Unveiling the Epoch: Exploring Pesticide Utilization and Trade Trends Globally and Regionally from 1990 to 2020

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Unveiling the Epoch: Exploring Pesticide Utilization and Trade Trends Globally and Regionally from 1990 to 2020

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ABSTRACT
Over the past three decades, a rapid increase in pesticide usage has played a central role in transforming the landscape of modern agriculture. The objective of this research is to conduct a comprehensive analysis of changes in pesticide usage from 1990 to 2020, emphasizing the complexity of global trends, environmental impacts, and pesticide trade dynamics. This study utilizes agri-environmental indicators and relies on the latest statistical data from FAOSTAT in 2022. The applied research method is a quantitative approach based on secondary data.The research findings indicate that global pesticide usage reached 2.7 million tons in 2020, with an average of 1.8 kg/ha. Although reaching a stable level, pesticide trade experienced a significant increase, particularly in the disinfectant category. Over the past three decades, there has been an approximately 50 percent increase in pesticide usage, especially in herbicides. Per capita analysis shows a relatively stable consumption rate, although there is an increase in pesticide usage per unit of agricultural land. Regional levels reveal significant disparities, with Asia as the largest contributor, Europe implementing strict policies, the Americas having the highest usage rates, Oceania experiencing low trade, and Africa applying low usage rates. Some countries, such as Saint Lucia, exhibit high pesticide application rates per unit of agricultural land, and this variation requires in-depth analysis to understand influencing factors. To mitigate negative impacts, international cooperation, the development of sustainable technologies, and a profound understanding of pesticide applications are necessary. Therefore, more effective and sustainable agricultural policies need to be designed to protect the environment and human health.
Keywords: pesticide usage trends; pesticide trade; global; regional.

INTRODUCTION

Over the past three decades, the Earth has witnessed rapid growth in the use of pesticides, chemical compounds that play a crucial role in modern agriculture. Various factors, ranging from changes in cropping patterns to the global population growth, have shaped the complexity of trends in pesticide usage, trade, and indicators worldwide (Wisnujati et al., 2023). In this research article, we will guide readers through an in-depth analysis, exploring the changes in the pesticide landscape from 1990 to 2020. Pesticides, when used responsibly, are key agricultural inputs that can help protect seeds and safeguard crops from unwanted plants, insects, bacteria, fungi, and pests (Wisnujatia & Sangadji, 2021). However, the use of pesticides can also have negative environmental impacts, including soil, water, and plant contamination, as well as non-target animal harm, leading to reduced biodiversity and, in some cases,

decreased crop yields (Alfiansyah et al., 2023; Benu et al., 2020; Hertika & Putra, 2019; Mudjiono, 2013; Qosim et al., 2018; Suluh et al., 2021).

The use of pesticides in agriculture, as an input and an agri-environmental indicator measuring usage in crop areas, serves to monitor global pesticide use, including at regional and country levels (Lanslor, 2010). Pesticide trade statistics are relevant for sustainable agriculture monitoring. FAOSTAT pesticide trade data cover the period from 1961 to 2020, with data for 1961–1989 encompassing only monetary values, while data for 1990–2020 also include physical quantities. The 2022 update on the Pesticide Trade domain includes data up to 2020, with intra-regional and inter-regional aggregates to highlight trade among various regions worldwide.

According to Carvalho (2006) updates in the Pesticide Indicator domain involve normalizing the pesticide application rates per hectare of crop land (kg/ha), as well as two additional normalizations: per capita (kg/person) and per agricultural production value expressed in international dollars (kg/1000 I$). It is important to note that pesticide trade figures may exceed pesticide usage figures for various reasons, such as non-agricultural use for imported pesticides, storage of imported pesticides for use in subsequent years, and the import of pesticide formulations, including adjuvants to enhance efficacy and shelf life.

This research not only explores the extent to which pesticides have become an integral part of modern agriculture but also highlights significant changes in global and regional trade patterns. We will uncover the complexities of pesticide market dynamics, identifying global driving trends that influence pesticide use in various countries. Furthermore, this study aims to deeply discuss the impact of pesticide use on the environment and human health. By analyzing pesticide indicators globally, regionally, and nationally, we will reveal patterns and trends that require special attention in sustainable policy planning. Confronting various questions and challenges related to pesticides, this article will provide comprehensive insights, highlighting critical areas that require further action.

METHOD

This research employs a quantitative method as the primary approach. Quantitative method is a research approach that utilizes numbers and statistics to detail and analyze collected data (S. Sangadji et al., 2022). The fundamental philosophy of this method is positivism, which believes that reality can be observed and measured objectively (Sangadji, 2023). By utilizing the quantitative method, this research aims to provide a deeper understanding of the investigated phenomena. The main source of data in this research is secondary data. Secondary data refers to information previously collected by others and can be found in various forms, both oral and written (Agusta, 2003; Sarosa, 2021; Sidiq et al., 2019). The researcher obtained secondary data from the Food and Agriculture Organization of the United Nations (FAO), an institution known for providing credible data related to agriculture and food globally. These secondary data include various types, such as research

findings, books, journals, articles, and data from government agencies, companies, or other organizations.

Data analysis in this research is conducted through a descriptive analysis approach. Descriptive analysis is used to detail the characteristics and patterns of the existing data. By using this approach, the researcher can provide a more detailed overview of the information contained in the secondary data collected from FAO. It is important to note that data analysis is based on three main indicators: global, regional, and country indicators. The selection of these indicators aims to investigate specific aspects of data relevant to the global, regional, and country levels. By focusing the analysis on these three levels, this research can offer a more comprehensive insight into the conditions of the studied agriculture and food. Through this approach, the researcher aims to depict changes or trends in the secondary data collected from FAO. By understanding these changes, this research can contribute to our understanding of the dynamics of agriculture and food at the global and regional levels. Additionally, this research also provides insights into the potential differences among countries in the context of agriculture and food.

RESULTS AND DISCUSSION

Global Level

On a global scale, the utilization of pesticides in agriculture exhibited stability throughout the year 2020, amounting to a cumulative 2.7 million tons (Mt) of active ingredients. When evaluated on a per-unit basis of agricultural land, the average pesticide usage reached 1.8 kg/ha. Calculated in terms of per capita consumption and the value of agricultural production, pesticide applications stood at 0.69 kg/1000 I$ and 0.37 kg/person, respectively. The collective pesticide trade for the year 2020 approximated 7.2 Mt of formulation products, commanding a market value of USD 41.1 billion.

Despite experiencing a plateau in recent years, the overall average pesticide usage has seen a significant uptick, escalating by approximately 50 percent over the past decade when compared to the levels observed in the 1990s. Pesticide deployment per unit of agricultural land surged from 1.2 to 1.8 kg/ha during this temporal span. Furthermore, a discernible trend emerged in the global pesticide application landscape, manifesting an upswing in the categories of herbicides, fungicides, bactericides, and insecticides. Notably, there was a pronounced elevation in the share of herbicides, ascending from 41 to 52 percent of the total pesticides deployed. Concurrently, the proportion of fungicides experienced a dip from 25 to 23 percent, and insecticides witnessed a decline from 24 to 18 percent. This nuanced shift in the composition of pesticide categories underscores the evolving dynamics within global agricultural practices.

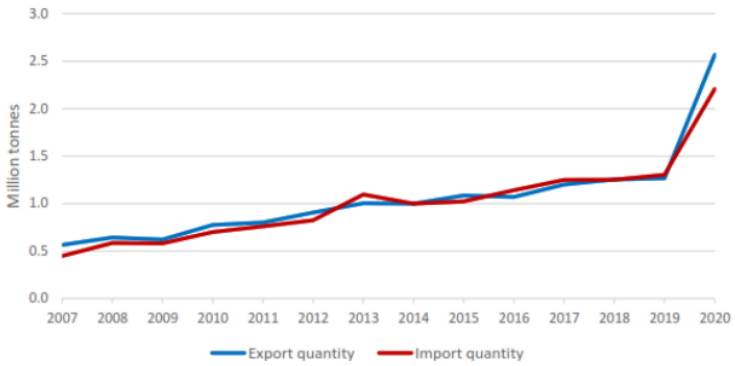

Figure 1. Global Export and Import of Disinfectants

The year 2020 marked a noteworthy upswing in the global pesticide trade, with a remarkable 30 percent surge in total volume. This substantial increase was chiefly propelled by a dramatic uptick in the trade of disinfectants, catapulting from 4.0 to 8.7 million tons between 2019 and 2020, as reported by the World Trade Organization (WTO) in 2020 (refer to Figure 1 for a visual representation). It is imperative to highlight that disinfectants, despite their distinct application from traditional agricultural pesticides, are classified under the same Harmonized System (HS) subheading, HS Code 3808. This subheading encompasses a wide array of products, including insecticides, rodenticides, fungicides, herbicides, anti-sprouting products, plant growth regulators, disinfectants, and similar items.

Furthermore, the surge in disinfectant trade underscores the significance of recognizing their placement within the broader pesticide category. The HS Code 3808 classification brings together disparate products under a common umbrella, showcasing the diverse nature of substances that fall within the pesticide trade ambit. Notably, a substantial portion of the traded disinfectants isn't destined for agricultural use, challenging the conventional association of pesticides solely with farming practices. Despite their divergence in application, the inclusion of disinfectants within this overarching category is pivotal for comprehending the overall dynamics of pesticide trade. Acknowledging the role played by disinfectants in propelling the surge in trade volumes provides a nuanced understanding of the multifaceted landscape of pesticide commerce in the pivotal year of 2020.

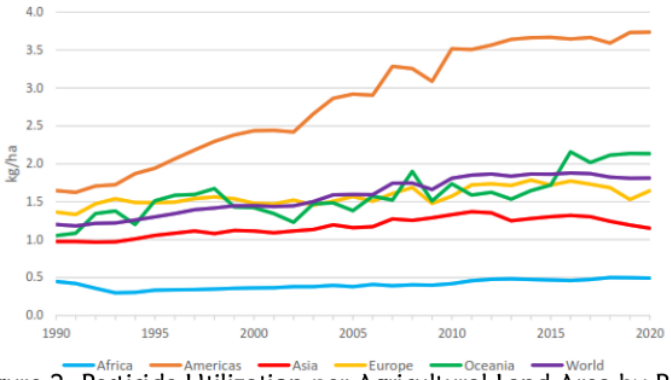

Figure 2: Pesticide Utilization per Agricultural Land Area by Region

Over the last thirty years, there has been a consistent average pesticide usage of 1.58 kg per hectare annually, 0.37 kg per person per year, and 0.79 kg per 1000 I$ per year, as illustrated in Figures 2, 3, and 4. These figures provide a comprehensive overview of the sustained global trends in pesticide application. Despite achieving a stable level in 2020, the total pesticide usage per agricultural land area remains elevated compared to the levels observed in the 1990s. This upward trajectory is predominantly attributed to the surge in herbicide usage, which has emerged as a dominant component within the overall pesticide landscape. Simultaneously, the diminishing use of fungicides and insecticides indicates a noteworthy shift in global pesticide preferences.

The persistent rise in total pesticide usage signifies a complex interplay of factors influencing agricultural practices worldwide. It is crucial to acknowledge the pivotal role played by herbicides, whose increasing usage has significantly contributed to the overall uptrend. The data reveal that even after reaching a plateau in 2020, the agricultural sector continues to grapple with higher pesticide consumption per unit of land compared to previous decades. This phenomenon calls for a closer examination of the driving forces behind the surge in herbicide application and the associated implications for global agricultural sustainability.

Furthermore, the declining trends in fungicide and insecticide usage underscore a changing dynamic in pesticide preferences. This shift may be indicative of evolving agricultural practices, including the adoption of alternative pest management strategies or the development and utilization of more targeted and efficient pesticides. As the world navigates the challenges posed by a growing population, climate change, and the need for sustainable agriculture, understanding these shifts in pesticide usage becomes paramount. It opens avenues for exploring innovative approaches to pest control and cultivates a broader discourse on the environmental and health impacts of different pesticide categories. In conclusion, the intricate patterns in global pesticide usage underscore the need for a nuanced understanding of evolving agricultural landscapes and the imperative to develop strategies that balance productivity with environmental and human well-being.

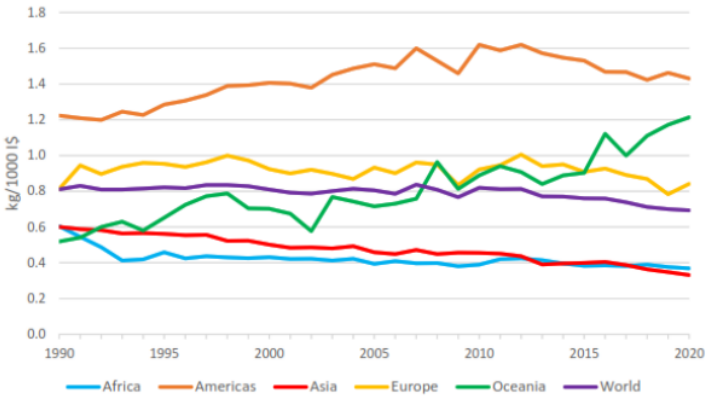

Figure 3: Pesticide Usage per Agricultural Production Value by Region

The examination of per capita and per agricultural production value calculations elucidates an intriguing trend: despite the escalation in pesticide utilization per agricultural land area, the rates of consumption per individual and per unit of agricultural production value exhibit a notable stability. This suggests that, while the per capita consumption rates remain relatively constant, the overall pesticide usage is markedly influenced by the simultaneous growth in population and agricultural production. This intricate relationship underscores the potential for significant shifts in total pesticide consumption, even in the face of seemingly unchanging per capita rates.

The stability in per capita pesticide consumption rates implies that, on an individual level, there hasn't been a substantial increase or decrease in the amount of pesticides used. However, when considering the broader scope of population growth and the expansion of agricultural activities, a different narrative emerges. The sustained stability in per capita rates may mask the underlying dynamics of increased pesticide usage associated with the overall growth in population and agricultural production. In essence, while each person might be using pesticides at a consistent rate, the cumulative effect on total pesticide usage becomes more pronounced as both the population and agricultural output expand.

This phenomenon has significant implications for understanding the environmental and health impacts of pesticide use. The apparent stability in per capita consumption might lead to the misconception that pesticide-related risks are not escalating. However, the overarching increase in total pesticide usage underscores the potential for broader ecological consequences and raises questions about the sustainability of current agricultural practices. Additionally, it prompts a critical examination of the efficiency and necessity of pesticide application methods to mitigate potential adverse effects on both human health and the environment. In conclusion, a comprehensive analysis of per capita and per agricultural production value considerations reveals a nuanced interplay between individual consumption patterns, population dynamics, and agricultural practices, emphasizing the importance of a holistic approach in addressing the challenges posed by pesticide usage.

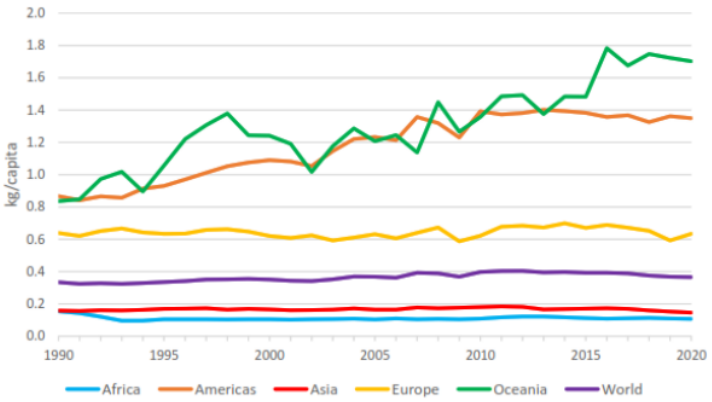

Figure 4: Pesticide Usage per Capita by Region

The global trend in pesticide usage, observed over the past few decades, mirrors the evolution of consumption patterns and preferences. While the overall pesticide usage stabilized in 2020, significant shifts in the types of pesticides employed have introduced new dynamics to the industry. A notable aspect is the rise in the trade of disinfectants, even though not all of them find application in the agricultural context. This underscores the importance of comprehending diverse pesticide uses that extend beyond the conventional agricultural sector.

Given the escalating global population and the mounting pressure to augment agricultural production, diligent monitoring and evaluation of pesticide usage become imperative. This necessity arises not only from the need to understand the potential impacts on human health and the environment but also to identify and promote sustainable farming innovations and practices. These endeavors are crucial in fostering a reduction in dependence on chemical pesticides, aligning with the broader goal of creating environmentally friendly and health-conscious agricultural systems. By adopting a proactive approach to the assessment of pesticide usage, stakeholders can contribute to the development and implementation of policies that prioritize the well-being of both ecosystems and communities.

In essence, the stability in total pesticide usage serves as a pivotal point for deeper scrutiny and proactive measures. The changing landscape of pesticide types, especially with the surge in disinfectant trade, necessitates a nuanced understanding of their applications. As we navigate the challenges posed by a growing population and the need for heightened agricultural output, a comprehensive evaluation of pesticide use emerges as a cornerstone for sustainable development. Through this lens, the agricultural community and policymakers can collaboratively strive towards fostering innovations that not only meet the demand for increased productivity but also ensure the long-term health of ecosystems and the welfare of global populations.

Regional Level

In 2020, Asia set a record for pesticide exports, reaching 3.7 million tons valued at USD 16.1 billion, as depicted in Figure 5. This surge was primarily driven by an exceptional surge in disinfectant usage, skyrocketing by over 450 percent compared to the preceding year. Notably, Asia emerged as the leading global contributor to pesticide exports, supplying 2.5 million tons worth USD 10.8 billion to other regions. Figure 3 illustrates Asia's consistent and substantial use of pesticides, averaging 0.65 million tons annually over the past three decades. However, when evaluating these figures on a per capita, per agricultural production value, and per hectare basis throughout this period, Asia consistently falls below global averages. The respective averages stand at 0.17 kg per person per year, 0.47 kg per 1000 I$ per year, and 1.17 kg per hectare per year. Despite Asia's significant overall pesticide usage, these metrics highlight a relative moderation when normalized by population, economic output, and agricultural area, suggesting a nuanced perspective on the region's pesticide consumption trends.

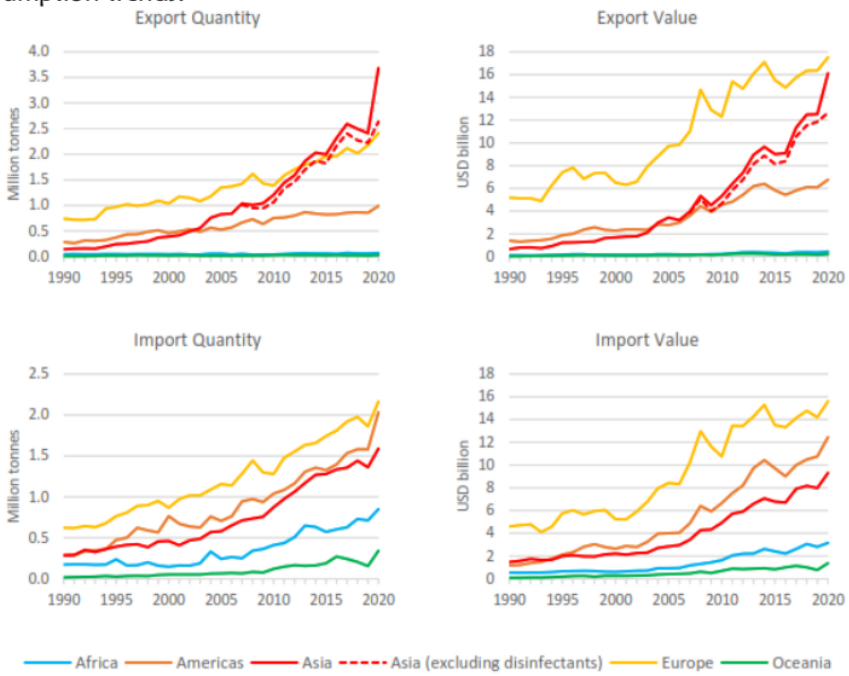

Figure 5: The total export and import of pesticides, including quantities and values by region.

The utilization of pesticides in European agriculture witnessed a modest increase of merely 3 percent between the 1990s and the most recent decade. This marginal surge can be attributed to the stringent regulatory measures implemented by the European Common Agricultural Policy, which effectively monitors and regulates pesticide usage across the continent. Notably, this region distinguishes itself by maintaining the lowest

proportion of pesticide use originating from insecticides, constituting a mere 12 percent of the overall pesticide usage, as elucidated in Figure 6. Moreover, when considering intra-regional trade dynamics, European countries collectively imported an average of over 1.2 million tons of pesticides annually over the entire period, underscoring the intricate trading partnerships prevalent within this geographically interconnected region, as visually depicted in Figure 5.

Despite the substantial volume of pesticide imports, the per-hectare application of pesticides in European agricultural landscapes stands at a relatively modest 1.6 kg/ha in 2020, a figure that falls below the global average. This implies a judicious and measured use of pesticides within European agriculture. Noteworthy is the fact that throughout this chronological span, the application of pesticides per hectare of agricultural land in Europe closely approximated the global average of 1.57 kg per ha per year. Furthermore, when evaluated on a per capita basis, Europe slightly exceeded the global average with a consumption rate of 0.64 kg per person per year. Similarly, in terms of agricultural value, the region demonstrated a slightly higher usage at 0.92 kg per 1000 I$ per year. These figures collectively underscore Europe's commitment to maintaining a delicate balance between agricultural productivity and environmental sustainability, as reflected in its judicious employment of pesticides on a per-unit basis.

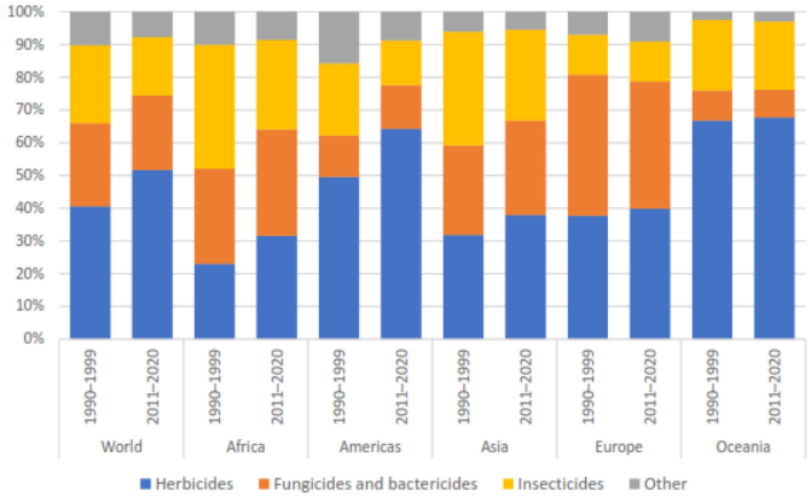

Figure 6: Pesticide Usage by Region and Category, 1990–1999 and 2011–2020

In 2020, the United States emerged as a significant player in the global pesticide market, showcasing a noteworthy import of 1.1 million tons valued at USD 6.9 billion. This surge included a substantial uptick of 160 percent in disinfectant imports, reaching 0.6 million tons compared to the preceding year. Over the entire review period, the United States consistently led in pesticide application in the agricultural sector, averaging an annual use of over 1 million tons. Notably, the region exhibited the highest pesticide application rates across multiple metrics, including 2.83 kg per

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hectare per year, 1.17 kg per person per year, and 1.43 kg per 1000 I$ per year concerning agricultural land area, per capita, and agricultural production value, respectively. The decade witnessed a surge in herbicide, fungicide, and insecticide utilization, with figures escalating from 362 to 852 kt, 93 to 177 kt, and 159 to 181 kt per year, respectively, as compared to the 1990s.

On the other hand, Oceania participated in a more restrained pesticide trade landscape, primarily engaging in intra-regional transactions. In 2020, the region's total pesticide imports amounted to 342 kt, valued at USD 1.4 million. Remarkably, the majority of these transactions occurred internally, with only about 30 kt, worth USD 0.22 million, being exported outside the region. Oceania maintained a comparatively modest pesticide usage, averaging around 62 kt annually over the past decade, constituting less than 1 percent of the global share during that timeframe. Over the recent decade, the region experienced an increment in pesticide application from 1.4 kg/ha to 1.8 kg/ha. The increase was also evident in herbicide, fungicide, and insecticide utilization, rising from 20 to 41 kt, 3 to 5 kt, and 7 to 13 kt per year, respectively. Despite this upward trend, Oceania sustained low pesticide levels per agricultural land area (1.58 kg per ha per year), per capita (1.30 kg per person per year), and normalized based on agricultural production value (0.80 kg per 1000 I$ per year).

In Africa, the dynamics of pesticide trade presented a distinct pattern, with a significant portion of imports originating from outside the continent, while the majority of exports stayed within the region. In 2020, the total pesticide imports in Africa reached 850 kt, valued at USD 3.1 million, with a substantial 779 kt (USD 2.8 million) sourced from other global regions. Conversely, the region exported 71 kt (USD 0.45 million) of pesticides, with only 20 kt directed outside Africa (USD 0.12 million). Herbicides, fungicides, and insecticides maintained stable shares in total pesticide usage over the past decade, with 32 percent, 33 percent, and 27 percent, respectively. Africa demonstrated a frugal approach to pesticide application, averaging approximately 0.11 tons per year in the recent decade. The region also showcased the lowest pesticide levels per agricultural land area, per capita, and per agricultural production value, recording figures of 0.41 kg per ha per year, 0.11 kg per person per year, and 0.42 kg per 1000 I$ per year, respectively.

The pesticide user country

Figure 5 illustrates a significant disparity in pesticide application rates across various regions. In 2020, African countries predominantly applied low levels of pesticides to their agricultural land, reflecting a common trend. Notably, Mauritius, Seychelles, and Egypt stood out as exceptions, surpassing the global average in pesticide application. Conversely, Oceania, known for its generally low pesticide usage per unit of agricultural land, witnessed exceptions in Samoa, Fiji, and New Zealand, where application rates were higher than the regional norm. Moving to Western and Northern Europe, the more industrialized countries exhibited elevated pesticide application levels compared to other parts of the region. Moreover, within Asia, the

West Asian countries emerged as the major contributors to the continent's high pesticide application rates. Meanwhile, in the Americas, Saint Lucia claimed the top spot with the highest pesticide application rate globally.

The disparity in pesticide application rates signifies diverse agricultural practices and environmental considerations across continents. In Africa, the majority of nations adhered to a trend of restrained pesticide use on agricultural land during the year 2020. However, the distinctive cases of Mauritius, Seychelles, and Egypt deviated from this norm by implementing pesticide levels surpassing the global average. In Oceania, where a general trend of limited pesticide usage prevails, Samoa, Fiji, and New Zealand exhibited an anomaly with elevated application rates. Western and Northern Europe, marked by higher industrialization, stood out with increased pesticide application compared to their regional counterparts. Within Asia, the concentration of countries with the highest pesticide application rates was notable in West Asia. Lastly, in the Americas, Saint Lucia emerged as the global leader in pesticide application rates, underlining the regional variations in agricultural practices. This comprehensive analysis of pesticide application trends across continents emphasizes the need for nuanced agricultural policies that consider regional disparities and environmental impact.

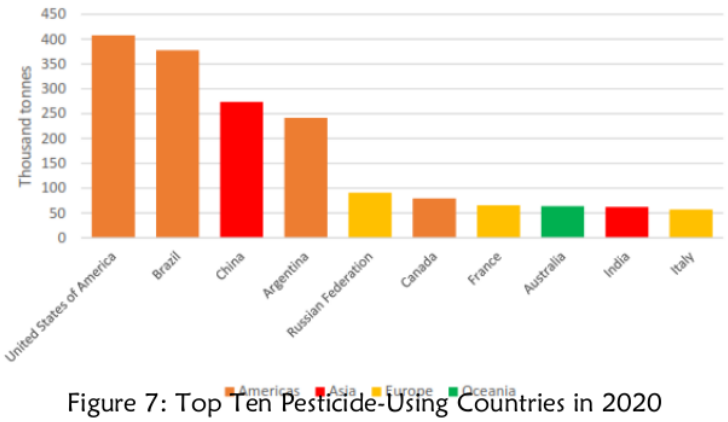

Figure 7: Top Ten Pesticide-Using Countries in 2020

In Figure 7, the data reveals that the United States took the lead as the foremost pesticide consumer in 2020, utilizing a substantial 408 thousand tons of pesticides for agricultural activities. Among the top 10 nations in pesticide usage, the subsequent rankings are noteworthy: Brazil closely followed the United States with 377 thousand tons, while China and Argentina utilized 273 thousand tons and 241 thousand tons, respectively. The Russian Federation applied 91 thousand tons, Canada used 79 thousand tons, France employed 65 thousand tons, Australia utilized 63 thousand tons, India implemented 61 thousand tons, and Italy rounded out the list with 57 thousand tons.

As previously noted, it is crucial to highlight a noteworthy alteration in the dataset pertaining to China. There was a significant downward revision in China's pesticide usage, marking a substantial decline of 70 percent. Consequently, China, which had previously held the position of the largest pesticide consumer, underwent a notable shift and now occupies the third position in the global rankings. This shift in the standings underscores the dynamic nature of pesticide consumption patterns and the evolving landscape of global agricultural practices.

The disparity in pesticide usage among these nations underscores the diverse approaches and priorities in agricultural practices across the globe. The United States, with its status as the leading consumer, signifies a reliance on extensive pesticide application, possibly driven by factors such as large-scale farming and a focus on high crop yields. Conversely, other nations in the top 10 exhibit varying levels of pesticide usage, reflecting the interplay of factors such as agricultural policies, environmental considerations, and technological advancements.

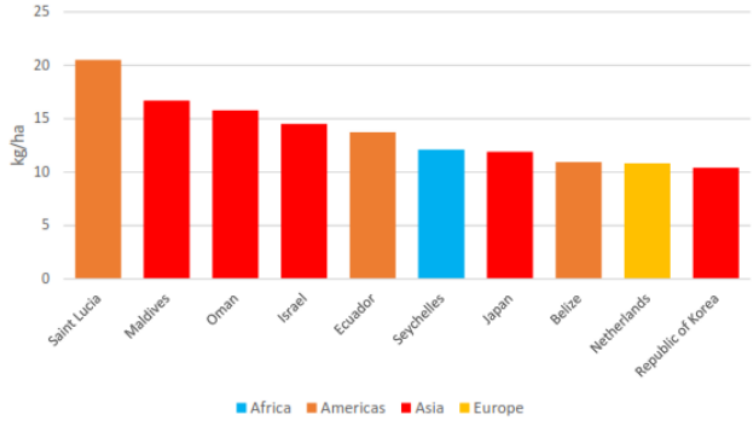

Figure 8: Top Ten Countries with the Highest Pesticide Usage per Agricultural Land Area in 2020

Figure 8 displays the leading countries in pesticide usage per agricultural land area in 2020, namely Saint Lucia (20 kg/ha), Maldives (17 kg/ha), Oman (16 kg/ha), Israel (15 kg/ha), Ecuador (14 kg/ha), Seychelles (12 kg/ha), Japan (12 kg/ha), Belize (11 kg/ha), the Netherlands (11 kg/ha), and the Republic of Korea (10 kg/ha). This data provides an overview that some countries exhibit significant pesticide usage rates per unit of their agricultural land area. For instance, Saint Lucia stands out with a rate of 20 kg/ha, indicating a high level of pesticide application compared to other countries.

The presence of such variations indicates differences in agricultural strategies or policies among countries that need further understanding. Deeper analysis is required to comprehend the factors underlying high or low pesticide usage rates in each country. Factors such as dominant crop types, common farming practices, and government policies related to agriculture can offer further insights into these patterns. Furthermore, the environmental and health impacts of high pesticide application rates

need to be further evaluated to identify potential risks and opportunities for sustainable improvements in pesticide management.

In order to enhance understanding of the pesticide usage patterns depicted by this data, international cooperation in sharing experiences and best practices can be a positive step. Additionally, supporting the development of environmentally friendly alternatives or more sustainable agricultural technologies can help reduce dependence on chemical pesticides and mitigate their negative impacts on the environment and human health. Through a profound understanding of pesticide applications in various countries, we can design more effective and sustainable agricultural policies. Thus, concrete steps can be taken to reduce disparities in pesticide usage, support more sustainable farming practices, and protect both the environment and human health.

CONCLUSION

Globally, the use of pesticides in agriculture reached 2.7 million tons in 2020, with an average of 1.8 kg/ha. Despite reaching a stable level, there has been a significant increase in pesticide trade, especially in disinfectants. Over the past three decades, pesticide use has increased by approximately 50 percent, particularly in herbicides. Per capita analysis indicates a relatively stable consumption rate despite the increased use of pesticides per unit of agricultural land. Regional levels show significant disparities, with Asia being the largest contributor, Europe implementing strict policies, America having the highest usage rate, while Oceania exhibits low trade levels, and Africa implementing low levels. Specific countries, such as Saint Lucia, demonstrate high pesticide application rates per unit of agricultural land. This variation requires in-depth analysis to understand influencing factors. To mitigate negative impacts, international cooperation, the development of sustainable technologies, and a profound understanding of pesticide applications are necessary. Thus, more effective and sustainable agricultural policies can be designed to protect the environment and human health.

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