Food and Agriculture Organization of the United Nations

European Bank for Reconstruction and Development

INVESTING IN TRADE DIGITALIZATION
THE CASE OF ePHYTO

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INVESTING IN TRADE DIGITALIZATION
THE CASE OF ePHYTO

Dmytro Prykhodko
Anne-Christelle Ott
Evgeniya Koroleva

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Foreword

Global trade in plants and plant products continues to expand rapidly, driven by the growing demand for food, fuel, and fibre across the world. Exports of cereals, oilseeds, pulses, fibre, and tuber crops have more than doubled since 2000, reaching 702 million tonnes in 2023. According to medium-term outlook provided by the Organisation for Economic Co-operation and Development (OECD) and the Food and Agriculture Organization of the United Nations (FAO), trade in these products is set to increase by a further 11 percent per year by 2032. Meeting this growing demand in a cost-effective manner will require substantial investments in both hard and soft trade infrastructure.

In the countries where the European Bank for Reconstruction and Development (EBRD) operates – which are among the world's largest exporters and importers of cereals, oilseeds, fruits, and vegetables – agricultural trade plays a vital role in supporting rural livelihoods and ensuring food security. Achieving sustainable trade growth in plants and plant products requires concerted efforts by both public and private actors to address the evolving challenges, particularly in managing agricultural pests and adhering to phytosanitary standards. In the context of a changing climate, this task is becoming increasingly complex.

The electronic phytosanitary certificate (ePhyto) solution, developed by the International Plant Protection Convention (IPPC) Secretariat hosted by the Food and Agriculture Organization of the United Nations (FAO), is a key tool in tackling some of these challenges. By digitalizing phytosanitary certificates, the IPPC ePhyto solution contributes to the safe trade of plants and plant products, aligning with international standards while enhancing the efficiency of cross-border trade.

Although the global shift toward digitalization, especially in the wake of the COVID-19 pandemic, has gained momentum, the adoption of these instruments has been uneven across regions and countries. The benefits of trade digitalization have not always been immediately apparent, which has delayed much-needed investments in digital trade transformation. Recognizing the broader challenges of agrifood systems transformation, the EBRD and FAO have collaborated since 2018 on a range of analytical and technical assistance projects to reduce barriers to digitalization. These include reviews of digital technologies in the grain value chain in Ukraine (FAO, 2022a), digital technologies for agriculture in Türkiye (FAO, 2025), evolution of food e-commerce during the COVID-19 pandemic (FAO, 2023) and others that identified key enablers and constraints to digital adoption and explored mechanisms for EBRD to support investment.

This report continues the shared commitment of EBRD and FAO to advancing the adoption of digital solutions in the wider food system context. For the first time, this report provides a comprehensive assessment of the costs and benefits of the IPPC ePhyto solution for both the private sector and society, highlighting the potential for trade cost reductions, and underscores ePhyto's positive impact on trade at the global level.

While the recommendations for maximizing the benefits of the electronic certificates and prioritizing areas for intervention outlined on this report will provide guidance for policymakers and industry leaders, FAO and EBRD stand ready to provide further advice and technical assistance to our member countries and clients in this important area.

Mohamed Manssouri
Director
FAO Investment Centre

Natalya Zhukova
Director
Head of Agribusiness – EBRD

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Abbreviations

AIC	Akaike Information Criterion
BIC	Bayesian Information Criterion
CBA	cost–benefit analysis
CEFTA	Central European Free Trade Agreement
CF	conversion factor
CPM	Commission on Phytosanitary Measures
EBRD	European Bank for Reconstruction and Development
EGP	Egyptian Pound
ePhyto	electronic phytosanitary certificate
FAO	Food and Agricultural Organization of the United Nations
FDI	foreign direct investment
GHG	greenhouse gas
GeNs	Generic ePhyto National System
HS	harmonized system
IPPC	International Plant Protection Convention
ISPM	International Standards for Phytosanitary Measures
NPPO	national plant protection organization
NPV	net present value
NTMs	non-tariff measures
PC	phytosanitary certificate
PPML	poisson-pseudo maximum likelihood
RSD	Serbian dinar
RTA	regional trade agreement
SEED	Systematic Exchange of Electronic Data
SPS	sanitary and phytosanitary
STDF	Standards and Trade Development Facility
TRACES	Trade Control and Expert System
TTRI	Tariff Trade Restrictiveness Index
UAH	Ukranian hryvnia
UN	United Nations
UNCTAD	United Nations Conference on Trade and Development
UNESCAP	United Nations Economic and Social Commission for Asia and the Pacific
UNICC	United Nations International Computing Centre
USD	United States of America dollar
UZS	Uzbekistan sum
WCO	World Customs Organization
WO/eP	without ePhyto
W/eP	with ePhyto
WTO	World Trade Organization

Executive summary

This report, a result of cooperation between the Food and Agriculture Organization of the United Nations (FAO) and the European Bank for Reconstruction and Development (EBRD), presents some of the first assessments on the impact of digital transformation in trade facilitation through the use of electronic certificates. Specifically, it assesses how the "ePhyto" solution – the use of electronic phytosanitary certificates in XML format in accordance with the International Standard for Phytosanitary Measures 12 (ISPM 12) (IPPC, 2017) – impacts global plants and plant product trade.

All plants and plant products require phytosanitary certification, paper or digital, for export in line with ISPM 12 and national phytosanitary regulations of IPPC contracting parties. This report shows that the **extent of coverage of global trade via the digital ePhyto solution has increased steadily: from 2 percent in December 2019 to 6 percent in March 2020, driven by the COVID-19 pandemic; and to 17 percent by September 2023** as more countries adopted the ePhyto solution. In 2023, the estimated value of all plants and plant product exports from countries that use ePhyto was **approximately USD 90 billion**. This significant progress in ePhyto adoption highlights its growing importance in facilitating trade across borders.

To consider whether countries should invest in adopting ePhyto, this report analyses the impact of ePhyto from two perspectives. First, a country-level analysis in four countries where EBRD has a presence – Egypt, Serbia, Ukraine and Uzbekistan – most of which have adopted, tested, or implemented the ePhyto solution. This considers the costs and benefits to these countries of adopting ePhyto and highlights the pathways through which the use of the digital certificates can reduce trade cost. Second, a global econometric assessment of how ePhyto affects trade between a country pair.

Our cost–benefit analysis confirms that ePhyto lowers trade costs for plants and plant products, helping exporters achieve higher margins and improving overall economic returns. At the national level, the transition to ePhyto yields benefits not only for private businesses but also for public administrations. In contrast, experience from various countries shows that the costs of adopting ePhyto are low. The technology requires little digital infrastructure because the IPPC has already developed the Generic ePhyto National System (GeNS) for country use, and most countries already have the hardware and infrastructure necessary for using ePhyto.

The benefits are particularly significant for exporting companies, with potential savings per shipment ranging **from USD 3.7 per fruit shipment in Uzbekistan (USD 0.18 per tonne)** to USD 83.5 per fruit shipment in Egypt (USD 4.24 per tonne). The main benefits correspond to savings in costs associated with containers waiting at the border when phytosanitary certificates are delayed or need to be reissued. Although these savings may appear small relative to total shipping costs, which are in the range of USD 1000–7000 for fruit exports from Serbia depending on export markets and fuel prices, they accumulate to substantial amounts when aggregated over multiple shipments and years of effective usage. For example, in Egypt, a company could save in the range of USD 80 000 to USD 200 000 per year. For companies with large export volumes and small margins, these savings represent significant reductions in operational costs, contributing to higher profitability.

Overall, the analysis demonstrates a strong case for countries adopting ePhyto. Over a 20-year period, the net present value (NPV) of the ePhyto investments ranged from **USD 43 million to USD 76 million for Ukraine and from USD 27 million to USD 71 million for Egypt** reflecting high export volumes of both countries and the high potential savings per shipment for Egypt. The savings for Serbia were less pronounced due to relatively modest export volumes. At the same time, exporters in Uzbekistan continue to obtain paper certificates in parallel with the digital ones as trucks must transit through countries that do not accept ePhytos. Considering the rigid methodological framework used for assessing benefits from reducing trade costs, Uzbekistan would expect to see the positive returns from ePhyto when its transit countries and all trading partners also adopt the ePhyto as described in the report.

Further, the global-level econometric analysis presented in this report confirms that ePhyto has a positive impact on bilateral trade between countries that use the system, driven largely by reduced transaction costs. However, the increase in trade is not immediate and typically occurs only after the exchange of ePhytos reaches a certain threshold. The minimum number of ePhytos needed to generate a measurable positive effect on trade between two trading partners is 57 per year for all plants and plant products. This threshold is well below the number of certificates that countries typically issue per destination market, so countries quickly reap the positive impact of ePhyto adoption on trade.

The effect of ePhyto on trade also varies across product categories. For example, cereals – due to their bulk and mostly non-perishable nature – require approximately 112 ePhytos to achieve a positive trade impact, while fruits need 45 and vegetables require just 30 per year to realize trade-enhancing effect. These findings **suggest that countries can prioritize the introduction of ePhyto to high-value, perishable products such as fruits and vegetables** during testing and pilot phases in order to maximize benefits.

Recommendations for maximizing ePhyto's impact and the way forward

The two assessments build a strong case for countries investing in adopting and using the ePhyto solution, and highlight several factors that influence the extent to which countries and companies benefit from the adoption of ePhyto. These can significantly affect cost savings, operational efficiency, and trade outcomes.

- Adoption by trade partners: One of the most critical factors is the extent to which a country's trade partners have also adopted ePhyto. As more countries adopt the system, the potential for cost savings increases because more trade flows benefit from the lower trade costs.

- Transit and neighbouring countries: For landlocked countries like Uzbekistan, where goods must pass through multiple borders to reach their destination, the full benefits of ePhyto adoption would be realized when neighbouring transit countries and importers also use the system without requiring a paper certificate. The absence of ePhyto in transit countries can create bottlenecks at borders that diminish the cost-saving and time-reducing advantages of ePhyto. In this context, Uzbekistan stands as a case study highlighting both the challenges faced by landlocked countries and the potential for amplified economic benefits of wider adoption of ePhyto.
- Broader adoption of digital trade-related documents: While the ePhyto is an essential pre-requisite for exporting plants and plant products, it is just a part in a broader ecosystem of trade-related documents, such as customs declarations, certificates of origin, food safety certificates, conformity, quality certificates and others that often must accompany the shipment at the same time. Expanding digitalization to cover other critical documents would further enhance the impact of ePhyto. The introduction of integrated systems like government single-window applications and interoperable platforms could significantly amplify the cost savings and efficiency gains offered by ePhyto in the future. A more comprehensive approach to digitalizing trade documents would lead to further reductions in transaction costs and delays.

The conclusion presents some additional suggestions for maximizing the impact of ePhyto certificates and trade digitalization more generally, considering different stakeholders. These recommendations include rules for potential data sharing, technical and financial assistance for wider trade digitalization implementation and the ability of national plant protection organizations (NPPOs) to allocate adequate resources for digitalization

While the report focuses primarily on the shift from paper to electronic phytosanitary certificates, interviews with exporting companies highlighted additional areas of improvements in streamlining broader phytosanitary measures. Introducing risk-based approaches to product sampling and laboratory testing were mentioned as potential areas of improvement, especially as these measures typically precede the issuance of either paper or electronic phytosanitary certificates by NPPOs. Exporters of plants and plant products are encouraged to engage with their respective country NPPOs in discussing these, as part of a broader process of risk communication in line with the framework for pest risk analysis (ISPM 2).

The evidence presented in this report confirm that ePhyto has potential to facilitate smoother cross-border exchanges, thereby reducing trade costs and improving profit margins for exporters, illustrating the value of investing in this digital trade measure. These findings emphasize how adopting ePhyto reduces trade costs, both for businesses and national economies, and underscores the value of investing in digital trade transformation. The initial results of this analysis were well-received at the ePhyto Industry Advisory Group (IAG) Annual Meeting, which took place on the margins of the Ninth Global Review of Aid for Trade hosted by the World Trade Organization (WTO) in June 2024 and the Strategic Planning Group of IPPC in October 2024.

The ePhyto solution and its increased use in global trade is the fruit of coordination between the IPPC Secretariat, NPPOs, development partners and the private sector and a success story in the realm of trade digitalization and trade facilitation. By investing in and adopting digital tools like ePhyto, countries can position themselves to reap the full benefits of a more efficient, transparent, and sustainable global trading system.


HIGH
CORTEN STEEL PARTS
ZINC PRIMER
PLANILLA DESPACHO


Introduction

TRADE COSTS AND INVESTMENTS

Trade costs encompass all costs incurred in getting a good to a final user, including transportation costs, policy barriers (tariffs and non-tariff barriers), information costs, contract enforcement costs, costs associated with the use of different currencies, legal and regulatory costs, and local distribution costs (Anderson & van Wincoop, 2004).

Evidence shows an overall downward trend in trade costs in the last half-century (WTO, 2018). However, trade costs for agricultural products appear higher compared to other products, are much higher in low-income countries than elsewhere (ibid), and contrary to manufacturing, have remained rather unchanged since the 1990s (Arvis *et al.*, 2012; FAO, 2022). In addition, while applied tariffs have been declining globally over the past few decades, non-tariff measures (NTMs) are widespread and costly. It is estimated that the trade costs of NTMs are more than double those of customs tariffs (UNESCAP and UNCTAD, 2019). Much of the NTM-associated trade costs are derived from sanitary and phytosanitary (SPS) measures and technical barriers to trade, which together account for approximately 1.6 percent of the global GDP (equivalent to USD 1.4 trillion) (UNESCAP and UNCTAD, 2019).[1]

1 In the agriculture sector, the combined costs of NTMs are up to 20 percent for imports (UNESCAP and UNCTAD, 2019).

Several studies show that lowering trade costs can boost trade volumes. OECD evaluated trade facilitation indicators across 107 countries, revealing that improved measures such as information availability, document harmonization, automated processes, and streamlined procedures significantly reduce costs (Moïsé and Sorescu, 2023). Comprehensive trade facilitation reforms can reduce trade costs by up to 15.5 percent for lower-middle-income countries, which in turn can increase trade flows. These impacts are particularly strong for manufactured goods and vary by country income levels, with low-income countries benefiting most from document simplification. Another study assessed the impact of trade facilitation on manufactured goods trade across 75 countries from 2000–2001 (Wilson et al., 2005). They find that improvements in port efficiency, customs, regulations, and service infrastructure would have increased global trade flows by USD 377 billion over those two years, with significant export increases, particularly to OECD markets. The study highlights that a country's own trade facilitation efforts are crucial for maximizing these gains. Another study shows that reductions in tariffs and non-tariff barriers results in increases in trade flows by making markets more competitive and diverse, and leads to welfare gains (Broda and Weinstein, 2006). In fact, WTO estimates that, until 2030, trade could grow by an additional 1.8 to 2 percentage points each year because of falling trade costs, amounting to a cumulated growth of 31 to 34 percentage points over 15 years (WTO, 2018).

One pathway through which lower trade costs increase trade volumes is that lower exporting costs increase margins on exports and firms are incentivized to invest to increase their export volumes. Local businesses that are productive enough to export are incentivized to invest to access export markets (Melitz, 2003). Empirically, improvements in trade logistics and customs procedures have been found to significantly increase sectoral investment (Hausman et al., 2005). It has been shown that a 1 percent reduction in trade non-tariff costs results in a 0.8 percent increase in foreign direct investment FDI (Duval and Utokham, 2014).

There are other advantages of reducing trade costs, besides increasing trade volumes and incentivizing investments. For example, Melitz' 2003 model demonstrates that lower trade costs lead to significant intra-industry reallocations, where more productive firms grow and less productive firms shrink or exit, thereby enhancing aggregate industry productivity. In addition, high trade costs in agriculture may have food security implications, especially for net food-importing countries, because they increase prices to final consumers and thus reduce product accessibility. For producers, high trade costs in agriculture may increase the price of imported inputs and constrain agricultural productivity, especially for net importers of agricultural inputs (FAO, 2022).

While trade costs alone do not explain the development pathways of economies, they are a major factor explaining why some countries are unable to grow and diversify. High trade costs can weaken a country's comparative advantages. They can also insulate countries, in particular low-income ones, limiting their potential to grow and develop (FAO, 2022).

DIGITALIZATION AND DECREASING TRADE COSTS

Digitalization of trade processes is a key contributor to lower trade costs (López González and Ferencz, 2018; Duval *et al*., 2018; Jensen, 2020) and can increase the scale, scope and speed of trade (López González and Ferencz, 2018). In particular, digitalization can reduce costs associated with complying with NTMs. A considerable portion of trade costs are derived from inefficient and expensive means of exchanging, verifying, and approving data in trade documentation, which is mostly in paper format and rely on manual clearance processes.

Digital technologies can help lower trade costs by making trade more efficient and transparent (WTO, 2018). They have three main use cases in international trade. First, digital platforms offer a single location for multiple stakeholders to communicate and exchange trade-related information electronically. This can be done through electronic single windows, as well as through digital trade finance platforms, which reduce the length of payment terms and lower costs for lenders to issue trade finance for micro, small, and medium-sized enterprises (MSMEs). For instance, several technology providers use blockchain and smart contracts to offer banks, traders, and customs agents a 'one-stop-shop' open account and letter of credit trading platforms (Tripoli, 2021).

Second, the issuance and exchange of digital trade certificates instead of paper documents are another tool for lowering trade costs, helping to facilitate trade by reducing fraud and document loss, and enabling faster border transactions. In addition to electronic phytosanitary certificates, other trade documentation – such as certificate of origin, permits, cargo manifests, and customs declarations – can be issued and exchanged in electronic format.

Third, digital technology can help build more effective traceability systems that collect, analyse, and share product data in agrifood supply chains, which helps to ensure compliance with food and sustainability standards, manage food safety risks, and facilitate communication flows between producers and national authorities (Tripoli, 2021). Agrifood traceability systems can be supported by a range of technologies, such as mobile devices and remote sensing for data collection, artificial intelligence, and big data for data-driven decision making, and blockchain for data sharing (Tripoli and Schmidhuber, 2020).

The impacts of electronic certification on trade have not been studied thoroughly. Literature focuses rather on the impacts of having in place a digitalized process on trade flows (e.g. Abendin *et al*., 2022; OECD, 2018; Roy *et al*., 2020) or on the online single window approach[2] (e.g. Porto *et al*., 2015; Martinez-Zarzoso *et al*., 2020).

OECD provides one of the most thorough assessments of the impact of digital phytosanitary certification on trade, using data from questionnaires sent to its member countries using e-Cert (receiving/sending e-certs from/to and since when, and for which harmonized system code level, e.g. HS-6, those HS codes with six digits) to measure the trade facilitation effects of electronic SPS certificates and to quantify the increase in exports from

2 A single window environment is "a cross border, 'intelligent,' facility that allows parties involved in trade and transport to lodge standardized information, mainly electronic, with a single entry point to fulfill all import, export, and transit related regulatory requirements" (World Customs Organization, WCO, 2025).

implementing SPS e-certificates over time for selected agrifood product groups (OECD, 2021). However, it did not provide any information on the number of ePhytos that should be issued to augment trade. Even though the information on the number of ePhytos certificates exchanged bilaterally is available, it has not been used in the literature as a measure of the intensity of ePhyto participation and its effects on enhancing trade and reducing trade costs have not been quantified.

ANALYSING THE IMPACT OF THE IPPC ePHYTO SOLUTION

The electronic phytosanitary certificates developed and launched by the International Plant Protection Convention (IPPC) in December 2017 to modernize the issuing and exchange of phytosanitary certificates provide an opportunity to assess the economic impact of a trade digitalization tool on global trade and adopting countries.

Box 1

THE INTERNATIONAL PLANT PROTECTION CONVENTION (IPPC)

The International Plant Protection Convention is the intergovernmental treaty aiming to protecting the world's plant resources from the spread and introduction of pests, and promoting safe trade; it has been signed by 185 countries (IPCC, 2025a). The Convention introduced International Standards for Phytosanitary Measures (ISPMs) as its main tool to achieve its goals, making it the sole global standard-setting organization for plant health.

The IPPC is one of the "three sisters" recognized by WTO's Agreement on the Application of Sanitary and Phytosanitary Measures (the SPS agreement), along with the FAO-WHO Codex Alimentarius Commission for food safety standards and the World Organization for Animal Health (WOAH, formerly OIE) for animal health standards.

Each of the IPPC 185 contracting parties has a national plant protection organization (NPPO) and an official IPPC contact point. The IPPC Secretariat, established in 1992 and hosted at FAO headquarters in Rome, coordinates the work of IPPC contracting parties to achieve the convention's goals. It develops a variety of resources to provide technical guidelines, it implements plant health related projects, organizes the Commission on Phytosanitary Measures (CPM) and other major committee meetings, and is responsible for communication and external cooperation programmes.

SOURCE: Authors' own elaboration.

Phytosanitary certificates, in their paper or electronic form, are used to attest that consignments meet phytosanitary requirements of their destination markets and are the official documents issued by the NPPO of an exporting country to the NPPO of an importing country. This certification is applied to most crops that are traded internationally (IPPC, 2017). It is crucial for the protection of human, animal and plant life or health, and to ensure safe and transparent trade. Products that require phytosanitary certification include seeds, grains, oilseeds, fresh fruits, vegetables, tubers, live plants, cut flowers and many others (see Appendix A for a list of plants and plant products that require phytosanitary certification). Processed plants and plant origin products typically do not require phytosanitary certification, however, this depends on specific phytosanitary requirements of importing countries.

Traditional paper phytosanitary certificates are transferred between NPPOs by post, courier or other physical means accompanying the consignment. Their delivery can be prone to delays and loss. Paper certificates are also prone to fraud, often resulting in shipment delays, product rejection, and, as a result, higher trade costs, reputational damage, and in repeated cases, the loss of market access. Electronic certification systems, on the other hand, can reduce the time and cost spent on processing and transmitting phytosanitary data, doing so in a safe and more secure manner that results in increased exports, savings for traders, and lower prices to consumers.

The IPPC ePhyto solution allows for the electronic exchange of phytosanitary certificates (PCs) between countries. It provides a single point of exchange in the system, to facilitate data exchange through:

- The ePhyto Hub, a centralized system accessible to NPPOs to exchange electronic phytosanitary certificates produced in their own national systems.
- The ePhyto Generic ePhyto National System (GeNS), to give countries without their own national systems the possibility to produce, send and receive electronic PCs through the ePhyto Hub.

In September 2024, 91 countries were officially exchanging certificates through the ePhyto Hub and 30 of them used the ePhyto GeNS System. An additional 43 countries are testing ePhyto, including 24 with the GeNS. However, countries that are exchanging ePhytos do not systematically use the solution on a large scale. The choice to use a paper or digital PC for a particular export depends on whether the importing partner country has adopted the ePhyto solution as well as industry and exporter preferences.

This report assesses the economic impact of the use of ePhyto on trade. The report considers the ePhyto solution from three angles. First, the report presents some trends on the use of ePhyto by adopting countries based on a survey conducted with national and regional plant protection organizations to understand how countries have adopted and used this digital solution. Second, cost benefit analyses assess the financial and economic viability of the ePhyto solution in four countries: Serbia, Egypt, Uzbekistan and Ukraine. This country-specific approach highlights how ePhyto will reduce both trade costs for companies and administration costs for governments, while having wider societal benefits through reduced greenhouse gas (GHG) emissions. The analysis is based on interviews with exporting companies, focusing on exports of fruit products representing the countries' main exports,[3] and allows for in-depth assessment of procedures and costs associated with issuing phytosanitary certificates. Third, an econometric analysis using a gravity model assesses how ePhyto will affect bilateral trade. This latter analysis uses global trade data, which allows for assessing a wider country range and the full range of plants and plant products typically covered by phytosanitary certification.

The cost–benefit analysis and econometric analysis complement each other. While the first allows for a better understanding of the mechanisms through which the ePhyto solution can reduce trade costs and facilitate trade, the latter provides global-level evidence of ePhyto's potential to increase trade flows between the two countries that use the ePhyto solution (a country pair).

The study is organized as follows. Chapter 1 discusses the evolution of ePhyto use in trade of plants and plant products, including the results of a survey conducted among multiple NPPOs on the use of paper and electronic phytosanitary certificates. Chapter 2 presents cost and benefit analyses at the country level for four countries: Serbia, Egypt, Ukraine and Uzbekistan. Chapter 3 presents an econometric analysis of the effects of ePhyto on trade based on the gravity model. The report closes with policy implications and conclusions.

3 As well as cereals in the case of Ukraine.


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Chapter 1
Evolution of trade in plants and plant products

This section provides evidence of the use of ePhyto across countries, examining its growth and patterns in global trade of plants and plant products (Box 2). The adoption of the ePhyto solution by countries around the world has transformed the exchange of phytosanitary certificates.

Box 2

GLOSSARY OF TERMS

This report uses key terms as defined by the ISPM.

Phytosanitary certificate: An official paper document or its official electronic equivalent, consistent with the model certificates of the IPPC, attesting that a consignment meets phytosanitary import requirements

Plants: Living plants and parts thereof, including seeds and germplasm.

Plant products: Unmanufactured material of plant origin (including grain) and those manufactured products that, by their nature or that of their processing, may create a risk for the introduction and spread of pests.

Regulated article: Any plant, plant product, storage place, packaging, conveyance, container, soil and any other organism, object or material capable of harbouring or spreading pests, deemed to require phytosanitary measures, particularly where international transportation is involved.

An exchange is counted for a contracting party when it sends or receives an ePhyto. Only unique ePhytos are counted (e.g. if the same ePhyto is sent or received more than once it is only counted once). ePhytos are only counted if they have a tracking status of "delivered" or "delivered with warnings." Those with the status "withdrawn," "rejected" or "subject to clearing" are not included. Messages sent or received while a contracting party is in the testing phase are not counted. Acknowledgement messages associated with an ePhyto are not counted.

SOURCES: IPPC. 2017. Phytosanitary certificates. International Standards for Phytosanitary Measures 12. (A.k.a. ISPM 12). Rome, FAO and IPPC. www.ippc.int/static/media/files/publication/en/2017/10/ISPM_12_2014_En_2017-10-26_InkAm.pdf

IPPC. 2024a. Glossary of phytosanitary terms (as adopted by CPM-18). International Standard for Phytosanitary Measures (ISPM) No. 5. Rome, IPPC and FAO. www.ippc.int/en/publications/622/

IPPC. 2024b. Funding of the IPPC ePhyto Solution. Commission on Phytosanitary Measures (CPM) Eighteenth Session Agenda Item 12.5. Rome. https://assets.ippc.int/static/media/files/publication/en/2024/03/15_CPM_2024_Rev1_Proposed_ePhyto_Funding_Model_2024-03-08_if9QI1G.pdf

1.1 EVOLUTION OF ePHYTO'S USE AND TRADE SHARES

Since its launch in December 2017 and until 2023, 4.3 million ePhytos were issued by exporting countries around the world. In 2018, only five countries used the ePhyto solution, constituting 15 unique country pairs[4] that together generated 38 369 ePhytos. The cumulative number of ePhytos issued between 1489 unique country pairs in 2023 grew to 4.3 million by the end of 2023. Figure 1 shows the number of ePhytos exchanged monthly between 2017 and 2023, as well as the number of unique country pairs.

The first spike in ePhyto certificate issuance, as illustrated in Figure 1, occurred at the onset of the COVID-19 pandemic (between January and March 2020, with a 98 percent increase), while the increase in the number of unique country pairs occurred later, namely between April and June 2020 (more than a 400 percent increase). This implies that the increase in the number of ePhytos traded between January and March 2020 was mostly between the same trading partners and that new partners started issuing ePhytos later that year. Overall, there has been a steady increase in the number of country pairs issuing ePhytos, while the number of ePhytos issued has grown in multiple jumps. This suggests that once two countries form a pair to exchange ePhyto, they try to rapidly move trade from paper to the electronic phytosanitary certificates to reduce costs.

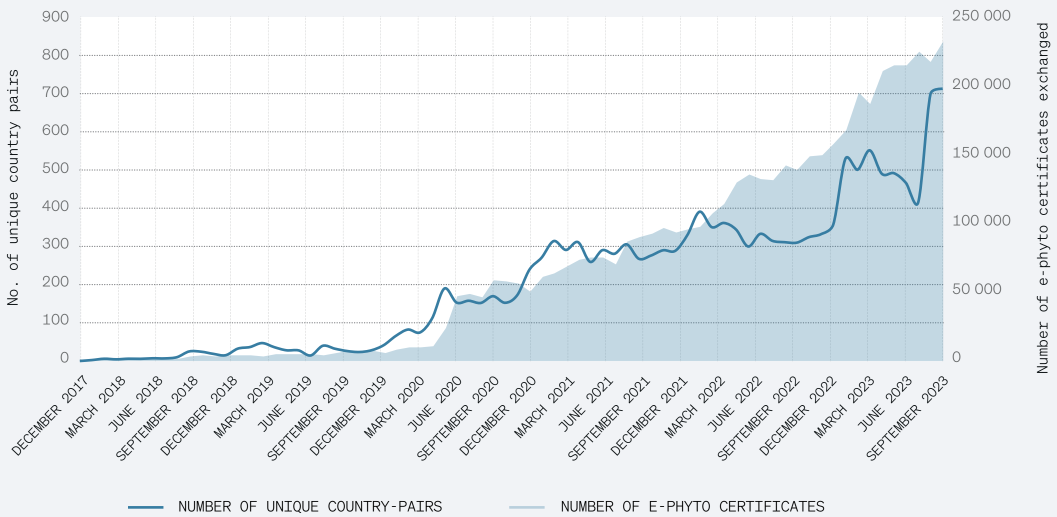


Figure 1
Number of ePhytos issued and number of unique country pairs by month and year

SOURCE: Monthly data on bilateral ePhyto issuance provided by the IPPC for this report. Authors' calculations.

4 A country pair consists of an exporting country which sends ePhytos to an importing country that accepts ePhytos.

It should be noted that Argentina was the first country to report issuance of ePhytos in 2017 and that the United States of America was the first country to receive ePhytos that year from Argentina. The countries issuing the greatest total number of ePhytos in 2017–2023 were: the United States of America (1 076 986); Kenya (597 573); Chile (377 221); Morocco (373 493), Costa Rica (292 850); Argentina (265 852); and South Africa (245 434) (Figure 2).

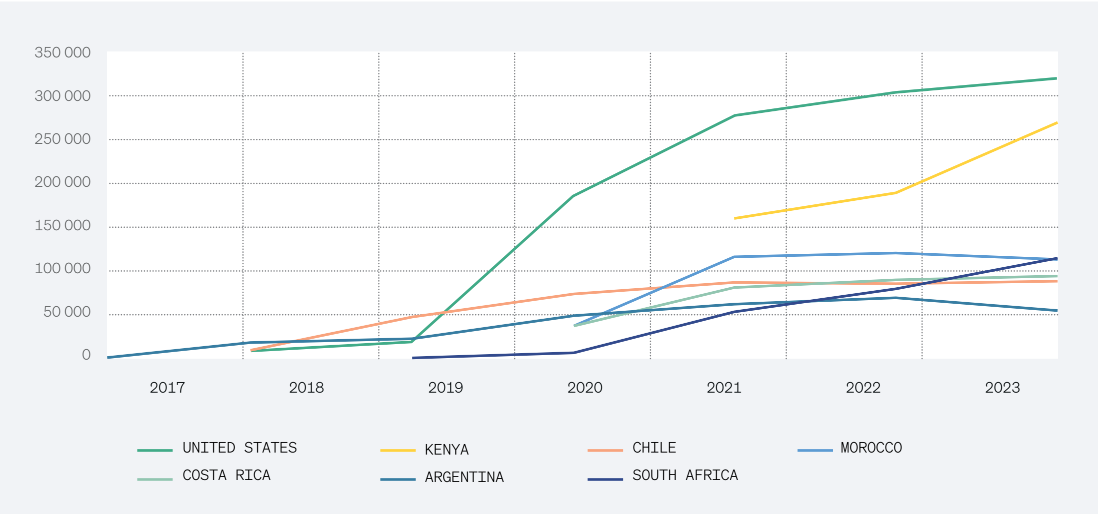


Figure 2
Total number of ePhytos issued annually by top seven countries

SOURCE: Authors' own elaboration.

The number of countries receiving ePhytos (importing countries) exceeds the number of issuing (exporting countries). In 2017–2023, 86 countries received ePhytos as compared with 71 countries that issued these certificates. The countries receiving the greatest total number of ePhytos in 2017–2023 were: the United States (1 011 398); the Kingdom of the Netherlands (852 695); Mexico (450 667); Spain (296 569); France (199 910); and the Republic of Korea (185 458).

The estimated monthly value of plants and plant products exported from countries that use ePhyto also increased. From January 2020 to mid-2023, the value of plants and plant product exports assumed to be covered by ePhyto increased from zero to USD 10 billion (Figure 3), reflecting seasonal fluctuations with a noticeable increase at the beginning of 2020 with the onset of the COVID-19 pandemic, when many countries implemented movement restrictions and lockdowns, and decreasing in 2022 as a reflection of global trade disruptions. In 2023, the value of all plant exports made by countries that use ePhyto was estimated to be USD 90 billion.

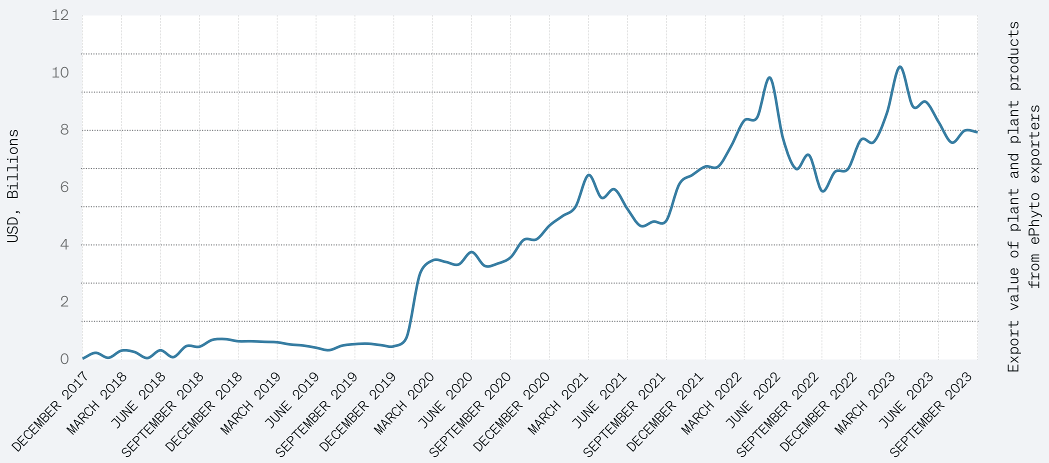


Figure 3
Export values of plants and plant products from ePhyto issuing countries

SOURCE: Authors' calculations based on data provided by the IPPC for this report, and on: TDM (Trade Data Monitor). 2025. Trade Data Monitor. [Accessed on 31 December 2023]. https://tradedatamonitor.com/ Licence: Trade Data Monitor, LLC. Authors' calculations.

As more countries adopt ePhyto, the estimated share of their exports in total world exports of plants and plant products also increased, rising from zero to 17 percent by the end of 2023 (Figure 4) with a noticeable increase at the onset of the COVID-19 pandemic (around February 2020). Restricted physical mobility and limited opportunities to physically exchange paper certificates may have driven trading partners to either start or accelerate the process of digitalizing certificate exchanges. The steady increase in the value of plant exports from ePhyto participant countries between 2017 and 2023 could also be attributed to the ePhyto solution becoming fully operational in July 2019 (IPPC, 2020a) and to NPPOs using national systems that issued electronic phytosanitary certificates to join the ePhyto Hub (FAO, 2020). Implementing digital certification in international trade is a lengthy and resource-consuming process. Therefore, countries that already had an established national system for issuing electronic certificates could adapt quickly to the ePhyto solution.

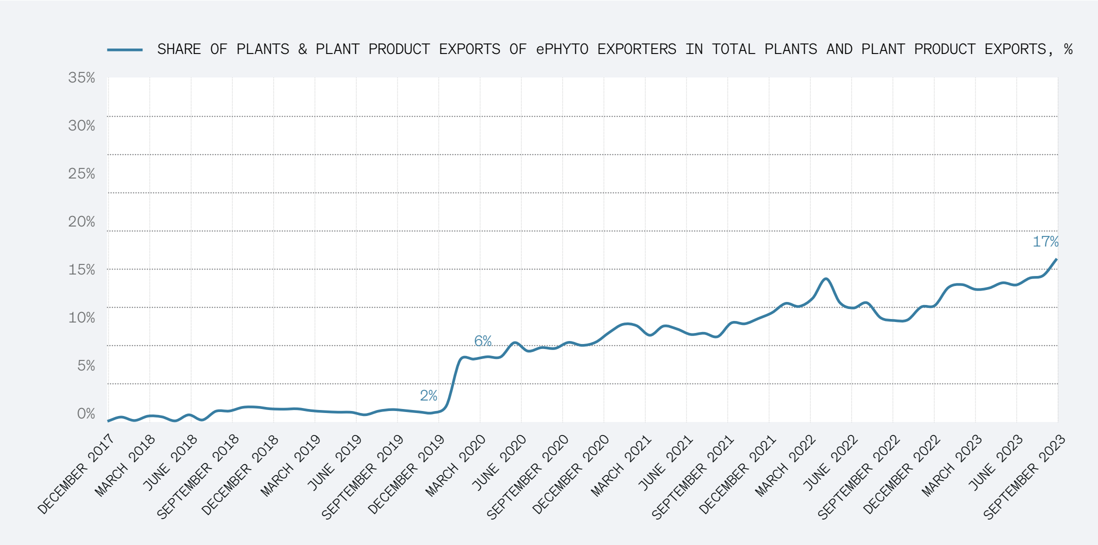


Figure 4
Value share of plants and plant product exports

SOURCE: Authors' calculations based on data provided by the IPPC for this report, and on: TDM (Trade Data Monitor). 2025. Trade Data Monitor. [Accessed on 31 December 2023]. https://tradedatamonitor.com/ Licence: Trade Data Monitor, LLC. Authors' calculations.

NOTE: Agrifood products are defined as those covered in the 1994 Agreement on Agriculture – also known as the Marrakesh agreement, which is now under the jurisdiction of the WTO – as well as fish.

1.2 SURVEY ON THE USE OF PAPER AND ELECTRONIC CERTIFICATES

In collaboration with the IPPC and the NPPOs, the authors conducted a survey requesting data on the number of phytosanitary certificates issued annually between 2017 and 2023 from all NPPOs. Results show that out of 36 responding NPPOs, 23 reported using ePhyto, indicating a significant shift towards ePhytos.[5] These NPPOs provided data on the proportion of ePhytos among all phytosanitary certificates, both paper and electronic, while attempting to account for any duplicates.

5 These countries reported issuing ePhytos during 2017–2023: Albania, Argentina, Australia, Cameroon, Costa Rica, Côte d'Ivoire, Cook Islands, Czechia, Ecuador, France, Germany, Ireland, Republic of Korea, Malaysia, Mexico, Nepal, the Kingdom of the Netherlands, New Caledonia (France), New Zealand, Nigeria, Sao Tome and Principe, Sweden, United States of America. Countries that responded to the survey but did not issue ePhytos: Azerbaijan, Belgium, Bhutan, Canada, Finland, the Islamic Republic of Iran, Iraq, Japan, Kuwait, Philippines, Suriname, Syrian Arab Republic, United Kingdom of Great Britain and Northern Ireland (specifically: England and Wales).

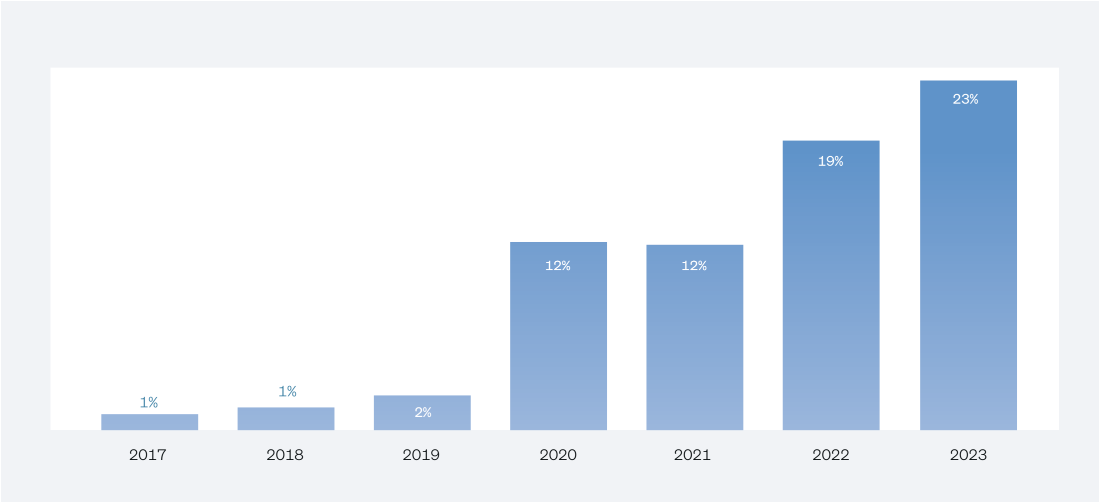


Figure 5
ePhyto certificates as a percentage of total phytosanitary certificates issued (paper and ePhyto)

SOURCE: Authors' calculations based on data from 23 NPPOs.

In the next chapter, we will explore a detailed cost–benefit analysis of ePhytos, examining how ePhyto can reduce exporting costs.

Chapter 2
Country-level cost benefit analyses

The objective of the cost–benefit analyses is to assess and quantify how countries would benefit from adopting the ePhyto solution. It illustrates and provides evidence of how digital solutions can reduce trade costs, benefitting exporters, the government and society more broadly. This section presents cost–benefit analyses of the IPPC ePhyto solution for four countries: Serbia, Egypt, Ukraine and Uzbekistan.

The analyses assess whether the use of the ePhyto solution decreases exporting costs and whether adopting the ePhyto solution results in a positive financial return for trading firms and in a positive economic return for countries. Assessing the costs and benefits of the ePhyto solution at the country level allows for better understanding of how different stakeholders in the country, in particular firms and the government, might face incremental or reduced costs as they adopt and trade with ePhyto.

The approach was similar across all four countries, with minor variations based on country specifics at the time. It compares:

- the *without ePhyto* (WO/eP) situation, in which the country does not shift from using paper certificates to ePhyto, to a
- *with ePhyto* (W/eP) situation, in which the country uses ePhytos in trade, and paper PCs are no longer required for trading with the ePhyto importing country.

The analyses considered potential benefits or savings from ePhyto in the exporting countries. Several scenarios were also developed for the W/eP situation depending on the extent of ePhyto adoption by importing countries.

The four countries were chosen because each can provide interesting insights on the economic impact of ePhyto. All belong to the EBRD's region of operations given the scope of the broader project under which this study was conducted. Egypt is a major exporter of citrus fruits and vegetables, notably to the European Union. While the European Union countries are exchanging ePhytos via their Traces NT system (IPPC, 2020b), Egypt has not adopted the ePhyto solution. Serbia has the largest export volumes in the Western Balkans, however, the country does not use the ePhyto despite being connected to the ePhyto hub. Ukraine is a major exporter of plants and plant products, in particular, cereals, to other countries in the EBRD region of operation. Ukraine also plays a major role in global food security. The country has developed a national digital system for the exchange of phytosanitary certificates and – at the time of this writing – was testing the ePhyto solution. In contrast, Uzbekistan is already connected to the IPPC ePhyto Hub while using digital PCs in addition to paper ones, as will be discussed in the analysis. Uzbekistan is a major producer and exporter of fruits and vegetables in Central Asia and it is a double landlocked country, i.e. a landlocked country surrounded by other landlocked countries, a circumstance with implications for trade costs.

In typical cost–benefit analyses, the with-intervention and without-intervention scenarios are both associated with specific costs and benefits. However, because this analysis involves no revenues and benefits per se, the analysis compares only costs in the WO/eP and the W/eP situation, considering costs for companies, costs for the government and social costs. The costs for exporters are more important in the WO/eP situation: companies have costs associated with applying for the paper PC – for example picking up the empty PC form and/or picking up and sending to the importing party the final certificate – but also extraordinary costs associated with potential reissues and/or delays of PCs. The WO/eP situation also implies an additional cost for the government, i.e. printing forms for the PCs to be printed on. The W/eP situation, in contrast, incurs the government cost of setting up the system for ePhyto and the recurrent maintenance expense, but avoids the costs noted above for the WO/eP.

The cost–benefits analyses are first undertaken at the **company level**, using a financial analysis with financial prices (i.e. the prices paid), to show the savings for a typical exporting company in the assessed subsector and country. For exporting companies, there are no investment costs to switching to ePhyto, so the analysis focuses on assessing savings per PC and per year for the company. The analysis is then also undertaken at the **country level**, using an economic analysis with economic prices (a.k.a. the social opportunity costs), to see the return on the ePhyto investment for the country.

The W/eP situation corresponds to situation where digital PCs are used and paper PCs are not compulsory and not used for border control. In the case of Uzbekistan, the W/eP situation still involves paper PCs because the transit countries still require them.

2.1 PHYTOSANITARY CERTIFICATION IN THE ASSESSED COUNTRIES

2.1.1 Application for phytosanitary certificates

The benefits of adopting the ePhyto solution depend on several factors, including the current process for obtaining PCs for exports. This section briefly presents some aspects of phytosanitary certification processes in the assessed countries.

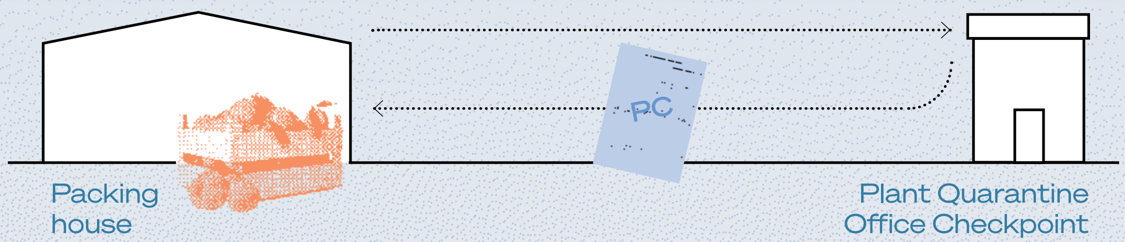
The PC application process generally involves four steps.

- The exporter submits a request for inspection and for a PC. This request can be done digitally, which is typically the case in Serbia, where companies email the request, and in Uzbekistan, where companies use the online single window. This can also be done in person, as is typically the case in Ukraine.
- The inspector inspects the shipments and takes a sample of the products for laboratory if needed. The inspection might take place at the company's loading site, as is the case in Serbia and Egypt, or directly at the customs point, as is sometimes the case in Uzbekistan.
- Upon results of the inspection and laboratory tests (when applicable), the inspector issues the certificate. If the certificate is not issued digitally or on the site of the inspection, the company might have to travel to the plant quarantine office/point to pick up the PC.
- The PC travels with the shipment or by courier to arrive at the border of the importing country. In Egypt, the PC is often sent after the shipment has already left to avoid delaying the shipment's departure.

In Egypt, inspectors typically remain on-site (usually the packing house) for the duration of the exporting season because shipments leave every day. The company must pick up blank PC forms at the start of the day (or most days), based on expected export volumes for the day. The inspection results are used to apply for a bill of lading, which is then used to apply for a PC at the customs check point.

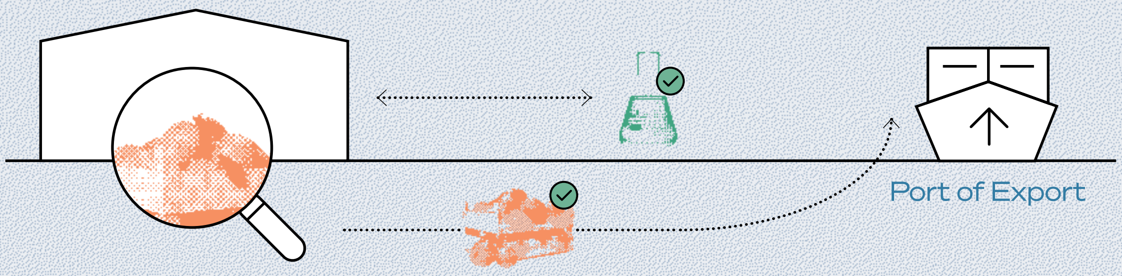
Process of issuing a paper Phytosanitary Certificate in Egypt

1 **Exporter** goes to the Plant Quarantine Office Checkpoint to pick up the **Phytosanitary Certificate Form** and returns back to the packing house.



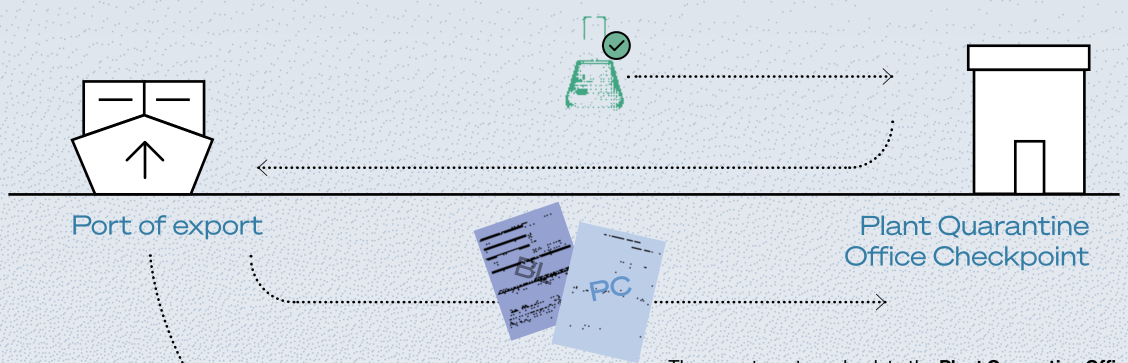
2 Shipment inspected at packing house. Samples are sent for **laboratory testing** and the exporter awaits the **laboratory results.**

3 The shipment travels from the **Packing House** to the **port of export.**



4 The **exporter** goes to the **Plant Quarantine Office** near the port of export with the lab results to apply for the **Bill of Lading** and returns back to the port of export.

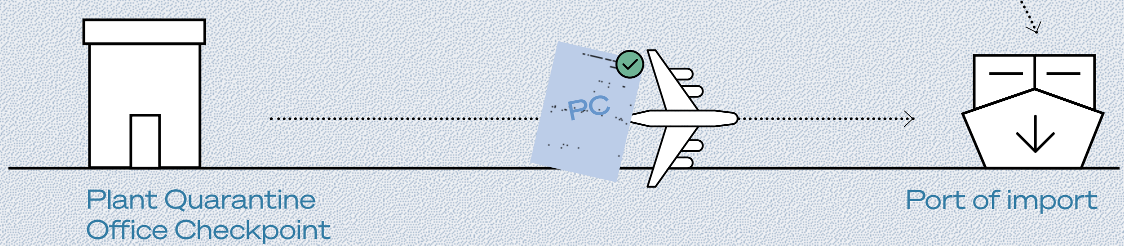
5 Once the **Bill of Lading** has been received, the shipment leaves.



6 The exporter returns back to the **Plant Quarantine Office** near the port of export with the **Bill of Lading** to apply for the **Phytosanitary Certificate**.

7 The **Phytosanitary Certificate** is issued and is sent to the **importing port** by courier.

8 The **Phytosanitary Certificate** is used to clear the shipment.



! If the **Phytosanitary Certificate** has a problem and **needs to be reissued**, then the certificate must be sent back by courier. **Steps 1, 6, and 7 must be repeated**, resulting in significant delays.

! If the **Phytosanitary Certificate** arrives **after** the shipment, the shipment waits at the border, incurring costs.

2.1.2 Status of ePhyto adoption in the assessed countries

Of the assessed countries at the time of writing, only Uzbekistan has adopted the ePhyto solution, while the other countries are at different stages in the process of adoption.

The current process for issuing PCs for exports in Egypt is based on paper certificates. Egypt has not yet registered for ePhyto, however, the country's NPPO – the Central Administration of Plant Quarantine (CAPQ) of the Ministry of Agriculture and Land Reclamation – envisions joining the ePhyto Hub.

Serbia has not yet adopted the ePhyto. Serbia benefited from SEED+, an upgraded version of the SEED system, which includes systematic data exchange among all parties to the Central European Free Trade Agreement (CEFTA) Additional Protocol 5 as well as the development of CEFTA TRACES New Technology (NT), which is based on the European Union's TRACES NT. This allows for integration with European Union systems and ePhyto. At the time of the field visit, digital certificates were already available within the Western Balkans while paper certificates remained compulsory.

Box 3

SEED AND SEED+

The Systematic Exchange of Electronic Data (SEED) was launched in 2010 to improve border management in the Western Balkans. The system allows for electronic and pre-arrival exchange of information for exports, transits and imports. Notably, it set up a legal basis for electronic data exchange, operational guidelines and instructions for customs administration and an IT infrastructure and system for data matching and alarm module on pre-arrival data.

SEED+ provides for the development of CEFTA TRACES NT and an upgrade of SEED. Through CEFTA TRACES NT, which is based upon the European Union's TRACES NT, countries are able to generate and process phytosanitary, veterinary and pharmaceutical certificates and entry documents in CEFTA parties; it also allows them to rapidly exchange information on non-compliant shipping.

SOURCE: CEFTA. 2023. Systematic Exchange of Electronic Data (SEED). In: CEFTA. Brussels. [Cited 28 August 2023]. https://cefta.int/projects/seed/

Ukraine presently uses the national system Phytosanitary Information System (PHIS) to manage the application process, sample assignment for lab analysis, costing of inspection services and generation of paper PCs. The PHIS is linked to the ePhyto Hub in a test mode. Test exchanges of phytosanitary certificates began in May 2024, and digital certificates were exchanged with France, the United States of American, Uzbekistan and Nigeria. Ukraine is also updating its legislation on plant quarantine to provide a framework for the use of electronic phytosanitary certificates. This will provide a crucial step for the use of ePhyto in trade.

Box 4

IMPACT OF THE WAR ON UKRAINIAN EXPORTS SINCE 2022

Ukraine is a large exporter of plants and plant products, especially grains such as wheat, maize, soybeans, barley and other crops. The war in Ukraine has profoundly affected its export capacity. The blockade of Ukrainian Black Sea ports significantly increased logistics and insurance costs, which remain a substantial impediment for grain exports.

Prior to the war, an estimated 98 percent of Ukraine's agricultural product exports went through the sea route. Since the start of the war, exporters have had to reroute exports and the share of export consignments going through the marine route decreased to 17 percent at its lowest point in March 2022. The Black Sea Grain Initiative, launched in July 2022, allowed exports from some sea ports to resume and recover to around 75 percent in December 2022. After the termination of the initiative in August 2023, Ukraine opened its own maritime corridor, which further improved maritime export logistics. In 2024, the share of agricultural product exports via river and sea ports reached about 88 percent as compared with 2 percent exported by auto and 10 percent exported by railway transport. The reliance on land transport routes, which limit shipment sizes to a railway wagon, container or truck-load, or exports of cereals by small barges via the Danube ports, increases the number of consignment and accompanying documentation.

The war has also changed trade relations with neighbouring countries. The European Union has notably removed quotas and import duties on agricultural imports from Ukraine through so called Autonomous Trade Measures. These were initially put in place for two years in July 2022 and later extended until June 2025. To limit consequences of the war on agricultural product imports, the European Union has also tried to reduce bottlenecks for agricultural imports to the European Union.

These liberalization measures were met with some resistance. In particular, there was a temporary ban on grain imports from Ukraine into Bulgaria, Hungary, Poland, Romania and Slovakia while transit of grain to other European Union countries was allowed. The ban was lifted in September 2023 following discussion with the European Commission.

SOURCES: European Commission. 2022. *An action plan for EU-Ukraine Solidarity Lanes to facilitate Ukraine's agricultural export and bilateral trade with the EU.* Communication from the EU Commission to the European Parliament, the council, the European Economic and Social Committee and the Committee of the Regions. Brussels. https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:52022DC0217

European Parliament. 2024. *Press Release: Deal to extend trade support for Ukraine with safeguards for EU farmers.* Strasbourg, France. www.europarl.europa.eu/pdfs/news/expert/2024/3/press_release/20240318IPR19422/20240318IPR19422_en.pdf

Krzysztoszek, A. 2024. Poland launches import controls at Ukrainian border to protect domestic market. In: *Euractiv*. Brussels. www.euractiv.com/section/politics/news/poland-launches-import-controls-at-ukrainian-border-to-protect-domestic-market/

Uzbekistan has adopted the ePhyto solution through E-fitouz, the national system connected to the IPPC ePhyto Hub and developed by the Uzbekistan's Plant Quarantine and Protection Agency (AQPP). The E-fitouz system is used in exports and is being tested for imports.

Since May 2020, the procedures for issuance of import permits and export certificates have been simplified thanks to the digital online application system. Payments are also available through mobile banking with QR codes. Applications for phytosanitary certificates are submitted online through a single window, and PCs are issued both in paper and electronic form. The paper form contains the QR code with the link to the electronic PC. The Uzbek State Customs Committee has developed a single window to simplify and streamline customs procedures related to imports and exports. The single window provides a single platform for several permits and processes under different authorities.

The exporting companies interviewed for this analysis reported using the single window and appreciating its simplified export procedures. It has improved the procedure to apply and pay (of applicable) for the export PC. The time gains from using the single window approach were not considered as cost-savings in this analysis, because the time invested was not limited to ePhyto but covered multiple certification services.

All exporters interviewed continued to use the paper PCs as well. Hence, Uzbekistan's system can best be described as hybrid, where both digital and paper certificates are systematically issued in parallel. Exporters usually export by truck through transit countries that do not use ePhyto, so the trucks must carry a paper copy of the PC even if the final importing country accepts ePhyto.

2.2 METHODOLOGY

This section summarizes the methodology of the cost–benefit analysis, with emphasis on the costs that were considered for the analysis and the data collection process.

2.2.1 Assessed costs

In cost–benefit analyses, WO/eP and W/eP situations are both associated with specific costs and benefits. However, because there are no revenues and benefits per se, the analysis compares costs in the WO/eP and the W/eP situations, considering costs incurred by companies, the government and social costs (Table 1). Costs for exporters are more important in the WO/eP situation: companies have costs associated with applying and dealing with the paper PC – for example employee time and other resources to pick up, deliver and send the signed certificate to the importing party – but also extraordinary costs associated with potential reissues and/or delays of PCs upon consignment arrival. The WO/eP situation also implies an additional cost for the government: printing of PCs and their forms. The W/eP situation, in contrast, incurs government cost of setting up the system for ePhyto, but avoids the costs noted above for the WO/eP. The following table summarizes the costs considered in this analysis.

Table 1
Assessed costs

Cost	Who pays	Additional cost or savings when switching to ePhyto
Cost of obtaining the certificate (applying for and/or picking up the certificate)	Exporters	Savings
Costs associated with reissues and/or delays	Exporters	Savings
Administration printing costs	Administration	Savings
Setup costs for ePhyto	Administration	Additional cost
Operational costs	Administration	Additional cost
GHG emissions associated with reissues of PCs	Society	Savings

SOURCE: Authors' own elaboration.

Results are assessed from the exporters' perspective, considering savings per shipment and per exporter, as well as for the country as a whole. For the exporter, costs are initially estimated on a per PC basis, which usually means per shipment as there is one PC per shipment. The cost of obtaining the certificate typically applies to all shipments while the shipping costs associated with PC reissues and/or delays apply to affected shipments (e.g. a percentage of total shipments). Costs per shipment are therefore based on the expected value resulting from the frequency of event occurrence multiplied by the cost associated with it.

This analysis focuses on the various costs associated with trading with phytosanitary certificates, without considering the fee of the certificates. The analysis assumes the fee is a transfer from exporters to the government for certain services, so not a cost from the perspective of an economic analysis, and that the fee would remain unchanged in the event of a transition to ePhyto. Box 5 presents additional information on the fee system per country.

Box 5

ADMINISTRATIVE FEE OF PHYTOSANITARY CERTIFICATES

The fee paid for certificates vary by country and are based on the service provided. For fruit shipments, the results show that container sizes were similar across the assessed countries, in the range of 18 to 20 tonnes per PC, so the fees per PC correspond to similar volumes.

For Egypt, exporters reported paying around EGP 500–750 per certificate, which amounts to roughly USD 10–15 dollars. In Serbia, the fee was RSD 690 per certificate, corresponding to about USD 6.3. In Uzbekistan, there are no fees for PCs for the export of horticulture products. An exporter of peaches reported paying a fee of UZS 340 000, corresponding to about USD 30. The same exporter reported that the PC was free for sour cherries exports. In Ukraine, the average fee for the issuance of a phytosanitary form was around UAH 45.3, corresponding to about USD 1 dollar. The cost of the inspection and examination, including laboratory services, depends on the assessed volumes and crops.

SOURCE: Authors' own elaboration based on company interviews.

At the company and country levels, savings from ePhyto would not apply to all shipments, but only to shipments to a country that accepts ePhytos for imports. Export data broken down by commodity and importing partner country is used to determine the shipments to ePhyto importing partner countries vs shipments to non ePhyto importing partner countries. Savings are only considered for shipments to ePhyto importing partner countries.

At the aggregate level, both for a typical company and the country, four different scenarios for ePhyto importing partner countries were developed to illustrate how ePhyto adoption results vary.[6]

6 The analysis assumes that if the exporting and importing countries both exchange with ePhyto, the exporting firm will systematically trade using ePhyto and not the paper certificates. The practice might differ depending on how firms and governments switch to and adopt ePhyto, with a gradual introduction across all products, for example: product-specific, regional, port or other focus. The W/eP situation is therefore one of full adoption of ePhyto by firms in the exporting country.

- **Current scenario:** ePhyto importing partners include countries that currently use ePhyto.[7,8]
- **Testing and registered scenario:** ePhyto importing partners include countries that currently use ePhyto ("current" scenario) and additional countries that tested and registered for ePhyto use as reported on the ePhyto Hub.
- **The Russian Federation scenario:** ePhyto importing partners include countries that currently use ePhyto and those testing and registered ("Current" and "testing and registered" scenarios combined) and the Russian Federation considering its importance as an importer of fruits and vegetables exported from Egypt, Serbia and Uzbekistan.
- **All scenario:** all importing partners adopt and use ePhyto.

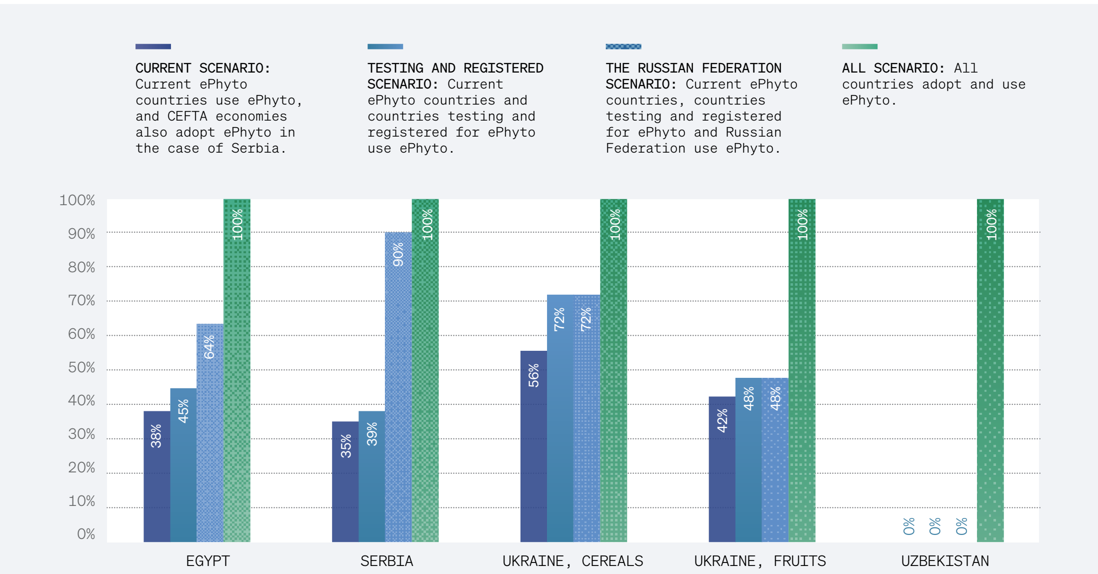


Figure 6
Percentage of shipments benefitting from ePhyto by scenario, by country in 2022 (2023 for Ukraine)

SOURCE: Authors' own elaboration.

7 The status per country is the status as of March 2024.
8 For the analysis of Serbia, we also assume that CEFTA economies would adopt ePhyto concomitantly with Serbia because of the joint hub.

Applying this methodological approach to Uzbekistan, the benefits to exporting companies would accrue only in the “all” scenario. Because of Uzbekistan’s landlocked location, the country exports primarily by trucks that transit through Kazakhstan and other neighbouring countries in Central Asia. A typical trade route for a truck to the European Union would transit through Kazakhstan and the Russian Federation or through Turkmenistan, the Islamic Republic of Iran, and Türkiye, where the truck would be shipped by sea to the European Union. At the time of the field mission, none of those transit countries were using ePhyto, so the driver would need a paper certificate for physical product inspection to cross those borders. Hence, to achieve savings on shipments, not only the importing countries need to adopt ePhyto, but all transit countries must adopt ePhyto as well. In our analysis, this only happens in the “all” scenario, in which all countries adopt ePhyto. Even if Kazakhstan adopted ePhyto after testing it, the trucks transiting through Kazakhstan to the Russian Federation would still benefit from ePhyto only if the Russian Federation as the importer adopts ePhyto too (e.g. “the Russian Federation” scenario).

2.2.2 Assessed products

The analysis focused on a group of products or subsector for each country. Interviewing exporters with similar trade patterns allowed better understanding of how ePhyto could lower costs for each export consignment, taking into consideration the typical process, export routes, and consignment size in the subsector. The products or subsector chosen for each country includes some of the most important plants and plant products that are exported.

The assessed products consist of a range of regulated articles – “[a]ny plant, plant product, storage place, packaging, conveyance, container, soil and any other organism, object or material capable of harbouring or spreading pests, deemed to require phytosanitary measures” (IPPC, 2024a) – with some variation across the countries. The exports refer to fresh products, unless otherwise specified. The analysis of savings for exporters assesses potential savings for the average volume exported per phytosanitary certificate.[9] This means that the analysis can cover several products per country without having to systematically collect all data points for all products covered.

Fruits were selected for analysis in all four countries to provide a basis for comparing results. However, it was not possible to select the same fruits or other products for all countries considering their export specializations. Companies also tend to export a variety of products, so it was not always possible to isolate findings for only one or two fruit products. The shipment sizes and volumes per PC for fruits are similar across all countries (Table 2) making the results relatively comparable.

For Egypt, the analysis covers citrus fruits (primarily oranges but also other citruses such as grapefruits and clementines), potatoes, onions, sweet potatoes, pomegranates, garlic, strawberries, tomatoes, mangos and guavas. Most exporters interviewed exported more than one product.

9 Depending on the country and commodity, this can correspond to the volume in one container or several containers.

For Serbia, the analysis focuses on fruit exports. Given that most Serbian fruit export companies tend to export a wide range of fresh fruits – including apricots, nectarines and peaches – the analysis focuses on fruits in general, rather than on any specific fruit.

For Ukraine, the analysis had to cover two different product groups at company level: one for grain shipments and the other one for apples and blueberries. The grain shipments tend to be much larger, dry bulk consignments exported mostly by sea, with a variation in the volume per certificate issued depending on export market, the size of shipment, vessel type and other factors. In contrast, fruits and berries are exported by standard 20 tonne trucks. The savings for both groups of exporters were then included in the country-level analysis.

For Uzbekistan, the analysis covers fresh fruits. The companies interviewed reported exporting a wide range of products: primarily fresh fruits (e.g. sour cherries, apricots) but also dried fruits and sometimes vegetables, beans, nuts or seeds. However, dry fruits were not included in the analysis because European Union countries do not require PCs for dry fruit imports. Vegetables, beans, nuts and seeds were not included because they were exported by fewer companies.

Box 6

WHAT SHARE OF THE COUNTRY'S EXPORTS DO THE ASSESSED COMMODITIES REPRESENT?

The savings that exporters can obtain from switching to ePhyto depend on product-specific factors including average container size, containers per PC, product perishability and typical export route. The export of wood products and seeds, for example, would differ considerably based on these factors. For this reason, it was important to assess savings by focusing on specific products or product groups to ensure a sufficient sample size and limit variance within the data. It is possible, to some extent, to estimate the share of exports covered by the assessed commodities.

Because the identified savings are per PC, the share of exports covered by the assessed commodities correspond to the number of export PCs for the assessed products over the total number of issued export PCs.

Overall, the assessed products represented about a third of issued PCs. In Serbia, according to the Plant Protection Directorate, about 37 000 PCs were issued in 2022. The analysis covers an estimated 11 377 PCs, so about 31 percent of the total. In Ukraine, about 411 323 phytosanitary certificates were issued in 2023. The analysis covers an estimated 156 446 PCs, or about 38 percent of the total. In Egypt, about 200 000 certificates were issued in 2022. The analysis covers an estimated 112 304 PCs, so 56 percent of the total. In Uzbekistan, about 150 000 to 200 000 are printed every year, and the assessed products correspond to an estimated 38 320 products, so 19–26 percent of the total.

SOURCE: Authors' own elaboration.

2.2.3 Sources of data

As noted above, the analysis uses a traditional cost–benefit methodology that compares trade costs for companies, the government and society more broadly without and with ePhyto. The analysis focuses on costs only, given that ePhyto is not expected to generate additional revenues. Of course, in the longer term, cost savings contribute to the competitiveness of the industry, which might lead to increased revenues, but the analysis does not make assumptions in this regard (see Box 9 for a discussion of this issue).

To assess trade costs for companies, data-finding missions took place using a questionnaire focused on the cost-savings expected from a transition to ePhyto. The costs associated with trading using paper PCs included both (i) regular costs associated with obtaining the paper PC and (ii) costs linked to specific trade disruptions that might only occur a few times per year. To understand better the second type of costs, unstructured discussions were more suited.

Table 2
Companies interviewed and volumes per PC

	Egypt	Serbia	Ukraine (cereals)	Ukraine (fruits)	Uzbekistan
Number of companies interviewed	12	9	7	8	**13**
Average volume of exports per PC (kg)	19 691	20 000	241 646	17 937	**20 750**

SOURCE: Author's own elaboration.

Serbia: Field mission and interviews

The mission for Serbia took place from 31 July to 4 August 2023 to interview nine fruit exporters and two logistics service providers working with fruit exporters. The fruit exporters were located in the areas of Belgrade, Topola, Brestovik, Boleč and Udovice. Almost all of the companies export different types of fresh fruits, mostly but not limited to apples, nectarines and peaches. The main export markets were the European Union and the Russian Federation but also the Persian Gulf countries. The companies reported having between 98 and 400 shipments of 20 tonnes of fruits per year, with an average of 250 shipments per year. Companies traded their own production, produce from other farms or both. All companies took care of sending the information for the PC themselves, but the transportation of fruits was typically undertaken by third parties.

The interviews of fruit exporters highlighted typical issues associated with paper PCs that led to extraordinary costs, focusing on problems that a transition to ePhyto could reduce. By understanding the cost and frequency of each of these problems, the analysis can quantify extraordinary costs associated with paper PCs.

In addition to costs at the company level, the analysis also considers costs for the government. To assess WO/eP trade costs for the government, the team followed up with the Serbian Plant Protection Directorate of the Ministry of Agriculture and Environmental Protection using online interviews, email exchanges and a questionnaire sent to the directorate. These discussions highlighted that one source of savings from switching to ePhyto would come from ceasing the costly production of PC forms, which are printed by the Institute for Manufacturing Banknotes and Coins.

Egypt: Field mission and interviews

The mission in Egypt was held from 4–8 March 2024. Interviews were conducted with 12 exporters of plants and plant products, as well as a customs broker who obtains PCs for multiple exporters.

Products exported by interviewees were primarily oranges and potatoes but also included sweet potatoes, onions, grapefruits, peanuts, strawberries, and other plants and plant products. Export markets covered almost the entire globe, with European Union countries most frequently mentioned. Companies issued between 65 and 14 000 PCs per year, and shipments ranged from 65 to 3500 per year. Companies issued one PC per container or per shipment, depending on the company and export market.[10] The youngest company had been in operation for only five years while the oldest had been operational for about 60 years.

Data on the volumes of PCs issued and the costs of printing the forms were obtained from the Central Administration by an FAO phytosanitary expert.

Ukraine: Interviews

In Ukraine, an FAO phytosanitary expert interviewed seven cereal companies; eight fruit companies exporting apples, blueberries and – in some cases – other fruits; and a customs broker. Interviews were conducted using a mix of in-person and virtual means. The grain companies tend to be large exporters that have been exporting for decades, while fruit exporting companies tend to be smaller and more recently established, with about a decade of exporting experience on average. Most companies handled the process of obtaining the PC themselves, but some went through an external agent.

10 Increasingly, companies issued one PC per container for European markets to avoid delaying multiple containers in the event of a problem with one PC.

Uzbekistan: Field mission and interviews

The Uzbekistan mission took place from 28 April to 3 May 2024. The team interviewed 12 exporters of plants and plant products: fruits, including sour cherries, melons and apricots; vegetables, including onions and cabbages; and seeds and nuts, including almonds and sunflower seeds. Most exporters also exported dried fruits such as dried apricots or dried melons. Uzbekistan requires phytosanitary certification for the export of dried fruits, although some importing countries do not require PCs for these products. In the European Union, for example, PCs are not required for dried fruits. For this reason, the team prioritized interviewing those companies that export fresh fruits or nuts. Interviews were held in Tashkent and in or around Samarkand.

The interviewed companies had various profiles. On average, export volumes were small, at about 2000 tonnes per year. Shipments took place mostly through trucks that carried between 20 and 23 tonnes of the exported products. In a minority of cases, exports took place by train (e.g. certain exports to China) or by plane (e.g. exports to the Republic of Korea). Most companies go through a broker for the export documentation, including PCs, but some companies do it in house or use a mix of both. Most companies were recently established (circa 2019 or later); the oldest had been in operation since the early 2010's.

Other sources of data

To understand benefits at the aggregate level, the analysis relies on the UN Comtrade Database on trade flows by country, partner countries and product across years (UN Comtrade Database, 2025). The data is disaggregated based on whether the importing partner country is exchanging, testing, registered or unregistered with the ePhyto solution. With one exception, the analysis uses 2022 data on exports, with HS-6 products and a breakdown by the importing partner country. In the case of Ukraine, the war significantly affected 2022 export volumes, so the analysis uses 2023 export data. Results for Ukraine also rely on plant protection data on exports and issued PCs by commodity, which was used to triangulate some of the interview and other export data.

Limited data was available on W/eP trade costs, i.e. the costs of setting up and operating the software, hardware and overall infrastructure for ePhyto. The cost estimates are therefore derived from case studies.

Economic values

For the country-level economic analysis, financial costs were transformed into economic costs by removing costs corresponding to transfers within the economy, such as taxes. A shadow exchange rate was also computed. Generally, the conversion used for converting the costs of delays and reissues corresponds to the foreign exchange conversion factor, because these are international costs. For the costs of applying for PCs and printing forms, the conversion factor corresponds to the standard conversion factor. The costs of setup and recurrent costs for ePhyto maintenance are as reported above, directly as economic values. The value of GHG emissions presented above also directly affects economic values.

2.3 COSTS AND SAVINGS FROM SWITCHING TO ePHYTO

2.3.1 Without ePhyto: costs to export companies

Exporter costs associated with the WO/eP situation (paper PCs) are generally threefold.

- Cost of obtaining the PC: This is the staff time and travel costs associated with picking up the paper PCs in person from the customs office; in Egypt, the application itself must also be picked up and submitted in person. The savings here include only those attributed to switching to digital certificates.
    - In Serbia, the application process is done by email. The inspector typically brings the PC to the packing house at the time of inspection, so there is no additional trip needed to pick up the PC. Hence, there are no savings in the case of Serbia.
    - In Egypt, there are costs associated with both applying for and picking up the PC. Companies have to pick up the paper application, submit it in person, and then pick up the PC, though some PCs were delivered domestically by courier. Switching to ePhyto would result in cost savings for both the application and delivery processes.[11]
    - In Uzbekistan, applications are done online through the single window approach for both paper and digital PCs, so there is no change attributable to ePhyto. There are some costs linked to picking up the PC (fuel and staff time needed to travel to the customs office).[12]
    - In Ukraine, there are costs linked to staff time and fuel expense to pick up the PC.[13]
- Costs of sending the PCs by courier: Companies sometimes send

11 Responses from interviewees in Egypt were diverse. Company employees used public transportation, their own personal car or a rented car for the application process, and some certificates were delivered by courier domestically. So, the analysis assumes a cost of USD 20 per certificate in Egypt.

12 The assumptions for Uzbekistan are a monthly wage of about USD 400 (UZS 5 million) and fuel cost of USD 0.69 per litre. For both Uzbekistan and Ukraine, it was assumed that a litre of fuel covers 10 km.

13 The assumptions for Ukraine are a monthly wage of USD 600 per person and fuel cost of USD 1.37 per litre. For both Uzbekistan and Ukraine, it was assumed that a litre of fuel covers 10 km.

PCs by courier. In Egypt, most companies send the PC by courier after the shipment has already left; this allows the shipment to leave the harbour prior to all the documentation being finalized. In Serbia, exporters tend to send PCs by courier for specific export markets, for example in the gulf countries. In Uzbekistan, PCs are couriered in exceptional circumstances, such as when a PC must be reissued. However, eliminating this step in Uzbekistan is not indicated as a savings because the PC is usually sent along with other documents. Switching to ePhyto would therefore not remove this cost. On the other hand, if other certificates were also digitalized (e.g. certificates of origin), there would be room for saving on these costs too.

- **Costs associated with reissues and/or delays:** Sometimes, the PC arrives after the shipment has departed, in which case, the shipment is held at the importing country's customs office until the PC arrives. Other times, there is a mistake in the PC – e.g. the licence plate of the truck or client address are incorrect, or there is a change of client last minute. This results in holding the shipment at the customs until the reissued PC arrives. Whenever shipments wait at the border, there are demurrage costs, power costs and other storage costs.

All these costs are assessed to derive an average cost per shipment. For each, there is a frequency with which the cost occurs and a cost every time the event occurs, and the expected cost is the product of these. The results per country are presented below.

Table 3
Egypt, exporters' costs

	Frequency of the cost occurring (%)	Additional cost or savings when switching to ePhyto (USD)	Expected cost per shipment (USD)
Cost of obtaining the PC	100	20	20
Costs associated with reissues	6.34	244	27
Costs associated with delays (also due to reissues)	3.85	3392	37
Average cost per PC			84

SOURCE: Authors' own elaboration based on interviews with respondents in Egypt.

NOTE: In Egypt, the expected cost per PC is the average of expected costs, rather than a computed expected cost based on the average frequency and average cost per event. This is because companies with higher cost per event typically had lower frequencies of the event, so the average expected cost is lower than the expected costs based on the average frequency and average cost per event.

Table 4
Serbia, exporters' costs

	Frequency of the cost occurring (%)	Additional cost per occurrence (USD)	Expected cost per shipment (USD)
Cost of obtaining the PC	100	–	–
Costs associated with reissues	2.60	43	1.11
Costs associated with delays (also due to reissues)	1.20	282	3.38
Average cost per PC			4.48

SOURCE: Authors' own elaboration based on interviews with respondents in Serbia.

Table 5
Ukraine, exporters' costs

	Frequency of the cost occurring (%)	Additional cost per occurrence (USD)	Expected cost per shipment (USD)
Cost of obtaining the PC, grains	100	3	3
Cost of obtaining the PC, apples/ blueberries	100	17	16
Costs associated with reissues, grains	2.36	2672	63
Costs associated with reissues, apples/blueberries	0.00	213	0.85
Average cost per PC, grains			66.3
Average cost per PC, apples/ blueberries			18.4

SOURCE: Authors' own elaboration based on interviews with respondents in Ukraine.

Table 6
Uzbekistan, exporters' costs

	Frequency of the cost occurring (%)	Additional cost per occurrence (USD)	Expected cost per shipment (USD)
Cost of getting the initial PC	100	2	2
Costs associated with reissues	1.51	121	2
Average cost per PC			3.7

SOURCE: Authors' own elaboration based on interviews with respondents in Uzbekistan.

Costs per shipment are highest in Egypt and in Ukraine for grains exports. Costs of obtaining PCs in Egypt are a rough estimate because it varied significantly by company, from zero to having to rent a car to pick up the PCs or having to send the PC separately by mail. Costs associated with reissues and delays are also high because there were more frequent delays and reissues of certificates, usually lasting a few days and leading to power, storage and demurrage costs. This is partly because PCs in Egypt were typically sent separately from the shipment, and the PC might arrive after the shipment, especially for nearby markets such as Italy, Greece and Slovenia. In addition, exporters in Egypt tended to export large volumes and some companies reported the having to change consignees at the last minute. For grain exports from Ukraine, the frequency of delays is not particularly high, but the costs associated with each delay are high because the shipments are particularly large. Based on interview responses, a single day of shipment delay could cost between USD 2000 and USD 25 000.[14]

Costs per shipment are low in Serbia, for Ukrainian fruit exporters, and in Uzbekistan. In these cases, exporters reported few instances of having to reissue PCs or delays associated with PCs, and the PCs systematically travel with the truck. While Ukrainian fruit exporters revealed some delays due to PCs, these would not have been solved by switching to ePhyto, so they were not considered in the analysis. Some trade issues reported in Ukraine's European Union trading partners were not due to phytosanitary certification issues but to the war in Ukraine (Box 4).

14 Exporters' answers regarding the costs of delay varied. One company reported USD 200 per day, another reported USD 1500 per day, and a third said between USD 2000 and USD 25 000 per day. For that latter company, a cost of USD 2000 was considered to be on the low end of the range and therefore more conservative in the results. The other respondents simply reported that costs per day depends on the type of transport and contract.

Box 7

OTHER TRADE COSTS ASSOCIATED TO PHYTOSANITARY MEASURES

The cost–benefit analysis only considers PC-related costs that could be reduced through ePhyto. However, interviewees revealed problems with other phytosanitary measures that ought to be mentioned. Discussions about the risk-based approaches to product sampling and testing could allow requirements to be further streamlined.

Some exporters reported a shortage of inspectors, who not only inspect shipments but also prepare the PCs. Inspectors are busy, visiting multiple loading sites per day and conducting visits even when they are not required to sample or test the shipment. Loading and shipping delays can occur due to the timing of the inspector's visit.

Inspectors sometimes require 24-hour advance notice when a consignee or truck licence plate is changed, but such changes often occur at the last minute, causing problems when inspectors arrive on the scene with pre-filled PCs. Those PCs have to be reissued, a process that is further complicated when the inspector has travelled to the inspection site from another city.

SOURCE: Authors' own elaboration.

These costs per PC that could be saved by switching to ePhyto for a particular volume of exports associated with the PC. For example, for fruit exports, each PC typically corresponds to a volume of about 20 tonnes. The estimates of PCs issued for a country are derived from country-level data on export volumes to importing partner countries. For the average export company, the distribution of importing partners corresponds to the national-level distribution and the number of PCs issued comes from the company interviews. The savings per PC are then aggregated at the country or exporter level.

The United Nations Comtrade database provides trade flows by country, country trade partner and product across years. The analysis for this report uses 2022 export data, with HS-6 products by importing partner. For Ukraine, the analysis relies on 2023 data from the Global Trade Tracker for the selected products (Global Trade Tracker, 2025), because the war affected trade volumes in 2022. Importing partner countries were then categorized by their ePhyto status: exchanging, testing, registered or unregistered. For Ukraine, only a portion of the volume exported to the European Union was considered for the analysis because the PCs did not seem to cover the entire volume of cereals exported to the European Union.[15]

Considering a breakdown of export shipments by importing partner country is important because the savings would not apply to all markets. Not all importing countries use ePhyto (IPPC, 2025a). In particular, the Russian Federation, which is an important export market for Serbia and Uzbekistan, has not yet registered for ePhyto. The scenarios show how aggregated savings change based on different scenarios of ePhyto adoption by importing partners.

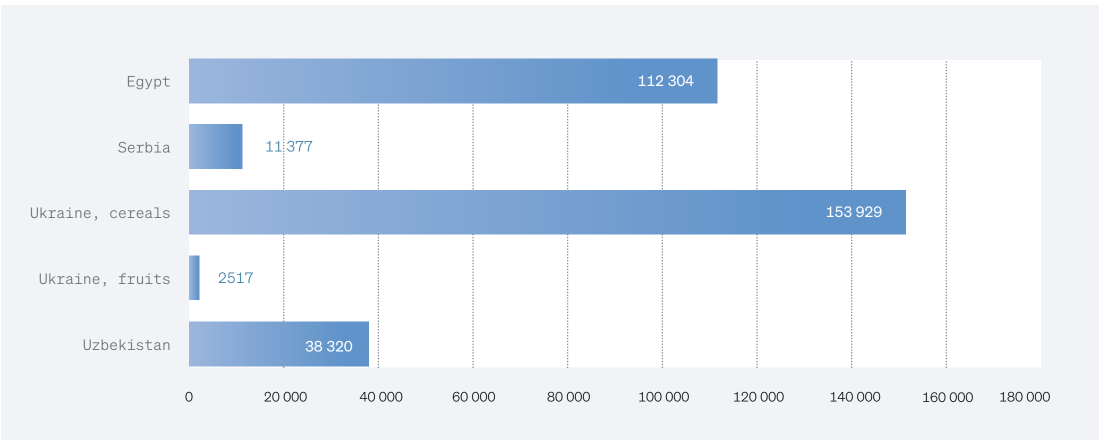


Figure 7
Number of PCs considered in the country analysis

SOURCE: Authors' own elaboration based on 2022 trade volumes for Egypt, Serbia and Uzbekistan; based on 2023 trade volumes for Ukraine.

15 According to export data from the Global Trade Tracker, Ukraine exported 44.6 million tonnes of cereals in 2023, of which 24.4 million tonnes went to European Union countries. According to plant quarantine data, Ukraine exported 37.2 million tonnes of cereals with a PC. The difference between the trade monitor and plant quarantine export volumes amount to 7.4 million tonnes, so the analysis considers that exports to the European Union with a phytosanitary certificate amount to 17.0 million tonnes, corresponding to 24.4 million tonnes minus the 7.4 million tonnes.

2.3.2 Without ePhyto: costs to governments of printing paper certificates

One major cost for governments WO/eP is printing the PC forms, which are typically use special paper to avoid counterfeits. In Serbia, the printing is done at the Serbian Institute for Manufacturing Banknotes and Coins. For Egypt and Uzbekistan, the reported data is an average of 2019 to 2023 data. In Egypt, the total cost is only for the assessed products. In Serbia and Ukraine, it is for all PC forms printed in the country. In Uzbekistan, the data is an estimate.

Table 7
Printing costs of PC forms

	Egypt (USD)	Serbia (USD)	Ukraine (USD)	Uzbekistan (USD)
Total PC printing costs per year	34 568	31 269	67 711	29 590
Cost per form	0.18	0.85	0.17	0.20

SOURCE: Authors' own elaboration.

At the country aggregate level, only a portion of the printing costs is considered to be saved in the WO/eP category, based on the export markets using ePhyto as in the scenarios described above.

2.3.3 With ePhyto: costs to governments of setting up and operating ePhyto

The costs of switching to ePhyto are expected to be rather low. To estimate the setup costs, case studies from other countries were considered (Box 8), with two countries recording setup costs of around USD 30 000. These costs were partly associated with the setup of workstations. Hence, a setup cost of USD 35 000 is assumed for all countries. In the case of Serbia and Uzbekistan, the setup costs are probably much lower in practice. In the case of Serbia, the country already has the hardware and infrastructure necessary for the transition to ePhyto, including computers and internet for phytosanitary inspectors. In addition, Serbia is already connected to CEFTA NT TRACES, which gives Serbia the option of connecting to the ePhyto Hub at almost no additional cost. The Plant Protection Directorate similarly estimates that internet coverage, quality and stability is sufficient for the IPPC ePhyto solution. In the case of Uzbekistan, the ePhyto implementation case study does not note any setup costs paid for by the government.

For maintenance costs, the analysis assumes incremental recurrent costs of USD 15 000 per year for each country. Out of the three case studies considered, only one, the Republic of Korea, mentioned recurrent costs (Box 8). It spent USD 35 000 annually due to adjustment problems with some of its trading partner countries who were new to ePhyto, and which have their own national systems. However, it is not clear whether these adjustments would be necessary for countries adopting ePhyto through the IPPC Generic ePhyto National System (GeNS).

Box 8

BENEFITS AND COSTS OF SWITCHING TO EPHYTO, EXPERIENCES FROM OTHER COUNTRIES

The IPPC Secretariat has compiled case studies of some countries transitioning to ePhyto, documenting the benefits (e.g. reduced costs), as well as the costs of switching to ePhyto. The experiences of Costa Rica, the Republic of Korea and Sri Lanka are especially notable.

All three countries note that its national plant protection organization (NPPO) saved money and staff time. They eliminated the expense of printing the PCs, no longer had to scan paper PCs into their systems, avoided the loss of certificates and reduced the number of counterfeit certificates. They also gained the possibility of correcting certificates more easily, and were able to transmit data more quickly. The Republic of Korea noted that the transition contributed to reduced GHGs, helping it achieve its goal.

As for costs of setting up ePhyto, the Republic of Korea notes that setup costs were low, as they only had to adjust the national system to the ePhyto Hub exchange and monitor test exchanges with certain countries, making adjustments as needed, to confirm that the exchange is stable. In terms of recurrent costs, the country budgets USD 35 000 per year to maintain the system. For Sri Lanka, the reported setup costs included LKR 10.30 million (USD 31 795) for establishing 17 workstations and LKR 19.2 million (USD 59 268) for a pilot project. Costa Rica mentions an initial setup cost of USD 29 850, but reported no particular maintenance costs.

Trading companies also reported saving time and money under ePhyto, eliminating much of the time and expense associated with obtaining paper PCs from phytosanitary authorities and avoiding costly problems related to the loss of the PC.

Reducing fraud is especially important. An evaluation of the ePhyto solution by the Standards and Trade Development Facility (STDF) notes:

"Of the effects of transitioning to ePhyto, the benefit most cited by agricultural inspectors and other NPPO staff in developing country contexts has been the greatly enhanced fraud detection resulting from having an easily accessible and uniquely coded electronic phytosanitary certificate to compare to any hard copy presented. [...] Historically, fraud has been committed either using fake documents or altered official documents. ePhyto has effectively made both much more difficult to accomplish successfully" (Pogorelsky, 2023).

SOURCES: IPPC. 2021a. The ePhyto Solution: EPhyto Implementation Case Story - Costa Rica. IPPC. Rome. www.ephytoexchange.org/landing/assets/docs/2021-10_CostaRica_ePhyto_Implementation_CaseStory.pdf

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2.3.4 Without ePhyto: greenhouse gas emissions

In addition to reduced costs borne by companies and the government, it is important to consider potential social cost savings of switching to ePhyto. One saving that is considered is the value of avoided GHG emissions.

In general, there are three ways in which switching to ePhyto avoids creating GHGs. The first is reduced trips to apply for and pick up the PCs, although this is a rather small reduction corresponding to travelling a few kilometres by car. The second is reduced emissions associated with sending reissued certificates, which is usually done by express courier but sometimes involves a trip by car to the border. These emissions are also presumably relatively low. The third is avoiding emissions caused by trucks or containers waiting at the importing country's border for the PC to arrive, including power costs for keeping the truck or containers refrigerated. These emissions are more significant.

To assess the value of avoided emissions linked to containers waiting at the importing border, the analysis considers the emissions of a load in a refrigerated (reefer) truck or container delayed at the importing country. For exports by sea, the analysis uses a container emissions factor for a twenty-foot equivalent unit (TEU) (Clean Cargo, 2021). Using a 70 percent utilization factor as per standard practice, the emission factors amount to 123.4 grams by 20-foot equivalent kilometre on average. To estimate emissions over 24 hours at the harbour, it was considered that a container travels approximately 710 kilometres over 24 hours with total emissions for this period of 88 kilos of CO_2, corresponding to 0.088 tonnes of CO_2. For a 40-foot container, that would mean 0.18 tonnes of CO_2 per 24-hour period. For exports by truck, the analysis considers that an idle heavy-duty truck would consume about 73 litres of diesel per 24-hour period (United States Department of Energy, 2015), corresponding to 0.19 tonnes of CO_2 every 24 hours.

Country-wide emissions without ePhyto (WO/eP) correspond to the emissions per 24-hour period multiplied by the expected duration of delay per shipment and the number of shipments. The average duration delay per shipment corresponds to the frequency of delays multiplied by the average duration per delay. In the case of Egypt, the emissions per 24-hour period are those for export by sea. In the case of fruit exports from Uzbekistan, delays at the border were either not reported or not applicable.[16] In the case of Serbia, there were occasional delays due to PC reissues and an average delay of 24 hours was assumed. For cereal exports from Ukraine, the loads are not refrigerated so emissions were not calculated, while other reported delays or reissues were not attributable to PCs themselves.

Table 8
Greenhouse gas emissions analysis

	Egypt	Serbia	Ukraine, cereals	Ukraine, fruits	Uzbekistan
Emissions per container per 24-hour delay (tonnes of CO_2 equivalent)	0.18	0.19	NA	0.19	0.19
Expected days of delay, average per shipment	0.46	1.00	NA	0.01	NA
Total emissions per year, all assessed shipments, without ePhyto (tonnes of CO_2 equivalent)	9129	26	NA	4	NA
Cost of emissions per year, low social price of carbon (SPC), year 2, without ePhyto (USD)	496 086	1440	NA	212	NA

SOURCE: Authors' own elaboration.

16 In Uzbekistan, some PCs were reissued but this did not cause delays at the importing country because the problems were usually noticed before the shipments arrived.

The savings associated with ePhyto are the difference between the value of GHG emissions without ePhyto (WO/eP) and with ePhyto (W/eP). The value of GHG emissions without project is calculated using the total emissions per year and the low social price of GHG as estimated by the World Bank (World Bank, 2017), adjusted in 2023. The savings associated with ePhyto are based on the percentage of shipments that experience ePhyto savings in the different scenarios of ePhyto partner countries.

2.4 RESULTS

2.4.1 Company level results

The analysis computes company-level savings using the average savings per PC and the average number of PCs per company. The terms PC and shipment correspond to the same volumes in all countries other than Egypt, where a shipment might include more than one PC because multicontainer shipments might include one PC per container. Savings per PC are on par in Serbia and Uzbekistan, respectively USD 4.5 and USD 3.7, but much higher for Egypt at USD 83.5. The average volumes associated with a PC are consistent across all three countries, about 20 000 kilos per PC, but companies in Egypt export more per year – 2499 PCs on average – compared to Serbia and Uzbekistan, where companies export on average 250 shipments and 103 shipments respectively.

Table 9
Findings at company level

	Egypt	Serbia	Ukraine, cereals	Ukraine, fruits	Uzbekistan
Average saving per certificate where ePhyto applies (USD)	83.5	4.5	66.3	18.1	3.7
Average saving per tonne exported (USD)	4.24	0.22	0.27	1.01	0.18
Average number of PCs per company (PCs)	2499	250	153	122	103

SOURCE: Authors' own elaboration.

As previously noted, four scenarios are considered to consider how company-level results vary based on ePhyto adoption. The savings per company are systematically lowest for the "current" scenario, in which only countries that currently have ePhyto in place trade with ePhyto; and highest for the "all" scenario, in which all countries adopt and use ePhyto.

Indeed, the more countries adopt ePhytos, the higher the share of shipment on which the company can reap benefits when exporting. In Uzbekistan, the companies only reap benefits when all countries adopt ePhytos, because transit countries must also adopt ePhyto for companies in landlocked Uzbekistan to export without paper certificates and reap the benefits of digitalization.

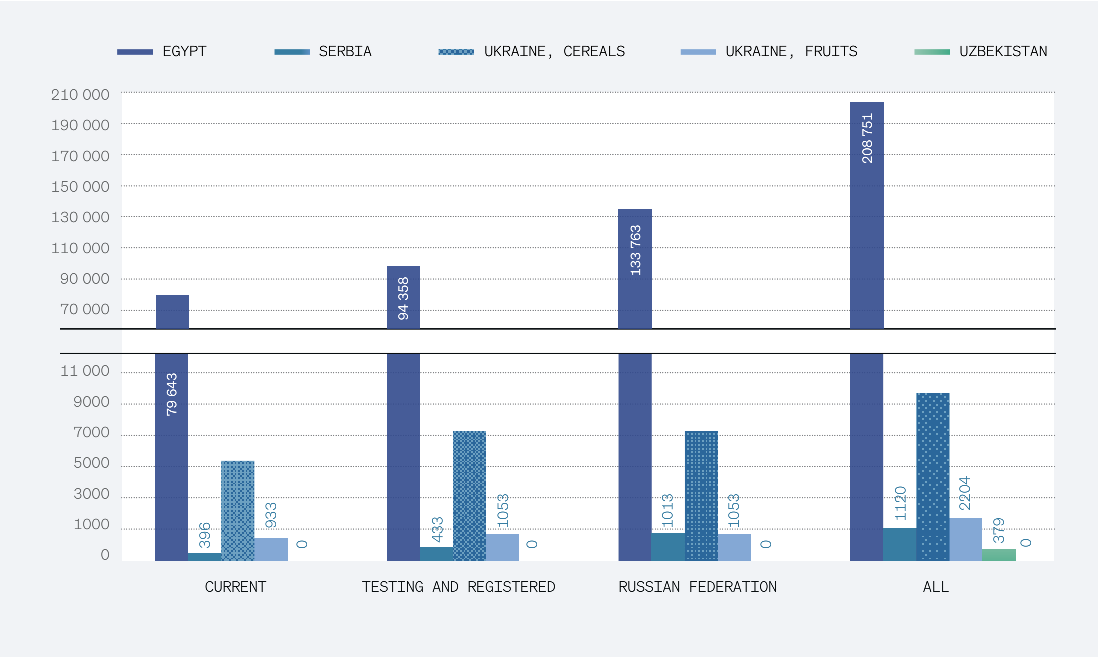

Figure 8
Savings per year per exporter, per scenario, financial values, USD

SOURCE: Authors' own elaboration.

Savings for Egyptian companies are systematically much higher across all scenarios because of the higher savings per PC and because of larger company sizes. Savings per PC are more than ten times higher in Egypt compared to Uzbekistan and Serbia, and the number of PCs is also ten times larger than in Serbia and 20 times larger than in Uzbekistan. Hence, in the "current" scenario, Egyptian companies stand to gain more than 100 times more than Serbian companies from the transition to ePhyto, USD 79 643 per company per year for Egypt compared to USD 396 per company per year in Serbia. Uzbekistan stands to gain least per company, even in the "all" scenario, because of the small savings per shipment and the small volumes of export per company. Savings are also significant for grain exports from Ukraine on a per PC basis, but not on a per kilo basis because each PC is associated with a large export volume.

Box 9

COULD ePHYTO INCREASE EXPORTS AND REVENUES?

Using a conservative approach, this analysis does not include increased revenues as part of the benefits of ePhyto. That said, it could be hypothesized that ePhyto would increase export competitiveness and exports volumes by reducing exporting costs.

However, it is important to keep in mind the magnitude of cost savings enabled by ePhyto. In Serbia, the savings per PC would amount to USD 4.5 on average. In contrast, one company reported that shipping costs for a 20 tonne shipment to the Russian Federation had fluctuated from USD 3500 in October 2021, to USD 5000 in December 2021, to up to USD 10 000 when fuel costs peaked in 2022. The savings associated with ePhyto are therefore of a small magnitude compared to potential savings from fuel or energy costs. In addition, the discussions point to demand inelasticity in pricing when it came to Serbian fruit exports. Indeed, several companies noted that shipping costs could fluctuate without mentioning that this affected their ability to export or led to a market loss. This might indicate that the ability to increase the production/supply of fruits is instead the constraining factor for increasing exports, which would be expected for perennial crops, at least in the short term.

In contrast, in Egypt, the savings per PC would be more significant at around USD 84 per PC. There, companies appeared to have very small margins during certain seasons. Potential costs linked to delayed or reissued PCs had more significant consequences. In a market with tighter margins, a decrease in trade costs might allow certain companies to export greater volumes.

Another consideration is that the ePhyto solution is not necessarily a stand-alone solution. Trade costs could decrease further if ePhyto is adopted jointly with other trade facilitation measures, such as a single window for export procedures and a more efficient inspection process.

SOURCE: Authors' own elaboration.

2.4.2 Results at country level

Country level results are computed for all countries by considering the various savings for exporters, the government and society more broadly via reduced GHG emissions, and additional costs of setting up and operating/maintaining ePhyto for the government. The results are computed for the various scenarios, considering an implementation period of 20 years. The cost for setting up ePhyto are for the first year of the investment while all other benefits and operational costs are from the second year onwards. The value of carbon savings changes every year based on the evolution of the social price of carbon. Other savings and costs are assumed to be constant. As Figure 9 shows, the cost savings for exporters weigh most in the economic analysis, in particular in Ukraine, while savings on printing costs and GHG emissions weigh relatively less.

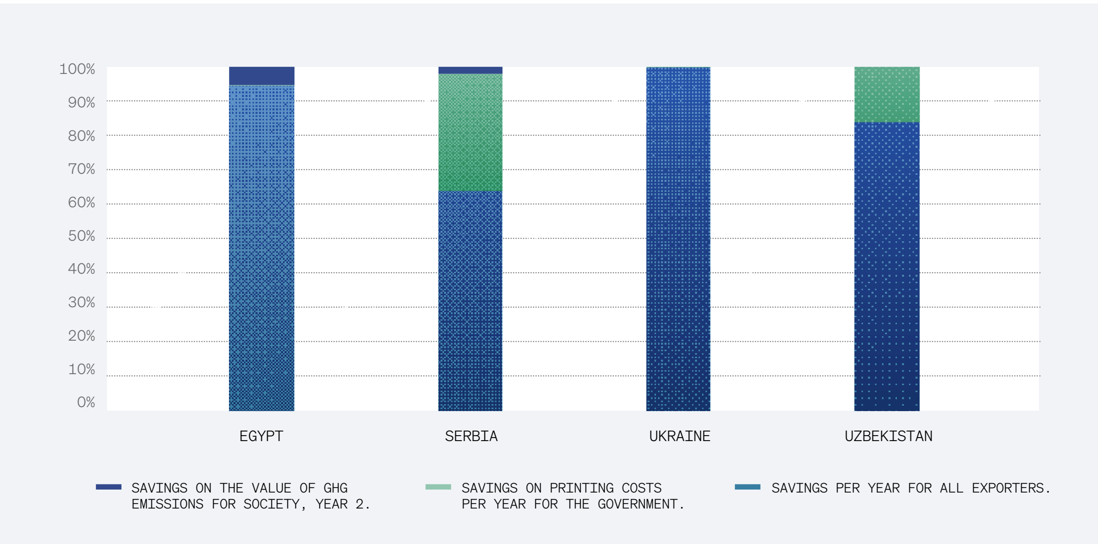

Figure 9

Breakdown of savings in the "all" scenario

SOURCE: Authors' own elaboration.

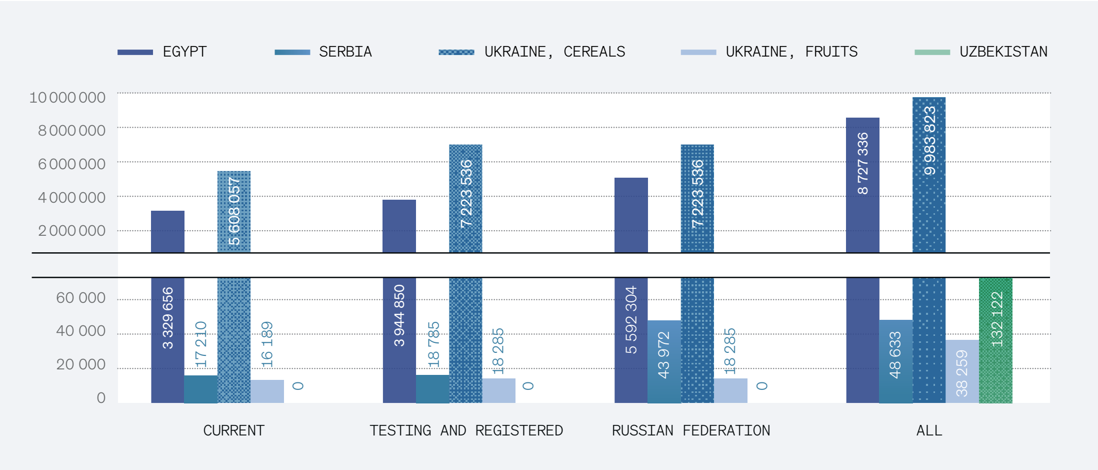

Figure 10
Savings per year for all exporters per scenario, economic values, USD

SOURCE: Authors' own elaboration.

The aggregated savings for all exporters are much higher in Egypt (USD 3.3 million in the "current" scenario), and for cereals in Ukraine (USD 5.6 million in the "current" scenario) compared to other countries (Figure 10). The magnitude of the aggregate company savings stem from both significant savings per shipment and high export volumes for Egyptian and Ukrainian companies. The aggregated gains for exporters are much smaller for the other two countries.

The net present value (NPV) of the ePhyto investment for the countries are computed over a 20-year period considering the savings and costs described above and using a discount rate of 10 percent. The same discount rate is used for all countries to keep results comparable. From the country's perspective, aggregated savings correspond to the savings for exporters, the savings on printing forms for the government and the savings associated with the reduction in GHG reduction. The costs correspond to the costs of setting up and operating the system to use ePhyto.

The results are systematically positive for Serbia, Egypt and Ukraine, as the savings more than offset the relatively low setup and maintenance costs. In contrast, as Uzbekistan must still issue paper phytosanitary certificates to meet requirements of its surrounding transit countries, the full benefits of the ePhyto would be realized only if all countries adopt the ePhyto ("all" scenario). In our analysis, it was assumed that Uzbekistan will have to keep the hybrid system in place until the countries through which shipments transit also adopt ePhyto. In practice, of course, some benefits might be envisaged earlier than that. For example, if a PC needs to be reissued at a European Union border, it could be reissued immediately with ePhyto. However, the companies interviewed in Uzbekistan did not bring up these situations and instead referred more to reissues taking place while the trucks were still in transit (e.g. without reporting delays at the entry point to a destination country). In the "all" scenario, the results are positive for Uzbekistan.

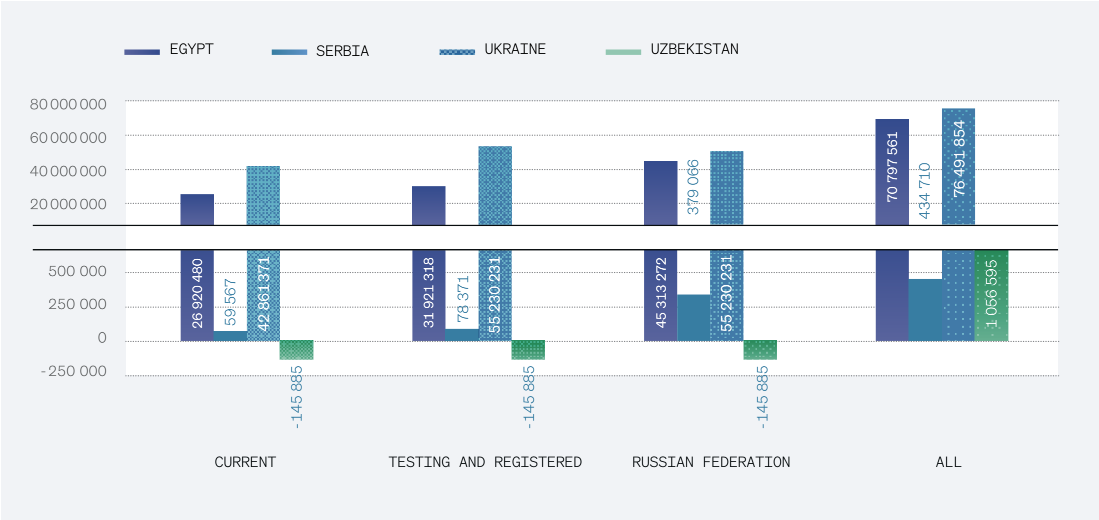

Figure 11

Net present value of the ePhyto investment per scenario, economic values, USD

SOURCE: Authors' own elaboration.

As expected, the results are much higher for Ukraine and Egypt, with the NPV ranging from USD 42.9 million to USD 76.5 million for Ukraine, and from USD 26.9 million to USD 70.8 million for Egypt. This reflects the high export volumes and the high potential savings per shipment for these two countries. Savings in the "all" scenario are lowest for Serbia because it has the lowest export volumes.

Box 10

UNQUANTIFIED BENEFITS OF ePHYTO

This analysis focused on the main quantifiable benefits of trading with ePhyto. There are other expected benefits that are more difficult to quantify and still others that could yet be explored. For example, we only estimated the costs of PC reissues that occurred after the shipment had left the loading site, which required delivering the reissued PC to the border. Yet, those PCs reissued earlier in the process (not factored here) also consume time and resources. And one important aspect still to be examined is the long-term impact of ePhyto on trade volumes (Box 9 and Chapter 3).

Surprisingly, none of those interviewed in any of the four countries studied mentioned problems related to counterfeit certificates, even though other countries outside this analysis have noted reduced counterfeit certificates as a key advantage of ePhyto (Box 8).

SOURCE: Authors' own elaboration.

2.5 SUMMARY AND LIMITATIONS

The analysis demonstrates how the adoption of digital solutions can reduce trade costs. For companies, lower trade costs result in higher margins, which might allow some firms to remain profitable and operational in highly competitive environments. Specifically, the analysis shows that gains from switching to ePhyto for the assessed countries range from USD 3.7 per PC for fruit shipments from Uzbekistan to USD 83.5 for fruit shipments from Egypt. In a context where shipment costs are in the range of USD 2000 per shipment or more, the gains are relatively small when compared to the cost of shipping a container. On the other hand, the benefits are important at the aggregate level, as the small savings per PC apply to hundreds of PCs per year for companies and thousands of PCs per year for the country.

For companies, there is a clear gain from switching to ePhyto. However, experience shows that some companies prefer to continue trading using paper certificates despite the availability of digital certificates. Discussions with IPPC officials and companies suggest that this could be because companies might use the paper certificate for other business purposes (documentary requirements for opening an letter of credit, cash-against documents contracts, etc). Another possibility is that companies lack awareness and understanding of the ePhyto benefits and how it works.

Those actors who stand to lose from switching to the digital technology may be reluctant to do so. For example, companies and institutions that print the PC forms will not be pleased to lose those contracts, and customs agents may fear the simpler ePhyto process threatens some of their business revenues.

Overall, registering for and using the ePhyto solution is a very profitable investment for countries. Experience from different countries shows that switching to ePhyto is relatively inexpensive, making the transition a very profitable investment over the long term, especially for countries such as Egypt and Ukraine, which export large volumes.

There are some limitations to the analysis, which are important to note. It only considers specific products among plants and plant products, and the analysis cannot be extrapolated to assess the full magnitude of savings at the country level. The methodology based on interviewed exporters makes it difficult to extrapolate to other products that may have their own trade specifics because the savings per PC and exported volumes per PC might differ based on the mode of transportation and trade routes.

Another limitation is that the exporters' costs are assumed to occur equally frequently across all markets, which was not the case in practice. Discussions both in Serbia and Uzbekistan, for instance, suggest higher needs for PCs reissuance for exports to the Russian Federation as compared to European Union markets, sometimes for simple transliteration issues or others. In Egypt, trade delays attributable to PCs were more common for shipments to Italy, Slovenia or Greece as short voyages results in higher chances of the PC arriving after the shipment, requiring the shipment to wait one or two days for the certificate to arrive prior to port clearance. Shipment routes were also assumed to be homogenous for similar products. For instance, some fruits might exceptionally be exported by plane early or late in the season. This was not considered as the average saving per shipment is based on the most frequent routes.

Box 11

EXPORTS BY PLANE FROM UZBEKISTAN

The analysis of Uzbekistan reflects the primary export routes by truck through transit countries. Recognizing the particularities of a land-locked country, it is also important to probe whether ePhyto could have more immediate benefits, for example for exports by plane.

Only one interviewed company reported exporting by plane. This company exported cherries, a highly perishable product, to an ePhyto exchanging trade partner by plane. The company did not report any problems with phytosanitary certificates at the border, so we could not validate benefits by switching to ePhyto on this trade route.

In fact, exports by plane are rare here. So is the frequency of delays or reissues of PCs due to problems with phytosanitary certificates. Transport by plane accounts for 4 percent of cargo from Uzbekistan (Asian Development Bank, 2009). This means that there are likely some exports by plane that experienced savings from switching to ePhytos, but this corresponds to only a few certificates per year. When it comes to potential savings by avoiding costs and delays linked to reissues, interviews suggest these savings could occur on 1.5 percent of all shipments

We can broadly estimate the extent to which there might be some savings on cherry exports. In 2022, Uzbekistan issued about 1200 ePhytos to that specific trading partner and about 8 percent of Uzbekistan's plants and plant products exports to that trade partner corresponded to cherries. Assuming that 8 percent of the ePhytos similarly correspond to cherry exports and considering that reissues or delays apply to about 1.5 percent of certificates, savings associated to reissues or delays would apply to about 1 certificate per year.

SOURCE: Authors' own elaboration.

Another limiting factor is that the analysis relies on interviewees' ability to recall information. This is particularly limiting for grain exports from Ukraine, where the modalities for exports were more likely to vary, together with contract terms for delays. This made it more difficult for companies to provide answers.


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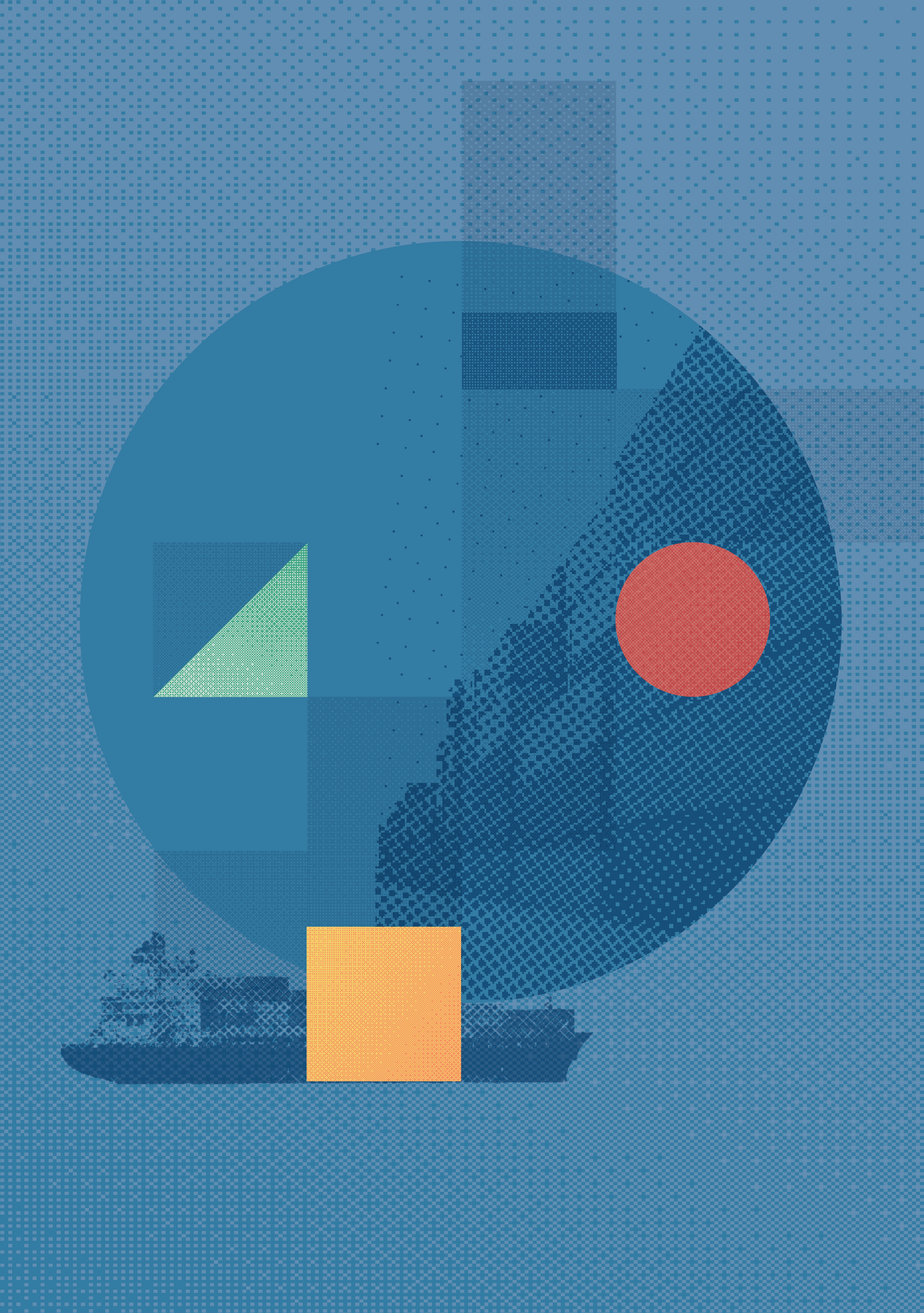

Chapter 3
Global level impact of the ePhyto solution on trade

Adoption of ePhyto aims to streamline the certification process, improve the efficiency of trade logistics, and reduce the potential for fraud or delays caused by paper-based certification systems. This chapter analyses the global-level impact of the ePhyto solution based on historical trade flows from January 2015 to December 2023 (e.g. ex-post analysis) of plants and plant products, and using an empirical approach grounded in the gravity model of trade.[17]

The chapter seeks to answer the following key questions. Does the adoption of the IPPC ePhyto solution lead to an increase in bilateral trade flows between countries? Is the positive effect immediate or is a certain number of certificates needed to attain this positive effect? Are there differences in the impact of ePhyto adoption across different types of products, especially perishable versus non-perishable goods?

17 The gravity model of international trade suggests that the volume of trade between two countries is determined by two key factors: the economic size or mass of each country, typically measured by indicators such as GDP, and the degree of trade friction that exists between them. Trade friction can include barriers such as tariffs, transportation costs, and differences in regulatory standards. According to the model, larger economies tend to trade more with each other, while the presence of higher trade frictions reduces the volume of trade between them (Baier and Standaert, 2020).

3.1 METHODOLOGY

The gravity model is the workhorse for trade policy analysis in international economics (Head and Mayer, 2014; Yotov *et al*., 2016). Several authors have successfully demonstrated the theoretical foundations of this model in economic literature (Eaton and Kortum, 2001; Anderson and van Wincoop, 2003). Capitalizing on its intuitive appeal and applicability to diverse types of trade data, the application of these models has grown exponentially.

The dependent variable on the left-hand side of the standard gravity equation is a trade flow (export or import, expressed in value or volume terms). The variable indicating the trade policy or trade-related factor of interest (e.g. issuance of ePhytos), trade cost proxies (distance, tariffs, etc.) and other standard gravity variables (such as participation in trade agreements, common borders, common language, colonial past) are used as regressors on the right-hand side. The estimated model allows to assess the effects of desired variables on trade flows. By construction, these trade effects are homogeneous across all country pairs in the sample.

Following the best practices and recommendations (Yotov *et al*., 2016), this paper estimates the following structural model to quantify the impact of introducing ePhytos for plants and plant product exports. The main objective in a structural gravity model is to find a structural explanation of bilateral trade between exporting and importing countries. In line with recent literature on the estimation of gravity models, the analysis relies on the poisson-pseudo maximum likelihood (PPML) estimator (Santos Silva and Tenreyro, 2006), which allows the estimates to be consistent and robust to different patterns of heteroskedasticity and measurement errors and has been shown to exhibit several properties that make it more attractive than alternative estimators (Santos Silva and Tenreyro, 2022).

$$X_{ijt}=\exp[\alpha * ePhyto_{ijt} + \gamma * GRAV_{ij} + \beta_1 RTA_{ijt} + \beta_2 \log(1+tariff_{ijt}) + fe_{it} + fe_{jt}]\ \varepsilon_{ijt}$$

The variable X_{ijt} denotes nominal international trade flows between exporting country **i** and importing country **j** at month **t** (later, we will also rerun the analysis on the annual basis where **t** is yearly frequency). $GRAV_{ij}$ is a vector of control variables that includes all standard time-invariant gravity covariates (the log of bilateral distance, common language, common borders, past colonial relationships). The covariate RTA_{ijt} stands for regional trade agree-ments dummy between trading countries. Next, $tariff_{ijt}$ represents the bilateral ad-valorem tariff that country **j** imposes on imports from country **i** at time (month) **t**. For aggregate export models, tariff data also needs to be aggregated. To limit the endogeneity between tariff and RTA, this paper follows the Tariff Trade Restrictiveness Index (TTRI) (Fugazza and Nicita, 2013) (see Appendix B for construction of the TTRI).

For more than 20 years, it has become standard to estimate gravity equations accounting for multilateral resistance by including a dummy for each origin and a dummy for each destination, the so-called origin and destination fixed effects, as they allow to control for unobservable heterogeneity (see the seminal work of Anderson and van Wincoop, 2003).[18] Researchers often use panel data to estimate three-way gravity models that include origin-time fixed effects, destination-time fixed effects and country pair-fixed effects to control for possible endogeneity (Baier and Bergstrand, 2007). Use of panel data can also help address endogeneity bias and the PPML has proven to be consistent in this context (Weidner and Zylkin, 2021). Thus, to get consistent estimation of the gravity equation, exporter-time fixed effects fe_{it} and importer-time fixed effects fe_{jt} are included in the regressions.[19]

Finally, $ePhyto_{ijt}$, the main variable of interest, stands for the indicators used to represent the intensity of issuance of electronic certificates by the exporting country i to the importing country j in a specific time t (year and month).

Since the effect of the number of certificates may not be linear, we consider two model specifications:

linear specification:[20]

$$\alpha * ePhyto_{ijt}$$

quadratic model specification:

$$\alpha_1 * ePhyto_{ijt} + \alpha_2 * ePhyto_{ijt} * ePhyto_{ijt}.$$

It should be noted that using the number of ePhytos in a structural gravity model has not been tested before.

In our estimated models, the results reveal that α_1 is never positive and α_2 is never negative, which means that the quadratic polynomial expression (equation 2) has a U-shape with a vertex (turning point) such that for the number of ePhytos below N_0, the effect of using ePhytos on export is negative, and above N_0 – it is positive.

18 Inclusion of these fixed effects can lead to incidental parameter problems when estimating using traditional methods. PPML, however, does not suffer from the incidental parameter problem in such case, which is another reason why the PPML estimator was chosen over other estimators (Fernández-Val and Weidner, 2016).

19 The model was also estimated with country pair fixed effects, but the estimated standard errors were quite large and the signs for some key parameters of interest were not correctly estimated. This is in line with findings from other researchers (Weidner and Zylkin, 2021), who show that, while inconsistency is not a problem for three-way fixed effects PPML, the estimated coefficients and standard errors are affected by biases due to the incidental parameter problem for estimation over shorter time periods. Consequently, this paper uses only exporter-time and importer-time fixed effects for the main specification. Additional robustness tests were also conducted to check for possibly endogeneity issues.

20 Previously, the OECD used lagged values on the dummy variable. In our analysis, having given access to the data on the number of ePhytos sent, coefficients on the lagged values of the number of ePhytos gives estimated coefficients that are not significant (i.e. zero).

3.2 PRODUCTS REQUIRING PHYTOSANITARY CERTIFICATION

The list of products that require phytosanitary certification has been obtained from four countries – Egypt,[21] Georgia,[22] Ukraine,[23] and Uzbekistan[24] – at the HS-6 level of disaggregation and combined into a unique commodity set. However, considering that the analysis requires trade data ranging from 2015 to 2021 as well as tariff data, which were published using different classifications, a mapping procedure[25] of the products reported under different classifications has been applied, to make trade values comparable across time and ensure no single data point is lost, misclassified, or mistreated. This resulted in a total of 267 plant products that required phytosanitary certification when traded. The choice of the period is led by the fact that the first official ePhyto record was made in December 2017 from Argentina to the United States of America. To identify the full impact of introducing ePhytos, the analysis included two years before the introduction of the certificates, hence the starting time point of analysis is January 2015. Appendix A presents the full list of plants and plant products that require phytosanitary certification when traded internationally at the HS-6 level.

3.3 DATA FOR THE GRAVITY MODEL

Data on bilateral ePhyto exchanges for the analysis in this paper was provided by the UNICC that has developed the IPPC ePhyto solution consisting of the ePhyto Hub and the ePhyto GeNs (IPPC, 2025b). The ePhyto Hub allows for the extraction of bilateral monthly data on the number of ePhytos exchanged between exporting and importing countries in both testing and production environment, as well as the type of certificate (ePhyto for export or for re-export) and its delivery status. However, all other information regarding each shipment and including for which products the electronic certificate was issued, remains encrypted and confidential for the parties involved receiving the actual certificate. This implies that it is not possible to match the exchanged ePhytos to specific commodities. As a result, the gravity model (equation 2) can be estimated either for all crops for which ePhytos are required, or for crops requiring ePhytos arranged in subgroupings (e.g. fruits, vegetables, decorative plants etc). In the latter case, the number of countries considered in the gravity model varies, as it excludes countries which did not export products within one or the other subgrouping.

21 List of products requiring PS certification in Egypt was obtained via written communication from Islam Aboelela, International Phytosanitary Specialist, FAO consultant.

22 List of products requiring PS certification in Georgia is available on the IPPC webpage (IPPC, 2025c).

23 List of products requiring PS certification in Ukraine was obtained via written communication from Vladyslav Sedyk, International Phytosanitary Specialist, FAO consultant.

24 List of products requiring PS certification in Uzbekistan was obtained from the Agency of Plant Protection and Quarantine of the Republic of Uzbekistan.

25 The mapping procedure aims at matching commodity codes of the HS-6 classification. There are several revisions of such classification available (1992, 2002, 2007, 2012, 2017, 2022). Even though our time reference for the analysis is 2015-2021 and the TDM reports trade data mainly using the HS 2017 revision, countries have been slow at adopting the change and lag in full transition to the following classification (with respect to the one previously used). By converting all product nomenclature into the 2017 HS nomenclature using correlation tables, we have created a mapping procedure that allows matching the codes from previous revisions to the 2017 revision.

Since the inception of the ePhytos in 2017 and until December 2023, 71 countries reported issuing and 86 countries reported receiving ePhytos. This study considers only the production period for the analysis, with the first record dating to December 2017 and excludes the piloting or testing period of newly joined countries. Only certificates that possess the status "delivered" or "delivered with warning" (Box 2) are considered for the current study. Preprocessed data on ePhyto ready to be used in the regression are shown in Table 10.

Table 10
Preprocessed ePhyto data example

Exporting country	Importing country	Date	Number of ePhytos issued by exporting country to importing country
Argentina	United States	December 2017	142
United States	Kingdom of the Netherlands	January 2018	1
Argentina	Kingdom of the Netherlands	January 2018	56
United States	Argentina	January 2018	81
Argentina	United States	January 2018	680
Argentina	Kingdom of the Netherlands	February 2018	155
Kingdom of the Netherlands	Argentina	February 2018	400
United States	Argentina	February 2018	436
Argentina	United States	February 2018	792
United States	Kingdom of the Netherlands	March 2018	1

SOURCE: Authors' compilation based on raw data from the IPPC ePhyto solution.

Data on bilateral monthly exports were extracted from the Trade Data Monitor (TDM, 2025). Based on the classification of products requiring phytosanitary certification, data were extracted on export flows at the HS-6 commodity level from January 2015 to December 2023 and were mirrored for filling any gaps (missing values). In the next step, missing data points were replaced with zeros. We then selected and aggregated only the products requiring phytosanitary certification, as well as subgroupings of products (namely vegetables, fruits and nuts, cereals, and other crops) to create aggregate export values for the respective commodity groupings.

Tariff data for the period 2015–2023 are sourced from the UNCTAD TRAINS database (UNCTAD, 2025).

For estimating the TTRI, the most recent trade elasticity data were used (Utoktham *et al.*, 2020). Bilateral trade data were averaged over 2010–2012 to avoid endogeneity problems between trade and tariff data.

Finally, standard gravity variables used in the analysis such as bilateral distance, contiguity (common language dummy), common border dummy, colonial past link dummy, as well as regional trade agreements, were extracted from CEPII (2005).

3.4 EMPIRICAL RESULTS

This section presents the estimation results. Following the methodology outlined above, two specifications of the gravity model were tested:

1. a model that uses the number of ePhytos exchanged (linear specification, equation 1); and
2. a quadratic specification that also uses the number of ePhytos (equation 2).

For each plants and plant product group, both specifications were compared using standard goodness of fits statistics (R-squared, AIC, BIC).

For all commodity groups, the quadratic specification 2 was found to be the best with respect to the linear specification 1. The significance of quadratic polynomial terms is persistent and occurs both in the total plants and plant products export model (column aggregate) and in the models by group of products (vegetables, fruits and nuts, cereals, all other remaining crop products requiring phytosanitary certification, such as flowers, decorative plants, tea, coffee, tobacco, spices, cocoa, and others).

The interpretation of the regression coefficients (elasticities) on the polynomial terms and of equation 2 is not straightforward and required further transformation and calculation of a turning point, namely approximation of the quadratic logarithmic term (for details, see Appendix C). In short, to calculate the turning point, one needs to extract estimated values of the regression coefficients of the quadratic polynomial and solve it for extremum, without forgetting to exponentiate the solution and deduct 1 (inverse transformation of log of one plus number of ePhytos). Based on knowledge obtained about the signs of those regression coefficients for each model (aggregate, as well as by subgroups), the turning point in this estimation reflects the minimal number of ePhytos that should be exchanged monthly between an exporting and an importing country before the exporting country sees an increase in its exports as a result of using the ePhytos rather the paper. Therefore, the discussion of the results in this section is based on the results of the second specification.

Appendix C reports the detailed results of the second specification for all crops that require ePhyto certification (column "aggregate") as well as for each of the commodity subgroupings for which the model was estimated. Across the six columns in the Appendix C table, all coefficient estimates have the expected signs and magnitudes. The presence of a past colonial relationship, the existence of common borders, and, to a limited extent, a common official language between countries showed a positive effect on exports.

The results confirmed the negative effects of distance between trading partners on trade flows of products requiring ePhyto certification. For example, for the aggregate plant group, a 10 percent increase of distance between trading partners would decrease exports by around 8 percent. The results differ between the various commodity subgroups considered, depending mainly on the distance between the trading countries as well as the perishability of the different products. Cereals seem to be the most affected by distance, partially due to weight of shipments, followed by vegetables and fruits. Indeed, the distance elasticity of exports was estimated respectively at -0.78 for fruits, -1.13 for cereals, and -1.05 for vegetables (refer to respective columns in Appendix C). The large distance elasticity of fruits and vegetables is related to their perishability, namely greater distance more negatively affects exports of perishable goods, which is in line with the literature (Emlinger *et al.* 2006). To summarize, larger distance elasticity is explained by heavier shipments and high perishability levels.

Similarly, weighted tariffs (TTRI) display negative and highly significant effects on export values for all commodity groups covered, except cereals and cut flowers, for which applied and preferential tariffs were lower compared to other products considered. Tariffs tend to show a stronger impact (double in magnitude) for fruits and nuts groups than for vegetables. The coefficient of the average weighted tariff (TTRI) suggests a negative effect of import tariffs on trade in plants and plant products.

For all commodity groupings, the coefficient of regional trade agreements (RTA) is highly significant (except for cereals, where it is zero) and positive, which is consistent with the general literature. For example, the coefficient of 0.4683 in the column “aggregate” corresponds to an RTA increasing the value of trade by 59.7 percent. Vegetables and fruits seem to benefit the most from RTA as results show that the existence of regional trade agreements would increase the exports of vegetables by 109.5 percent compared to an increase of 88 percent for fruits. This is because preferential agreements lead to substantially lower applied tariffs both for vegetable and fruits compared to other commodities, for which the difference between the preferred and the most favourite nation tariffs is less pronounced. For cereals, the coefficient of RTAs is not significant, reflecting the small difference between the preferential and the most favourite nation import tariffs compared to other products.

The results on the turning point N_0 suggest that the **minimum number** of ePhytos after which exports start increasing for plants and plant products (for all aggregated plants and plant products in one group) **is 57 ePhytos per year and per destination market** (Figure 12). The results also show that different product groups have different minimum numbers of ePhytos to achieve positive effects on trade.

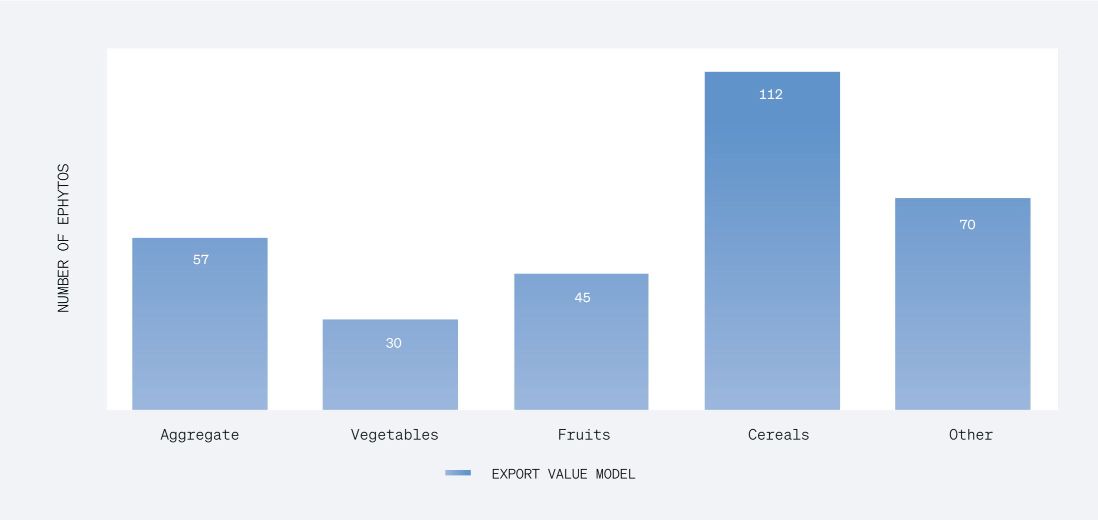

Figure 12
Minimum annual number of ePhytos exchanged bilaterally to increase exports

SOURCE: Data provided by NPPOs. Authors' calculations.

These differences may reflect the divergent structure and magnitude of trade costs for different groups of traded products and how they are traded – in particular whether they are bulk or perishable products. Cereals require issuance of more ePhytos monthly to attain positive effects (112 ePhytos) compared to fruits (45 ePhytos) or vegetables (30 ePhytos) (Figure 12). For vegetables, the effect of ePhyto adoption is positive with the smallest number of e-certificates. These results could be indicative of countries prioritizing vegetables and fruits when they pilot the use of electronic certification, given the relatively high value and perishability of these two groups of products.

The minimal numbers may seem small (Table 11) compared to the aggregated number of certificates, but this is a common case based on the data: countries form multiple country pairs and issue ePhytos with multiple partners throughout each year, and the more time passes, the more country pairs are formed and the higher number of certificates are sent out. However, smaller number of (1–100) certificates per country pair indicate validity of our numerical results for the threshold number of minimal ePhytos to boost trade, as illustrated in the exchanges of Argentina with several other countries.

Table 11
Bilateral issuance of ePhyto by country pair

Exporting country	Importing country	2017	2018	2019	2020	2021	2022	2023
Argentina	Australia				32	500	389	241
	Austria				23	73	57	41
	Belgium				618	930	1227	738
	Plurinational State of Bolivia							332
	Bulgaria				257	354	348	240
	Cameroon						21	27
	Chile		2082	5939	9823	12 526	13 979	9955

SOURCE: Authors' calculations based on data provided by the IPPC.

The minimum number of ePhytos is well below the number of phytosanitary certificates countries issue per month and per destination market. This means that countries that do not participate in the IPPC ePhyto solution would need to replace only a small part of the paper phytosanitary certificates they issue with electronic ones in order to benefit from the trade-enhancing effects of the electronic certification.

For example, in Egypt,[26] the number of paper phytosanitary certificates issued in 2021 for export of fruits was 82 640. Egypt exported fruits to 143 destination markets in 2021, which is equivalent to an average of 86 paper phytosanitary certificates issued monthly for each market. The results reported in Figure 5 show that a minimum of 45 electronic certificates are needed annually to attain a positive effect on fruit exports. Thus, if Egypt starts using ePhytos for its fruit exports, there would be a positive effect on trade after issuing 45 ePhytos per year and destination market.

At the aggregate level, after a country pair issues a minimum of 57 certificates per year, the impact of ePhyto on exports is positive but declines over time because there are more certificates issued and these would become invisible to capture by the current model once 100 percent replacement of paper certificates occurs. The magnitude of the positive impact also depends on the starting point and final value of ePhytos delivered. The greater the increase in the number of ePhytos, the faster the pair of countries benefits from it, as Figure 12 illustrates.

26 Inclusion of these fixed effects can lead to incidental parameter problems when estimating using traditional methods. PPML, however, does not suffer from the incidental parameter problem in such case, which is another reason why the PPML estimator was chosen over other estimators (Fernández-Val and Weidner, 2016).

Figure 13
Percentage increase in plants and plant product exports based on the increase in ePhytos from the initial number by deltaN

SOURCE: Authors' calculations.

NOTE: The vertical dashed line indicates the threshold of 57 ePhytos. After passing this threshold and issuing more than 57 ePhytos, the impact of ePhyto on plants and plant product exports becomes positive and depends on how many certificates are issued after 57 (value deltaN). For example, if an exporting country starts issuing from 57 to 57+200=257 ePhytos (equivalent to deltaN=200, green line), the agrifood exports rise by 0.175 percent. Hence, the adoption of ePhyto by a country pair has a positive impact on bilateral trade after the minimum threshold has been reached, but the increase in trade diminishes as ePhyto adoption increases.

3.5 ROBUSTNESS CHECKS

The methodology section above provides details for the robustness of the PPML estimator and the chosen specification for assessing the impact of ePhyto using the gravity model. A Durbin–Wu–Hausman test (augmented regression test) was conducted to check for possible endogeneity. The resulting p-value of 0.8888 indicates that we fail to reject the null hypothesis. In other words, there was no evidence to suggest that the variable ePhyto was endogenous in our model. An argument explaining the absence of endogeneity is the fact that countries start exchanging ePhytos not with their closest partner countries but with those partner countries that adopted ePhyto as well.

Nonetheless, based on the literature, some additional tests were conducted to address and check for possible endogeneity. In particular, two additional specifications were assessed: (a) an IV approach and (b) a one-year lag of the ePhyto variable. For the IV, based on the suggestion of a peer reviewer, the analysis employed as an instrument the average number of ePhytos applied by the exporter country i to all countries z located in the same region of j but country j. [27] The results were robust to both alternate specifications.

3.6 SUMMARY AND LIMITATIONS

This section provides evidence of the impact of adopting the IPPC ePhyto solution on plants and plant product exports using novel data on ePhyto exchanges combined with recent trade data. The contribution of the current paper is a novel application of the methodology to analyse effects digital solutions such as the ePhyto have on trade as well as the implications for countries when adopting such digital solutions.

Methodologically, the paper first compiled a unique list of HS-6 level agrifood commodities that require phytosanitary. Second, the paper used novel and recent data on the number of ePhytos exchanged between countries and combined them with recent trade data to estimate the effects of exchanging ePhytos.

The results confirm that countries that switch from paper to electronic phytosanitary certificates show an increase in their bilateral plants and plant product exports. There is therefore significant value in fully joining the IPPC ePhyto solution for imports and exports of plants and plant products that require phytosanitary certification.

The analysis suggests that the introduction of the IPPC ePhyto solution does not have a positive effect on increasing exports in the beginning of its use and it requires issuing ePhytos above a threshold number to before a trade-enhancing effect is observed. One exception is vegetables, for which the effect of trading with ePhytos is positive immediately after the inception due to their perishable nature.

The primary limitation of this study is related to data availability, particularly the inability to link ePhytos to specific products traded and the assumptions made to address this issue. The ePhyto Hub provides aggregate data on the volume of certificates exchanged but does not disclose detailed shipment information, including the types of products or the specifics of individual shipments. This confidentiality, while protecting trade data's sensitive nature, limits the depth of the analysis and prevents a granular assessment of ePhyto's impact on different product categories and sectors. Further efforts to obtain detailed data on the types, quantities, and values of products traded with ePhytos that can be obtained via country surveys or upon their consent through UNICC, would allow further exploration of how ePhyto adoption affects specific goods and sectors. For example, how the value of the product influences ePhyto impact on trade. The lack of detailed shipment-level data also hampers the ability to compare the performance of electronic and paper certificates directly.

27 Inclusion of these fixed effects can lead to incidental parameter problems when estimating using traditional methods. PPML, however, does not suffer from the incidental parameter problem in such case, which is another reason why the PPML estimator was chosen over other estimators (Fernández-Val and Weidner, 2016).

Conclusions

The findings presented in this report substantiate and quantify the hypotheses that digitalization of trade-enabling certificates, such as ePhyto, can reduce trade costs. These reduced trade costs and other potential benefits of ePhyto – such as the potential to speed up shipment of highly perishable fruits and vegetables, reduce counterfeit certificates and increase trust between trade partners – could in turn increase trade flows. The country-level analysis confirmed and quantified reductions in trade costs linked to the use of ePhyto at both the company and country levels, estimating expected returns on investment in switching to the ePhyto for four countries, highlighting the direct impact of a wider ePhyto adoption by IPPC member countries on their economies. Subsequently, the econometric analysis using global trade data demonstrates and quantifies that a country pair using ePhyto will observe an increase in its bilateral trade, at least partially because of the decreased transaction costs after achieving a minimum number of certificates.

There are indications from both studies that a countries' adoption of the IPPC ePhyto solution would eventually lead to an increase in investments in plants and plant product exports and increase export volumes. In the short term, there would be an increase in export net revenues, as the use of ePhyto would decrease unnecessary storage, demurrage costs and other trade costs linked to problems with paper phytosanitary certificates. In the longer term, the theory would predict that the increase in exporters' returns could lead to an increase in investments because firms would invest to expand their export markets or new actors would invest to enter the sector. This would also increase export volumes and revenues.

Further research could assess potential changes on exporting firms' investment decisions and export volumes following the adoption of ePhyto. This type of assessment could be conducted in a country such as Egypt, where firm-level benefits are more substantial because the savings per PC and number of shipments exported per company are higher.

The evidence provided by these analyses is sufficient to promote further efforts in the adoption of the IPPC ePhyto solution. The country-level analyses clearly demonstrate a positive return on investment. Countries with large export volumes and exporting to existing ePhyto users particularly stand to gain from the transition.

The study also highlights some considerations on how to maximize benefits of the ePhyto solution for companies and countries. One major factor is whether a particular country's trade partners have also adopted ePhyto. The more a country trades with other ePhyto users, the higher the share of trade on which the cost-savings associated with ePhyto will apply. Another factor is whether the country's exports have to transit through other countries, and whether these transit countries are also using ePhyto. The case of Uzbekistan illustrates how exports going through land transport are dependent on trade regulations and practices of the transit countries.

The analyses presented in this report also highlight some potential complementary measures and policy implications to maximize the impact of ePhyto. Some gains from digitalization will only materialize once other export-related certificates are also digitalized. PCs are often sent by courier. This cost could be avoided with ePhyto, however, companies often have to send other required certificates by mail even if ePhyto effectively replaces the paper PC. If digital solutions were adopted for certificates of origin, quality, conformity and others, companies would benefit from additional savings. In addition, ePhyto benefits can be complemented by the adoption of other trade digitalization measures, such as the use of a single window.

To maximize returns from ePhyto, increased public investment in digital trade solutions is essential. Moreover, integrating ePhyto with other digital trade systems – such as customs declarations, certificates of origin, and quality and safety certificates – could unlock even greater cost savings and operational efficiencies, digitalizing trade processes and facilitating global trade. By investing in and adopting digital tools like ePhyto, countries can position themselves to reap the full benefits of a more efficient, transparent, and sustainable global trading system.

Moving forward

The successful implementation and wider adoption of ePhyto requires continued coordinated efforts across the public sector, encompassing the IPPC Secretariat, development partners, and national governments and private sector players.

The IPPC Secretariat plays a central role as the custodian of the ePhyto solution. Its ongoing efforts to provide technical support, enhance the system's functionality, and facilitate knowledge-sharing among contracting parties remain critical. The secretariat may consider stepping up assistance to help countries adopt the ePhyto solution and use it effectively, ensuring it aligns with ISPMs and is interoperable with other digital trade platforms for future growth in the dynamic digital world. The later includes developing rules for potential data sharing on the request of IPPC member countries with other government and private entities, as well as considering data gathering on types of products covered by the certificates in addition to their numbers to evaluate their impact in the future.

Development partners, specifically international organizations and multilateral financial institutions, are equally vital in driving the adoption of ePhyto by funding infrastructure development, training programmes, and outreach initiatives. Their technical and financial assistance is essential to help countries, particularly those with limited resources, overcome initial barriers to wider trade digitalization implementation. Development partners can help harmonize data sharing and security protocols to create synergies for greater interoperability of various digital trade support systems. Continued investment in enhancing hardware and software solutions and data-sharing platforms will also provide a solid foundation for scaling up the ePhyto solution.

National governments/IPPC contracting parties have a crucial role in prioritizing ePhyto adoption as part of their broader trade and digital transformation agendas. This includes allocating and prioritizing resources for establishing the necessary infrastructure, including robust digital platforms and single-window systems, and ensure that NPPOs are adequately equipped with technical skills. Governments should also work to streamline regulatory frameworks for mutual recognition of electronic certificates and electronic signatures.

Private sector is key. As this report shows, businesses will capitalize on the operational efficiencies and cost savings that ePhyto provides to improve profit margins and competitiveness. This requires collaborating with NPPOs to streamline implementation processes and ensure smooth integration into existing trade workflows. Private sector actors, including exporters, logistics providers, and trade associations, should consider actively supporting the transition to ePhyto by fully integrating it into their operations. In specific cases, some training might be necessary to ensure the adoption of ePhyto is as rapid and smooth as possible.

Moving away from paper-based or hybrid systems that still require paper certificates in the wider trade-enabling environment, including financial institutions, freight forwarding companies, customs brokers, fumigation companies, etc., will enhance ePhyto benefits.

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Appendix A
Agrifood products at the HS-6 level requiring phytosanitary certification

Commodity group	HS-6 codes
Vegetables	70519, 70420, 70610, 70490, 70511, 70529, 70410, 70521, 70320, 70390, 70110, 70190, 70200, 70310, 70700, 70690, 71220, 71190, 71159, 71151, 71140, 71120, 71490, 71450, 71440, 71430, 71231, 71232, 71310, 71290, 71040, 71239, 71233, 71420, 70993, 70999, 71010, 71021, 71022, 71029, 71030, 70992, 71090, 71335, 71410, 71390, 71360, 71350, 71340, 71339, 71320, 71080, 70940, 70951, 70959, 70960, 71334, 70991, 70930, 70970, 70810, 71331, 70820, 70890, 70920, 71332, 71333
Fruits and nuts	80830, 80590, 80550, 80540, 80529, 80522, 80521, 80510, 80610, 80620, 80840, 80910, 80921, 80719, 80810, 80720, 80711, 80450, 80262, 80280, 80270, 80222, 80261, 80252, 80251, 80242, 80241, 80232, 80231, 80290, 80440, 80430, 80420, 80410, 80390, 80310, 80929, 81020, 80930, 80112, 80111, 80119, 80121, 80122, 80131, 80132, 80211, 80212, 80221, 81290, 81400, 81350, 81060, 81050, 81040, 81070, 80940, 81010, 81030, 81090, 81340, 81190, 81330, 81320, 81310, 81210, 81120, 81110, 120190, 120110, 120230, 120770, 120991, 121190, 121130, 121140, 121150, 120241, 120242, 120710, 120730, 120760, 120799, 120721, 120729, 120929, 120910, 121292, 121293, 121294, 121299, 121300, 121410, 121291, 121490, 120930, 120925, 120924, 120923, 120999, 121010, 121020, 121120, 121221, 121229, 120600, 120590, 120510, 120400, 120300, 120740, 120922, 120921, 120890, 120810, 120791, 120750
Cereals	100610, 100590, 100510, 100620, 100630, 100191, 100640, 100710, 100790, 100810, 100490, 100290, 100410, 100111, 100119, 100199, 100210, 100310, 100390, 100821, 100860, 100829, 100830, 100840, 100850, 100890
Flowers, cut	60319, 60314, 60311, 60312, 60313, 60315, 60390
Decorative plants (other than cut flowers)	60230, 60120, 60210, 60220, 60240, 60290, 60110, 60420, 60490
All other crops	180200, 180100, 90821, 90812, 90822, 91011, 90962, 90961, 90932, 90931, 90922, 90921, 90832, 90831, 90811, 90720, 90412, 90411, 90300, 90421, 90220, 90210, 90190, 90112, 90422, 90710, 90620, 90619, 90611, 90520, 90510, 91012, 91099, 91020, 90111, 90230, 91030, 91091, 90121, 90122, 90240

Appendix B
Calculation of tariff index

To estimate gravity export models (from HS-6 to aggregate level or group of products level), we also need an alternative measure to tariff **$tariff_{ij,t}$**. We employ the Tariff Trade Restrictiveness Index (**$TTRI_{ij}$**) (Fugazza and Nicita, 2013), which enters the gravity equation in a log (**$1+TTRI_{ij}$**) form. The **TTRI** gives the equivalent uniform tariff that will keep the exports from country i to country j constant. The main input for its computation is tariff data, average exports (x_{ijk}) for the previous period (to avoid endogeneity) and import demand elasticity for individual products (ε_{ijk}). The index is computed as follows:

$$TTRI_{ij} = \frac{\Sigma_k x_{ijs} * \varepsilon_{ijk} * tariff_{ijs}}{\Sigma_k x_{ijs} * \varepsilon_{ijs}}$$

Appendix C
ePhyto gravity models – annual data

Dependent variable: plants and plant product exports (USD million)	Aggregate	Vegetables	Fruits and nuts	Cereals	Other
Log (distance)	-0.7809*** (0.0284)	-1.047*** (0.0359)	-0.7773*** (0.0351)	-1.131*** (0.0629)	-0.6948*** (0.0331)
Common border dummy	0.3004*** (0.0813)	0.5139*** (0.0890)	0.2543** (0.0835)	0.3793** (0.1265)	0.5226*** (0.0816)
Common language dummy	0.0291 (0.0696)	0.2085* (0.1008)	0.1360 (0.0858)	-0.0926 (0.0631)	-0.0353 (0.0654)
Colonial past	0.2835*** (0.0546)	0.5365*** (0.0722)	0.2236*** (0.0625)	0.4932*** (0.1014)	0.3815*** (0.0694)
Regional Trade Agreement	0.4683*** (0.0459)	0.7397*** (0.0943)	0.6327*** (0.0582)	0.0463 (0.0664)	0.5004*** (0.0545)
Log (1 + TTRI)	-0.1819*** (0.0291)	-0.0595* (0.0296)	-0.1972*** (0.0292)	0.0065 (0.0283)	-0.0569* (0.0241)
Log (1+ePhyto_N)	-0.3554*** (0.0502)	-0.4011*** (0.0544)	-0.3163*** (0.0632)	-0.3724*** (0.0727)	-0.1225** (0.0457)
Log (1+ePhyto_N) squared	0.0440*** (0.0046)	0.0586*** (0.0060)	0.0414*** (0.0059)	0.0394*** (0.0069)	0.0144*** (0.0043)
Fixed-effects	–	–	–	–	–
Exporting country-year	Yes	Yes	Yes	Yes	Yes
Importing country-year	Yes	Yes	Yes	Yes	Yes
Observations	167 482	164 670	166 649	159 267	166 564
Pseudo R2	0.82721	0.86604	0.84717	0.77861	0.8491

NOTE: Level of significance for p-values: (.) for p<0.1, (*) for p<0.05, (**) for p<0.01, (***) for p<0.001

Appendix D
On the interpretation of the quadratic polynomial coefficients

Interpreting the quadratic polynomial term $\alpha_1 * \log(1 + ePhytoN_{ijt}) + \alpha_2 * [\log(1 + ePhytoN_{ijt})]^2$ in the specification (ii) is not straightforward and requires a further transformation and calculation of a turning point $N_0 = \exp(-\alpha_1 / (2 * \alpha_2)) - 1$ for each model. For each of the aggregate models, the equivalent signs of betas $(\alpha_1 \leq 0, \alpha_2 \geq 0)$ suggest a U-shape behaviour. This can be interpreted as follows: with smaller number of ePhytos (less than N_0) exchanged monthly by a country pair, the effect of the ePhyto solution on export is negative; once a pair of countries starts exchanging more than N_0 e-certificates monthly, the ePhyto solution has a trade-enhancing effect on the value of export. The calculations of such turning points N_0, or in other words, minimal required number of ePhytos for trade-boosting effect, for each aggregate gravity model are summarized in the Figure 12.

In order to calculate (and visualize) how a change in the number of ePhytos results in the change in the dependent variable (log of export), one needs to perform the following simulations. Let the following function $F(x,a,b)$ be such that $\log(y+1) = F(x,a,b)$ + rest, where the rest incorporates other variables and error term, y is the export value, x is the number of ePhytos:

$$F(x,a,b) = -a * \log(x+1) + b * (\log(x+1))^2$$

Calculation of the change from the initial number of ePhytos x0>0 to the jump value x1 is equivalent to the following:

$$\frac{\log\left(\frac{y(x1)}{x(x0)}\right)}{x0} \quad \text{is equivalent to} \quad \frac{F(x1,a,b) - F(x0,a,b)}{x0}$$

Exponentiating both sides and rerunning on the computer for several values of ePhyto number, one can obtain Figure 12.

Appendix E
Examples of digital trade certification initiatives

Digital trade certificates implementation matrix

Certificate type	Issuing/standard organization	Digital solutions & exchange tools	Global standard & year adopted	Current implementation status
Customs declaration	World Customs Organization (WCO)	Automated System for Customs Data (ASYCUDA)	WCO SAFE Framework (2005) Revised Kyoto Convention on Simplification of Customs Procedures	Over 100 countries use ASYCUDA
Animal health certificates	World Organisation for Animal Health (WOAH)	TRACES NT (European Union) e-Cert (New Zealand) eCert (Australia)	OIE (now WOAH) Terrestrial Code Chapter 5.2 (2013) European Union Regulation 2019/1715 on TRACES NT	TRACES NT fully operational in the European Union
Food safety/health certificates	FAO/WHO Codex Alimentarius	TRACES NT (food modules) eCert, a UNECE/CEFACT global electronic sanitary and phytosanitary certificate	Codex CAC/GL 38-2001 (revised 2021 UNECE/CEFACT e-Cert standard	e-CERT regulates the content and structure of electronic certificates, including but not limited to the Codex Alimentarius
Phytosanitary certificates	IPPC	IPPC ePhyto solution TRACES integration	ISPM 12 (ePhyto standard 2014)	See the section on the Evolution of trade in plants and plant products in this report
Conformity certificates	International Organization for Standardization (ISO)	ISO conformity assessment electronic certificates International Accreditation Forum	ISO/IEC 17065:2012	IAF CertSearch: Over 400 000 valid certifications in 2020
Certificates of Origin (CO)	International Chamber of Commerce (ICC)	ICC CO Verification website eCO platform	ICC Guidelines for electronic certificates of origin (2019) ICC CO Chain	49 members implemented an electronic system
Bills of lading	Various (including Covantis consortium)	Covantis blockchain platform launched an electronic bill of lading, eBL. TradeLens is another eBL based on blockchain WAVE BL	DCSA eBL standard (2021)	Covantis eBLs accounted for 4% of shipments in 2024

SOURCES: ASYCUDA (Automated System for Data). 2025. About ASYCUDA. In: *ASYCUDA*. Geneva. [Cited 5 February 2025]. https://asycuda.org/en/about/

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Global trade in plants and plant products is rapidly expanding – more than doubling in some cases – and set to grow another 11 percent by 2032. Yet, many countries still employ mostly manual rather than electronic means for issuing the phytosanitary certificates required to trade goods internationally. Relying on paper slows applications for and delivery of these certificates. They are not easily corrected when last-minute changes must be made and can be lost, causing days-long delays at border crossings, jeopardizing the freshness of highly perishable goods and increasing refrigeration needs. This – together with transporting printed certificates to and from customs offices – increases greenhouse gas emissions. Electronic phytosanitary certificates – ePhytos – are easier to use, cheaper, safer and more responsive to changing circumstances. They speed up exports, increasing trade between countries. This report examines how the ePhyto solution can facilitate the export trade of four countries where the European Bank for Reconstruction and Development (EBRD) operates: Serbia, Egypt, Ukraine and Uzbekistan. It is part of the Directions in Investment series under the FAO Investment Centre's Innovation and Knowledge for Investment (IK4I) programme.

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