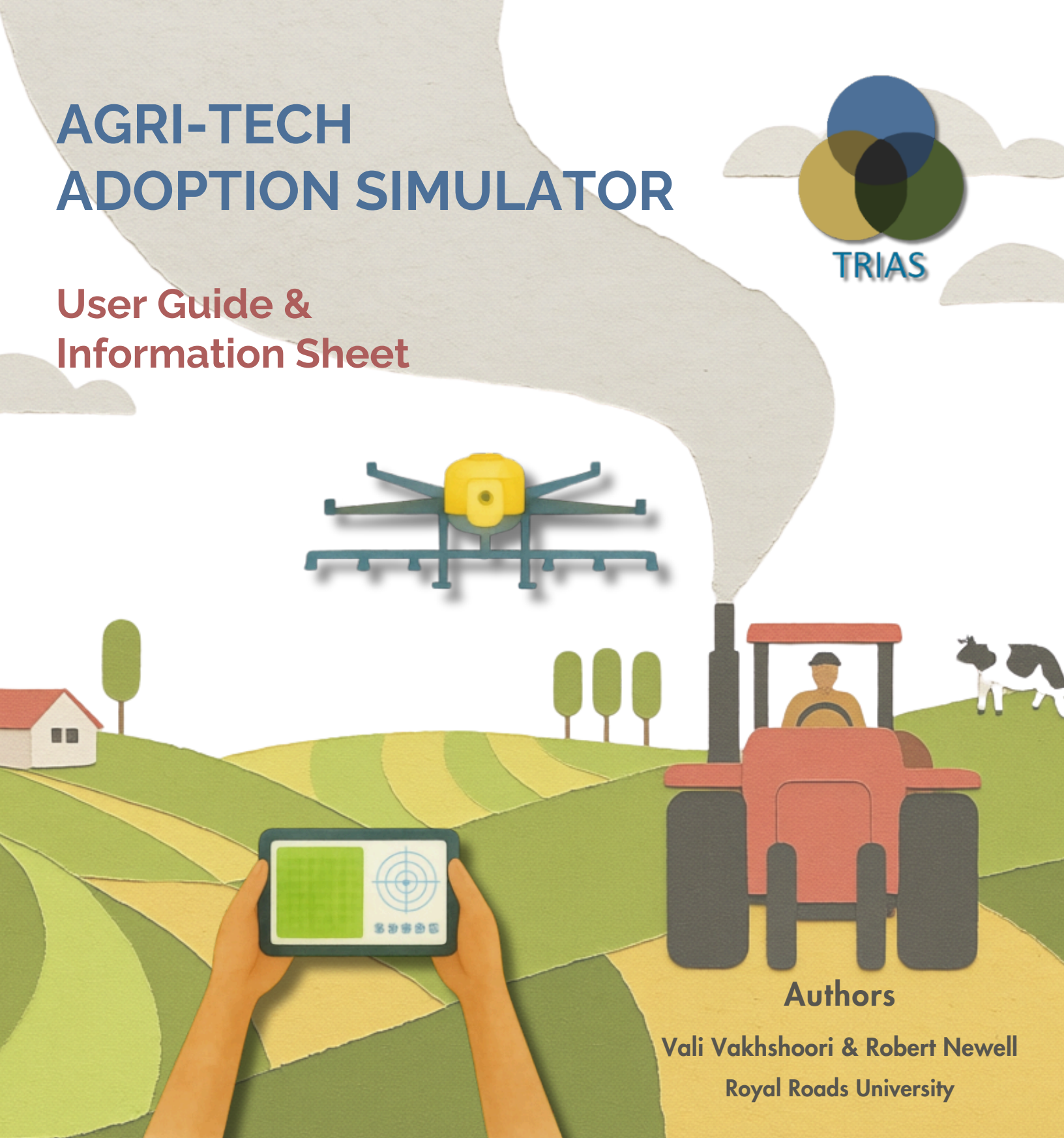


AGRI-TECH ADOPTION SIMULATOR

User Guide & Information Sheet



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1. Purpose and objective of the tool

The **Agri-Tech Adoption Simulator (ATAS)** is a tool designed to help researchers and policymakers understand how different policy interventions and farmer/farm characteristics influence the probability of adopting agricultural technologies (i.e., agri-tech). **ATAS** specifically focuses on technologies in the areas of:

- Digital agriculture
- Controlled environment agriculture
- Agri-genomic technologies

ATAS simulates the likelihood of agri-tech adoption based on:

- the type of agri-tech to be adopted,
- whether climate and geopolitical conditions will result in increased or decreased production,
- the types of policies that are in place to incentivize adoption, and
- the socioeconomic characteristics of the local farmer population.

2. How the Model Works

ATAS estimates the likelihood that a farmer, given a specific socio-economic profile, will adopt a particular agri-technology under defined policy and scenario conditions. The system is based on an ensemble of machine learning models (using random forest techniques) and is trained on survey data collected from farmers in British Columbia.

The models are trained using selected socioeconomic variables as predictors of adoption. The user can control these variables, as well as the conditions for adoption (agri-tech type, expected future production trends, and implemented policies). Based on these inputs, **ATAS** creates an ensemble of the top 20-performing random forest models, and the outputs from these models are used to estimate the probability of agri-tech adoption.

3. How to access the tool

ATAS is publicly available via: <https://agritech-adoption-app.streamlit.app/>

The tool is accessed and used in a web browser. A screenshot of the application's interface is shown in Figure 1.

Figure 1. **ATAS** online web application interface

1. Configuration

Agri-Technology
Digital

Production Scenario
Decrease

Policy
Financial

2. Socioeconomic Profile

Age: 45 - +
Total area: 2 - +
Employee number: 2 - +
Farm Revenue: Under \$10k
Assets Value: Under \$100k
Hours on Farm: Fewer than ...
Hours OFF Farm: None
Education: No certificate
Gender: Men
Immigration: No
Indigenous: No

Run Ensemble Prediction

> Batch Processing (16 Scenarios for Digital)

4. How to use the application

The application consists of four components:

- A. Configuration**
- B. Socioeconomic profile**
- C. Results**
- D. Batch processing**

A. Configuration

The Configuration panel is located on the left-hand side of the interface (see Figure 1). It includes three dropdown menus:

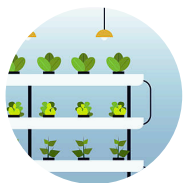
- Agri-technology
- Production scenario
- Policy

Agri-technology:

The agri-technology dropdown box is used to select the type of agricultural technology for which the adoption probability will be estimated. The available options include:



- **Digital agriculture:** This form of agri-tech consists of digital tools for improving farm management and decision-making. Examples include farm management software, sensors, GPS-based precision agriculture, satellite and drone imagery, and data-driven analytics.



- **Controlled environment agriculture:** This form of agri-tech produces crops in indoor environments, where factors such as temperature, humidity, light, and water are controlled to enable year-round production. Examples include greenhouses, vertical farming systems, hydroponics, and climate-controlled facilities.



- **Agri-genomic technologies:** Agri-genomics uses genetic approaches to improve crop traits such as yield, disease resistance, drought tolerance, and nutritional value. Technologies include DNA sequencing, genetic markers, and gene editing.

Production scenario

The production scenarios represent potential changes in farm production conditions due to environmental, economic, or policy-related factors. For example, climate change will adversely affect food production in some areas, while offering new agricultural opportunities in other areas due to (for instance) increases in growing days and frost-free days. The production scenarios are used to simulate a farmer's likelihood of adopting a given technology, which may change under declining production conditions (stress scenario) or improving production conditions (growth scenario). Accordingly, **ATAS** simulates two production scenarios:

Increase scenario











Decrease scenario



Policy:

The Policy dropdown box presents 8 types of policy interventions that may influence farmers' adoption decisions. These policies represent different forms of institutional and governmental support mechanisms. A list and description of these policies is provided in Table 1.

Table 1. List of eight policies included in the policy tab under configuration section of the app.

Policy	Description
 Financial	Financial support (e.g., incentives, subsidies, cost-share programs)
 Education	Education and training programs (e.g., workshops, online courses)
 R&D	Research and development support
 Market	Improved market access (e.g., direct-to-consumer platforms, export aid)
 Infrastructure	Infrastructure development (e.g., broadband Internet, food storage and distribution facilities)
 Risk management	Risk management support (e.g., enhanced crop insurance, price protection)
 Technical	Technical support or advisory services (e.g., expert consultations, troubleshooting helplines)
 Data regulations	Regulations for increased data security, privacy and ownership

B. Socioeconomic Profile

In this section, users input the socioeconomic characteristics of a farmer and their farm. These inputs are used by the machine learning models to estimate the probability of agri-tech adoption based on socioeconomic and demographic characteristics. Depending on the agri-tech, production scenario, and policy options selected in the Configuration panel, some variables may be activated (i.e., available for inputs) or deactivated (i.e., greyed out).

- **Active variables** are included in the model because they have been found to influence predictions under the selected agri-tech, production, and policy scenarios.
- **Inactive variables** are not used in the model, as they have been found to have no influence under the selected agri-tech, production, and policy scenario conditions.

For the active variables, **ATAS** users can enter information about both farmers and farms. Such information includes:

Farmer variables:

- Age
- Gender
- Immigration status
- Indigenous status
- Education
- Hours on farm (number of hours a farmer works on the farm per week)
- Hours off farm (number of hours a farmer works off farm)

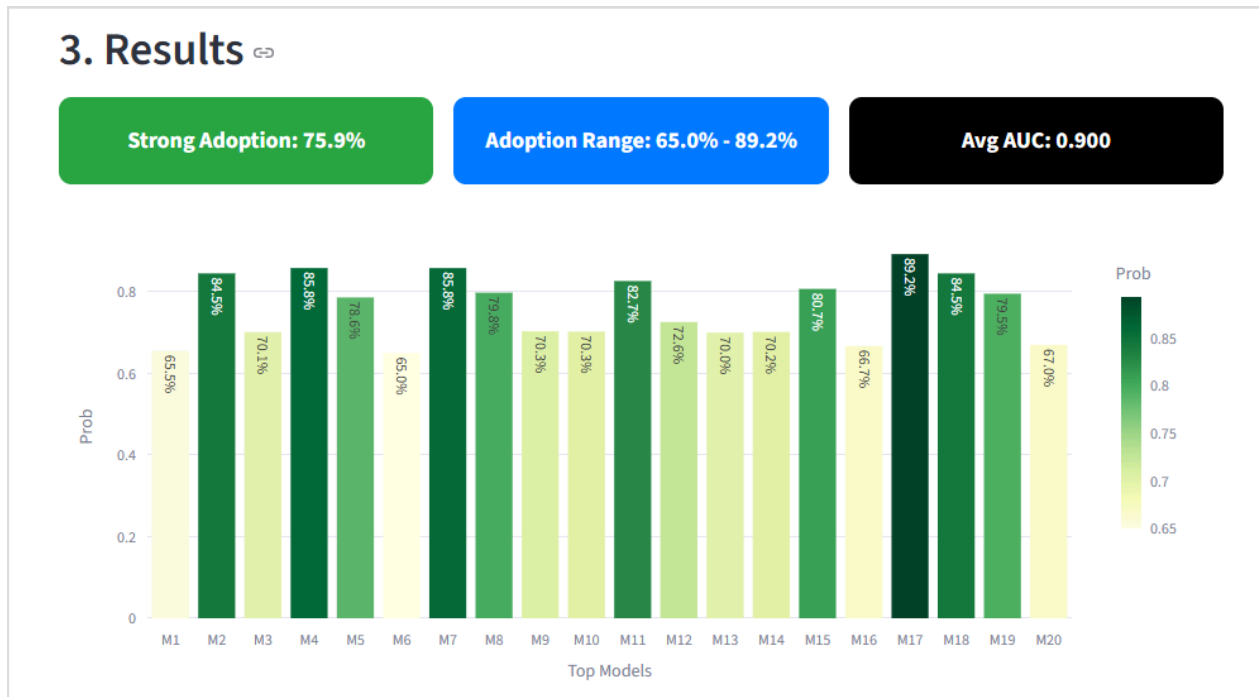
Farm variables

- Total farm area
- Number of employees
- Farm revenue
- Asset value

C. Results (which appear after running ensemble prediction)

The Results section appears after the user clicks the “Run Ensemble Prediction” button (see Figure 2). The model produces three outputs: adoption probability, uncertainty range, and model performance.

Figure 2. Example of **ATAS** results for digital agriculture adoption under a decrease in production and financial policy scenario



- **Adoption probability (green box):** The adoption probability value represents the likelihood that a farmer will adopt a particular type of agri-tech under a certain production change and policy scenario. The value is expressed as a percentage ranging from 0% to 100%, with 0% indicating no likelihood of adoption and 100% indicating a (virtually) certain likelihood of adoption.
- **Uncertainty range (blue box):** The uncertain range value captures the variability in predictions across the ensemble of models. The value is reported as the minimum and maximum adoption probabilities, derived from the individual models in the ensemble. A wider range indicates greater discrepancies between models, suggesting higher uncertainty in the prediction.
- **Model performance (black box):** Model performance is evaluated using the Area Under the Receiver Operating Characteristic Curve (AUC) metric. AUC values range from 0.5 to 1.0, and values closer to 1.0 indicate better model performance. The AUC value displayed in the **ATAS** interface represents the average AUC across all models in the ensemble and reflects the model’s ability to correctly distinguish between adopters and non-adopters.

D. Batch Processing

The batch processing feature allows users to upload and analyze multiple farmer profiles simultaneously. This feature automatically evaluates all combinations of scenarios and policies for a selected agri-tech type. For each dataset upload, both production change scenarios and all policy types are simulated:

- 2 production scenarios × 8 policy types = 16 simulations

Users can upload an Excel or CSV file with the farmer profiles by clicking the “Upload” button in the “Batch Processing” panel (click the arrow icon next to “Batch Processing (16 Scenarios for Digital)” to open/close the panel). Note that the input file must follow a specific format, as shown in Figure 3.

Figure 3. Example input file structure for batch processing.

	A	B	C	D	E	F	G	H	I	J	K
1	Age	Total_area	Employee_number	Total_revenue_enc	Assets_value_enc	Hours_on_farm_enc	Hours_off_farm_enc	Education_enc	Gender_enc	Immigration_enc	Indigenous_enc
2	69	4,957	864	350,000	2,500,000	10	0	High school	No Answer	no	yes
3	32	2,402	695	350,000	150,000	10	50	Trade cert	No Answer	no answer	yes
4	89	811	619	750,000	2,500,000	25	10	No certificate	Other	yes	yes
5	78	2,790	28	2,500,000	400,000	50	10	No certificate	No Answer	yes	yes
6	38	639	694	35,000	2,500,000	50	0	No certificate	Other	no answer	yes
7	92	154	632	350,000	50,000	50	35	Uni (below bach)	Women	no	yes
8	92	2,435	79	2,500,000	50,000	25	0	Uni (below bach)	No Answer	no answer	no answer
9	41	2,740	387	5,000	400,000	35	35	Trade cert	Other	no	yes
10	20	140	163	350,000	150,000	35	25	High school	No Answer	no	no answer
11	39	727	969	350,000	2,500,000	25	10	Bachelor+	No Answer	no answer	no
12	70	3,544	31	1,500,000	750,000	25	35	College diploma	Other	yes	no answer

Running batch predictions

After uploading the file, users can run batch predictions. The system will:

- Process all farmer profiles
- Simulate all 16 scenario–policy combinations
- Generate an output file for download

The output file from the batch processing includes the original input data along with six additional fields:

- **Scenario** indicates the anticipated change in crop production conditions (i.e., decrease or increase).
- **Policy** specifies the policy type explored in a given simulation.

- **Adoption Probability** provides the predicted likelihood of technology adoption, expressed as a percentage.
- **Adoption Range** provides the minimum and maximum predicted probabilities across ensemble models, and it represents the level of uncertainty associated with the model outputs.
- **Ensemble AUC** provides the model performance metrics in the form of AUC values, and it represents the average accuracy of the ensemble models.
- **Adoption Category** classifies adoption likelihood, using low, moderate, and high categories.

5. Model Limitations

It is important to recognize the limitations of the models and ATAS tool. The models are based on limited set of self-reported data from 72 farmers, obtained via survey responses. In addition, the model represents adoption behaviours in a static manner with no temporal aspects. Furthermore, the model does not explicitly account for external shocks such as sudden changes in crop prices, fuel costs, machinery costs, input prices, or other rapidly changing market conditions.

6. Image References

To support the visual narrative of this project, the following graphics and icons have been modified from their original formats, sourced from the following references:

- AJP. (2021). Illustration of a tractor moving through a farm [Digital image]. Shutterstock. <https://www.shutterstock.com/image-vector/1900549963>
- AJP. (2022a). An Indian farmer using a drone for spraying fertilizer in the agricultural field [Digital image]. Shutterstock. <https://www.shutterstock.com/image-vector/2116655078>
- AJP. (2022b). Illustration of a hand remotely controlling a drone spraying fertilizer in the agricultural field [Digital image]. Shutterstock. <https://www.shutterstock.com/image-vector/2117274536>
- Canva. (n.d.). [Various icons] [Digital images]. Canva. <https://www.canva.com/>
- Riokratok, A. (n.d.). Green barley seedling DNA helix structure in a glass test tube. Plant *Hordeum vulgare* seeds, root growth, and genetic modification experiment for cultivation. Biotechnology agriculture science. Vector. [Digital image]. Shutterstock. <https://www.shutterstock.com/image-vector/2604300555>

Figure 3. **ATAS** Quick Reference Diagram (QRD)

