臺灣獎助金 TAIWAN FELLOWSHIP

# *„The development of high technologies and digital waste: the experience of Taiwan and the Baltic states”*

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## Introduction

The progress that the fourth revolution has brought us is obvious: the processes of digitalization of society have accelerated, but their acceleration, in addition to another round of human progress, has brought another problem to solve: an increase in the amount of digital waste.

Every year, millions of broken or obsolete electrical and electronic devices are thrown away around the world. This unused equipment is considered electronic waste, and without proper preparation for disposal or recycling, it may pose a threat to the environment and human health. In 2030, the amount of e-waste will reach 74.7 million metric tons, which is 39% more than in 2019. The Asian region is the leader: 23.9 million metric tons in 2019, or 46.5% of the total amount of global digital (!). Millions of tons of e-waste are disposed of in environmentally unsafe ways each year or continue to be stored in homes and warehouses, piled up in landfills, exported to other countries, or recycled in appropriate conditions. When e-waste is not properly recycled, it releases up to 1000 different chemicals into the environment, including dangerous neurotoxins such as lead[1]. Such substances are especially dangerous for women considering their impact on their bodies and their age characteristics.

Electronic waste contains valuable and non-renewable resources that, if properly recovered, can be reused. For this reason, collecting and recycling of e-waste can become an important source of income for individual collectors and even entire groups of people. However, e-waste poses serious health risks to people living in low- or middle-income countries that lack adequate regulatory frameworks, recycling infrastructure, and system of training of workers. Here, the embedded components of the circular economy can serve as a powerful mechanism for solving both environmental problems and motivating the conduct of green business.

The goal of the research is to develop suggestions for the Baltic States in the field of digital waste management, based on the studied experience of Taiwan and calculations using a partial least square's structural equation modeling (PLS SEM) method.

For the fulfillment of the set goal, it is necessary to solve the following objectives:

1. To analyze the theoretical aspects of green and circular economy;

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[1] World Health Organization https://www.who.int/en/news-room/fact-sheets/detail/electronic-waste-(e-waste)

2. To conduct an analysis of waste classification and determine the place of digital waste in the circular economy;
3. To conduct an assessment of digital waste management in Taiwan and EU countries;
4. To analyze the governance structures of Taiwan and the Baltic States in the field of environmental policy implementation;
5. To study Taiwan's experience in digital waste management;
6. To analyze digitalization processes in Taiwan and the Baltic States;
7. Using a partial least square's structural equation modeling (PLS SEM), calculate the factors influencing the digitalization processes of Taiwan and the Baltic States;
8. Based on the obtained results, the PLS SEM method suggests directions for activities in the field of waste management for the Baltic countries.

*The subject of the research* is the patterns of digitalization processes and the dynamics of digital waste.

*The object of the research* is the digitalization processes of Taiwan and the Baltic States.

*The novelty of the presented research* lies in the suggestions for digital waste management in the Baltic States.

*Limitations of the research*: The research was conducted based on statistical data of digitalization processes of Taiwan and Baltic States from 2017 to 2022. Recommendations for the Baltic States are formulated on the basis of PLS-SEM method calculations.

The structure of the research: presented by an introduction, three chapters, conclusions, and a list of references.

The introduction formulates the goal, objectives, subject, and object of the research, as well as the scientific novelty and practical significance of the research.

In the first chapter, the author researches the theoretical aspects of green and circular economy, describes the components of the circular economy, provides the author's classification of waste, determining the place of digital waste in this classification.

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The second chapter is devoted to the analysis of state structures for managing environmental policy in Taiwan (R.O.C.) and the Baltic States. The author paid special attention to studying Taiwan’s experience in the field of digital waste management.

In the third chapter, the author analyzes the indicators of digitalization processes of Taiwan and the Baltic States based on calculations using the PLS-SEM method. Based on the results of the PLS-SEM method, the author suggested the areas of activity for the Baltic States in the field of digital waste management.

In conclusion, the author formulates conclusions and suggestions.

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# Part 1. Theoretical aspects of the formation of a green and circular economy

## 1.1. Elements of sustainable development in a green and circular economy

First of all, let’s note that both the green economy and the circular economy are based on three pillars, or so-called three Ps: People, profit, planet Figure 1.1, only in the trinity we can ensure sustainability. Analyzing the situation in the present, it should be noted that only 10% is people and planet, but 90% is profit[2].

As we know, the goal of a sustainable business strategy is to have a positive impact on the environment, society, or both while simultaneously benefiting shareholders. Business leaders are increasingly recognizing the power of sustainable business strategies not only to solve the world’s most pressing issues but also to ensure the success of their companies. However, defining what sustainability means, setting clear and achievable goal, and formulating a strategy to achieve these goals can be challenging.

The dilemma here is the primacy or priority of factors: what comes first, profit, or the planet, or people? There is also a debate among scientists on this issue[3]. Some of them choose profit as the first factor because without it, shareholders and other stakeholders will not be able to support the planet or provide social guarantees to workers.

According to the author, the main factor in the development of any economy, both linear and closed cycle, are resources, and the main resource of both the company and the whole world is people. Therefore, in the author’s opinion, it is undeniable that people should be put first, since they are the ones who will be able to generate the profit and help the planet.

Thus, people-profit-planet. In this order and priority, we should approach the implementation of the sustainable development strategy.

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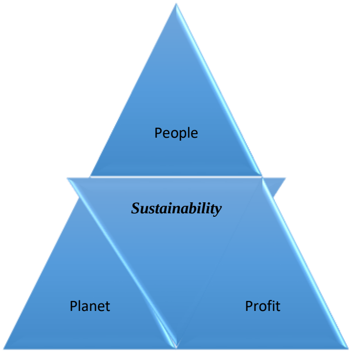
[2] (Pierre Galame)

[3] Kelsey Miller, THE TRIPLE BOTTOM LINE: WHAT IT IS & WHY IT’S IMPORTANT, Harvard Business School, december 2020



Picture 1.1 Three P model. Source: John Elkington

For some, adopting the Three Ps approach may seem idealistic in a world where profit is prioritized above all other goals. However, innovative companies have proven time and time again that you can succeed by doing good.

One of the common ways to understand a business's efforts in sustainable development is to use a concept known as the *triple bottom*.[4]

Thus, the first component of the *triple bottom* emphasizes the impact of business on society or its commitment – *people.*

As companies increasingly turn to sustainable development, they have shifted their focus towards creating value for all stakeholders affected by business decisions, including customers, employees, and community members.

The next component of sustainable development of the linear and circular *economy* is *profit.*

In the past, the goals of many companies were focused solely on economic impact and growth. Now, purpose-driven leaders are discovering that they have the opportunity to use their business to achieve positive changes in the world without compromising financial performance.

The final component of the triple bottom concerns having a positive impact *on the planet.* Since the dawn of the industrial revolution, large corporations have made a staggering contribution to environmental pollution, which has become a key factor in climate change and ecological issues.

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[4] John Elkington , 25 Years Ago I Coined the Phrase "Triple Bottom Line." Here's Why It's Time to Rethink It, Harvard Business Review, April, 2020

Business has historically had the greatest impact on pollution and climate change on the planet; however, there is currently a trend towards positive changes. Many business leaders are now aware of their social responsibility for this.

## 1.2 The concept and classification of waste

Thus, in the last decade, particular relevance in the scientific and practical fields has been given to digital waste[5, 6,7.]. However, the analysis conducted by the author showed that there is no clear classification of the concept of "waste."

Since the goal of our research is a comparative analysis and assessment of the activities of the Baltic countries in the field of digital waste based on the studied experience of Taiwan, however, we should first summarize the approach to waste classification. According to the authors, we should start, first, with subjects: who produces it: households or production? Therefore, let's start with the subject: industrial waste and commercial waste. For waste management, this is especially important as we adopt different approaches in management, either for a production or an enterprise with its volumes, goals, and objectives. Either these are households working with individuals. Thus, industrial waste: These are the wastes created in factories and industries. Most industries dump their wastes in rivers and seas, which causes a lot of pollution. Commercial waste: Commercial waste is produced in schools, colleges, shops, and offices. Household waste: The different household wastes which are collected during household activities like cooking, cleaning, etc. are known as domestic wastes.

*Classification of waste based on its physical state*

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[5] Massimo Saita, Maria Vittoria Franceschelli The Role of Waste Management in the Green Economy: an Empirical Analysis of Economic data of the Business. Edited by Andrei Jean Vasile, Domenico Nicolo, Sustanable Enterprenership and Investments in the green Economy , IGI global, USA 2018, pp 169-199

[6] Wasim Ayub Bagwan, Electronic waste (E-waste) generation and management scenario of India, and ARIMA forecasting of E-waste processing capacity of Maharashtra state till 2030, Waste Management Bulletin, Volume 1, Issue 4, March 2024, Pages 41-51 https://doi.org/10.1016/j.wmb.2023.08.002

[7] Minh-Hieu Le, Wen-Min Lu, Recycling E-Waste and the Sustainable Economy: A Bibliometric Exploration, Sustainability, 2023, **https://doi.org/10.3390/su152216108**

*Solid wastes* are any discarded or abandoned materials that can be solid, liquid, semi-solid, or containerized gaseous material discarded by human society. These include urban wastes, agricultural wastes, biomedical wastes, and radioactive wastes. The term refuse is also used for solid wastes. Examples of solid wastes include waste tires, septage, scrap metal, latex paints, furniture and toys, garbage, appliances and vehicles, oil and anti-freeze, empty aerosol cans, paint cans and compressed gas cylinders, construction and demolition debris, asbestos, plastics, styrofoam containers, bottles, etc.

*Liquid wastes*: Liquid wastes can be defined as liquids/fluids that are generated from washing, flushing, or manufacturing processes of the industries. They are also called sewage. The most common practice of disposing of liquid waste is to discharge it in the ground or rivers and other water bodies without treatment.

*Gaseous wastes:* It is a waste product released in the form of gases from automobiles, factories, industries, burning of fossil fuels, etc., and gets mixed in the atmosphere. These gases include carbon monoxide, carbon dioxide, sulfur dioxide, nitrogen dioxide, ozone and methane, etc. Depending on the decomposition period, we classify waste into biodegradable and non-biodegradable waste.

Biodegradable waste: These are the wastes that come from our kitchen, and it includes food remains, garden waste, etc. Biodegradable waste is also known as moist waste. This can be composted to obtain manure. Biodegradable wastes decompose themselves over a period of time depending on the material.

Non-biodegradable waste: These are the wastes that include old newspapers, broken glass pieces, plastics, etc. Non-biodegradable waste is known as dry waste. Dry waste can be recycled and can be reused. Non-biodegradable wastes do not decompose by themselves and hence are major pollutants.

Source-based classification Wastes are produced from different sources and are categorized as follows: Classification, figure 1.2.

Chemical waste is waste that is produced from harmful chemicals, which are mainly produced in large factories. Chemical waste may or may not be hazardous. Hazardous chemical wastes can be solid, liquid, or gaseous and may exhibit dangerous characteristics such as toxicity, corrosivity, flammability, and reactivity.

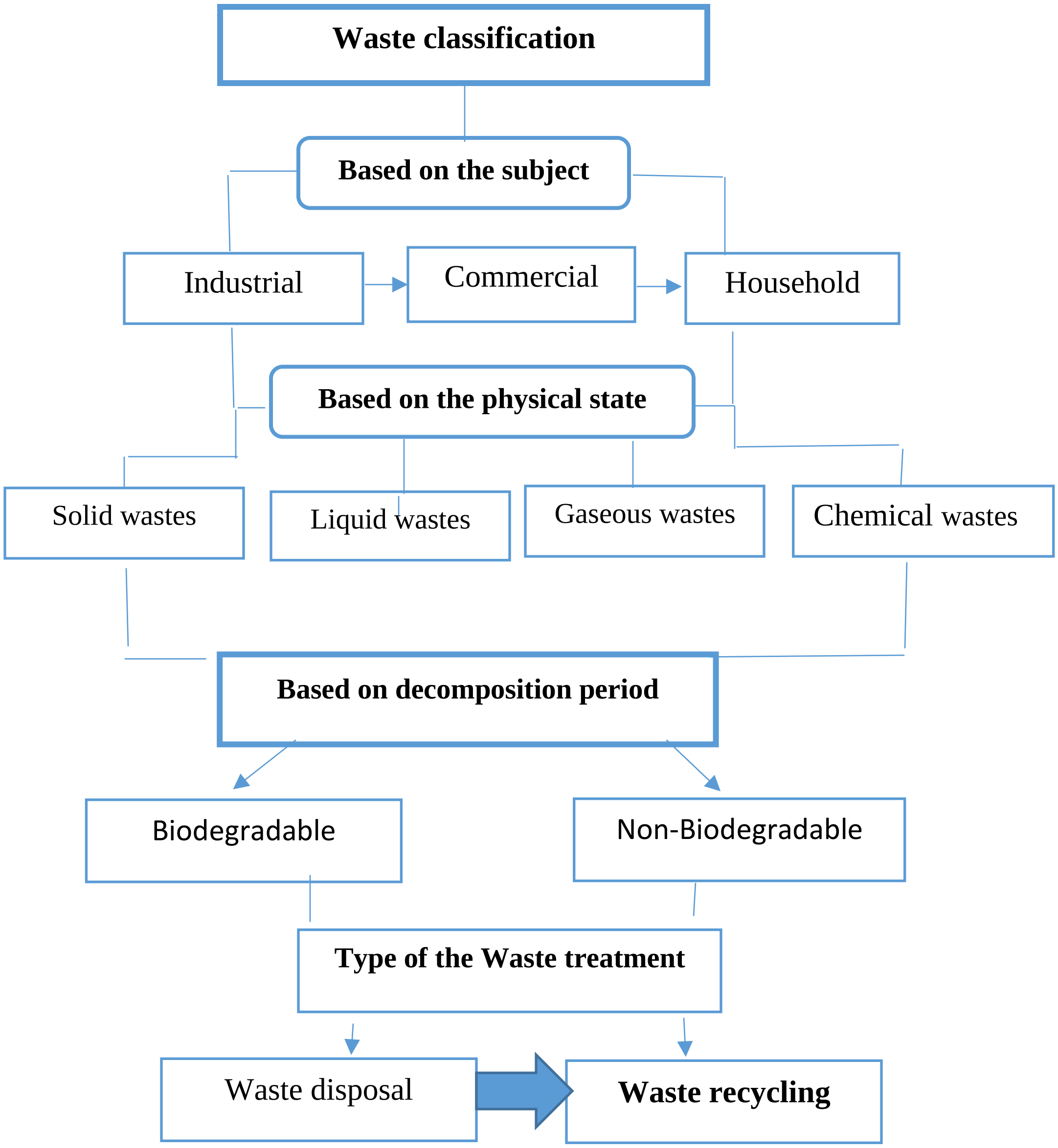

Figure 1.2. Classification of waste depending Classification of waste depending on factors: subjects, author's scheme

Thus, to determine approaches to waste management, it is necessary to classify them depending on the entity (production or households), their physical properties (solid wastes, liquid wastes, gaseous wastes, chemical wastes), and the possibility of decomposition (biodegradable, non-biodegradable). Next, we determine the approach: burial or recycling. According to the author, and this is highlighted by the author in Figure 4, the main objective of the circular economy is to recycle waste as much as possible.

### 1.2.1 Digital waste.

Thus, in order to address the issues of digital waste management, it is necessary to provide a definition. In EU countries, digital waste collection is carried out on the basis of the adopted digital waste market in the European Union, which defines a number of documents, including "a Single Market For Digital Services and amending Directive 2000/31/EC" (Digital Services Act), etc., [8],[9]. To identify types of digital waste, the classification of the European Parliament is used (Table 1). Thus, in the EU countries, digital waste is defined by the following document: *Waste Electrical and Electronic Equipment*" (WEEE)– Definition and Understanding of the 6 Categories (15.08.2018)[10]. This document provides guidance for and clarification of the definition of the categories, examples of misinterpretation, dimensions, and measurement of (WEEE). The classification of the waste electrical and electronic equipment in the EU includes 6 categories: 1. Temperature exchange equipment (TEE); 2. Screens, monitors, and equipment containing screens having a surface greater than 100 cm²; 3. Lamps; 4. Large equipment (any external dimension more than 50 cm); 5. Small equipment (no external dimension more than 50 cm); and 6. Small IT and telecommunication equipment (no external dimension more than 50 cm). Based on this

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[8] a Single Market For Digital Services and amending Directive 2000/31/EC» (Digital Services Act)

[9] Commission Implementing Regulation (EU) 2019/290 of 19 February 2019 establishing the format for registration and reporting of producers of electrical and electronic equipment to the register

[10] European Commission, *Waste Electrical and Electronic Equipment*" (WEEE): Definition and Understanding of the 6 Categories (15.08.2018).

classification, EU countries develop a system of subsidy for residents of their country (community).[11,12,13]

A similar approach in Taiwan, where there is a department called the Environmental Protection Administration of Taiwan (EPAT), which developed the "4 in 1" waste recycling programme in 1997. The document states that among the wastes targeted by the EPAT recycling and resource recovery programme, waste electrical and electronic equipment (WEEE)[14] is the fastest growing. The subjects of the "4-in-1" waste recycling programme unite manufacturers and importers of new RRW products into a holistic system. The subjects of this system are recyclers, municipal waste collection groups, and residents of local communities.

EPAT has classified e-waste collection into two categories: e-waste from home appliances and e-waste from IT equipment. Here the document also defines the amounts of subsidies for products that have been disposed of as waste; see Table 1.1.

Table 1.1. Classification of Waste Electrical and Electronic Equipment (WEEE) in Taiwan (R.O.C)[15].

| № | Category | Item |
|---|---|---|
| 1 | Home Appliances | Television, refrigerator, washing machine, air conditioner , fan |
| 2 | IT equipment<br>Lighting equipment | Monitor, mainframe, printer, notebook, keyboard |

It should be noted that the collection rate of certain WEEE items in Taiwan consistently exceeds 50%. These rates are on par with or exceed the return rates in developed countries such as Japan and Korea, and they are twice as high as the estimated WEEE recycling rate (25%) in the US[16].

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[11] Jaco Huisman, The Dutch WEEE , United Nations University (UNU)2012, DOI:10.13140/RG.2.1.3193.7446

[12] National eco-organization for the prevention, collection and recycling of WEEE, ASL and ABJ Th. https://www.ecologic-france.com/

[13] Deutsche Recycling, https://deutsche-recycling.de/produktverantwortung

[14] Recycling and waste electrical and electronic equipment management in Taiwan, Environmental Protection Administration, Executive Yuan, 1997

[15] Recycling and waste electrical and electronic equipment management in Taiwan, Environmental Protection Administration, Executive Yuan, 1997

Starting from April 1, 2024, Taiwan will introduce regulations requiring local mobile phone suppliers to establish waste recycling enterprises and assist users in such practices, as announced by the Ministry of the Environment[16].

Waste management can be defined as a system or procecc[17], Picture 1.3.

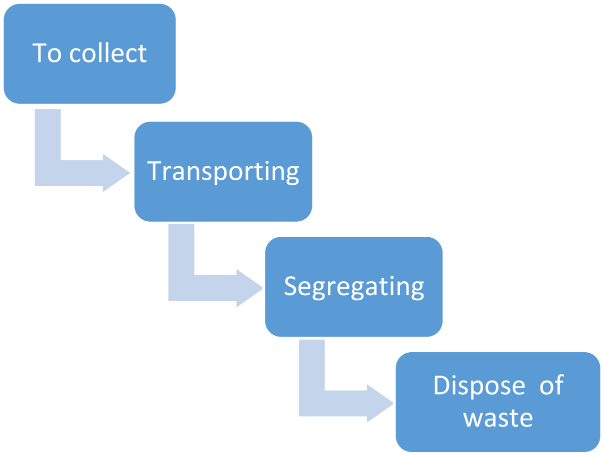

Figure 1.3. Stages of digital waste management, author's figure, Source[28]

- To collect digital waste: It is the collection of solid waste from the point of use (industry or household).
- Transporting—transporting digital waste from the location to the recycling or disposal site.
- Segregating digital waste—segregation of waste means dividing waste into types and categories.
- Dispose of digital waste—transformation operations required its reuse, recovery, or recycling.

This approach is oriented to a given process with concerns for the environmental effects of the processes and contaminant elimination.

An important aspect in the context of a circular economy and the disposal of digital waste is the prevention of waste generation. Recycling and secondary processing of waste. These two concepts are interconnected, but there is a slight difference between them. Recycling is the preparation of

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[16] Taiwan Ministry of Environment, https://law.moj.gov.tw/ENG/News/NewsList.aspx

[17] Ionel Ioana 2010/5 advances in Waste Management, 4th WSEAS International Conference on Waste Management, Water Pollution, Air Pollution, Indoor climate (WWAI'10) Tunis 2010:

waste for conversion into secondary raw materials: separation, purification. Recycling is the process of recycling itself. For example, waste paper—into toilet paper, fabrics—into clothing. Based on the works of a number of authors[18], it is necessary to consider the prevention of waste generation in issues of digital waste management.

This includes the following aspects of activity: redaction of waste, reuse of waste, recycle of waste. It is in this sequence that redaction of waste allows you to select the waste obtained, reviewing its possibility for reuse, perhaps not as a whole component, but perhaps its parts, mechanisms. Only after assessing for reuse it is offered for recycling. In fact, the cycle described in the circular economy is repeated (see Figure 1.1.).

## 2. Analysis of governance structures of Taiwan and the Baltic countries in the implementation of environmental policy

### 2.1 History and Governance Structure of the Ministry of the Environment of Taiwan

In Taiwan, special attention has been paid to environmental protection for many decades, as the entire environmental protection system in Taiwan is divided into the following five stages:

<u>Stage 1: History up to March 17, 1971.</u>

- As is known, the government of the province of Taiwan was established in 1947, and the Ministry of Health was expanded and began to focus on improving and promoting environmental sanitation. The Taiwan Provincial Environmental Health Experimental Institute was founded by the Ministry of Health in 1955 to conduct survey, research, water sanitation management, sewage treatment, garbage disposal, water quality control, overall environmental health, air pollution control, radiation safety, and noise control.

- In October 1968, the Taipei City Government merged the Municipal Purification Division and the Sewage Treatment Commission into the Environmental Purification Department to take responsibility for air and water pollution control and waste recycling. Responsibility for control of public hazards was assigned to the Department of Health of the Taipei City Government.

- Under the auspices of the Ministry of Internal Affairs, the Department of Health was established to be responsible for infectious disease prevention, epidemic control and surveillance, international health inspection and quarantine, environmental sanitation, public health facilities, and medical management. The Ministry of Economy established the Industrial Development Bureau in 1969. The IDB (Industrial Development Bureau) was responsible for the management of industrial gases and water emissions and the prevention and elimination of hazards to society.

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[18] Raimund Bleischwitz, Paul J.J. Welfens, ZhongXiang Zhang International Economics of Resource Efficiency/ Eco-Innovation Policies for a Green Economy Springer 2011, 394

## Stage 2: From March 17, 1971, to January 28, 1982.

- In March 1971, the Executive Yuan of the Ministry of Health established the Environmental Health Department. This unit was responsible for the management and monitoring of waste and wastewater disposal in health care facilities, public places, and food processing plants; the use of pesticides; research, management, and supervision of air, water, and noise pollution control. In addition, the Ministry of Economy also established the Water Pollution Control Section under the Water Resources Integrated Planning Commission to monitor water pollution control.
- In addition to the Ministry of Health and the Experimental Institute of Environmental Health, the government of Taiwan Province has established the Water Pollution Control Institute under the Department of Construction, which is responsible for pollution control, watershed designation, planning and training in water pollution control, issuing permits, dispute resolution and enforcement, as well as supervision, auditing, and research on wastewater treatment plant control technologies.

## Stage 3: From January 29, 1982, to August 21, 1987.

- The Executive Yuan enacted the "Environmental Protection Law of Taiwan" in April 1979 to comprehensively develop a plan for establishing a reliable environmental management system. The Environmental Health Department of the Executive Yuan's Department of Health was transformed into the "Bureau of Environmental Protection," which assumed the following functions: air pollution control and environmental hygiene, water pollution control, and road noise control. The control over public hazards was also actively promoted to lay a solid foundation for environmental protection policies and measures, as well as for the establishment of the Environmental Protection Agency.
- Since September 1984, each city and county has designated Division II of the Health Bureau as the responsible authority for addressing environmental protection issues.

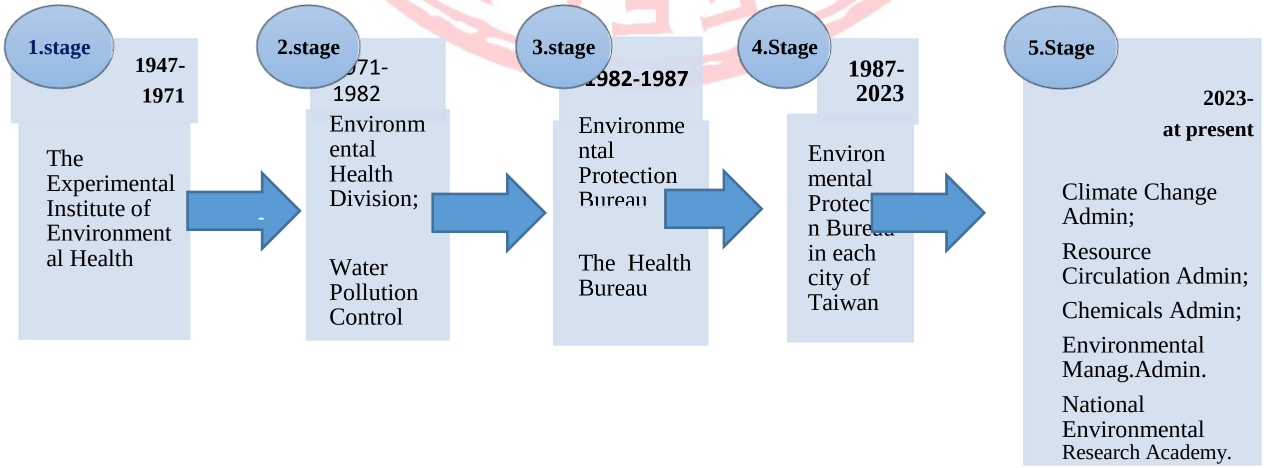

Figure 2.1 History of the Development of the Ministry of the Environment of Taiwan, author's figure. Source:

<u>Stage 4: From August 22, 1987, to August 21, 2023.</u>

On August 22, 1987, the Bureau of Environmental Protection, Department of Health, Executive Yuan, was transformed into the "Environmental Protection Administration, Executive Yuan." It consisted of seven departments: integrated planning, air quality protection and noise control, water quality protection, waste management, environmental health and toxic substances management, supervisory assessment and dispute resolution, environmental monitoring and information management. From 1988 to 1991, the government of each city and county gradually established an Environmental Protection Bureau to improve environmental protection operations and functions. By January 2003, the environmental protection organization and structure were completed.

<u>Stage 5: From August 22, 2023, to the present.</u>

- The Environmental Protection Administration was reorganized into the Ministry of the Environment. At the same time, four tertiary agencies were created—the Office of Climate Change, the Office of Resource Management, the Office of Environmental Management, and the Office of Chemicals—as well as the National Academy of Environmental Research. In response to the international trend towards zero emissions and other global environmental changes, the government has changed its approach from "managing natural resources" to "actively responding to the global environmental situation and creating opportunities for Taiwan's transformation." This entails the integration of expanded mandates and systematically addressing climate change, resource recycling, chemicals management, environmental quality management, and strengthening environmental research.

## 2.2. Management structure of the Ministry of Environment of Lithuania

Table 2.1. Management structure of the Ministry of Environment of Lithuania, author's table, source [19]

| **Position** | **Areas of responsibility** | **Coordinates and controls of the institutions** |
|---|---|---|

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[19] the Ministry of Environment *of the Republic of Lithuania* https://am.lrv.lt/en/contacts-and-structure-1/management/

| | | |
|---|---|---|
| **Minister** | Implementation of Environmental Policy;<br>Corruption Prevention; Internal Audit;<br>Strategic Communication;<br>Strategic Changes;<br>Waste Management | Environmental Protection Agency;<br>Environmental Protection Department. |
| The Vice-Minister | Waste;<br>Pollution Prevention;<br>Water Resources and Wastewater;<br>Subsoil;<br>Museum policy | Lithuanian Geological Service<br>V. Intas State Museum of Stones<br>Public Agency Soil Remediation Technologies**;**<br>Environmental Protection Agency<br>Environmental Protection Department under the Ministry of Environment |
| The Vice-Minister | Territorial planning, urban planning, and architecture;<br>Construction, renovation, housing;<br>Spatial data and its digitization policy;<br>Land use, geodesy, topography, cadaster policies. | State Territorial Planning and Construction Inspectorate;<br>Agency for Construction Sector Development;<br>Certification Centre for Construction Products. |
| The Vice-Minister | Management and use of public land;<br>Spatial planning;<br>Development of municipal infrastructure;<br>Geodesy, cartography, spatial data management;<br>Development of Lithuania's spatial information infrastructure. | National Land Service |
| The Vice-Minister | Nature Protection;<br>Forests;<br>Climate change;<br>Protected Areas and Landscape. | State Service for Protected Areas;<br>Kaunas Tadas Ivanauskas Zoological Museum;<br>Lithuanian Zoological Garden;<br>State Forest Enterprise;<br>State Forest Service<br>Lithuania Hydrometeorological Service |

As we can see from the table presented by the author, the Ministry of Environment of the Republic of Lithuania is headed by a minister and four vice-ministers. The deputy ministers also have corresponding responsibilities and institutions.

The minister is responsible for the implementation of the state's environmental policy, strategic communications, is responsible for the internal audit of the ministry, and oversees the fight against corruption.

## 2.3 Management Structure of the Ministry of the Environment of the Republic of Estonia

According to climatologist, polar explorer, and politician Andres Tarand, the first instrumental weather observations in Estonia were made by military doctor Johann Jacob Lerche on board a sailing ship in the Vilsandi roadstead on August 18, 1731. The oldest series of observations in Estonia were carried out by officer Breckling in 1774–1777 and by L. Carpov, professor of the Reval Cathedral School, in 1785–1800 in Tallinn. The observations last for more than half a century (1835–1885); the book of observations is kept in the Estonian Meteorological and Hydrological Foundation (EMHF).

The Ministry of Climate in the Republic of Estonia was founded on December 21, 1989. In 1991, Estonia became independent again. At the University of Tartu and the Tartu Observatory, meteorological and climatological research continues in depth. Since 1992, the Republic of Estonia has been a member of the World Meteorological Organization (WMO).

The Ministry of Climate in the Republic of Estonia is, in the literal sense, the most nature-friendly.

The Ministry of Climate of Estonia focuses on enhancing the living environment while taking into consideration environmental protection. The ministry’s work ensures sustainable development and responsible economic growth, considering both current and future generations.

The structure of management and the responsibilities of the minister and his deputies are presented by the author in the form of a table.

Table 2.2. Structure of the Ministry of the Environment of Estonia, author's table, source. [20]

| Position | Areas of responsibility | Coordinates and controls of the institutions |
|---|---|---|
| Minister | To create such prerequisites and conditions that ensure us and the following generations a diverse nature and clean living environment as well as the sustainable use of natural resources. | Seven Deputy Secretaries, 28 departments<br>Estonian Environment Agency<br>Estonian State Fleet<br>Estonian Transport Administration<br>Estonian Museum of Natural History<br>IT center of Ministry of Environment<br>Geological survey of Estonia |
| Secretary General | | |
| Deputy Secretary General on Environmental Protection and Biodiversity | - organizing of national environmental and nature protection,<br>- fulfilling tasks related to land and databases containing spatial data,<br>- organizing the use, protection, reproduction, and accounting for natural resources,<br>- ensuring radiation protection,<br>- performing tasks related to the decrease of climate change,<br>- environmental supervision,<br>- organizing meteorological observations, nature and marine research, | Biodiversity protection department<br>Environmental management and radiation department<br>Forest department |
| Deputy Secretary General on Green Transition | | Green Transition department<br>Climate department<br>International Affairs department |
| Deputy Secretary General on Energy and Mineral Resources | | Energy department<br>Mineral Resources department<br>Ambient air department |
| Deputy Secretary General on Living Environment and Circular Economy | | Circular Economy department<br>Building and living department |
| Deputy Secretary General on Mobility | | Mobility department<br>Investment department<br>Road and Railways department<br>Air department |
| Deputy Secretary General on Maritime Affairs and Water Resources | | Maritime department<br>Water department |

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[20] Ministry of Climate *Republic of Estonia* https://kliimaministeerium.ee/en/ministry-news-and-contact/about-ministry/administrative-area

| | | |
|---|---|---|
| Deputy Secretary General on Strategy and Innovation | geological, cartographic, and geodetic operations,<br>- maintenance of land cadastre,<br>- organizing the use of external tools for environmental protection, as well as compiling strategic documents and draft legislation | Crisis management and IT security department<br>Financial department<br>Strategy analyses and digital services<br>Public relations department<br>Legal department |

It should be noted that the Living Environment and Circular Economy department has been created to manage waste, focusing on waste disposal and recycling.

## 2.4. Management structure of the Ministry of Environment of Latvia

The Ministry of Environmental Protection and Regional Development of the Republic of Latvia (VARAM) is responsible for the implementation of policies in three areas: environmental protection, regional development, and digital transformation.

In the field of environmental protection, the Ministry of Latvia is engaged in the creation of prerequisites and conditions for the preservation of nature, a clean environment, and ensuring the efficient and sustainable use of natural resources.

In the field of regional development, the Ministry of Latvia implements and evaluates regional policy at the state level, provides methodological recommendations, and controls the process of territorial development planning, as well as ensures the development and supervision of local government activities with the overall goal of achieving good results—balanced and sustainable development of the country.

The implementation and coordination of e-governance is another broad policy area of the Latvian ministry. It includes the establishment of a “one-stop shop” principle in the provision of public services and local government services, as well as the introduction of modern and efficient information and communication technologies in the public sector.

According to the amendments to the law on the structure of the cabinet of ministers, adopted by the Saeima on Thursday, June 6, 2024, the Ministry of Environmental Protection and Regional Development (VARAM) will be called the Ministry of Smart Governance and Regional Development (also VARAM) from July 1, 2024, in the final reading.

Changes were adopted for the reorganization (VARAM) and the Ministry of Climate and Energy (KEM).

The changes are "necessary to separate the spheres of nature protection and environmental protection." KEM will take over environmental protection, while VARAM will remain responsible for nature protection.

The Ministry is headed by the Minister for Smart Administration and Regional Development of Latvia. The policy is then distributed among the deputy secretaries of state:

State Secretary

Deputy State Secretary on Administration

Deputy State Secretary on Regional Development

Deputy State Secretary on Investment Funds and Financial

Deputy State Secretary for Digital Transformation

The State Environmental Service[21] plays a special role in regulating environmental policy, performing the following functions:

- Carries out environmental impact assessment of proposed activities and planning documents;
- Implements tasks delegated by the “Law on Pollution” with regards to category A and category B integrated permits for polluting activities;
- Assesses risk of industrial accidents and measures for its minimization;

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[21] Ministry of Smart Administration and Regional Development https://www.varam.gov.lv/en/node/5

- Acts as a competent body of eco-management and audit scheme (EMAS);
- Implements tasks delegated by the “Law on Packaging” with regard to the management of packaging and packaging waste;
- Revises claims and complaints and takes decisions in the cases referred to in the environmental legislation;
- Ensures information to the public regarding all activities of the Bureau in accordance with the requirements of legislation and the Aarhus convention.[22]

## 3. Analysis of factors influencing the increase of digital waste

### 3.1 Analysis of e-waste in the world.

In the previous chapter we found that in the definitions of both Taiwan and the Baltic countries and the EU as a whole there is a classification for Waste Electrical and Electronic Equipment (WEEE). To analyze the impact of digitalization on the environment, we will conduct an analysis of digitalization processes in Taiwan and the Baltic countries, during which the author plans to identify digitalization indicators and their impact on the environment.

"Thus, the volume of digital waste is increasing all over the world, according to the statistical agency Statista[23] **.**

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[22] *Environment State Bureau* www.vpvb.gov.lv

[23] Statista Agency**,** **https://www.statista.com/topics/3409/electronic-waste-worldwide/**

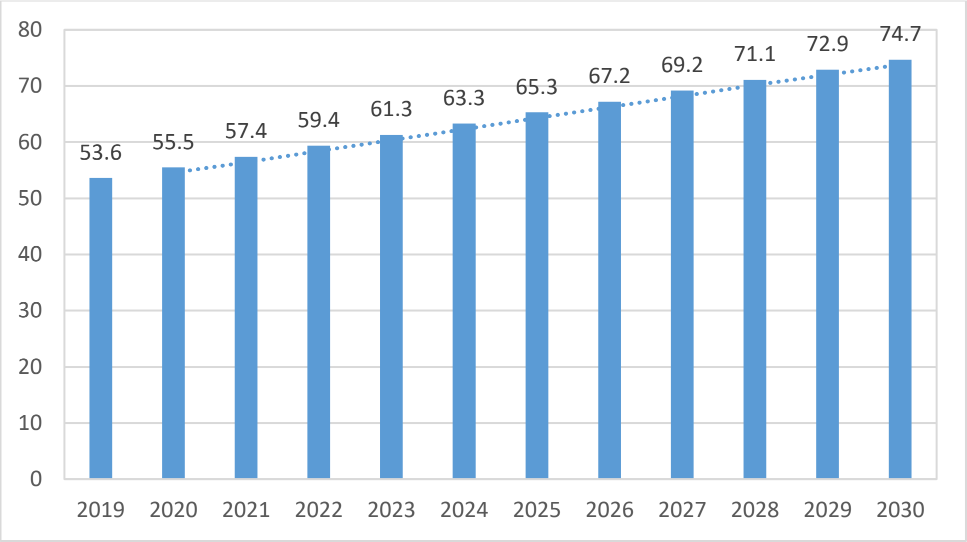

Figure 3.1 Dynamics of changes in e-waste in the world, million metric tons, Source.[38]

As we can see from the presented graph and forecast until 2030, the volume of digital waste from 63.3 million tons in 2024 will increase in 2030 by 11.5 million metric tons and will amount to 74.7 million metric tons. This fact shows the relevance of the issues studied in this research and the need for effective implementation of digital waste management.

According to the analytical department of Statista by regions of the world, waste is distributed as follows, Figure 3.2.

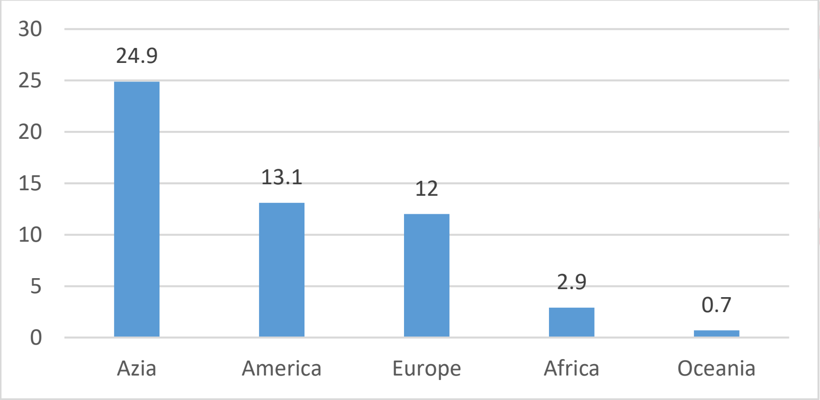

Figure 3.2. Digital waste by regions of the world in million metric tons in 2019, in million metric tons in 2019, **Statista.[38]**

"Thus, the chart clearly shows that the maximum amount of waste, 24.9 million metric tons, comes from Asian countries, which is quite logical considering the population size in this region."

America is in second place, with 13.1 million tons. Europe comes next with 12 million metric tons of digital waste. Africa and Oceania account for 2.9 and 0.7 million metric tons, respectively. According to the Global E-waste Monitor 2024 release, in 2022, almost 62 Mt of WEEE were generated globally, and this number is growing every year. The estimated global production of WEEE is expected to increase to 82 Mt by 2030[24].

Table 3.1. Dynamics of changes in e-waste in the world by region, kg/inhabitant.[25]

| Continent | E-waste generated per capita in kg | E-waste documented to be collected and recycled per capita in kg | Annual average formal collection and recycling rate |
|---|---|---|---|
| **Oceania** | 16.1 kg | 6.66 kg | 41.4% |
| **Europe** | 17.6 kg | 7.53 kg | 42.8% |
| **Asia** | 6.4 kg | 0.76 kg | 11.8% |
| **Americas** | 14.1 kg | 4.2 kg | 30% |
| **Africa** | 2.5 kg | 0.018 kg | 0.7% |

*Source: The Global E-Waste Monitor 2024, Minor inconsistencies may have occurred due to rounding of values during the calculations.*

Thus, assessing e-waste by regions of countries of the world, we can state the following: Europe leads in measurement with 17.6 kg per person, Oceania holds second place with 16.1 kg per person, and Asia is only in fourth place with 6.4 kg per person." Africa is at the bottom of the list—2.55 kg per person. However, undocumented waste is a concern: In Europe and Oceania, about 40% of waste is documented, but more than half is undocumented. Only about 40% is officially confirmed by documents. In America, only 30% is officially recycled, and 70% is not tracked, respectively. In Asia, only 11% of e-waste is documented, and in Africa the situation is sad: less than one percent—0.7%—is officially registered for recycling. Undoubtedly, the entire world will have to face the challenge of digital waste.

Next, we will examine e-waste processes by countries around the world. In the table we have presented a rating of the maximum amount of e-waste by countries around the world.

Table 3.2. Countries that generated the most WEEE by volume in **kt**

| № | Country | In kt | № | Country | In kt |
|---|---|---|---|---|---|

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[24] Global E-waste Monitor 2024 release, https://www.marketresearchfuture.com/reports/e-waste-management-market-21978?utm_term=&utm_campaign=&utm_source=adwords&utm_medium=ppc&hsa_acc=2893753364&hsa_cam=20543884685&hsa_grp=153457592316&hsa_ad=673752668768&hsa_src=g&hsa_tgt=dsa-2312647798749&hsa_kw=&hsa_mt=&hsa_net=adwords&hsa_ver=3&gad_source=1

[25]

| | | | | | |
|---|---|---|---|---|---|
| **1.** | China | 10 129 | **7.** | Indonesia | 1618 |
| **2.** | USA | 6918 | **8.** | Germany | 1607 |
| **3.** | India | 3 230 | **9.** | United Kingdom | 1598 |
| **4.** | Japan | 2569 | **10.** | France | 1362 |
| **5.** | Brazil | 2 143 | **11.** | Mexico | 1 220 |
| **6.** | Russia | 1631 | **12.** | Italy | 1063 |

**Source:** Global E-waste Monitor 2024 release

Increasing volumes of e-waste are directly linked to economic developments. According to the Global E-waste Monitor 2024 release, in 2022, almost 62 Mt of WEEE were generated globally, and this number is growing every year. The estimated global production of WEEE is expected to increase to 82 Mt by 2030.

What is interesting, in our opinion, is the distribution of WEEE per capita in kg. Countries that generated the most WEEE kg/per capita in 2023: First place goes to Norway: 26 kg, followed by the United Kingdom: 23.9 kg, Switzerland: 23.4 kg, Denmark: 22.4 kg, Australia: 21.7 kg, the Netherlands: 21.6 kg, Iceland: 21.4 kg, the USA and France: 21.0 kg, Japan and Belgium: 20.4 kg in 10th place are China and Canada: 20.2 kg. Of the thirteen countries represented in the ranking, nine are European countries. Once again demonstrates the relevance of research in the field of e-waste.

### 3.2. Analysis of the factors of digitalization in Taiwan and the Baltic countries

Thus, Taiwan, one of the leaders in the field of high technologies in the global economy, is also a representative of the Asian region. The increase in demand for electronic components and parts in the global economy became one of the key factors determining Taiwan's high industrial production indicators in 2022.

As shown above, the main entities producing waste are production. Thus, Taiwan's industrial output in the third quarter of 2022 increased by 3.75% compared to the corresponding indicator of 2021 and reaching US$140 billion, due to the effect of factors such as the launch of new mobile devices and increased demand for cutting-edge innovative technology applications. The share of computers, electronic, and optical products in Taiwan's economy accounted for 38.78% of the total volume of industrial output in 2022 (!). The production output in this segment increased by 26.54% to 301.5 billion n.t. dollars, which is approximately 10.05 billion USD. In the electronic components and parts segment, the production output increased by 11.9% to 1.39 billion n.t. dollars.

The Ministry of Economy explains such significant growth by the increase in demand for integrated circuits due to the increase in the scale of their use in the segments of high-performance computing and electronic products used in automobiles.[26]

The EPA has enforced registration and tracking management of recycling operators, and in the future it will set up a comprehensive detection management system[27].

To address the growing waste problem and promote a circular economy that minimizes resource loss, the Environmental Protection Administration of Taiwan (EPAT) has developed "4 in 1" waste recycling programmes. Among the wastes targeted by the EPAT recycling and resource recovery programme, which has been implemented since 1997, the fastest growing is waste electrical and electronic equipment (WEEE). The 4-in-1 waste recycling programme unites manufacturers and importers of new RRW products into a coherent system. The subjects of this system are recyclers, municipal waste collection groups, and residents of local communities. The 4-in-1 Recycling Programme has created a system of fees and subsidies, administered by the EPAT Recycling Fund Management Board (RFMB), which is used to encourage recycling of waste, including WEEE.

Until 1997, Taiwanese citizens recycled waste voluntarily, usually to earn extra money by selling the waste. Individual citizens worked as informal waste collectors, paying citizens for their waste and reselling the waste to recyclers. Waste recycling was unregulated and had negative impacts on the environment and human health. The 4-in-1 recycling programme aims to formalize MSW recycling channels and reduce the environmental impact of recycling. Under the programme, residents can send their waste to municipal waste collection teams, private collectors with an EPAT license, or to the second-hand market.

The role of each party in the 4-in-1 Recycling Program is as follows:

1. Community residents: Community residents make up the foundation of the 4-in-1 Recycling Programme. Residents who deposit their waste at municipal collection points must separate their recyclable, non-recyclable, and organic wastes.

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[26] https://Taipanorama.tw/news

[27] Taiwan recycles e-waste into 'gold': EPA minister
https://english.ey.gov.tw/Page/61BF20C3E89B856/522532de-5206-488e-96e2-72b2b72334c2

2. Recyclers and Collectors: Private recyclers and collectors buy regulated recyclable waste (RRW), including waste electrical and electronic equipment (WEEE), from residents, community organizations, retailers, businesses, and others in order to recover resources from these wastes and generate revenue in the process.

3. Local Governments: Municipalities and local governments organize collection teams to collect RRW and other wastes from community collection sites. They sell RRW and other MSW of value to private recyclers and give a portion of the income back to the local government in order to fund grants for community waste collection sites.

4. Recycling Fund: The Recycling Fund is the most important aspect of the 4-in-1 Recycling Programme because it subsidizes municipal RRW collection as well as private collectors and recyclers who meet EPAT's environmental and safety standards. Under the 4-in-1 Recycling Programme, manufacturers and importers of new RRW products, including EEE, are required to pay fees to EPAT depending on the quantity of items they put on the market. These fees feed into the Recycling Fund, which is managed by the Recycling Fund Management Board (RFMB). [12].

It seems that Taiwan's leadership in the field of waste recycling is generally associated with the philosophy of life of the Taiwanese population. As mentioned above by the author, the implementation of the ideas of green and circular economy is connected with a number of related disciplines: philosophy, political economic sciences, and applied sciences.

Figure. 3.3

The Taiwanese approach to life is rooted in the philosophy of Yin Yang, which serves as a reminder of the interconnectedness of opposites and the need for balance for harmonious existence[28]. As is well known, Yin and Yang embody the profound idea that balance and harmony

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[28] The green Economy and its implementation in China , edited by Manhong Mannie Liu, David Ness and Huang Haifeng, 2011, Enrich Professional Publishing HK p. 378

arise from the recognition and acceptance of the interaction between seemingly opposing forces. The ideas laid down by the philosophical principle of life, Yin Yang, contribute in general to the advancement of the ideas of a circular economy: the flow from one matter to another, reuse. For conducting a comparative analysis of the digitalization processes in Taiwan and the Baltic countries, we will present in Table 3.3 the indicators that describe the digitalization market in the world: population size, Internet users, smartphone users, and active social users. This will allow us not only to carry out an analysis between the countries under study but also to show their place as a whole in the global system of users.

Table 3.3. Dynamics of the level of digitalization in the world in the period from 2017 to 2023

| **World** | **2017** | **2018** | **2019** | **2020** | **2021** | **2022** | **2023** |
|---|---|---|---|---|---|---|---|
| **total population, bn** | 7.476 | 7.593 | 7.676 | 7.75 | 7.83 | 7.91 | 8.01 |
| **internet users, bn** | 3.773 | 4.021 | 4.388 | 4.54 | 4.66 | 4.95 | 5.16 |
| **unique mobile users, bn** | 4.917 | 5.135 | 5.112 | 5.19 | 5.22 | 4.62 | 4.76 |
| **active social users, %** | 50 | 53 | 57 | 59 | 59.5 | 62.5 | 64.4 |

Thus, the data provided show that with the growth of the planet's population, there is also an increase in Internet users: so in 2023, the planet's population was 8 billion people, of which 5.16 billion were Internet users, while it is worth noting that the population increased by 7.2%, and Internet users by 36.7%, compared to 2017. The number of social media users is also increasing, growing by 14.4% in 2023 and reaching 64.4%. Undoubtedly, the increase in the number of Internet users leads to an increase in the market for computers, laptops, and mobile phones, which over time will lead to the need for their disposal. Countries must be prepared for this flow of digital waste.

Next, we will present in the form of tables the level of digitalization in the Baltic countries and Taiwan, which are presented in tables 3.4-3.7.

Table 3.4 Dynamics of the digitalization level in Taiwan in the period from 2017 to 2023

| **TW** | **2017** | **2018** | **2019** | **2020** | **2021** | **2022** | **2023** |
|---|---|---|---|---|---|---|---|
| **Total population** | 23.46 | 23.66 | 23.73 | 23.8 | 23.84 | 23.87 | 23.91 |

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| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **internet users** | 20.44 | 20.82 | 28.48 | 20.51 | 21.45 | 21.72 | 21.68 |
| **active social users** | 81 | 19 | 21 | 21 | 19.7 | 21.35 | 20.2 |
| **internet users, %** | 88 | 88 | 88 | 86 | 90 | 91 | 90.7 |
| TW device usage | | | | | | | |
| **mobile phone** | 92 | 92 | 92 | 97 | 98.7 | 98.2 | 95.1 |
| **smartphone** | 82 | 81 | 81 | 97 | 98.7 | 98 | 95.1 |
| **laptop** | 69 | 67 | 67 | 76 | 71.8 | 72.9 | 68.2 |
| **tablet computer** | 30 | 29 | 29 | 43 | 42.1 | 42.5 | 42.3 |
| **makes online purchasing** | 68 | 67 | 78 | 46 | 42.8 | 56.1 | - |

As we can see from the table presented, 91% of the population in Taiwan, according to data for 2022-2023, are active Internet users; more than 95% of the population use mobile phones and smartphones, about 70% of them use computers and laptops.

Table 3.5.

Dynamics of the level of digitalization in Latvia in the period from 2017-2023, compiled by the author, source Digital Global Overview, 2024; Eurostat , 2024

| LV | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|
| | | | | | | | |
| **total population, mln** | 1.95 | 1.94 | 1.92 | 1.9 | 1.88 | 1.86 | 1.84 |
| **internet users, mln** | 1.63 | 1.59 | 1.66 | 1.63 | 1.67 | 1.71 | 1.7 |
| **active social users, mln** | 0.8 | 0.92 | 0.98 | 1 | 1.38 | 1.45 | 1.48 |
| **internet users, %** | 84 | 82 | 87 | 86 | 88.9 | 92 | 92.4 |
| LV device usage | | | | | | | |
| **Mobile phone, %** | 97 | 98 | 98 | | | | |
| **smartphone, %** | 57 | 60 | 60 | | | | |
| **Laptop, %** | 71 | 70 | 70 | | | | |
| **tablet computer, %** | 24 | 26 | 26 | | | | |
| **E-waste, ton** | 9339 | 10051 | 11241 | 11524 | 16879 | - | |

The data presented in Table 3.3 indicate that the number of Internet users in the country is also growing. Thus, in 2022 their number was 92%, and in 2023 it was already 0.4% more, or 92.4%. It should be noted that this growth is taking place against the backdrop of a decline in the country's population. Unfortunately, we must state that the volume of digital waste also shows positive dynamics.

Table 3.6. Dynamics of the level of digitalization in Latvia in the period from 2017-2023, compiled by the author, source Digital Global Overview, 2024; Eurostat , 2024

| **LT** | **2017** | **2018** | **2019** | **2020** | **2021** | **2022** | **2023** |
|---|---|---|---|---|---|---|---|
| **total population** | 2.84 | 2.88 | 2.87 | 2.74 | 2.71 | 2.68 | 2.73 |
| **internet users** | 2.4 | 2.28 | 2.6 | 2.22 | 2.22 | 2.35 | 2.43 |
| **active social users** | 1.5 | 1.6 | 1.7 | 1.8 | 2.04 | 2.08 | 2.12 |
| **internet users, %** | 53 | 55 | 91 | 81 | 82 | 88 | 88.9 |
| **LT device usage** | | | | | | | |
| **mobile phone** | 97 | 96 | 96 | | | | |
| **smartphone** | 56 | 64 | 64 | | | | |
| **laptop** | 71 | 70 | 70 | | | | |
| **tablet computer** | 27 | 30 | 30 | | | | |
| **makes online purchasing** | | 31 | 56 | 55.9 | 41.2 | 52.5 | nd |

The presented indicators for Lithuania also reflect the dynamics of population decline: since 2019, the country's population has decreased by 4.9% compared to 2023. However, at the same time, the number of Internet users continues to grow: there is an increase of 15.9% compared to 2017. Based on the data available to the author, we can also indicate that the number of devices used is increasing.

Table 3.7. Dynamics of the level of digitalization in Estonia in the period from 2017-2023, compiled by the author, source Digital Global Overview, 2024; Eurostat , 2024

| **EE** | **2017** | **2018** | **2019** | **2020** | **2021** | **2022** | **2023** |
|---|---|---|---|---|---|---|---|
| **total population** | 1.31 | 1.31 | 1.31 | 1.33 | 1.33 | 1.32 | 1.32 |
| **internet users** | 1.2 | 1.27 | 1.28 | 1.19 | 1.21 | 1.22 | 1.22 |
| **active social users** | 0.66 | 0.72 | 0.75 | 0.76 | 0.986 | 1.05 | 1.07 |
| **internet users, %** | 92 | 97 | 98 | 90 | 91 | 92 | 92.3 |
| **EE device usage** | | | | | | | |
| **mobile phone** | 96 | 97 | 97 | | | | |
| **smartphone** | 63 | 63 | 65 | | | | |
| **laptop** | 78 | 78 | 78 | | | | |
| **tablet computer** | 26 | 25 | 25 | | | | |
| **makes online purchasing** | | 64 | 75 | 75 | 46.7 | 68.5 | |

The population indicators of Estonia have been at 1.3 million people for the last four years: from 2020-2023, but similar to Latvia, the number of Internet users is at the level of 92%. In terms of the number of Internet users in 2023, Lithuania is behind its neighbors Estonia and Latvia by almost 4% in 2023. Estonia has a high rate of mobile phone users—97%.

Thus, comparing the indicators of Internet users, as well as social network users in the Baltic countries and Taiwan, we can conclude that the countries significantly outpace the world average. But this factor, as indicated above, is accompanied by the growth factor of digital waste.

In Figure 3.5. The author presented data on the amount of e-waste in countries around the world in 2023.

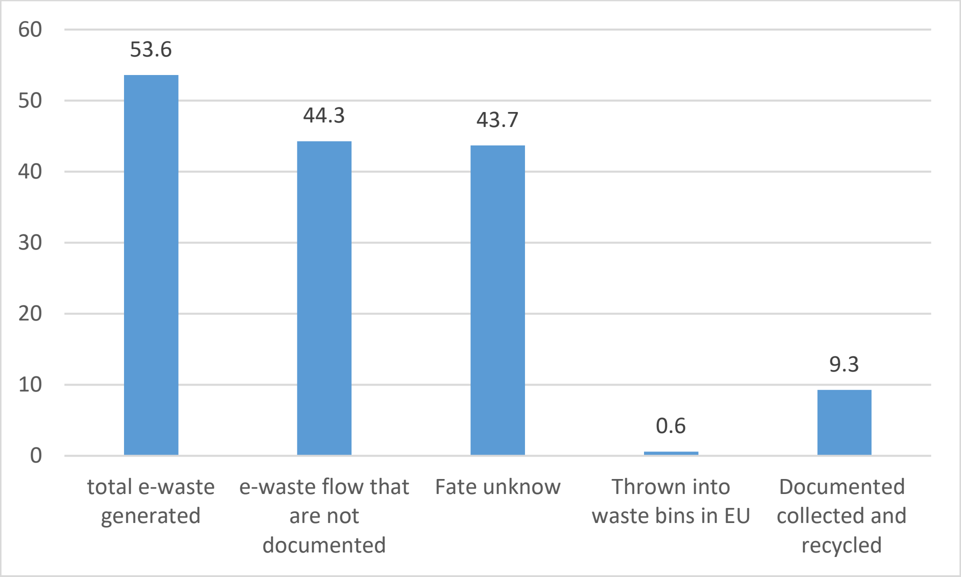

Figure 3.5. Distribution of e-waste in countries of the world, million cubic tons, author's figure according to *The Global E-Waste Monitor 2024.*

Thus, graph 3.4 clearly shows that, according to data for 2023, countries in the world generated 53.6 million tons of e-waste, of which only 9.3 million tons were documented as collected and recycled. The waste in the amount of 43.7 million tons unknown—this is where the global problem for the environment is reflected. Countries should conduct the collection and processing of e-waste more clearly and transparently. Otherwise, according to the author, this unregistered waste ends up in the recycling process, causing irreparable harm to the environment.

Thus, let's present a comparative analysis of Internet users in Taiwan, the Baltic countries, and the world on a graph, Fig. 3.6.

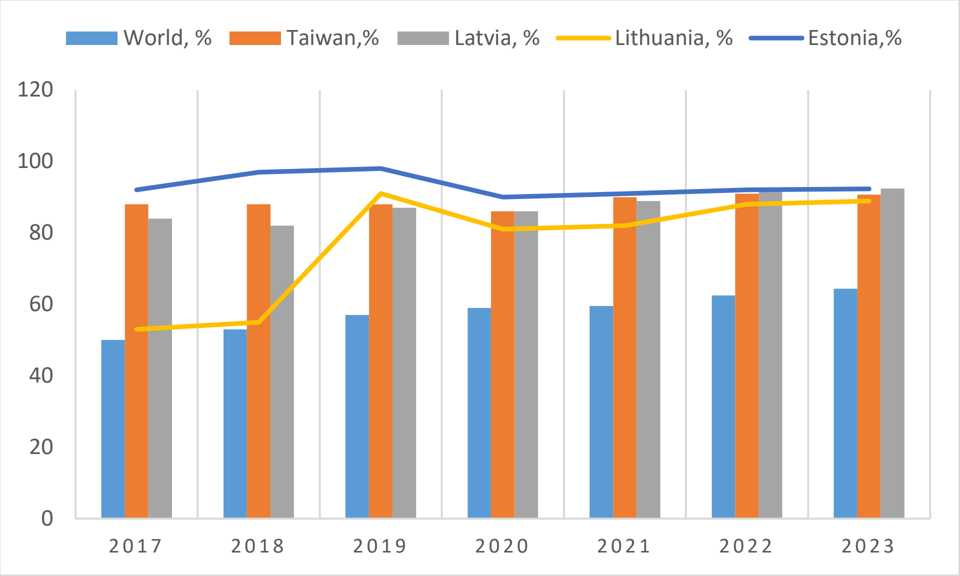

Table 3.6. Comparative analysis of Internet users in the world, Taiwan, and the Baltic countries, % from 2017-2023, author's figure

As we can see from the graph presented by the author, Taiwan and Latvia have almost the same number of Internet users: in 2023, Taiwan has 90.7%, Latvia has 92.4%, the countries exceed the average number of Internet users in the world by almost 30% in 2023. Lithuania shows the lowest rate of internet users in 2023—88%. In Estonia, the percentage of internet users is 92.3% for the same period.

Thus, the conducted analysis showed that in the Baltic countries and Taiwan there is an increase in the number of Internet users, which leads to an increase in the use of devices, and this ultimately creates waste at the end of the equipment’s service life, the recycling of which countries must plan in advance.

### 3.3. Assessment of factors influencing the growth of digital waste

As the author pointed out in the previous chapter, the growth of digitalization processes leads to an increase in the use of equipment: computers, laptops, tablet computers, and, of course, mobile phones. An analysis of Taiwan and the Baltic states showed that the number of Internet users is growing faster than the country's population. Improving technical characteristics leads to an increase in the number of *devices used* (see table №), and therefore in the near future an increase in waste.

In the presented research, the author suggests assessing the relationship between Internet users %, device usage, and e-waste based on a partial least square’s structural equation modeling (PLS-SEM) approach.

## Research methodology

To assess the empirical relationship between latent variables, the author uses the PLS-SEM method. This method was suggested by Wold (Wold, 1982). The evaluation method is based on the consistent use of orthogonalization and PLS regression, and according to a number of scientists (Becker et al., 2013; Hair et al., 2012; Pages et al., 2001) has the following advantages, such as conditions related to the object under study, volume, correlation, and normal distribution. This method processes a small amount of data, which increases statistical power. PLS-SEM tests complex theories using empirical data (Sarsted et al., 2014), which indicates that an important characteristic of PLS-SEM is that it provides latent variable scores as specific linear combinations of their manifestations.

Schubring and others (2016) show that the success of PLS is due to its ability to estimate the parameters of complex models without many of the distributional and other limitations of traditional econometric models. PLS-SEM has become a common statistical method in many scientific fields (Sarsted et al., 2014; Schubring et al., 2016).

In the first procedure, latent variables are determined by the manifest indicators:

$$Y\text{i} = \sum_{h=1}^{p} \left( w_{jh} * x_{jh} \right) \qquad (1)$$

The following equation illustrates a measurement model using composite indicators, where Y is a linear combination of indicators xj, each of which has a weight of wj.

In the second stage, each latent variable was estimated by other latent variables using the following formula:

$$Z(j) = \sum_{i=j}^{p} \left(e_{ij} * yi\right) \quad (2)$$

Where $e_{ij}$ = $sign\ cor\ (y_i\ y_j)$ $w_{yh} = cor\ (Z_j,\ xj_h)$

Then, we perform the previous steps until the algorithm converges. Finally, we have determined coefficients from least squares regression.

The structural model was then assessed as reliable and valid. An $R^2$ estimate is required for each endogenous latent variable. Pages J. and Tenenhaus M. (Pages et al., 2001) define $R^2$ as:

$$R^2 = \sum_{k=0}^{n} aj * \text{correl}\ (Yj\ xj) \quad (3)$$

A higher indicator of $R^2$ indicates a higher degree of prediction accuracy (Pages et al., 2001).

To achieve the goal, the authors put forward the following hypotheses:

Assessment of factors influencing the level of e-waste in Taiwan and the Baltic States.
H1: The level of e-waste is influenced by the activity of Internet users.

H2: E-waste influences device usage.

**Table 3.8.** Assessment results of the measurement model in Taiwan, calculated by the authors.

| Latent variable | Indicator | Loading | CR | AVE |
|---|---|---|---|---|
| E-waste | E-waste, ton | 0.883 | 0.824 | 0.787 |
| Users | Internet users, % | 1.000 | 1.000 | 1.000 |
| Device | device usage, % | 0.865 | 0.871 | 0.848 |

Reliability assessment is assessed by Composite Reliability (CR). The AVE is calculated as the mean of the squared loadings of each indicator associated with a construct. Statistically, convergent validity is established when the Average Variance Extracted (AVE) is >0.50. In our case, all indicators are more than 0.5.

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Table 3.9. Discriminant validity assessment.

| *Fornell-Larcker Criterion* | | | |
|---|---|---|---|
| | E-waste | Users | Device |
| E-waste | 0.798 | | |
| Users | 0.623 | 1.000 | |
| Device | 0.599 | 0.613 | 1.000 |
| *Heterotrait-Monotrait Ratio (HTMT)* | | | |
| | E-waste | Users | Device |
| E-waste | 0.721 | | |
| Users | 0.732 | 0.716 | |
| Device | 0.748 | 0.728 | 0.727 |

Table 3.10. Structural relationships and hypotheses testing.

| Hypotheses | Path coefficient | Standard Error | T-Statistic | P-Value | Result |
|---|---|---|---|---|---|
| Internet users and e-waste | 0.423 | 0.0995 | 3.895 | 0.002 | Supported (H1) |
| E-waste and device usage | 0.437 | 0.0398 | 3.112 | 0.003 | Supported (H2) |

In Table 3.9., we present the structural model results. According to the Fornell-Larcker criterion, the square root of the average variance extracted by a construct must be greater than the correlation between the construct and any other construct. The acceptable level of discriminant validity for the Heterotrait-Monotrait ratio of correlations (HTMT) is suggested to be less than 0.90 (Pages et al., 2001).

All the path coefficients in Table 3.10 related to the inner relations are shown as unstandardized; in particular, we obtain full support for H1 relative to the positive impact of Internet users on e-waste ($\beta = 0.423$, $p < 0.01$). Similarly, the study discovered how internet users are positively related to e-waste, and it is statistically significant at a 1% significance level.

The increase in usage of devices such as smartphones, mobile phones, laptops, and computers is also leading to an increase in digital waste. The hypotheses put forward by the authors for H2 are also relative to the positive impact of device usage on e-waste ($\beta = 0.437$, $p < 0.01$).

For comparative analysis, we will carry out similar calculations for Latvia tables 3.11-3.13.

**Table 3.11**. Assessment results of the measurement model in Latvia, calculated by the authors.

| Latent variable | Indicator | Loading | CR | AVE |
|---|---|---|---|---|
| E-waste | E-waste, ton | 0.765 | 0.794 | 0.756 |
| Users | Internet users, % | 1.000 | 1.000 | 1.000 |
| Device1 | device usage, % | 0.833 | 0.813 | 0.799 |

**Table 3.12.** Discriminant validity assessment

| Fornell-Larcker Criterion | | | |
|---|---|---|---|
| | E-waste | Users | Device |
| E-waste | 0.711 | | |
| Users | 0.613 | 1.000 | |
| Device | 0.568 | 0.609 | 1.000 |
| *Heterotrait-Monotrait Ratio (HTMT)* | | | |
| | E-waste | Users | Device |
| E-waste | 0.699 | | |
| Users | 0.712 | 0.725 | |
| Device | 0.684 | 0.744 | 0.682 |

**Table 3.13.** Structural relationships and hypotheses testing

| Hypotheses | Path coefficient | Standard Error | T-Statistic | P-Value | Result |
|---|---|---|---|---|---|
| Internet users and e-waste | 0.371 | 0.0993 | 3.895 | 0.002 | Supported (H1) |
| E-waste and device usage | 0.326 | 0.0317 | 3.112 | 0.003 | Supported (H2) |

In Tables 3.10, 3.13. we show the structural model results. All the path coefficients related to the inner relations are shown as unstandardized. We proved full support for H1 relative to the positive impact of Internet users on e-waste ($\beta = 0.371$, $p < 0.01$), table 10. Similarly, the study discovered how internet users are positively related to e-waste, and it is statistically significant at a 1% significance level.

The increase of e-waste has an impact on the increase of device usage. The hypothesis put forward by the authors for H2 is also relative to the positive impact of device usage on e-waste ($\beta = 0.326$, $p < 0.01$).

Further, we will carry out similar calculations for Lithuania and Estonia.

**Table 3.14.** Assessment results of the measurement model in Lithuania, calculated by the author.

| Latent variable | Indicator | Loading | CR | AVE |
|---|---|---|---|---|
| E-waste | E-waste, ton | 0.772 | 0.784 | 0.776 |
| Users | Internet users, % | 1.000 | 1.000 | 1.000 |
| Device | device usage, % | 0.735 | 0.791 | 0.746 |

**Table 3.15**. Discriminant validity assessment.

| *Fornell-Larcker Criterion* | | | |
|---|---|---|---|
| | E-waste | Users | Device |
| E-waste | 0.776 | | |
| Users | 0.603 | 1.000 | |
| Device | 0.579 | 0.613 | 1.000 |
| *Heterotrait-Monotrait Ratio (HTMT)* | | | |
| | E-waste | Users | Device |
| E-waste | 0.712 | | |
| Users | 0.682 | 0.701 | |
| Device | 0.698 | 0.716 | 0.727 |

In Table 3.15, we present the structural model results. According to the Fornell-Larcker criterion, the square root of the average variance extracted by a construct must be greater than the correlation between the construct and any other construct. The acceptable level of discriminant validity for the Heterotrait-Monotrait ratio of correlations (HTMT) is suggested to be less than 0.90 (Pages et al., 2001).

**Table 3.16.** Structural relationships and hypotheses testing

| Hypotheses | Path coefficient | Standard Error | T-Statistic | P-Value | Result |
|---|---|---|---|---|---|
| Internet users and e-waste | 0.413 | 0.0995 | 3.895 | 0.002 | Supported (H1) |
| E-waste and device usage | 0.426 | 0.0318 | 3.112 | 0.003 | Supported (H2) |

All the path coefficients in Table 3.16 related to the inner relations are shown as unstandardized; in particular, we obtain full support for H1 relative to the positive impact of Internet users on e-waste ($\beta = 0.413$, $p < 0.01$). Similarly, the study discovered how internet users are positively related to e-waste, and it is statistically significant at a 1% significance level.

The increase in usage of devices such as smartphones, mobile phones, laptops, and computers is also leading to an increase in digital waste. The hypotheses put forward by the authors for H2 are also relative to the positive impact of device usage on e-waste ($\beta = 0.426$, $p < 0.01$).

Thus, let's calculate the impact of the number of Internet users on the volume of **device usage and e-waste.**

Table 3.17. Assessment results of the measurement model in Estonia, calculated by the author.

| Latent variable | Indicator | Loading | CR | AVE |
|---|---|---|---|---|
| E-waste | E-waste, ton | 0.773 | 0.782 | 0.774 |
| Users | Internet users, % | 1.000 | 1.000 | 1.000 |
| Device | device usage, % | 0.734 | 0.789 | 0.745 |

Table 3.18. Discriminant validity assessment.

| *Fornell-Larcker Criterion* | | | |
|---|---|---|---|
| | E-waste | Users | Device |
| E-waste | 0.774 | | |
| Users | 0.602 | 1.000 | |
| Device | 0.577 | 0.627 | 1.000 |
| *Heterotrait-Monotrait Ratio (HTMT)* | | | |
| | E-waste | Users | Device |
| E-waste | 0.711 | | |
| Users | 0.682 | 0.711 | |

| | | | |
|---|---|---|---|
| Device | 0.699 | 0.715 | 0.726 |

Table 3.19. Structural relationships and hypotheses testing.

| Hypotheses | Path coefficient | Standard Error | T-Statistic | P-Value | Result |
|---|---|---|---|---|---|
| Internet users and e-waste | 0.412 | 0.0995 | 3.886 | 0.002 | Supported (H1) |
| E-waste and device usage | 0.423 | 0.0318 | 3.124 | 0.003 | Supported (H2) |

Thus, the obtained results indicate that the Heterotrait-Monotrait ratio of correlations (HTMT) is suggested to be less than 0.90 (Pages et al., 2001), table 3.18. The calculations obtained in Table 3.19 show that we obtain full support for H1 relative to the positive impact of Internet users on e-waste ($\beta = 0.413$, $p < 0.01$). Similarly, the study discovered how internet users are positively related to e-waste, and it is statistically significant at a 1% significance level.

The increase in usage of devices such as smartphones, mobile phones, laptops, and computers is also leading to an increase in digital waste. The hypotheses put forward by the authors for H2 are also relative to the positive impact of device usage on e-waste ($\beta = 0.426$, $p < 0.01$).

In the given calculations of both Taiwan and the Baltic countries, the hypotheses put forward by the author are proven and the following pattern is revealed: an increase in the number of Internet users leads to an increase in e-waste, and this in turn affects the acquisition of device.
In Taiwan, each percent of growth of Internet users leads to a 0.42% increase in digital waste, and each percent of growth of digital waste leads to a 0.43% increase in device usage. In Latvia, each percent of growth of Internet users leads to a 0.4% increase in digital waste in the country. But the growth of digital waste leads to an increase in the acquisition of device usage by 0.33%. In Lithuania and Estonia, the situation looks similar: each percent growth of Internet users increases the use of devices by 0.41 %, which leads to an increase in waste by 0.42 % and Estonia shows results that are almost identical to those in Latvia. Thus, the circle closes: digitalization processes lead to an increase in users, and this in turn leads to an increase in devices and electronic waste.

## 3.3. Implementation of environmental policy by the Baltic countries in the field of digital waste

Thus, as stated in Chapter 1, the modern extractive system, or linear economy, encourages unlimited extraction of raw materials. Undoubtedly, changes are needed in policy, finance, and the formation of environmental awareness, which creates favorable conditions for systemic support of waste-free production. Thus, the first question for building a waste management strategy is to focus on resources—what resources need to be attracted for waste management in the country? Taking into account the studied experience of Taiwan (R.O.C.), the author believes that the Baltic countries should focus on the following areas in e-waste management:

1. **Resource sharing strategy and budget.**

The constant is the fact that the basis of activity in the field of waste management is formed on the basis of the knowledge of the population and motivation to change the behavior of society; the organization of educational events to improve the ecology of the country, region.

In the waste classification (subchapter 1.2), we deliberately divided the waste types into industrial, commercial, and household, since the methods of waste management implementation will depend on the entity: a company or a household.

According to the author, it is necessary to carry out educational work to convince households and businesses to correctly separate waste in accordance with local waste sorting streams (e.g., recyclable, residual). Here, it is possible to significantly contribute to the transition to a circular economy. It is also important for which generation we conduct educational events, since the source of communication is changing. In order to build a circular economy, educational activities should begin in elementary school and cover environmental protection issues throughout all educational cycles. In the best examples, communities use different approaches to engage citizens, such as continuous education or the integration of digital tools, which helps to establish the practice of source sharing as a norm within society. In addition, communities with developed waste management programmes also rely on targeted behavior change efforts among “big generators” (e.g., large enterprises or public organizations), as they often generate a significant portion of the overall waste stream.

2. The second stage in an effective waste management implementation programme is the **collection and sorting of WEEE (digital) waste.**

The launch of efficient collection, sorting, and recycling operations is crucial for the cost-effective production of usable e-waste recycling. Taking into account the author's calculations on the relationship between the number of Internet users and the growth of digital waste, responsible organizations can preliminarily calculate and forecast the amount of waste for the planned period.

Thus, the measurement of the waste management level can be:

- ✓ Modernization of waste sorting and processing facilities, as well as their operation. Expansion of waste collection services.
- ✓ Monitoring waste streams to optimize collection routes and monitor the system's input and output data.
- ✓ Ensuring safe operation of waste disposal sites.

3. Measuring market demand, demand for secondary raw materials (Market Demand Capabilities and Partnerships).

Successful waste management and the transition to a circular economy depend on the ability to return materials for productive use. This may require significant work from city authorities. Together with the private sector (e.g., waste management companies, recyclers) and the social sector to better link supply and demand for recyclable materials. The provision of a constant ability to collect recycled content (waste) enables further investments in extraction and processing, thereby enhancing the overall circular flow by adjusting the supply chain dimensions.

The following activities can be used as measurements of this activity:

- ✓ To conclude agreements on the acceptance of all recovered and recycled materials.
- ✓ To create a public-private partnership to increase the demand for reclaimed materials.
- ✓ To support the creation of ethical and transparent supply chains to help meet the customer needs.
- ✓ To assess air emissions in the region.

4. **Strategy and budget**

Municipalities need to develop a long-term vision and an effective strategy for the transition to a circular economy. Considering the results obtained by the author on the impact of internet user growth on e-waste or "triple I" levels, city authorities can make long-term predictions about e-waste volumes, along with this supply chains and budgets. For example, a city may develop a strategy to increase waste recycling, which may require sufficient knowledge, infrastructural capacity, and stuff for its implementation. This operational planning must be carried out in parallel with adequate financial planning, taking into account that the service life of most waste treatment infrastructure will be 15-20 years. The formulation of a clear strategy and budget helps to set the direction for all participants in the system.

At this stage, it is necessary to evaluate:

- ✓ The vision and strategy for stimulating the circular economy.
- ✓ A detailed understanding of waste management costs, income sources, and opportunities. Financial means to achieve goals.
- ✓ Making technological decisions.
- ✓ Regular studies of waste characteristics.

## 5. Policies and Regulations

Undoubtedly, the main goal of implementing the policy is to build a circular economy. Municipalities should consider circular economy policies (e.g., establishing legal mechanisms for source separation and separate waste collection streams). Implementation of this policy may include new rules or stricter compliance with regulatory requirements. However, municipalities have different levels of regulatory control. Some cities may have the opportunity to adopt more comprehensive waste management legislation, while other municipalities may be more dependent on regulation at the federal or provincial level. Regardless of the level at which the policy is implemented, support from government agencies for a strong waste management system is a very important measurement of the level of development of waste management is:

- ✓ Special KPIs of the circular economy implemented in departments.
- ✓ Opportunities and development of stakeholders’ talents.
- ✓ Stimulating and empowering of workers in waste recycling.

- ✓ Having an effective partnership with the waste management company and (informal) waste disposal workers[29].

One of the challenges of our time is waste, the proper disposal of which is also important for preserving the ecological environment of the world.... They are associated with causing mass illnesses and deaths. The main source of solid waste in the world is the United States, followed by Japan. Particularly harmful are wastes from the metalworking and chemical industries, as well as the processing of mineral raw materials (“imported sustainability”).

## Conclusions:

Thus, the conducted research allowed the author to draw the following conclusion:

1. The green economy acts as an umbrella concept that includes elements of the circular economy concept. The green economy approaches reduce pollution levels, but they are not sufficient to solve environmental conservation issues. The transition to a circular economy is one of the possible solutions that will theoretically allow eliminating the generation of waste.

2. The author identified the elements of sustainable development in a green and circular economy, which is based on three pillars, or the so-called three Ps: people, profit, planets; only in the trinity can we ensure sustainability. In this approach, according to the author, it is undeniable that people should be put first, since they are the ones who will be able to generate profit and help the planet. Namely, in this sequence—People-Profit-Planet—we must approach the implementation of the sustainable development strategy.
3. However, the analysis conducted by the author showed that there is no clear classification of the concept of “waste”. Based on the research, the author suggested the following classification: by subjects—industrial, commercial, or household waste. This approach to classification will also influence the formation of a strategy for managing digital waste. Classification of waste based on their physical state (liquid, gaseous wastes) based on decomposition period (biodegradable waste Non-biodegradable waste, chemical waste). And recyclable waste or non-recyclable.

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[29] Shannon Bouton , The Six Dimensions of Circular Waste Management , https://delterra.org/wp-content/uploads/2023/03/Delterra-Circular-Cities.pdf

4. The author studied the classification of Taiwan's e-waste, which has been disposed of in the country since 1997. The control is carried out by the Environmental Protection Administration of Taiwan (EPAT), which developed the "4 in 1" waste recycling programme in 1997. The subjects of this system are recyclers, municipal waste collection groups, and residents of local communities. In the EU countries, digital waste is defined by the document "*Waste Electrical and Electronic Equipment*" (WEEE)—Definition and Understanding of the 6 Categories (15.08.2018). The experience of countries in processing e-waste has shown that the stages of digital waste management consist of: *to collect digital waste, transporting, segregation of waste, dispose of digital waste*.
5. An important aspect in the circular economy is the definition of the concepts: *Recycling and secondary processing of waste*. These two concepts are related to each other, but there is a slight difference between them. *Secondary recycling* is the preparation of waste for conversion into secondary raw materials: separation, cleaning, and *Recycling* is the recycling process itself.
6. The author conducted an analysis of the governance structures of environmental policy in Taiwan and the Baltic states. In Taiwan, the entire environmental protection system of Taiwan is divided into the following five stages: History before March 17, 1971; from March 17, 1971, to January 28, 1982; from January 29, 1982, to August 21, 1987; from August 22, 1987, to August 21, 2023; Stage 5: from August 22, 2023, to the present.

7. The author conducted an analysis of digital waste in the world: the volume of digital waste will increase from 63.3 million tons in 2024 by 11.5 million metric tons by 2030 and will amount to 74.7 million metric tons. The maximum amount of waste, 24.9 million metric tons, comes from Asian countries, taking into account the population size in this region. America is in second place, with 13.1 million tons. Europe comes next with 12 million metric tons of digital waste. Africa and Oceania account for 2.9 and 0.7 million metric tons, respectively. An analysis of undocumented waste showed: In Europe and Oceania, about 40% of waste is documented, but more than half is undocumented. Only about 40% is officially or documented. In America, only 30% is officially recycled, while 70% is not tracked accordingly. In Asia, only 11% of e-waste is documented, and in Africa the situation is dismal: less than one percent (0.7%) is officially registered for recycling. Undoubtedly, the entire world will have to face the challenge of digital waste. According

to the *Global E-Waste Monitor 2024, c*ountries that generated the most WEEE by volume (in kt) China—10,129; the USA—6,918; India—3,230. It is worth noting that China and India have almost the same population, but the level of digital waste is three times higher in China than in India. The amount of e-waste by country has the following indicators: Norway: 26 kg, followed by the United Kingdom: 23.9 kg, Switzerland: 23.4 kg, Denmark: 22.4 kg, Australia: 21.7 kg, The Netherlands: 21.6 kg, Iceland: 21.4 kg, USA and France: 21.0 kg, Japan and Belgium: 20.4 kg, and in 10th place are China and Canada: 20.2 kg. Of the thirteen countries represented in the ranking, nine are European countries.

8. The author conducted an analysis of digitalization factors in the world, Taiwan, and the Baltic countries, so in 2023 the world's population was 8 billion people, of which 5.16 billion were Internet users, while it is worth noting that the population increased by 7.2%, and Internet users by 36.7%, compared to 2017. The number of social media users is also increasing, growing by 14.4% in 2023 and reaching 64.4%. In Taiwan, according to data for 2022-2023, 91% of the population are active Internet users, more than 95% of the population use mobile phones and smartphones, about 70% of them use computers and laptops. The number of Internet users in Latvia is also growing, so in 2022 their number was 92%, and in 2023 it was already 0.4% more, or 92.4%. It should be noted that this is an increase against the backdrop of a declining population in the country. Unfortunately, we must note that the volume of digital waste also shows positive dynamics. Lithuania's data also reflects the dynamics of population decline: since 2019, the country's population has decreased by 4.9% compared to 2023. However, at the same time, the number of Internet users continues to grow: there is a 15.9% increase compared to 2017. The population figures for Estonia over the past four years, from 2020 to 2023, have remained at around 1.3 million people; however, similar to Latvia, the number of internet users is at a level of 92%. In terms of the number of Internet users in 2023, Lithuania is behind its neighbors, Estonia and Latvia, by almost 4% in 2023. Estonia has a high rate of mobile phone users —97%.
9. The problems of increasing digital waste in the world are aggravated by the amount of undocumented digital waste. Thus, according to data for 2023, countries in the world generated 53.6 million tons of e-waste, of which only 9.3 million tons were documented as collected and recycled. The waste in the amount of 43.7 million tons is unknown — namely

here the global problem for the environment is reflected. Countries should conduct the collection and processing of e-waste more clearly and transparently.

10. To confirm the hypothesis that the increase in Internet users leads to an increase in digital waste, the author used the PLS-SEM method. The evaluation method is based on the consistent use of orthogonalization and PLS regression, and according to a number of scientists (Becker et al.,2013; Hair et al., 2012; Pages et al., 2001) has the following advantages, such as conditions related to the object under study, volume, correlation, and normal distribution. This method processes a small amount of data, which increases statistical power. PLS-SEM tests complex theories using empirical data (Sarsted et al., 2014), which indicates that an important characteristic of PLS-SEM is that it provides latent variable scores as specific linear combinations of their manifestations.
11. In the calculations presented for both Taiwan and the Baltic countries, the hypotheses put forward by the author are proven, and the following pattern is revealed: an increase in the number of Internet users leads to an increase in e-waste, and this in turn affects the acquisition of devices. Thus, in Taiwan, every percent increase in Internet users leads to an increase in digital waste by 0.42%, and every percent increase in digital waste leads to an increase in device usage by 0.43%. In Latvia, each percent of growth in internet users leads to a 0.4% increase in digital waste in the country. But the growth of digital waste leads to an increase in the acquisition of device usage by 0.33%.
12. Taking into account the studied experience of Taiwan (R.O.C.), the author believes that the Baltic countries should focus on the following areas in e-waste management: a resource-sharing strategy and budget (supporting the components of the circular economy: people, profit, and planet); the second stage in an effective waste management implementation programme is the collection and sorting of WEEE (digital) waste. The third direction: measuring market demand, demand for secondary raw materials (Market Demand Capabilities and Partnerships); strategy and budget; implementing a unified policy and ensuring legal provisions for the implementation of this policy.

**References:**

2. Bader, C., Hanbury, H. A., Neubert, S. F., & Moser, S. (2020). Weniger ist Mehr–Der dreifache Gewinn einer Reduktion der Erwerbsarbeitszeit. Weniger arbeiten als Transformationsstrategie für eine ökologischere, gerechtere und zufriedenere Gesellschaft–Implikationen für die Schweiz.
3. Becker, Jan-Michael, Arun Rai, Christian M. Ringle, and Franziska Völckner. (2013). “Discovering Unobserved Heterogeneity in Structual Equation Models to Avert Validity Threats.” MIS Quarterly 37, 665–694
4. Edmond, C. (2020). Germany Eyes a Four-Day Week to Help Prevent Mass Layoffs. *World Economic Forum*. https://www.weforum.org/agenda/2020/08/germany-four-day-week-industry-covid-19/?fbclid=IwAR3nw99Tj70vybWuNKOi_aAuU6l0JXf7zZKXhOsCWlr_7mDEk-ttNkrfntw
5. Ego European Green Office, Ego European Green Office Existing Labels and Certifications, Available online in: Dec 14, 2016, Available from: http://www.eugreenoffice.eu/ existing labels and certifications
6. Elkington, J. (1999) The triple bottom line: *Cannibals with forks: the triple bottom line of 21st century business*.
7. Environmental Protection Department, GovHK, The Government of the Hong Kong Special Administrative Region, Air Quality Objectives, Available online in: Dec, 14 2016, Available from: http://www.epd.gov.hk/epd/english/ environmentinhk/air/air quality objectives/air quality objec tives.htm
8. European Commission, A Sustainable Europe by 2030, https://commission.europa.eu/publications/sustainable-europe-2030_en
9. Gilchrist, K. (2020). Finland's New 34-Year-Old Prime Minister Wants Her Citizens on a Four-Day Workweek. *CNBC* https://www.cnbc.com/2020/01/07/flexible-work-finlands-pm-sanna-marin-wants-citizens-on-a-four-day-workweek.html
10. Green Office Movement UNESCO https://www.unesco.org/en/articles/green-office-movement
11. Hong Chen, Wei Luo, Fengbing Zhao, Limei Geng Research on Green Design Strategy of Office Building, E3S Web of Conferences (2021) https://doi.org/10.1051/e3sconf/202127102011 ICEPE 2021, DOI:10.1051/e3sconf/202127102011
12. Green Office, Faculty of Environment and Resource Studies, Mahidol University. ISO 14001- Environmental Management, Available online in: Dec 3, 2016, Available from: http://www.ensave.mahidol.ac.th/news/greenweb/index.html.
13. Green Business Bureau, Ways to Make Business Environmentally Friendly, Available online in: Dec 16, 2016, Available from: http://www.gbb.org/members/blog/10-greenbusiness-tips
14. Keynes, J.- M., *A Treatise on Money*, UK, 1930

15. Knight, K. W., Rosa, E. A., & Schor, J. B. (2013). Could working less reduce pressures on the environment? A cross-national panel analysis of OECD countries, 1970–2007. *Global Environmental Change*, *23*(4), 691-700.
16. Low Carbon Development, by editors Frauke Urban, Johan Nordensvārd, Teylor and Francic group, London and NY, 2014, p. 330
17. Lewis, Kyle, Stronge, Will, Kellam, Jack , Kikuchi. L, The results are in: the UK's four-day week pilot, UK, 2023 https://autonomy.work/portfolio/uk4dwpilotresults/
18. National Development Council, Taiwan’s Pathway to Net-Zero Emissions in 2050, https://www.ndc.gov.tw/en/Content_List.aspx?n=B154724D802DC488#:~:text=In%20March%202022%2C%20Taiwan%20officially,new%20wave%20of%20economic%20growth
19. Pesaran, M.H., Shin, Y., (1999). An autoregressive distributed lag modelling approach to cointegration analysis. In: Strom, S. (Ed.), Econometrics and Economic Theory in 20th Century: The Ragnar Frisch Centennial Symposium, Chapter 11. Cambridge University Press, Cambridge.
20. Porshen, P. “Decent work, Green jobs and sustainable Economy, ILO , 2015, p.182
21. Project Eco Office-SEC, Project Eco Office - A green initiative by Singapore Environment Council (SEC) and City Developments Limited (CDL), Available online in: Dec 17, 2016, Available from: http://www.sec.org.sg/ecooffice/abouteco-office.php
22. Raimund Bleiswitz, Paul J.J. Welfens, ZhongXiang Zhang International Economics of Resource Efficiency, Physica- Verlag, Springer, 2012, p.394
23. Sayam Aroonsrimorakot, Meena Laiphrakpam, Chamlong Arunlertaree, Chonticha Korattana Green office, its features and importance for sustainable environmental management: A comparative review in search for similarities and differences, 2019, Interdisciplinary Research Review, p. 31-38 DOI:10.14456/jtir.2019.46
24. Schmid. D., Sustainable Development Impact Meetings , 2023 https://www.weforum.org/agenda/2023/09/8-steps-towards-achieving-net-zero-in-your-organization/?gad_source=1&gclid=CjwKCAjwr7ayBhAPEiwA6EIGxAKjtQoVCFiqZWgG8F0RcbDMp7pFhQfPrdXwDVApk3Z5v0aSW8YlVxoCfAIQAvD_BwE
25. Shao, Q., & Shen, S. (2017). When reduced working time harms the environment: a panel threshold analysis for EU-15, 1970–2010. *Journal of cleaner production*, *147*, 319-329.
26. Schubring. Sandra, Iris Lorscheid, Matthias Meyer, and Christian M. Ringle. 2016. “The PLS Agent: Predictive Modeling with PLS-SEM and Agent-Based Simulation.” *Journal of Business Research* 69, 4604–12.
27. Singapore Environment Council, Project Eco Office-SEC, Project Eco Office - A green initiative by Singapore Environment Council (SEC) and City Developments Limited (CDL), Available online in: Dec 17, 2016, Available from: http://www.sec.org.sg/ecooffice/abouteco-office.php
28. Stecenko I., Reshina G., Stecenko A., Promotion of Environmental Audit for Transport Companies in Latvia, International Conference on Reliability and Statistics in Transportation and Communication, 2021, Riga Pages 546-555, Publisher Springer, Cham, Scopus
29. Stecenko. I., Ecological audits and green office in road transport company, *XXXII INTERNATIONAL SCIENTIFIC CONFERENCE trans & MOTAUTO'24, PROCEEDINGS* ISSN 2535-0307(Online) YEAR VII, USSUE 1 (11) 24 - 27.06.2024 – Varna, Bulgaria *pp 34-36*

30. Stecenko I., Tien Han Kuang, Assessment of Digital Waste Management in the Baltic States and the Experience of Taiwan, International EUROASIA conference: 3rd World Conference on Engineering, Technology, and Applied Science-Bangkok-2024, 18 November, Tailand, p.20 https://doi.org/10.62422/978-81-9743114-7-0-007
31. The Sustainable Development Goals, https://unstats.un.org/sdgs/report/2023/
32. United Nations Climate Change, 2023 https://unfccc.int/process-and-meetings/the-rio-conventions?gad_source=1&gclid=CjwKCAjwnei0BhB-EiwAA2xuBsz1P98T8Q3gdyfNxaNxuPer4Qhs9vPZUgPqMtzUdx_FKlZcQRSoyRoCU4cQAvD_BwE
33. U.S. Environmental Protection Agency, 1968 https://www.epa.gov/laws-regulations/laws-and-executive-orders
34. By editor Ulas Akkucuk, The Circular Economy and its Implications on Sustainability and the Green Supply Chain , IGI Global, US, 2019, p.327

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