MITICA

MITIGATION-INVENTORY TOOL FOR INTEGRATED CLIMATE ACTION

MITICA Regional Workshops

United Nations
Framework Convention on
Climate Change

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AGENDA

MITIGATION-INVENTORY TOOL FOR INTEGRATED CLIMATE ACTION

1. MITICA Approach
2. Key Takeaways

AGENDA

MITIGATION-INVENTORY TOOL FOR INTEGRATED CLIMATE ACTION

1. MITICA Approach
2. Key Takeaways

General context

- Despite synergies between reporting elements such as national GHG inventories, PAMs, projections, NDC updates, and NDC tracking, **consistency issues** and **difficulties** in **periodically producing and reporting** on these elements are anticipated.

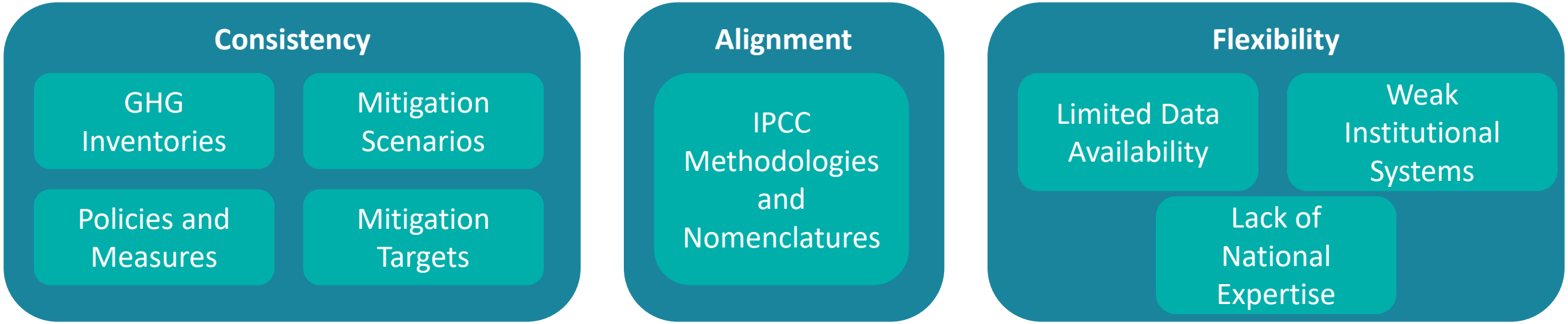
- These include the **inconsistency** observed between national GHG inventories and projections, a **disconnection** between PAMs and mitigation scenarios, and the **utilization of inconsistent** methodological approaches across different sectors.

- This **leads to a lack of clarity** regarding aggregated emissions and mitigation targets, resulting in increased uncertainty.

- This is particularly attributed to **data collection**, **lack of national expertise** and **weak institutional systems**.

What is the added value of MITICA?

- To effectively address these challenges in developing mitigation scenarios for NDC design and tracking requires careful **consideration of specific key elements**.

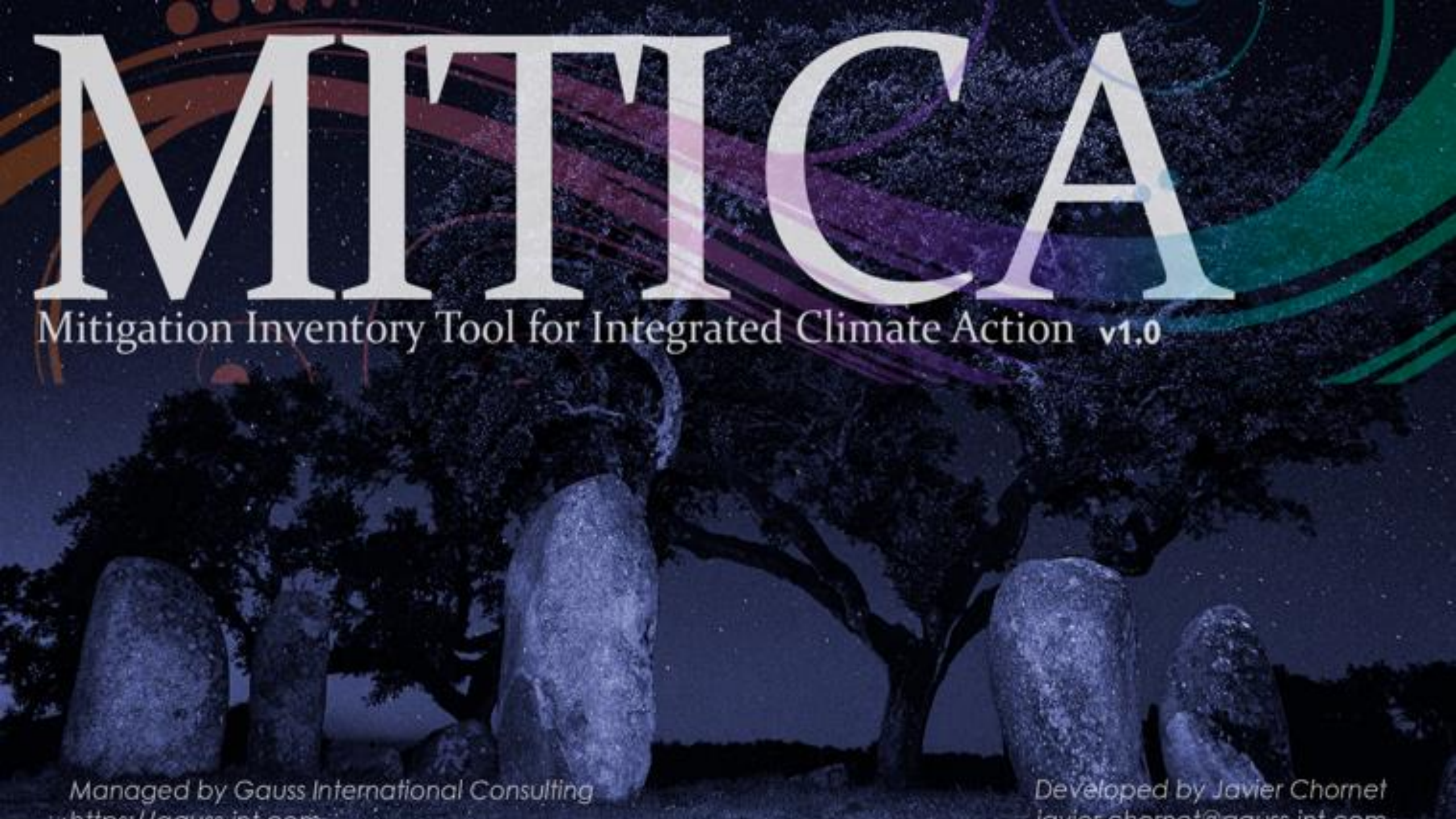


- The **current landscape of models and tools** for developing mitigation scenarios **falls short** of meeting these criteria.

- **MITICA bridges these gaps** by leveraging existing IPCC methodologies and expertise from developed and developing countries in developing national GHG inventories.

MITICA

Mitigation Inventory Tool for Integrated Climate Action v1.0



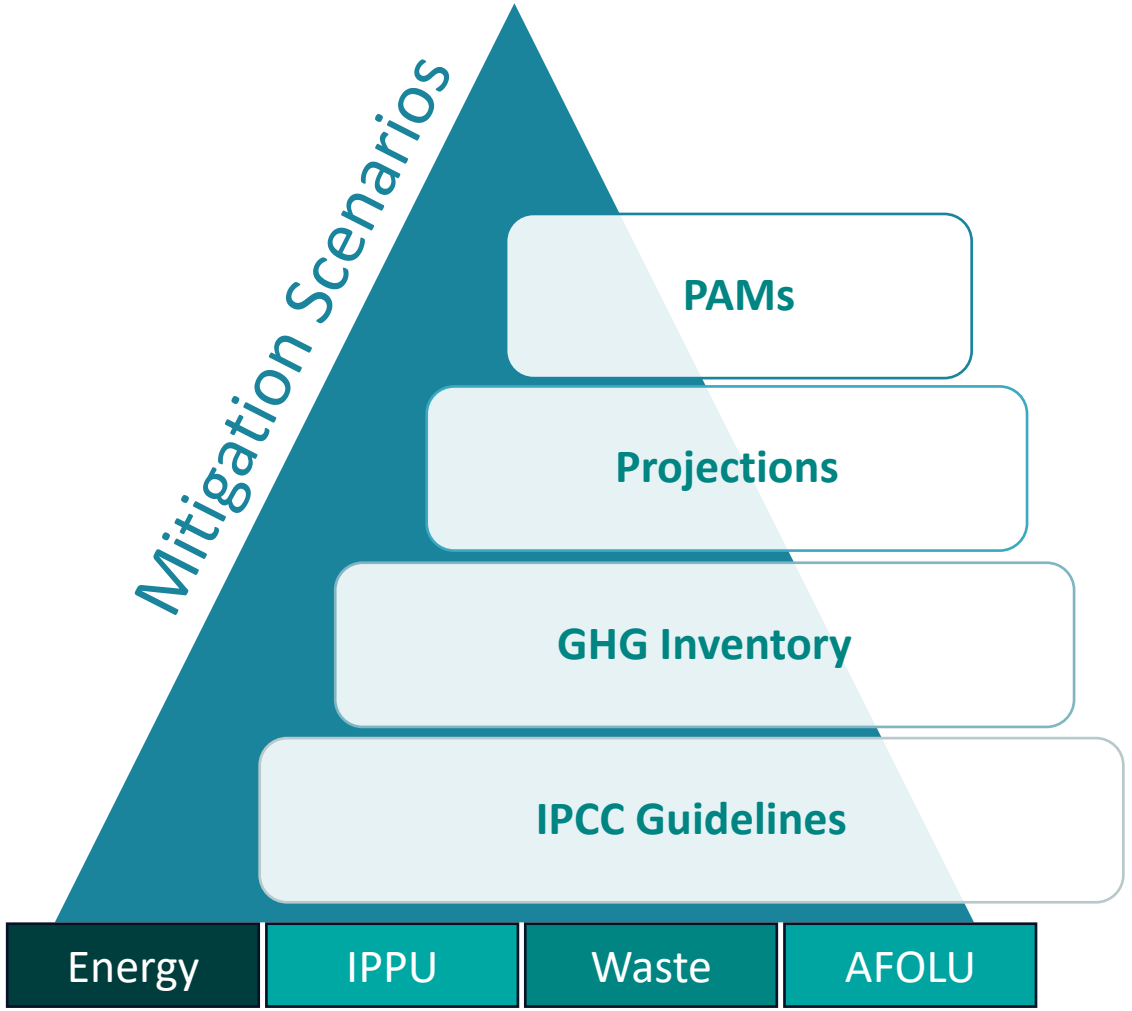
Managed by Gauss International Consulting

Developed by Javier Chornet

Why do we need MITICA?

MITICA overcomes all these challenges by:

- **Creating a universally applicable and standardized methodological framework and a tool** for developing consistent mitigation scenarios from the national GHG inventory.
- **Developing a link between key elements** (GHG inventory, GHG projections, and PAMs).
- **Creating consistent scenarios for all IPCC sectors up 2050.**



What is MITICA?

- A Tool for developing **mitigation scenarios up to 2050 for all IPCC sectors (Energy, IPPU, Waste, AFOLU) based on GHG inventory data**.

- A **desktop application**, allowing creation of scenarios without high-speed internet.

- An integrated **bottom-up & top-down** model. Estimated at **IPCC category** following an **integrated modelling approach** that is **specified at the sectoral level**.

- **Supported by the UNFCCC**, MITICA aims at supporting countries to implement systems and tools to participate under the Enhanced Transparency Framework.

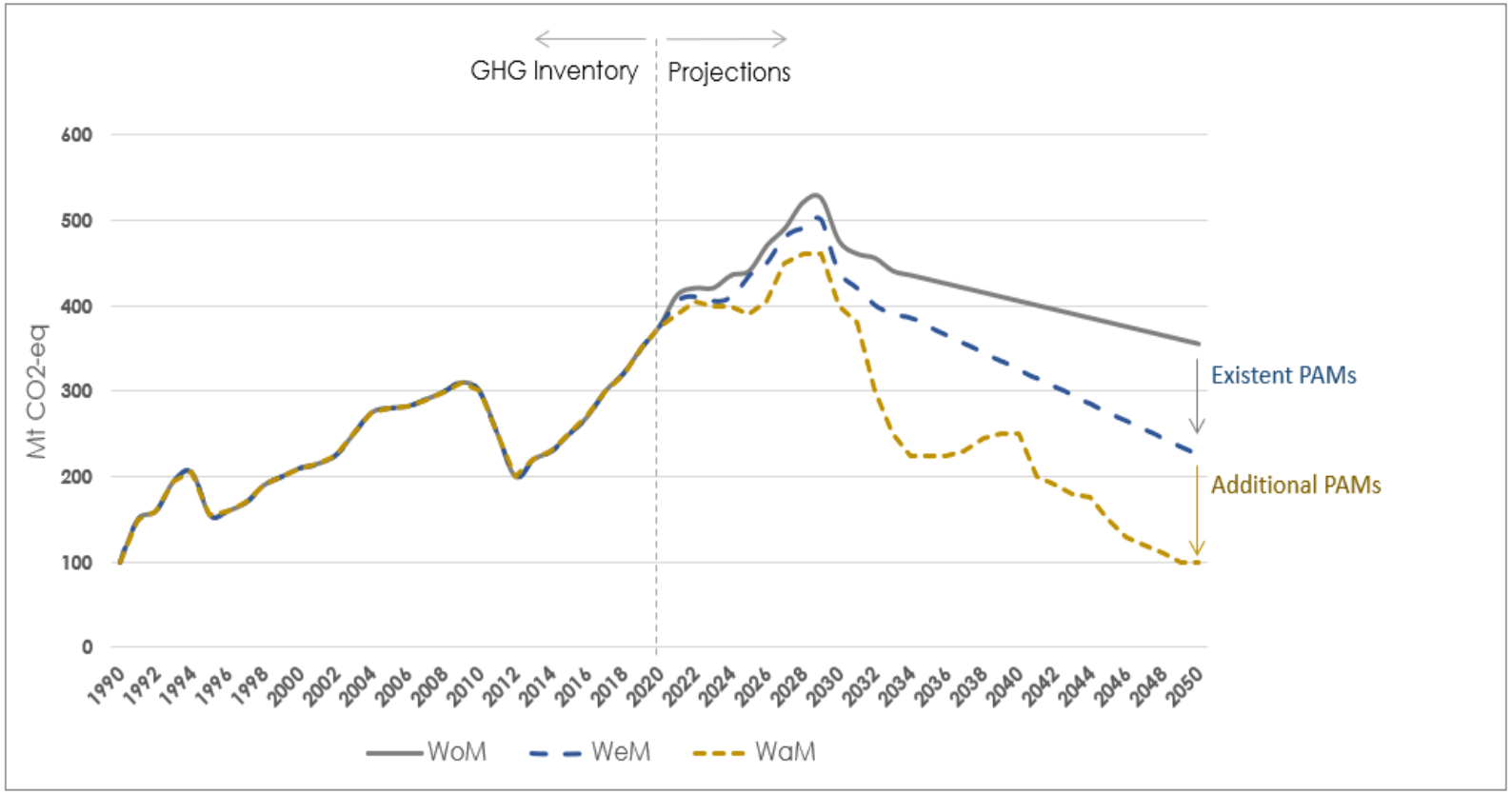
What is MITICA?

Key Concepts

Projections: future GHG emissions.
Scenarios:

- WoM: Without Measures, similar to a Business-as-Usual scenario
- WeM: With Existing Measures
- WaM: With Additional Measures

PAMs: Policies and Measures that reduce GHG emissions
Mitigation targets: Objectives, such as the NDC



- In line with **ETF and MPGs specifications** and **definitions** and **IPCC nomenclatures**.

Data needs, methodology and results

Data Needs

- GHG emissions by IPCC category from the inventory, from the IPCC software or excel files (mandatory).
- Macroeconomic proxies, historical and projected (mandatory).
- Sectoral proxies, historical and projected (optional).

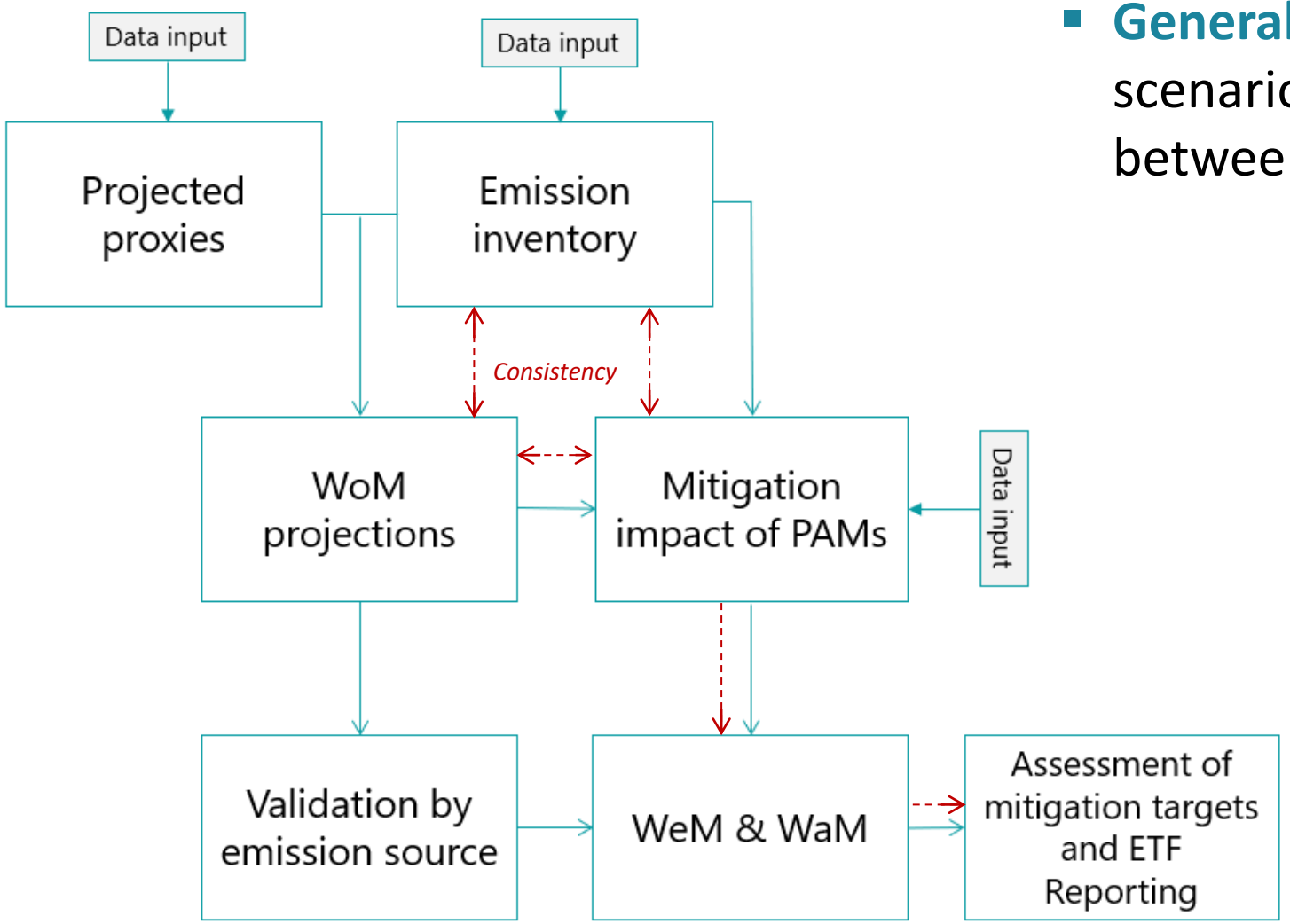
Modelling Approach

- Without measures (WoM) scenario estimated through innovative statistical techniques (regression-based machine learning methods) which automatically define nationally-specific models at IPCC category based on time series (input data).
- MITICA is coded using Phyton in a desktop application.
- More than 60 PAMs predefined with default parameters, that need to be customised by users.
- With existing measures (WeM) and with additional measures (WaM) easily designed by users by selecting the PAMs by scenario.

Results

- WoM, WeM, and WaM scenarios for NDC tracking.
- Rank PAMs by magnitude.
- Information needed to report projections and mitigation actions in CTF tables.

Data needs, methodology and results



- **Generalised steps** to obtain mitigation scenarios in MITICA **ensuring consistency** between components.

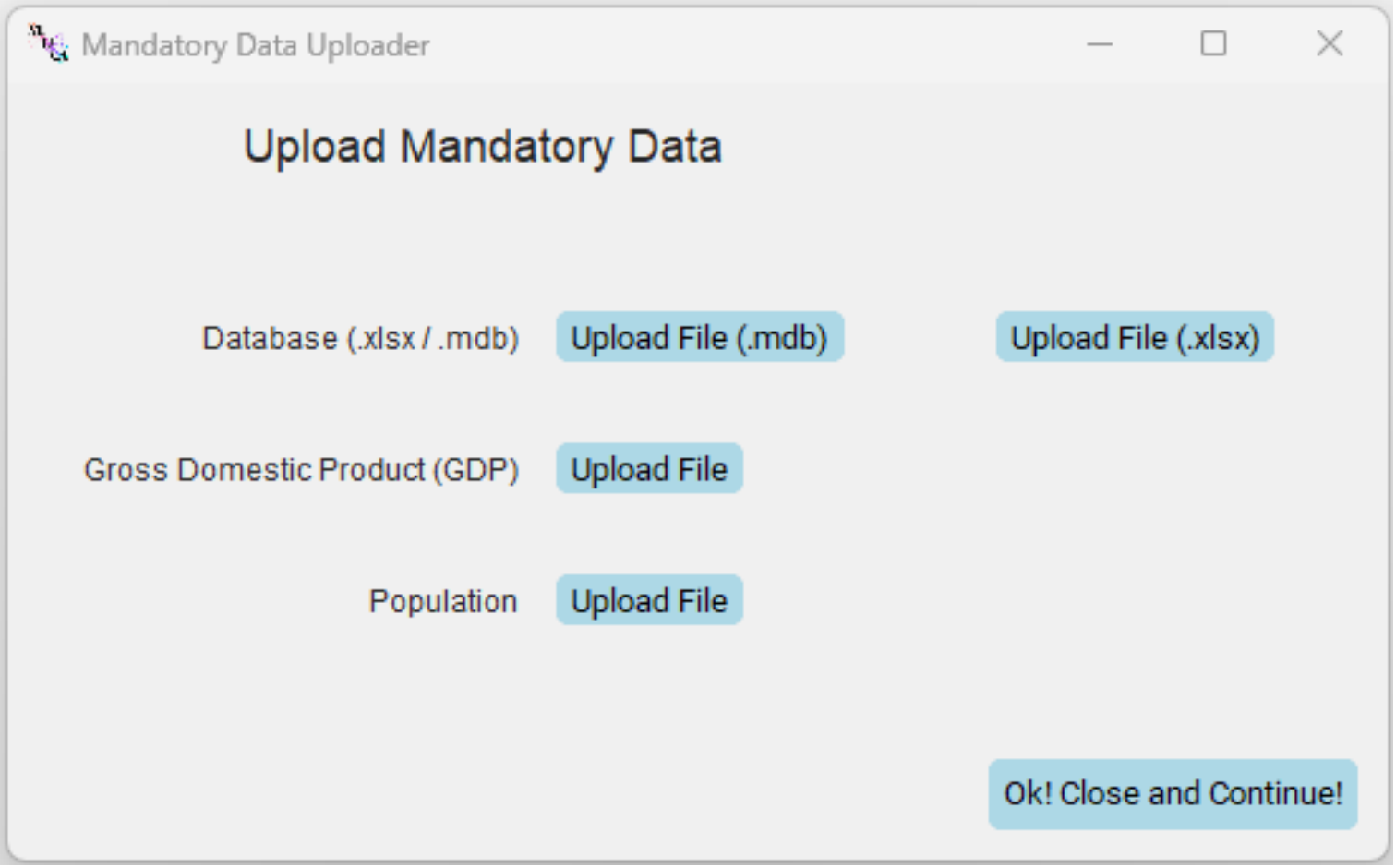
Consistency:

Time series consistency in trends is ensured through:

- The use of the same nomenclatures, categories and sectors.
- Same methodologies.

Allowing to define and track fully consistent mitigation targets.

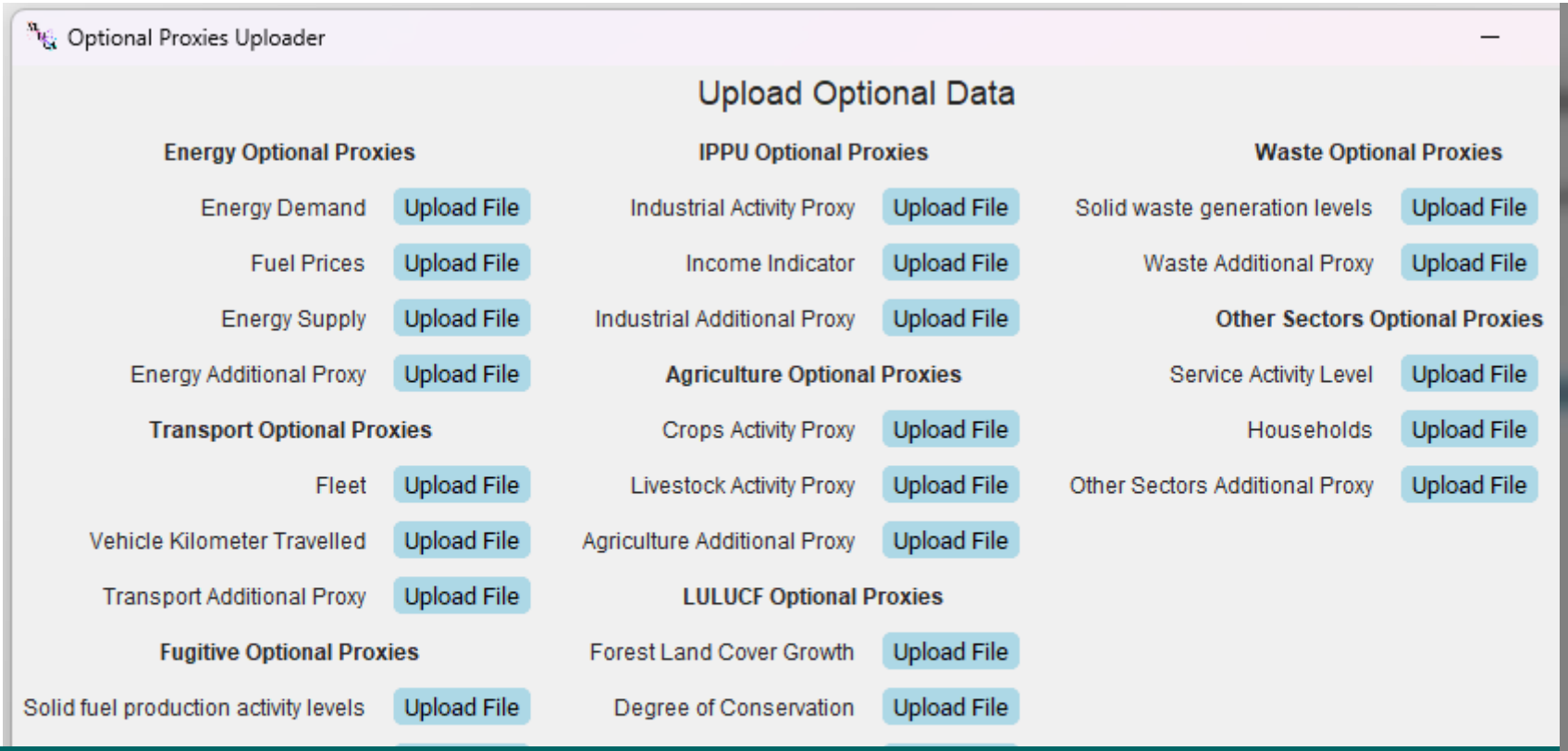
Data needs



Data needs

- Minimum data requirements include:
  - The inventory results (.mdb & .accdb file extracted from the IPCC software; excel files also allowed).
  - GDP time series, uploaded in excel file.
  - Population, uploaded in excel file
  - The time series of GDP and population should include the inventory years plus projected years.

Data needs



- Inputs and results from other sectoral models/tools can be added by users to improve the modelling.

- Additional sectoral proxies can be added to improve the model specification by sector.
- MITICA would use mandatory proxies (GDP and population) plus sectoral proxies to define, through computing techniques, a best-fit model by IPCC category.

Modelling approach

The **modelling approach** was defined under the following considerations:

A **common framework** is needed for all IPCC sectors to ensure consistency.

The **completeness of the inventory** and the **length of the time series** is uneven.

The **only differences** between scenarios shall be the **PAMs implemented**.

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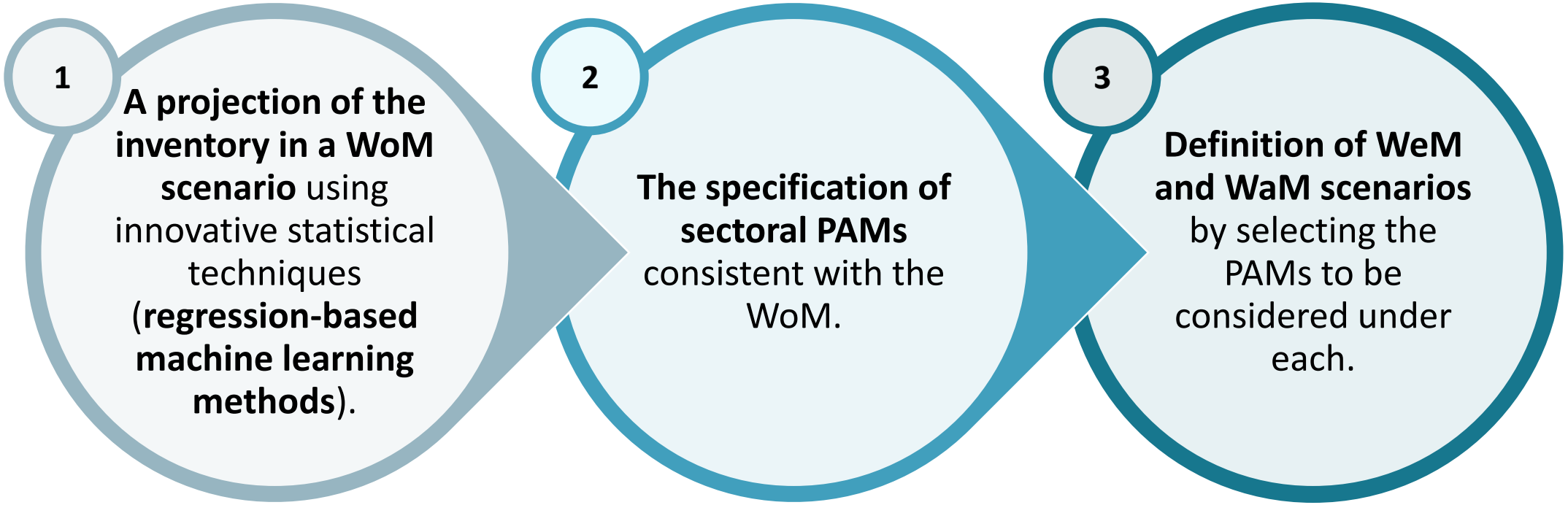
Modelling approach

- The **modelling approach** is organized into three steps:



Further details of the three steps are provided in the following slides.

Modelling approach – projection of the WoM

- Different projection models are offered to make predictions. They are all **designed statistically robust to handle the type of data they will work with**, and in all cases, an automated model is used to generate the best parameter combination to optimize the prediction.

- The projection of the WoM separates **the trend from the noise** of the time series, to address statistical problems that hamper the model specification. Noise are outliers in the training data.

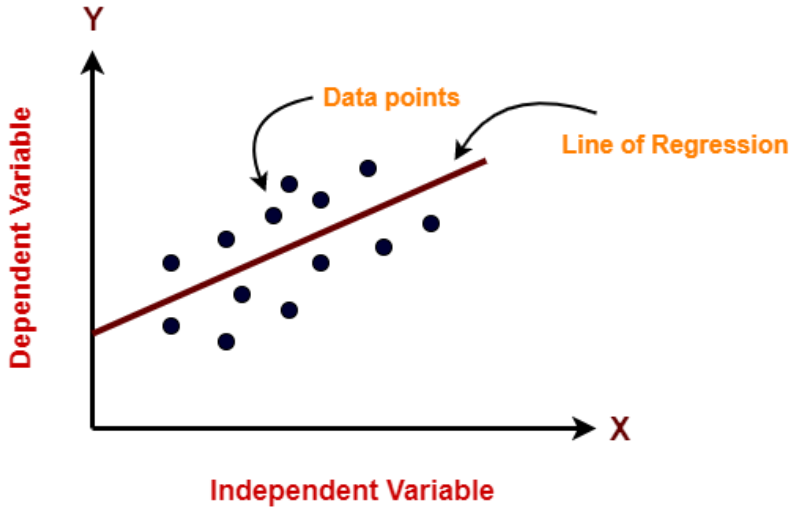
- The modelling approach uses **regression based-machine learning methods**. Longer time series allows the model to be "trained" with more data, leading to better results.

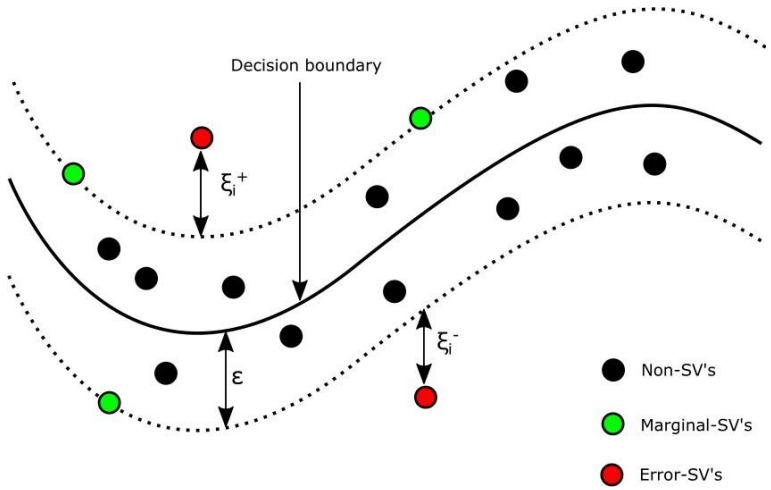
Modelling approach – projection of the WoM

- MITICA offers **classical statistics models** as well as **models that incorporate artificial intelligence**:

- **Classical statistics models take into account all points** in the historical series as well as all proxies.

- **Artificial intelligence models evaluate the predictive capacity of each point or proxy** detecting non-representative points (errors, outliers…) as well as correlated proxies that do not add relevant information and removes them before running their algorithms.





Based on A. Singh et al., 2020.

Modelling approach – projection of the WoM

- Linear regression utilizes a weighting system that **minimizes the amount of unexplained data while maximizing the consideration of each point based on the predictive weight** assigned to them.

- **SARIMAX (Seasonal Autoregressive Integrated Moving Average with eXogenous variables)** is defined as:

$$Y_t = \beta_0 + \beta_1 X_{1,t} + \beta_2 X_{2,t} + \beta_3 X_{3,t} + \ldots + \beta_k X_{k,t} + \theta_1 Y_{t-1} + \theta_2 Y_{t-2} + \ldots + \theta_3 Y_{t-3} + \varepsilon_t$$

Each parameter in the equation playing a specific role:

- Y_t is $the\ endogenous\ time\ series (e.g., GHG emissions)$.
- $X_{1,t}$, $X_{2,t}$,..., $X_{k,t}$, *are exogenous variables (proxies).*
- $\theta_1, \theta_2, \ldots, \theta_p$ $are\ the\ autoregressive\ parameters\ of\ the\ endogenous\ variable\ (GHG\ emissions)$
- $\beta_{1,t}$, $\beta_{2,t}$,..., $\beta_{k,t}$, *are the coefficients associated with the exogenous variables.*
- ε_t *is the error term representing unobserved influences on the endogenous variable*

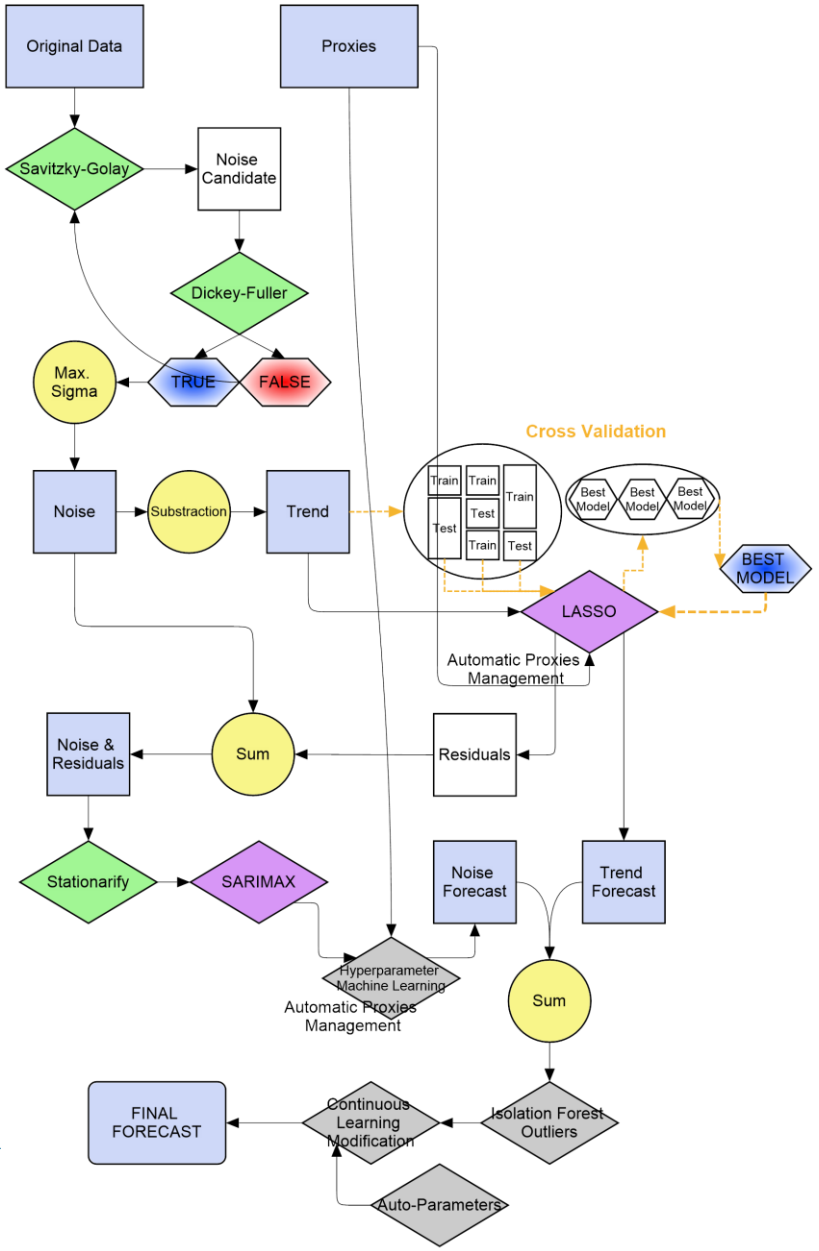
Where each **hyperparameter is automatically determined** by MITICA to optimize results.

Modelling approach – projection of the WoM

- The **performance of SARIMAX is very good** in terms of results when the data and proxies are of very good quality. However, when this is not the case, its predictive capacity is drastically reduced as it is forces to use all the data, and sometimes there are data points that do more harm than adding information.
- **To address this, MITICA utilizes Gradient Boosting Regression (GBR) and Artificial iNtelligeNce And cLassIcal STatistics (ANNALIST)**.
  - **GBR** is a sequential model that generates a new model at each point, improving the weaknesses of the previous model while retaining its strengths. It performs better with larger datasets.
  - **ANNALIST** is explicitly developed for MITICA, taking into account the specific type of data it will use.

Modelling approach – projection of the WoM

- **ANNALIST** makes the best possible separation between **noise and trend**, ensuring certain statistically advantageous conditions to maximize precision.
  - The **trend** is predicted using the **Least Absolute Shrinkage and Selection Operator (LASSO) model**, which allows to find the best-fit model specification (best points and proxies) by IPCC category for projecting the trend.
  - The **noise** is passed through an **optimized SARIMAX model** thanks to the a priori knowledge of proxies and properties derived from the decomposition between noise and trend.
  - **Isolation Forest model for data processing** to learn from each iteration and improves the model step by step.
  - **Random Forest Regression model** to train on historical data and update projections.
  - Hyperparameter optimization is made through **Grid Search CV**.



Modelling approach – projection of the WoM

- **MITICA design the best-fit model by IPCC category learning from the historical data**, defining the best proxies and hyperparameters, to project the GHG emissions of each IPCC category, while meeting the classical model specification requirements (**avoiding heteroskedasticity**, **serial correlation**, and **non-stationarity**).

- Improvements in the projection of the WoM are obtained through **improvements in the input data**, notably in the national GHG inventory and the reported proxies.

- Users are requested to **validate the WoM projection** of each IPCC category. Guidance for validation is provided in the Tool manual.

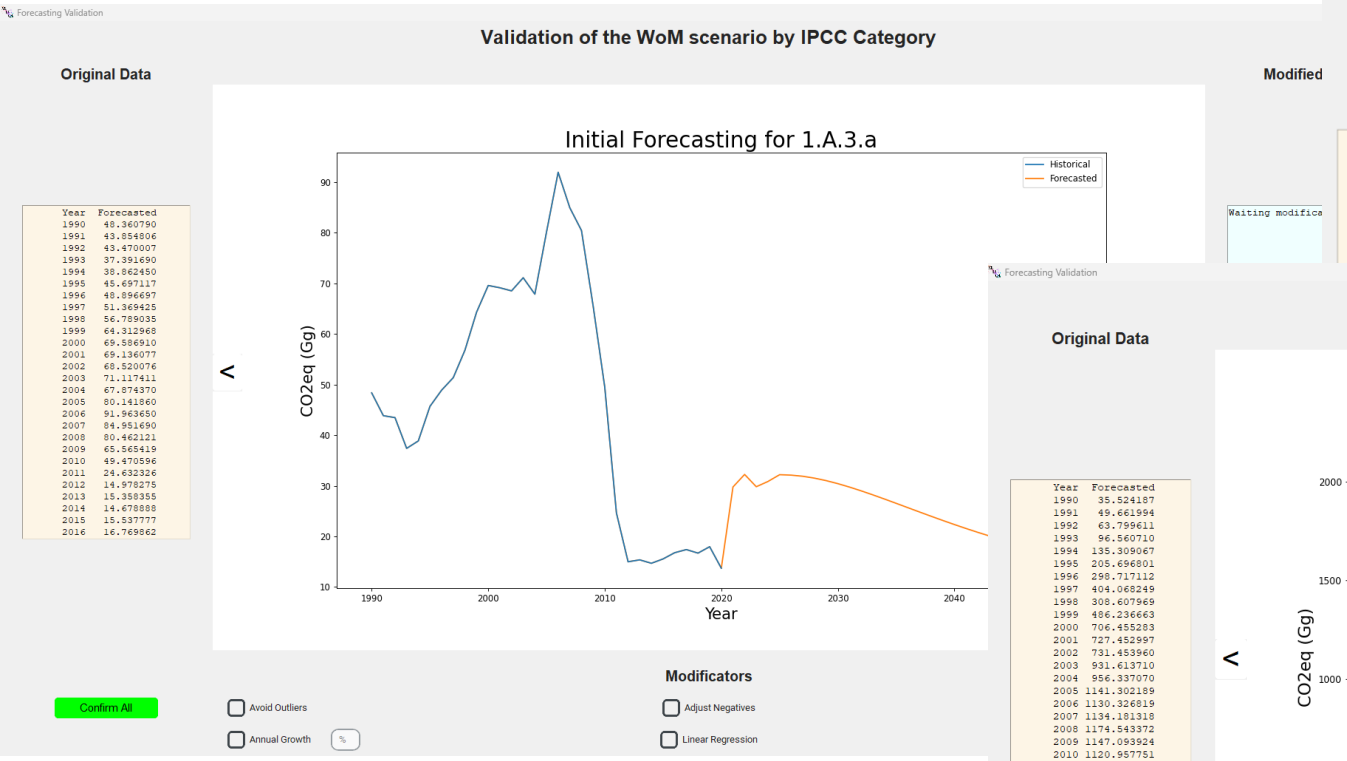
- The statistical techniques used require **minimum characteristics for the computers in which the tool is used**. Alternative statistical methods are provided to reduce the computing load in case of need.

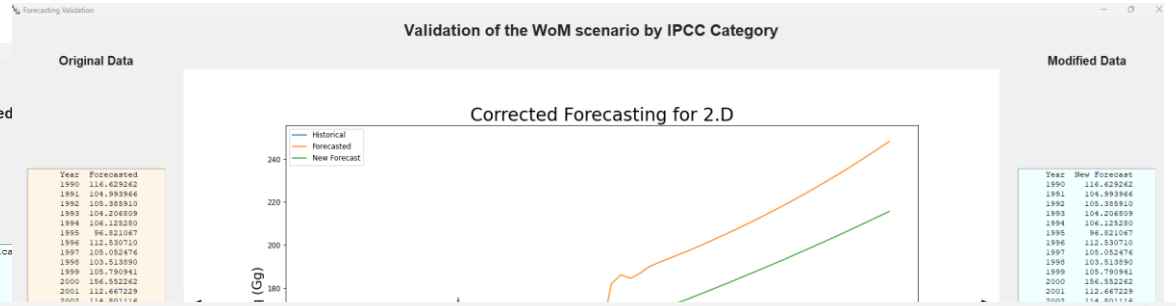
Modelling approach – projection of the WoM

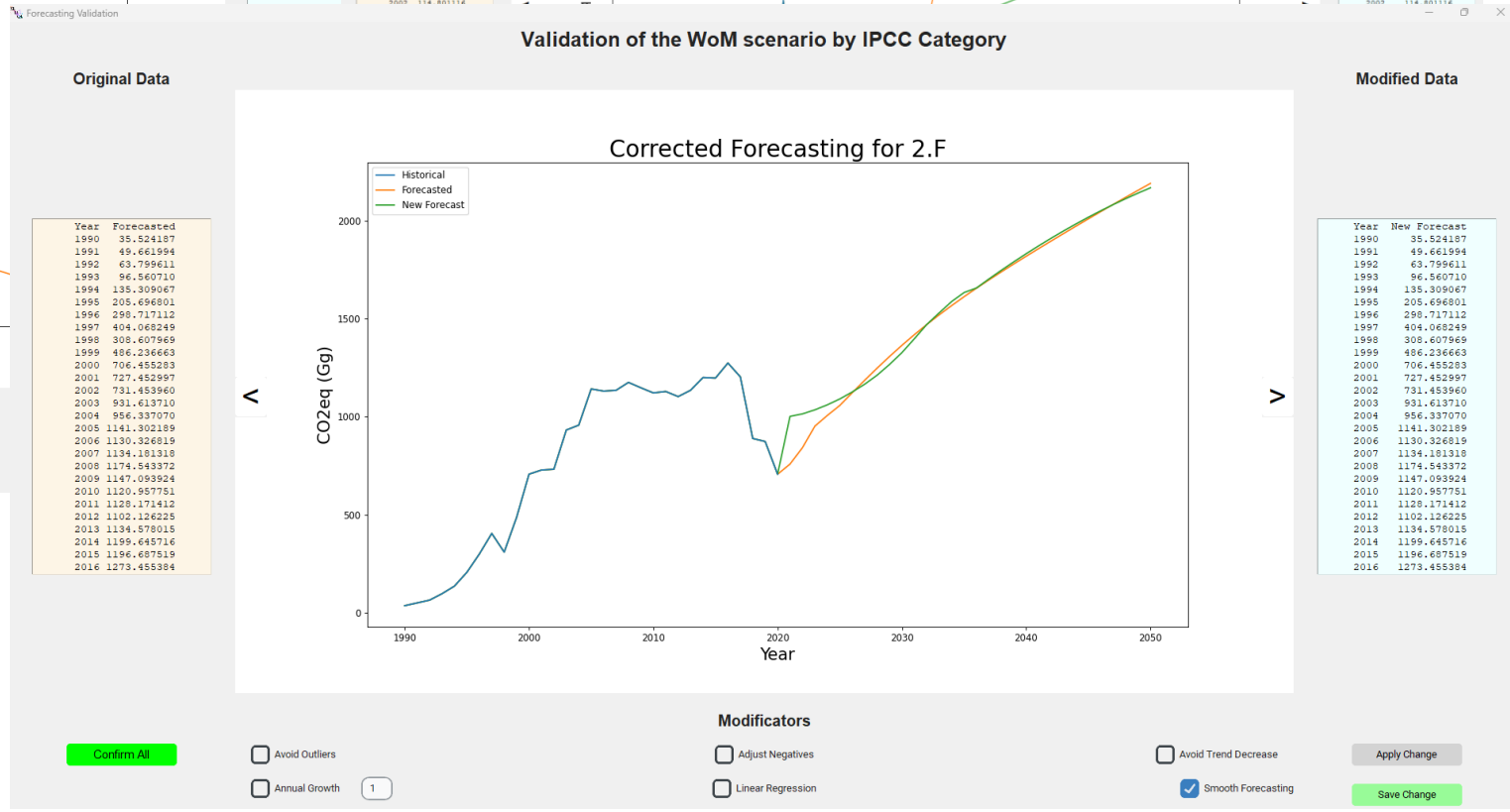
- MITICA generates a **best-fit model** for each category and employs this model to project GHG emissions up to a chosen horizon year.

- Nevertheless, it's crucial for users to **validate the results of the WoM scenario by source/sink category**, making adjustments as needed concerning:
  - **Identification of outliers**
  - **Identification of maximum/minimum values in the time series of GHG emissions**
  - **Identification of structural changes in the historical time series that have not been adequately identified by the model**
  - **Sudden Shifts**
  - **Event Identification**
  - **Data Quality Issues**

Modelling approach – projection of the WoM







Alternative methods to **adjust projections by IPCC category** under certain circumstances: structural breaks in the time series, plants decommissioning, etc.

Modelling approach – specification of sectoral PAMs

- **More than 60 PAMs** with default parameters across IPCC sectors are defined in MITICA. Users need to specify the magnitude and certain parameters to obtain GHG emission results. Default parameters are provided by the tool to allow calculation.

- **PAMs are linked with the IPCC categories estimated in the WoM**. Thresholds are established to avoid reducing more emissions that the estimated at the WoM.

Power Sector
Use of RES for power production
Commissioning of new efficient plants and /or fuel switch to less carbon intensive fuels
Production of electricity from biomass residues
Improvement of the energy efficiency of the electricity grid
Development of advanced metering infrastructure in the electricity grid

Extract from the list of PAMs for the Power sector

- **Additional nationally specific PAMs** can be defined by users within MITICA.

Modelling approach – specification of sectoral PAMs

Industry

Replacement of clinker
physical raw materials

CHP in in

Fuel swit
Natural G

N2O aba
producti

Substitut
low GWP

Livestock and

Improved feed

Feed additives

Optimization
livestock

Longer-term m
animal breeding

Cropland and grassland

Reduced and Zero Tillage

Agronomic practices: Resi
management

Soil and nutrient managen

Biological N fixation in rota
forages

Rice management

Transport

vehicles

ic means or transport

Forestry

Afforestation and reforestation

Restoration of degraded forests

Reducing deforestation

Management of organic/peaty soils

Agroforestry

Modelling approach – specification of sectoral PAMs

- The **general approach** for PAMs assessment can be simplified as follows:

$$ME_{t_i-t_f} = R \cdot M_{t_i-t_f} \cdot [REF_t - MEF_t]$$

Where $ME_{t_i-t_f}$ represents the **Mitigation Effect of the PAM** for the entire projected period,

$M_{t_i-t_f}$ is the **Magnitude** of the PAM representing the **affected activity levels**

R represents the **Reduction factor in magnitude** from PAM implementation,

REF_t stands for the **reference emission factor in the absence of the PAM** at time t,

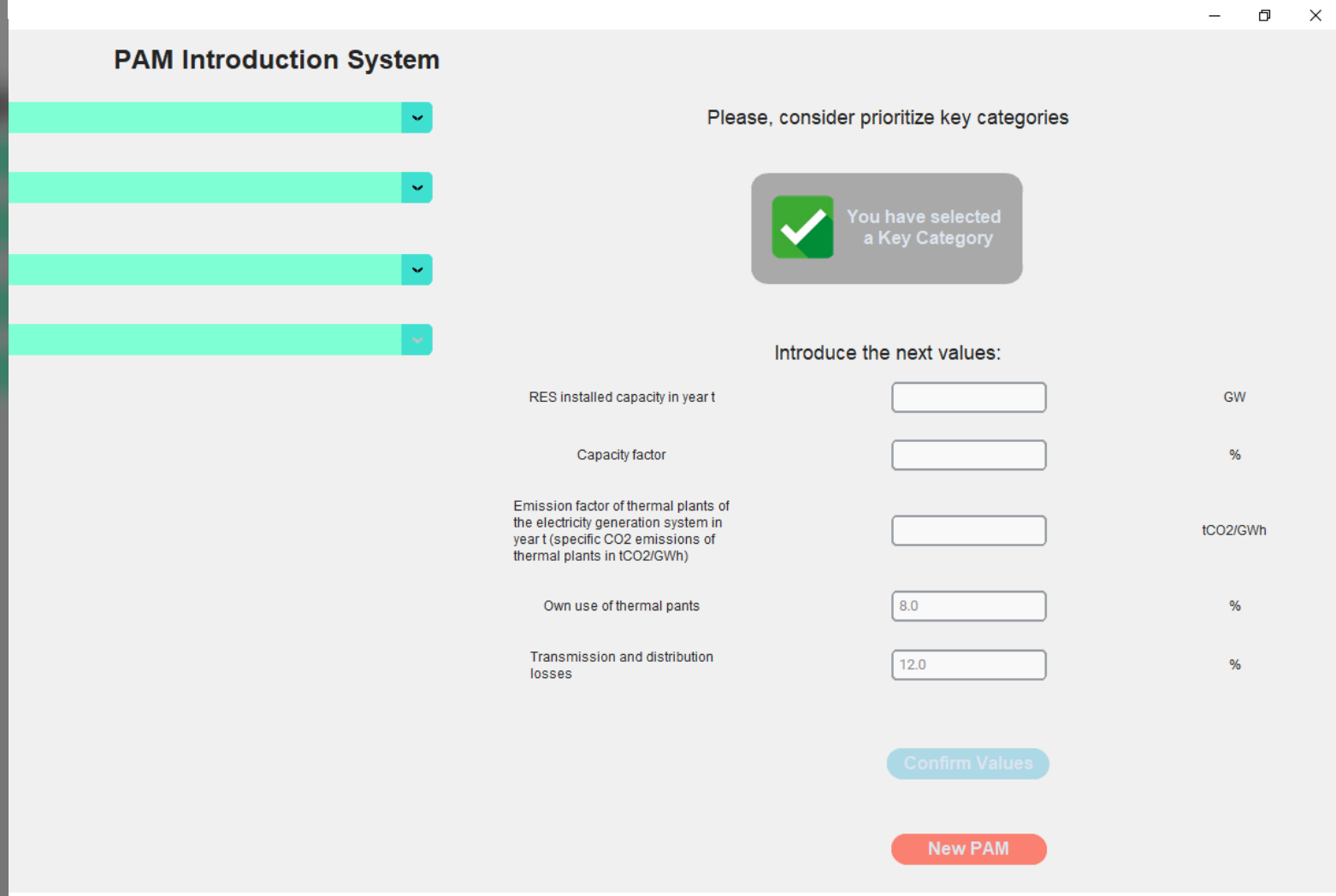
MEF_t is the **mitigation emission factor, post implementation of the PAM** at time t.

- From this generalization, PAM methodologies are specified case by case, and **linked to the reference inventory through the REF**, and **linked to the WoM scenario through $M_{t_i-t_f}$**.

Modelling approach – specification of sectoral PAMs

Modelling approach – PAMs

- All these PAMs are integrated in the tool in a user-friendly way.
- MITICA provides guidance in the tool highlighting certain issues, and providing default values, when applicable.



Modelling approach – specification of sectoral PAMs

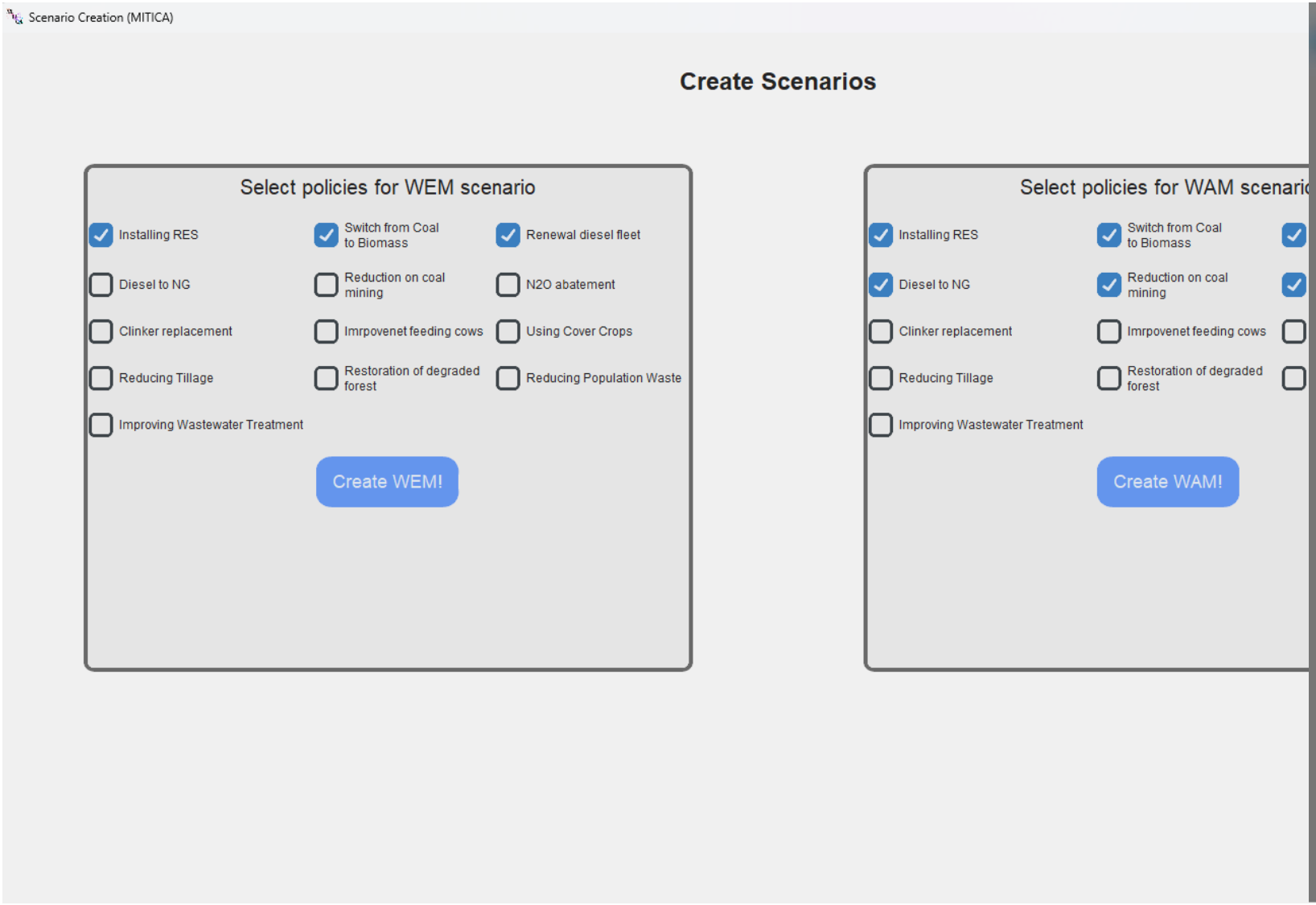
PAMs Manager (MITICA)

Manage your policies!

PAM Name	Category Affected	Total Mitigation Potential	Cost (USD/t)	Total Cost (USD)
Installing RES	1.A.1.a	21900.0 ktCO2eq	11.3	247.47
Switch from Coal to Biomass	1.A.2	2327.35 ktCO2eq	31.6	73.54
Renewal diesel fleet	1.A.3.b	3.51 ktCO2eq	6.7	0.02
Diesel to NG	1.A.4.b	899.17 ktCO2eq	28.6	25.72
Reduction on coal mining	1.B	3.47 ktCO2eq	0.71	0.0
N2O abatement	2.B	936.51 ktCO2eq	3.1	2.9
Clinker replacement	2.A	14700.0 ktCO2eq	6.7	98.49
Imrpovenet feeding cows	3.A	9364.95 ktCO2eq	7.91	74.08
Using Cover Crops	3.D	1600.0 ktCO2eq	0.92	1.47
Reducing Tillage	4.B	426.3 ktCO2eq	2.1	0.9
Restoration of degraded forest	4.A	5074.64 ktCO2eq	27.2	138.03
Reducing Population Waste	5.A	-7076.7 ktCO2eq	1.1	-7.78
Improving Wastewater Treatment	5.D	414.54 ktCO2eq	3.8	1.58

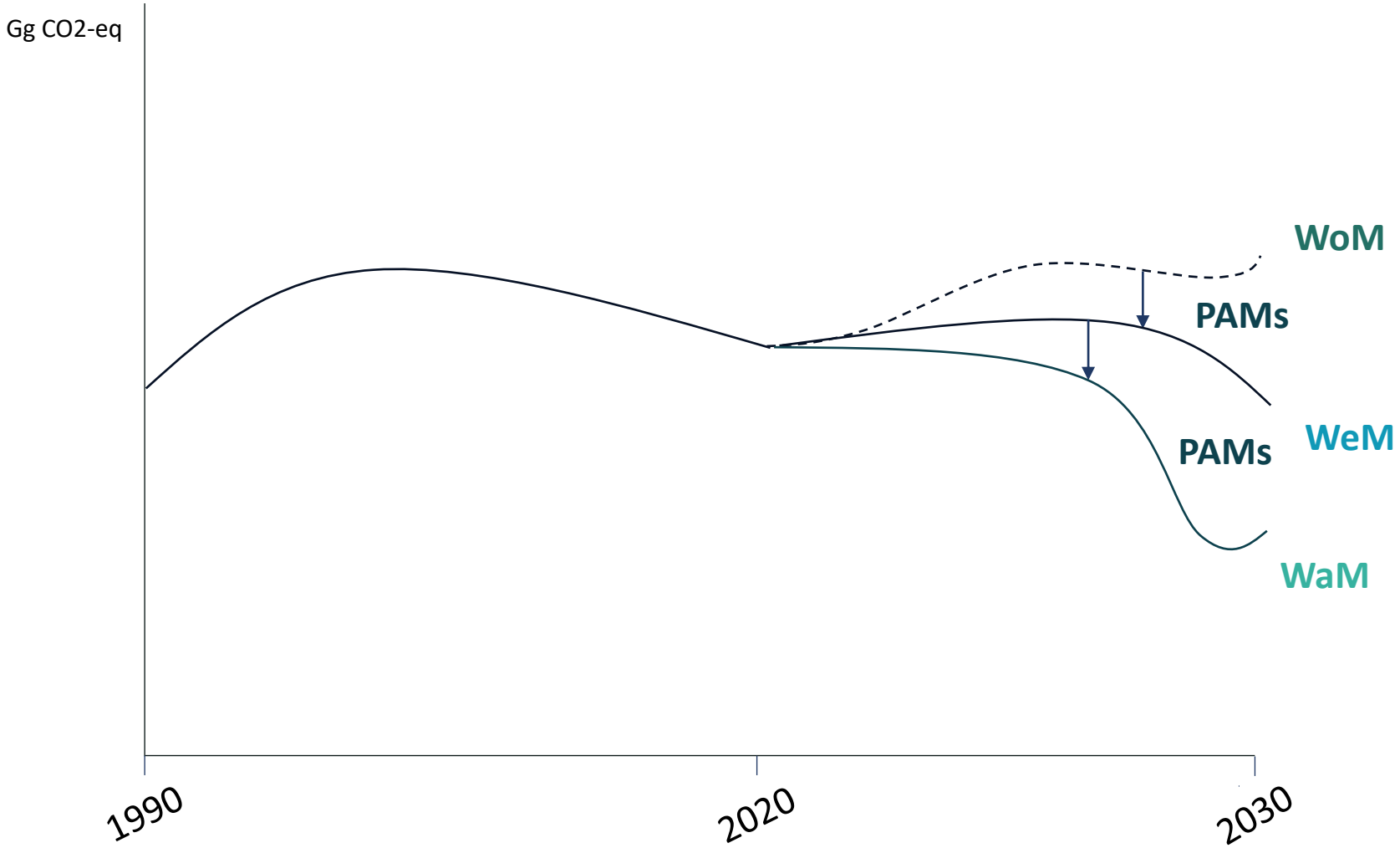
- The PAMs Manager allows to cross-check the PAMs added, and QA/QC the parameters defined.
- Inventory categories affected are always displayed, for easing the understanding of impact in terms of GHG reductions.

Modelling approach – design of WeM and WaM scenarios



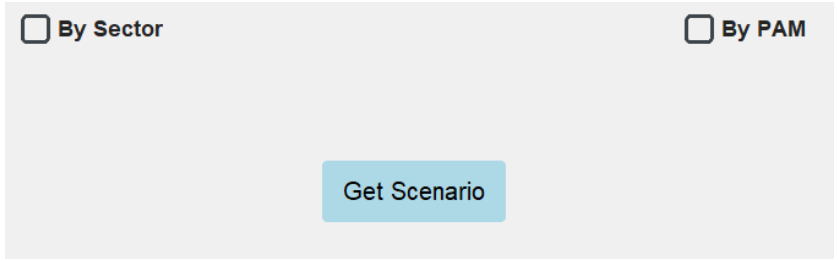
- PAMs are allocated within scenarios to produce the WeM and the WaM, considering the impact of the selected PAMs in line with national needs and priorities.

Results – GHG emission scenarios

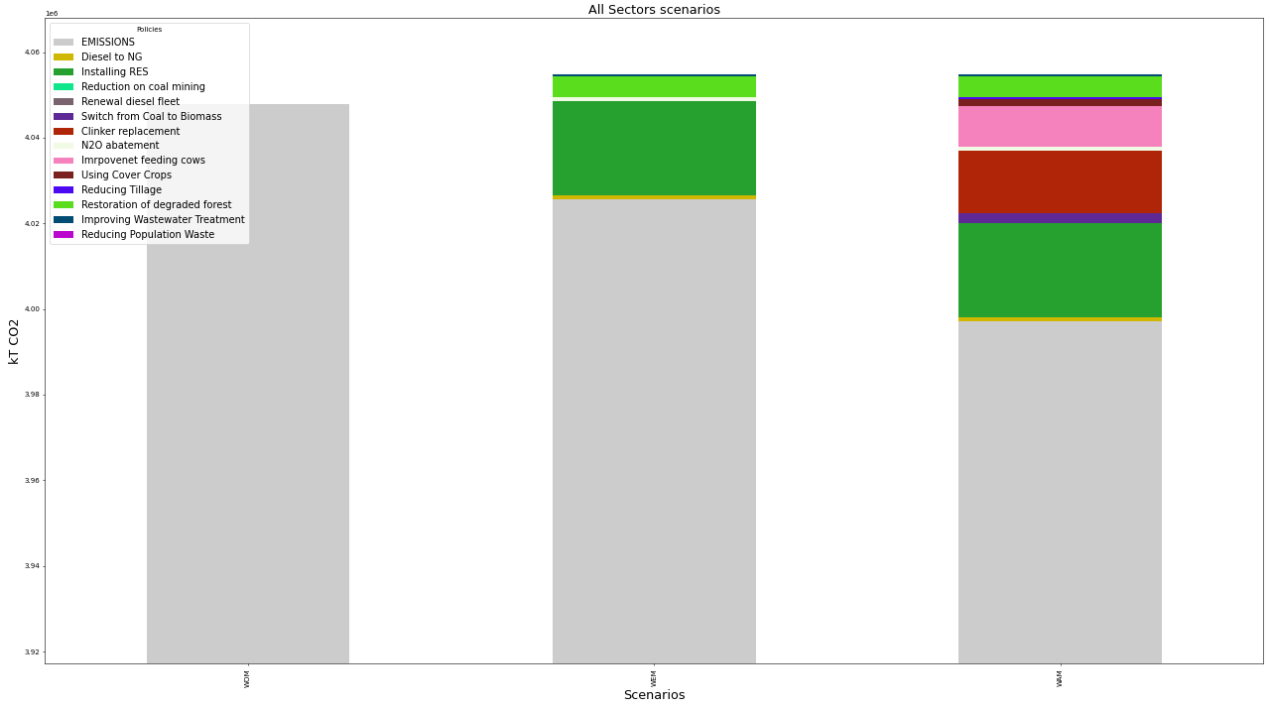


- MITICA allows the user to **extract figures and tables** with the created scenarios, by sector or for the total emissions of the country.
- PAMs results can also be extracted.
- The information exported **allows for reporting under the ETF**.

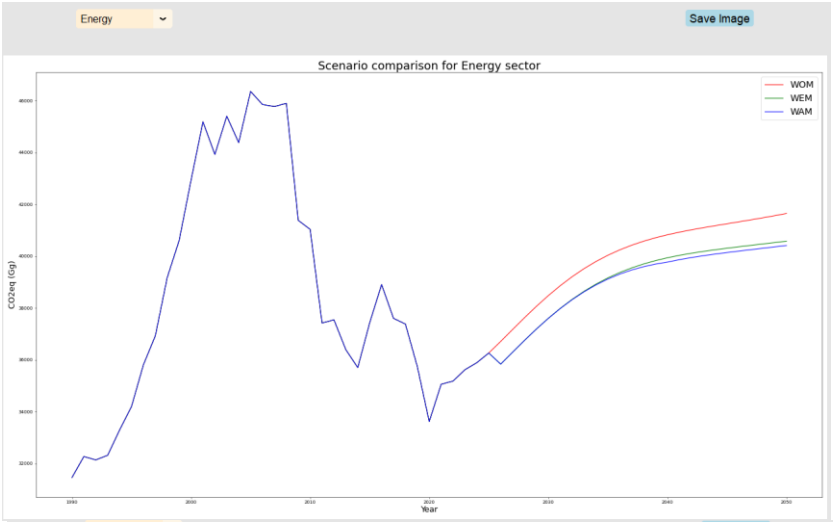
Results – GHG emission scenarios

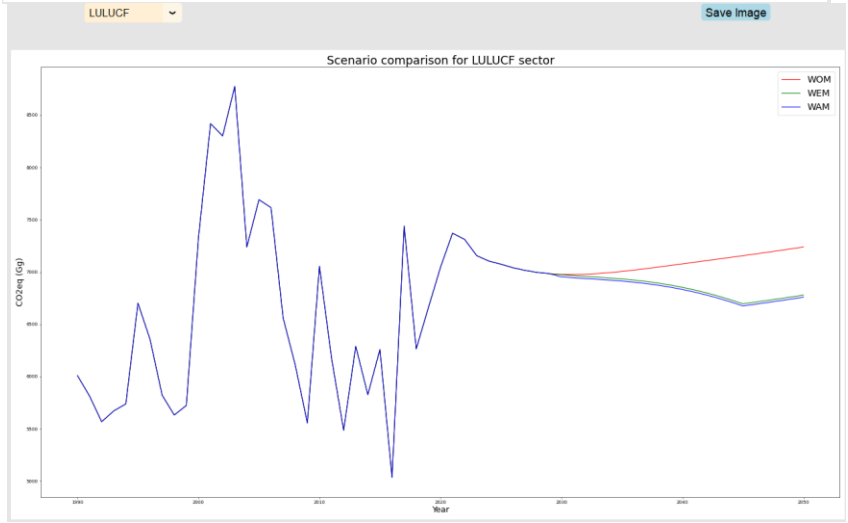


PAMs by Scenario



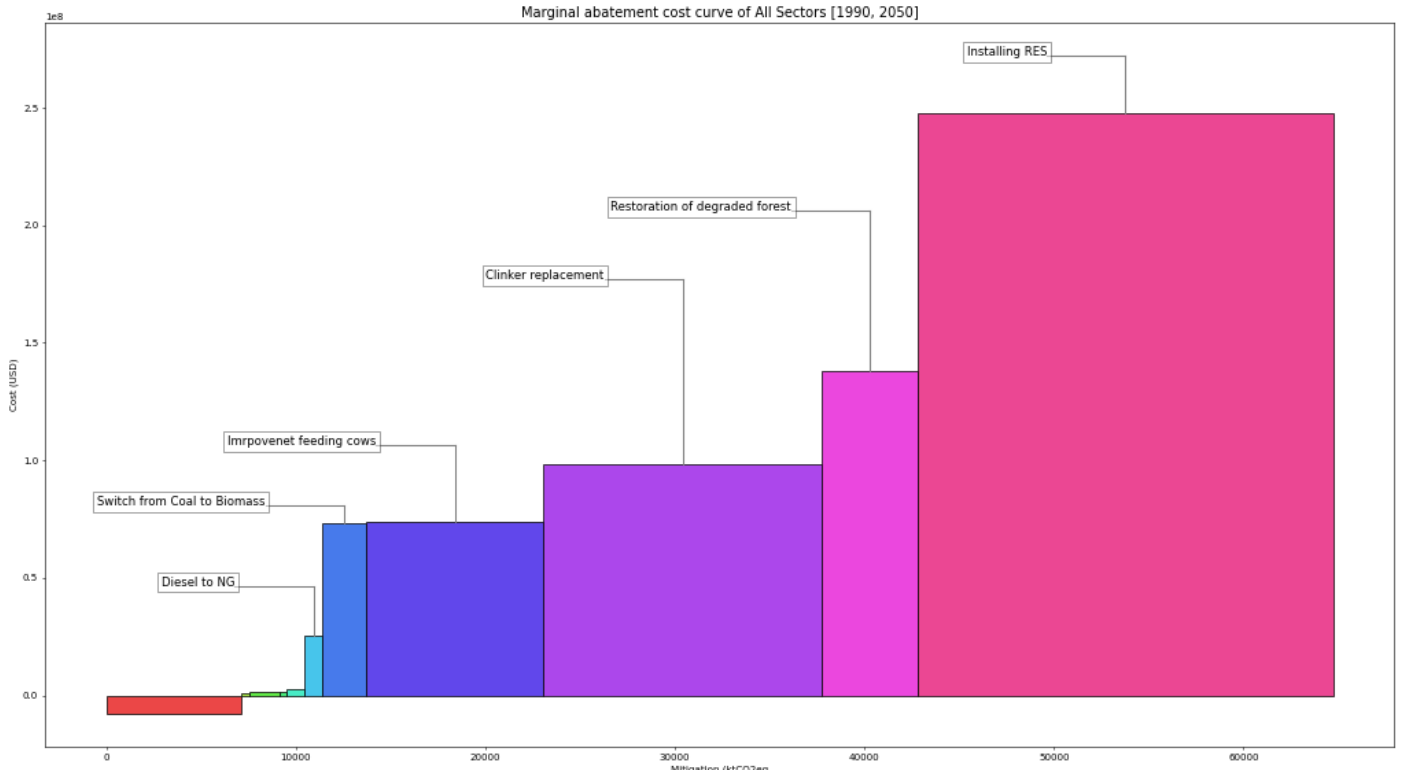
Scenarios by Sector





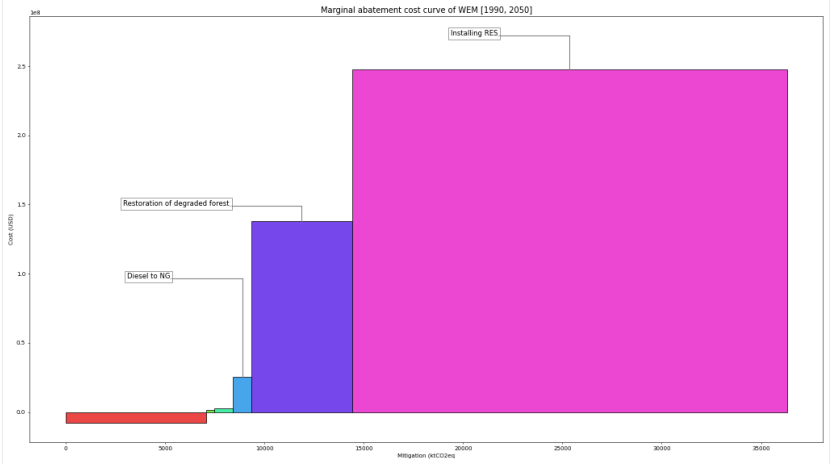
Results – Marginal Abatement Cost Curve (MACC)

MACC by Sector

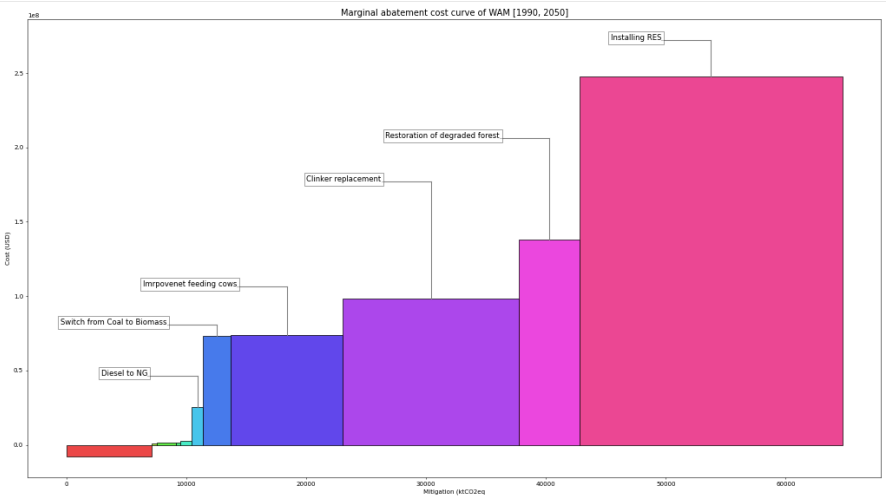


All Sectors

MACC by Scenario



WeM



WaM

Complementarity with other tools

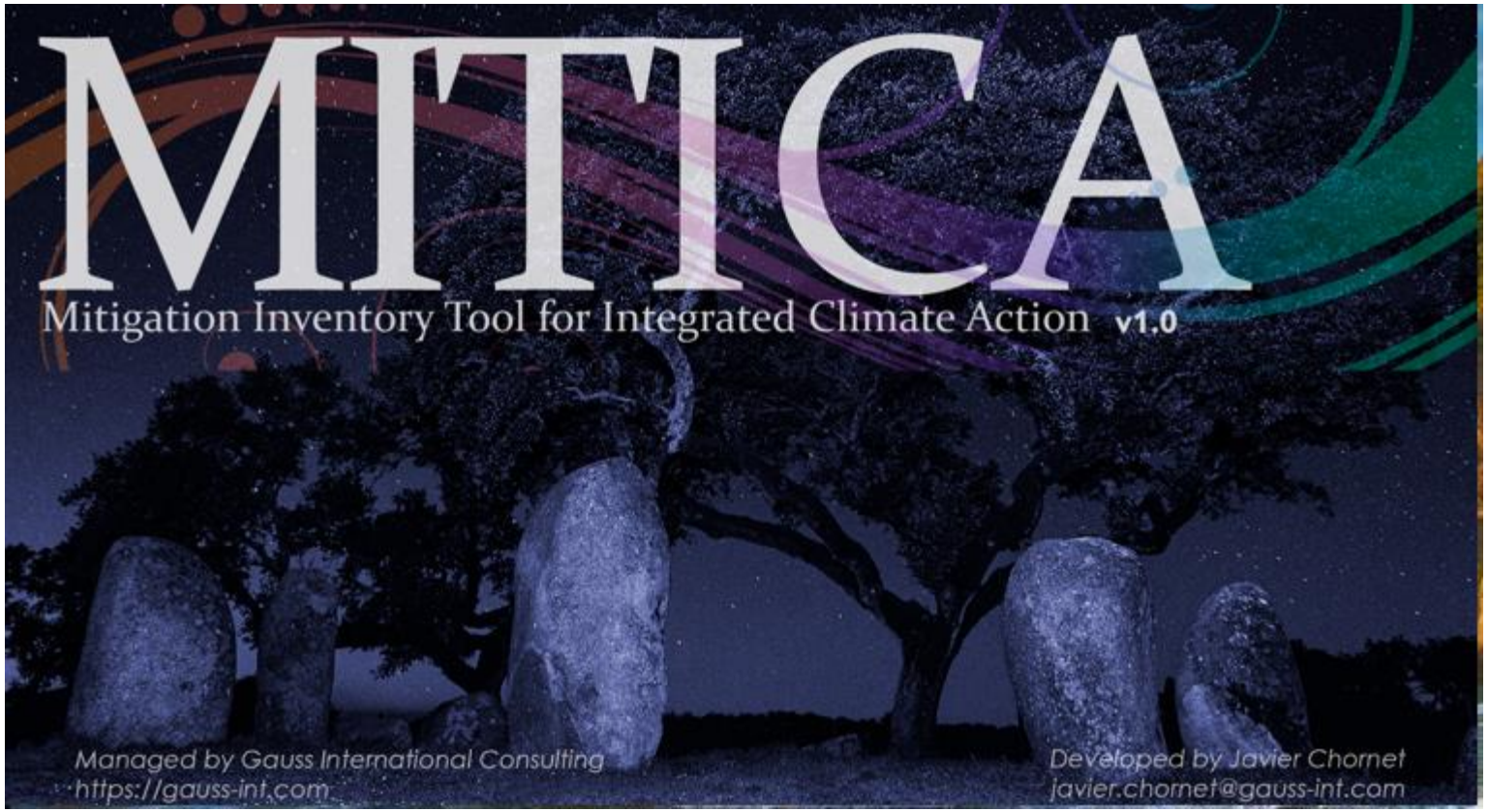
- **With GACMO**: MITICA does not provide costs of PAMs. However, users can input information on costs, using GACMO or other sources as CDM/IPCC databases as a reference. MACC curves are displayed in the dashboard for easy use.

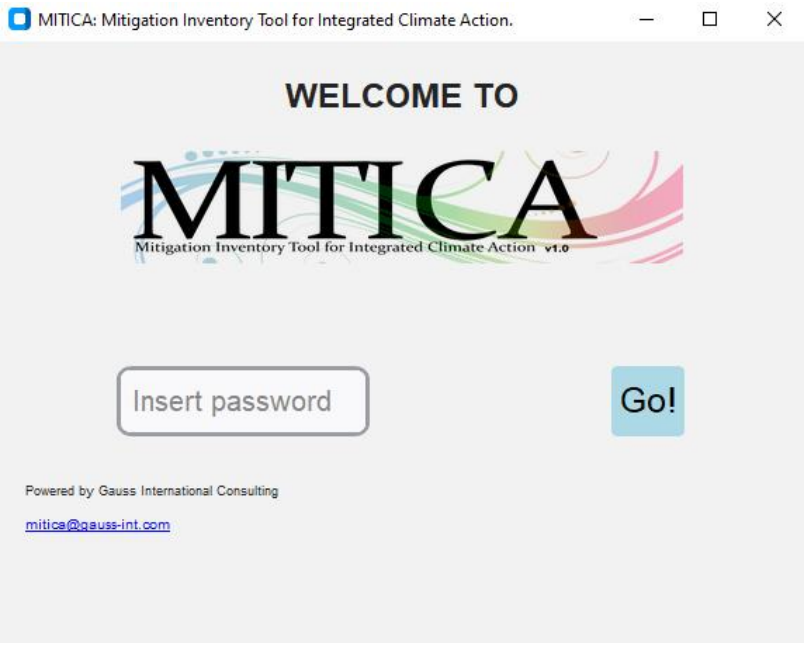
- **With other sectoral approaches**: results from energy planning tools (such as TIMES), Forest & Soil Carbon models, etc can be inputted as proxies to the model, or used for adjusting WoM results. They can also feed the PAMs assessment, when relevant.

Obtaining and using MITICA

- MITICA will be **made available by the Secretariat to UNFCCC focal points upon request**.
- MITICA will also be **available to researchers**.
- MITICA **will not** be shared for commercial purposes.
- Further information: https://gauss-int.com/MITICA

Obtaining and using MITICA

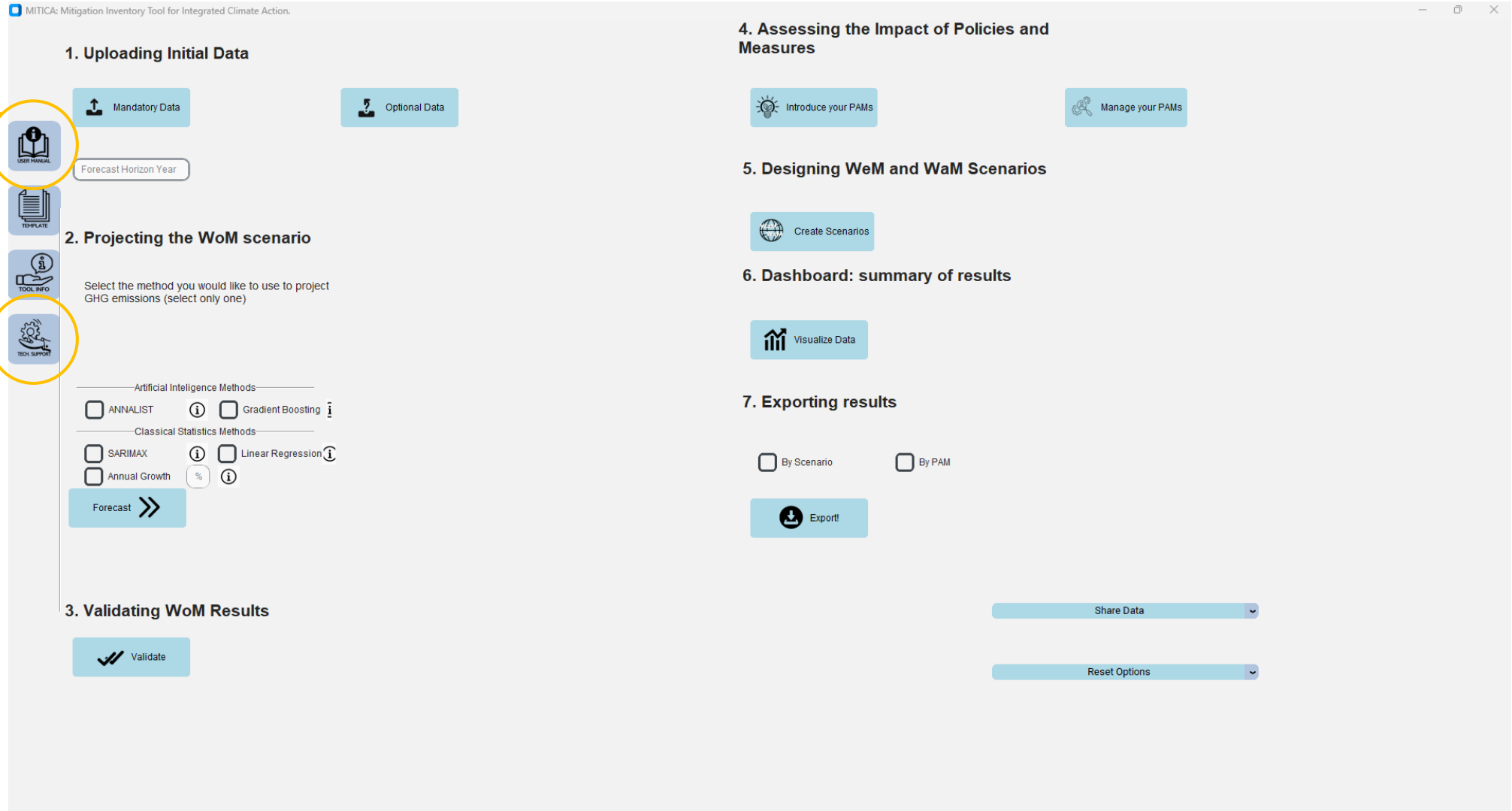




Obtaining and using MITICA

A **user manual** is available providing a step-by-step guide for the tool.

Assistance will be available in case of technical difficulties.



Future Improvements

MITICA has been tested with a number of inventory databases. Further testing and fine-tuning will be implemented in the coming months and years.

Future improvements for MITICA include adding atmospheric pollutants, integrating a back-casting approach, the cost of PAMs, and socioeconomic impact of scenarios.

AGENDA

MITIGATION-INVENTORY TOOL FOR INTEGRATED CLIMATE ACTION

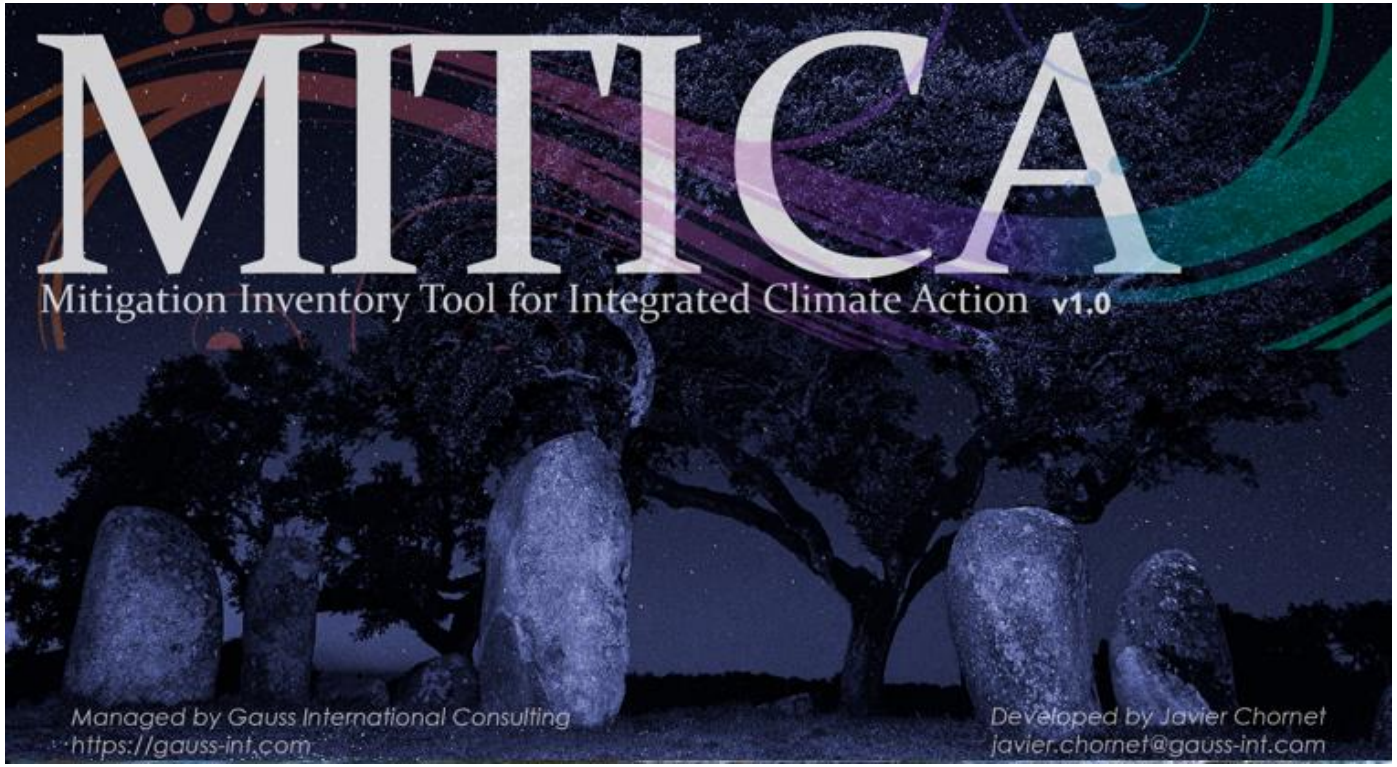
1. MITICA Approach
2. Key Takeaways

Key Takeaways

MITICA places the importance on **the inventory, inventory data, and IPCC guidelines** to estimate consistent GHG emission scenarios for all IPCC sectors.

MITICA leverages existing GHG inventory knowledge and IPCC guidelines to **reduce the burden on developing countries** in capacity building for modelling.

MITICA provides a consistent approach to create GHG emission scenarios which are **understandable, traceable, and easy to use** to design and monitor mitigation targets such as those in NDCs.



Thank you!

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