MITICA

MITIGATION-INVENTORY TOOL FOR INTEGRATED CLIMATE ACTION

MITICA Regional Workshops

United Nations
Framework Convention on
Climate Change

GAUSS International Consulting

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SANDER AKKERMANS

AGENDA

MITIGATION-INVENTORY TOOL FOR INTEGRATED CLIMATE ACTION

1. Introduction
2. Concepts and background
3. Tools and methodologies for developing mitigation scenarios

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Introduction to the workshop

Workshop objective and scope

Two-day workshop to train on the fundamentals of mitigation scenarios and to introduce the Mitigation-Inventory Tool for Integrated Climate Action (MITICA).

Day 1:

- Background, reporting requirements, fundamentals, and introduction to MITICA.

Day 2:

- Practical training for building mitigation scenarios using MITICA.

Introduction to the workshop

Agenda for today

Time (CET)	Topic
9:00 – 9:40	**Concepts and background** of the transparency for climate change mitigation, including: - Main definitions and concepts used internationally related to mitigation scenarios; - Paris Agreement reporting requirements, analysing synergies and links between components; - Discussion of the main challenges for developing mitigation scenarios in the context of designing and tracking of NDCs and ETF reporting; and - Setting the context of MITICA and its added value for NDC designing and tracking, as well as ETF reporting.
9:40 – 10:00	**Analysis of the tools and methodologies available** for developing mitigation scenarios for policy planning, GHG scenarios and NDC tracking. Comparative assessment of modelling approaches and alternatives.
10:00 – 10:10	**Questions and Answers.**
10:10 – 10:50	**Methodological approach and characteristics of MITICA** for developing GHG scenarios. Discussion on data needs and outcomes; showing relevant examples.
10:50 – 11:00	**Questions and Answers.**

Introduction to the workshop

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2 Concepts and background

1. Definitions
2. Paris Agreement reporting requirements
3. Challenges for developing mitigation scenarios

1 Definitions

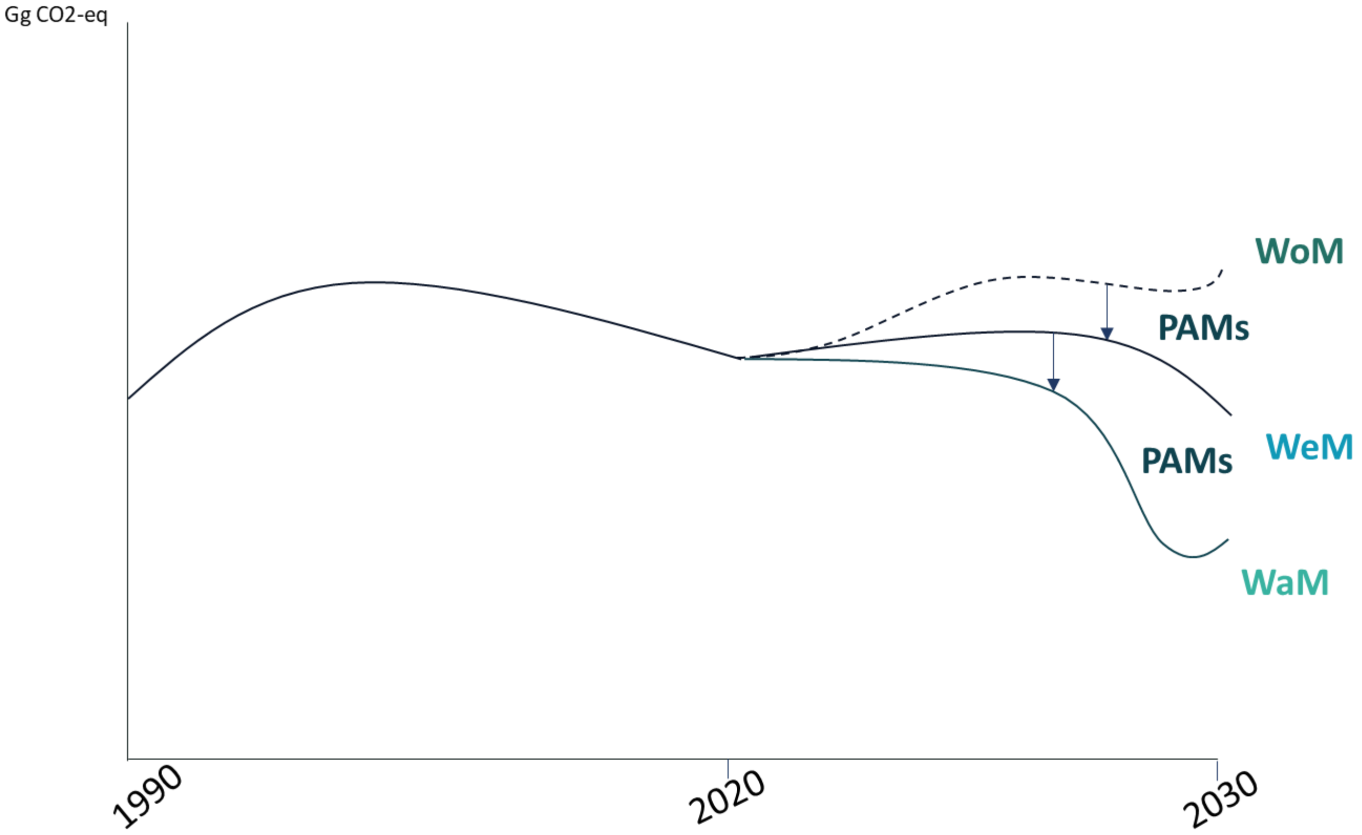
Mitigation (of climate change): A human intervention to reduce emissions or enhance sinks of GHGs.

Mitigation target: Specific objective(s) to reduce emissions or enhance sinks of GHGs for particular emission source(s), sink(s) or sector(s), for one or several gases over a set geographical scope and a reference period. When these targets encompass all sectors of the economy, they are named as economy-wide targets.

Mitigation Policies and Measures (PAMs): All types of actions, measures, and policies that reduce emissions or enhance sinks of GHGs.

1 Definitions

Policy scenarios or mitigation scenarios: Different scenarios encompassing different set of PAMs:



- **Without Measures Scenario (WoM):** Excludes all policies and measures implemented, adopted and planned after the year chosen as the starting points for the projection.
- **With Measures Scenario (WeM):** Encompasses currently implemented and adopted policies and measures.
- **With Additional Measures Scenario (WaM):** Encompasses adopted and planned policies and measures to be implemented.

1 Definitions

Forecasting

Aim to predict or anticipate future conditions.

Projection

An in-depth estimate of the potential future evolution of values, often computed with drivers and models, with the objective to assess scenarios rather than predict future conditions.

≈ **Optimisation:** The process of identifying the optimum value for a predefined objective, typically aiming for minimal cost while maximizing value.

1 Definitions

Climate projection (IPCC)

The simulated response of the climate system to a scenario of future concentrations of GHGs and aerosols, generally derived using climate models.

Emissions projection (ETF)

Indicative of the impact of mitigation policies and measures in future trends in GHG emissions and removals.

1 Definitions

Model: A structured representation of a system, designed to abstract and simulate the essential features, relationships, and dynamics of the real-world system, expressed through mathematical equations, computational algorithms, conceptual frameworks, or a combination thereof. Models can be used to project future values of any variable, including GHG emissions and other indicators (energy demand, energy supply, forest growth, etc.).

Proxy/driver: A variable that is believed to be correlated with the variable of interest (i.e. GHG emissions). Changes in the proxy variable are expected to reflect changes in the variable of interest, implying causality.

Causality: The theoretical relationship between variables and the direction of influence between them. Spurious relationships refer to cases where there is correlation but not causality.

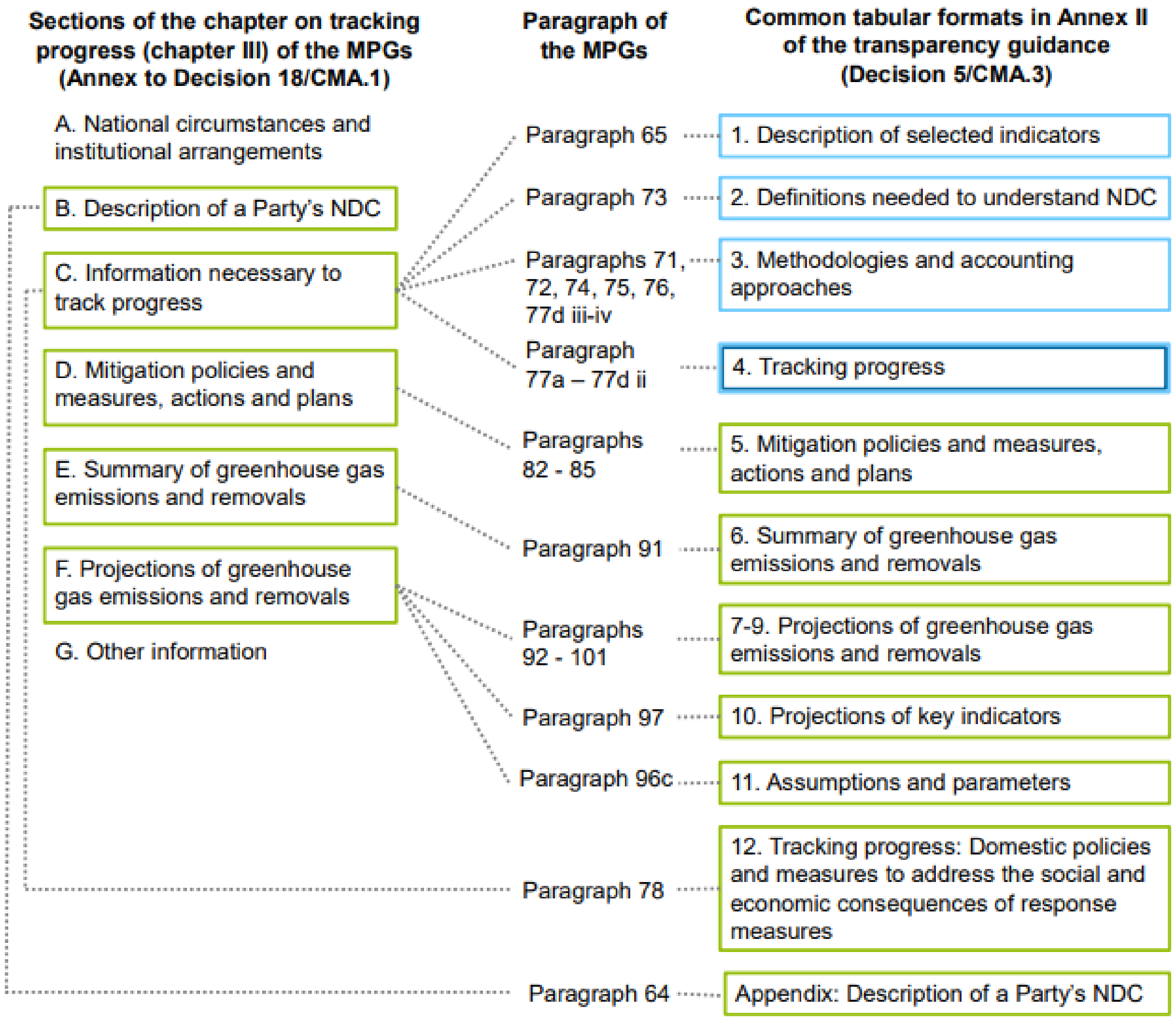
Sources: IPCC glossary, MPGs and Brittanica.

2 Paris Agreement reporting requirements

GHG emissions / removals	• Each Party **shall** provide a national inventory report of anthropogenic emissions by sources and removals by sinks of GHGs.	Chapter II of the MPGs
NDC progress tracking	• Each Party **shall** provide the information necessary to track progress in implementing and achieving its NDC under Article 4 of the Paris Agreement.	Chapter III of the MPGs
Climate change impacts and adaptation	• Each Party **should** provide information on climate change impacts and adaptation under Article 7 of the Paris Agreement.	Chapter IV of the MPGs
Support provided	• **Developed country Parties shall** provide information pursuant to Article 13 paragraph 9 of the Paris Agreement. Other Parties that provide support should provide such information.	Chapter V of the MPGs
Support needed and received	• **Developing country parties should** provide information on financial, technology transfer and capacity-building support needed and received under Article 9, 10, and 11 of the Paris Agreement.	Chapter VI of the MPGs

2 Paris Agreement reporting requirements

NDC progress tracking



2 Paris Agreement reporting requirements

Signatories of the Paris Agreement are required to periodically submit a set of **interconnected elements** related to their greenhouse gas (GHG) emissions, including:

GHG emissions inventory

Article 13 of the PA, and paras. 17-58 of the MPGs

A **GHG emissions inventory** estimated following IPCC Guidelines

NDCs

Article 4 of the PA and Decision 1/CP.21 and Decision 4/CMA.1

Successive **Nationally Determined Contributions** increasing ambition

Projections

Article 13 of the PA, paragraphs 92 - 102 of the MPGs

Projections presented relative to actual inventory data

Policies and measures – PAMs

Article 13 of the PA, paragraph 75 of the MPGs

Information on the methodologies used to track progress arising from the implementation of **PAMs**

Information to track progress of NDCs

Article 13 of the PA, paragraph 76 of the MPGs

Information to track progress of NDCs explaining **the methodological inconsistencies** with the Party's most recent national inventory

2 Paris Agreement reporting requirements

Role of modelling and projections in the Paris Agreement

(1)

Target-setting for increased ambition in subsequent NDCs and informed **decision-making** for breaking down, prioritizing and mainstreaming long-, medium- and short-term goals.

(2)

Tracking progress against targets (% reduction compared to base year values and reduction compared to the BAU scenario) and **identification of additional PAMs** needed to reach target over time.

(3)

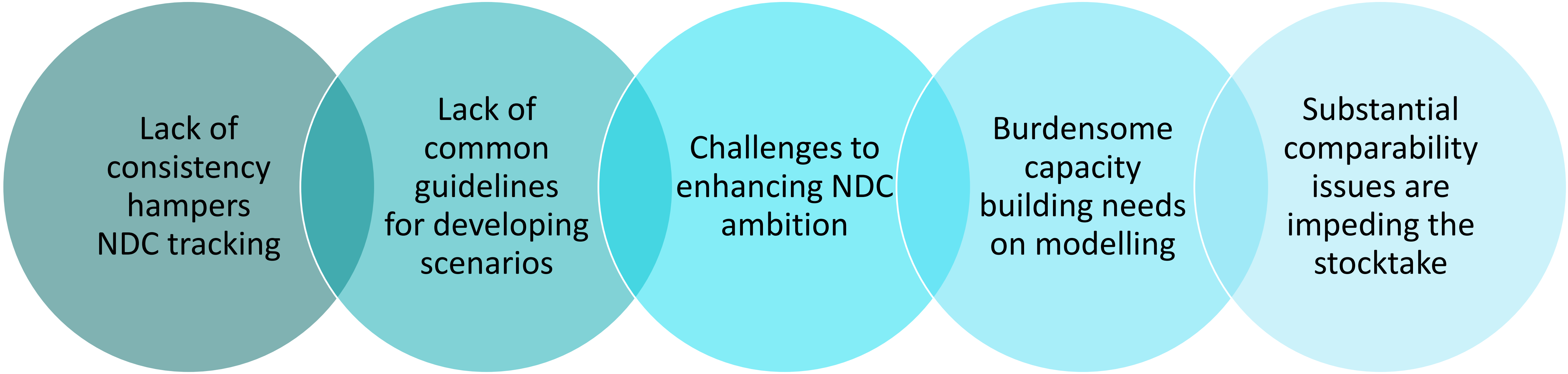
Increased **transparency** in compliance with the biennial transparency report (BTR) reporting provisions under the enhanced transparency framework (ETF).

2 Paris Agreement reporting requirements

Modelling influence on transparency			
MPG Para.	Reporting Requirement	Developed Country Parties	Developing Country Parties
85	Estimates of expected and achieved GHG emission reductions for its actions, policies, and measures.	Shall	Encouraged
86	Methodologies and assumptions used to estimate the GHG emission reductions or removals due to each action, policy, and measure.	Shall	Encouraged
89	Information about how actions, policies, and measures are modifying longer-term trends in GHG emissions and removals.	Should	Should
92 – 96, 98 – 102	Projections indicative of the impact of mitigation policies and measures on future trends in GHG emissions and removals.	Shall	Encouraged
97	Projections of key indicators to determine the progress towards NDC.	Shall	Encouraged

3 Challenges for developing mitigation scenarios

Different reports and studies have identified **gaps and challenges for reporting on these interconnected elements.**



Studies such as Rogelj et al., 2017, Monier et al., 2018, OECD, 2018 , Meerow & Woodruff, 2020, UNFCCC, 2020; IIASA, 2020; Weikmans et al., 2021 among many others.

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3 Tools and methodologies for developing mitigation scenarios

1. Model approaches and alternatives
2. Timeseries forecasting techniques
3. What approaches are used by Annex I - developed country Parties?
4. What approaches are used by non-Annex I - developing country Parties?
5. Setting the stage for MITICA

1 Model approaches and alternatives

1	Physical models	VS	Statistical models
2	Projections models	VS	Optimization models
3	Forecasting	VS	Back-casting
4	Integrated assessment models	VS	One-domain models
5	Sectoral models	VS	Integrated models
6	Bottom-up models	VS	Top-down models
7	General equilibrium models	VS	Partial equilibrium models

1 Model approaches and alternatives

1 Physical models vs statistical models

- A mathematical model embodying a set of statistical assumptions based on the probability distribution sample data, representing, often in considerably idealized form, the interrelations between variables.

Statistical models

- Represent the biophysical interactions behind a particular GHG emission or source/sink based on scientific biological, and/or chemical processes.

Physical models

For example…

- YASSO
- Vintage model
- IPCC FOD

1 Model approaches and alternatives

2 Projections models vs optimization models

- Identify the optimum value for a predefined objective, typically aiming for minimal cost while maximizing value.

Optimization models

- Provide an in-depth estimate of the potential future evolution of values, often computed with drivers and models, with the objective to assess scenarios rather than predict future conditions.

Projection models

1 Model approaches and alternatives

2 Projections models vs optimization models

Optimization models

PROs	CONs
• Very useful for micro-economic planning, for instance for designing the nominal capacity needed by a production plant. • Useful to estimate peak loads, grid capacities, and technological choices once the main policy decisions are taken. • Needed for assessing feasibility, cost, and full set of implications by particular-individual policies and actions.	• Not aimed at projecting, but at finding cost-efficient solutions to predefined frameworks - objectives. • Regardless of the optimization, GHG emissions are driven by external drivers and policy decisions not related to the cost of technologies. • Difficulties to isolate, differentiate and aggregate the effect of PAMs when there are several. • Consistency issues with national inventories due to different nomenclatures and principles. • Substantial data needed.

1 Model approaches and alternatives

3 Forecasting vs back-casting

For example…

To "forecast" the impact of current PAMs in the energy sector, one would ask " what would the resulting GHG emissions from the energy sector be in 2050?"

- Prediction of the unknown future values of the dependent variables based on known values of the independent variable.
- Estimating what the end results would be from PAM implementation.

Forecasting

- Prediction of the unknown values of the independent variables that could exist to explain the known values of the dependent variable.
- "Working backwards" from a set target to assess necessary PAMs to achieve it.

Back-casting

For example…

To "back-cast" a future net zero target in the energy sector in 2050, one would ask "what PAMs would need to be implemented between 2024 to 2050 to make this 2050 vision true?"

1 Model approaches and alternatives

4 Integrated assessment models vs one-domain models

- Integrate knowledge from two or more domains into a single framework.
- Simplified representation of complex physical and social systems, focusing on the interaction between economy, social and technological development, and the environment (climate change).

Integrated assessment model

For example…

- Representations of the interactions of multiple sectors of the economy and representations of the climate system.
- Cost–benefit framework assessing the socioeconomic and environmental costs of carbon and the impacts (+/-) of mitigation and inaction.

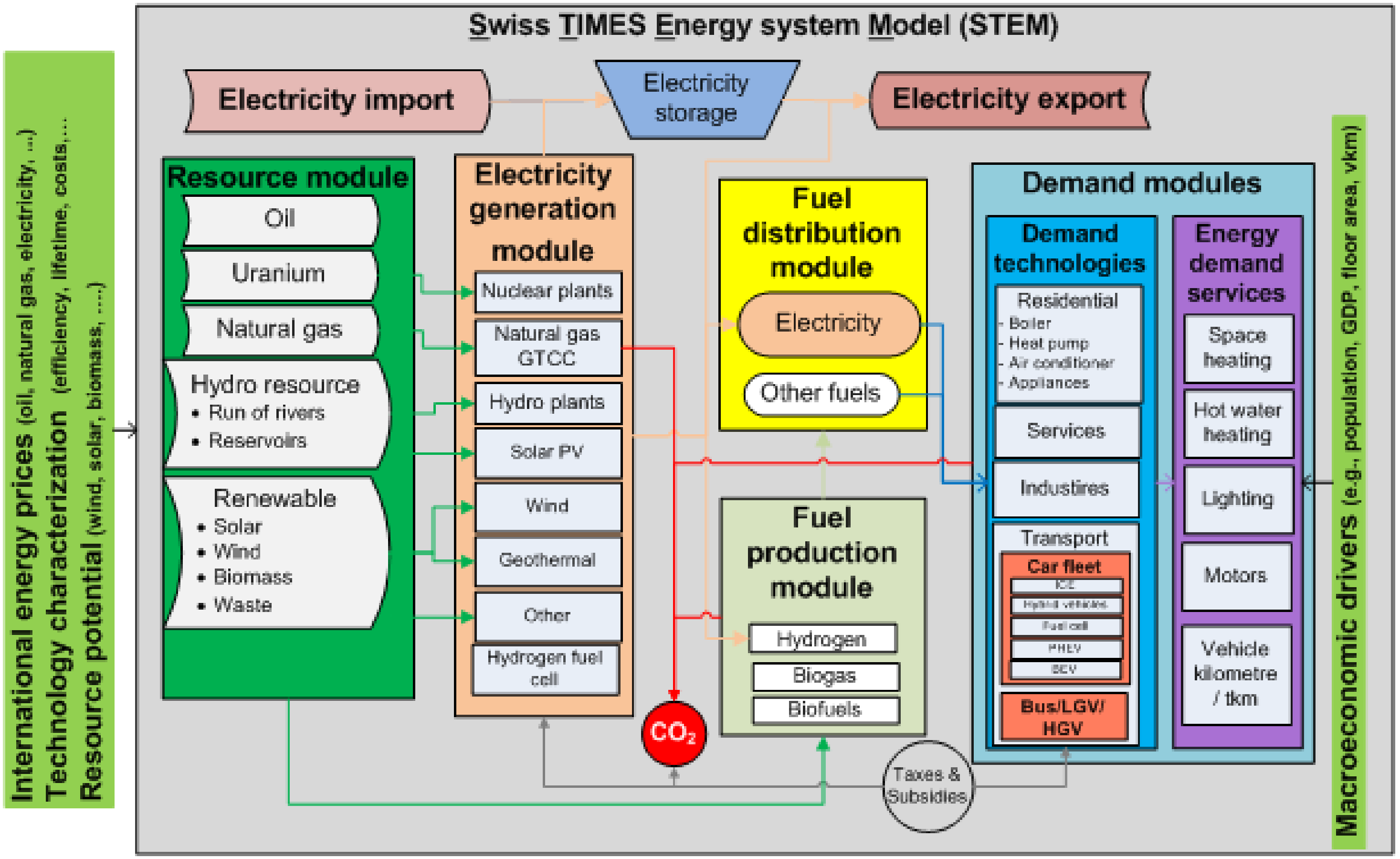
5 Sectoral models vs integrated models

- Focus on a single economic or IPCC sector.

Sectoral model

- Focus on the ensemble of economic or IPCC sectors.

Integrated model



6 Bottom-up models vs top-down models

Bottom-up model

- Provides detailed information on individual emission sources and sinks.

Top-down model

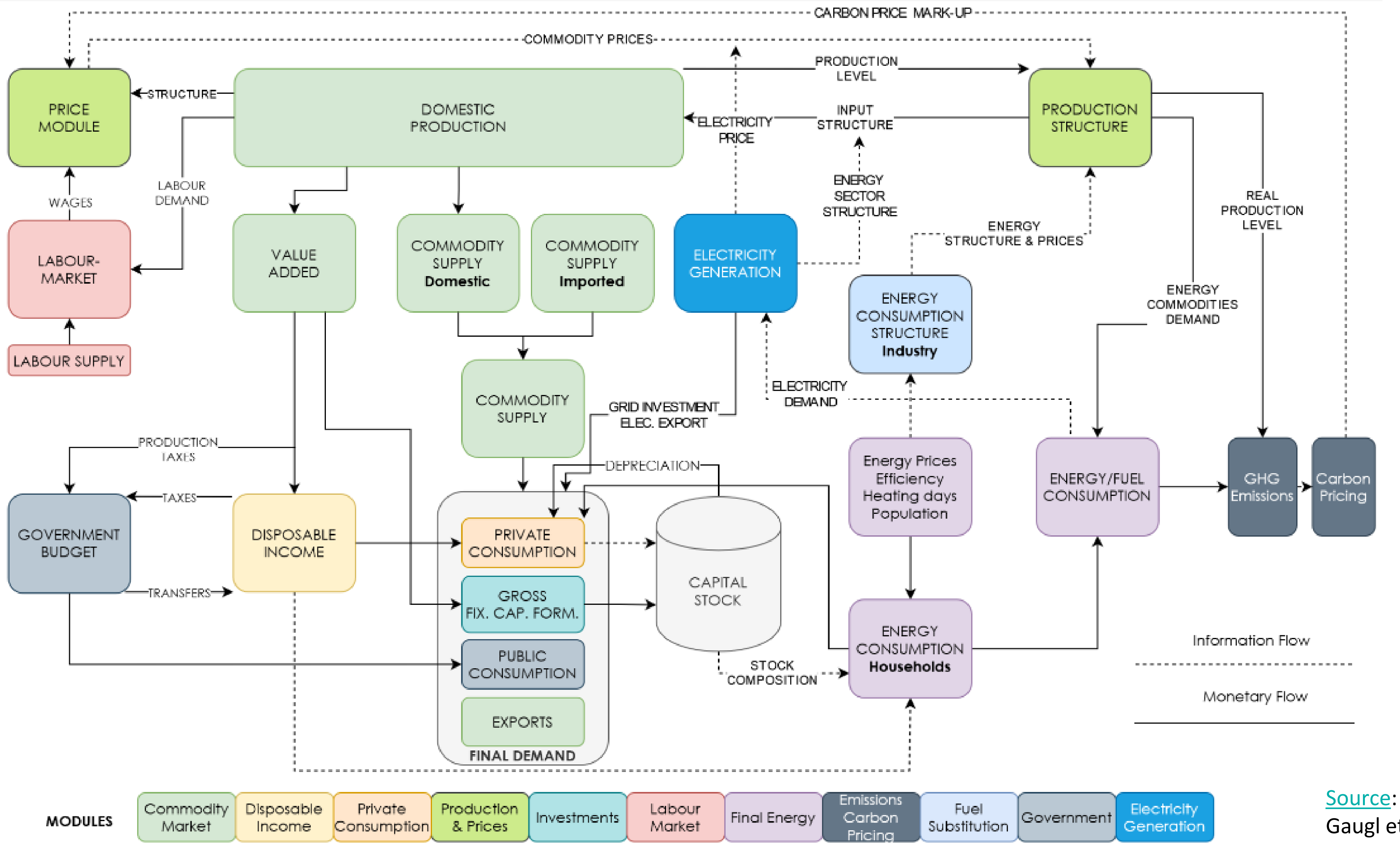
- Focused on projecting the economic structure, and are generally combined with other models, providing overarching emission and removals.

1 Model approaches and alternatives

6 Bottom-up models vs top-down models

Top-down model

For example…



Source: Gaugl et al., 2023

1 Model approaches and alternatives

6 Bottom-up models vs top-down models

Top-down model

PROs

- Provides a more robust approach for projecting proxies, instead of using them as exogenous information.
- Can provide aggregate estimates focusing on the main relationship between GHGs and economic drivers.

CONs

- It is too focused on the exogenous variables forgetting about endogenous parameters and drivers.
- Not specific to emission source/sink.
- Generally, not in line with IPCC methodologies.

1 Model approaches and alternatives

7 General equilibrium models vs partial equilibrium models

General equilibrium model

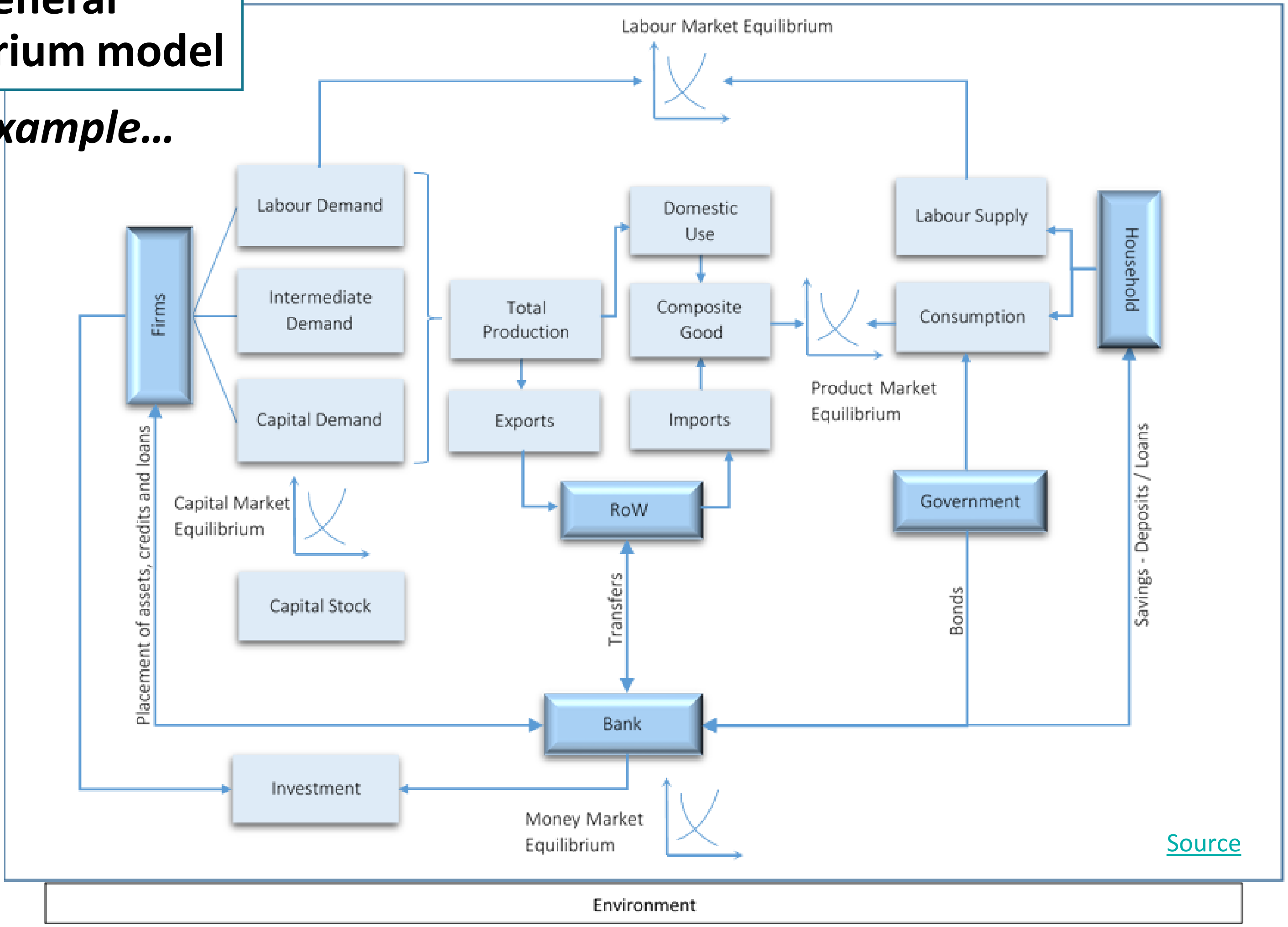
- Analyzes the economy as a whole, rather than single markets in partial equilibrium, showing how supply and demand interact and tend towards a balance.

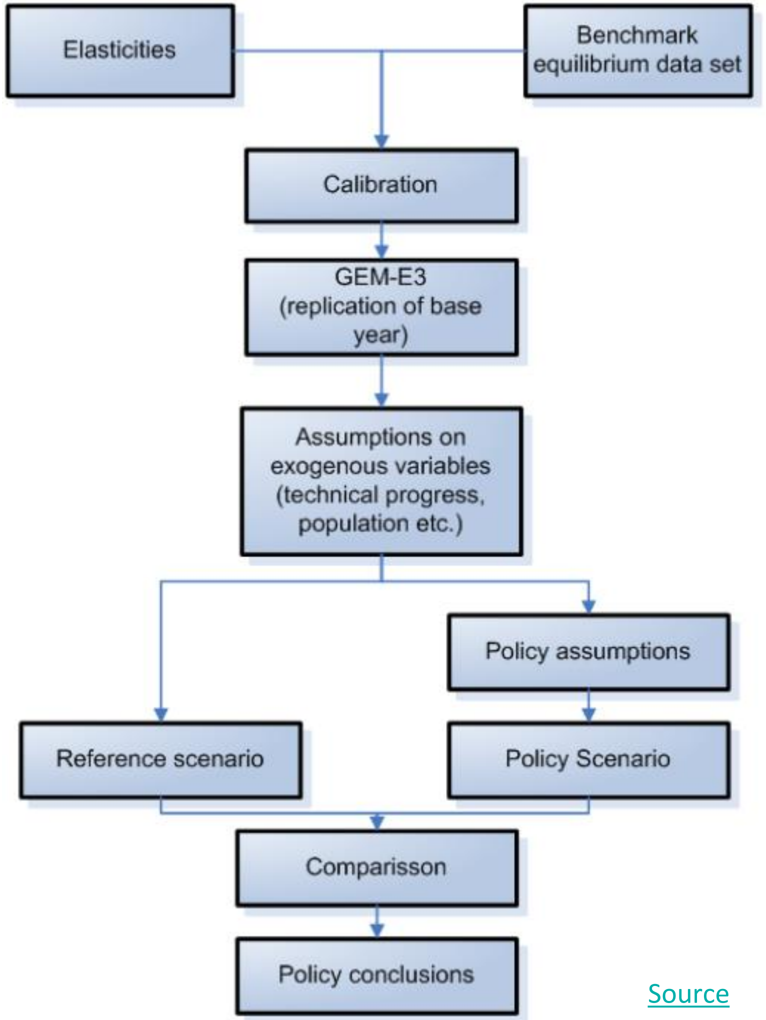
PROs	CONs
• Most advanced models that allow an integral assessment of impact into different domains. • Used in numerous policy assessments made by the EU. • Academic robustness is generally ensured.	• Complex approaches need full input-output tables and the characterization of national and international economies. • Macroeconomic framework can be endogenous or exogenous - numerous assumptions. • Emissions are generally driven by projected demand (exogenous). • Difficulties to isolate, differentiate and aggregate the effect of the PAMs when there are several. • Consistency issues with national inventories due to different nomenclatures and principles.

1 Model approaches and alternatives

General equilibrium model

For example…





Source

2 Time series forecasting techniques

What is time series forecasting?

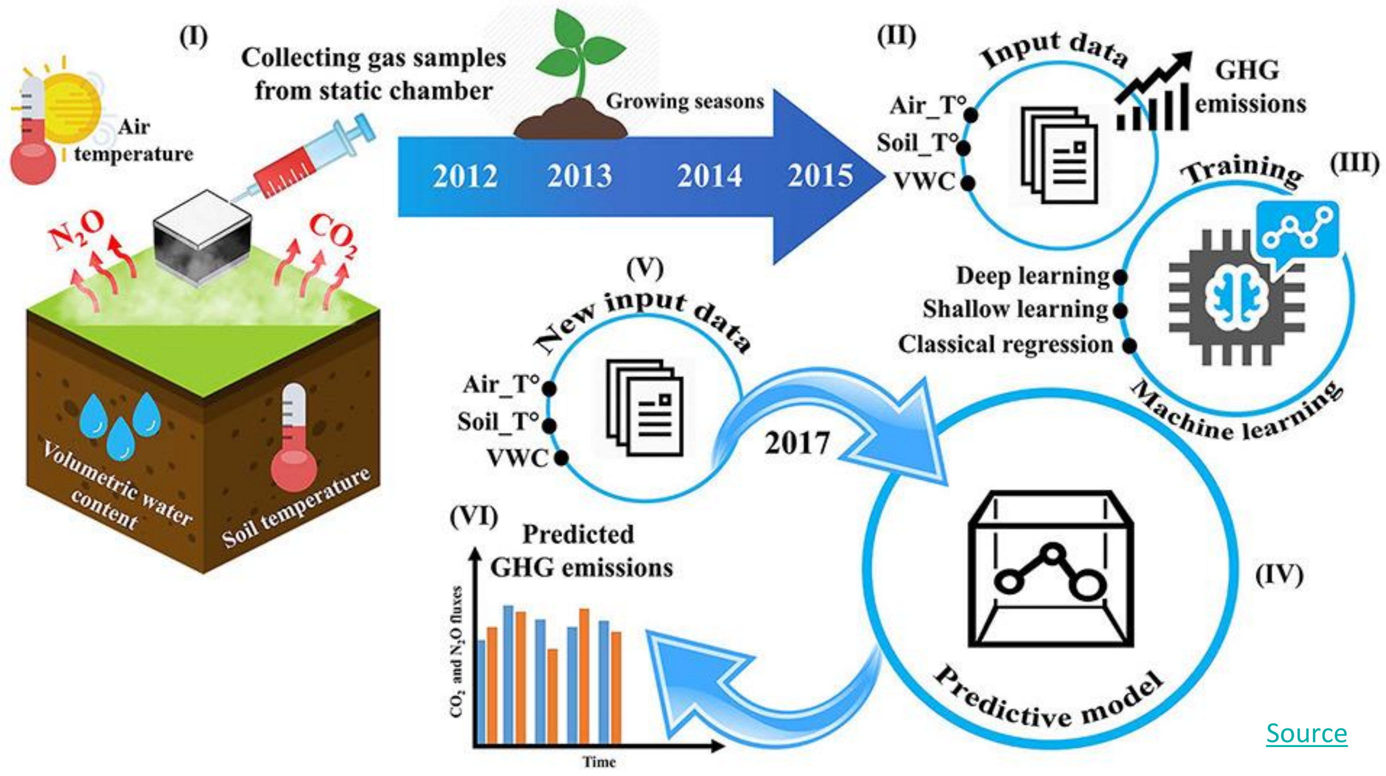
An approach to statistically estimate future values of one variable using observed data as well as proxies.

- Time series forecasting is also integrated in some of the previous models.
- Focuses on developing strong projections.
- Solves some of the problems identified in optimisation and general equilibrium models.
- Applications of this technique include climate models and economic forecasting.
- Widespread use in the academia with research purposes.
- Latest developments of this type of models apply machine learning, neuronal networks and artificial intelligence techniques to project based on previous real data.

2 Time series forecasting techniques

What is time series forecasting?

An approach to statistically estimate future values of one variable using observed data in the time series as well as factors that "explain" its evolution (proxies). This technique uses the behavior of the past to improve the understanding of the future.



Source

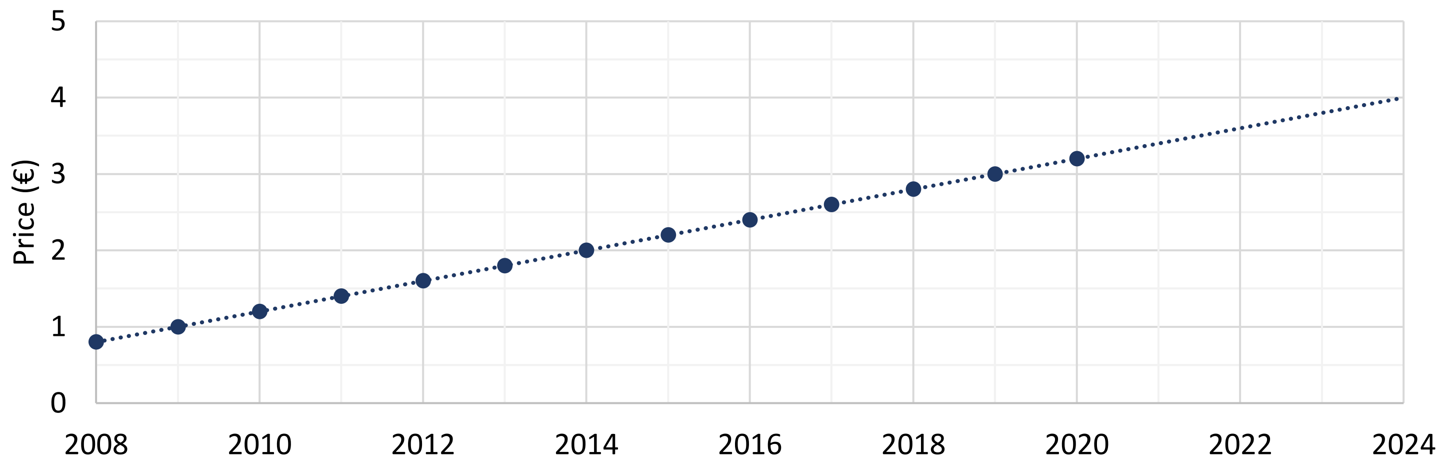
Foundations

Example: The price of a cup of coffer over the years.

Year	Price (€)
2008	0.8
2009	1.0
2010	1.2
2011	1.4
2012	1.6
2013	1.8
2014	2.0
2015	2.2
2016	2.4
2017	2.6
2018	2.8
2019	3.0
2020	3.2

What we observe:

- Price increase following a linear increasing trend - we can understand a trend and even "predict" future values.
- We do not know (yet) why this price increases, however, there must be reasons (drivers) behind this trend.



The concept of drivers

Example: Relationship between sales, discount, and advertising.

Sales (€)	Average discount (%)	Advertising budget (€)
48,000	4	500
20,000	2	150
35,000	3	400
32,000	3	300
16,000	2	100
58,000	6	500
40,000	4	380
30,000	3	280
32,000	3	290
31,000	3	315
63,000	6	625
57,000	6	385

What we observe:

- There are reasons (**drivers**) that could explain the evolution of a variable - important to define what variable are you trying to explain (Sales in this case).
- It is important to identify **causality** (why?) and **correlation** (how?).
- Correlation is not causality.

Univariable regression

Suppose we have monthly data on the number of ice cream sales (dependent variable) over a year:

Month	Ice cream sales (#)
Jan	100
Feb	120
Mar	150
…	…
Dec	80

Using a **univariable regression**, we might find a positive correlation between the months (as a numeric variable, e.g., 1 for January, 2 for February, etc.) and ice cream sales.

The regression equation might look like:

Ice cream sales = 80 + 25 · Month

This equation suggests that ice cream sales increase by 25 units each month, following a lineal trend.

$$Sales = \beta_0 + \beta_1 \cdot Month + \varepsilon$$

β_0 *is the intercept*

β_1 *is the slope*

ε *is the error*

Multivariable regression

Now, let's incorporate an exogenous variable, the average temperature, into the model.
Assume we have the following data for average temperature:

Month	Ice cream sales (#)	Average Temperature (°C)
Jan	100	5
Feb	120	7
Mar	150	12
…		…
Dec	80	2

Using **multivariable regression**, we find that ice cream sales is dependent on both the month and the average temperature:

The regression equation might look like:

$$Sales = \beta_0 + \beta_1 \cdot Month + \beta_2 \cdot Average\ Temperature + \varepsilon$$

β_0 *is the intercept*

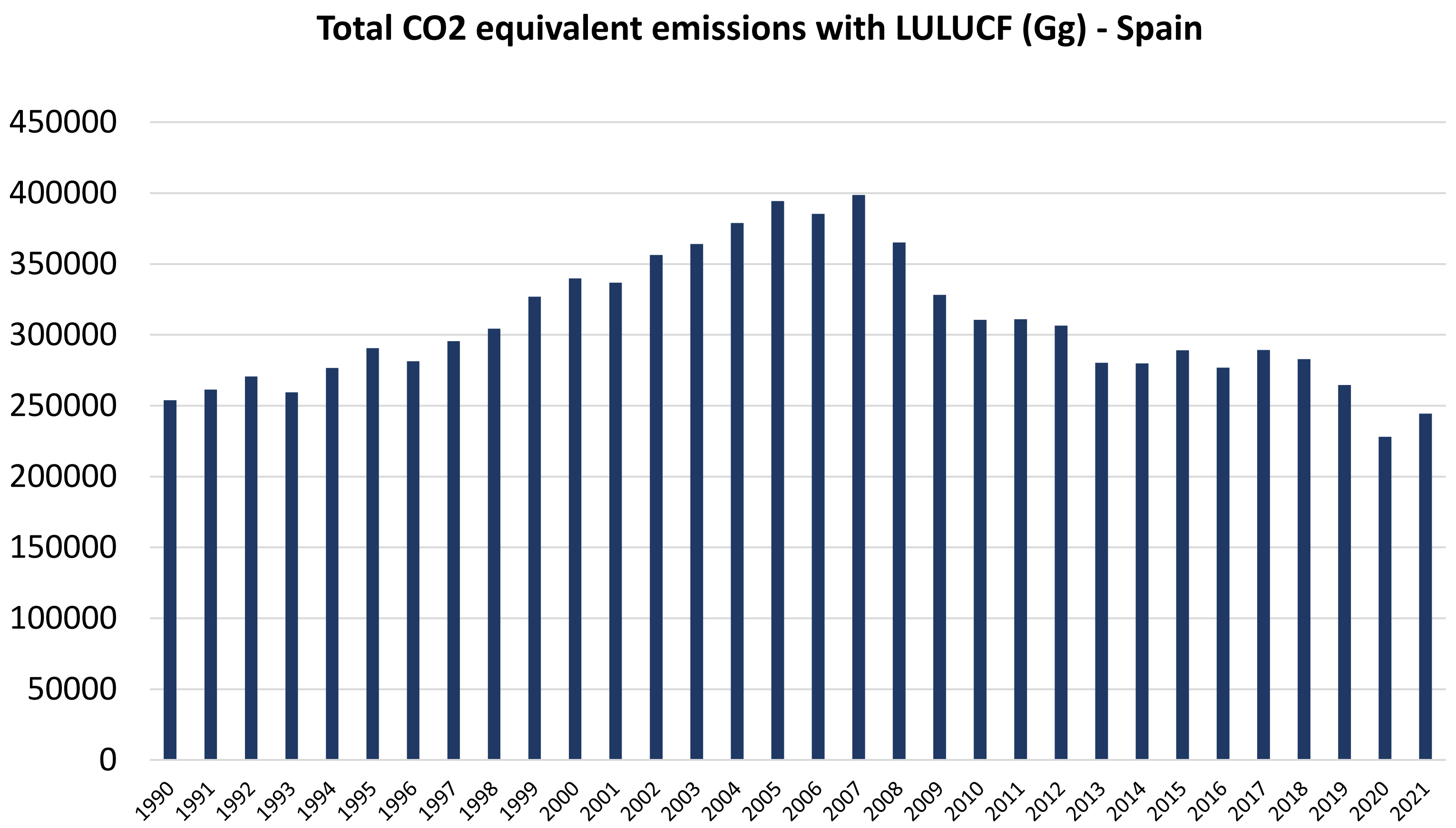
β_1 *is the slope for variable* 1 (*month*)

β_2 *is the slope for variable* 2 (*temp*)

ε *is the error*

2 Time series forecasting techniques

Example 1: Total CO_2eq emissions in Spain



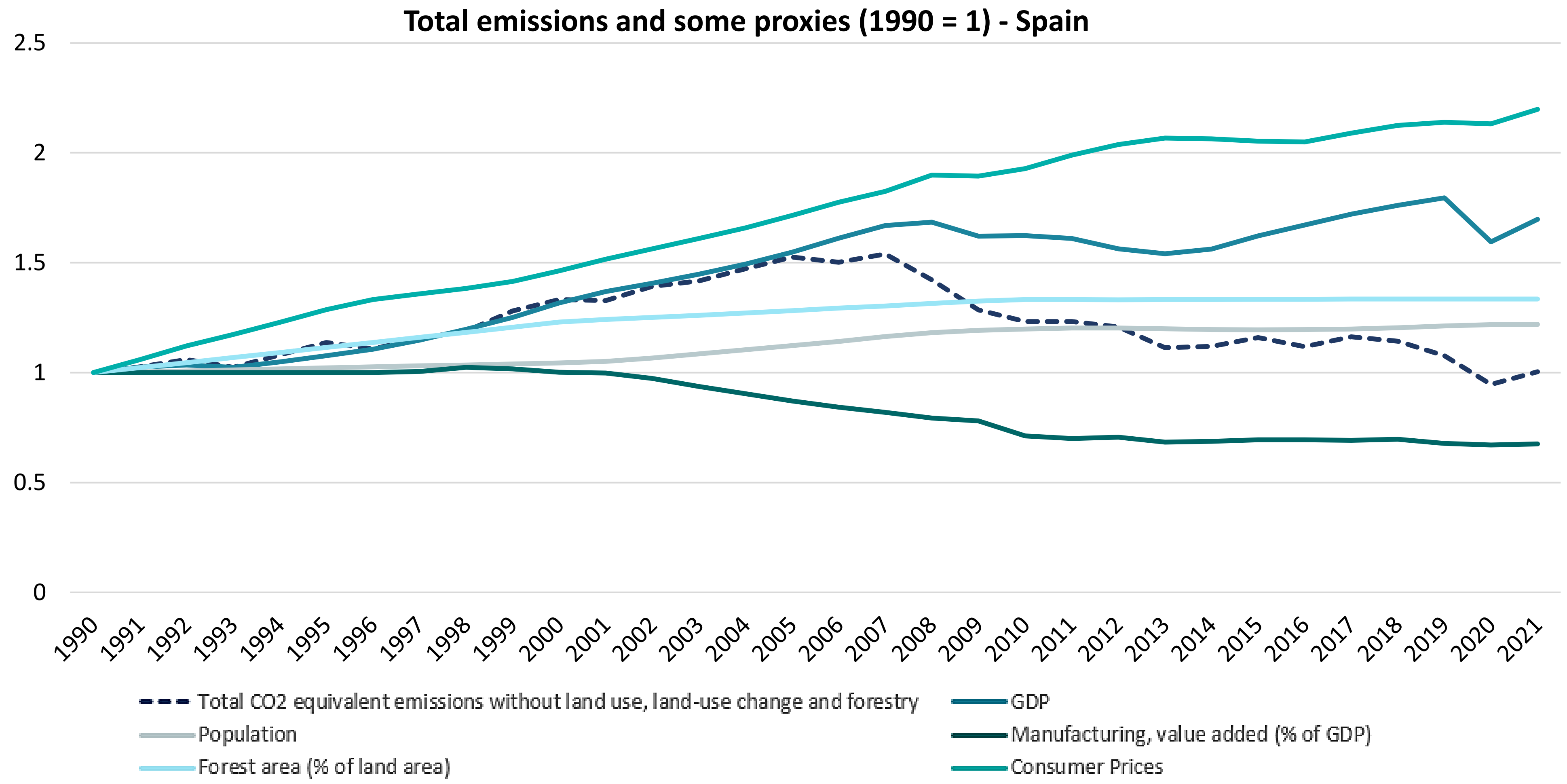
What are the "reasons" explaining the evolution of emissions?

2 Time series forecasting techniques

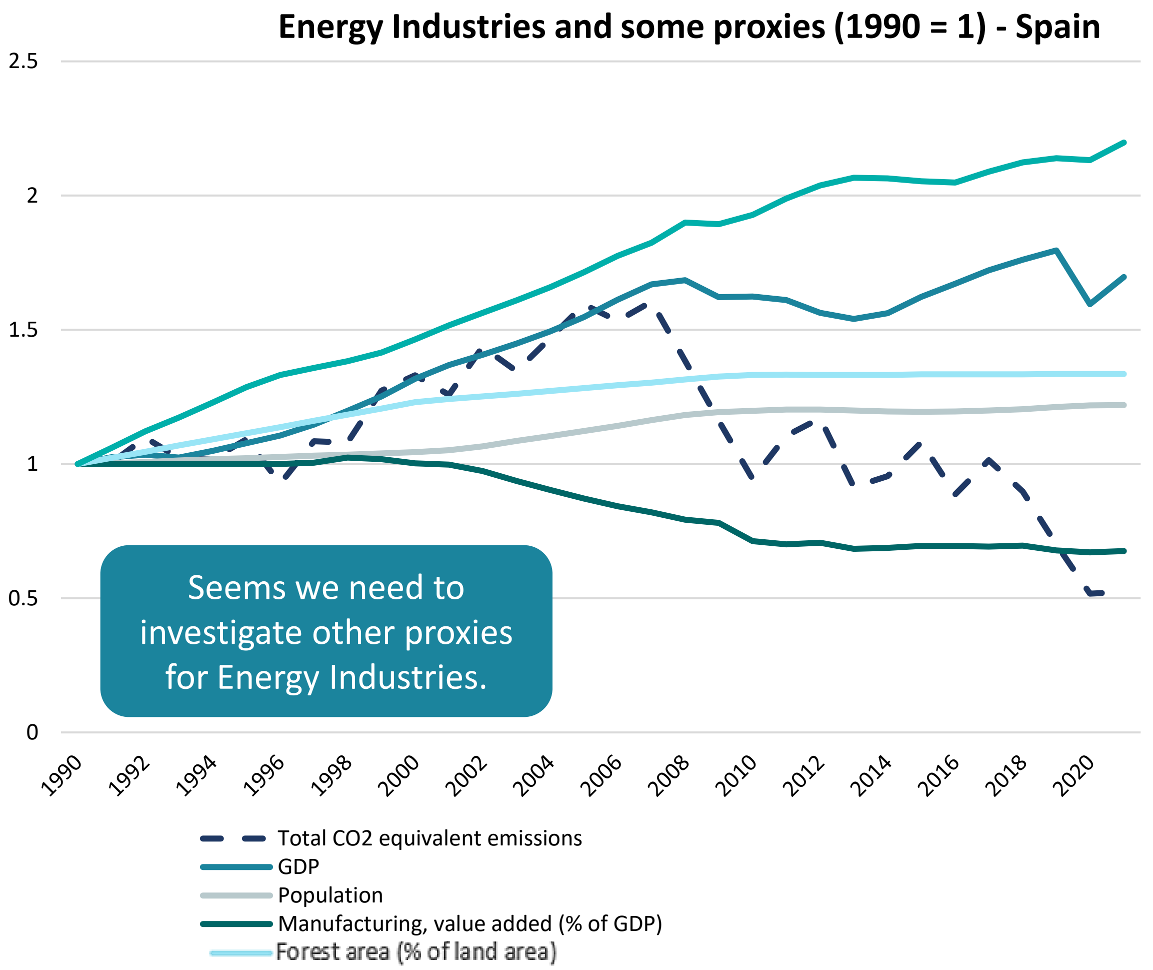
Example 1: Total CO_2eq emissions in Spain

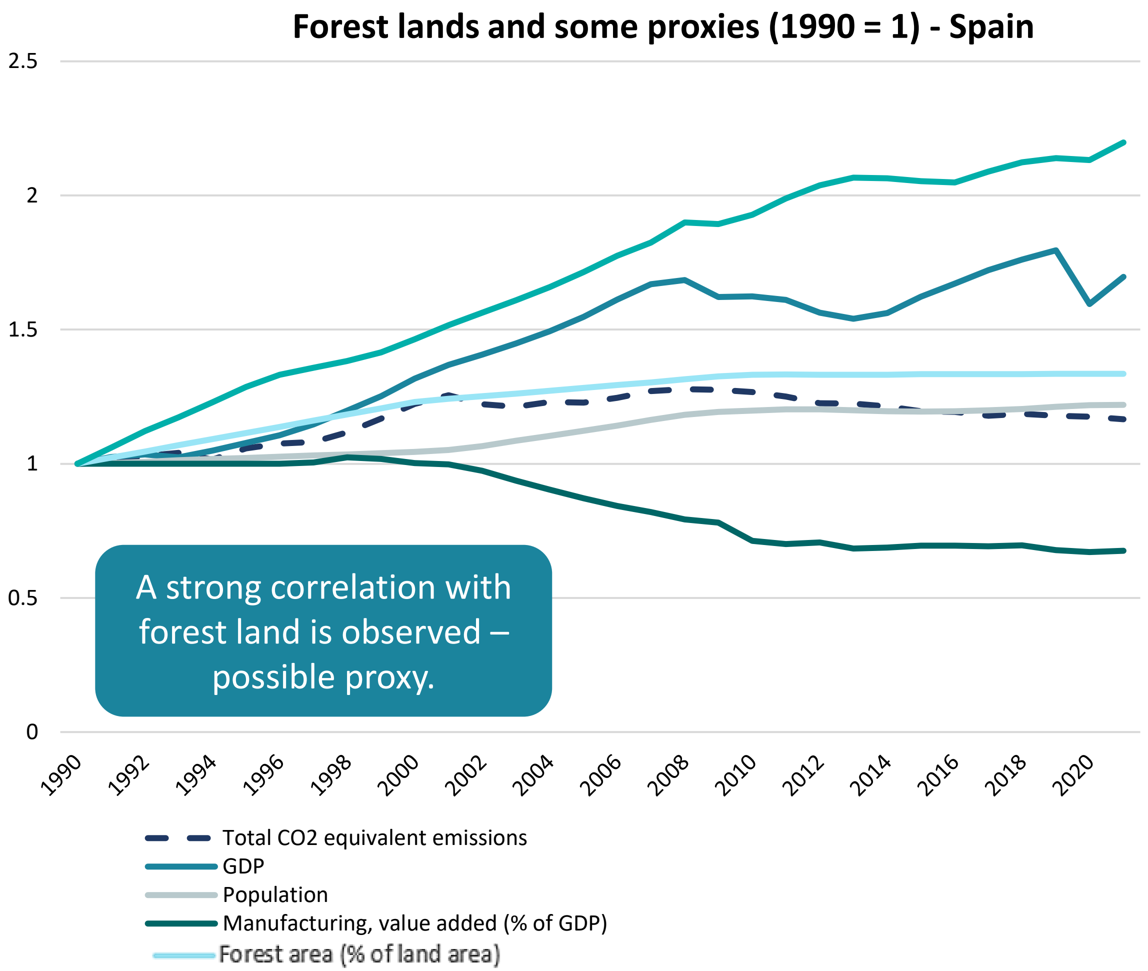
What are the “reasons” explaining the evolution of emissions?

Let´s take a closer look disaggregated by sector.

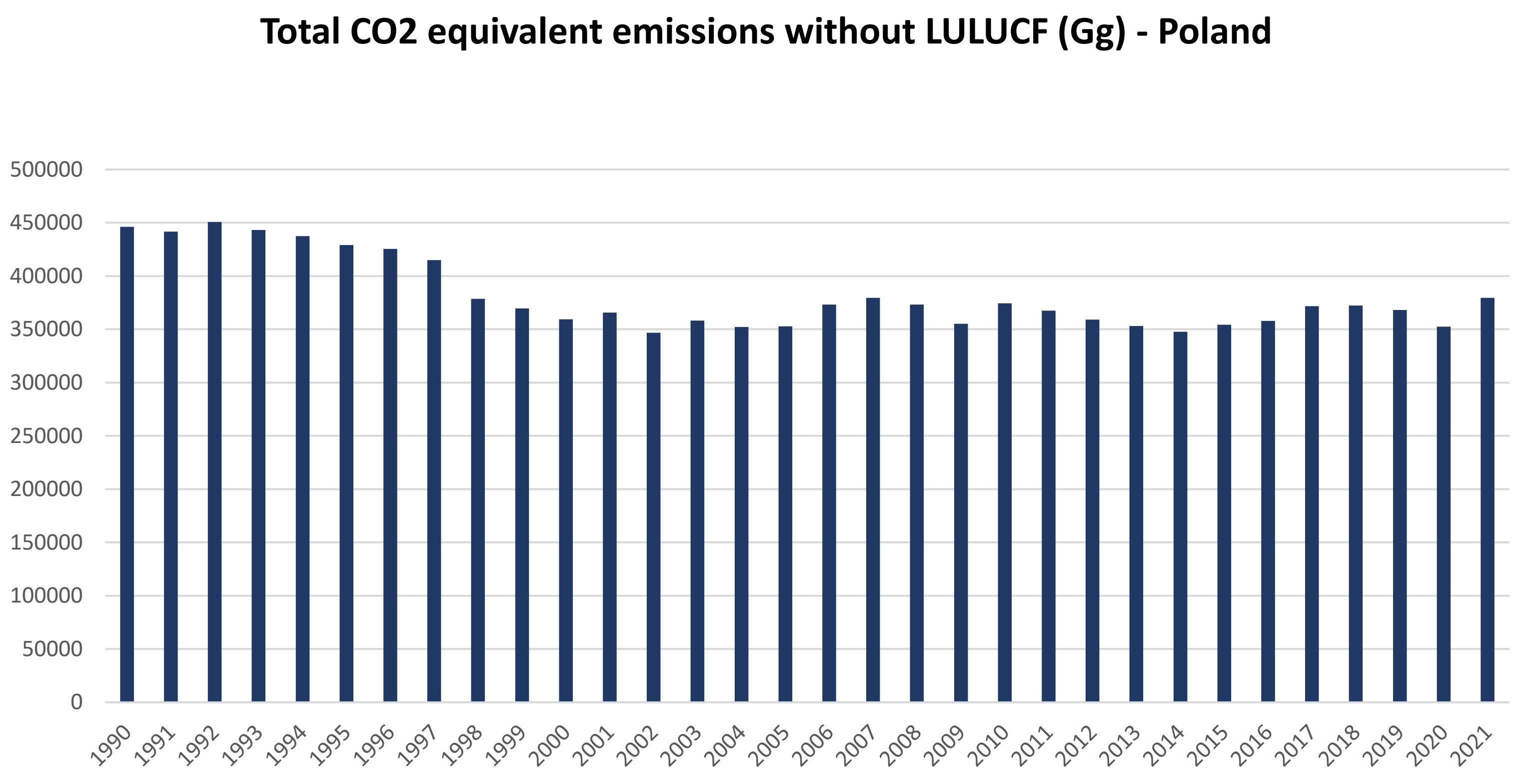


Example 1: Total CO_2eq emissions in Spain





Example 2: Total CO_2eq emissions in Poland



What are the "reasons" explaining the evolution of emissions?

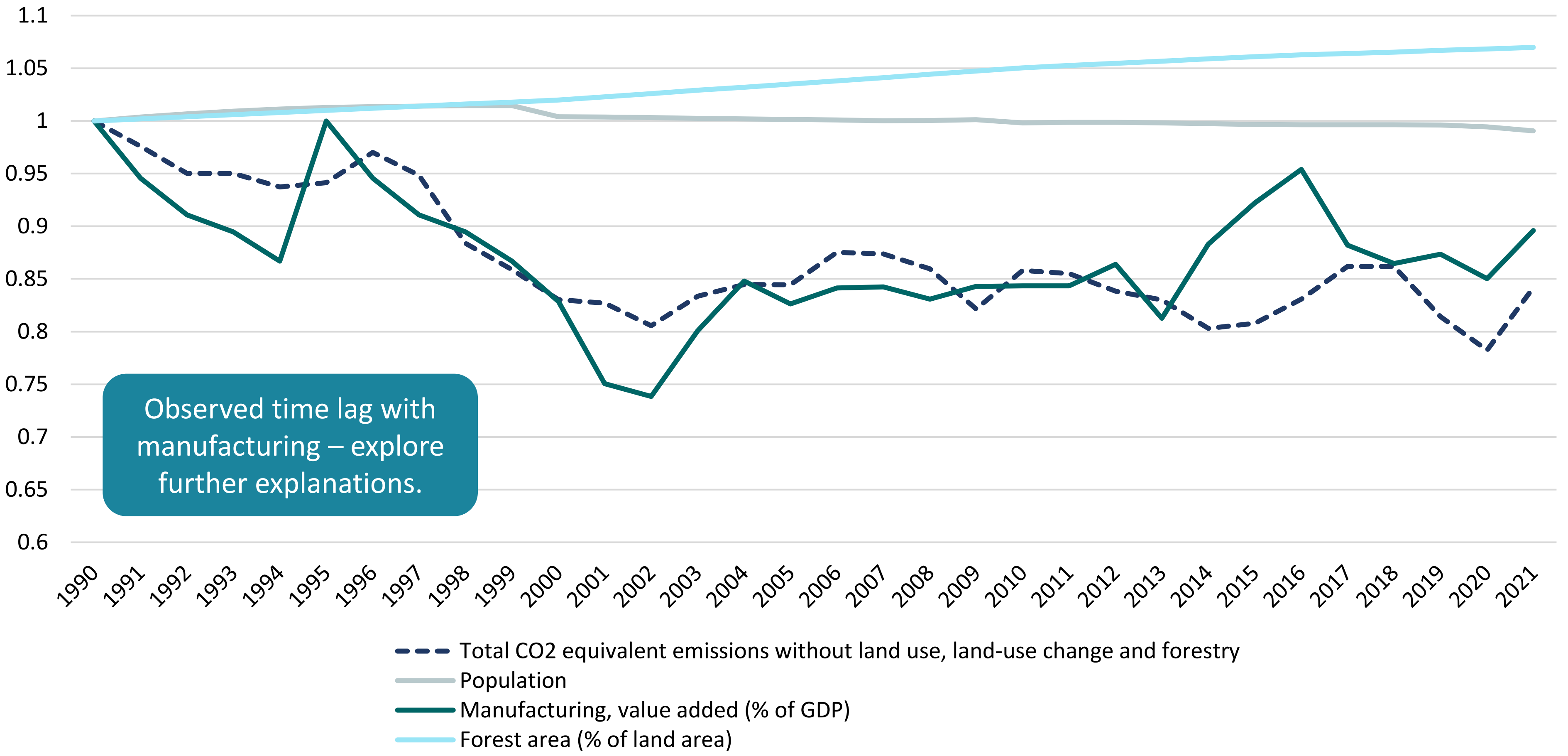
2 Time series forecasting techniques

Example 2: Total CO_2eq emissions in Poland

What are the "reasons" explaining the evolution of emissions?

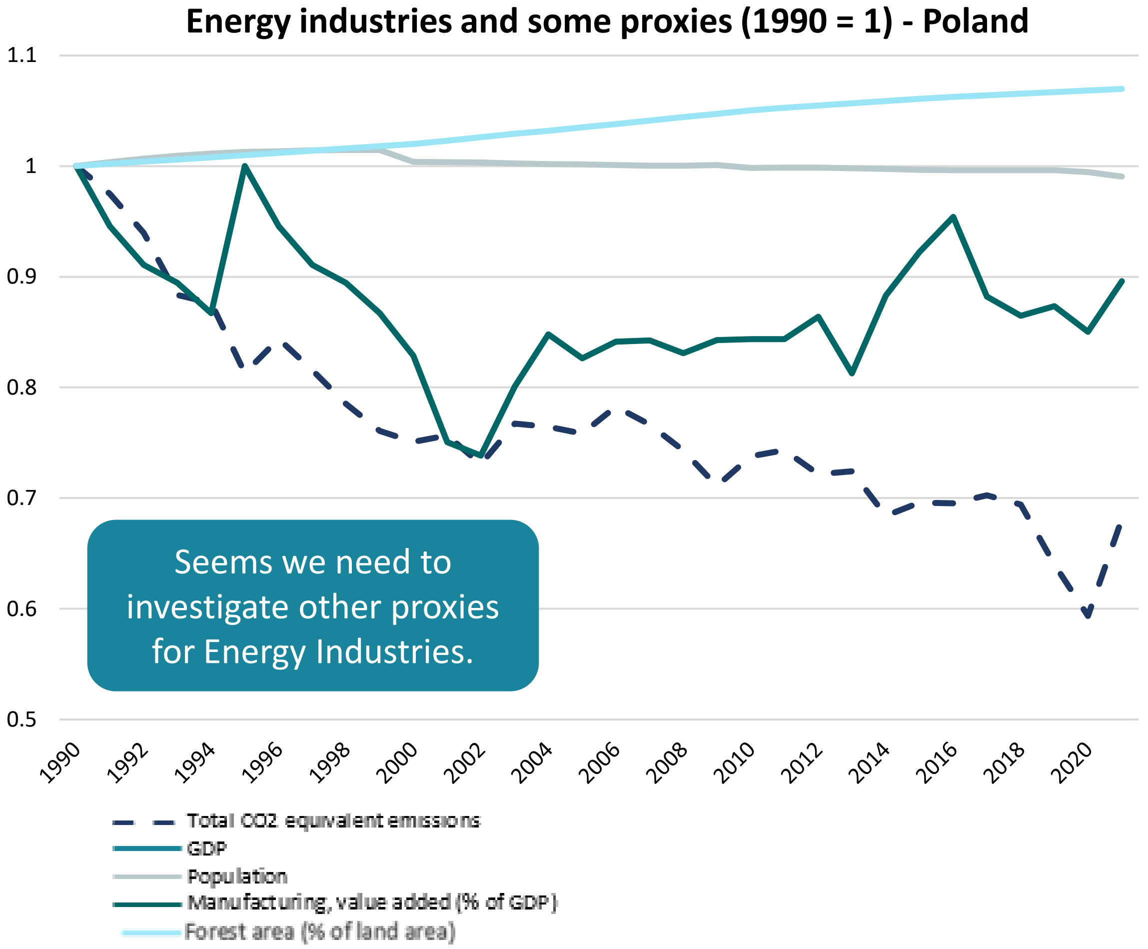
Let´s take a closer look disaggregated by sector.

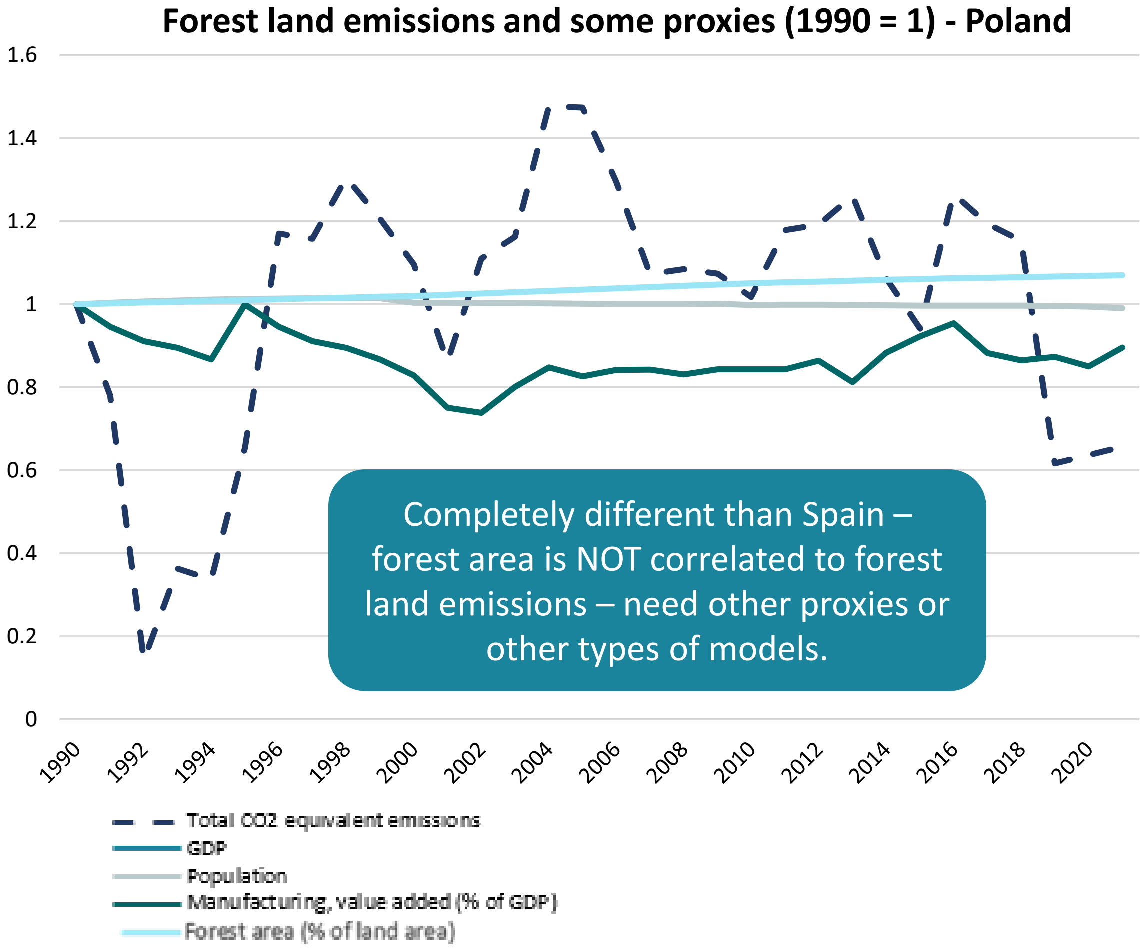
Total emissions and some proxies (1990 = 1) - Poland



2 Time series forecasting techniques

Example 2: Total CO_2eq emissions in Poland





2 Time series forecasting techniques

Key takeaways

- We can use proxies and their relationship with GHGs to approximate future GHG emissions - understanding emission sources, the way they are calculated, and finding reasons to trends are key.
- The relationship between proxies and GHGs is not the same for all countries or between sectors/categories.
- The level of aggregation is important to identify the dynamic evolution of emissions – the more disaggregated the better.
- Models (and the identified suitable proxies) need to be defined considering observed data.
- Finding the right proxies and obtaining "long" time series is key for defining good models.
- Defining models is not that easy.

How does MITICA help?

MITICA uses specific proxies by category and identifies those that are most relevant for the country´s particular context.

MITICA estimates at the highest disaggregation level available in the inventory for improved accuracy.

MITICA defines models and proxies using machine learning to develop the most robust outcomes.

3 Approaches used by Annex I - developed country Parties

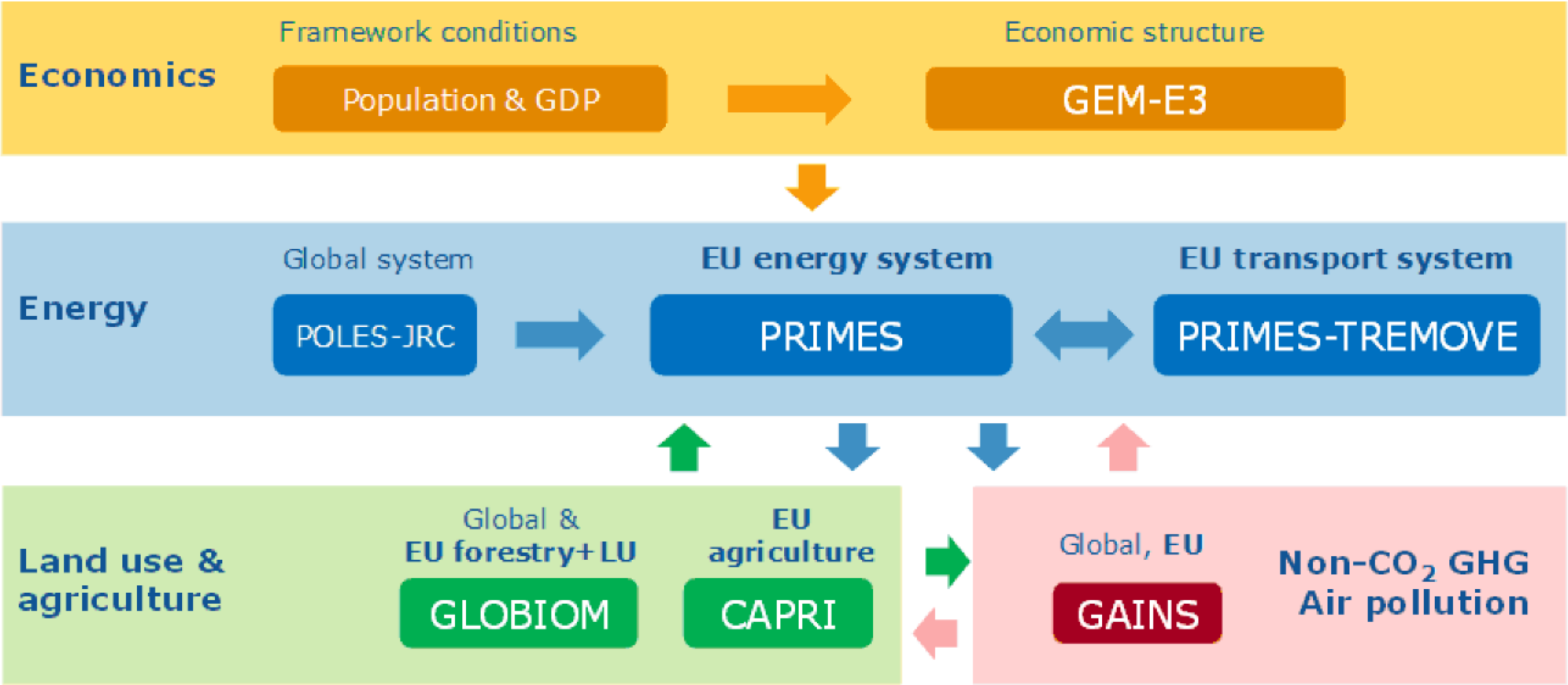
- Annex I countries use **sector-specific models** for projections.
- The results of these models are considered and integrated into the national projections of total GHG emissions estimated from the GHG emission inventory.
- The types of software typically used by Annex I countries are:
    - **TIMES/MARKAL**
    - General equilibrium models such as **GEM3**
    - Many others
- In all cases, when different sectoral models are used, Annex I countries **define the interrelationships between models and common references** before running the modelling approach.

Currently, the use of advanced sector-specific models is **not considered feasible for developing countries**, due to their high data collection requirements and the need to complement at least 2 of these models. It should be noted that this type of modelling is usually associated with several years of implementation at the national level.

3 Approaches used by Annex I - developed country Parties

For example….

Sectoral approach to GHG modelling followed by the EU



Source: https://ec.europa.eu/clima/policies/strategies/analysis/models_en

4 Approaches used by non- Annex I - developing country Parties

Developing countries tend to use **tools** such as:

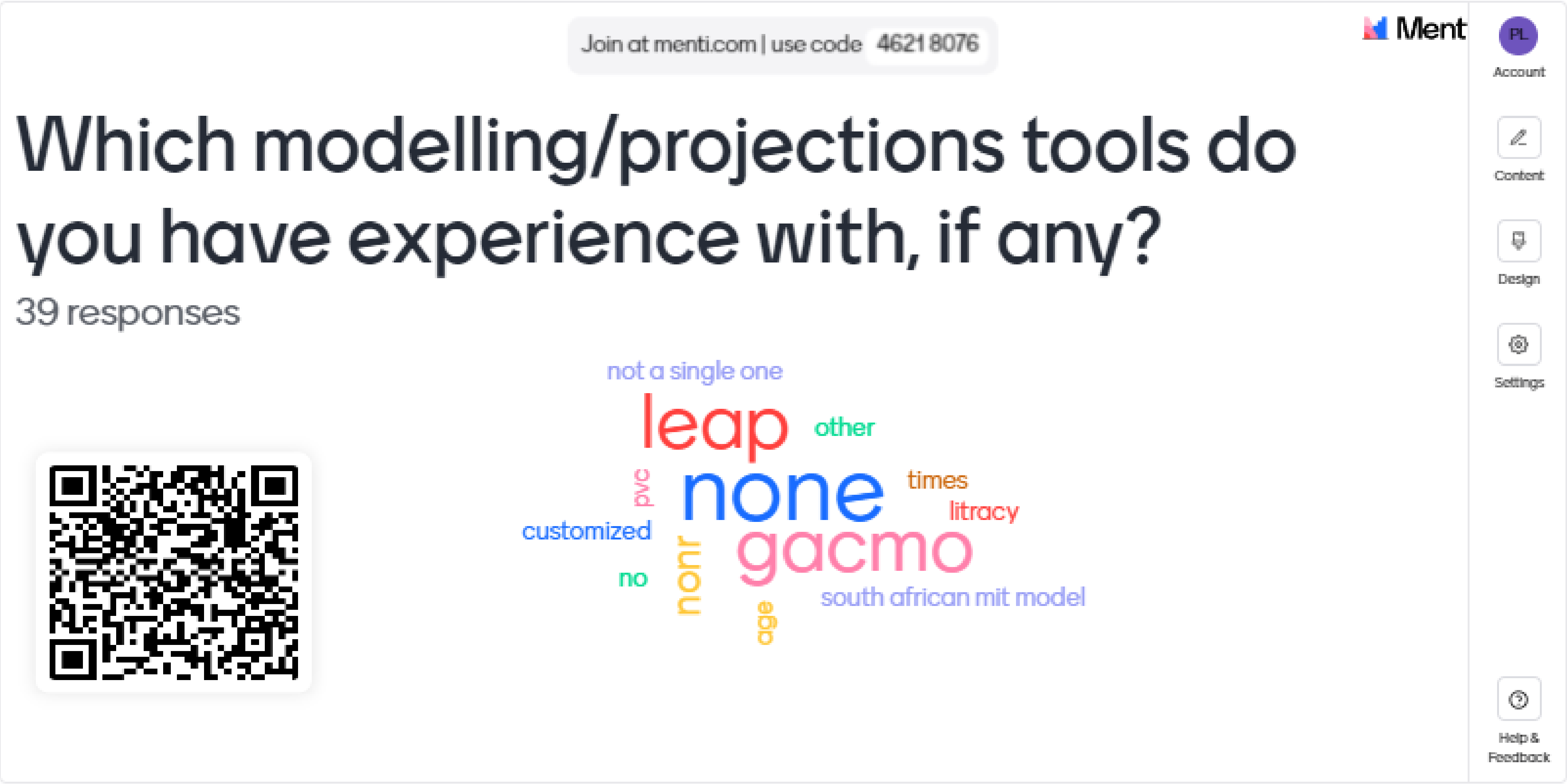
- **LEAP** (**L**ow **E**missions **A**nalysis **P**latform)
- **Prospects+**
- **GACMO** (**G**reenhouse gas **A**batement **C**ost **Mo**del)

4 Approaches used by non- Annex I - developing country Parties

Developing countries tend to use **tools** such as:

	LEAP	Prospects+	GACMO
Projection method	Equations can be defined by users (accounting model)	Classical regressions	Growing rates
Consideration of PAMs	Within scenarios, not allowing for differentiation of impacts	Within scenarios, not allowing for differentiation of impacts	Several PAMs by sectors, but challenges to incorporate them into scenarios
Link with the inventory	The trend is not considered, nor all inventory categories	The inventory can be adjusted to the tool	Not addressed
WoM/WM/WaM scenarios?	Not in line with ETF definitions	Not in line with ETF definitions	Not in line with ETF definitions

5 Setting the stage for MITICA



5 Setting the stage for MITICA

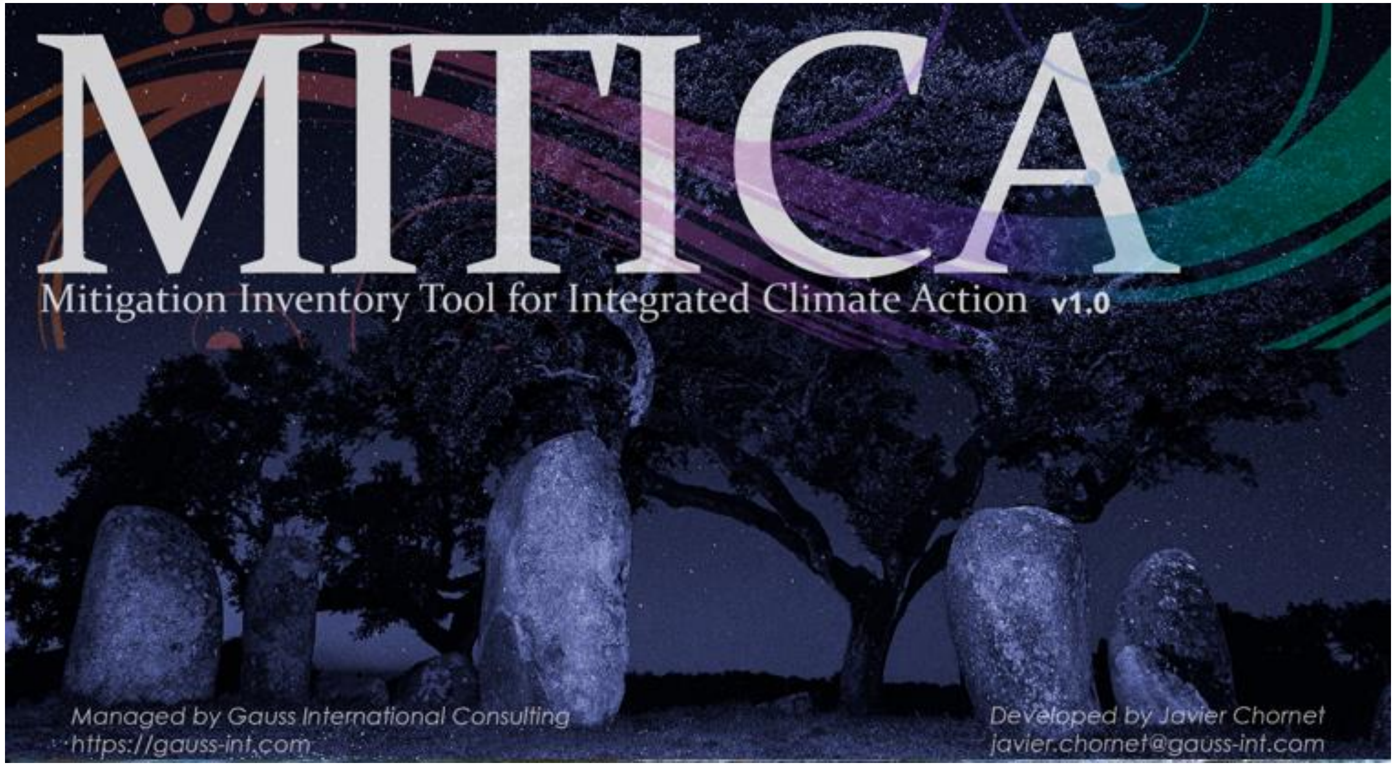
MITICA builds from the strengths of approaches and models used by both developed and developing countries, to create an approach to develop mitigation scenarios which meets ETF requirements and supports the elaboration of mitigation assessments based on national GHG inventories.

Similar to developed countries, MITICA…

- ✓ Creates bottom-up models for all sectors/emission sources, streamlined by a common macroeconomic structure.
- ✓ Integrates PAMs within different scenarios to assess potential impacts and assess mitigation targets.
- ✓ Uses the inventory as a robust methodological and statistical reference for projections.

Inspired from developing countries, MITICA…

- ✓ Provides numerous alternatives for designing Policies and Measures, ensuring the methods align with IPCC good practices and inventory methodologies.
- ✓ Address sectoral characterisation by developing category specific models by country, in line with inventory dynamics.



Thank you!

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