Grabocka, Asano Frey	**Machine Learning WT 25/26** Final Assignment	**UTN** 09.02.2026

Mapping Urban Change in Nuremberg with Machine Learning

Context

Cities change continuously through densification, greening, sprawl, and infrastructure expansion. Satellite imagery makes these changes observable, but turning raw geospatial data into **reliable, interpretable, and responsible insights** is a challenging machine learning problem.

In this assignment, you will build a **model-based system** that analyzes how land cover in the city of **Nuremberg** has changed over time. You will work with satellite imagery and **predefined land-cover labels** to train predictive models that quantify urban change and communicate it to a non-expert audience.

The final outcome must be a **working, interactive product** that visualizes predicted land-cover and land-cover change, together with uncertainty and limitations.

You are explicitly allowed and expected to use ChatGPT. However, **critical judgment and independent reasoning** are essential for full credit.

Learning Objectives

By completing this assignment, you will demonstrate your ability to:

- Frame an ill-defined real-world ML problem
- Engineer tabular representations from geospatial data
- Train and evaluate predictive models under noisy supervision
- Quantify and interpret change over time

- Evaluate models beyond standard accuracy
- Communicate uncertainty and limitations to non-experts
- Critically assess and challenge AI-generated suggestions
- Deliver a polished, usable ML product

Core Task (Mandatory)

Your task is to build a machine learning system that:

> **Predicts land-cover composition and land-cover change in Nuremberg using tabular features derived from satellite imagery.**

What “land cover” means in this assignment

You must use **ESA WorldCover** land-cover maps as the **primary source of labels**.

- ESA WorldCover provides yearly, Europe-wide land-cover classifications at 10 m resolution.
- If ESA WorldCover is unavailable for a chosen year, **CORINE Land Cover** may be used as a fallback (with justification).

You may not invent your own land-cover labels.

You may focus on, for example:

- Urban expansion or densification
- Green space loss or gain
- Industrial vs residential development
- Infrastructure growth
- Mixed-use land-cover transitions

Required Labels

For each spatial unit (e.g. grid cell) and time step, you will use:

1. Land-cover composition labels

Proportions of land-cover classes such as:

- Built-up
- Vegetation (tree, grass, crops)
- Water
- Other (as applicable)

2. Land-cover change labels

Defined as the **difference in land-cover composition between two time steps**, for example:

- Δ built-up proportion
- Δ vegetation proportion

Optionally, you may derive a **binary change / no-change label** from these deltas using a justified threshold.

Data Requirements

Mandatory Data

You must use all of the following:

1. **Satellite imagery** covering Nuremberg for at least **two time periods**
   Recommended sources:
   - Sentinel-2 (ESA)
   - Landsat
2. **ESA WorldCover land-cover maps** for corresponding years
   - Used as ground-truth labels
   - Must be cited and spatially aligned

Optional (Bonus)

You may additionally use:

- OpenStreetMap-derived features (e.g. building or road density)
- Population or housing statistics (if spatially alignable)
- Environmental indicators

All data must be:

- Publicly available
- Properly cited
- Spatially aligned (or misalignment explicitly discussed)

Modeling Constraints (Important)

This course does **not** require convolutional neural networks.

- **End-to-end neural network models (e.g. CNNs/Transformers) are not allowed**
- All models must operate on **tabular or fixed-length feature vectors**
- Features must be **engineered or aggregated** from imagery and auxiliary data

Allowed model types include:

- Linear or logistic regression
- Random forests / gradient boosting
- Multilayer perceptrons (MLPs)
- Simple temporal models over tabular data

Required Components

1. Problem Framing & Scope

You must clearly define:

- Which land-cover classes you focus on and why
- Your spatial unit (grid cells, hexagons, districts, etc.)
- Your temporal setup (which years, which prediction task)
- The intended user of your system
- Which decisions **must not** be made based on your results

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2. Data Exploration & Reality Check

You must perform exploratory analysis on:

- Engineered features
- ESA WorldCover labels

- Derived change labels

Identify at least **three non-trivial data issues**, such as:

- Seasonal effects
- Cloud cover and missing data
- Label noise in land-cover maps
- Spatial resolution mismatch
- Spatial autocorrelation

Explicitly choose **one issue you do not fix**, and justify why.

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3. Modeling & Change Prediction

You must implement **at least two different models**, for example:

- An interpretable model (required)
- A more flexible nonlinear model

Each model must predict **either**:

- Land-cover composition at a later time step, **or**
- Land-cover change between two time steps

You must justify:

- Feature choices
- Model choices
- Spatial and temporal resolution

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4. Evaluation Beyond Accuracy

Your evaluation must include:

- A spatial or temporal hold-out strategy
- At least one change-specific metric (e.g. false change rate, stability)
- At least one stress test (e.g. feature noise, missing data)

- A discussion of where and why the model is likely wrong

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5. Explainability & Trust

Your system must explain to a non-expert:

- What changed
- Where it changed
- How confident the system is

You must show:

- One explanation that is helpful
- One explanation that could be misleading, and why

Mandatory ChatGPT Reflection

You must include **two labeled sections**:

- *Arguing Against ChatGPT – Case 1*
- *Arguing Against ChatGPT – Case 2*

Each must document a case where you **disagreed with ChatGPT** on a modeling, evaluation, or interpretation decision and explain why.

Final Product (Mandatory)

You must deliver a **working interactive system**, such as:

- Streamlit or Gradio app
- Interactive notebook behaving like a product
- Lightweight geospatial dashboard

Minimum features:

- Map of Nuremberg
- Time selection
- Predicted land-cover and change visualization
- Uncertainty and limitation explanations

Deliverables

- Technical report (max 10 pages)
- Code repository (reproducible, documented)
- Running product + 5-minute demo video
- ChatGPT usage log (prompts, disagreements, one misleading example)

Important Notes

- This is **not** a computer vision benchmark.
- Purely descriptive analysis will not pass.
- Thoughtful modeling choices and limitations matter more than model complexity.
- ChatGPT is a tool, not an authority.