

Data and Artificial Intelligence for African Trade (DAIAT) Initiative

Work program 1: Identify realistic export opportunities

Summary of key findings and resources in the construction of an Agricultural Growing Season and Trade Dataset

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Introduction and background

- The Data and Artificial Intelligence for African Trade (DAIAT) Initiative [<https://www.ucc.ie/en/daiat/>] is a consortium of European and African-based scholars and practitioners who focus their research, teaching and policy making to develop and promote data-driven decision-making tools for the expansion of inclusive and sustainable trade between the continents.
- This part of the work elaborates on the evidence to identify and select key variables of interest for the construction of the "**Agricultural Growing Season/Cycle and Trade Dataset**" database, which forms part of Work Program 1 of the DAIAT Initiative.

Introduction and background (continued)

- **Work program 1** (Identification of export opportunities) is motivated by the need to expand African countries' exports at the extensive margin. This work program will develop a decision-support model for export opportunity identification for Ethiopia, Kenya, Nigeria, Burkina Faso, and Tanzania. These five countries have seen relatively fast growth in industrialization since 2010 and may need access to expanded markets to continue to raise productivity growth.
- For each of the five countries, the detailed opportunities to export to Ireland and for Ireland to export to these countries will be identified using advanced data analytics. Such mutual opportunity identification will support the engagement of Ireland with these countries based on an advantageous mutual expansion of trade. It will also generate a template for expanding to other EU countries.
- The second aim of this work program would be to consider the availability of export data per region and firm - i.e., decentralized export data in Africa. Most governments (e.g., through the tax revenue departments) have access to this data but tend not to make this available. This may impose an information cost/gap on trade.

Introduction and background (continued)

- The growing season for [primary] agricultural products is opposite/different from that in other countries (i.e., not all countries growing seasons/periods are aligned), thereby complementing rather than competing with agricultural production.
- Therefore, even if it is assumed that, for example, South Africa significantly increases its exports of agricultural products to Ireland, it is more likely to displace other countries' share of Irish imports than to affect the level of Irish consumption of domestic agricultural goods. Therefore, the economic impact on the level of Irish agricultural product consumption and production resulting from this change will most likely be small.
- The length of the growing season is an essential determinant of plant growth and distribution. Longer growing seasons may increase plant productivity and allow for new planting opportunities in agricultural and forestry settings. However, related changes in pest species, fire regimes, droughts, and other climate extremes may limit the extent to which these gains are realized.

Summary of evidence

- 01. The development and growth of crops (**sugar beet, spring barley, maize, winter wheat and potato.**) are influenced both directly by increased **carbon dioxide concentration** in the atmosphere as well as indirectly by associated **climate changes** caused by the enhanced greenhouse effect, such as increased temperature. Agricultural land use is strongly influenced by abiotic factors (e.g., **water availability**), all of these being sensitive to climate change, as well as by immediate economic interests and higher-level decisions by policy-makers. ***Using daily input data, short-time effects of environmental factors (e.g., high air temperature or low soil moisture) on plant growth may be ignored.***
- Crops are grouped into **spring and winter crops** depending on their vernalization requirement.

Sources: <https://d-nb.info/986419168/34> and potential support for emission data <https://www.worldometers.info/co2-emissions/co2-emissions-by-country/>

Summary of evidence [continued]

- 02. Countries with respectively more **area per person** A/P are prone to have more of a comparative advantage in agricultural production.

Sources: [Trade openness and the nutrient use of nations – IOPscience](#) and data available from <https://data.worldbank.org/indicator/EN.POP.DNST>

Summary of evidence [continued]

- 03. Access to abundant **water resources** may enable countries to produce and trade more.
- Conversely, if these wealthy countries implement policies such as **agricultural subsidies**, they are likely to boost their agricultural production, leading to more trade and more water use.

Source: <https://agupubs.onlinelibrary.wiley.com/doi/full/10.1002/2017WR021102> some data on water available from <https://www.fao.org/3/y4473e/y4473e08.htm>

Summary of evidence [continued]

- 04. Relevant in terms of how to create land accounting tables.

Source: <https://seea.un.org/file/15011/download?token=MIOlafXn>

Summary of evidence [continued]

- 05. **Population growth has a significant positive impact on agricultural sector growth in upper-middle-income countries**, whilst population growth's influence on agricultural sector growth was observed to be significantly deleterious. Consistent with majority of available literature, the study observed that the impact of urbanization on agricultural growth was significantly positive.

Source: <https://dj.univ-danubius.ro/index.php/AUDOE/article/view/1532>

Summary of evidence [continued]

- 06. **Geography** is a powerful determinant of bilateral trade...simply knowing how far a country is from other countries provides considerable information about the amount that it trades.
- In contrast to conventional gravity equations for bilateral trade, our trade equation includes only geographic characteristics: **countries' sizes**, their **distances from one another**, whether they **share a border**, and whether they are **landlocked**. (This paper provides the countries of the world sizes)

Source: <https://pubs.aeaweb.org/doi/pdf/10.1257/aer.89.3.379>

Summary of evidence [continued]

- 07. BRT model shows that **rainfall** is the most important factor affecting vegetation evolution (63.1%), followed by **temperature** (15%), **land cover change** (8.6%), **population** (6.5%), **elevation** (6.4%), and **nightlight** (0.4%)... The NDVI (normalized difference vegetation index) is sensitive to phenology and is often used as the best indicator of vegetation growth and coverage change.
- **Rising atmospheric CO₂ concentration [also see Article 01]** and **nitrogen deposition** are identified as the most likely causes of the greening trend in China.
- ...Southern Africa; the **increase in temperature** is not conducive to the growth of vegetation in the region. The negative correlation may be caused by an increase in the evaporation of soil moisture resulting from the rise in temperature, which then leads to the decline of soil moisture...
- NDVI showed significant positive correlation with **rainfall** in the... northern and southern margins of the Sahara Desert, southern Africa... These areas exhibit sparse vegetation coverage, which indicates that water is the most important factor that **limits the growth of vegetation in the area**.

Source: [https://www.proquest.com/openview/ca59da90737d342c39363e15bd4fdd23/1?pq-origsite=gscholar&cbl=2032398#:~:text=The%20results%20show%20that%20rainfall,0.4%25\)%20\(Figure%208\)](https://www.proquest.com/openview/ca59da90737d342c39363e15bd4fdd23/1?pq-origsite=gscholar&cbl=2032398#:~:text=The%20results%20show%20that%20rainfall,0.4%25)%20(Figure%208))

Summary of evidence [continued]

- 08.
- Relevant in terms of graph usage.

Source: <https://www.mdpi.com/1911-8074/15/6/263/pdf?version=1655168898>

Summary of evidence [continued]

- 09.
- Agricultural growth in developing countries is composed of several parts, **including 1) area effects, defined as changes in the gross plated area.**
- Differences among countries can be attributed primarily to differences in non-price factors such as access to technological change and other non-traditional types of capital.
- The elasticity of production with respect to non-price factors typically tends to be greater than for price factors. This has been shown consistently for India in the case of the roles of prices vis-à-vis irrigation in explaining wheat and rice production growth.
- **Technology and public sector support boost agricultural performance** in African countries. (page 54 and 55)
- Increasing the productivity of the food crops concerned or developing reliable food markets by investing in roads and other constraining factors may be the more realistic option to release resources for the production of export crops...
- Rural infrastructure, such as **roads, irrigation, drainage systems, communications networks and delivery systems**, is necessary to provide farmers with access to markets for modern inputs and for their increased output. In much of Africa, the scarcity of rural roads means that marketing margins between producers and customers are as much as four times higher than in Asia, reducing returns to producers and limiting the potential for growth in their production.

Source: https://pdf.usaid.gov/pdf_docs/PNABK480.pdf

Summary of evidence [continued]

- 10. ...we do expect that the capacity for a country to produce more or less agriculture could reinforce the impact of openness on especially the levels of nutrient use.
- In sum, these results indicate that **openness does not impact nutrient use**.

Source: <https://iopscience.iop.org/article/10.1088/1748-9326/aaebcb>

Summary of evidence [continued]

- 11. Relative Importance Analysis: A Useful Supplement to Regression Analysis
- Not related. Relevant in terms of possible econometric analysis to use in study

Source: <https://link.springer.com/article/10.1007/s10869-010-9204-3>

Summary of evidence [continued]

- 12. The causal impact of trade openness on agricultural variables is negative as per the results. But still another case that wasn't covered in this work in the concept of comparative advantage, which could have an impact on these relations, as can be seen from Dang et al., as well. In conclusion, I would like to say that this is a preliminary work which requires further extension to provide a better ground for establishing the casual relationship between Trade openness and Agricultural variables.

Source: Final Project Report, CEE-598-Globalization of Water; Causal Impact of Trade Openness on Agricultural Variables; Akshay Pandit; Department of Civil and Environmental Engineering, University of Illinois, Urbana-Champaign

Summary of evidence [continued]

- 13. **The length of the growing season** is an important determinant of plant growth and distribution. **Longer growing seasons may increase plant productivity** and allow for new planting opportunities in agricultural and forestry settings in **Canada**. However, related **changes in pest species, fire regimes, droughts, and other climate extremes may limit the extent to which these gains are realized.**
- *Further analyses indicate that this change has been driven by both earlier start dates in the spring and later end dates in the fall.*
- The growing season is the period during which the weather conditions are conducive to plant growth. The length of the growing season is limited by different factors, such as **air temperature, frost days, rainfall, or daylight hours**

Source: <https://www.nrcan.gc.ca/climate-change/impacts-adaptations/climate-change-impacts-forests/forest-change-indicators/growing-season/18470#how>

Summary of evidence [continued]

- 14. We find that improvements in agricultural science and management, increased fertilizer use, and **changes in crop mix** around the world explained **most of the gain in global crop yields**
- Climate change over this time period caused yields to be only slightly lower than they would have been otherwise. In some cases, **cropland extensification had as much of a negative impact on global and regional yields as climate change.**
- We find that **improvements in agricultural science and management (e.g., technology and chemical use), increased fertilizer use, and changes in crop mix** around the world explained most of the gain in global crop yields from 1975 to the mid-2000s. Improvements in agricultural science and management were particularly important drivers of yield growth in the temperate region and changes in **crop** mix and increased fertilizer use were particularly important drivers of yield growth in the tropics.

Source: [Measuring the relative importance of different... | F1000Research](#)

Summary of evidence [continued]

- 15. This paper establishes the determinants of the export durability of agriculture products in **Zambia** with specific attention to **maize, sugar, cotton, and tobacco** between 1996 and 2019.
- **Colonial history** and **Zambia's GDP** reduced export duration, while contiguity, **partner's GDP**, **initial exports**, and **total exports** increased the durability of exports in Zambia. The effect of Zambia's GDP was uniform across all individual agricultural products. Total exports also significantly impacted all other agriculture products in a similar manner except for maize. Export durability for cotton was significantly impacted by the **Regional Trade Agreements (RTAs)**, while the export durability of **tobacco** was significantly impacted by **distance, contiguity, and partner's GDP**.

Source: [\(PDF\) Durability of Zambia's Agricultural Exports \(researchgate.net\)](#)

Summary of evidence [continued]

- 16. The most basic factors determining the international supply of horticultural products are **climate, proximity** to the major importers, and **growing season**. Other important factors include a country's **supply of suitable land** and **human capital and its infrastructure for exploiting its resources** and marketing potential.
- **...transportation costs** are still an important barrier for exporters.
- **Regional trade agreements** also significantly affect patterns of trade because of lower tariffs.
- For fresh fruits and vegetables, where transportation costs are large, countries tend to import from the closest producers.

Source: [Global Trade Patterns in Fruits and Vegetables \(usda.gov\)](https://www.usda.gov/global-trade-patterns-fruits-vegetables)

Summary of evidence [continued]

- 16. Cont'
- **Seasonality** is an important feature of the global trade in fruits and vegetables. Improvements in production methods, as well as the development of more varieties of fruits and vegetables, have allowed growers in the Northern Hemisphere to expand their production seasons.
- **Improvements in production methods**, as well as the **development of more varieties of fruits and vegetables**, have allowed growers in the Northern Hemisphere to expand their production seasons.
- The importance of **exchange rates** can also be an important factor in the movement of prices
- Advances in transportation and the handling of fruits and vegetables have extended the distance and shortened the time that previously defined the market reach of many commodities

Source: [Global Trade Patterns in Fruits and Vegetables \(usda.gov\)](https://www.usda.gov/global-trade-patterns-in-fruits-and-vegetables)

Summary of evidence [continued]

- 16. Cont'
- Technology has been at the forefront of changes making fresh fruits and vegetables available to consumers globally... In particular, advances in **controlled atmosphere (CA) technologies** have extended the shelf life of perishable products and continue to improve product quality and variety on a worldwide basis. With CA, products hold up better during transportation. CA technologies allow operators to lower the respiration rate of produce by monitoring and adjusting oxygen, carbon dioxide, and nitrogen levels within a refrigerated container. In this way, CA can slow ripening, retard discoloration, and maintain freshness of **perishables like lettuce, asparagus, peaches, mangoes, and avocados** that would not remain fresh during ordinary refrigerated ocean transport. Some sophisticated CA systems are combined with systems that maintain relative humidity—a crucial factor for some produce such as **grapes, fruit with pits, and broccoli**—and that control levels of ethylene, a naturally occurring gas that accelerates the ripening of fresh fruits and vegetables.

Source: [Global Trade Patterns in Fruits and Vegetables \(usda.gov\)](https://www.usda.gov/global-trade-patterns-fruits-vegetables)

Summary of evidence [continued]

- 16. Cont'
- The streamlining of **phytosanitary barriers** through technology has opened new markets for many products. **Declining trade barriers**, including bilateral and multilateral trade agreements, **harmonization of sanitary and phytosanitary regulations**, and dispute settlements under the auspices of the WTO, have also fostered more trade.
- **Anti-dumping practices** affect the patterns of trade in fruits and vegetables and remain a threat to the trade of some commodities in some countries.

Source: [Global Trade Patterns in Fruits and Vegetables \(usda.gov\)](https://www.usda.gov/global-trade-patterns-fruits-vegetables)

Summary of evidence [continued]

- 17. With globalization in recent decades, **virtual water trade** has increasingly become an important component of water management. Understanding the flow of virtual water through agricultural product trade can guide the management of regional physical water scarcity, especially in **arid regions**
- In this study, three water-intensive agricultural products (**wheat, cotton, and livestock products**) were used to analyze spatiotemporal trends in virtual water flow in **Central Asia** in 2000–2018.
- To calculate the amount of virtual water flow for various agriculture products, the trade volumes (ton/year) of the products were multiplied by their respective virtual water content (VWC, m³/ton). The VWC is defined as the water requirement in the production of a unit weight of an agricultural product in a country.

Source: <https://onlinelibrary.wiley.com/doi/abs/10.1111/1752-1688.12959>

Summary of evidence [continued]

- 17. Cont'
- Approximately 24% of the world's agricultural blue water consumption is used in the production of agricultural commodities for international trade.
- ..the elimination of exports could have little impact on water stress in the region. From the case of the three net exporting countries (Kazakhstan, Uzbekistan, and Turkmenistan), however, virtual water export elimination would have different impacts on different countries.
- **Virtual water trade** is key in managing severe water stress and environmental degradation in **Central Asia**.

Source: <https://onlinelibrary.wiley.com/doi/abs/10.1111/1752-1688.12959>

Summary of evidence [continued]

- 18. Model results show that for a percentage change in population, global production and consumption of major field crops respond at nearly the same rate.
- A negative shock to global agricultural productivity could come about through a decrease in **investments** in agricultural research and development over time or through other economic or environmental factors such as **climate change**.

Source: [\(PDF\) Global Drivers of Agricultural Supply and Demand \(researchgate.net\)](#)

Summary of evidence [continued]

- 19. Agricultural productivity has improved rapidly in past decades, but prospects for future growth are uncertain, especially considering **climate change**.
- This study uses the **Future Agricultural Resources Model (FARM)** to simulate agricultural demand, supply, and land use for 13 world regions from 2005 through 2050.
- Agricultural productivity changes over time, due to **changing temperature, precipitation, and humidity. Climate** impacts vary by world region and crop type.
- Summary of drivers of agricultural supply: **Agricultural productivity**. (The technology dimension as a driver of agricultural production and land use, allowing crop yields to vary, holding agricultural resource use constant.)

Source: https://www.ers.usda.gov/webdocs/publications/45272/49034_err174_summary.pdf?v=0

Summary of evidence [continued]

- 19. Cont'
- ...the increased demand for agricultural products associated with greater incomes and a larger population can be met **without significant increases in cropland area** or product prices. The increases in **agricultural productivity** assumed by the reference scenario are sufficient to keep up with growing demand for agricultural products.
- ...considerable uncertainty about the future growth in agricultural productivity in the face of global **climate change, unpredictable public and private investment** decisions concerning agricultural **R&D**, and myriad other factors that could affect productivity trends.

Source: https://www.ers.usda.gov/webdocs/publications/45272/49034_err174_summary.pdf?v=0

Summary of evidence [continued]

- 19. Cont'
- The sources of agricultural output growth can be partitioned into increases in land in **production** and changes in **crop yield**. **Yield growth** (output per unit of land) represents—in a single indicator—multiple sources of production growth. One source is farmer intensification of inputs, such as **irrigation, fertilizer, and capital equipment per unit of land** in response to price signals. Another source is increases in total factor productivity (TFP), which reflects **improved technologies** and improved management resulting from **long-term R&D investments**

Source: https://www.ers.usda.gov/webdocs/publications/45272/49034_err174_summary.pdf?v=0

Summary of evidence [continued]

- 20. **Enabling the Business of Agriculture** presents indicators that measure the laws, regulations and bureaucratic processes that affect farmers in 101 countries. The eight core indicators are: **supplying seed, registering fertilizer, securing water, registering machinery, sustaining livestock, protecting plant health, trading food and accessing finance.**
- **Time** is recorded in calendar days and captures the median duration of each procedure. The time span for each procedure starts with the first filing of the registration application and ends with the last procedure required to release the variety on the market, which is often the listing in the national catalogue or its publication in the official gazette.
- Only official **costs** are recorded, including any applicable fees and taxes. In the absence of official fee schedules, the estimates provided by expert respondents are recorded and the median of the responses is taken. Professional fees (for example, notary fees) are only included if the applicant is required to use such services. All costs are recorded as percent of income per capita (using current US dollars).
- A country is considered “no practice” on the time and cost components if either no seed variety was registered by the private sector between July 1, 2016 and June 30, 2018, or if seed registration legislation is not yet in force or implemented. A score of 0 is recorded if a variety registration is not done in practice.

Source: <https://eba.worldbank.org/en/methodology#1>

Summary of evidence [continued]

- 21. **Determinants of trade in fruit...** The **climate, proximity of the grower to the market** and the **timing of the growing season** are the most basic factors in determining the international supply of horticultural products. Other factors may include the **availability of land, human and financial capital, infrastructure (roads, railways and ports)** and the **ability to access a market as well as market the produce**.
- Climate determines what varieties of fruit can be grown. Whilst some varieties are fairly robust and can be grown in various different soils and climates, others have specific needs. Traditionally, northern hemisphere countries have only been able to grow those fruits classified as 'temperate fruits', or those that can be grown in temperate locations (apples, pears, deciduous fruits like peaches and nectarines, grapes, melons, strawberries, etc.) and certain sub-tropical fruits, which require slightly warmer conditions (citrus fruits like oranges, mandarins and lemons, avocados, lychees, passion fruit, figs, etc.).
- In the EU, much of the sub-tropical fruit is grown in the Mediterranean region. The third group of fruits, tropical or exotic fruits, traditionally have been and still are for the most part grown in the southern hemisphere or warmer countries (bananas, pineapples, mangoes, papayas, dates, etc.).

Source: https://www.tips.org.za/research-archive/trade-and-industry/trade-information-briefs/item/download/1285_2ffd2cbbd1c97d538007c0965670ef0e

Summary of evidence [continued]

- 21. **Cont'**
- Whilst technological advantages such as greenhouses and growing different (heat-insensitive) varieties have made it possible to grow these products in colder countries, most of the time it is simpler and more cost-effective to grow these fruits in climates to which they are suited and then import them. Bananas are the single most important imported fruit for this very reason.
- Proximity to markets is the second major determinant of trade. Although transportation costs have decreased significantly over the last 20 years or so and storage technology has advanced, the distance to a market can still be a considerable barrier to trade. The US imports most of its produce from its neighbours Canada and Mexico and from South America (Chile). Japan and the EU show a similar pattern, which to a large degree is influenced by the proliferation of preferential and regional trade agreements. The most obvious example is that of the EU, as well as NAFTA (the North American Free Trade Agreement). Zero tariffs and standardised quality, marketing, packaging and labelling systems also allow for less handling of the fruit and more timeous delivery.

Source: https://www.tips.org.za/research-archive/trade-and-industry/trade-information-briefs/item/download/1285_2ffd2cbbd1c97d538007c0965670ef0e

Summary of evidence [continued]

- 21. **Cont'**
- The third and most relevant determinant to SADC countries is that of **seasonality and price**. Countries in the southern hemisphere can produce and export fruit during the northern hemisphere's winter months when domestic producers cannot adequately supply the major northern markets. Even countries that are net exporters of a commodity during peak seasons (like the US that exports oranges) may import that commodity during the off-season.
- Without such trade, the seasonal nature of production, combined with the limited (or costly) storage of certain fruits, would result in massive price troughs and peaks. More consistent prices can also stimulate demand and assist in developing longer term relationships. It can further facilitate better planning for farmers/exporters and so introduce more attractive or less risky investment options.
- **Technology** is another increasingly important determinant of the level of trade in fruit. Traditional exporters had to contend with much higher shipping costs, shorter 'window' periods to get their products to the desired destination and the ever-present risk of fruit losing their freshness, leading to a loss in value. Controlled atmosphere technologies and improved cold chain management can extend shelf life, while satellite technologies and other electronic and computer advances enable shorter cargo delivery time. Remote monitoring systems alert to problems such as a change in the storage conditions and can thus reduce potential losses.

Source: https://www.tips.org.za/research-archive/trade-and-industry/trade-information-briefs/item/download/1285_2ffd2cbbd1c97d538007c0965670ef0e

Summary of evidence [continued]

- **22. Virtual water trade and water footprint of agricultural goods: the 1961–2016 CWASI database:** To support national and global assessments of water use in agriculture, we build a comprehensive database of country-specific water footprint and virtual water trade (VWT) data for 370 agricultural goods.
- The water footprint, indicating the water needed for the production of a good including rainwater and water from surface water and groundwater bodies, is expressed as a volume per unit weight of the good (or unit water footprint, uWF) and is here estimated at the country scale for every year in the period 1961–2016. The uWF is also differentiated, where possible, between production and supply, referring to local production and to a weighted mean of local production and import, respectively.
- The VWT data, representing the amount of water needed for the production of a good and virtually exchanged with the international trade, are provided for each commodity as bilateral trade matrices, between origin and destination countries, for every year in the period 1986–2016. **The database, developed within the CWASI project, improves upon earlier datasets because it takes into account the annual variability of the uWF of crops, it accounts for both produced and imported goods in the definition of the supply-side uWF, and it traces goods across the international trade up to the origin of goods' production.**

Source: <https://essd.copernicus.org/articles/13/2025/2021/>

Summary of evidence [continued]

- **23. The effect of increased weather volatility on agricultural trade:** The study applied an econometric gravity model to estimate the effects of weather volatility on international trade flows.
- To account for variation in weather conditions, the authors included the standardised precipitation-evapotranspiration index (SPEI).
- **The study found that smaller variations in weather has no impact on trade, but for more extreme events (i.e., more than two standard events from the mean), the trade impacts are substantial, i.e., reduced by around 46%.**
- **Using the estimation results, the authors simulated the trade impacts of more widespread weather events and found that the impact varies by crop, with the largest effect being for wheat and the smallest impact for soybeans.**

Source: <https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&ved=2ahUKEwjFi9G0j-75AhW9QkEAHWQ6D3sQFnoECAgQAQ&url=https%3A%2F%2Fageconsearch.umn.edu%2Frecord%2F322305%2Ffiles%2F23078.pdf&usg=AOvVaw1lKxraiTKszeaR9MirrsKU>

Variables selected for the AGST Dataset

- The selected variables listed in the following tables were obtained from the relevant sources and placed in the 'RawData' folder on the GitHub repository. First, several scripts were written to extract some required data (e.g., the monthly bilateral trade data were obtained via the UN Comtrade API).
- Next, the raw data were read into R, the relevant variables extracted and cleaned, and the required mapping (or keys/ lookup variables) added to each dataset to enable combining/ merging the data sources on the country, commodity, year and/or month in the final AGST dataset.
- The following tables also provide an illustration of the outline of the final AGST database produced following the previous steps. This database will be used to identify new export opportunities between various African countries and Ireland, where potential is identified for areas/countries with different growing seasons that could potentially fill a gap in the market for different periods of the year.

Variables selected for Agriculture Growth Database

- Table of selected key variables and relationships...

Selected Variables	Variable Name	Expected Outcome	Theoretical Explanation	Data Resource
Bilateral Trade	Monthly bilateral trade volume/value of primary agricultural goods	—	Monthly bilateral trade volume/value between countries	UNCOMTRADE (Unit: USD)
Agricultural Variables	Area Harvested, Production, Yield and Fertilizer Products used in production	Positive / Negative	Area Harvested, Production, Yield and Fertilizer Products used in production	FAOSTAT (Unit: Hectares, Tonnes, Hectograms/Hectare)
Monthly irrigated crop calendars	Monthly growing areas of 26 irrigated crops (MGAG-I) and related crop calendars	Positive / Negative	Monthly growing areas of 26 irrigated crops (MGAG-I) and related crop calendars	AQUASTAT (Unit: Hectares, % share)
Irrigated area and cropping seasons	Area equipped for irrigation and actual irrigated area per country	Positive / Negative	Area equipped for irrigation and actual irrigated area per country	AQUASTAT (Unit: m ³)
Virtual water trade	Virtual Water Trade and Water Footprint of Agricultural Products	Positive / Negative	Virtual Water Trade and Water Footprint of Agricultural Products	AQUASTAT (Unit: 109 m ³ /year)

Variables selected for Agriculture Growth Database

- Table of selected key variables and relationships... [cont.]

Selected Variables	Variable Name	Expected Outcome	Theoretical Explanation	Data Resource
Water use	Water withdrawals for agriculture, annual quantity of self-supplied water withdrawn for irrigation, livestock and aquaculture purposes	—	Water withdrawals for agriculture, annual quantity of self-supplied water withdrawn for irrigation, livestock and aquaculture purposes	AQUASTAT (Unit: 109 m ³ /year)
Agricultural productivity	Total factor productivity (TFP)	Positive	Total factor productivity (TFP)	USDA (Unit: Index, 2015=100)
Geography	Several cross-sectional variables, including national land area, distance between a pair of nations, landlocked dummy, monthly precipitation, temperature, latitude, population, capital stock, northern and southern hemisphere	Positive / Negative	Several cross-sectional variables, including national land area, distance between a pair of nations, landlocked dummy, monthly precipitation, temperature, latitude, population, capital stock, northern and southern hemisphere	CEPII, WB, GEODATASOURCE (Unit: Various)

Variables selected for Agriculture Growth Database

- Table of selected key variables and relationships... [cont.]

Selected Variables	Variable Name	Expected Outcome	Theoretical Explanation	Data Resource
Trade Openness	Trade Openness is a summation of a country's total export and import over its GDP	Positive	Trade Openness is a summation of a country's total export and import over its GDP	WORLD BANK (Unit: USD)
Trade Agreements	World Trade Organisation (WTO) accessions, and Regional Trade Agreements (RTA). From these agreements, dummy variables were created to imply for a specific year if a nation is in regional agreement with the other and if a nation is a member of WTO.	Positive / Negative	World Trade Organisation (WTO) accessions, and Regional Trade Agreements (RTA). From these agreements, dummy variables were created to imply for a specific year if a nation is in regional agreement with the other and if a nation is a member of WTO.	UNCOMTRADE (Unit: DUMMY)

Variables selected for Agriculture Growth Database

- Table of selected key variables and relationships... [cont.]

Reporter	Partner	Year	Month	HS6	Temp	Rainfall	...	Crop Area
C004	C899	2017	01	HS060110	Agricultural Growing Season Indicators/Variables			
...				
...				
...				
C899	C8004	2022	08	HS180100	

Summary and concluding remarks

- The growing season is the period during which the weather conditions are conducive to plant growth. The length of the growing season is limited by different factors, such as air temperature, frost days, rainfall, or daylight hours. The length of the growing season indicates the amount of time that agricultural products have to grow during a given year. It is an essential determinant of plant growth and distribution. In principle, longer growing seasons could indicate increased productivity and planting opportunities in agricultural settings.
- The importance of each country's growing season and understanding those factors that determine the growing season may help identify new and previously unknown trade opportunities for agricultural products. Moreover, timely information for rapid decision-making during the growing season may help exporters and policymakers to make better-informed decisions. Finally, estimates of growing seasons and crop production are also helpful concerning trade, development policies and humanitarian assistance linked to food security.
- The constructed AGST database is a first step in providing more insight regarding potential trade opportunities between Africa and Ireland regarding agricultural trade. Moreover, evidence collected during the research process highlighted potential areas of focus for future work to refine and improve the AGST database.