ADAPTING AI AND TREE GROWTH MODELS FOR SUSTAINABLE FORESTRY IN LITHUANIA

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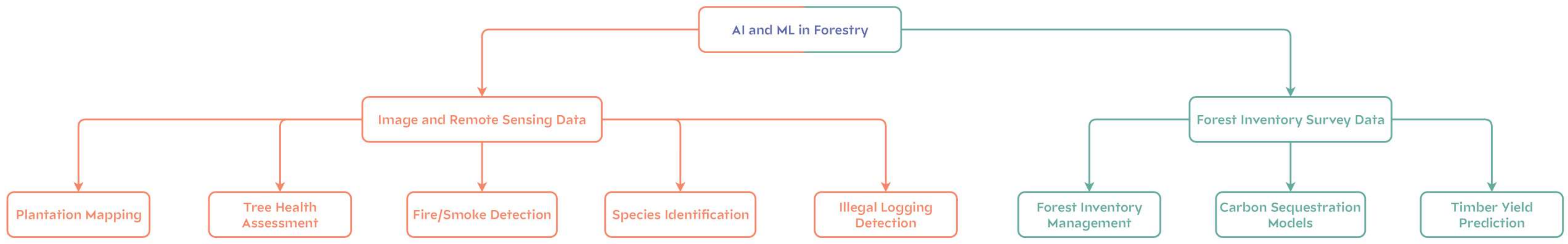
Forest management in Lithuania is focused on sustainable development, balancing economic, environmental, and social objectives. Lithuanian forests, covering approximately one-third of the country's land area, are a critical resource for biodiversity, timber production, carbon sequestration, and recreation. To better understand how forests develop over time and how various factors influence their growth, it is important to identify tree growth functions. These functions are mathematical models that describe the relationship between forest growth and other variables such as age, environmental conditions, and management practices. Additionally, Artificial Intelligence (AI) plays a crucial role in forest planning and management due to its ability to process large datasets, enhance decision-making, and improve sustainability practices. AI and Machine Learning (ML) are extensively used in forestry, as these methods enable the analysis of large datasets, including climate data, soil conditions, and historical forest management records, to optimise forest operations.

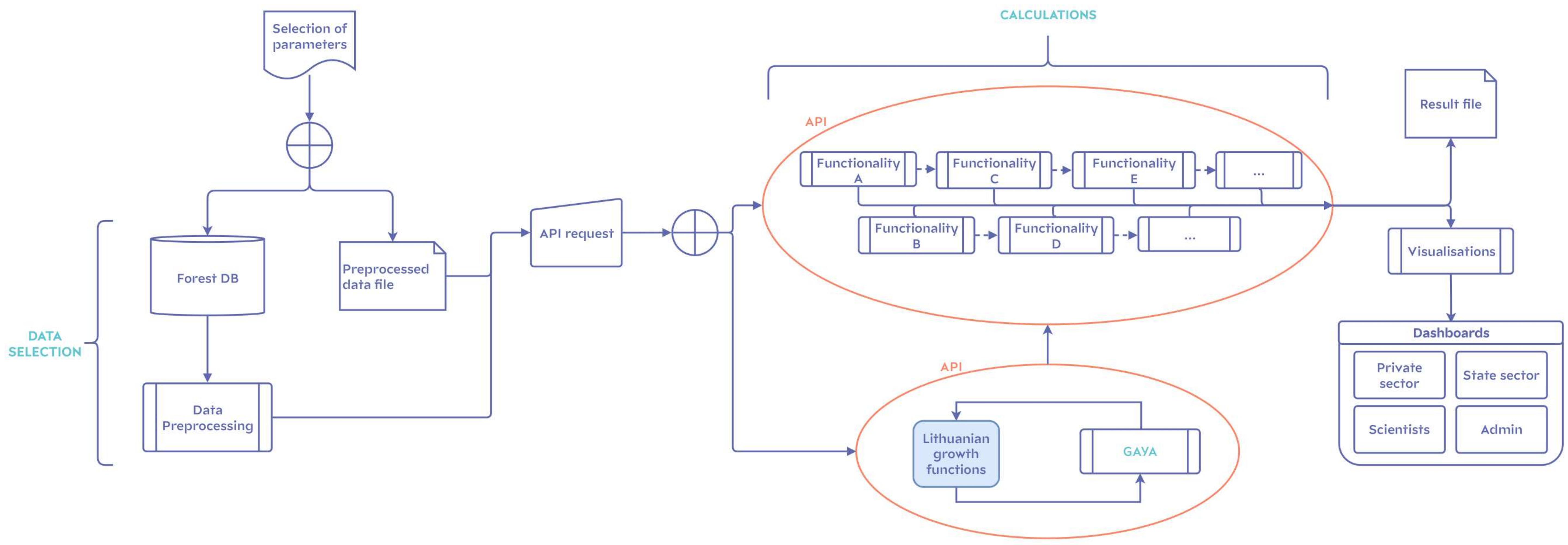
THE AIM

This research aims to develop tree growth functions for Lithuanian forests and extend the GAYA stand simulator to new contexts, adapting it to Lithuanian conditions and reflecting the country's unique compositions of species and ecological conditions.

KEY RESEARCH PROBLEMS ADDRESSED BY AI AND ML IN THE FORESTRY SECTOR



FRAMEWORK OF ADAPTING GAYA FOR LITHUANIAN FORESTRY



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LITHUANIAN TREE GROWTH FUNCTIONS

Mean height increment

$$Z_{HA_{+n}} = H_{A_{+n}} - \frac{H_A \cdot G_A - H_{OKA} \cdot G_{OKA}}{G_A - G_{OKA}}$$

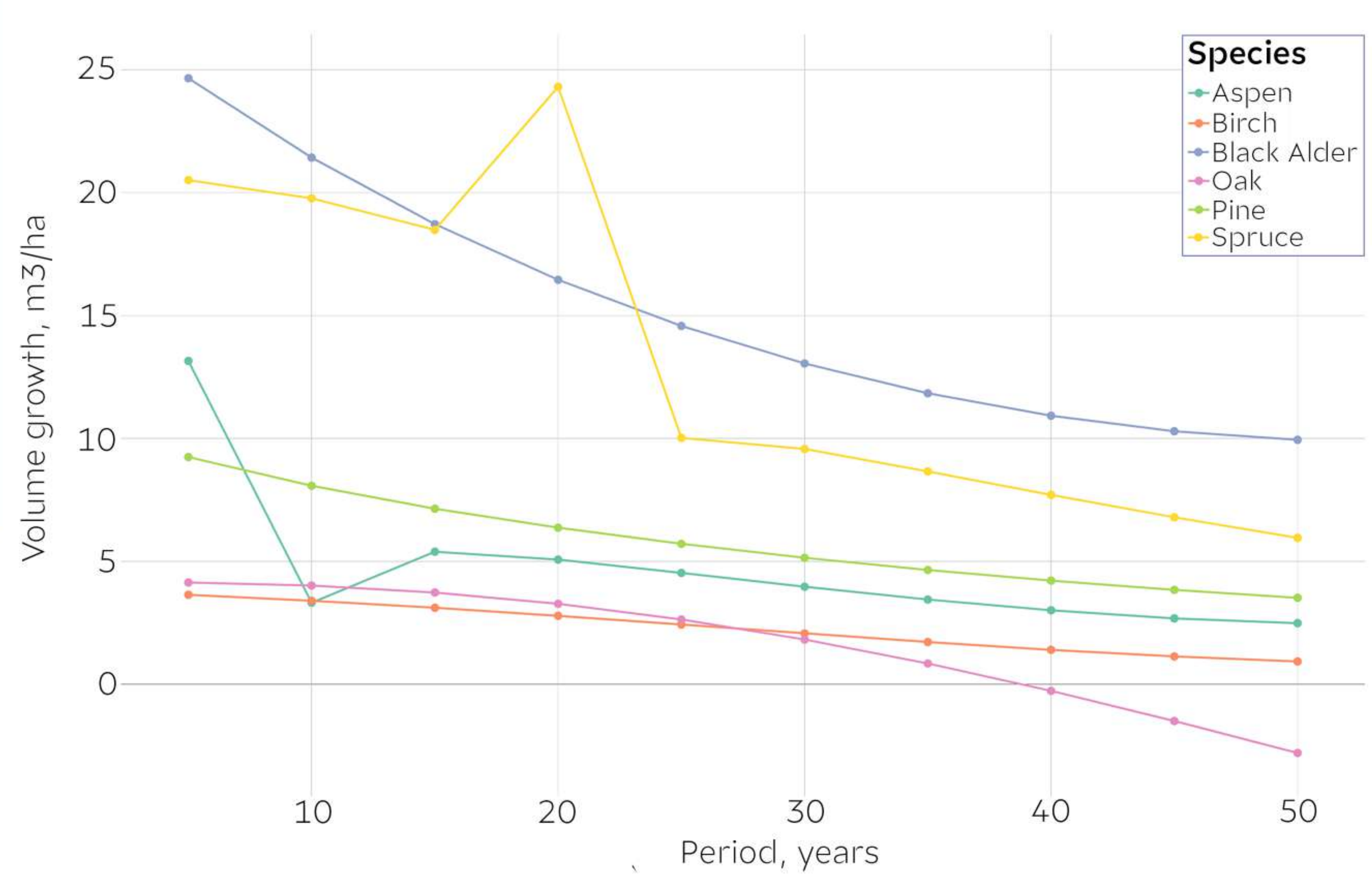
$H_A, H_{A_{+n}}$ – mean height (m) of trees at ages **A**, A_{+n};
G_A – basal area of living trees at age **A**, m2/ha;
H_{OKA} – average height (m) of trees that have died or been felled in intermediate cuttings;
G_{OKA} – total basal area of trees that have died or been felled in intermediate cuttings over **n** years, m^2/ha.

Portion of volume change accumulated over n years

$$\Delta_M = \frac{Z_{MA_{+n}} - M_{OA} + M_{KA}}{n}$$

M_{OA} – the most likely volume of dead trees or removed by intermediate felling, averaged over **n** years, m3/ha;
M_{KA} – the actual volume of trees felled in intermediate fellings over n years. The data is provided by the forest manager.

Tree volume growth by species



Gross increment of growing stock volume over n years, m3/ha

$$Z_{MA_n} = \frac{M_{A_{+n}} - m_A}{10} \cdot n$$

$M_{A_{+n}}$ – volume of tree stems at age A_{+n}, m^3/ha;
m_A – volume of tree stems, survived up to now, at age **A**, m^3/ha;
n – period, years.

Mean tree diameter increment (with bark) over n years, cm

$$Z_{DA_{+n}} = a \cdot D_{AB}^{a1} \cdot X_{A_{+n}}^{b \cdot D_{AB}^{b1}} \cdot e^{c \cdot X_{A_{+n}}} \cdot D_{A_B}^{c1} \cdot E \cdot 1 + \frac{A - X_{A_{+n}}^{B}}{C}, \quad X_{A_{+n}} = \frac{D_{A_{+n}}}{D_{A_B}}$$

$a, a_1, b, b_1, c, c_1, A, B, C, E$ – coefficients of regression and adjustments for climate change and other long-term impacts on forest stand growth, depending on tree species, year, and cultivation regime;
$D_{A_{+n}}$ – mean diameter (cm) of living trees at age A_{+n};
D_{A_B} – site productivity index based on the diameter growth of the forest stand's trees.

FUTURE PLANS

We are currently developing on GAYA's existing capabilities by adapting it to Lithuanian forest conditions and a wide range of input formats, and incorporating AI-driven functionalities that will allow users to conduct even more refined planning and analysis. The integration of AI algorithms will enhance GAYA's predictive and optimization features, making it a more powerful tool for forest management to deliver better balanced baskets of multiple ecosystem services. The decision support system is expected to become a central feature of forest sector modeling infrastructure, which will be validated in Lithuania, however, suitable for any international adaptation.

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