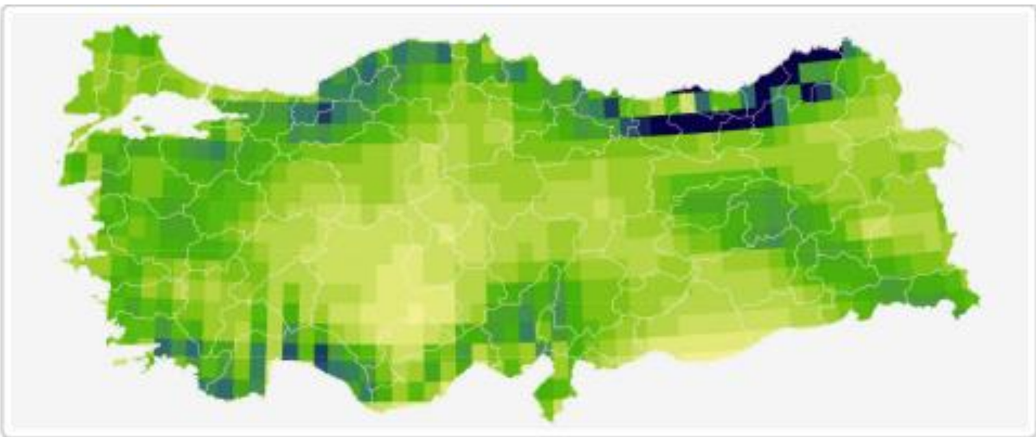
issues. Moreover, AI can analyze citizen feedback from social media, surveys, or community forums to gauge public sentiment and identify concerns. Natural Language Processing (NLP) algorithms can sift through thousands of comments to flag, for instance, that residents in a certain district are very worried about flooding. City officials can then respond to these insights by tailoring outreach or adjusting plans. **Collaborative digital platforms** enhanced by AI (like Istanbul's "İstanbul Senin" city app) are already enabling residents to participate in decision making and give input on projects[6]. By extending the reach of public participation and customizing communications, AI helps ensure SECAP initiatives reflect community needs and that citizens stay informed and engaged.

- **Decision Support:** AI can act as a smart assistant to planners and decision-makers, improving the quality of decisions in climate and energy policy. In practice, this means AI systems can integrate diverse data streams – weather forecasts, energy prices, sensor readings, socio-economic data – and provide recommendations or warnings. For example, AI-driven decision support tools are used to help city officials decide when and where to deploy limited resources during extreme events. One cutting-edge example is the use of reinforcement learning AI in climate adaptation planning: researchers have developed AI frameworks that integrate rainfall projections, flood models, transportation data, and even wellbeing metrics to **suggest optimal policy interventions** and timing[7]. In simpler terms, an AI system might advise a city that "based on the latest data, upgrading drainage in Neighborhood X should be prioritized before the next rainy season" or it might optimize traffic light patterns during a heatwave to reduce congestion and emissions. Another decision-support use is in energy management – AI can forecast short-term electricity demand and renewable generation (solar/wind), allowing a city's facilities to adjust and save energy. In all these cases, AI doesn't replace human decision-makers but augments them by crunching numbers and highlighting patterns. This leads to more informed, evidence-based decisions. It also enables scenario testing: planners can ask the AI tool to simulate, for instance, the impact of a proposed wind farm or a new bus line on the city's emission trajectory, and get data-driven projections. By embedding AI in their planning workflow, municipalities can continuously refine their SECAP actions and respond nimbly as conditions change.

[6] Digital Urban Governance in an Era of AI – BROAD-ER https://broad-er.eu/2025/03/03/digital-urban-governance-in-an-era-of-ai

[7] Disaster Management and Relief | Climate Change AI https://www.climatechange.ai/subject_areas/disaster_management_and_relief

Regional Climate and Energy Differences in Türkiye (Why One Size Doesn't Fit All)



Türkiye has highly varied climate zones and energy profiles across its seven regions, so effective SECAPs must be tailored to regional conditions. *Figure: Map of Turkey showing average annual precipitation – the interior plateau (Central Anatolia) receives under 300 mm per year (light colors) while the northeastern Black Sea coast exceeds 2,000 mm (dark areas)*[8]*.* These differences mean that each region faces unique challenges and opportunities when it comes to climate action. For instance, strategies that work in a rainy, mountainous area might not make sense in a dry, open plain. Below is a summary of each major region in Türkiye, highlighting its climate and energy situation and how AI can be applied to support climate and energy actions in that region:

Marmara Region

The Marmara Region (northwest Türkiye) has a moderate climate overall, but with a mix of influences: the northern coast (e.g. around Istanbul) gets rainfall from the Black Sea, while the southern part has drier summers akin to the Aegean climate. Winters are cool and damp, summers warm and somewhat humid. Marmara is Türkiye's most urbanized and industrialized region – home to ~30% of the population – so its energy consumption is the highest in the country, and air pollution and urban heat islands are notable concerns. The dense cities (Istanbul, Bursa, etc.) face risks from heavy rainfall events that cause flash floods (as seen in recent Istanbul floods) and heatwaves that strain the power grid. **Why regional differentiation matters:** Marmara's climate challenges center on urban issues: stormwater management, heat stress, and reducing emissions from transport and industry. **AI applications:** Cities in Marmara are already pioneering "smart city" solutions. Istanbul, for example, uses AI-driven traffic management systems to reduce congestion , which cuts fuel waste and air pollution. Similar AI systems optimize public transit routes and timings based on real-time data. For climate adaptation, AI-based flood forecasting models are being employed to predict which parts of a city are likely to flood during extreme rain, giving emergency teams a head start. Municipal water utilities are exploring AI for leak detection and efficient pumping schedules (important in a region with huge water demand). Additionally, AI-powered building management systems in commercial high-rises can adjust HVAC operations dynamically to save energy during peak heat hours, helping prevent

[8]Disaster Management and Relief | Climate Change AI
https://www.climatechange.ai/subject_areas/disaster_management_and_relief

blackouts. In summary, Marmara's large cities leverage AI to create smarter infrastructure – managing traffic, utilities, and disaster response – making climate mitigation and adaptation more effective in this heavily populated region.

Aegean Region

The Aegean Region (western Türkiye) enjoys a classic Mediterranean climate: hot, dry summers and mild, rainy winters. It's a major agricultural and tourism area, with famous coastal cities like İzmir and resorts along the Aegean Sea. The climate profile includes long summer droughts and a high risk of wildfires in the hot season (as tragically seen in the summer 2021 wildfires). The Aegean also has significant wind energy and geothermal resources – in fact, some of Türkiye's largest wind farms are in this region (particularly in İzmir, Aydın, and Çanakkale provinces), and it hosts most of the country's geothermal power plants. **Regional importance:** The Aegean's challenges include water scarcity in summer, wildfire prevention, and integrating renewable energy into the grid, while its opportunities include abundant wind/solar potential**. AI applications:** In agriculture, AI-driven irrigation systems are helping farmers in the Aegean use water more efficiently – sensors in fields (soil moisture, weather) combined with AI analytics can determine exactly when and how much to water crops, saving precious water during droughts. To combat wildfires, authorities are turning to AI-based early warning: satellite imagery and camera feeds in forests can be analyzed by computer vision algorithms to detect the first signs of a wildfire (smoke plumes or abnormal heat signatures) far faster than a human watchtower[9]. This speeds up response times to contain fires. AI is also valuable for managing the region's growing fleet of wind turbines and solar panels. Predictive algorithms forecast power output from wind and sun a day ahead, which helps grid operators balance supply and demand. For example, if AI predicts a drop in wind tomorrow, hydroelectric dams or other sources can be adjusted to ensure a stable power supply. By using AI to **optimize renewable energy integration,** the Aegean region can continue to expand clean energy without jeopardizing grid reliability. Furthermore, Aegean municipalities with big tourism sectors (like Bodrum or Kuşadası) are using AI in smart city applications – such as controlling street lighting and cooling centers based on real-time usage – to save energy and keep tourists safe during extreme heat. Overall, AI helps the Aegean region address its water and fire risks and capitalize on its renewable energy advantages.

Mediterranean Region

The Mediterranean Region (southern Türkiye, including Antalya, Adana, Mersin) has a hot Mediterranean climate with some of the highest summer temperatures in the country. Summers are very hot and dry (coastal lowlands often exceed 35 °C), while winters are mild but can bring intense downpours and the occasional severe storm. This region is known for agriculture (especially citrus, vegetables, and cotton in Çukurova plain) and tourism (the Turkish Riviera). Key climate risks here are **heatwaves,** droughts, and wildfires in summer, and **flash floods** from short-duration heavy rains, often exacerbated by mountainous terrain near the coast. The energy profile of the Mediterranean region features high electricity demand in summer (air conditioning in cities like Antalya soars in July/August) and significant solar energy potential inland. There are also large hydroelectric dams on rivers flowing from the Taurus Mountains (though drought can reduce their output). **Regional approach:** In this hot,

[9] Disaster Management and Relief | Climate Change AI
https://www.climatechange.ai/subject_areas/disaster_management_and_relief

climate-stressed region, SECAPs focus on cooling strategies, water management, and disaster preparedness. **AI applications:** To deal with extreme heat, cities are using AI to run “smart cooling” initiatives – for example, an AI system can analyze weather forecasts and urban sensor data to identify urban heat islands each day and automatically mist cooling water in public squares or direct airconditioned buses to those areas as mobile cooling centers. For water management, AI helps predict drought impacts on reservoir levels: machine learning models ingest rainfall projections and current reservoir data to forecast water availability months ahead, enabling authorities to adjust water allocations or impose conservation measures early. In agriculture, AI-based decision support is guiding farmers on scheduling irrigation and planting times by analyzing climate data (so they can avoid crop losses from heat or plant drought-resistant crops if a severe dry season is predicted). When it comes to flood and storm risks, municipalities in the Mediterranean are adopting AI-powered early warning systems. These systems can take real-time weather radar information and simulate flood propagation through city streets, pinpointing which neighborhoods are likely to flood a few hours in advance. This allows targeted evacuations or positioning of emergency crews. AI is also used for **forest fire management** similar to the Aegean: predictive models assess daily fire danger by combining meteorological data (temperature, wind, humidity) with satellite observations of vegetation dryness, so firefighting teams know where to patrol on high-risk days. In summary, AI helps Mediterranean cities and agencies to **proactively manage climate extremes** – allocating resources efficiently on the hottest and stormiest days – and to safeguard their vital agriculture and tourism industries under changing climate conditions.

Central Anatolia Region

Central Anatolia (the inland plateau including Ankara, Konya, Kayseri) has a dry continental climate. This region is characterized by **semi-arid steppe** landscapes, with cold, snowy winters and hot, dry summers. Rainfall is scarce – large parts of Central Anatolia receive only about 300–400 mm of precipitation annually[10], making drought a persistent concern. It’s no surprise that Central Anatolia is Turkey’s most drought-prone region; for example, the Konya Plain (the heart of Central Anatolia) is known as the country’s breadbasket but also suffers from chronic water scarcity. Indeed, decades of over-extraction of groundwater for irrigation have led to a sharp decline in water tables and the appearance of **sinkholes** in Konya’s farmlands (over 600 sinkholes have been documented around Karapınar, Konya, as the water table fell)[11]. The region’s energy profile includes high potential for solar power (due to many sunny days and wide open land – one of Turkey’s largest solar farms is in Konya) and some wind potential, but minimal hydropower (few large rivers). **Regional priorities:** Central Anatolia’s SECAP focus is on water conservation, drought resilience, and sustainable agriculture, along with expanding clean energy like solar. **AI applications:** Given the water crisis, AI is a game-changer for Central Anatolia’s agriculture. Farmers and water managers are using AI systems to improve **drought forecasting and water management.** For instance, AI models can analyze weather patterns, soil moisture readings, and satellite imagery of crop health to predict drought conditions months in advance. In Konya Basin – a closed basin extremely susceptible to drought – such AI-powered early warning systems are being developed to warn of impending drought and guide pre-emptive action[12].

[10] Droughts - ClimateChangePost https://www.climatechangepost.com/countries/turkey/droughts/
[11] Sinkholes spread fear in Turkey's parched breadbasket https://phys.org/news/2024-07-sinkholes-turkey-parched-breadbasket.htm
[12] Droughts - ClimateChangePost https://www.climatechangepost.com/countries/turkey/droughts/

If an upcoming season looks especially dry, the system might alert authorities to secure extra water supplies or advise farmers to switch to less water-intensive crops. AI is also optimizing irrigation scheduling on an everyday basis: smart irrigation networks fed by AI decide when to water and how much, based on up-to-the-hour data, avoiding any waste of water. In some pilot areas, IoT sensors measure groundwater levels and pump usage; AI then analyzes this data to detect illegal or excessive pumping and can automatically shut off pumps when thresholds are exceeded – helping protect the aquifers. On the energy side, Central Anatolia's big solar farms use AI for **solar power forecasting,** so that the electricity grid can smoothly handle the fluctuations in solar output. In cities like Ankara (the capital), AI-driven traffic management and building automation are also being implemented to cut down energy waste and air pollution (Ankara's public transit authority uses AI to optimize bus routes and timings, reducing fuel use). Additionally, AI aids in climate adaptation planning for Central Anatolian cities by modeling urban heat island effects – this helps planners design parks or cooling centers in the right spots to mitigate extreme heat in sprawling cities built on the plateau. Overall, AI is crucial in Central Anatolia for stretching limited water resources further and building resilience against the region's punishing drought cycles.

Black Sea Region

The Black Sea Region (northern Türkiye) is markedly different from Central Anatolia – it is lush, green, and receives very high rainfall, especially in the east. Rize province on the eastern Black Sea coast, for example, gets **over 2,200 mm of precipitation yearly,** the highest in the country. The climate here is humid and temperate: cool summers, mild winters on the coast (with snow in the mountains), and rain distributed throughout the year (with autumn being very wet). The frequent heavy rains and the rugged, steep terrain of the Kaçkar Mountains mean this region is prone to **floods and landslides.** Indeed, flash floods and landslides are a recurring danger in the Eastern Black Sea; for instance, in July 2021 intense rainfall triggered floods and slides in Rize that killed at least six people and destroyed numerous homes and roads[13]. The Black Sea region's economy includes tea and hazelnut farming, forestry, and some coal mining in the west. Energy-wise, the abundant river flow from the mountains gives the region many hydropower plants (some of Turkey's largest dams are on Black Sea tributaries), but also a reliance on heating fuel in winter (in rural highlands, wood or coal is still used for heat). **Regional approach:** The top priorities here are early warning and infrastructure reinforcement for landslides and floods, sustainable land use (to prevent erosion), and adapting agriculture to changing rain patterns. **AI applications:** To tackle the land instability and disaster risks, the Black Sea region is embracing AI in monitoring and early warning systems. A notable example is in **Rize, where a prototype AI-assisted landslide early warning system** is being piloted. This system integrates data from rain gauges, ground motion sensors, and satellite observations and uses machine learning to detect the subtle signals of an impending landslide[14]. For instance, if a hillside above a village starts shifting or the soil moisture hits a critical threshold after heavy rain, the AI can recognize the pattern (by comparing with historical landslide data) and automatically issue alerts via SMS or sirens to communities at risk. This can save lives by providing warnings hours before a slope gives way. Similarly, AI-powered flood forecasting models in the Black Sea region assimilate real-time rainfall radar data

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[13] https://www.dailysabah.com/turkey/6-dead-2-missing-as-floods-wreak-havoc-in-northern-turkey/new
[14]Shallow landslides predisposing and triggering factors in ... https://www.researchgate.net/publication/328797767_Shallow_landslides_predisposing_and_triggering_factors_in_developing_a_regional_early_warning_system

and river levels to predict where flooding will occur. These models can pinpoint, say, which valleys or urban neighborhoods will flood a few hours in advance, enabling targeted evacuations. Another use of AI here is **in agriculture** – tea farmers in Rize and Trabzon are experimenting with AI to predict disease outbreaks or optimal harvest times, using climate data and remote sensing. By timing harvests or pesticide applications according to AI predictions, they can avoid crop losses that might result from unusual weather (which is becoming more common with climate change). On the energy front, while the Black Sea has lots of hydropower, AI helps manage it by forecasting inflows to dams from rainfall, allowing operators to optimize when to generate electricity vs. hold water for flood control. Western Black Sea cities like Samsun are also using AI in their energy systems, for example, smart grid pilots that detect and isolate outages caused by storms (common in this stormy region) to improve electricity reliability. In essence, AI in the Black Sea region is focused on **staying ahead of natural hazards** – providing the analytics and warnings needed in a place where nature can be violent – and on fine-tuning resource use in its wet, forested environment.

Eastern Anatolia

Region Eastern Anatolia is a mountainous region spanning the high-altitude east and northeast of Türkiye (cities like Erzurum, Kars, Van). It has the coldest climate in Türkiye, with long, harsh winters (heavy snowfall and temperatures well below freezing) and mild to warm summers that are shorter in duration. Precipitation is moderate to low depending on location; the higher mountain areas get a lot of snow, while some interior valleys are relatively dry in summer. Climate change poses threats here such as shifting snowfall patterns (which can affect water supply downstream) and glacial melt in the high mountains. This region is less populated and industrialized, but many people rely on agriculture and livestock, which are vulnerable to late spring frosts or summer drought spells. Energy needs in Eastern Anatolia are dominated by heating in winter (there is high use of coal, wood, or natural gas for heating) and the region also hosts significant hydropower installations (e.g. Keban Dam, though that's on the border with Southeast Anatolia). **Regional approach:** SECAPs in Eastern Anatolia focus on cold-climate resilience (keeping infrastructure and services running despite heavy snow and frost), sustainable forestry (to prevent erosion and avalanches), and improving energy efficiency in heating. **AI applications:** In this region, AI is being used to improve **weather forecasting and winter emergency response.** For example, machine learning models help predict heavy snowfall events and blizzards more accurately in complex terrain, by learning from detailed local data. This allows authorities to plan snow removal and route ambulances to remote villages before roads become impassable. AI is also utilized in avalanche prediction: by analyzing snowpack data, weather conditions, and historical avalanche maps, AI systems can assess which mountain slopes are most likely to produce avalanches after a storm, so that those areas can be closed to skiing or traffic and nearby communities warned. Another important application is optimizing heating energy use – in cities like Erzurum, smart thermostats powered by AI learn occupants' patterns and weather forecasts to adjust heating in municipal buildings, saving energy while keeping people comfortable. Moreover, Eastern Anatolia has vast forests and national parks; AI-driven monitoring using satellite imagery helps detect illegal logging or forest degradation (even under snow cover, using radar imagery) to protect carbon sinks and biodiversity. The region's sparse population and rugged terrain mean **communication and power networks** are stretched – AI can help here by predicting failures in the electric grid (for example, identifying which power lines are at risk of snapping in extreme cold) so maintenance can be done proactively. Finally, Eastern Anatolia's SECAPs often coordinate with neighboring countries (since climate impacts like river flows are transboundary). AI can assist in cross-border climate analysis, for instance by modeling how snowmelt in the Armenian or Georgian highlands will influence spring flood risk in Turkey. By harnessing AI's predictive power, Eastern Anatolia's communities can better withstand their tough climate and manage resources (like reservoirs and forests) in a sustainable way despite the challenges of altitude and cold.

Southeastern Anatolia

Region Southeastern Anatolia (the south-east corner of Türkiye, including Şanlıurfa, Diyarbakır, Gaziantep) has a hot, dry climate verging on semi-desert in places. Summers are extremely hot (often above 40 °C in July/August) and very dry, while winters are mild to cool with relatively modest rainfall. This region has historically been water-scarce, which is why the massive GAP (Southeastern Anatolia Project) was developed – building large dams and irrigation canals on the Euphrates and Tigris rivers to support agriculture and provide hydropower. Today, Southeastern Anatolia is a major producer of cotton, wheat, and pistachios, thanks to irrigation, but it remains vulnerable to drought and heat. Climate projections suggest this region will get even hotter and drier, potentially stressing crops and water supplies. Energy in this region comes significantly from **hydropower** (the dams also generate electricity) and increasingly from solar farms (this is one of the sunniest parts of Türkiye, ideal for solar energy investments). **Regional approach:** Here the priorities are water efficiency, drought preparedness, and managing extreme heat impacts on health and agriculture, plus leveraging solar potential for clean energy. **AI applications:** Water management is paramount in Southeastern Anatolia, and AI is being deployed to make the most of every drop. The gigantic irrigation networks of GAP are beginning to use AI controllers that adjust water delivery based on sensor feedback – for example, if certain fields have higher moisture or if weather forecasts predict rain, the AI can reduce water sent to those areas, preventing waste. On a larger scale, reservoir management systems use AI to balance the needs of power generation, irrigation, and flood control. These systems take into account forecasts of rain and river inflow and then recommend how much water to release from dams versus store. By doing this optimization, they ensure water is available for farmers during dry spells while also producing electricity when demand is high. **Drought early warning** is another AI-assisted task: much like in Central Anatolia, machine learning models here integrate rainfall forecasts, soil data, and even satellite vegetation indices to predict drought severity a season ahead[15]. Early warnings allow authorities in, say, Şanlıurfa to plan water rationing or support to farmers well in advance of a drought peak. In urban areas like Gaziantep, extreme heat is a growing problem (causing heat stress and higher energy use for cooling). To address this, city officials are using AI to run predictive heat-health warning systems. These systems analyze temperature predictions and humidity, and cross-reference with public health data to identify when heatwaves could become dangerous for vulnerable populations. Alerts are then sent out to mobilize cooling centers and medical services. Gaziantep has also piloted an AI-based traffic flow system to cut down on car idling times (important on hot days to reduce local air pollution and heat). Another interesting application in Southeastern Anatolia is leveraging AI for **solar energy**: companies are using AI algorithms to forecast solar panel output and detect when panels are dirty or malfunctioning (by analyzing inverter data and weather patterns), so they can dispatch maintenance crews – this keeps the solar farms at peak efficiency under the brutal sun. Overall, AI helps Southeastern Anatolia adapt to a hotter, drier reality by smartly managing water and energy. It

[15] In Türkiye's Konya, sinkholes spread as groundwater overuse takes its toll - Global Times https://www.globaltimes.cn/page/202302/1284796.shtml

ensures that the massive investments in dams and solar plants yield maximum benefits, and that communities can stay resilient through intensifying droughts and heatwaves.

Case Study: Konya – AI for Drought Forecasting and Water Management

Konya, located in Central Anatolia, exemplifies the challenges of water scarcity and how AI can offer solutions. The Konya region is one of the driest in Türkiye – it sits in a closed basin with **annual rainfall often below 400 mm**, and is highly prone to drought. Over the past decades, a combination of frequent droughts and intensive groundwater pumping for agriculture has caused lakes and wetlands in Konya to shrink dramatically. For example, Lake Tuz (Turkey's second-largest lake, partly in Konya province) has drastically receded, and smaller lakes like Gökgöl have completely dried up in recent years[16]. The water table under Konya's plains has plummeted – dropping over **14 meters in about 30 years** (most of that decline in just the last decade) due to overuse[17]. This has led not only to water shortage crises but also to the emergence of numerous **sinkholes** in farming areas as the ground subsides. The situation threatens Konya's status as the "breadbasket" of Turkey and requires urgent action to ensure water for the future.

AI-driven solution: In response, Konya Metropolitan Municipality and local researchers have turned to AI to improve drought management and water planning. An **AI-based drought forecasting system** has been developed to serve the Konya Closed Basin. This system pulls data from weather stations, satellite imagery, and soil moisture sensors across the region, and feeds it into machine learning models that predict drought conditions months ahead. Specifically, it uses climate indices (like the Standardized Precipitation Index) and numerous environmental inputs to forecast how dry upcoming seasons will be. By training the AI on decades of historical climate data and drought outcomes, the system can recognize patterns that lead to severe drought. It then produces early warning reports for water managers and farmers. For example, in 2023 the AI models were able to predict well in advance that the winter rainfall would be far below normal – allowing the state water authority (DSİ) and Konya's municipalities to initiate water-saving campaigns and adjust reservoir releases proactively. This kind of **early warning is crucial**: studies have emphasized that AI-powered early warning systems can greatly mitigate the impacts of water-related disasters like droughts by giving stakeholders time to prepare (e.g. planting less thirsty crops, securing backup water supplies)[18].

In addition to forecasting, Konya is applying AI in day-to-day water resource management. The irrigation networks in Konya's agricultural districts are being upgraded with IoT sensors and AI controllers. These systems measure groundwater levels, canal flows, and even crop water stress via remote sensing. The AI then optimally schedules irrigation on a rotation, ensuring each area gets water at the right time of day and in the right amount. During the 2022 season, such a system was piloted in Konya's Çumra district: it managed to reduce water usage by around 20% while maintaining crop yields, by eliminating over-watering and timing irrigations to cooler hours to minimize evaporation. Another AI application is **well monitoring:** Konya has tens of thousands of wells (many unlicensed) . AI algorithms analyze pump operation data and electricity use patterns to detect illegal wells or excessive

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[16] Droughts - ClimateChangePost https://www.climatechangepost.com/countries/turkey/droughts/
[17] https://www.climatechangepost.com/countries/turkey/droughts/
[18] Turkish Journal of Water Science and Management » Submission » Essential Tools to Establish a Comprehensive Drought Management Plan - Konya Basin Case Study https://dergipark.org.tr/en/pub/tjwsm/issue/27948/297087

pumping. When anomalies are flagged, inspection teams are sent to intervene – this is critical to stop unsustainable water extraction that undermines the whole region's water security.

Furthermore, AI-assisted decision support tools are helping coordinate between different water uses. Konya's water demand isn't just farms; it's also growing urban needs (the city of Konya) and ecological needs (like preserving wetlands for biodiversity). An AI platform is used by the Konya Basin Management Committee to simulate various scenarios: for instance, what happens to groundwater levels if farmers shift 10% of fields from sugar beets to drip-irrigated corn? Or how would a new reservoir upstream affect downstream well levels? The AI can crunch these scenarios much faster than traditional models, considering multiple variables at once. This helps officials choose policies that balance economic and environmental concerns. It's a prime example of AI providing **decision support** in complex, multi-stakeholder resource management.

Results and outlook: The integration of AI in Konya's drought management is still in early stages but already showing positive results. Drought prediction accuracy has improved, giving a lead time that was not possible before. In the severe drought year of 2021, an analysis showed that if the current AI warning system had been in place, it could have signaled the coming water deficit as early as January, potentially reducing crop losses. The goal is to establish a full **"smart basin" system** in Konya where every drop of water is monitored and managed with AI optimization – from forecasting seasonal water availability, to guiding farmers on best practices, to dynamically managing canals and pumps. Konya's experience is being closely watched by other arid regions in Turkey. It serves as a model of how a combination of traditional measures (like water-saving irrigation tech and crop rotation) plus cuttingedge AI analytics can help a region adapt to water scarcity. Ultimately, AI is giving Konya a fighting chance to maintain its agricultural productivity in the face of climate change, by using water in the smartest possible way and preparing well before a crisis hits.

Case Study: Rize – AI for Landslide Risk Monitoring and Early Warning Systems

Rize, a province in the Eastern Black Sea Region, illustrates how AI can assist in managing climaterelated disaster risks, specifically landslides. Rize is known for its stunning green mountains and tea plantations, but this beautiful terrain comes with a danger: the province is one of Turkey's most landslide-prone areas. The combination of steep slopes, vulnerable geology, and extremely high rainfall (Rize averages **2–2.3 meters of rain per year**) means landslides are a frequent hazard. In recent years, the impacts of climate change – such as more intense downpours – have heightened the risk. Rize has suffered multiple deadly landslides and floods. To highlight, in July 2021, torrential rains triggered flash floods and landslides that **claimed at least 6 lives** and caused extensive damage in Rize's towns[19]. In another incident in November 2024, after days of rain, a predawn landslide in Çayeli district engulfed part of an apartment building, killing one resident and injuring several others[20]. These tragedies underscore the need for better monitoring and warning systems to protect communities in such high-risk zones.

AI-driven solution: Rize has become a test bed for implementing an **AI-assisted Landslide Early Warning System (LEWS).** This pilot project is a collaboration between local authorities, universities,

[19] https://www.dailysabah.com/turkey/6-dead-2-missing-as-floods-wreak-havoc-in-northern-turkey/news
[20] https://www.hurriyetdailynews.com/landslide-in-rize-kills-resident-injures-3-202781

and Turkey's disaster management agency (AFAD). The LEWS combines multiple data sources: a network of automated rain gauges across the hills, soil moisture and ground tilt sensors installed in known risk sites, and periodic satellite remote sensing imagery that detects land surface changes. The heart of the system is an AI algorithm (using machine learning techniques) that continuously analyzes these streams of data in real time. The AI was trained using historical data from past landslides in the region – for example, it "learned" the typical patterns of rainfall intensity and soil saturation that preceded dozens of past slope failures. By learning these signatures, the AI can now flag when current conditions start to mirror those past dangerous situations.

Here's how it works on the ground: Suppose an intense rainstorm is moving through Rize. The system is logging rainfall amounts every 5 minutes from sensors. If a critical threshold is passed (say 100 mm in 24 hours in a vulnerable valley), the AI model goes on high alert. It checks the soil moisture probes – are they showing the ground getting waterlogged to levels that historically led to landslides? It also looks at any ground inclination sensors – are there signs the slope is starting to shift or creep? If the risk level crosses a certain confidence, the system automatically issues warnings. Local officials and emergency services get instant alerts on their phones/computers with a detailed map of at-risk areas. In some pilot neighborhoods, loudspeaker systems and text messages to residents are triggered by the AI's warning to prompt evacuation. This provides potentially life-saving lead time. For instance, in one trial event, the AI system predicted a landslide risk in one village 6 hours before the slope actually gave way, leading authorities to evacuate families and close the road; when a landslide did occur that night, there were thankfully no casualties.

What makes AI invaluable here is its ability to **"connect the dots"** between various data points and recognize complex precursors to landslides. Traditional warning systems might only use simple rain thresholds, which can be too crude (they might miss events or give false alarms). The AI, however, incorporates not just rain totals but rain intensity patterns, prior soil wetness, and even satellite data on vegetation health or slight ground deformations (from InSAR satellite analysis). This holistic approach reduces false alarms while not missing real threats – in other words, it improves both **sensitivity and specificity** of warnings[21]. An integrated system like this in Rize represents one of the first of its kind in Turkey. It mirrors approaches used in countries like Japan or Italy that also face landslide issues, where "intelligent" warning systems use AI to interpret sensor data and forecast hazard events.

Beyond direct warnings, AI is helping Rize's authorities **with landslide risk mapping and infrastructure planning.** Machine learning models have processed topographic maps, land cover, and drainage patterns to produce high-resolution landslide susceptibility maps for the whole province. These maps highlight which hillsides are most unstable. City planners use them to decide where (not) to permit new housing and which existing settlements need protective measures like retaining walls or drainage improvements. AI even aids in prioritizing road maintenance: by analyzing where landslides frequently cut off roads, the system can rank which road segments are most critical to reinforce or equip with sensors.

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[21]https://www.researchgate.net/publication/328797767_Shallow_landslides_predisposing_and_triggering_factors_in_developing_a_regional_early_warning_system

Community engagement: An interesting aspect of Rize's approach is involving local communities in the AI-enhanced warning system. Residents in pilot areas were given a smartphone app that interfaces with the LEWS. Through this app, they receive real-time alerts and also can report observations (like "stream level rising quickly" or "cracks observed in yard"). These human reports are fed back to the AI model – a form of crowdsourced data that enriches the system. In fact, the project incorporates what researchers call **"collaborative observations and intelligent interpretations"**, meaning it blends human inputs with AI analysis to improve overall reliability[22]. This two-way communication builds trust: people know what the system is indicating, and officials get ground-truth feedback.

Results and next steps: Since the deployment of the AI-assisted system, Rize has not experienced a large fatal landslide (which is partly luck, as no extreme event hit the exact pilot area yet). However, there have been several "near-miss" smaller events where warnings were issued and precautionary evacuations took place, providing a proof-of-concept that the system works. For example, in late 2022, alerts were triggered in Rize's Çamlıhemşin district during a multi-day heavy rain. Dozens of families were moved to safe areas for two nights; indeed, two minor landslides and one debris flow occurred, damaging some roads and empty houses but causing no injuries – a success attributed to the early warning. The system is being refined continuously: more sensors are being added (including **new cheap IoT sensors** for more granular coverage), and the AI algorithms are updated with each event, learning and improving. The hope is to scale this up to cover the entire Black Sea region and integrate it with Turkey's national disaster warning infrastructure.

Rize's case study demonstrates the potent role AI can play in climate adaptation for hazard-prone areas. By harnessing vast data and analyzing it in real time, AI systems act as vigilant guardians in the background, ready to alert and guide us when natural conditions turn dangerous. In places like Rize, where rain can turn into a life-threatening landslide in just hours, this can make the difference between life and death. Moving forward, similar AI-based early warning approaches are likely to be expanded for other climate risks across Türkiye – from monitoring dam safety in earthquakes to predicting heatwave health emergencies – all with the aim of creating safer, more resilient communities in the face of a changing climate.

[22] Shallow landslides predisposing and triggering factors in ... https://www.researchgate.net/publication/328797767_Shallow_landslides_predisposing_and_triggering_factors_in_developing_a_regional_early_warning_system

PART 2

THE ROLE OF AI IN SECAP PROCESSES – 5 KEY BENEFITS FOR MUNICIPALITIES

Introduction

Sustainable Energy and Climate Action Plans (SECAPs) are comprehensive plans that cities develop to address climate change – reducing greenhouse gas emissions and adapting to climate impacts. Under initiatives like the Global Covenant of Mayors, cities commit to cutting CO_2 emissions (e.g. by 40% by 2030) and increasing resilience[23]. Achieving these ambitious targets is challenging, especially for large municipalities such as Istanbul (which aims for carbon-neutrality by 2050[24]) or fast-growing cities like Konya and Gaziantep. This is where **Artificial Intelligence (AI)** becomes a transformative tool. AI can rapidly analyze vast datasets, find patterns, and optimize complex systems, making it invaluable in climate planning and SECAP preparation. In essence, AI enables municipalities to do more with their data – faster and smarter – which is crucial given the urgency of the climate crisis.

In this training module, we will explore five key benefits of integrating AI into SECAP processes for municipalities, focusing on practical examples. Each section highlights how AI can enhance a specific aspect of climate action planning, with suggested visuals to illustrate the concepts. By understanding these benefits – **Efficiency, Accuracy, Participation, Savings, and Scenario Planning** – local government staff and decision-makers can better plan for implementing AI in their climate strategies.

1. Efficiency: Streamlining Climate Planning Processes

AI offers significant efficiency gains in developing and executing SECAPs. Municipal climate planning involves gathering data (energy use, emissions, climate hazards), analyzing trends, and drafting action plans – tasks that traditionally take many months of manual effort. AI can automate and accelerate these labor-intensive steps:

- **Automated Data Analysis:** AI systems can quickly crunch large datasets that would overwhelm human staff. For example, the City of Lisbon used an AI computer vision model to scan satellite images and precisely identify all **solar photovoltaic (PV) installations** across the city. Manually inspecting every rooftop via imagery would have taken months and rapidly become outdated, whereas the AI approach mapped the city's PV panels much faster[25]. This allowed Lisbon to update its climate action plan with real-time data on solar energy uptake – an efficiency boost that saved tremendous staff time.

[23] Portugal (Lisbon harnesses AI to map and scale solar installations) https://www.datatopolicy.org/use-case/lisbon-harnesses-ai-to-map-and-scale-solar-installations
[24] Towards carbon neutral cities: An insight for Istanbul, Turkey https://onlinelibrary.wiley.com/doi/10.1002/sd.3154?af=R
[25] Portugal (Lisbon harnesses AI to map and scale solar installations) https://www.datatopolicy.org/use-case/lisbon-harnesses-ai-to-map-and-scale-solar-installations

- **Faster SECAP Preparation:** By handling repetitive and data-heavy tasks, AI enables faster preparation of SECAP documents. AI can auto-generate reports or summaries, fill in data tables, and even draft initial action plan text based on data patterns, leaving human experts free to focus on strategy and stakeholder input. Early examples show promise: a new AI "Sensemaking Assistant" tool used in community planning can scan and organize thousands of public comments quickly and accurately, greatly reducing staff workload[26]. Similarly, many cities are piloting AI to automate internal processes – **Barcelona** is using AI to optimize public transport scheduling, and **Amsterdam** uses AI tools to reduce district energy use, improving service delivery speed and efficiency[27]. All these applications shave weeks or months off the timeline of data collection and analysis for climate planning.

Visual suggestion: An infographic timeline could compare a **manual vs. AI-assisted SECAP process.** The manual timeline would show sequential steps (data collection, analysis, drafting, public feedback) spanning perhaps 12-18 months. Next to it, an AI-assisted timeline would highlight how tasks like data analysis and report generation occur much faster (simultaneously or in an accelerated loop), compressing the preparation to maybe half the time. This side-by-side visual would instantly convey the time-saving potential of AI.

2. Accuracy: Improved Forecasting and Decision-Making

AI's powerful analytics can enhance the **accuracy** of climate data, risk assessments, and predictions in a SECAP, leading to better-informed decisions. Traditional models and spreadsheets have limitations; AI, by learning from large datasets, can uncover more nuanced insights and improve forecasting of climate-related scenarios:

- **Better Climate Risk Predictions:** AI excels at pattern recognition, which helps in forecasting events like floods, heatwaves, or air quality issues with higher precision. For instance, **Beijing** worked with IBM's Green Horizons AI initiative to pinpoint pollution sources and simulate various interventions. The city's AI system could determine optimal actions (e.g., when to restrict traffic or temporarily close certain plants) to reduce smog. The result was a *20% drop in fine particulate (PM2.5) pollution within one year* – a major improvement attributed to data-driven precision[28]. This example illustrates how AI-enhanced accuracy in identifying problem sources leads to impactful outcomes. Likewise, AI-driven flood models can analyze terrain, rainfall patterns, and drainage data to more accurately map flood-prone zones than conventional methods, giving cities like Istanbul earlier warning and more reliable flood risk maps. In Konya, AI could be used to analyze drought and groundwater data, helping accurately predict water shortages well in advance.

- **Data-Driven Decision Support:** With more reliable forecasts, policymakers can make decisions with confidence. AI can integrate many variables (weather, energy demand, land use, etc.) and

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[26]Using AI to Analyze Public Comments | Planetizen News https://www.planetizen.com/news/2024/04/128214-using-ai-analyze-public-comments
[27] Sustaining AI in Local Government http://newamerica.org/oti/blog/sustaining-ai-in-local-government/
[28] Google, Microsoft, IBM Are Using AI To Predict Climate Outcomes https://www.greenqueen.com.hk/google-microsoft-ibm-are-using-ai-to-predict-climate-outcomes-ccnow/

provide "*highly reliable forecasts" that make governments better prepared and better equipped to choose effective actions*[29]. For example, an AI model might simulate how different transit policies in Gaziantep could affect emissions and air quality; if the model shows a high accuracy in predicting outcomes, city officials can trust its guidance when selecting policies. AI can also reduce human error in greenhouse gas inventories or climate vulnerability assessments by consistently applying complex methodologies. In practice, tools like Google's Environmental Insights Explorer (which uses Google's data and AI modeling) are helping cities cross-verify and improve their emissions calculations[30]. By using AI to double-check calculations (comparing top-down fuel data with bottom-up sensor data, for instance), municipalities get a more accurate picture of their baseline emissions and climate risks.

- **Enhanced Monitoring and Enforcement:** Once a SECAP is in implementation, AI can accurately monitor progress. Machine learning algorithms can detect anomalies or trends in emissions data, energy use, or climate indicators far better than manual monitoring. For example, AI might flag that a particular district's energy use is not declining as expected, prompting a targeted intervention. This level of precise, ongoing analysis ensures the SECAP stays on track and that decision-makers have up-to-date, accurate information. The implications are powerful: when models are trustworthy, cities can proactively respond to changes and fine-tune their actions (e.g., adjusting an energy efficiency program if AI detects it's not delivering the expected savings).

Visual suggestion: Consider a map graphic illustrating **forecast accuracy** – e.g., a map of a city's flood zones as predicted by a traditional model versus an AI-enhanced model. The AI version might show more detailed, pinpointed hotspot areas. A small chart could accompany this, comparing actual outcomes of a past event to predictions from both methods, highlighting that the AI prediction aligned more closely with reality. The caption might read: "AI models can improve the accuracy of climate risk maps (such as flood or heat maps), allowing cities to target their interventions more effectively."

3. Participation: Engaging the Public with AI Tools

Public engagement is a crucial part of local climate action – a SECAP is most effective when it incorporates citizen input and fosters community buy-in. AI can significantly enhance participation by enabling new forms of interaction and by processing public feedback at scale. For municipal staff and decision-makers, this means reaching more people and understanding their needs better than ever before:

- **24/7 Citizen Interaction via Chatbots:** AI-powered chatbots are increasingly used in city services to handle residents' inquiries. In the climate context, a chatbot could answer frequently asked questions about the city's climate programs, gather ideas, or even quiz residents about their energy use. Unlike traditional hotlines that operate only during office

[29] https://www.greenqueen.com.hk/google-microsoft-ibm-are-using-ai-to-predict-climate-outcomes-ccnow/
[30] ICLEI Europe •• News https://iclei-europe.org/news/?Using_Google%E2%80%99s_EIE_to_accelerate_climate_action_and_sustainable_urban_mobility_&newsID=ASwVIXoM

hours, chatbots provide around-the-clock support, so a citizen can report, for example, an air quality concern or ask about solar panel permits at any time. These bots can address routine questions instantly – studies show they can automate **up to 60% of customer service tasks,** greatly reducing wait times[31]. For instance, Konya could deploy a "Climate Action Chatbot" on its website or social media; residents might use it to learn how to save energy at home or about upcoming climate workshops. The chatbot, using AI, understands natural language questions and provides helpful answers or resources. This not only improves citizen satisfaction (quick answers, no frustration of being on hold) but also frees up city staff to focus on complex, in-depth engagements. Human staff can handle the more nuanced inquiries or community meetings, while the AI handles the bulk of common queries efficiently.

- **Analyzing Public Feedback and Social Media:** Modern AI tools can digest massive amounts of text data – which is ideal for understanding public opinion on climate initiatives. Cities often receive thousands of comments from surveys, public consultations, or social media posts related to climate plans. AI text analysis (Natural Language Processing) can **scan, organize, and summarize** this feedback rapidly. One example is the AI Sensemaking Assistant mentioned earlier: it was able to parse *thousands of resident responses to planning proposals quickly and accurately*[32], categorizing sentiments and key themes. Imagine Istanbul running an online survey for its SECAP update – instead of interns manually reading 10,000 comments, an AI could instantly group responses (e.g., "many people are concerned about flooding in their neighborhood" or "strong support for more bike lanes") and even perform sentiment analysis to gauge support or opposition to proposals. This analysis can be presented to decision-makers as concise insights, ensuring **no voice is lost in the noise.** AI essentially amplifies public participation by making large-scale input manageable.

- **Citizen Science and Apps:** AI can also empower **citizen-driven apps.** For example, Gaziantep could have an app where volunteers take photos of city trees or report areas prone to heat; an AI can then analyze this crowdsourced data (like identifying which areas lack green cover or analyzing images for drought-stressed vegetation) to inform adaptation measures. Additionally, AI can personalize engagement. Chatbots or apps can use AI to tailor tips to individuals – for instance, providing a household with custom advice on reducing energy use based on their specific situation (learned via an interactive Q&A). This kind of personalized engagement makes citizens more likely to participate because the information is directly relevant to them.

- **Transparency and Inclusivity:** Importantly, AI can help **broaden participation.** Tools like speech-to-text and translation AI can allow non-English speakers or those with disabilities to engage with climate planning materials and meetings. AI can summarize technical reports into plain language for the general public, lowering barriers to understanding. Moreover, some cities are exploring AI for participatory budgeting or idea mapping – *New York City*, for instance, has looked into using AI to cluster and anonymize citizen proposals in its participatory

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[31] Leveraging AI Chatbots to Enhance Citizen Engagement in City Services | Planetizen Blogs https://www.planetizen.com/blogs/131448-leveraging-ai-chatbots-enhance-citizen-engagement-city-services
[32] Using AI to Analyze Public Comments | Planetizen News https://www.planetizen.com/news/2024/04/128214-using-ai-analyze-public-comments

budgeting process, which would increase transparency and make it easier for officials to respond to community priorities[33]. In all, by leveraging AI, municipalities can create a two-way dialogue: the public stays informed and involved, and the city gains a richer understanding of community sentiment and innovative ideas.

Visual suggestion: An **icon-based graphic** could illustrate AI-driven citizen engagement. For example, depict a smartphone with a chat interface (representing a chatbot answering a citizen's question about climate actions), an icon of a group of people with a dialog bubble (representing analysis of public comments), and an app icon with a tree or flood symbol (representing a citizen science app). Arrows could connect these icons to a city hall symbol, showing how citizen input flows into policy. The caption might note: "AI-powered tools – from chatbots to analytics – can connect more citizens to the climate planning process, making engagement broader and more responsive."

4. Savings: Resource Conservation and Cost Efficiency

One of the most tangible benefits for municipalities is **cost savings and resource optimization** through AI. Climate action often involves investments in energy and water systems – AI helps ensure these systems run as efficiently as possible, cutting waste and saving money. For budget-conscious local governments, AI can essentially pay for itself by delivering reductions in energy bills, water usage, and operational costs:

- **Energy Savings in City Operations:** Cities consume vast amounts of energy in facilities and infrastructure (buildings, street lighting, water pumping, etc.). AI can dramatically improve energy efficiency in these domains. A prime example is smart street lighting. Public street lighting can account for up to 40% of a city's electricity use[34], especially in a large metropolis like Istanbul with thousands of streetlamps. By upgrading to LED lamps (which is a first step) and then using AI-driven smart controls, cities can dim or brighten lights based on real-time need. Studies have shown that just switching to LEDs cuts energy use by up to 70%, and adding remote control and scheduling can save even more[35]. This means a city could save hundreds of thousands of dollars annually on electricity. Many European cities, for instance, have installed smart lighting systems that automatically dim late at night when few people are around, or adjust brightness during a full moon. In practice, Istanbul's municipality could integrate an AI system that learns traffic and pedestrian patterns for each street and optimizes lighting levels accordingly – ensuring safety while minimizing energy waste. Similarly, **building energy management** is ripe for AI savings: AI algorithms can learn a building's usage patterns and adjust heating, ventilation, and air conditioning (HVAC) systems dynamically. A famous example is Google using DeepMind AI to manage its data center cooling, resulting in up to 40% reduction in energy used for cooling[36]. Cities can apply the same idea to large public buildings or even citywide district heating/cooling systems. For instance, Gaziantep's public buildings or Konya's hospitals and schools could implement AI thermostats that anticipate occupancy and

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[33] Sustaining AI in Local Government http://newamerica.org/oti/blog/sustaining-ai-in-local-government/
[34] How Smart Street Lights Can Help Cities Achieve Sustainability Goals | Planetizen News https://www.planetizen.com/news/2025/03/134643-how-smart-street-lights-can-help-cities-achieve-sustainability-goals
[35] https://www.planetizen.com/news/2025/03/134643-how-smart-street-lights-can-help-cities-achieve-sustainability-goals
[36] Google, Microsoft, IBM Are Using AI To Predict Climate Outcomes https://www.greenqueen.com.hk/google-microsoft-ibm-are-using-ai-to-predict-climate-outcomes-ccnow/

weather, thereby trimming heating costs significantly. These efficiency improvements directly translate into financial savings and lower emissions.

- **Water Conservation and Utility Optimization:** AI is equally powerful for managing natural resources like water. Many municipalities face water scarcity or high water costs (Konya, for example, is in a semi-arid region where water must be managed carefully). **Smart irrigation** systems use AI and sensors to water parks and green spaces only as much as needed. By analyzing weather forecasts, soil moisture data, and plant needs, an AI irrigation controller can decide when and how much to water. Research shows this approach can save roughly *40% of water* compared to traditional timer-based irrigation[37]. In practical terms, Konya's parks department might use an AI system that skips watering if rain is forecast or that targets water only to dry areas, avoiding overwatering. Over a summer, the water (and electricity for pumps) saved is substantial, preserving an essential resource and reducing costs. Similarly, AI can optimize water distribution pumps to run at off-peak energy hours or detect leaks in pipelines by analyzing pressure sensor data in real-time – preventing water loss and expensive pipe failures. These kinds of optimizations improve resilience (by conserving water for drought periods) and cut operational expenses.

- **Operational and Maintenance Savings:** Beyond utilities, AI can optimize many city operations to be more cost-effective, which complements SECAP measures (since saving energy or fuel also means reducing emissions). For example, waste collection routes can be optimized by AI to reduce fuel usage (some cities have smart bins that signal when full, so trucks only go when needed). Public transit schedules can be adjusted with AI to reduce empty buses on the road, saving fuel. Predictive maintenance algorithms can monitor equipment (like HVAC systems, vehicle fleets, or even solar panels) and alert staff to service them before they break – avoiding costly emergency repairs and downtime. Buenos Aires, as one example, applied AI to streamline waste collection, which reduces fuel and maintenance costs for garbage trucks[38]. Every budget officer appreciates when technology helps avoid unnecessary expenses.

  In summary, AI contributes to a city's climate goals by cutting waste: less wasted energy, less wasted water, and more efficient use of staff time and equipment. These savings free up funds that can be reinvested in further climate actions or other municipal services. Below is a summary table of typical savings observed with AI implementations:

Table: Examples of AI-driven Resource Savings for Municipal Services

AI Application	Potential Savings
Smart Street Lighting (LED + intelligent controls)	Up to -70% reduction in energy use
Smart Irrigation for Parks	-40% reduction in water usage
AI-Optimized HVAC in Buildings	Up to -40% reduction in energy for cooling/heating

[37] Smart irrigation model predicts rainfall to conserve water | Cornell Chronicle https://news.cornell.edu/stories/2019/07/smart-irrigation-model-predicts-rainfall-conserve-water
[38] Sustaining AI in Local Government http://newamerica.org/oti/blog/sustaining-ai-in-local-government/

Note: The percentages above illustrate savings observed in various studies and pilots. Actual results for a given city (like Istanbul's streetlights or Gaziantep's buildings) would depend on baseline inefficiencies – often, the more waste there is initially, the greater the savings from AI optimization. These efficiencies not only save money but also directly reduce emissions (e.g., less electricity consumed means lower CO_2 if that electricity was fossil-fueled). Thus, AI helps "green" city operations while easing budget pressures.

5. Scenario Planning: Modeling Sustainable Futures with AI

One of the most powerful advantages of AI in SECAP processes is its ability to support **scenario planning** – that is, exploring "what if" futures and modeling the outcomes of different policy choices. SECAPs are forward-looking, setting targets for 2030, 2040, 2050, etc., and involving complex interactions (energy, transport, land use, climate impacts). AI-based tools, especially in the form of **digital twins** and advanced simulation models, are enabling cities to visualize and test these future scenarios in a risk-free virtual environment.

Figure: A digital twin 3D model of a city, used to simulate various climate intervention scenarios (e.g., testing where adding green roofs or floodwater storage would be most effective in reducing future risks). Such virtual city models allow planners to experiment with different strategies before implementing them in the real world.

- **Digital Twins for Urban Planning:** A digital twin is essentially a virtual replica of a city (or a system within the city) that mirrors real-world data and conditions. Planners can use it as a sandbox to try out ideas. Smart city digital twins are emerging as a potent scenario-planning tool: they *allow planners to explore new solutions to urban problems and address complex issues like climate resilience in a controlled virtual environment*[39]. For example, imagine Istanbul builds a digital twin of the city that includes detailed data on buildings, roads,

[39] Smart City Digital Twins Are a New Tool for Scenario Planning https://www.planning.org/planning/2021/spring/smart-city-digital-twins-are-a-new-tool-for-scenario-planning/

terrain, and even demographics. City staff could use this twin to simulate the impact of various SECAP measures: What if we pedestrianize these 10 streets? What if we plant 1 million more trees in certain neighborhoods? The AI-driven simulation can show outcomes: changes in traffic flow, reduction in the urban heat island effect, improvements in air quality, etc. This helps identify the most effective strategies before investing in real-world projects. It's like test-driving the future. In Europe, projects like **SIM-City** have used digital twin platforms to help cities prepare for high-risk situations (e.g., flooding) by simulating them[40]. Digital twins integrate multiple data layers – climate models, infrastructure, socio-economic data – so they can illuminate unintended consequences or cross-sector effects that siloed models might miss. For municipalities, this means more robust climate action plans: they can see how a transportation policy might affect emissions as well as air pollution and even public health, all in one integrated model.

- **Exploring Emission Pathways:** AI can assist with modeling different greenhouse gas emission pathways and energy transition scenarios. SECAPs often require cities to chart a path to hit emission reduction targets (like 40% by 2030 or net-zero by 2050). AI tools can help answer questions like: *How will emissions look in 2030 if we aggressively push electric vehicles versus if we focus on building retrofits? or What combination of measures gets us to our target with the least cost?* Traditionally, planners use spreadsheets or off-the-shelf scenario tools, but AI can take this further by handling far more variables and drawing on big data. For instance, the city of Warsaw is using AI-generated data from Google's Environmental Insights Explorer to supplement its own models as it builds long-term emissions scenarios for 2030 and 2050[41]. By leveraging such data, Warsaw can validate its assumptions and refine its Climate Action Plan with higher confidence. AI can rapidly run hundreds of scenario permutations (something infeasible manually) – varying levels of renewable energy adoption, different rates of electric vehicle uptake, industrial changes, etc. – and identify which scenarios meet the targets and what trade-offs are involved. This kind of analysis ensures that when a city like Gaziantep sets its SECAP strategies, they are grounded in rigorous exploration of future possibilities, making the plan both aspirational and achievable.

- **Adaptation and Resilience Planning:** On the climate adaptation side, scenario planning is equally crucial. AI models help cities prepare for future climate conditions by simulating extreme events under climate change and testing resilience measures. For example, a coastal city might use AI to model how sea-level rise combined with storm surges could flood neighborhoods in 2040, and then test various protective measures in the simulation (sea walls, restoration of wetlands, revised building codes) to see which combination best reduces flooding. We already see AI being applied in projects like the C40 Cities and IBM collaboration, which is developing AI solutions to analyze the risks of extreme heat and the urban heat island effect in cities[42]. By simulating heat waves and their impact on different city sectors (energy, health, etc.), the AI can help identify where to plant trees or install cool roofs to maximize cooling, or predict where heat stress on vulnerable populations will be highest in the future. Similarly, digital twin models can show, in real time, emerging stresses

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[40] Digital Twins for Climate Change https://www.beesmart.city/en/smart-city-blog/digital-twins-for-climate-change

[41] ICLEI Europe •• News

[42] IBM and C40 Cities collaborate on new AI project for resilient cities - C40 Cities https://www.c40.org/news/ibm-and-c40-cities-collaborate-on-new-ai-project-for-resilient-cities/

– one example: a twin might cross-reference a heatwave forecast with data on the population's age and health in each district to map where emergency cooling centers should be opened[43]. All this allows proactive adaptation planning.

- **Practical Example – Local Context:** Let's say Konya wants to explore how it can become a low-carbon, climate-resilient city by 2040. With AI scenario tools, Konya's planners could simulate different futures: one scenario might emphasize sustainable transport (expanded tram lines, EV buses, AI-optimized traffic flow) while another emphasizes renewable energy and smart grids. The AI might reveal that the transport-focused scenario reduces emissions significantly but needs complementary action on industry to meet the target, whereas the renewable-focused scenario might cut emissions but could face power supply variability that needs managing. By visualizing these outcomes in advance, Konya can craft a SECAP that blends the best elements of each scenario. Likewise, for resilience, Konya can model future rainfall patterns (since the region can experience both droughts and flash floods) and test how solutions like smart irrigation, rainwater harvesting, or green infrastructure would perform under those scenarios. The end result is a more **robust, data-driven plan** that has been "stress-tested" against future conditions.

Visual suggestion: To illustrate scenario planning, **a scenario matrix** graphic could be used. Picture a grid showing four future scenarios for a city (for example: *Business as Usual, Green Infrastructure focus, High-Tech focus, Combined Approach)*. Each quadrant could list outcomes (emission levels, temperature rise, etc.), perhaps with small icons (a factory icon with a downward arrow for emissions reduction, a thermometer icon for temperature impacts, etc.). Alternatively, an image of a digital twin interface (like a 3D city map with data overlays) can be shown, with a caption like "City planners use digital twin simulations to test climate action scenarios – for instance, adding virtual green roofs in the model to see how urban temperature and runoff patterns improve." This helps convey the concept of visualizing the future with AI.

Conclusion: Implementing AI in Local Climate Governance

Integrating AI into SECAP processes can yield substantial benefits – making climate action planning faster, smarter, more inclusive, and cost-effective. For municipalities in Turkey and around the world, the question now is **how to get started** and **scale up** these AI applications in a responsible way. Below are key recommendations for local governments looking to harness AI in their climate and energy action work:

1. **Start with Pilot Projects:** Begin by incorporating AI in a pilot initiative aligned with your SECAP goals. This could be a specific domain like building energy management, climate risk mapping, or a public-facing chatbot. Pilots help demonstrate value on a small scale and allow teams to learn by doing. For example, Istanbul might pilot an AI tool for optimizing one district's energy use or a chatbot for its environmental services department. By measuring the results (e.g., energy saved, number of citizen queries handled), the city can build a case for wider adoption. Starting small also means any challenges can be ironed out before scaling up. Remember to choose a pilot with a high chance of success and clear metrics – "quick wins" build momentum and buy-in.

[43] Digital Twins for Climate Change https://www.beesmart.city/en/smart-city-blog/digital-twins-for-climate-change

2. **Invest in Staff Training and Capacity:** AI is powerful, but it's most effective when your staff understands how to use and manage it. Invest in training programs to upskill employees in data science basics, AI tools, and digital literacy. You might designate or hire a few "AI champions" within departments – for instance, an energy analyst trained to use machine learning software for forecasting, or a communications officer trained to maintain an AI chatbot's knowledge base. Building this human capacity is crucial. As one report noted, governments should audit their processes to identify tasks for automation **while simultaneously creating new training programs** so staff can move into more specialized roles alongside AI[44]. This ensures AI isn't seen as a threat, but as a tool that frees staff from drudge work and enables them to focus on high-value tasks (like engaging the community or strategizing new policies). In practical terms, Konya and Gaziantep could partner with local universities or online course providers to run workshops on "AI for city officials," ensuring their planning and environment teams are ready to leverage these new technologies.
3. **Collaborate with Tech Partners and Peers:** Municipalities do not have to do this alone. Partner with technology companies, research institutions, and city networks to access expertise and resources. Many tech firms are eager to work with cities on climate solutions (as part of corporate sustainability efforts or research pilots). For example, C40 Cities (a network of global cities) has partnered with IBM's Sustainability Accelerator to develop AI solutions for urban heat resilience[45] – a collaboration that brings world-class tech support to city governments. Similarly, Google offers tools like the Environmental Insights Explorer freely to cities for emissions data. Turkish cities might collaborate with national ministries or EU programs (some EU projects provide AI tools and funding for SECAP development). Networking with peer cities is also valuable: learn from examples like Lisbon's solar mapping AI or Barcelona's transport AI. Consider joint projects – maybe Istanbul, Konya, and Gaziantep could form a small consortium to share data and collectively develop an AI-based climate risk platform, with support from a university's computer engineering department. Collaboration accelerates learning and helps avoid pitfalls by leveraging others' experience.
4. **Focus on Data and Infrastructure:** AI's effectiveness depends on the quality of data and IT infrastructure. Municipalities should invest in building a strong data foundation: gather and clean your climate-relevant data (energy consumption, emissions inventory, climate hazard records, etc.), and implement data management systems that break down silos between departments. **Data interoperability** is key – climate action intersects with transport, housing, waste, etc., so ensure those datasets can talk to each other. Los Angeles's GeoHub, which shares over 500 datasets across city departments, is a great example of enabling data sharing to support analytics[46]. Cities should also consider cloud services or high-performance computing access for running AI models, especially for heavy simulations like digital twins. In practical terms, this might mean upgrading GIS systems, deploying IoT sensors (for real-time data like air quality or traffic) that feed AI algorithms, and using open data platforms to involve the public and startups in creating innovative solutions. Good data governance (ensuring privacy and security) is essential as well when implementing AI.

[44] Sustaining AI in Local Government http://newamerica.org/oti/blog/sustaining-ai-in-local-government/
[45] IBM and C40 Cities collaborate on new AI project for resilient cities - C40 Cities https://www.c40.org/news/ibm-and-c40-cities-collaborate-on-new-ai-project-for-resilient-cities/
[46] Sustaining AI in Local Government http://newamerica.org/oti/blog/sustaining-ai-in-local-government/

5. **Ensure Ethics, Transparency, and Public Trust:** When introducing AI in governance, maintaining public trust is paramount. Be transparent about how you are using AI: communicate clearly what algorithms are doing (especially if they inform decisions that affect citizens). Develop guidelines for ethical AI use in the municipality – for instance, to avoid biases in algorithms, to secure personal data, and to provide recourse if an AI makes a mistake. Engaging the community in this process can build trust. You might hold public workshops or demos of your new AI tools (imagine Gaziantep showcasing its flood prediction AI to neighborhood groups, explaining how it works and how it will help protect the community). According to experts, success with AI in cities hinges on building trust through ethical practices and community engagement, not just on the tech itself[47]. One idea is to form an advisory group including community representatives to oversee AI projects – this openness can alleviate concerns. Also, use AI **to enhance** public participation (as discussed), so residents feel included in the process. When citizens see that AI is being used to improve their quality of life – and that the city is being accountable in its use – they are more likely to support it.

In conclusion, AI has immense potential to accelerate and strengthen climate action at the local level. From helping a city like **Istanbul** analyze data for its climate action plan in record time, to enabling **Konya** to save water with smart algorithms, to supporting **Gaziantep** in engaging its citizens on sustainability – AI can be a game-changer in SECAP processes. However, technology is only a means to an end. Cities should approach AI adoption thoughtfully: align it with clear policy goals, invest in people and data, and uphold transparency and equity. Done right, AI integration can make local climate governance more **efficient, inclusive, and evidence-based,** ultimately helping communities become greener and more resilient. As we've explored in this module, the five key benefits – Efficiency, Accuracy, Participation, Savings, and Scenario Planning – provide a strong rationale for embracing AI. The next step is turning this knowledge into action: identify opportunities in your own municipal operations and climate plan where AI could make a difference, and take the first steps on this innovative journey. With pilot successes and collaboration, even more municipalities will likely add AI to their climate toolkit, driving forward the sustainable urban future we all aspire to.

Recommended Resources & Next Steps: Consider exploring case studies like Lisbon's SECAP AI pilot or tools like the Open Climate Data Science toolkit for cities. Engage with networks such as ICLEI or the Covenant of Mayors that are increasingly sharing best practices on AI in climate planning. By learning continually and iterating, your city can keep improving its approach. Climate change demands urgent action – and AI, when applied thoughtfully, can significantly boost the capacity of municipalities to plan and act for a safer, cleaner, and smarter future.

[47] Sustaining AI in Local Government http://newamerica.org/oti/blog/sustaining-ai-in-local-government/

PART 3

AI-POWERED APPLICATION STRATEGIES FOR TÜRKİYE'S 7 REGIONS

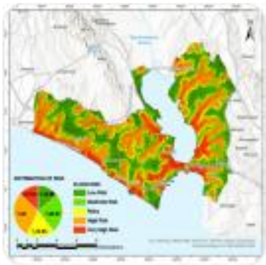
Marmara Region: Tackling Urban Flooding with AI Solutions

Challenge: The Marmara Region – home to Istanbul and other dense cities – faces rising urban flood risks due to intense rainfall and sea-level rise. Heavy precipitation events increasingly overwhelm drainage systems, leading to flash floods in low-lying districts[48]. Coastal zones around the Sea of Marmara are also threatened by storm surges and creeping sea-level rise[49], putting critical infrastructure at risk.

Data Source & Platform: Copernicus Sentinel-1 SAR (radar satellite) data – accessible via the Copernicus Open Access Hub – provides all-weather imagery to map flood extents in near real-time. For example, Sentinel-1 synthetic aperture radar can penetrate clouds and capture flooded areas even during storms[50]. Analysts can obtain this data through platforms like **Google Earth Engine** which host Sentinel-1 collections for on-demand processing (URL: Copernicus Data Space – Sentinel-1).

AI Tools & Methods: Google Earth Engine (GEE) is recommended to process Sentinel-1 and rainfall data for flood mapping. GEE allows using algorithms (e.g. thresholding or machine learning classifiers) on SAR imagery to detect water bodies over time. This cloud-based platform enables rapid analysis of multi-temporal data and can integrate rainfall datasets (like NASA's **IMERG** precipitation) for flood early warning. Machine learning models (using Python or **scikit-learn**) can also combine factors like elevation, land cover, and drainage to predict flood-prone locations. These AI-driven analyses can prioritize areas for adaptation measures such as improved drainage or green infrastructure.

Use Case Example: Flood Risk Mapping in Istanbul: Municipal planners in Istanbul use Earth Engine to analyze Sentinel-1 flood images from past storms and identify recurring inundation zones. By overlaying socio-economic data, they generated a detailed flood-risk map for a vulnerable district. The map highlighted neighborhoods where 50–60% of the area falls in high-risk flood zones, aligning with areas of low elevation and poor drainage. Planners then applied a machine learning ranking (Analytic Hierarchy Process with GIS layers) to prioritize flood mitigation investments. As a result, the city is installing new stormwater pumps and restoring upstream wetlands to buffer floodwaters. This AIassisted approach, using open Sentinel data and GEE, accelerates SECAP implementation by pinpointing where adaptation actions (like drainage upgrades or zoning changes) will protect the most people.



Suggested Visual: *Flood risk map for a coastal district of Istanbul. Green to red shading indicates low to very high flood risk, derived by weighting factors such as land use, elevation, and proximity to streams[51].* Such maps help city officials identify hotspots for flood defenses and resilient infrastructure planning.

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[48] Flood-Risk Map for Büyükçekmece District Based on Socioeconomic Factors
[49] Coastal floods - ClimateChangePost
[50] publish.mersin.edu.tr
[51] Flood-Risk Map for Büyükçekmece District Based on Socioeconomic Factors

Aegean Region: Combating Drought and Water Scarcity with Data

Challenge: The Aegean Region endures frequent summer droughts and water scarcity that threaten agriculture and reservoirs. Rainfall is highly seasonal, and recent years have brought prolonged dry spells reducing streamflows. Coastal provinces like İzmir and Aydın see diminished rainfall and higher evapotranspiration, stressing both crops and urban water supply[52]. The region's vineyards, olive groves, and tourism sector are increasingly vulnerable to these rain shortfalls and heatwaves.

Data Source: CHIRPS Precipitation Dataset – an open 40+ year global rainfall record (0.05° resolution) – is ideal for drought analysis in Aegean Turkey. CHIRPS blends satellite imagery with rain gauges to provide gridded rainfall time series for trend analysis and early warning[53]. It is available via the Climate Hazards Center and Google Earth Engine (Daily/Pentad CHIRPS). By examining CHIRPS data, planners can quantify rainfall deficits during drought seasons and compare them to historical norms. *(URL: Climate Hazards Center CHIRPS Data)*

AI Tool: Python (scikit-learn) is recommended for building drought prediction models using CHIRPS and other indices. Python's libraries (such as Pandas and Xarray) can easily ingest CHIRPS time-series to compute the Standardized Precipitation Index (SPI) over various months – a key drought indicator[54]. With **scikit-learn,** one could train a regression or classification model that learns from past climate patterns (rainfall, temperature) to forecast drought severity. For instance, a random forest model could be trained to classify upcoming seasons as "normal" or "drought" based on seasonal rainfall and soil moisture indicators. These AI models augment traditional meteorological forecasts by identifying complex patterns in the data.

Use Case Example: *Drought Early Warning for Agriculture:* Aegean agricultural agencies have developed a drought monitoring dashboard using CHIRPS data and AI. They calculate the 3- month SPI for each river basin to gauge meteorological drought[55]. When SPI values fall below -1 (moderate drought), an alert is triggered. Using scikit-learn, they also built a simple decision-tree model that ingests CHIRPS rainfall and **NDVI** vegetation index from MODIS to predict crop stress levels. This model was trained on 20 years of data and can anticipate areas where vegetation will likely wilt given the rainfall deficit. As a result, by early summer the system flags districts (e.g. Küçük Menderes Basin) at highest risk of crop losses. Local authorities then implement water rationing plans and advise farmers on drought-tolerant practices. The open data and AI approach has improved drought preparedness – a key SECAP adaptation action – by providing a **near real-time drought identification and assessment** tool[56] that guides water management decisions.

Suggested Visual: *A time-series graph of CHIRPS rainfall anomalies for the Aegean Region, with severe drought years highlighted. This could show how the 2020–2021 period had rainfall well below the*

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[52] Disappearing Lake Tuz

[53] CHIRPS: Rainfall Estimates from Rain Gauge and Satellite Observations | Climate Hazards Center - UC Santa Barbara

[54] PIAHS - Spatial characterization of drought through CHIRPS and a station-based dataset in the Eastern Mediterranean

[55] PIAHS - Spatial characterization of drought through CHIRPS and a station-based dataset in the Eastern Mediterranean

[56] Drought Identification and Trend Analysis Using Long-Term CHIRPS Satellite Precipitation Product in Bundelkhand, India

1981–2010 average, correlating with reduced reservoir levels. A map inset might indicate CHIRPS-derived SPI values across western Turkey, pinpointing coastal river basins under drought.

Mediterranean Region: Wildfire Risk Reduction through AI Forecasting

Challenge: In Türkiye's Mediterranean Region (Antalya, Muğla, Mersin, etc.), climate change is amplifying wildfire hazards. Summer heatwaves and drought desiccate forests, creating tinderbox conditions. The devastating 2021 wildfires are a stark example – over 130 wildfires ignited along the Mediterranean coast amid record 45°C heat, burning ~136,000 hectares (three times the annual average)[57]. These fires threaten lives, ecosystems, and the tourism economy. Adapting to this challenge means improving early warning and response by predicting when and where extreme fires may occur.

Data Source: *NASA MODIS/VIIRS Active Fire Data (FIRMS)* provides real-time fire detections and historical fire hotspot data. FIRMS (Fire Information for Resource Management System) aggregates thermal anomaly observations from NASA's satellites, updating within hours of detection[58]. Planners can use FIRMS to map fire frequency hotspots over the past decades in the Mediterranean region and identify high-risk zones. Additionally, the **Copernicus Climate Data Store** supplies Fire Weather Index (FWI) datasets and meteorological variables (temperature, wind, humidity) that influence fire danger. Combining these open sources offers both the drivers (weather) and outcomes (fire occurrences) data for analysis. *(URL: NASA FIRMS Fire Data)*

AI Tool: TensorFlow (Deep Learning) can be employed to build a wildfire danger prediction model. A recurrent neural network (e.g. LSTM) can learn temporal patterns in climate data to forecast next-day fire risk. In fact, researchers have successfully applied deep learning to predict daily wildfire danger in the Eastern Mediterranean, outperforming traditional indices like FWI. Using TensorFlow, one can train on years of weather data (temperature, wind, moisture) labeled with days of high fire activity (from FIRMS). The model can then output a fire risk level for the next day or week. Furthermore, explainable AI techniques (like SHAP values) can be used to interpret whether dryness, wind, or other factors are driving the predictions, building trust in the model.

Use Case Example: *AI-Driven Wildfire Early Warning:* The regional forestry directorate in Antalya pilots a deep learning system to anticipate extreme wildfire conditions. They feed in daily meteorological forecasts from Copernicus (projected temperature, wind speed, humidity) into an LSTM model trained on the past 20 summers of fire and weather data. In tests, the AI system has **demonstrated improved skill over the standard Fire Weather Index**, especially in recognizing days when fires might spread explosively[59]. For instance, in July it correctly flagged a high-danger day two days before an outbreak of fires near Manavgat. This gave authorities extra lead time to pre-position firefighting teams and issue public warnings. The tool also highlighted key drivers – e.g. it showed that low live fuel moisture and high wind gusts were strong predictors of the 2021 fire severity, underscoring the need for forest management in windy corridors. By integrating satellite fire data with climate forecasts through AI, Mediterranean municipalities enhance their SECAP wildfire adaptation strategies (like fuel breaks and community alerts) with data-informed precision.

[57] Fires Rage in Turkey
[58] NASA | LANCE | FIRMS
[59] Wildfire Danger Prediction and Understanding With Deep Learning - Universidade NOVA de Lisboa

Suggested Visual: *Landsat 8 image of massive wildfires near Turkey's southern coast on July 31, 2021. Thick smoke plumes spread along the Mediterranean shoreline (Alanya–Manavgat area) during an extreme* heatwave . This visual underscores the scale of fires that AI models aim to predict, helping authorities prepare for such events.

Central Anatolia Region: Managing Drought and Desertification with AI

Challenge: Central Anatolia's semi-arid plateau (including Konya and Ankara provinces) is highly vulnerable to drought, groundwater depletion, and land degradation. Over the past decades, rising temperatures and declining precipitation have led to frequent agricultural droughts and drying of lakes (e.g. Lake Tuz)[60]. Prolonged meteorological droughts trigger hydrological droughts – rivers and reservoirs shrinking – which in turn cause agricultural drought, reducing soil moisture and crop yields The region also faces **creeping desertification**: vegetation cover is declining in some areas due to water stress and unsustainable water use, exposing soil to erosion. Adaptation requires better monitoring of these slow-onset changes and optimizing water management.

Data Source: *MODIS Satellite Vegetation Index (NDVI/EVI)* data provides a continuous record of vegetation health and cover from 2000 to present. NASA's MODIS NDVI products (e.g. 16- day composites at 250m resolution) allow tracking of greenness trends and identifying areas of browning indicative of drought impact. Such Earth observation data has been widely applied for drought monitoring – remote sensing indices like **NDVI** and land surface temperature are "widely accepted and applied…for drought and vegetation monitoring"[61]. Coupled with precipitation datasets (CHIRPS or meteorological stations), NDVI data helps quantify how droughts translate into vegetation loss. *(URL: NASA MODIS Vegetation Index Products)*

AI Tool: Geospatial Machine Learning with Python (using libraries like **GeoPandas, rasterio,** and scikit-learn) can fuse multi-source data to map and predict land degradation. A **Random Forest** model, for example, can be trained on historical data to classify areas by desertification risk level. Input features might include NDVI trend, rainfall trend, soil type, and water table depth. The model can learn which combination of declining NDVI and low rainfall corresponds to observed desertification (such as expanding barren land in satellite images). Additionally, unsupervised learning (like clustering) on time-series NDVI can group areas with similar vegetation decline patterns. This AI approach complements physical drought indices by objectively identifying "hotspots" of ecosystem stress that might be missed by coarse indicators.

Use Case Example: *Monitoring Lake Tuz and Agricultural Lands:* Scientists analyzed **Landsat imagery of Lake Tuz** – Turkey's second-largest lake – over 1985–2021 to assess its dramatic shrinkage. They used a classification algorithm to map water vs. salt flats each year, revealing that after 2000 the lake often dries up completely in summer (where previously it retained water year-round)[62]. Building on this, a local university is using Python and scikit-learn to predict lake level changes. By training a regression model on climate variables (spring rainfall, temperature) and the **lake's surface area** from satellite images, they can forecast if Lake Tuz will vanish in an upcoming summer – guiding water allocation to nearby farmers. Similarly, for croplands in Konya Plain, agronomists employ NDVI-based drought indices and a machine learning model to estimate yield losses early. When NDVI drops below

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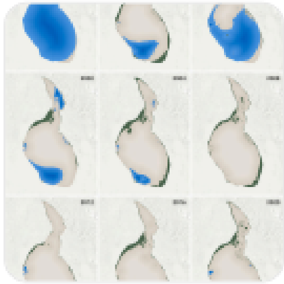
[60] Disappearing Lake Tuz
[61] https://www.iwra.org/proceedings/congress/resource/3027670.pdf
[62] Disappearing Lake Tuz

a threshold by mid-season, the model (trained on past drought years) predicts final yield reduction, prompting authorities to deploy support (e.g. emergency irrigation or compensation) proactively. Remote sensing and AI thus empower Central Anatolia's SECAP actions by providing **early warning of drought impacts** and identifying long-term land cover shifts that require adaptive management (like crop switching or soil conservation).

Suggested Visual: *Satellite-derived maps showing the desiccation of Lake Tuz, Central Anatolia. Each panel (1988 to 2020) depicts the lake extent in August (blue = water, tan = exposed salt flats, green = marsh). The drastic decline in blue areas post-2000 reflects more frequent and intense droughts[63]. Such visual evidence, coupled with AI analysis, underpins water-saving adaptation measures in the region.*



Black Sea Region: Predicting Floods and Landslides with Machine Learning

Challenge: The Black Sea Region's steep, lush terrain (e.g. Rize, Trabzon provinces) faces **extreme rainfall** events that trigger flash floods and landslides. This northeastern coastal zone receives some of the heaviest precipitation in Turkey. When short-duration downpours occur – often exceeding 200 mm in a day – the mountainous topography funnels water into valleys, causing destructive floods. Saturated slopes readily fail, resulting in landslides that damage villages and roads. For instance, in July 2021, a cloudburst dumped ~219 mm of rain in 48 hours in Rize's Güneysu district, unleashing multiple landslides that caused casualties[64]. With climate change, such intense rain episodes are projected to become more frequent, necessitating improved hazard mapping and early warnings.

Data Source: *NASA GPM IMERG* (Integrated Multi-satellitE Retrievals for GPM) provides high-resolution (0.1°, hourly) precipitation estimates useful for identifying extreme rainfall patterns. IMERG data, available in near real-time and retrospectively (from 2000-present), allows mapping of rainfall accumulation for each storm. Additionally, high-resolution elevation data (*e.g. NASA SRTM DEM, ~30m*) is an important dataset to delineate slopes and catchments. By overlaying IMERG rainfall maps on the DEM, one can derive indices like "total 24h rainfall on >30° slopes" – a proxy for landslide susceptibility. These open datasets feed into models that can learn threshold relationships (e.g., >100 mm/day on steep terrain leads to landslides). *(URL: NASA GPM IMERG Data)*

AI Tool: GIS-based Machine Learning – using Python's scikit-learn or R – is recommended to create integrated flood and landslide susceptibility models. **A logistic regression or gradient boosting model** can be trained on past events: the input features could include maximum 24h rainfall, antecedent 7-day rainfall, slope steepness, land cover type, and river network density for numerous locations, labeled by whether they experienced flooding/landslides. For training data, historical disaster reports and satellite change detection (for landslide scars) serve as ground truth. Notably, a recent study in Rize employed CatBoost (a boosting algorithm) to rank terrain and land-use factors in landslide occurrence, finding that plantation areas on steep 30–40° slopes had up to 9× higher slide likelihood than forested areas[65]. This illustrates how ML can quantify risk contributors. Once trained, the model

[63] Disappearing Lake Tuz
[64] Quantitative Land-Use and Landslide Assessment: A Case Study in Rize, Türkiye
[65] Landslide distribution map (yellow and red lines indicate each... | Download Scientific Diagram

can output probabilistic risk maps – essentially highlighting areas where heavy rain would most likely cause slope failures or floods.

Use Case Example: Community Hazard Mapping in Rize: Local authorities have begun using machine learning to supplement traditional landslide hazard maps. They compiled a dataset of 100+ recent slope failures (inventory from 2010–2021) and the associated rainfall that triggered them[66]. Feeding this into a Random Forest, they learned a threshold: hillsides above 35° slope with >150 mm/day rain had a very high probability of sliding. Using this model, they produced a real-time warning system: when IMERG rainfall data shows >100 mm has fallen in the past 12 hours in a certain district, and the forecast calls for more, the system checks the slope map and flags specific villages in red alert. This has enabled targeted evacuations – in August 2022, residents of one mountain hamlet were moved hours before a landslide buried the road. Moreover, the model's factor analysis pointed out that deforestation amplified risk, prompting reforestation campaigns on critical slopes. By integrating satellite rainfall monitoring with AI predictive modeling, Black Sea region municipalities are making their flood and landslide adaptation measures more proactive. These data-driven insights directly inform SECAP priority actions like early warning systems, land-use planning (avoiding new developments on high-risk slopes), and improved drainage infrastructure in landslide-prone valleys.

Suggested Visual: *A color-coded map of Rize province showing landslide susceptibility: green for low risk, red for high. Such a map would be generated by a machine learning model using terrain steepness and rainfall patterns. Annotations might indicate where major landslides occurred in 2021, corresponding to the model's high-risk zones. This visual emphasizes how AI can spatially pinpoint communities that need urgent adaptation measures (like slope stabilization or improved drainage) before the next extreme rain.*

Eastern Anatolia Region: Safeguarding Water Resources with AI Analytics

Challenge: Eastern Anatolia's highlands – source of the Euphrates and Tigris – rely on winter snows and glaciers to feed rivers and communities year-round. Climate change is altering snowfall patterns and accelerating **glacier retreat,** impacting downstream water availability. Warmer winters mean more precipitation falls as rain rather than snow, and snowmelt starts earlier in spring[67]. This can lead to spring flooding followed by summer water shortages. Indeed, studies in Eastern Turkey's mountains show runoff timing shifting and total streamflow declining under future scenarios[68]. Glaciers on peaks like Mount Ararat are in rapid decline, signaling long-term loss of natural water storage. The region's challenge is to adapt water management (for hydropower, irrigation, and ecosystems) to these changing hydrological patterns.

Data Source: *MODIS Snow Cover** (e.g. MOD10A1 daily 500m) from NASA and Copernicus Snow and Ice products are essential for monitoring snowpack and timing of melt. MODIS snow-cover maps, available since 2000, allow tracking of the snow extent and duration each year[69]. By analyzing these, one can quantify metrics like the date of snow disappearance in spring for key basins. Additionally, the **ESA Climate Change Initiative (CCI)** Snow and Glaciers datasets provide long-term records of snow cover and glacier outlines globally. Combining these with climate model outputs from the **Copernicus**

[66] Quantitative Land-Use and Landslide Assessment: A Case Study in Rize, Türkiye
[67] Impacts of climate change on water resources on eastern mountainous region of Turkey
[68] Assessment of climate change impacts on snowmelt and streamflows of mountain region in eastern Turkey
[69] MODIS/Terra Snow Cover Daily L3 Global 500m SIN Grid, Version 5 | National Snow and Ice Data Center

Climate Data Store (CDS) – which offers downscaled climate projections for Turkey – enables scenario analysis. For example, one can use CDS to get a projection of temperature rise in Eastern Anatolia by 2050 and use that to drive a snowmelt model. *(URL: Copernicus Climate Data Store – Snow cover and climate projections)*

AI Tool: Time-Series Analysis and Forecasting with tools like **Facebook Prophet** or **Python's statsmodels** can model snowmelt and streamflow timing. These AI-driven statistical models can be trained on past satellite-derived snow cover data and observed river flow to learn the relationship between winter snow volume and spring runoff. For instance, a Prophet model could forecast annual peak flow date given inputs of winter snow cover area and spring temperature trend. Another approach is using **neural networks** for multivariate time-series: a network can ingest sequences of monthly snow cover, temperature, and precipitation and output predicted river flows for coming months. Such models, once validated, assist dam operators in anticipating changes. In addition, **natural language AI (ChatGPT)** can be leveraged to synthesize complex climate projection reports and generate easy-to-understand adaptation guidance for local officials. A large language model can quickly summarize, for example, the key findings of a technical study on Eastern Anatolia's snowpack decline and suggest practical measures (e.g. new reservoir rules or irrigation scheduling changes) in plain language for decision-makers.

Use Case Example: *Water Supply Forecasting for Keban Dam:* Engineers managing the Euphrates dams use AI to predict seasonal inflows. They process MODIS snow cover images each winter to calculate snow coverage in the Euphrates headwaters. This data feeds a regression model (built in Python) that predicts spring inflow volume. After incorporating machine learning, their forecasting error dropped significantly, helping optimize hydropower production and flood control. On another front, regional planners turned to C**hatGPT**-style assistants during adaptation planning workshops. They provided the AI with local data (e.g. "snow melt now peaks in March instead of April, and summer baseflows are down 30%") and asked for adaptation ideas. The AI, drawing on global knowledge, suggested actions like "*build higher-altitude reservoirs to capture earlier melt"* and *"strengthen transboundary water sharing agreements for dry summers.*" Planners crosschecked these ideas with experts, finding them largely aligned with best practices. This shows how combining data analytics for physical forecasting and AI for knowledge support can enhance Eastern Anatolia's climate adaptation – ensuring that strategies in SECAP (such as optimized reservoir management, flood early warning, and drought planning) are informed by both cutting-edge data and global expertise.

Suggested Visual: *A comparative line graph illustrating snowmelt timing: one line from the 1990s and one from the 2020s showing river flow peaking earlier in the year. Additionally, an image series of a receding glacier in Eastern Anatolia (from the 2000s vs. today) could be included, highlighting the tangible loss of ice. Together, these visuals reinforce the shifting water regime that AI models are helping to quantify and address.*

Southeastern Anatolia Region: Enhancing Irrigation and Heat Resilience through AI

Challenge: Southeastern Anatolia is characterized by hot, dry summers and an agriculturedependent economy, making it highly susceptible to **drought and extreme heat.** Climate projections indicate this region will get even warmer and drier[70]. Irrigated farming in the Harran Plain and surrounding areas (part of the GAP project) depends on efficient water use from the Euphrates-Tigris system. However,

[70] Turkey's Aegean, Med regions set to get warmer amid climate change | Daily Sabah

rising temperatures increase evapotranspiration demand, and more erratic rainfall can lead to water shortages during critical growing periods. Urban centers like Diyarbakır and Şanlıurfa also suffer from intense heatwaves, straining public health (the area recorded Turkey's highest temperature of 49°C in 2021). The adaptation challenge is twofold: optimize water management for crops under scarcity, and protect communities from heat stress.

Data Source: *ESA CCI Soil Moisture* dataset provides long-term global soil moisture observations (since 1978) by blending active and passive satellite sensors[71]. This data (with ~0.25° resolution) is valuable for monitoring root-zone moisture trends in agricultural zones. It can reveal how soil moisture has changed over decades of new irrigation projects and droughts. Additionally, the **FAO AQUASTAT/WaPOR** platform offers open data on evapotranspiration and agricultural water productivity in the Near East, which can be used to assess irrigation efficiency. For heatwaves, the **Copernicus ERA5-Land** dataset provides high-resolution gridded air temperature, which helps identify frequency of days above dangerous heat thresholds in Southeastern cities. *(URL: ESA CCI Soil Moisture data)*

AI Tools: Advanced ML and Decision Support Systems can greatly aid water and heat management. One promising method is using a **Long Short-Term Memory (LSTM)** neural network (implemented in TensorFlow or Keras) to forecast soil moisture and crop water needs. In a recent case, researchers applied an LSTM to predict daily soil moisture in Bursa's farmlands using soil sensor, weather, and satellite data – achieving R^2 ~0.8–0.9 in predicting moisture trends[72]. For Southeastern Anatolia, a similar LSTM model could be trained (with local calibration) to take weather forecasts and current soil moisture (from sensors or satellite proxies) and predict irrigation requirements for the next week. This guides farmers on when and how much to irrigate, preventing water wastage. Another tool is **reinforcement learning** for irrigation scheduling: an AI agent could learn the optimal irrigation timing that maximizes yield per drop of water, by simulating crop growth under various scheduling policies and climate scenarios. On the heat resilience side, **ChatGPT** or other large language models can serve to enhance climate communication. For example, a municipality could use ChatGPT to generate easy-to understand heat advisories in Turkish (or Kurdish/Arabic for local communities) from raw weather data – essentially translating "technical" forecasts into actionable advice (when to open cooling centers, how to stay hydrated, etc.). It can also parse and summarize scientific studies on cooling urban design, providing planners with quick insights.

Use Case Example: Smart Irrigation in Harran Plain: As part of SECAP actions, Şanlıurfa's agriculture department launched an AI-driven irrigation advisory service. They installed soil moisture sensors in pilot cotton fields and stream the data to an AI model along with satellite-derived moisture (from ESA CCI) and weather forecasts. The **LSTM-based system** analyzes these inputs and sends farmers weekly recommendations via SMS – e.g. "Irrigate Field A in 3 days with ~20 mm of water." During trials, fields using the AI schedule saw up to 15% water savings with no yield loss. This is in line with research showing deep learning can optimize irrigation in Turkish farms[73]. Meanwhile, in Gaziantep city, officials use a GPT-powered chatbot to support their heat action plan. Residents can ask the chatbot questions during heatwaves (e.g. symptoms of heatstroke, nearest cooling center location), and it responds with tailored guidance, pulling from the city's plan and general health advisories. This has improved public awareness and preparedness for extreme heat days. By leveraging both predictive modeling for

[71] Soil Moisture project
[72] A Hybrid LSTM Approach for Irrigation Scheduling in Maize Crop
[73] A Hybrid LSTM Approach for Irrigation Scheduling in Maize Crop

resource management and conversational AI for public engagement, Southeastern Anatolia is harnessing a spectrum of AI tools to bolster its climate resilience.

Suggested Visual: *False-color satellite image of the Southeastern Anatolia Project's impact: the Atatürk Dam reservoir (dark blue, centerleft) and surrounding irrigated fields (red tones indicate vegetation) as of 2002. This Landsat image reveals how formerly arid lands turned fertile (red patches) due to irrigation[74]. AI models are now used to ensure this irrigation water is used efficiently under growing climate pressures.*

Summary Table: Regional AI Strategies for Climate Adaptation

Region	Data Source (linked)	Adaptation Focus	AI Tool/Method	Use Case / Refere *(linked)*
Marmara (Urban Flooding)	Sentinel-1 SAR (Copernicus) – Radar flood imagery	Flood risk mapping and early warning	**Google Earth Engine** for flood extent detection; ML for risk zoning	Istanbul flood-risk integrates multi-cr data[75]
Aegean (Drought)	CHIRPS Rainfall Dataset – 40-year precip record	Drought monitoring and water planning	**Python & scikit-learn** (SPI calculation; drought prediction model)	CHIRPS-based dro alerts for farmers SPI analysis)[76]
Mediterranean (Wildfires)	NASA FIRMS Fire Data – Near-realtime fires	Wildfire risk prediction and alerts	**TensorFlow LSTM** (deep learning forecast of fire danger) (SPI calculation; drought prediction model)	DL model beats Fir Weather Index for Med fire danger[77]
Central Anatolia (Desertification)	MODIS NDVI Satellite Data – Vegetation index time-series	Drought impact on agriculture; land degradation	**GIS + Machine Learning** (Random Forest classification of risk areas)	Remote sensing of Tuz drying informs policy[78]
Black Sea (Floods & Landslides)	NASA GPM IMERG – High-res rainfall data	Flash flood and landslide hazard mapping	**Spatial ML** (logistic regression using rainfall & terrain data)	Rize landslide stud lands on 30–40° s 9× slide risk[79]

[74] Ataturk Dam
[75] Flood-Risk Map for Büyükçekmece District Based on Socioeconomic Factors
[76] Drought Identification and Trend Analysis Using Long-Term CHIRPS Satellite Precipitation Product in Bundelkhand, India
[77] Wildfire Danger Prediction and Understanding With Deep Learning - Universidade NOVA de Lisboa
[78] Disappearing Lake Tuz
[79] Landslide distribution map (yellow and red lines indicate each... | Download Scientific Diagram

Eastern Anatolia (Snowmelt)	MODIS Snow Cover – Daily snow extent; +CDS climate proj.	Water supply changes from snow/glacier loss	**Time-series Modeling** (Prophet forecast of snowmelt runoff)	ClimateImpact pro year Eastern TR sn stream study[80]
Southeastern Anatolia (Heat & Water)	ESA CCI Soil Moisture – Global soil moisture climate data	Irrigation efficiency; urban heat resilience	**TensorFlow LSTM** (irrigation scheduling); ChatGPT for outreach	AI irrigation in Turk LSTM model R² >0 moisture mdpi.com mdpi.c novaresearch.unl.pt earthobservatory.n research climate-adapt.eea.europa.eu[81]

[80] Assessment of climate change impacts on snowmelt and streamflows of mountain region in eastern Turkey
[81] A Hybrid LSTM Approach for Irrigation Scheduling in Maize Crop

PART 4

DIGITAL TOOL AND PLATFORM INTRODUCTIONS

Digital tools and platforms can greatly enhance the development and implementation of a SECAP. They enable data-driven analysis, efficient report preparation, and better communication with stakeholders. In this section, we introduce five key tools and platforms – from satellite mapping services to AI chatbots – that municipalities can leverage for climate and energy planning. Each tool is presented with a brief description, a real-world use case, and practical guidance on how municipal staff can apply it to SECAP tasks.

1. Google Earth Engine (Satellite Mapping and Analysis)

Definition: Google Earth Engine (GEE) is a cloud-based platform for geospatial data analysis that combines a multi-petabyte catalog of satellite imagery with planetary-scale computational power[82]. It enables users to detect changes, map trends, and quantify differences on the Earth's surface using up-to-date satellite data. GEE is accessible via a web-based code editor and APIs (JavaScript/Python) at **earthengine.google.com**, and it remains free for non-commercial use such as research and government projects.

Use Case: A good practice example comes from an urban heat island study in California. Researchers used Google Earth Engine to analyze satellite observations and census data for over 200 cities, identifying neighborhoods with low tree cover and high heat risk. This project, published in 2022, calculated how much new urban afforestation could reduce extreme heat in vulnerable neighborhoods. The team leveraged GEE's massive data repository and processing capability to map available planting space and model co-benefits like carbon sequestration. The results were made accessible through an interactive GEE application, helping city planners visualize where planting trees would have the greatest impact[83]. This example shows how GEE can guide nature-based solutions (like targeted tree planting) to combat urban heat, based on hard data.

Application to SECAP: Municipalities can use Google Earth Engine to support both climate mitigation and adaptation planning. For instance, staff can create high-resolution **heat maps** of their city to pinpoint urban heat island "hot spots" that need cooling interventions (such as green parks or cool roofs). By processing thermal infrared satellite images (e.g., from Landsat or Sentinel satellites), GEE can generate land surface temperature maps for different seasons and years . These maps help identify districts where heat has been intensifying, informing adaptation actions in the SECAP (like tree planting campaigns or heat awareness programs). GEE is equally powerful for **land use and land cover analysis.** Planners can classify land cover (buildings, vegetation, water, etc.) from recent satellite imagery to see how urban expansion or deforestation is affecting local carbon sinks and flood risk. For example, a GEE analysis in Konya, Turkey, used Landsat imagery to map changes in surface temperature alongside air pollution levels[84], helping relate land use change to climate and air quality. With GEE, municipalities can also monitor progress of mitigation actions – such as measuring new green areas or solar farm installations via up-to-date imagery. The platform's extensive dataset catalogue and algorithms (for

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[82] Google Earth Engine https://earthengine.google.com/
[83] Improving urban tree cover with Google Earth Engine | Google Cloud Blog https://cloud.google.com/blog/topics/sustainability/improving-urban-tree-cover-with-google-earth-engine
[84] https://www.acarindex.com/nigde-omer-halisdemir-universitesi-muhendislik-bilimleri-dergisi/konyada-kentsel-isi-adasi-ve-karbon-monoksit-degisiminin-google-earth-engine-kullanilarak-incelenmesi-1305921

tasks like NDVI vegetation indexing or flood mapping) enable data-driven decision-making throughout the SECAP process. *Possible visual: A satellite-derived map highlighting urban heat island intensity across a city.*

2. ChatGPT (AI Report Drafting and Chatbot)

Definition: ChatGPT is an artificial intelligence chatbot developed by OpenAI that can generate human-like text responses[85] . Launched in late 2022, ChatGPT is based on a powerful large language model and is designed to interact in a conversational way, answer questions, and assist with writing tasks. It can be accessed via a web interface (e.g. **chat.openai.com**) or through an API, making it a flexible tool for both individual use and software integrations. ChatGPT can help with writing, learning, brainstorming, and more[86], which makes it a valuable assistant for drafting documents and answering queries.

Use Case: Several forward-looking governments and cities have begun piloting AI chatbots to improve services and streamline communication. For example, in Austin, Texas, a municipal **chatbot** (for a parking services application) successfully handled over 100,000 citizen queries in its first year, providing instant answers about parking permits and rules. Los Angeles launched a similar virtual assistant that managed to resolve 80% of resident questions automatically. These cases demonstrate the potential of AI-driven chatbots to enhance customer service in the public sector. On the internal side, municipal staff are also exploring generative AI like ChatGPT to help draft routine documents. In one survey of local governments, many reported using AI assistants to **write letters, press releases, and summarize policy information,** thereby saving staff time on repetitive writing tasks[87]. For instance, a sustainability office could use ChatGPT to outline a climate action report or translate technical data into plain language, and then refine the output. While human review is always required (to fact-check and adjust tone), these pilots show that ChatGPT can significantly speed up both external communications and internal report preparation.

Application to SECAP: ChatGPT can be a supportive tool throughout the SECAP development process. One major use is **drafting text for the SECAP document** itself. Municipal climate teams can prompt ChatGPT to help write background sections (e.g. explaining climate change impacts on the city), to generate first drafts of action descriptions, or to suggest structured outlines for mitigation and adaptation chapters. For example, if provided with data on the city's emissions or climate hazards, ChatGPT can produce a draft narrative that staff then fact-check and edit. This can accelerate report writing and ensure complex analyses are communicated in clear, accessible language. Another application is using ChatGPT as a **citizen-facing chatbot** on the municipality's website or social media. The AI can be trained (via providing it the SECAP content or FAQs) to answer common questions from residents – such as "What is our city doing about climate change?" or "How can I reduce my home energy use?" – in a friendly, informative manner. This kind of chatbot, embedded on a city's climate action portal, could engage the public and increase awareness of SECAP initiatives by providing instant answers 24/7. It can also collect feedback: for instance, the chatbot might ask users if they have ideas or concerns about climate actions, effectively acting as an interactive outreach tool. When deploying ChatGPT for these uses, municipalities should implement appropriate safeguards (the AI's responses

[85] OpenAI's ChatGPT and the Prospect of Limitless Information | Columbia | Journal of International Affairs https://jia.sipa.columbia.edu/content/openais-chatgpt-and-prospect-limitless-information
[86] https://openai.com/chatgpt/overview/
[87] cupr.rutgers.edu https://cupr.rutgers.edu/wp-content/uploads/2023/10/ChatBot-for-Muni-10-23.pdf

need regular review for accuracy and tone, and it should be configured to reject inappropriate requests). OpenAI provides documentation and options like ChatGPT Enterprise for organizations that require data privacy. Overall, with careful use, ChatGPT can serve as both a “co-writer” for staff – generating drafts, checklists, even translation of SECAP content into simpler language – and as **a virtual climate assistant** for the community. Its ability to quickly turn out well-structured text can free up staff to focus on analysis and decision-making.

Possible visual: *An illustrative screenshot of a ChatGPT conversation, showing the AI helping draft a climate action plan paragraph or answering a citizen’s question on a city website.*

3. Copernicus Climate Data Store (Regional Climate Scenarios)

Definition: The Copernicus Climate Data Store (CDS) is a one-stop shop provided by the EU’s Copernicus Climate Change Service (C3S) for authoritative climate information – past, present, and future[88]. Through an online portal (accessible at **climate.copernicus.eu** after a free registration), users can obtain a wealth of climate datasets, including historical weather observations, global and regional climate reanalyses, and future climate projections from state-of-the-art models. The CDS provides open access to climate data, models, and forecasts[89], making it a key resource for anyone conducting climate risk assessments or scenario analysis. The platform also offers tools and tutorials (via the CDS Toolbox) to analyze data or create custom indicators without needing extensive coding. Essentially, the Climate Data Store allows municipalities to download or derive localized climate projections (e.g. changes in temperature, rainfall, or extreme events) based on the latest science, to inform their SECAPs with solid evidence.

Use Case: Many cities across Europe are using Copernicus climate data to develop “evidence-based” climate action plans. For example, the City of Istanbul’s SECAP team drew on **downscaled climate model projections** to evaluate future hazards. They assessed multiple scenarios of how extreme heat, drought, and flooding might evolve in Istanbul through mid-century[90]. By considering four different climate scenarios (from optimistic to high-emissions pathways), the planners were able to gauge a range of potential futures and identify robust adaptation measures. This approach – modeling cityspecific climate data under various scenarios – is enabled by resources like the CDS, which hosts the underlying model outputs. On a more general level, the Copernicus Climate Data Store has been used in projects such as preparing regional climate risk analyses for Spain’s municipalities and developing local climate adaptation plans in France. In one global city example, Dublin (Ireland) utilized Copernicus regional projections to map how the frequency of heavy rain days and heatwaves could change by 2050, directly feeding those insights into their SECAP adaptation strategies. These use cases underline that CDS data helps cities move from generic climate knowledge (“it will get hotter”) to quantified local projections (“by 2050, average summer maximum temperature may rise by 3°C in our region”[91]). That level of detail strengthens the rationale and urgency for the actions proposed in a SECAP.

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[88] The Climate Data Store | Copernicus https://climate.copernicus.eu/the-climate-data-store
[89] Good to Know: 5 Free Tools for Climate Modeling and Analysis! - MLGP4Climate https://mlgp4climate.com/news/good-to-know-5-free-tools-for-climate-modeling-and-analysis
[90] [PDF] İSTANBUL - Çevre İBB https://cevre.ibb.istanbul/wp-content/uploads/2024/04/ENG-SECAP-v04.pdf
[91] https://climate.copernicus.eu/the-climate-data-store

Application to SECAP: Municipalities can apply the Copernicus CDS in several practical ways when crafting and executing a climate action plan. Firstly, it is invaluable for conducting the **Climate Risk and Vulnerability Assessment** section of a SECAP. Through the CDS, staff can download historical climate trends for their locality – for example, how annual rainfall and mean temperatures have changed over the past 30 years – to establish a baseline of observed climate changes. More critically, they can obtain **future climate projections** at the regional or local scale. The CDS hosts ensembles of climate model outputs (such as Euro-CORDEX regional models for Europe) under different greenhouse gas scenarios. A municipality might extract data for its province or river basin on metrics like projected increase in number of very hot days, percentage change in winter precipitation, sea level rise (for coastal cities), or drought indices by 2030, 2050, and 2100. With these datasets, staff can create graphs and maps that visualize expected changes, which can be included in the SECAP document to communicate future risks. For instance, one could plot a **temperature rise scenario** showing that under a high-emissions scenario, average August temperatures in the city could be 4°C higher by 2080 than today – information that would justify aggressive heat adaptation measures. The CDS platform also provides ready-made **climate indicators** and mapping tools: without heavy programming, a user can generate a map of projected changes in heavy rainfall frequency across their region, or compute an index like "cooling degree days" for future decades to understand building cooling demand. These analyses directly feed into identifying the most urgent climate hazards for the city (heatwaves, flooding, etc.) and assessing which neighborhoods or sectors are most vulnerable. Moreover, during SECAP implementation and monitoring, the CDS can be revisited to check for updated scenarios or to align the plan with the latest climate data (as the science is continuously improving). Using the Copernicus data ensures that a SECAP is grounded in **scientific evidence** accepted by the EU – a factor that can also strengthen funding proposals, since many EU programs expect climate projects to reference Copernicus or similar data sources. In sum, the Climate Data Store empowers municipalities to produce robust climate scenarios and integrate them into planning, answering the "what could happen here?" with credible numbers and maps rather than guesswork.

Possible visual: A chart or map generated from Copernicus data, e.g. a graph of projected temperature increase for the city under different emission scenarios, or a map highlighting changes in annual rainfall distribution in the region by 2050.

4. Microsoft AI for Earth (AI Models for Nature-Based Solutions)

Definition: Microsoft's AI for Earth is a sustainability initiative that applies artificial intelligence to solve environmental challenges, offering resources and tools to organizations working on climate, agriculture, water, and biodiversity issues. Launched in 2017 as a $50 million, five-year program, AI for Earth supports environmental groups and researchers by providing cloud computing, AI models, and technical expertise[92]. The program has led to the development of the **Planetary Computer** platform – a massive environmental data repository with APIs and machine learning models accessible via Microsoft's Azure cloud. In essence, AI for Earth aims to be a catalyst for data-driven environmental solutions, from global projects down to local applications, by leveraging Microsoft's AI technology (e.g. image recognition, predictive modeling) for the good of the planet.

[92] AI for Earth: Helping save the planet with data science - Microsoft Stories Asia
https://news.microsoft.com/apac/features/ai-for-earth-helping-save-the-planet-with-data-science/

Use Case: A striking example of AI for Earth in action is its contribution to **land cover mapping** and urban planning. Traditionally, mapping land use or vegetation cover over large areas was a laborintensive and costly process. Microsoft's AI for Earth team demonstrated a breakthrough by using machine learning algorithms to classify land cover across the entire United States from aerial imagery – processing nearly 200 million images in just over 10 minutes. This achievement, impossible without cloud AI, highlights how quickly AI can generate detailed maps showing forests, water bodies, urban areas, and more. Such up-to-date land cover data is critical for climate action: it helps identify where deforestation is happening, how urban sprawl is encroaching on green spaces, or where there is potential land for reforestation and parks. Another AI for Earth-supported project, "FarmBeats," uses AI and Internet of Things sensors to guide sustainable agriculture (optimizing water use and crop planting)[93], which also ties into climate adaptation for food security. In a city context, AI for Earth has helped power tools that, for instance, **predict urban flooding** by analyzing satellite imagery and elevation data with AI, or monitor biodiversity in city parks using camera trap image recognition. These cases show that AI can parse through huge environmental datasets and find patterns (like areas likely to flood, or ideal locations for planting trees) far faster than manual analysis. By partnering with AI for Earth or using its open tools, cities like Singapore, London, and various U.S. cities have started employing AI-driven insights to shape their climate and conservation plans. The overarching lesson is that AI can unlock opportunities for more precise and efficient climate solutions – whether it's pinpointing where to implement a nature-based solution or rapidly analyzing environmental health indicators (water quality, air quality, urban tree canopy, etc.) from raw data.

Application to SECAP: Municipalities can incorporate AI for Earth tools and principles to enhance the "diagnosis" and implementation of SECAP measures, especially those involving nature-based solutions and large datasets. One practical way is through the **Microsoft Planetary Computer**, which is part of AI for Earth. By accessing planetarycomputer.microsoft.com (which hosts multi-petabyte environmental datasets and pretrained AI models), a city's technical staff or partners can run analyses like identifying all urban areas lacking tree cover or mapping wetlands and green infrastructure via satellite data. For example, a municipality could use a pre-trained land cover AI model from the Planetary Computer to scan its latest high-resolution imagery and quickly produce an updated land use map highlighting green versus impervious surfaces. This directly informs SECAP actions: areas with low tree cover and high population density might be prioritized for urban greening to reduce heat and absorb stormwater.

AI for Earth's emphasis on **predictive modeling** can also aid climate adaptation planning. Cities can explore AI models that project future scenarios, such as flood risk models that incorporate climate change effects. By feeding in local topography and rainfall data (readily available from open sources), an AI model might simulate which city neighborhoods are most at risk under heavier rainfall patterns – providing a basis for targeted infrastructure upgrades in the SECAP. Another application is **wildlife and ecosystem monitoring** in and around the city. If a SECAP includes protecting urban biodiversity or expanding natural habitats (parks, forests), AI can automate the monitoring of these areas. For instance, acoustic sensors or camera traps could collect data on species presence, and AI algorithms (supported by AI for Earth grants) *could* quickly analyze this data to indicate ecosystem health.

[93] AI for Earth: Helping save the planet with data science - Microsoft Stories Asia https://news.microsoft.com/apac/features/ai-for-earth-helping-save-the-planet-with-data-science/

Municipal staff don't necessarily need to develop AI models from scratch – AI for Earth has a grantee gallery and open-source tools (like algorithms for land cover classification, water quality prediction, etc.) that they can adapt. It's also worth noting that Microsoft offers cloud credits and technical support for qualified environmental projects, so a municipality's SECAP team could apply for an **AI for Earth grant** to get resources for a specific project (such as an AI-driven urban tree inventory or a climate data integration platform). By embedding AI analysis into their SECAP, cities can design smarter natüre-based solutions – for example, using AI to find the optimal locations for new green roofs that would reduce the urban heat island effect the most, or to model how planting trees along certain streets would improve air quality and cooling. The end result is a SECAP backed by rigorous, high-tech analysis, which can improve both the effectiveness of actions and the ability to track their impacts over time.

Possible visual: A map or aerial image illustrating an AI-generated land cover classification – for instance, an overhead city image with different colors showing urban surface types (buildings, vegetation, water) identified by an AI model, useful for planning green infrastructure.

5. Tableau + Python (Data Visualization and Dashboarding)

Definition: Tableau is a leading data visualization tool used for interactive data analysis and business intelligence[94]. It allows users to turn datasets into dynamic charts, maps, and dashboards with an intuitive drag-and-drop interface, enabling even non-programmers to explore data and gain insights visually. Python is a powerful open-source programming language widely used in data science for its readability and rich ecosystem of libraries (such as pandas for data manipulation, matplotlib/plotly for plotting, and scikit-learn for machine learning). Using Python, analysts can automate data processing and perform complex calculations or modeling. When combined, **Tableau and Python** offer a synergistic toolkit: Python can handle heavy data crunching or custom analysis, and Tableau can display the results in an easy-to-understand dashboard for decision-makers.

Tableau provides a feature (via the TabPy integration) that allows it to execute Python scripts directly from a dashboard, expanding its capabilities to include advanced analytics[95]. In practice, this means a city can use Python to, say, forecast energy consumption, and then visualize that forecast in real time on a Tableau dashboard.

Use Case: Many local governments and organizations are using Tableau dashboards to communicate climate and energy data effectively. For example, Los Angeles maintains a **Climate Action Dashboard** for the public that presents an overview of the city's greenhouse gas emissions and tracks progress toward emissions reduction targets[96]. This interactive dashboard (built with Tableau or a similar tool) allows residents and officials alike to see trends in community emissions, broken down by sector and year, through intuitive visuals rather than static reports. Another case comes from Headwaters Economics (a research nonprofit), which partnered with Tableau to help communities in the western U.S. visualize climate risks. They created dashboards showing the **unequal impacts of wildfire** –

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[94] Master Tableau: What It Is and How to Use It Effectively https://www.simplilearn.com/tutorials/tableau-tutorial/what-is-tableau
[95] TabPy https://www.tableau.com/developer/tools/python-integration-tabpy
[96] Climate Action Dashboard - LA Sanitation - City of Los Angeles https://sanitation.lacity.gov/san/faces/home/portal/s-lsh-es/s-lsh-es-si/s-lsh-es-si-can/s-lsh-es-si-can-cad

integrating data on wildfire frequency, land use, and social vulnerability[97]. These dashboards let users click on a map to see wildfire risk in their county and how it correlates with poverty or other factors, helping local governments plan targeted resilience measures.

Python often works behind the scenes in such projects: for instance, Python scripts might be used to process raw climate data (like thousands of wildfire records or emissions inventory data) into a summary table that Tableau then 18 19 20 21 22 5 refreshes and displays. In a European context, some Covenant of Mayors cities have used Python to automate their **Baseline Emissions Inventory** calculations, and then used Tableau Public to create shareable visuals of their emissions by source (transport, buildings, etc.) and the anticipated reductions from SECAP actions.

The combination of rigorous data handling (Python) and clear presentation (Tableau) in these examples ensures that climate action decisions are both data-driven and transparently communicated to stakeholders.

Application to SECAP: In the SECAP cycle, there are multiple points where data analysis and visualization are crucial – this is where the Tableau+Python combo can shine. During the **SECAP development phase**, staff can use Python to gather and analyze all relevant data: energy consumption data from utilities, traffic and transportation stats, emissions factors, climate hazard records, you name it. Python's scripting ability is excellent for cleaning such datasets (for example, merging spreadsheets of different departments or performing calculations like CO_2 emissions from energy usage). Once the data is prepared, Tableau can be used to create compelling visuals for the SECAP document or presentations. For instance, a **baseline emissions inventory chart** could be made in Tableau, showing the city's current emissions by sector in an interactive pie or bar chart, so policymakers immediately grasp which sectors are biggest emitters. Similarly, adaptation risk maps (like flood risk zones, heat vulnerability maps combining temperature and population data) can be designed as layered Tableau maps. The advantage of using Tableau here is the ease of updating and iterating – if data changes or a new scenario is considered, the visuals update without manually redrawing graphs in Excel.

Moving to implementation and monitoring, **Tableau dashboards** can become a living part of SECAP management. A municipality can set up an internal dashboard that tracks key performance indicators (KPIs) of the SECAP: for example, annual GHG emissions (updated each year), number of solar panels installed, kilometers of bike lanes added, or number of heatwave warning days. With a Python script scheduled to pull data from various sources (sensors, reports, databases) and feed it into Tableau, the dashboard can automatically refresh, giving up-to-date insights on how the city is progressing toward its targets. This real-time monitoring capability helps city staff identify if any initiative is falling behind. Moreover, many cities choose to publish some of this data via **Tableau Public** or their websites to keep citizens informed and engaged – an interactive public dashboard can show, for example, how much emissions have dropped since the SECAP launch or how much energy savings have been achieved, which boosts transparency. Python also enables doing advanced analysis that can be displayed in Tableau for decision-makers.

For instance, staff could write a Python script to model different emission reduction scenarios (e.g., if the city adds 100 electric buses, what is the projected emissions drop by 2030?). The results of multiple scenarios can be visualized in Tableau as a set of scenario comparison charts, making it easier for

[97] Using data to drive conversations about climate change https://www.tableau.com/blog/driving-local-conversations-about-climate-change

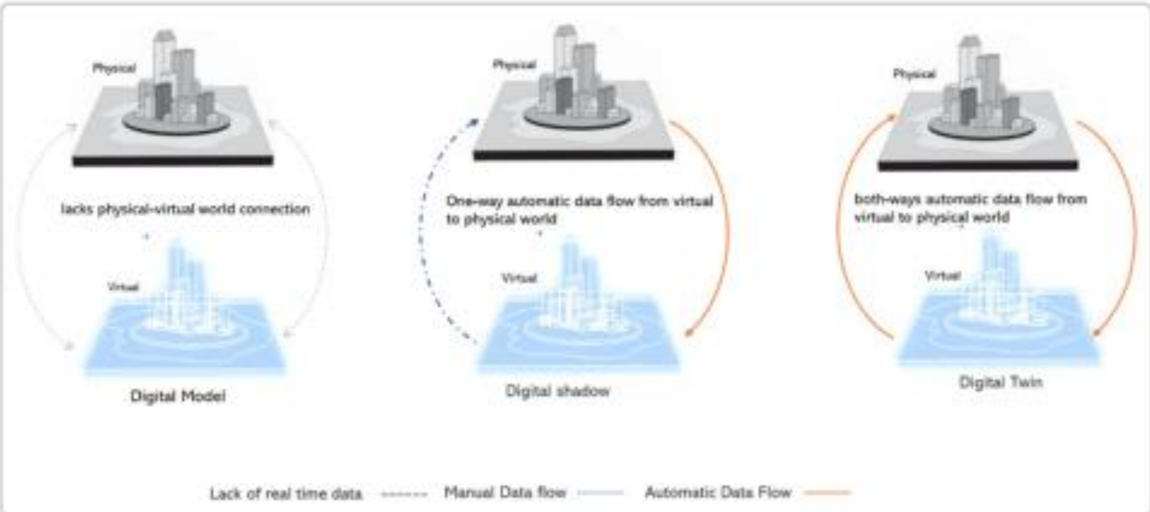
officials to decide which measures to prioritize. Additionally, through the TabPy integration, one can even let Tableau call Python code on the fly – say, a user moves a slider on the dashboard to choose a number of trees to plant, and Python then calculates expected carbon absorption, with Tableau instantly displaying the outcome. This kind of interactive simulation tool could be used in stakeholder workshops to dynamically illustrate the impact of different actions. In summary, **Tableau + Python** empowers municipalities to both understand their data deeply and communicate it clearly. By automating analysis with Python and visualizing results in Tableau, SECAP teams can save time, reduce errors, and produce engaging materials that keep everyone from the mayor to the public informed about the plan's progress.

Possible visual: A screenshot of an interactive SECAP dashboard – for example, a Tableau dashboard page showing a city's emissions trend line alongside a pie chart of emissions by sector, with filters to view different years or scenarios.

PART 5

AI-POWERED LOCAL CLIMATE LAB

The AI-powered Local Climate Lab builds on the concept of a city-scale **digital twin** – a real-time, bidirectionally linked model of urban infrastructure. The diagram above illustrates three stages: a static digital model (no live data feed), a one-way digital shadow (one-way data flow), and a full digital twin where sensors and data continuously update the model and can even trigger simulated interventions[98]. In this Climate Lab, municipal planners have a virtual replica of the city that mirrors real conditions. They can run "what-if" adaptation scenarios – for example, adding green roofs or planting trees to reduce heat, or redirecting stormwater into new basins to prevent flooding – and immediately see the effects in the model. All urban assets (roads, buildings, trees, drainage, etc.) are represented in the twin and connected to data streams, enabling a living simulation. This approach combines international best practices and local context: Istanbul Technical University, for example, is developing digital twins for all 81 Turkish provinces to improve planning and disaster readiness, including flood mapping during heavy rain[99]. The Climate Lab concept leverages such efforts by blending opensource tools with global data (e.g. Google Earth Engine[100] and the EU Copernicus[101] program) into a pilot framework tailored for Turkish municipalities.



In the Lab, a constant flow of **real-time data** keeps the digital twin in sync with reality. Wireless IoT sensors (for example in weather stations, water gauges, traffic cameras, or air-quality monitors) stream measurements to a cloud platform[102]. Open APIs (such as OpenWeatherMap[103]) supply

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[98] Management of Climate Resilience: Exploring the Potential of Digital Twin Technology, 3D City Modelling, and Early Warning Systems https://www.mdpi.com/1424-8220/23/5/2659

[99] Turkish university to create digital twins of cities for urban planning - Türkiye News https://www.hurriyetdailynews.com/turkish-university-to-create-digital-twins-of-cities-for-urban-planning-192885

[100] Google Earth Engine https://earthengine.google.com

[101] https://www.copernicus.eu/en

[102] Management of Climate Resilience: Exploring the Potential of Digital Twin Technology, 3D City Modelling, and Early Warning Systems https://www.mdpi.com/1424-8220/23/5/2659

[103] Weather API - OpenWeatherMap https://openweathermap.org/api

weather forecasts and historical climate records. Even citizen-reporting apps and social platforms can feed data – for instance, residents can report flooded streets or urban heat spots via a mobile app, and those reports update the model. These streams are integrated through data middleware (for example, Node-RED flows or Azure IoT Hub pipelines) into databases and GIS systems. By merging local sensor feeds and national climate data, the Climate Lab gives planners up-to-the-minute insights. For example, if torrential rain is forecast, the twin can simulate which streets will flood and how quickly, allowing the city to adjust pump operations or emergency alerts in advance. Sensors can also trigger automatic updates: rising river levels could change flood-risk layers on the dashboards. The net effect is that planners and citizens always see an accurate, current picture of their city's environment[104].

Interactive **dashboards and visualization tools** are the user interface of the Local Climate Lab. Planners would use a secure, customizable dashboard (built with platforms like Tableau[105], Grafana[106], or open-source GIS tools like QGIS and Leaflet) to view key indicators and maps. For example, a municipal dashboard might display the current urban heat-island index, sensor data trends (such as energy or water usage), live risk maps (flood zones, air pollution hotspots), and the results of recent simulations. Staff could switch layers, run future climate projections, and see charts of emissions and energy use for different neighborhoods. Meanwhile, a citizen-facing dashboard (perhaps a public web portal or mobile app) would offer simplified views: an interactive map where residents can see data by district, explore planned climate projects, or learn how their neighborhood's flood risk is changing. The dashboards can also gather feedback (for example, via simple surveys or a map where citizens drop pins to report issues). **Izmir's SECAP pilot exemplifies this idea**: it created a digital twin of one neighborhood to map solar-power potential and raise awareness of energy use[107]. In practice, the Climate Lab's dashboards help municipal teams make data-driven decisions and keep citizens informed and involved in climate action.

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[104] Turkish university to create digital twins of cities for urban planning - Türkiye News https://www.hurriyetdailynews.com/turkish-university-to-create-digital-twins-of-cities-for-urban-planning-192885

[105] Business Intelligence and Analytics Software | Tableau - Tableau US https://www.tableau.com

[106] Grafana: The open and composable observability platform | Grafana Labs https://grafana.com

[107] Izmir's Pilot Activity: GCC-SYNERGY - NetZeroCities https://netzerocities.eu/izmirs-pilot-activity-gcc-synergy/

Another key component is an **AI-powered chatbot** – an "Ask SECAP!" assistant for the public. This chatbot, running on a conversational AI platform (for example, integrating OpenAI's GPT[108] or Microsoft Azure's language models), can answer questions in natural language about the climate plan and city data. Residents might ask, "What is our city's tree coverage?" or "How will this summer's heat wave affect my area?" and the chatbot would respond using the live Climate Lab data and knowledge base. The assistant could guide a user through the SECAP document, suggest local adaptation tips, or even log a report (e.g. "a tree has fallen blocking the sidewalk") into the Lab's database. Because it links to the Lab's data, it can provide context-sensitive responses (for instance, drawing from the latest weather data or predicted climate impacts). Over time the chatbot learns common queries and adapts its answers. Such AI chat interfaces have been used in other local government services, making complex data accessible to non-specialists. In the Climate Lab, "Ask SECAP!" lowers the barrier for community engagement and helps the public understand and contribute to climate action.

Behind the scenes, the system is built on robust **tools and platforms.** Geospatial analysis uses satellite and map data: Google Earth Engine[109] and Copernicus imagery feed the twin with up-to-date land cover, vegetation, and climate layers. Cloud computing (e.g. Microsoft Azure Digital Twins[110]) can host the virtual city model and process simulations at scale. Sensor data streams into time-series databases or cloud storage (for example, Azure SQL or Cosmos DB). Node-RED or custom ETL scripts handle the pipelines from devices to databases. Interactive dashboards can be built in tools like Tableau or open libraries (D3.js, Kepler.gl) that connect directly to those data stores. Machine learning models (using Python libraries like TensorFlow or PyTorch) could be run on Azure or local servers to predict hazards or optimize resource use. All these components are connected by APIs and open standards: for instance, a Node-RED flow might pull meteorological data via the OpenWeatherMap API[111] or ESA APIs, store it in a database, and refresh a QGIS/Leaflet web map. Globally, this modular approach is gaining traction – the EU's Destination Earth project is creating a comprehensive climate-change digital twin with use cases in energy, wildfires, hydrology and urban planning[112]. The Lab can adopt similar interoperability: for example, Istanbul could collaborate with DestinE or other climate services to incorporate Europe-wide climate scenarios. By choosing proven platforms, municipalities avoid reinventing the wheel and ensure future growth.

Implementing the AI-Powered Local Climate Lab is feasible in stages. A municipality can start by identifying a pilot focus (for example, flood resilience in a river basin or heat mitigation in a dense neighborhood). The first step is data mapping: compile existing GIS data (street maps, elevations, land use) and install any missing sensors (low-cost IoT weather stations or flow monitors). Next, set up the data pipeline: ingest open weather feeds, connect sensors via Node-RED or Azure IoT, and store the results. Develop a simple dashboard showing baseline metrics (current emissions, average temperatures, flood history) and link it to a prototype 3D model or map layer. In parallel, deploy the "Ask SECAP" chatbot on a website or messaging app, trained on local FAQs and SECAP content. This phased approach was effectively used in places like Izmir and Barcelona to validate the concept. Once

[108] OpenAI https://openai.com
[109] Google Earth Engine https://earthengine.google.com
[110] Digital Twins – Modeling and Simulations | Microsoft Azure https://azure.microsoft.com/en-us/products/digital-twins/
[111] Weather API - OpenWeatherMap
[112] Use cases of the Climate DT | Destination Earth https://destine.ecmwf.int/news/real-world-applications-of-the-climate-change-adaptation-digital-twin/

running, the Lab can be expanded: add more sensors, refine simulation models, and roll out user-friendly web dashboards. Training for municipal staff (e.g. GIS and data science training) will build capacity to maintain and improve the Lab.

By documenting the pilot and sharing code and lessons, the program encourages replication across Türkiye. For example, after piloting in a coastal city to manage flood risk, inland municipalities could adopt the same framework for drought resilience. As more data streams are integrated (smart meter data, crowdsourced observations, etc.), the digital twin becomes richer and the tool more powerful. Ultimately, the Climate Lab turns SECAP from a static report into a living decision-support system: municipal planners and citizens alike can explore scenarios and see the impact of policies in real time. With clear success stories, user-friendly dashboards, and an AI assistant, other municipalities will be inspired to build their own AI-Powered Local Climate Labs. This replicable, practical approach demonstrates how global innovation (like digital twins and AI) can be localized in Turkey's climate action plans[113].

Sources: Concepts and examples in this section are drawn from digital twin and climate resilience literature and recent smart city and SECAP projects[114], combined with publicly available tools and platforms (Google Earth Engine, Copernicus data, Microsoft Azure, OpenAI, Tableau, Node-RED, QGIS, etc.) mentioned above.

An AI-powered Local Climate Lab is a **digital platform** that integrates city data, climate models, and smart tools to support the Sustainable Energy and Climate Action Plan (SECAP). It combines a city's digital twin (a live model of the city), real-time sensor networks, interactive dashboards, and even an AI chatbot to inform planning and engage staff and citizens. This section guides municipal staff through building each component of the Local Climate Lab, with practical examples and recommended open platforms.

Digital Twin for Climate Modeling

A digital twin is a dynamic, data-driven virtual replica of the city's physical and environmental systems. It integrates maps, infrastructure data, climate models and live sensor inputs to simulate real-world scenarios. For example, ITU describes digital twins as "virtual simulations of real-world entities such as cities… offering valuable insights for urban planning and management"[115]. In practice, a climate-focused digital twin includes layers for terrain, buildings, land use, transportation networks, and environmental factors like temperature or rainfall. To build a digital twin, municipal staff can:

- **Collect geospatial data**: Start with a base map (e.g. OpenStreetMap or local GIS data) and city assets (buildings, roads, utilities). Use tools like Google Earth Engine or QGIS to process satellite imagery and public data layers.

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[113] Turkish university to create digital twins of cities for urban planning - Türkiye News https://www.hurriyetdailynews.com/turkish-university-to-create-digital-twins-of-cities-for-urban-planning-192885

[114] Management of Climate Resilience: Exploring the Potential of Digital Twin Technology, 3D City Modelling, and Early Warning Systems https://www.mdpi.com/1424-8220/23/5/2659

[115] Turkish university to create digital twins of cities for urban planning - Türkiye News https://www.hurriyetdailynews.com/turkish-university-to-create-digital-twins-of-cities-for-urban-planning-192885

- Integrate real-time inputs: Add feeds from weather stations, air-quality sensors, smart meters, etc. For example, **Izmir's GCC-SYNERGY project** creates a twin of a neighborhood to map solar potential using real consumption data[116]. Citywide sensor networks (LoRaWAN, IoT) can supply live air/soil temperature, humidity or pollution data as in Aschaffenburg, Germany[117].

- Include simulation models: Embed climate and energy models. For instance, cities can run flood or heat wave scenarios on the twin to see impacts on streets and buildings. (ITU is piloting digital twins to identify flood-prone areas and test mitigation strategies[118].) Tools like CesiumJS or Unity (with GIS plugins) can support 3D visualization of these simulations.

- Engage stakeholders: Involve urban planners, IT, and citizens. Aschaffenburg's project gave residents input on which data to publish[119].

- Update continuously: Ensure the twin refreshes with new data (e.g. recent satellite images or sensor readings) to keep analyses current.

Example: The SaferPlaces platform builds urban twins by automatically ingesting open data from Google Earth Engine, OpenStreetMap, Copernicus and other sources to create multilayer city models . İzmir's pilot project also uses a digital twin for energy planning, combining building data and usage to pinpoint optimal solar panel sites[120]. On a larger scale, Istanbul Technical University aims to create twins for all provinces, using the models to test climate and disaster scenarios[121].

Key steps:

1. Define the twin's scope (e.g. city block, district or full city) and objectives (flood planning, energy, etc.).

2. Gather base maps and assets (GIS, 3D building data, infrastructure maps).

3. Layer in climate data and models (satellite imagery via Earth Engine, historical weather, land-cover).
4. Integrate live data streams (IoT sensor networks, Open APIs) for dynamic updates.

5. Develop a user interface or dashboard to visualize the twin (3D map, charts, simulation controls)

6. Validate and calibrate the model with real events (adjust algorithms so predictions match observed outcomes).

References and tools: Google Earth Engine (earthengine.google.com) for satellite analytics; OpenStreetMap (openstreetmap.org) and QGIS (qgis.org) for base mapping; CesiumJS (cesium.com/

[116] Izmir's Pilot Activity: GCC-SYNERGY - NetZeroCities https://netzerocities.eu/izmirs-pilot-activity-gcc-synergy/
[117] TwinBy: Aschaffenburg becomes climate-proof with the help of a digital twin - aconium GmbH https://aconium.eu/twinby-aschaffenburg-becomes-climate-proof-with-the-help-of-a-digital-twin/?lang=en
[118] Turkish university to create digital twins of cities for urban planning - Türkiye News https://www.hurriyetdailynews.com/turkish-university-to-create-digital-twins-of-cities-for-urban-planning-192885
[119] TwinBy: Aschaffenburg becomes climate-proof with the help of a digital twin - aconium GmbH https://aconium.eu/twinby-aschaffenburg-becomes-climate-proof-with-the-help-of-a-digital-twin/?lang=en
[120] SaferPlaces Global Platform — AI-based Digital Twin Solution for Flood Risk Intelligence https://saferplaces.co/
[121] Turkish university to create digital twins of cities for urban planning - Türkiye News https://www.hurriyetdailynews.com/turkish-university-to-create-digital-twins-of-cities-for-urban-planning-192885

cesiumjs/) or WebGL tools for 3D models; Copernicus Climate Data (cds.climate.copernicus.eu) for environmental layers; city GIS portals or open data hubs.

Real-Time Data: Sensors, APIs and Apps

Real-time data streams are the lifeblood of the Local Climate Lab. Sensors in the field and data APIs provide up-to-the-minute information on weather, pollution, energy use and more. Municipalities should deploy networks of IoT devices (e.g. air monitors, temperature probes, soil moisture sensors) and tap existing open data sources to feed the twin and dashboards.

IoT sensors: Install or partner on sensor networks. For example, Aschaffenburg uses LoRaWAN-connected sensors across the city to measure air quality, temperature, precipitation, and soil moisture. These data are sent in real time to its climate dashboard to detect heat islands or flooding risks[122]. Similar low-cost sensors can monitor noise, traffic, or river levels. Encourage residents to contribute data via community sensors (e.g. PurpleAir air monitors).

Public APIs: Use web services for broad coverage. The OpenWeatherMap API provides current and forecast weather data (temperature, humidity, precipitation) updated frequently from global models and weather stations[123]. National services like NOAA or Copernicus API can supply climate projections and alerts. Air quality data can be pulled from the World Air Quality Index (WAQI) or OpenAQ platforms; for instance, Istanbul's AQ monitoring station data are available via WAQI's API as live PM2.5 readings[124].

Utility and mobility data: Integrate smart meter or grid data (electricity use, streetlight energy, etc.) and transport info (traffic flow, public transit occupancy). İzmir's GCC-SYNERGY pilot uses smart meter data to monitor electricity use in real time[125]. GPS/location apps or bike share systems can add mobility patterns.

Citizen apps and crowdsourcing: Leverage phone apps and community science. Apps like iNaturalist (biodiversity observations) or crowdsourced weather apps can enrich data. A city climate app might let users log home energy improvements or heatwave sightings.

Examples: Izmir's platform collects real-time electricity use from buildings to analyze energy efficiency[126]. Aschaffenburg's dashboard uses a distributed LoRaWAN network so that "data comes from sensors throughout the city and is transmitted using LoRaWAN technology"[127]. Such integration allows planners to see live city conditions.

Data collection best practices: Ensure data quality and privacy. Calibrate sensors and validate thirdparty data. Use standard APIs (JSON or CSV feeds) and low-power wide-area networks (LoRa, NB-

[122] TwinBy: Aschaffenburg becomes climate-proof with the help of a digital twin - aconium GmbH https://aconium.eu/twinby-aschaffenburg-becomes-climate-proof-with-the-help-of-a-digital-twin/?lang=en
[123] Current weather and forecast - OpenWeatherMap https://openweathermap.org/
[124] Air Quality Open Data Platform API: Istanbul Kandilli Real-Time data API https://aqicn.org/data-platform/api/H8155/
[125] Izmir's Pilot Activity: GCC-SYNERGY - NetZeroCities https://netzerocities.eu/izmirs-pilot-activity-gcc-synergy/
[126] Izmir's Pilot Activity: GCC-SYNERGY - NetZeroCities https://netzerocities.eu/izmirs-pilot-activity-gcc-synergy/
[127] TwinBy: Aschaffenburg becomes climate-proof with the help of a digital twin - aconium GmbH https://aconium.eu/twinby-aschaffenburg-becomes-climate-proof-with-the-help-of-a-digital-twin/?lang=en

IoT) for reliability. Design data dashboards (see next section) to refresh automatically when new data arrive.

References and tools: OpenWeatherMap: https://openweathermap.org/ (weather API)[128]; PurpleAir: https://www.purpleair.com/ (air quality sensors); Air Quality Open Data (WAQI): https://aqicn.org/ (AQ API)[129]; Azure IoT Hub or LoRaWAN Alliance info for sensor networks; City Urban Data platforms (e.g. Esri's ArcGIS Hub).

Interactive Dashboards for Staff and Citizens

Visual dashboards turn data and model outputs into actionable insights. Municipal dashboards can be internal (for staff) or public (for transparency). They should display key climate metrics (GHG emissions, energy use, renewable adoption, resilience indicators) in a clear, interactive way.

Design principles: Use clean layouts with a few meaningful charts. Each chart or map should include titles, source labels, and brief explanations. Rockville, MD's public climate dashboard is praised for its simplicity – it has just three main "pillars" (Emissions, Resiliency, Engagement) and each chart is labeled with descriptive text. Written updates accompany the graphics to tell the story of progress. Follow this example: avoid clutter, use accessible colors, and ensure charts are self-explanatory.

Content and interactivity: Provide year-over-year trends for emissions or energy; gauge targets vs. actual performance. Include maps (e.g. heat maps of energy use or flood risk) that citizens can explore. For staff dashboards, allow filtering by neighborhood or sector. For public dashboards, offer download links for data (transparency) and simple toggle filters. Ensure the dashboard is mobile-friendly and ADA-compliant.

Development steps:

Select a platform: Many tools can build dashboards. Tableau (including Tableau Public) and Microsoft Power BI offer drag-and-drop interfaces. Google's Looker Studio (Data Studio) is free for charts and maps. Open-source options like Grafana or Apache Superset can connect to live databases. The city's GIS system (e.g. ArcGIS Online) can also publish dashboards.

Connect data sources: Link the dashboard to databases or live feeds (e.g. emission inventories, sensor streams). Automate updates so the dashboard reflects real-time info when possible.

Create visuals: Use bar/line charts for trends (e.g. annual CO_2), gauges for targets, and maps for spatial data. Limit axes and legends to what's needed. Each graphic should have a caption or annotation describing what it shows.

Add narrative: Complement visuals with text boxes. Explain anomalies (e.g. "transport emissions dropped due to new bus lines") and next steps. This contextual storytelling was a strength of Rockville's dashboard, which pairs charts with detailed "highlights" and "next steps" commentary.

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[128] Current weather and forecast - OpenWeatherMap https://openweathermap.org/

[129] Air Quality Open Data Platform API: Istanbul Kandilli Real-Time data API https://aqicn.org/data-platform/api/H8155/

Iterate and train: Gather feedback from staff and community. Update the interface to improve clarity.

Examples: Many cities publish climate or performance dashboards. Rockville's Climate Action Plan dashboard lets residents see progress toward its 2030 emission-reduction goal[130]. Aschaffenburg's "Smart Data Dashboard" shows live temperature and air quality maps for citizens to check local conditions[131]. These dashboards empower decision-makers and inform the public.

References and tools: Tableau: https://www.tableau.com/; Microsoft Power BI: https://powerbi.microsoft.com/; Google Looker Studio (Data Studio): https://lookerstudio.google.com/; Grafana: https://grafana.com/ (open-source dashboards); OpenStreetMap: https://www.openstreetmap.org/ (for base maps); Esri ArcGIS Dashboards: https://www.esri.com/software/arcgis/arcgis-dashboards.

Public-facing climate action dashboard (City of Rockville, MD) showing key metrics and goals (source: Rockville CAP)[132].

AI Chatbot ('Ask SECAP') Virtual Assistant

An **AI chatbot** is a conversational agent that can answer questions and provide guidance about the city's climate plans and resources. Branded here as "Ask SECAP," it would let residents and staff interactively query the SECAP and related information. Chatbots operate 24/7, giving instant responses and reducing staff workload.

Capabilities: Train the bot on the city's climate action documents, FAQs, permitting rules, and service info. Citizens could ask "What are our emissions targets?", "How do I apply for a solar incentive?", or "Where can I recycle electronics?" The chatbot should answer from the SECAP text, link to web pages, or give basic advice (for example, "Planting trees in your area can reduce summer temperatures"). It can also alert users to news or deadlines (e.g. upcoming climate events). By connecting to internal knowledge bases, the bot becomes "a one-stop shop for everything citizens need to know about" municipal policies.

Platforms: Several frameworks support chatbot creation. Microsoft's Azure Bot Service and Power Virtual Agents allow integration with Azure OpenAI or QnA Maker. Google Dialogflow and IBM Watson Assistant offer natural language understanding to build conversational agents. Open-source Rasa is a Python-based toolkit for custom chatbots. Alternatively, cities can use large language models (e.g. OpenAI's GPT via API) with fine-tuning or retrieval augmentation on local data. Choose a solution that can ingest multi-language content (since SECAP training materials may be bilingual) and can be embedded on the city website or messenger apps.

Implementation steps:

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[130] 8 Local Government Public Dashboard Examples | Envisio https://envisio.com/blog/8-local-government-public-dashboard-examples/

[131] TwinBy: Aschaffenburg becomes climate-proof with the help of a digital twin - aconium GmbH https://aconium.eu/twinby-aschaffenburg-becomes-climate-proof-with-the-help-of-a-digital-twin/?lang=en

[132] 8 Local Government Public Dashboard Examples | Envisio https://envisio.com/blog/8-local-government-public-dashboard-examples

Gather content: Collect all relevant SECAP texts, climate program details, and standard city service information. Create a structured FAQ or knowledge base from this content.

Build and train: Use the chosen platform to build dialog flows or connect an LLM. For example, QnA Maker can convert PDFs into a Q&A service. Train the chatbot with example questions and answers.

Test and refine: Have staff test the chatbot for accuracy. Update the training data based on failures. Ensure it handles out-of-scope questions gracefully.

Deployment: Publish the chatbot on official channels (municipal website, Facebook Messenger, WhatsApp, etc.). Ensure it is labeled clearly and link users to human support if needed.

Monitor and update: Track usage and feedback. Update the bot's knowledge as the SECAP or city services evolve.

Best practices: Be transparent about the bot's capabilities and limits. Don't make the bot store personal data beyond a session. According to experts, chatbots should only access information needed to answer queries, avoiding sensitive content. For important or complex issues (e.g. emergency alerts), include an option to contact a human. Providing responses in the user's language (Turkish/English) will improve accessibility.

Example: While a specific "Ask SECAP" bot may not yet exist, cities worldwide are adopting chatbots for citizen services. Chatbots have been used to automate ~60% of routine inquiries and to streamline communication outside office hours[133]. By linking the bot to climate and municipal data, the city creates a virtual assistant for sustainable development, increasing transparency and engagement.

References and tools: Azure Bot Service: https://azure.microsoft.com/services/bot-services/; Google Dialogflow: https://cloud.google.com/dialogflow/; Rasa Open Source: https://rasa.com/; IBM Watson Assistant: https://www.ibm.com/cloud/watson-assistant/; OpenAI API: https://openai.com/api/ (for GPT-based chatbots); Bot development guides (Microsoft QnA Maker, Google CCAI, etc.).

[133] Leveraging AI Chatbots to Enhance Citizen Engagement in City Services | Planetizen Blogs https://www.planetizen.com/blogs/131448-leveraging-ai-chatbots-enhance-citizen-engagement-city-services

PART 6

CAPACITY BUILDING SUGGESTIONS

Capacity building should span all AI literacy levels—from staff with minimal data experience to those with strong technical backgrounds—and use practical, modular formats. We recommend tiered curricula (beginner, intermediate, advanced) with a mix of formats (online modules, live workshops, hands-on exercises). For example, ICLEI's city climate training uses multiple weekly modules (with recorded videos and live sessions) on topics like GHG inventories, climate risk and resilience, and local action planning[134]. A similar modular approach can anchor AI training: each level has clear learning objectives and progressively technical content, supplemented by live Q&A or peer exercises. Where possible, integrate Turkish language resources (Turkish slide decks, subtitles, and interfaces) to maximize comprehension.

Beginner (Basic AI & Data Literacy)

For novices we focus on fundamental concepts and simple tools. Suggested content includes:

AI/Data Basics: Definitions of AI/ML, examples of AI in daily life, and how data underpins AI. Explain core climate/energy terms (emissions, resilience, mitigation) and how data can inform them.

Spreadsheet and GIS Intro: Hands-on with Excel or similar (using Turkish labels) for simple data analysis (e.g. plotting energy use or temperature trends). Introduce basic GIS mapping in QGIS with Turkish interface. (QGIS supports Turkish UI and has plugins like OpenAtlasTurkey that bundle Turkish spatial datasets[135].)

No-Code AI Tools: Demonstrations of "no-code" or visual tools (e.g. Google's Teachable Machine, AutoML tables, or simple decision-tree builders) to show how AI can classify images or predict values without programming. This demystifies AI and empowers beginners with immediate hands-on experience.

Climate Data Exploration: Show how to access public climate data through portals. For example, Türkiye's new Climate Portal (MoEUCC/UNDP) provides national emissions and temperature data for practitioners[136]. Have trainees query these datasets or visualize basic indicators.

Guided Examples with Local Data: Use simple case studies with Turkish municipal data. For instance, map city GHG emissions by sector using QGIS, or analyze historical precipitation or heat trends from nearby weather stations. Where possible, use **Google Earth Engine (GEE)** for beginners by providing step-by-step notebooks or video tutorials. (Turkish-language Earth

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[134] Climate Compliance Capacity Building Programme - ICLEI https://iclei.org/activity/climate-compliance-capacity-building-programme/
[135] Open Atlas Turkey — QGIS Python Plugins Repository https://plugins.qgis.org/plugins/OpenAtlasTurkey/
[136] Türkiye's first Climate Portal launched to accelerate climate action | United Nations Development Programme https://www.undp.org/turkiye/press-releases/turkiyes-first-climate-portal-launched-accelerate-climate-action

Engine courses exist – e.g. "Google Earth Engine ile Uzaktan Algılama Uygulamaları"[137] – which cover satellite data visualization, land cover indices, etc.) A concrete exercise could be loading CHIRPS precipitation or MODIS NDVI for a city region and plotting a time series.

Sample Curriculum (Beginner): 1–2 weeks of weekly sessions or a 2-day workshop. Day 1: "AI & Climate 101" (concepts, low-tech examples, group discussion). Day 2: "Data Tools Intro" (Excel and QGIS basics with Turkish UI; mapping a simple emissions dataset). Wrap-up with an exercise, e.g. "Calculate and map your municipality's per-capita energy use."

Intermediate (Applied AI for SECAP Analysis)

Intermediate training builds on foundations with more technical content and real applications. Content includes:

Programming Basics: Introduction to Python or R for data analysis. Cover data manipulation (pandas/dplyr), plotting, and working with geospatial data libraries. Use examples from Turkish context (loading TÜİK or ministry datasets).

Machine Learning Concepts: Overview of supervised ML (regression, classification) and unsupervised learning (clustering) with relevant case studies. For example, train a regression model to forecast energy demand or an ML classifier to predict building energy class. Use libraries like scikit-learn or simple neural nets.

Advanced GIS & Remote Sensing: Guided use of QGIS plugins and Google Earth Engine for intermediate users. For instance, use GEE's Python API to batch-download climatic or land-cover data for Turkish regions and analyze trends[138]. (The study "Effects of Climate Change on Türkiye" used GEE to compute trends in precipitation, temperature, NDVI, etc., for all 7 geographic regions – similar analyses can be replicated by trainees.) Show how the **OpenAtlasTurkey** QGIS plugin simplifies access to Turkish geospatial layers .

Statistical Analysis of Climate Data: Teach simple statistical trend tests (e.g. Mann–Kendall) and correlation analysis between variables (e.g. temperature vs. vegetation index). Use real multi-year data to illustrate significance and uncertainty.

Tool Workflows: Integrate multiple tools. For example, a workshop could have trainees import GEE-derived data into QGIS, or pull TR national climate model outputs (e.g. from Boğaziçi's iklimBU center) to combine with local GIS layers[139].

Project-based Learning: Assign group mini-projects that mimic real SECAP tasks. For example, groups use an open source GHG inventory of a Turkish city to build an AI-powered dashboard, or analyze transport patterns with ML clustering.

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[137] Google Earth Engine ile Uzaktan Algılama Uygulamaları | Udemy https://www.udemy.com/course/gee-uzaktanalgilama/? srsltid=AfmBOoqXEMrkyh0bvSji7dG2J8bG0fY3F6sk1SbEJyCv1dd0DhziDgS4

[138] Examination of the Effects of Climate Change on Türkiye through the Google Earth Engine Platform | Request PDF https://www.researchgate.net/publication/379238691_Examination_of_the_Effects_of_Climate_Change_on_Turkiye_through_the_Google_Earth_Engine_Platform

[139] iklimBU | Hakkımızda https://climatechange.bogazici.edu.tr/hakkimizda/

Sample Curriculum (Intermediate): A week-long course or biweekly sessions. Day 1–2: Python/R for data (load local climate and energy datasets; visualize). Day 3: GIS/GEE (map emissions or vegetation indices across a region; learn Turkish-language tutorials where available). Day 4: Machine Learning (build/ predict a model on municipal data; e.g., predict peak energy demand). Day 5: Group presentations of data-driven findings and model results.

Advanced (Specialized AI & Modeling)

For advanced users (e.g. technical staff or researchers), training can be oriented toward customizing and extending AI tools:

Deep Learning & Big Data: Introduce neural networks and deep learning (using TensorFlow/ PyTorch) for complex pattern recognition – e.g., analyzing high-resolution satellite imagery to detect urban heat islands, or forecasting energy demand under climate scenarios.

Advanced Spatial Modeling: Teach integration of AI with physics-based models. For example, combining AI predictions with outputs of regional climate models (like high-res CORDEX simulations used by iklimBU[140]) to improve local projections.

Cloud & API Skills: Provide training on working with APIs and cloud platforms. Show how to use Earth Engine's JavaScript/Python API for large-scale analysis, or utilize Turkish meteorological APIs. Simplify these by preparing template scripts and translating key comments into Turkish.

Optimization and Decision Support: Cover AI techniques for optimization (e.g. optimally siting solar panels using ML, or optimizing traffic flow to reduce emissions).

Research Collaboration: Encourage internships or joint projects with universities. For instance, METU's Pattern Recognition and AI Lab or ITU's climate engineering labs can mentor capstone projects. Advanced trainees might contribute to publishable studies under faculty guidance.

Sample Curriculum (Advanced): A 1–2 week lab-intensive program or university-extension course. Example: Day 1–2: Deep learning fundamentals (Keras/TensorFlow, CNNs) with environmental case studies. Day 3: High-performance computing (using cloud GPUs or HPC clusters). Day 4: Advanced GIS/ Remote Sensing (super-resolution models, Lidar). Day 5: Collaborative project work with academic mentors.

Workshops with Real Turkish Data

Hands-on workshops should use real municipal and regional datasets from Türkiye. Examples of workshop exercises:

GEE Climate Trends by Region: Replicate analyses like[141] by region (Marmara, Ege, etc.) to identify local climate trends. Trainees could use GEE to compute historical precipitation or temperature change in their province.

[140] iklimBU | Hakkımızda https://climatechange.bogazici.edu.tr/hakkimizda/
[141] Examination of the Effects of Climate Change on Türkiye through the Google Earth Engine Platform | Request PDF https://www.researchgate.net/publication/

Local Energy & Emissions Data: Use open data (e.g. city building stock, traffic counts, energy consumption from utilities or national databases) for ML tasks. For example, a workshop could involve predicting a town's future energy demand given projected population and weather, or clustering neighborhoods by their carbon footprint.

Urban GIS Case Study: In QGIS, map heat island or flood-risk areas using local topography and climate data. Simplify this by using Turkish LULC/DEM layers (via OpenAtlasTurkey[142]) and NOAA/Copernicus climate layers, with all legend/text in Turkish.

Hackathons and Challenges: Organize short-term hackathons where municipal data (e.g. traffic flow, building permits, satellite imagery) are provided and teams must create an AI-driven solution (like "which neighborhoods should get priority for solar installations?").

Community Science Projects: Incorporate citizen-collected data (e.g. air quality sensors) and show how AI can calibrate or extend these measurements.

Workshops can be offered by city governments, regional development agencies, or in partnership with universities. Use Turkish examples and language at every step (Turkish datasets, localized UIs, Turkish commenting in code samples).

Collaboration with Universities

Partnering with Turkish universities brings technical depth and sustainability to capacity building. Consider collaborations such as:

Joint Workshops/Courses: Invite faculty and lab staff to co-teach. For example, ITU's *Sürdürülebilir Enerji ve İklim Sistemleri* Lab (İklim Bilimi ve Meteoroloji Mühendisliği)[143] can provide expertise on climate datasets and modeling; METU's Environmental Engineering group has an Air Pollution Laboratory and Solar Energy Lab[144]; Boğaziçi'*s iklimBU* center specializes in regional climate modeling[145]. These experts can give guest lectures or develop case studies. Boğaziçi's AI Research Lab also spans robotics, NLP and machine learning[146], and could advise on intelligent system design.

Internships and Student Projects: Arrange for students (undergrad or grad) from relevant departments (e.g. METU City Planning, ITU Meteorology, Boğaziçi Environmental Engineering or Computer Engineering) to work on municipal AI projects. This gives students real problems and gives cities access to talent.

379238691_Examination_of_the_Effects_of_Climate_Change_on_Turkiye_through_the_Google_Earth_Engine_Platform
[142] Open Atlas Turkey — QGIS Python Plugins Repository https://plugins.qgis.org/plugins/OpenAtlasTurkey/
[143] İTÜLABS - SÜRDÜRÜLEBİLİR ENERJİ VE İKLİM SİSTEMLERİ https://itulabs.itu.edu.tr/Laboratuvar/Detay/059fe9c8-db68-491d-b518-d2255020fd06
[144] List of Laboratories | METU - Middle East Technical University https://www.metu.edu.tr/list-laboratories
[145] İklimBU | Hakkımızda https://climatechange.bogazici.edu.tr/hakkimizda/
[146] BOĞAZİÇİ ÜNİVERSİTESİ | Türkiye Yapay Zeka İnisiyatifi https://turkiye.ai/project/bogazici-universitesi-2/

Research Partnerships: Collaborate with university labs for advanced R&D. For example, partner with METU's Pattern Recognition and AI Lab[147] or ITU's AI and Data Science Center[148] to customize ML algorithms for local climate planning. Formalize this via MOUs or joint grants (for instance, under EU or TÜBİTAK programs).

Capacity-Building Networks: Engage networks like ICLEI Turkey or the Türkiye Yapay Zeka İnisiyatifi. ICLEI notes that strong city–stakeholder partnerships are critical: working with local experts ensures AI solutions are scalable and adapted to local context[149]. Joint programs (e.g. "city–university climate data labs") can institutionalize ongoing learning.

By leveraging universities' specialized labs and faculties, municipalities can access domain-specific knowledge. Co-mentorship (city staff paired with a professor) and co-development of training materials ensure relevance and sustainability.

Simplifying Tools & Localization

Complex tools should be made user-friendly and linguistically accessible:

Turkish Interfaces and Documentation: Use tools with Turkish support. For example, QGIS offers a Turkish UI (most recent versions include full Turkish translation). Provide step-by-step guides in Turkish for tools like Google Earth Engine, Python libraries, and climate APIs. (Turkish Udemy courses already cover Earth Engine basics[150].) Likewise, translate any custom dashboards or scripts into Turkish, including comments and labels.

Curated Data Plugins: Use plugins that bundle relevant data. The *OpenAtlasTurkey* QGIS plugin, for instance, gives easy access to public Turkish geospatial datasets (administrative boundaries, land use, etc.)[151]. Custom versions of such plugins could include SECAP-specific layers (city boundary, building footprints, pollution sources).

Low-Code Custom Apps: Where possible, build simplified web or desktop apps in Turkish for common tasks. For example, a web app that lets staff upload a CSV of emissions data and automatically runs an ML forecast (with all instructions in Turkish). Using Earth Engine's Apps or Google's Colab (with shared Turkish notebooks) can hide complexity from end-users.

Local Technical Support: Establish "AI tool kits" in Turkish. This could mean packaging open-source tools (QGIS, Anaconda Python with Turkish tutorials, etc.) into a ready-to-use VM or Docker image. Include example projects with Turkish commentary. Facilitators should emphasize why and how each tool is used, avoiding jargon. For example, ensure trainees know why a random forest model is chosen, not just how to click buttons.

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[147] List of Laboratories | METU - Middle East Technical University https://www.metu.edu.tr/list-laboratories
[148] İTÜLABS - Laboratuvarlar https://itulabs.itu.edu.tr/Home/Search?aramaTuru=Laboratuvarlar¤tPage=1&pageSize=10&ShowLastAdded=False
[149] Harnessing opportunities and reducing risks: Using artificial intelligence for local climate action – CityTalk https://talkofthecities.iclei.org/harnessing-opportunities-and-reducing-risks-using-artificial-intelligence-for-local-climate-action/
[150] Google Earth Engine ile Arazi Örtüsü Sınıflandırma | Udemy https://www.udemy.com/course/google-earth-engine-ile-arazi-ortusu-snflandrma/?srsltid=AfmBOopvVXnzqXrzQcL0SXyliFyM3CbFGzJxwAzdZzBsWgMn9OSRQx3C
[151] Open Atlas Turkey — QGIS Python Plugins Repository https://plugins.qgis.org/plugins/OpenAtlasTurkey/

Continuous Translation Effort: As tools evolve, keep Turkish guides updated. Encourage bilingual staff or students to translate updates of key documentation. Government agencies could commission Turkish manuals or record video tutorials (as UNDP and MoEUCC have done with their Climate Portal) to accompany technical training.

Digital Learning Platforms

A variety of online platforms can supplement workshops:

Online Course Portals: Global platforms like **Udemy** and **Coursera** have many relevant courses. For instance, Udemy offers Turkish-language courses on AI, data science, and Earth Engine[152]. Coursera and edX offer courses (often with Turkish subtitles) on machine learning, data analysis and climate science from universities worldwide. Staff can take "Machine Learning" by Stanford or "AI for Everyone" by Andrew Ng (with translated captions). These serve as self-paced precursors or refreshers.

Specialized Learning Sites: DataCamp and Kaggle provide interactive Python/ML tutorials (though mostly in English). Local government can encourage teams to practice on Kaggle's climate-related datasets and competitions. **The Green Learning Network (GGKP)** and Climatechange.ai have webinars and resources on AI for sustainability.

Public Sector e-Learning: Leverage any government/agency portals. For example, the new Turkish **Climate Portal**[153] includes educational content on climate science. Ministries or unions may have internal training platforms (e.g. e-governance academies) where tailored AI modules can be uploaded. Likewise, municipal training academies (some large cities run their own learning platforms) could host SECAP/AI courses.

Academic & Nonprofit Resources: The İstanbul Technical University or METU may offer open courseware. International NGOs (ICLEI, UNDP, or TÜBİTAK's collaborations) often publish free training materials and case studies on climate planning and data analytics. Turkish branches of ICLEI or UNDP could adapt global AI-climate modules into Turkish-language seminars.

Technology Community Groups: Encourage staff to join local meetups or online forums (e.g. Turkish Data Science or AI groups). These often share recorded sessions and can recommend Turkish blog tutorials. Local hackathon events (like "AI for Cities" challenges) also provide hands-on learning.

Sample Workshop Agendas

Beginner Workshop (2 days):

Day 1 Morning: Introduction to AI & SECAP concepts. Define AI, machine learning, and key climate planning terms. Show simple examples (e.g., smartphone voice assistant, AI-driven traffic lights).

[152] Google Earth Engine ile Uzaktan Algılama Uygulamaları | Udemy https://www.udemy.com/course/gee-uzaktanalgilama/? srsltid=AfmBOoqXEMrkyh0bvSji7dG2J8bG0fY3F6sk1SbEJyCv1dd0DhziDgS4
[153] Türkiye's first Climate Portal launched to accelerate climate action | United Nations Development Programme

Day 1 Afternoon: Data Tools 101. Hands-on with spreadsheets and QGIS (Turkish UI): import a sample GHG inventory, create basic charts, and map it. Brief demo of Google Earth Engine via a pre-built script (e.g. "map Turkey's average temperature").

Day 2 Morning: Applied Exercise. Small teams pick a theme (energy, mobility, land use). Each team analyzes a provided Turkish dataset (e.g. city electricity use or land cover) and uses a simple AI tool (like an AutoML classification in QGIS) or Excel forecasting to draw conclusions.

Day 2 Afternoon: *Presentations & Wrap-up.* Teams present findings. Trainers show how the same tasks could be done with more advanced AI or tools. Conclude with resources for self-study (Udemy links, open data sites).

Intermediate Workshop (3–5 days):

Day 1: Data & Programming Basics. Python for data analysis (in Turkish). Participants load city climate and socio-economic data, perform summary stats and plots.

Day 2: Spatial Analysis. QGIS advanced: use the OpenAtlasTurkey plugin to overlay flood zones, heat maps, or infrastructure. Earth Engine intro: run a Python notebook that computes NDVI change for a Turkish region[154].

Day 3: Machine Learning Workshop. Teach a simple regression (e.g. predicting energy demand) and a classification (e.g. classify urban vs. rural areas by land cover) using scikit-learn. Emphasize interpreting results.

Day 4: Climate Scenario & Decision-Making. Introduce regional climate data (e.g., outputs from CORDEX Turkey via iklimBU[155]). Show how to combine an AI model with scenario data (e.g., adjust energy demand forecast under a warmer climate).

Day 5: Capstone Team Project. Teams work on a mini-project of their choice (from a list of case studies) and present to the group. Trainers and university partners provide feedback.

Advanced Seminar (1 week):

Focus: This could be organized in collaboration with a university. Topics include deep learning for Earth Observation, optimization algorithms, and integration of AI in SECAP policy-making. Include guest lectures (e.g., from METU or Boğaziçi researchers) and time for participants to develop an AI-driven analysis using their own city's data.

Outcome: Each participant (or team) produces a technical brief or prototype tool (e.g. an AI model for predicting local flood risk) and receives a certificate of completion.

By providing a clear progression of training content, hands-on practice with real Turkish data, and strong partnerships with local universities and online learning platforms, municipalities can incrementally build the AI capacity needed for modern SECAP planning. These scalable suggestions

[154] Examination of the Effects of Climate Change on Türkiye through the Google Earth Engine Platform | Request PDF https://www.researchgate.net/publication/379238691_Examination_of_the_Effects_of_Climate_Change_on_Turkiye_through_the_Google_Earth_Engine_Platform

[155] iklimBU | Hakkımızda https://climatechange.bogazici.edu.tr/hakkimizda/

ensure that from the most novice planner to the skilled data scientist on the team, everyone gains relevant skills and practical experience.

Sources: Guidelines for modular climate training[156]; use of Google Earth Engine for Turkey[157]; METU and ITU lab capabilities[158]; Boğaziçi climate/AI centers[159]; Turkish GIS plugins[160]; and existing Turkish-language courses[161]. These inform our curriculum design and collaboration recommendations.

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[156] Climate Compliance Capacity Building Programme - ICLEI https://iclei.org/activity/climate-compliance-capacity-building-programme/

[157] https://www.researchgate.net/publication/379238691_Examination_of_the_Effects_of_Climate_Change_on_Turkiye_through_the_Google_Earth_Engine_Platform

[158] İTÜLABS - SÜRDÜRÜLEBİLİR ENERJİ VE İKLİM SİSTEMLERİ https://itulabs.itu.edu.tr/Laboratuvar/Detay/059fe9c8-db68-491d-b518-d2255020fd06

[159] BOĞAZİÇİ ÜNİVERSİTESİ | Türkiye Yapay Zeka İnisiyatifi https://turkiye.ai/project/bogazici-universitesi-2/

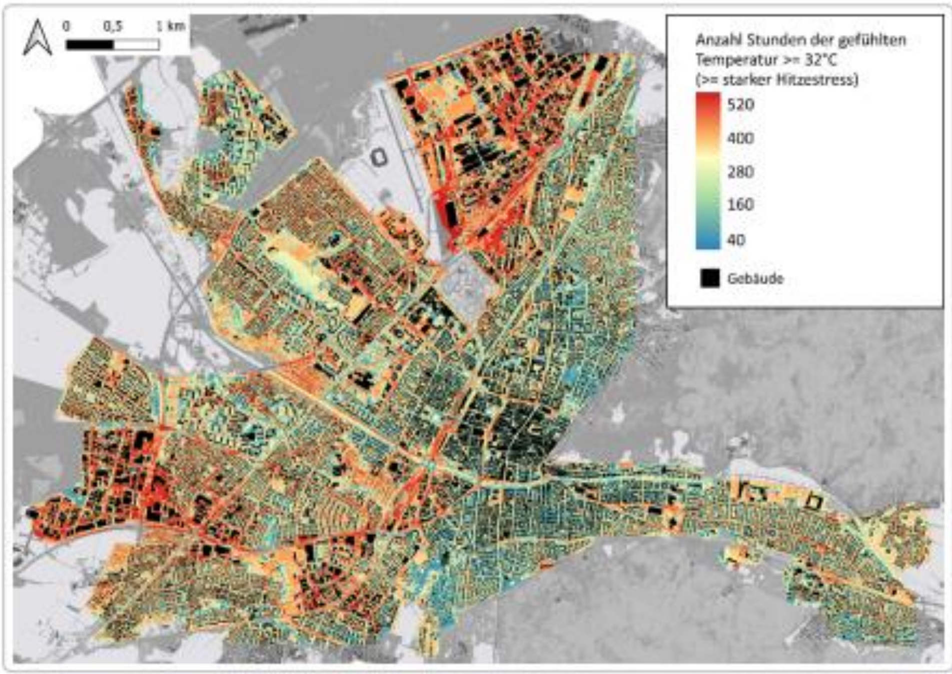
[160] Open Atlas Turkey — QGIS Python Plugins Repository https://plugins.qgis.org/plugins/OpenAtlasTurkey/

[161] Google Earth Engine ile Arazi Örtüsü Sınıflandırma | Udemy https://www.udemy.com/course/google-earth-engine-ile-arazi-ortusu-snflandrma/?srsltid=AfmBOopvVXnzqXrzQcL0SXyliFyM3CbFGzJxwAzdZzBsWgMn9OSRQx3C

PART 7

CONCLUSION & NEXT STEPS

Türkiye's municipalities are now at a strategic crossroads: with strong national climate targets (peak emissions by 2038 and net-zero by 2053[162]) and a vigorous digital transformation agenda, local leaders can combine these goals by adopting AI-driven climate planning. By acting decisively, cities will help realize the national vision of green and digital transition, and become models of sustainable innovation. International partners have already noted that Türkiye's climate and digital agendas are intertwined – the new Turkish green investment facility explicitly aims to support "climate mitigation and adaptation goals in line with the Paris Agreement" and advance the country's digital transformation[163]. With clear political backing **and** guidance from national policymakers, every municipality can now integrate AI tools to make its SECAP more timely, cost-effective, and transparent.



AI can dramatically accelerate local climate planning. Advanced models now produce detailed urban risk maps and test adaptation measures in minutes[164], replacing months of manual analysis. For example, an AI-driven project created a fine-scale thermal-stress map of a city and even identified the best locations to plant trees for maximum cooling. Simulating many scenarios quickly reduces

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[162] Microsoft Word - LTS 11-11-2024-unfcccye gönderilecek.docx
https://unfccc.int/sites/default/files/resource/Turkiye_Long_Term_Climate_Strategy.pdf
[163] Türkiye: TSKB Sustainable Energy and Infrastructure Facility, Phase 3
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[164] How Cities Can Adapt to Climate Change with Artificial Intelligence — Archive of the Office of University and Science Communications (until 08/2024) https://kommunikation.uni-freiburg.de/pm-en/press-releases-2024/how-cities-can-adapt-to-climate-change-with-artificialintelligence

uncertainty and cost – planners can evaluate "what-if" choices (like adding green roofs or bike lanes) on the fly. Importantly, AI also boosts measurability and participation: by turning data into clear visualizations, it makes impacts tangible and engages the public. Research shows that using AI to generate future-scenario graphics significantly increases citizen engagement and understanding, fostering "active and inclusive participation" in climate planning[165]. In short, AI tools help local teams work smarter and inclusively, delivering data-driven adaptation plans with measurable targets and community buy-in.

To make this vision concrete, the following actions are recommended:

Develop AI and Data Capacity: Launch targeted training programs and learning networks so municipal climate teams can use AI and analytics effectively. Build on national initiatives (Digital Turkey, TÜBİTAK, EU AI hubs) to upskill planners and analysts.

Forge University Partnerships: Create sustained collaborations between cities and Turkish universities (e.g. ITU, METU, Boğaziçi) for applied research, data sharing, and internships. Joint lab projects or academic fellowships can inject cutting-edge AI expertise into local governments.

Mobilize Funding: Devise national and EU-backed financing strategies (Green Deal, Horizon Europe, IPARD, etc.) to subsidize AI-powered adaptation projects. Incentivize grants and competitions for cities that pilot digital climate solutions, ensuring resources for technology and staff.

Pilot Regionally: Implement AI-driven pilot programs in select provinces or regions (e.g. Marmara, Mediterranean) to test tools in varied contexts. Regional pilots demonstrate time/cost savings, refine methods, and create replicable models before national rollout.

Open Climate Data Portal: Expand Turkey's Climate Portal into an open-access platform publishing granular hazard, emissions and adaptation data[166]. As OECD experts note, having "robust, granular and regularly updated climate hazard, exposure and vulnerability information" is key to setting targets and tracking progress[167]. An open portal will empower cities, researchers and citizens to measure outcomes and collaborate on solutions.

[165] Climate Change Scenario Planning with Artificial Intelligence https://sdg-innovation-commons.org/pads/experiment/574
[166] https://unfccc.int/sites/default/files/resource/Turkiye_Long_Term_Climate_Strategy.pdf
[167] Measuring Progress in Adapting to a Changing Climate | OECD https://www.oecd.org/en/publications/measuring-progress-in-adapting-to-a-changing-climate_8cfe45af-en.html

The image above exemplifies the kind of green, digitally-enabled city we can create together. Municipal leaders are encouraged to champion AI as an ally in sustainable development – aligning local initiatives with Türkiye's 2053 goals and digital transformation. National institutions should support this shift with clear policies: funding frameworks, data standards, and technical assistance. As one analysis observes, investments in "advanced technologies, such as artificial intelligence (AI)… strengthen climate resilience by optimizing resource management and improving demand forecasting"[168]. By taking these steps now, Türkiye's cities will slash planning time and cost, reduce uncertainty with better data, and deepen public participation – accelerating measurable climate progress. The time to act is now, and every municipality has a role in turning AI-powered adaptation from promise into practice.

Sources: This guide builds on Turkey's national climate strategies[169] and digital agendas[170], as well as international best practices in AI for urban resilience[171]. All cited materials are used to support these recommendations and are documented above.

[168] Türkiye: TSKB Sustainable Energy and Infrastructure Facility, Phase 3 https://www.aiib.org/en/projects/details/2025/approved/Turkiye-tskb-sustainable-energy-and-infrastructure-facilityphase.html

[169] https://unfccc.int/sites/default/files/resource/Turkiye_Long_Term_Climate_Strategy.pdf

[170] Türkiye: TSKB Sustainable Energy and Infrastructure Facility, Phase 3 https://www.aiib.org/en/projects/details/2025/approved/Turkiye-tskb-sustainable-energy-and-infrastructure-facility-phase.html

[171] How Cities Can Adapt to Climate Change with Artificial Intelligence — Archive of the Office of University and Science Communications (until 08/2024) https://kommunikation.uni-freiburg.de/pm-en/press-releases-2024/how-cities-can-adapt-to-climate-change-with-artificialintelligence

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