PRIME MINISTER'S DEPARTMENT
ECONOMIC PLANNING UNIT

AKADEMI SAINS MALAYSIA

WATER SECTOR TRANSFORMATION 2040

SUB-SECTORAL FINAL REPORT

VIRTUAL WATER AND WATER FOOTPRINT (VW&WF)

(VOLUME VI)

WATER SECTOR TRANSFORMATION 2040 (WST2040)
VIRTUAL WATER AND WATER FOOTPRINT (VW&WF) (VOLUME VI)

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FOREWORD

The Economic Planning Unit (EPU), on 3rd April 2020, appointed the Academy of Sciences Malaysia (ASM) as its strategic partner to undertake the Study on Water Sector Transformation Agenda 2040 (WST2040), to transform the water sector from an enabler to becoming a dynamic growth engine by 2040, as stated in the 12th Malaysia Plan (12th MP). This standalone Volume 6, 'Virtual Water and Water Footprint' (VW&WF), forms part of 9 compendia of reports. Volume 1, the Main Report, summarised the output of Volume 2 to Volume 9. The details in Volume 1, can be found in each of the 8 standalone reports.

The emphasis in all these reports is on achieving a secure, sustainable and vibrant water industry in Malaysia, to forge it into a dynamic, efficient, sustainable and revenue-generating industry. The study, if the recommendations are implemented, will contribute significantly to the national gross domestic product (GDP), create new job opportunities and facilitate the development of science, technology, innovation and economy (STIE), and enhance the research, development, innovation, and commercialisation (RDIC) of indigenous new products for both the national and global platforms. This transformation agenda is planned over two decades with four phases of four 5-year Malaysia Plans (MP), starting with the 12th MP.

The VW&WF sub-sector study is a game-changer for WST2040. The concept of virtual water (VW) refers to the embedded water via export or import of commodities, products, or services, whereas water footprint (WF) refers to the total amount of direct and indirect freshwater required in the production of goods, commodities, or services along its supply chain. Benefits that can be accrued through this study include, amongst others, effective water use, identifying water-related risks in the supply chain, improving the distribution and utilisation of water across sectors, etc. This study quantified the WF for six major products and services in Malaysia, namely crude palm oil (CPO), latex, paddy, rubber glove, semi-conductor and tourism.

To achieve this ambition, ASM has partnered with expert advisors and researchers from multiple organisations led by Universiti Teknologi Malaysia (UTM). Moreover, by leveraging on their knowledge and expertise, we were able to produce outputs and recommendations that, we believe, can initiate and improve the VW&WF implementation in Malaysia. On behalf of ASM, I would like to take this opportunity to thank the VW&WF team headed by Professor Dr. Zulkifli Yusop FASc, for all their dedication, hard work and commitment.

Thank you.

Ir. Dr. Salmah Zakaria FASc,
Chairperson, Project Management Committee WST2040,
Water Sector Transformation (WST2040) Study Team, EPU-ASM,
Chairperson, ASM Water Committee, 2015-2021

PREFACE

Water is vital to life, socio-economic development and the environment. Besides direct water usage, more water is hidden in our food, clothes, the energy we use, transportation and other products. While certain parts of the world have excess water, others are experiencing water scarcity. Globally, water uses are still largely inefficient, especially for agriculture, with about 50% of water withdrawal being wasted. Similarly, huge losses occur in domestic, industrial and commercial uses. The water footprint (WF) is a promising tool to minimise these losses and raise water efficiency. A WF measures the amount of water an individual, community, institution, or country uses throughout the day, either directly or indirectly. WF is the amount of water that has been used, or polluted in all stages of producing or manufacturing a product or service.

Worldwide, at least 18 countries have started WF initiatives at various degrees, mainly in policy, WF calculator, standards, WF measurement of certain products and WF assessment at the river basin scale. This report reviewed the international initiatives, mainly by China, Germany, the Netherlands, and other major players in WF. It is possible to quantify hidden water import and export, or virtual water (VW) movement and identify the most critical regions for formulating strategies to optimise water use worldwide and help water-scarce countries to meet their water needs. Water-rich countries like Malaysia should take the opportunity to export VW through bilateral and multilateral trade agreements to fulfil the economic benefits.

This study has identified major gaps that need immediate attention to strengthen Malaysia's position in the WF agenda. The existing policies are generally inadequate. It is timely to introduce WF requirements in the relevant feder) Department of Irrigation and Drainage (DID) Malaysia on the National Water Balance Study (NAWABS), which cover the WF assessment for agriculture. It is crucial to strengthen the earlier initiative by the Standard and Industrial Research Institute of Malaysia (SIRIM) on ISO 14046 that outlines the principles, requirements and guidelines for assessing and reporting WF.

As local WF data is lacking, this study has quantified the WF for six major products and services, selected based on their economic contribution and food security, namely crude palm oil (CPO), latex, paddy, rubber glove, semi-conductor and tourism. This information could help the industry to benchmark with the best practices at various stages and manufacturing processes. VW&WF initiatives have multiple benefits, which include: 1) more effective water use through appropriate policy, incentive and penalty; 2) pinpointing water-related risks in the supply chain; 3) supporting water education and awareness programmes; 4) improving the distribution and utilisation of water across sectors; 5) as communication tools for the government, industry and public; and 6) as a benchmarking tool in terms of water use pattern.

The VW&WF study proposes ten strategies, 22 programmes/initiatives and 45 activities concerning water as resources and livelihood that falls under five focus areas (people, governance, information, research, development, innovation and commercialisation [RDIC], finance, and infrastructure), which forms the basis for developing a roadmap for the National Agenda on Water Sector Transformation 2040 (WST2040) that is to be considered for implementation through the 12th MP to 15th MP.

Perhaps, we should view the presence of VW&WF initiatives in the same manner as to how the carbon footprint evolves. The journey is long, however, the opportunity is great, both from a water sustainability perspective as well as for propelling the future business.

Prof. Dr. Zulkifli Yusop
FASc
Chairperson
Virtual Water and Water Footprint Task Force

ACRONYMS

AFC	Asian Financial Crisis
AFTA	Asian Free Trade Agreement
AI	Artificial Intelligence
AR	Augmented Reality
ASM	Academy of Sciences Malaysia
ASU	Arizona State University
BAKAJ	Johor Water Regulatory Body
BERNAS	Padiberas Nasional Berhad
CEPA	Communication, Education, and Public Awareness
CEPES	Peruvian Centre for Rural Development
CEPT	Common Effective Preferential Tariff
CF	Characterisation Factor
CLCA	California Landscape Contractors Association
CMOS	Complementary metal–oxide–semiconductor
CNIS	China National Standardisation Institute
COD	Chemical Oxygen Demand
CONAGUA	Mexican Water Commission
COVID-19	Coronavirus disease
CPO	Crude Palm Oil
CTA	Centre for Science and Technology Antiochia
CWU	Consumptive Water Use
DID	Department of Irrigation and Drainage
DOA	Department of Agriculture
DOE	Department of Environment
DOSM	Department of Statistics Malaysia
DRAM	Dynamic random-access memory
DSS	Decision Support System
E&E	Electrical and Electronic
EPD	Environment Protection Department Sabah
EPU	Economic Planning Unit
ESG	Environmental, Social, and Governance
ET	Evapotranspiration
EU	European Union
FAO	Food and Agriculture Organisation of the United Nations
FELCRA	Federal Land Consolidation and Rehabilitation Authority
FELDA	Federal Land Development Authority
FGD	Focus Group Discussion
FMM	Federation of Malaysian Manufacturers
FOMCA	Federation of Malaysian Consumers Associations
GATT 1994	General Agreement on Tariffs and Trade 1994
GDP	Gross Domestic Product
GEC	Global Environment Centre
GFC	Global Financial Crisis

GHG	Greenhouse Gas Emissions
GLC	Government-Linked Companies
GRACE	GRACE Communications Foundation
GSI	Good Stuff International
IADA	Integrated Agricultural Development Area
IDEAM	Institute of Hydrology Meteorology and Environmental Studies
IFC	International Finance Corporation
IoT	Internet of Things
IPASA	Centre for Environmental Sustainability and Water Security
ISO	International Organisation for Standardisation
JBA	Jabatan Bekalan Air
JPBW	Jabatan Perancang Bandar dan Wilayah
JPS	Department of Irrigation and Drainage
JSM	Department of Standards Malaysia
JTS	Jabatan Tanah & Survei
KADA	Kemubu Agricultural Development Authority
KASA	Ministry of Environment and Water
Kc	Crop coefficient
KKMM	Ministry of Communications and Multimedia
KPKT	Local Government Department
KWB	Kuching Water Board
kWh	Electricity consumption
LA	Local Authorities
LAUT	Terengganu Water Resources Board
LCA	Life Cycle Assessment
LCI	Life Cycle Inventory Analysis
LCIA	Life Cycle Impact Assessment
LESTARI UKM	Institute For Environment and Development (LESTARI), UKM
LGM	Malaysian Rubber Board
LHDN	Inland Revenue Board of Malaysia
LIGS	Sabah Rubber Industry Board
LUAS	Lembaga Urus Air Selangor
MADA	Muda Agricultural Development Authority
MAFI	Ministry of Agriculture and Food Industries
MAH	Malaysian Association of Hotels
MARDI	Malaysian Agricultural Research and Development Institute
MATA	Malaysian Association of Tour and Travel Agents
MCO	Movement Control Order
MEA	Multilateral Environmental Agreements
MICCI	Malaysian International Chamber of Commerce & Industry
MITI	Ministry of International Trade and Industry
ML	Manufacturing License
MOE	Ministry of Education
MOF	Ministry of Finance
MOHE	Ministry of Higher Education
MOSTI	Ministry of Science, Technology and Innovation

MOT	Ministry of Transport
MOTAC	Ministry of Tourism, Arts and Culture Malaysia
MP	Malaysia Plan
MPC	Malaysia Productivity Corporation
MPOB	Malaysian Palm Oil Board
MRAM	Magnetoresistive random-access memory
MRCA	Malaysia Retail Chain Association
MWA	Malaysian Water Association
MyCAC	Malaysian Climate Change Action Council
NAFAS	National Farmers Organisation
NAHRIM	National Water Research Institute of Malaysia
NAWABS	National Water Balance System
NDC	Nationally Determined Contribution
NEP	National Ecotourism Plan
NGO	Non-Governmental Organisation
NIWRMP	National Integrated Water Resources Management Plan
NOAA	National Oceanic and Atmospheric Administration
NQI	National Quality Infrastructure
NREB	Natural Resources and Environment Board Sarawak
NVW	Net virtual water
NWRP	National Water Resources Policy
NZ	New Zealand
OECD	Organisation for Economic Co-operation and Development
PBT	Local Authorities
PIA	Promotion of Investments Act
PTA	Preferential Trading Arrangements
R&D	Research and Development
RAM	Random Access Memory
RDIC	Research, Development, Innovation, and Commercialisation
RISE UTM	Research Institute for Sustainable Environment (RISE), UTM
SC	Securities Commission Malaysia
SCP	National Sustainable Consumption and Production
SDC	Swiss Development Corporation
SEDC	Sarawak Economic Development Corporation
SIRIM	Standard and Industrial Research Institute of Malaysia
SME	Subject Matter Expert
SMEs	Small and Medium-Sized Enterprises
SPAN	National Water Services Commission
SPS	Sanitary and Phytosanitary
SUK	State Agency
SWAT	Soil and Water Assessment Tool
TF	Task Force
TOR	Terms of Reference
TPP	Trans-Pacific Partnership
UAE	United Arab Emirates
UK	United Kingdom

UKM	Universiti Kebangsaan Malaysia
UM	Universiti Malaya
UN	United Nations
UPEN	Economic Planning Unit
USA	The United States of America
USGS	United States Geological Survey
UTM	Universiti Teknologi Malaysia
VR	Virtual Reality
VW	Virtual Water
VWT	Virtual Water Trade
WEF	World Economic Forum
WF	Water Footprint
WFA	Water Footprint Assessment
WFD	Water Framework Directive
WFN	Water Footprint Network
WoS	Web of Science
WSI	Water Stress Index
WST2040	Water Sector Transformation 2040
WTO	World Trade Organisation
WWF	World Wide Fund for Nature

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Jabatan Standard Malaysia
MITI
NAHRIM
MPOB
DID
Top Glove
Micron Semiconductor Sdn. Bhd.
BERNAS
Faiza Sdn. Bhd
FMM

MOT	Hotel (Terengganu, JB, KL, Selangor, Pahang, Sabah, Sarawak)
MOHE	BAKAJ
MOE	GEC
MOF	LUAS
MADA	DOA
MARDI	LAUT
FELCRA	LIGS
FELDA	NAFAS
MOSTI	LESTARI UKM
DID Sabah	IPASA UTM
LGM	RISE UTM
EPD	NREB
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BPEN Kedah	Lembaga Air Kuching
UPEN Kelantan	Jabatan Bekalan Air Terengganu
UPEN Terengganu	

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Chapter 8. Virtual Water and Water Footprint Case Study Approach

Executive Summary of Virtual Water and Water Footprint

This report focused on two key concepts that can drive the water sector transformation in Malaysia; virtual water (VW) and water footprint (WF). VW measures the amount of water embedded in the production, import and export of commodities, products, or services, while WF calculates the way freshwater resources are used by humans and the impacts of the production system on water resources. VW&WF study aims to calculate Malaysia's VW, and establish a WF inventory of several essential economic sectors. This study's intent is part of the Water Sector Transformation (WST) Plan 2040[1], and is aligned with Theme 3 (Advancing Sustainability) under the 12th MP[2], which is to transform the water sector, strengthen the implementation of policies and achieve a more effective water resources management.

These aims are achievable through the following specific objectives:

i. To identify the main players and potential international collaborators in VW&WF initiatives;
ii. To identify the economic sectors that will be the focal point of VW&WF inventory study based on sets of criteria;
iii. To establish VW&WF inventory for selected case studies;
iv. To calculate and analyse VW of the selected economic sectors utilising the collected secondary data;
v. To calculate and analyse WF inventory of selected industrial and tourism sector, and agricultural crop;
vi. To review and suggest improvement on the current policy, acts, enactments, and ordinances to incorporate elements of WF; and
vii. To prepare a roadmap for the National Agenda on Water Sector Transformation 2040 (Roadmap WST2040).

This VW&WF study was conducted at the national level to quantify Malaysia's VW and to establish a WF inventory on three vital economic sectors: agriculture, manufacturing, and services. Six case studies were executed to assess the WF values on six sectors: palm oil, rubber, paddy, rubber glove, semiconductor, and tourism. All case studies were strategically chosen based on their economic contributions towards Malaysia's gross domestic product (GDP) (economic strength), and water consumption of the final product. The findings gathered from various verified sources in Malaysia indicated that the WF values calculated for crude palm oil, rubber, and paddy ranged from 4,447 m^3/t to 9,911 m^3/tonne, 9,060 m^3/t to 22,876 m^3/tonne, and 975 m^3/t to 2,641 m^3/t, respectively. The WF of synthetic rubber glove ranged from 1.9 m^3/1000 pcs to 6.0 m^3/1000 pcs for gloves, and 1.3 m^3/1000 pcs to 3.4 m^3/1000 pcs for natural rubber gloves. Furthermore, NAND Flash that represented the semiconductor sector was 0.002 m^3/cm^2, while WF for tourism was 4.89 m^3 (tourist/day).

The VW&WF study also reviews and suggests improvements on the current policy, acts, enactments, and ordinances to incorporate WF to raise awareness on WF accounting amongst decision-makers, consequently ensuring better planning, management, and water allocation consumption. The incorporation of WF elements for water governance in the country can be improved at different tiers and levels of governance, namely federal and state governments, based on comprehensive policy reviews and focus group discussions. Overall, all water enactments have identical provisions aiming at establishing

[1] The study commenced in May 2020, and to be completed by end of 2021 between the EPU and ASM.

[2] The 12th MP is a development roadmap for 2021 to 2025 presented by the Prime Minister of Malaysia, Dato' Sri Ismail Sabri Yaakob.

water management in each state. Ten federal government acts and 23 enactments/ordinances have been reviewed for possible WF inclusion in this study. However, the WF elements to be added under the water provisions are subject to each state's enactment section that covers the dynamic of states' water management, such as water resources, the responsibility of water resources, control of use and flow of water, licensing as a controlling method, water costing/charging, management plan, and control demand management.

A roadmap was drafted through a series of successful engagements with various stakeholders, including representatives from relevant ministries, government agencies, non-governmental organisations (NGOs), industry players, and academicians. The VW&WF study proposes ten strategies, 22 programmes/ initiatives, and 45 activities concerning water as resources and livelihood that fall under five focus areas (people, governance, information, research, development, innovation and commercialisation (RDIC), finance and infrastructure), which form the basis for developing the roadmap for the National Agenda on WST2040 that is to be considered for implementation through the 12MP to 15MP. To materialise the aim of transforming the water sector, a budget allocation of RM156.2 million has been proposed to drive the VW&WF initiatives to transform the water sector in the country. A summary of the initiatives under the five focus areas are listed below:

I. Empowering People to Drive Water Sector Transformation

Two key strategies have been proposed, with each strategy devised concerning water as a resource and livelihood. Under the strategy for water as resources, the strategy to empower people to drive the water sector transformation is by heightening awareness on the importance of WF accounting amongst three main target groups; the public, younger generation, and industry players, which can be done through national initiatives and community engagement programmes. Several awareness programmes and knowledge dissemination have been proposed to increase public awareness of WF under the nationwide initiatives to tackle the public, schools, universities, and industries. For the public, several activities are proposed, including roadshows to get buy-in from federal agencies and state governments, with special highlights on WF during the National Environment Day, planned programmes under IHP-UNESCO and DID, WF programmes advertised through social media platforms and mass media, workshops and webinars on WF awareness, planned exhibitions and programmes to the parliamentary special committee and state assemblymen as well as promotion of local food amongst the public to help lower WF. As for educating the younger generations, awareness programmes and knowledge dissemination will be conducted at schools and universities through several programmes, including introducing the WF concept in co-curriculum activities, social media and mass media, competitions in WF-related themes, Doctor H2O programme, and incorporation of WF-related themes in conjunction with World Water Day, National Science Week, and other related events. Finally, awareness programmes and initiatives also tap into increasing awareness amongst industry players through establishing networking with the industry to update them about the progress on WF initiatives and success stories, training programmes and through the incorporation of WF element in assessment criteria in prestigious awards, including the Prime Minister's Hibiscus Award. These activities will instil awareness amongst water users to reduce WF per capita and get buy-in from agencies, state governments, and the public. Under the key strategy for water as livelihood, empowering people to drive the water sector transformation will be done by enhancing WF competency by developing training modules, and attaining recognition by certification bodies (statutory/private). Both strategies outlined under the aspects concerning water as resources and livelihood are deemed essential in increasing public awareness about VW&WF agendas.

II. Strengthening Governance of Water Sector at All Governmental Levels

The second focus area is concerned with efforts to strengthen the governance of the water sector at all governmental levels. In doing this, several recommendations are proposed. Under the water as a resource initiative, the first strategy is to incorporate the WF component in *Dasar Air Negara* to initiate WF implementation across the country to enhance the policy and law supporting WF initiatives. Next, is to mainstream WF in businesses by establishing the requirement of water accounting reports, and strengthening the reports. Furthermore, it is proposed for WF to be incorporated in the water accounting reports, whereby the reports will be reviewed to identify possible gaps and suggestions for improvement. The next strategy is to be the global champion by positioning Malaysian WF experts at the international platform, which can be done by strengthening collaborations with key WF players, including those from China, the Netherlands, and Germany. Malaysia's role as the global player can also be achieved by increasing the number of WF-related outputs (publications, joint research, and capacity building). Alternatively, Malaysia can also export WF knowledge by developing modules and training in WF amongst the Southeast Asian countries. Another strategy is to establish WF governance by creating a national VW&WF task force, and formulating guidelines on WF implementation. The final strategy is to enhance global trade by establishing committee members to prepare a white paper on VW for international trade agreements, and optimising global water management through VW trade that can be established by formulating terms and conditions on VW for mutual trade. The inclusion of VW in an international trade agreement is also proposed by forming a VW caucus for trade negotiation. Optimisation of global water management/consumption can be achieved if all countries agree to meet and seek common grounds concerning water trading.

As for the initiative outlined under water as livelihood, three key strategies have been proposed: mainstreaming WF in business, enhancing WF competency, and strengthening institutional setup. Under the first strategy, promotion of WF labelling scheme amongst local producers is proposed to provide updates on the water scarcity index, and climate change scenario at the district level as well as the development of a WF calculator through the identification of suitable online domains and inclusion of WF inventory from case studies. The second strategy is to enhance WF competency amongst water professionals (industrial players, consultants, researchers, government officers), which can be done by conducting competency training programmes for water managers. Finally, the third strategy is to strengthen institutional set up by establishing a model river basin to implement the WF concept fully. Strengthening the governance of the water sector at all levels can expedite the water sector transformation in the country.

III. Strengthening the Financial Capability to Support Water Sector Transformation

The next focus area addresses strategies to strengthen the financial capability to support water sector transformation. One key strategy outlined under water as resources is by establishing the provision of financial rewards and incentives at the national level. The strategy is by initiating tax incentives upon completion of water reporting, whereby drafting of financial rewards in the form of tax incentives is proposed. Under water as a livelihood aspect, the study proposes the mainstreaming of WF in businesses by incorporating the WF element in the current environmental, social, and governance (ESG) initiatives under Bursa Malaysia.

IV. Enhancing Data-Driven Decision-Making for Sustainability

Another focus area is the enhancement of data-driven decision-making for sustainability. In this area, three key strategies are proposed involving strategies to be conducted at a national scale. The first strategy is the incorporation of WF in the National Water Balance System (NAWABS) within the river basin framework. This study proposes that a comprehensive WF study should be conducted for selected river basins. The current NAWABS study conducted by *Jabatan Pengairan dan Saliran* (JPS) can be strengthened for WF study at the river basin scale. This can be done by carrying out WF analysis within the boundary of the selected river basin followed by establishing a model river basin for full implementation of the WF concept. Another strategy is through WF study for selected sectors that helps facilitate the WF analysis, and calculation for 20 major products and services. The final strategy is to enhance global trade, which can be done by conducting comprehensive studies addressing VW's global economic opportunities, drivers, and impacts.

V. Developing Sustainable Water Infrastructure with Cost-effective Technology

The final focus area highlighted in this study looks into developing sustainable water infrastructure with cost-effective technology. To achieve this aim, one key strategy has been put forward: strengthening institutional set-up through identification of location that involves establishing a WF centre, and recruiting experts and staff, which will be conducted at a national scale.

This study has gathered essential information regarding Malaysia's VW&WF accounting in major economic sectors and addresses the importance of WF accounting amongst decision-makers that may lead to better water allocation and consumption decisions. Therefore, improving and expanding the VW&WF concept application in all sectors will positively impact the water sector in Malaysia to achieve the expected water transformation targets. A total of RM156.2 million has been proposed to drive VW&WF initiatives in Malaysia to achieve these targets. Under the 12MP, RM20.4 million has been proposed, followed by RM71.6 million for 13MP, RM41.6 million for 14MP, and RM22.6 million for 15MP.

1.0 Introduction: Concept and Relationship

In developing a more prosperous, inclusive and sustainable Malaysia and minimising the adverse effects of economic growth on the environment, one of the key initiatives that need to be accelerated is transforming the water sector in the country. Water is a vital resource to sustain civilisation and economic development. Therefore, each country should ensure that water is sufficient, safe for various uses, and meet future demands. The global water demand is expected to increase by about 50% in 2030 (UN-Habitat, 2016). Globally, freshwater is massively used in the agricultural sector. However, it is also being consumed significantly in the industrial and domestic sectors (Hoekstra et al., 2011). Consequently, efficient water management is needed as one of the measures against water depletion and degradation by human activities. One of the ways to effectively manage water is by conducting a proper mechanism to monitor water usage, and available water resource management. Therefore, WF has been proposed as a metric to measure water usage, and its impacts on the production system on water resources. WF can be used to underpin an environmental product declaration and acts as a means of communication of environmental performance to stakeholders (Cha et al., 2017). The WF concept has been developed as analogous to that of the ecological footprint concept. Furthermore, the WF concept that was thoroughly described by Chapagain and Hoekstra (2003), is closely linked to the VW concept.

The VW concept was first introduced by Allan (1998), which relates to the embedded water via export or import of commodities, products, or services. Allan (1998) elaborated on the idea of using VW import (coming along with food imports), as a tool to release the pressure on the scarcely available domestic water resources. VW import, therefore, becomes an alternative water source, next to endogenous water sources. Imported VW has also been referred to as 'exogenous water' (Haddadin, 2003). When assessing the nation's WF, it is essential to quantify the VW's flow that leaves and enters the country.

Since VW is traded, countries with water scarcity problems can formulate 'water savings' strategies by importing high VW products from water-abundant countries, rather than producing them locally. Figure 1.1 illustrates VW balance per country and the most extensive international gross VW flows. The countries with negative balances are shown in green to signify their net VW export. In contrast, the countries in yellow and red indicate their net VW import.

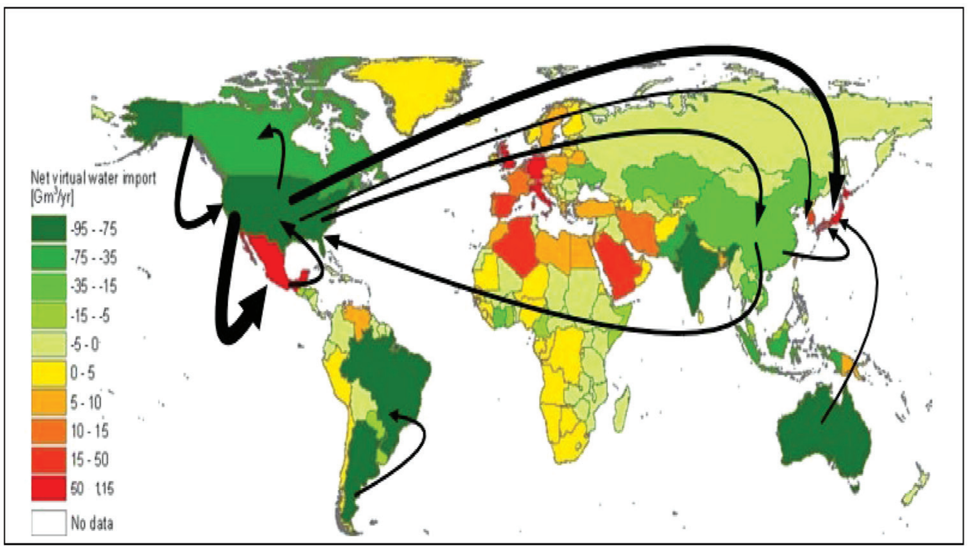

Figure 1.1. VW Balance and Flow for Agricultural and Industrial Products Trade (1996–2005)

(*Source*: Mekonnen and Hoekstra, 2011)

*Note***:** VW balance per country and direction of gross VW flows related to agricultural and industrial products trade from 1996-2005. Only the most significant gross flows (> 15 Gm^3 /year) are shown; the arrow's width indicates the proportion of VW flow.

As an extension to VW's idea in early 2000, Arjen Hoekstra (2003) introduced another important water management concept: water footprint (WF). WF is defined as the total volume of direct, and indirect freshwater used to produce goods, commodities, or services along its supply chain (Hoekstra, 2003). It is also related to the temporal and spatial distribution of freshwater used through the production, or process (Hoekstra & Chapagain, 2007). Consumption in WF terms refers to water that is 'lost' from the system, and therefore, cannot be used for other purposes at that particular time and location. WF consists of three components: green water, blue water, and grey water. Green WF is sourced from rainwater and soil moisture consumed, and the production is either through evaporation, transpiration, or incorporation in plants. Green WF is often calculated for agricultural, horticultural, and forestry products. On the other hand, blue WF is sourced from the surface and/or groundwater, and incorporated into products, or lost in another catchment or water body. The third component, grey WF is the amount of water needed to assimilate a load of pollutants into acceptable water discharged standards into a desired quality level. Figure 1.2 illustrates the simplified categories of WF components.

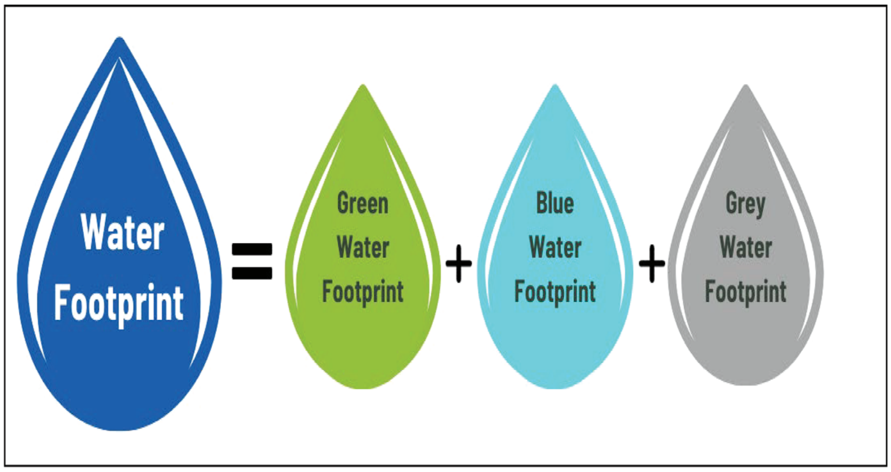

Figure 1.2. Components of WF

(Adapted from Hoekstra et al., 2011)

There are two main methodological approaches used when conducting water footprint assessment (WFA). These approaches have been widely recognised: WFA and the life cycle assessment approach (LCA). WFA, a comprehensive analytical tool, evaluates water consumption, and pollution-related to human activities (Hoekstra and Chapagain, 2007). The volumetric method is widely used in WFA and was developed by the Water Footprint Network (WFN) and focuses on the volume of direct and indirect freshwater consumption (Hoekstra et al., 2011). It classifies water use into three types: green water (i.e., the volume of precipitation that does not run off), blue water (i.e., the consumption of surface, and groundwater resources), and grey water (i.e., the volume of freshwater consumed to assimilate pollutants) (Chapagain and Hoekstra, 2011). In comparison, the life cycle assessment (LCA) approach has been standardised and accepted as the international standard on WF (ISO 14046). Both proposed approaches are broadly similar, and include both the calculation of water use and its impacts, but differ in the communication of a WF result. WFN quantifies the amount of water associated with the production of products and/or services, while ISO 14046 is more comprehensive, such as the calculation from cradle to grave that takes into consideration the potential environmental impact from water use to the natural environment, resources, and human health aspects (Cha et al., 2017).

From 2004 onwards, practices in calculating WF by integrating LCA approaches have risen, including assessing the potential environmental impact by water use in the process, product, and services. WF then evolved to a hybrid with LCA in which potential environmental impacts of certain products, commodities, or services are determined within the same boundary. Nevertheless, there is no doubt that the WF inventory remains the basis of every impact assessment, and is an important component of the ISO-based WF. Therefore, both communities have a lot in common, but maintain different viewpoints. Considering the advantages and limitations of both methods shown in Table 1.1, this study employs a hybrid in doing the WFA. WFA, according to ISO 14046, shall include four phases of LCA: goal and scope definition, WF inventory analysis, WF impact assessment, and interpretation of the results.

On the other hand, a WF inventory study itself consists of goal and scope definitions, WF inventory analysis, and interpretation. To define the appropriate impact categories, besides methods of the impact assessment of WF, data related to the type of water resource used, affected water resources, and associated changes in water should be collected (ISO 14046, 2014). However, due to time constraints and data limitations, this study only focused on WF inventory, whereby the amount of freshwater embedded (consumption and pollution) in a product/service was assessed. Consequently, this hybrid WF should complement each other rather than compete with the disadvantages of both methods.

Table 1.1. Comparison between WFN and ISO 14046

ITEMS	WFN	ISO 14046
Concept & Definition	The WF is an indicator of freshwater use that looks at the direct and indirect total water use (blue, green, grey) of a consumer, or producer through the full supply chain.	The WF assessment should be comprehensive, and consider all relevant attributes, or aspects related to the natural environment, human health, and resources.
Aim	WFN aims to account for water productivity, as global freshwater is a limited resource and opts for a subsequent, optional sustainability assessment of the water consumed.	LCA aims to account for environmental damage, and deprivation caused by water use.
Scope	WF assessment consists of four distinct phases; setting goal and scope, WF accounting, WF sustainability assessment, and WF response formulation (Hoekstra et al., 2009).	WF assessment following the International Standard can be conducted and reported as a stand-alone assessment, or as part of a life cycle assessment, which includes four main phases: Goal and Scope Definition, Inventory Analysis (LCI), Impact Assessment (LCIA), and interpretation of the results.
Approach	• WF as a volumetric approach, focusing on water productivity. • WF provides spatiotemporally explicit information on how water is appropriate for various human purposes (Hoekstra, 2017).	• ISO 14046 is used to estimate the different sorts of potential environmental impact attributable to the life cycle of a product, from cradle to grave (Hellweg & Canals, 2014). • Focuses on interpreting the assessment at different levels, where accounting for water flows and related impacts are complementary steps.
	• Differentiate water elements into three sources: * **Blue water**: Water sourced from the surface, or ground water resources; either evaporated, incorporated into a product, or taken from one body of water and returned to another, or returned at a different time. * **Green water**: Water from precipitation stored in soil root zone and evaporated, transpired, or incorporated by plants. * **Grey water**: Amount of fresh water required to assimilate pollutants to meet specific water quality standards.	• Differentiate water elements into two sources: * **Direct water use**: Considers the inputs and outputs, resulting from activities within the boundaries. * **Indirect water use**: Considers the inputs and outputs from activities through the process within the boundaries.

WF has been developed and used to feed discussions about sustainable, efficient, and equitable allocation of limited freshwater resources and resource security, given that many countries depend on water resources outside their territory. The WF concept introduces supply-chain thinking in water management, and helps analyse the link between human consumption and the appropriation of freshwater (Hoekstra et al., 2011). Most importantly, the mutual scope of both approaches is to study a system and learn about its improvement potentials. Both approaches provide information to the stakeholders and decision-makers. ISO water footprint and LCA allow this for a manufacturing, organisational, consumer, and (with non-marginal factors) territorial focus.

However, since ISO 14046 has been accepted globally as the WFA international standard, this study utilises the general structure to frame the study, as demonstrated in Figure 1.3.

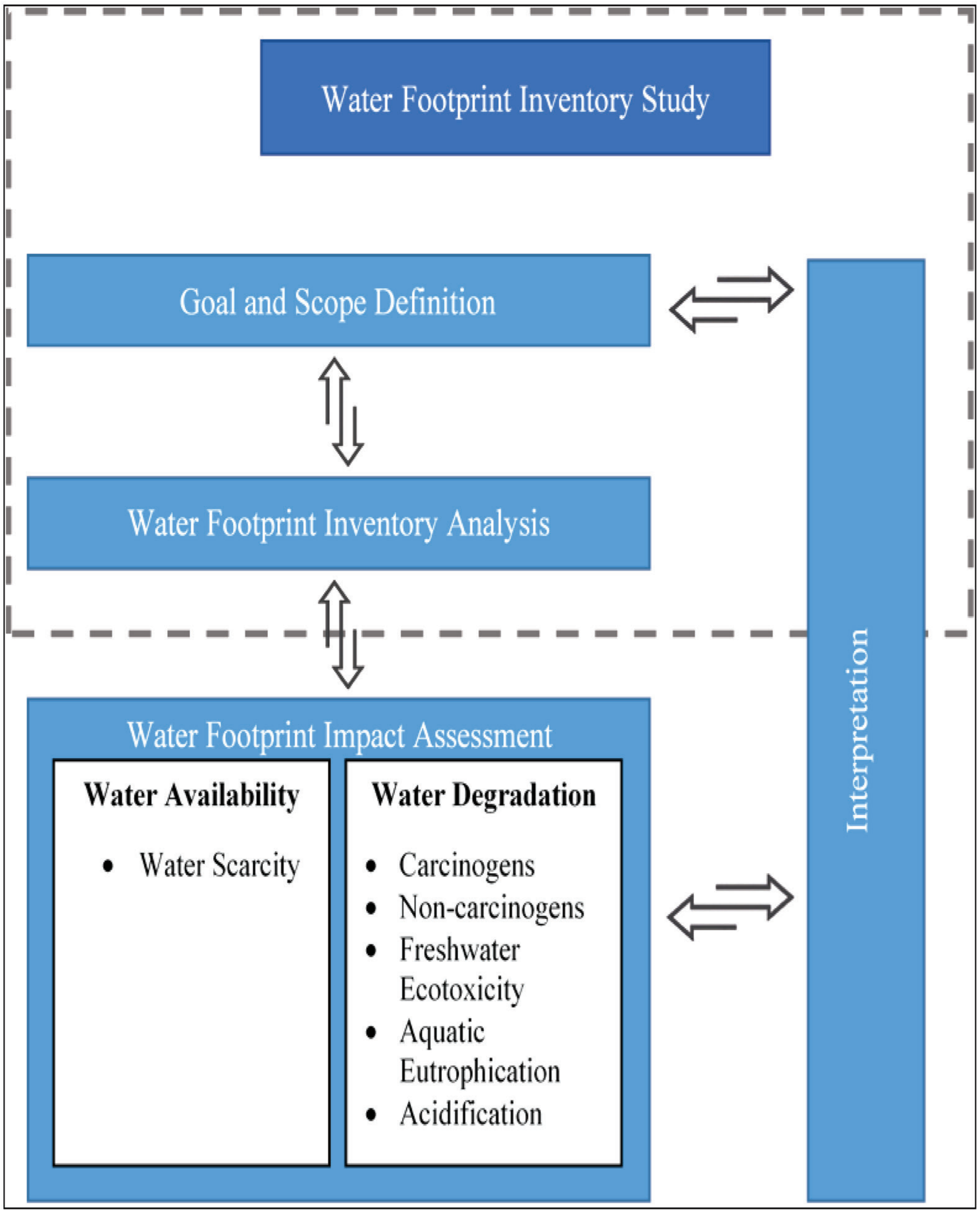

Figure 1.3. WF Assessment Framework Based on ISO 14046

The development of WF method over the past decades is shown in Figure 1.4.

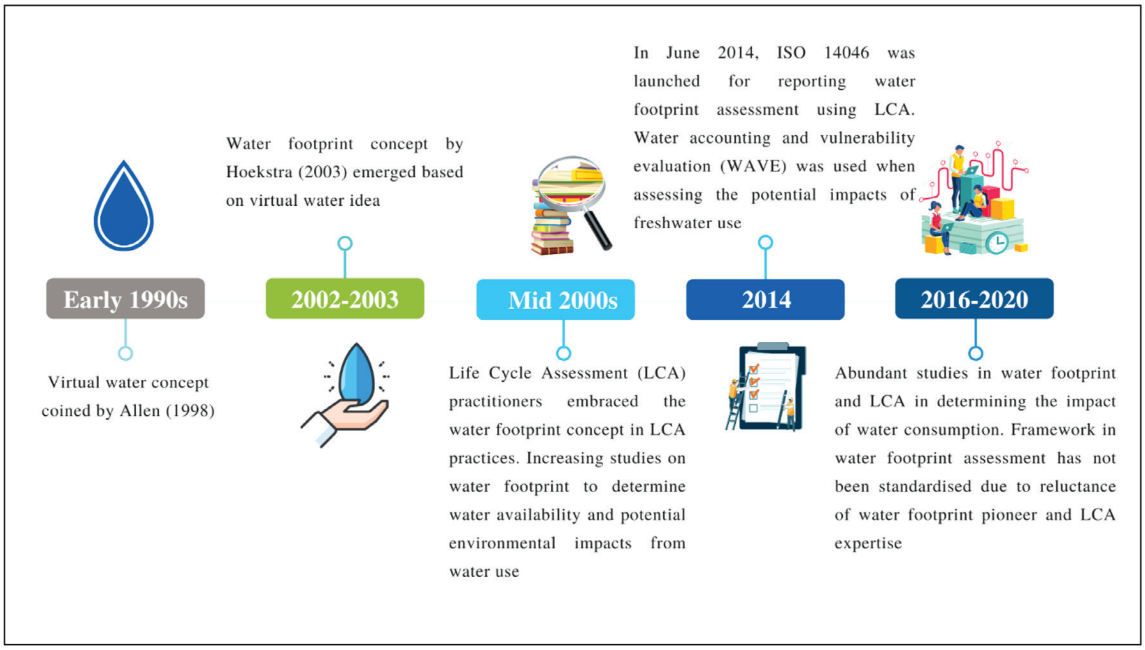

Figure 1.4. Evolution of WF Assessment

The National WF accounting scheme proposed by Hoekstra and Chapagain (2008; 2009; 2011), as depicted in Figure 1.5**,** is used in this study to calculate the value of the VW budget, which is the summation of WF within the nation and the VW import. The framework consists of four main parts; consumption, production, export, and import. It is crucial to determine the internal and external WF for the national WF accounting scheme since this will affect the VW calculation.

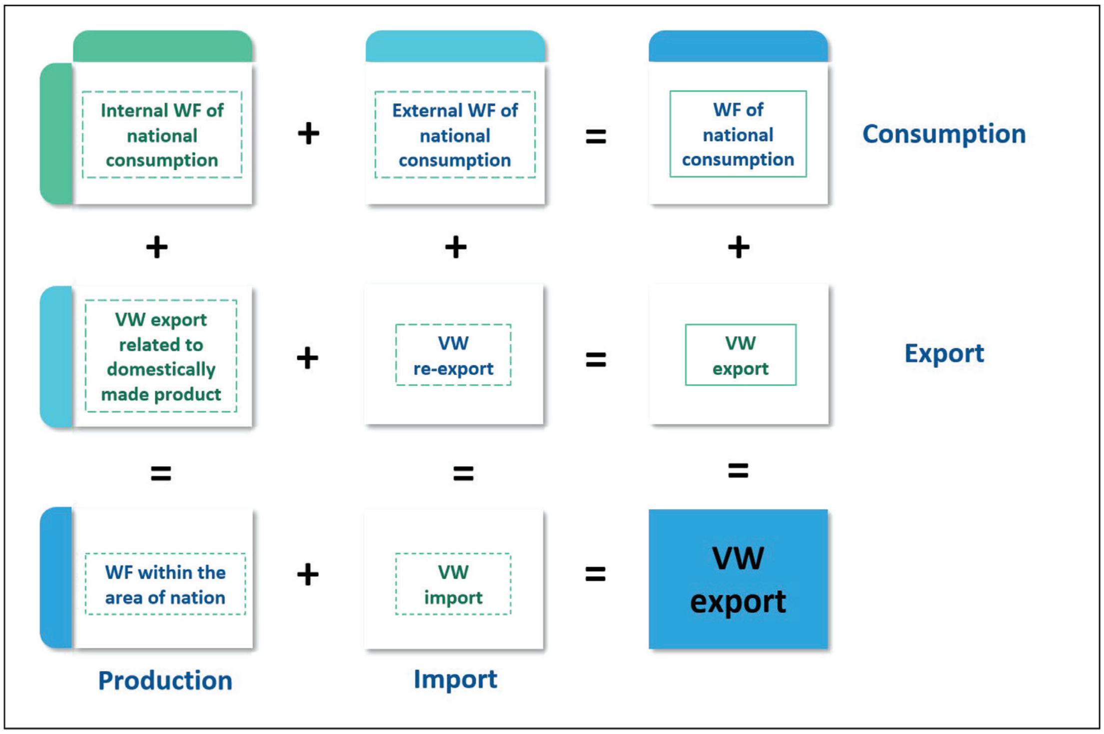

Figure 1.5. National WF Accounting Scheme

(*Source*: Hoekstra et al., 2011)

The WF within the nation (volume/time) is defined as the total freshwater volume consumed, or polluted within its territory. It can be calculated by summing the WF of all water-consuming, or polluting processes in the country. The gross VW import is calculated by multiplying import volumes of various products by their respective WF product in the nation of origin. The WF of national consumption is calculated by adding the nation's direct and indirect WF consumers.

Most products, or services will consume water from combinations of full WF internally and externally, or VW export and import for the same supply chains. However, there are also cases, whereby the VW import is only partly consumed, particularly when the VW import for re-export is consumed with external WF. Therefore, the total amount of WF&VW of specific products, or services can differ depending on the water sources, and where the process takes place within a particular time frame.

2.0 Objectives

This study's primary aim is to quantify Malaysia's VW and establish a WF inventory of selected economic sectors towards more efficient use of water, as an economic sector by considering the direct and indirect water being consumed and traded inside and outside of the country. This aim will be achieved through the implementation of the following specific objectives:

i. To identify the main players and potential international collaborators in VW&WF initiatives;
ii. To identify the economic sectors that will be the focal point of VW&WF inventory study based on sets of criteria;
iii. To establish VW&WF inventory for selected case studies;
iv. To calculate and analyse the VW of the selected economic sectors, utilising the collected secondary data;
v. To calculate and analyse WF inventory of selected industrial and tourism sector, and agricultural crop;
vi. To review and suggest improvement on the current policy, acts, enactments, and ordinances to incorporate elements of WF; and
vii. To prepare a roadmap for the National Agenda on Water Sector Transformation 2040 (Roadmap WST2040).

This study also considers the recently launched 12MP[1], which strongly emphasises the water transformation agenda. The most relevant strategies related to VW&WF initiatives are spelt out in Chapter 8 under Priority Area A (strategy A2), and Chapters 9 under Priority Area B (strategy B1, B2, B3, and B5) and as listed in Table 2.1.

[1] The 12th MP was launched on 27 September 2021 by the Prime Minister of Malaysia, Dato' Sri Ismail Sabri Yaakob. The 12th MP encompassed shared prosperity initiative, involving three dimensions: economic empowerment, environmental sustainability, and social re-engineering.

Table 2.1. Relevant Game Changer and Strategy for Theme 3 - Advancing Sustainability under 12th MP

Game Changer	Chapter	Priority Area	Strategy
Game changer VIII: Embracing the circular economy	Chapter 8: Advancing Green Growth for Sustainability and Resilience	Priority Area A: Implementing a Low Carbon, Clean and Resilient Development	A2 - Accelerating Transition to the Circular Economy
Game changer IX: Accelerating Adoption of Integrated Water Resources Management (IWRM)	Chapter 9: Enhancing Energy Sustainability and Transforming the Water Sector	Priority Area B: Transforming the Water Sector	B1-Empowering People B2-Strengthening Governance at All Levels B3 -Enhancing Capability in Data-Driven Decision-Making B5-Developing Sustainable Infrastructure with Cost-Effective Technology

3.0 Scope of the Study

The study is designed to enable the outputs of this study to be aligned with the 12MP focus areas, as depicted in Table 3.1. The following points highlighted the scope and boundary of the study.

1. Performing a bibliometric study, recent literature, and expert reports related to VW&WF research.
2. Systematic reviews on existing policy (national and international), recent literature, and expert reports related to VW&WF inventory.
3. Primary data collection through the conduction of interviews as well as dissemination of surveys and questionnaires.
4. Secondary data collection from relevant agencies on import and export, water consumption, and other relevant information for the conduction of VW&WF inventory assessment.
5. Selection of top sectors based on sets of criteria, including their economic strength and values for VW analysis.
6. Selection of specific industry and tourism sectors, and agricultural crops for WF inventory case studies.
7. Comparative assessment of VW&WF inventory performance based on the findings of items (1), (2), (5), and (6) with other countries, whereby data is readily available.
8. Conduction of a series of stakeholders' engagements to deliberate, finalise and endorse the strategic policy framework.
9. Providing inputs for the preparation of a roadmap for the National Agenda on Water Sector Transformation 2040 (Roadmap WST2040), based on the finalised strategic policy framework.

4.0 Current Status on Global and Malaysia Virtual Water (VW) and Water Footprint (WF)

4.1 WF Mapping using SciVal Analysis

WF has been used widely as one of the assessment tools in evaluating the utilisation of water resources to produce products, or services. The population growth and economic development have mainly influenced the water consumption trend in industrial and agricultural products, and households' consumption. The

Table 3.1. Matrix of Study Scope Requirements by EPU that aligns with the 12th MP

Scope Sectoral Study	Review and Analyse Current Policies with a view to Improvement	Undertake Comparative Strategy Analysis/Business Models with other nations	Study Potential of the Nation's Water Sector Industry Taking into Consideration Current Global Markets Towards Making the Water Sector As a Dynamic New Economic Sector capable of Driving the Nation's GDP Growth in the Future	Prepare a Transformation Strategy and Initiative Implementation Framework for each of the 4 Phases including the Implementing Agencies, Estimated Budgets and Main Target Achievements Based on the Analyses Undertaken and Expert Reviews	Undertake Consultations with Stakeholders and Experts with the Aim of Finalising the Proposed Strategies and Initiatives of the Nation's Water Sector Transformation	Prepare a Complete Roadmap for the National Agenda on the Water Sector Transformation 2040 for the various Ministries' and Agencies' Information and Guide for the Implementation of Programmes and Activities towards Achieving the Targeted Transformation Objectives
Virtual Water and Water Footprint	▪ Systematic reviews on existing policy (national and international), recent literature and expert reports which are related to VW and WF inventory.	▪ Performing a bibliometric study, recent literature and expert reports related to VW and WF research ▪ Comparative assessment of VW and WF inventory performance based on the findings of policy reviews with other countries, and selection of top sectors and case studies which data is readily available.	▪ Selection of top sectors based on sets of criteria including economic strength and value for the VW analysis. ▪ Selection of specific industry and tourism sector, and agricultural crops for the WF inventory case studies.	▪ Roadmap Framework already prepared and approved by both the Technical Committee and Steering Committee. Sub-sectors to use this Framework for their Consultations	▪ Primary data collection through conduction of interviews as well as dissemination of surveys and questionnaires. ▪ Secondary data collection from relevant agencies on import and export, water consumption and other relevant information for the conduction of VW and WF inventory assessment. ▪ Conduction of series of TF meeting, FGD and stakeholders' engagements to deliberate, finalize and endorse the strategic policy framework and proposed strategies and initiatives	▪ Providing inputs for the preparation of Roadmap for the National Agenda on Water Sector Transformation 2040 (Roadmap WST 2040) based on the finalised strategic policy framework

**Note*: Refer to Sub-section 4.3

assessment using WF can be applied for different groups of products and/or services, consumers, and producers that consider spatial and temporal aspects. The WF current framework refers to the Water Footprint Network (WFN) and the International Organisation for Standardisation (ISO 14046). This broad sustainability assessment of WF has been rapidly developed since the last decade (Zhang et al., 2017). Therefore, WF studies are evaluated using a bibliometric mapping by considering the main contributors through the authorship profile, Web of Sciences (WoS) categories, authors' institutions and countries, and those who published VW&WF articles. Besides, WF studies are also linked with other concepts, such as energy and carbon elements.

The methodologies for bibliometric mapping are performance analysis and science mapping. Performance analysis includes identifying the attributes of publication outputs, for instance, institutions, countries, authors, journals, and citations. On the other hand, specific key terms were used to determine the connections between countries and institutions for science mapping. SciVal, a web-based analytics response tool that allows complete access to over 20,000 research institutions' research performance, including their associates from various nations worldwide, was utilised in the analysis. It is a remarkable tool to evaluate researchers' performance on research, their collaboration and partnerships, and their global rank, or position. SciVal is capable of processing a large amount of data for generating impactful analyses and visualisations. This large data technology allows the analysis of over 50 million publications in more than 22,000 journals globally.

The analysis starts with deciding on the cluster topic on *Water; Water Resources; Water Management,* and narrows down the search to *Water Footprint's* key phrase. This analysis utilised databases from 2015 to 2020. It was found that China is the leading country with 321 publications in WF topics, followed by the United States (US) and the Netherlands with 136 and 106 publications, respectively. Figure 4.1 shows the publications in WF topics for the top three countries compared with WF publications in Malaysia. Based on this analysis, it can be seen that WF research has led to numerous publications under environmental sciences topics, as represented by the size of bubbles in Figure 4.1. The number of bubbles suggested that WF is multi-disciplinary, and mainly associated with energy, environmental science, earth and planetary science, material science, computer science, social science, and medicine. The bubbles for environmental science, whereby most WF studies fall into, are the largest for the Netherlands and about the same size for China and US. Although Malaysia's bubble is still relatively small, some studies in these areas have already been initiated.

From 907 publications, the keywords were narrowed down to related sectors (i.e., sectors currently being studied), as illustrated in Figure 4.2. Furthermore, 106 publications have been published focusing on energy (WF in energy systems, WF in renewable energy technologies, and WF in energy sources) from 867 publications under other categories. Moreover, 80 papers had been published on crops, including studies of WF on major crop production in China, Austria, Chile, and other countries, and studies on the sustainability of the blue WF of crops. Thirty-two papers had been published concerning agriculture sectors, including assessing the sustainability of agriculture and international trade of global scarce water used in agriculture. In addition, 24 publications provided reviews ranging from reviews on WF of crop production, WF of cities, and WF methods.

A total of 27 WF publications were related exclusively to paddy/rice. Numerous studies on paddy/rice are understandable as it is a staple food source in many countries, including Malaysia. Based on different bibliometric studies carried out by Zhang et al. (2017) between 2006 and 2015, a total of 636 WF-related publications had been found, which saw a dramatic increase in the number of publications (271 publications) for the following five-year period.

Figure 4.1. Publications on WF Topics for China, the United States, the Netherlands, and Malaysia

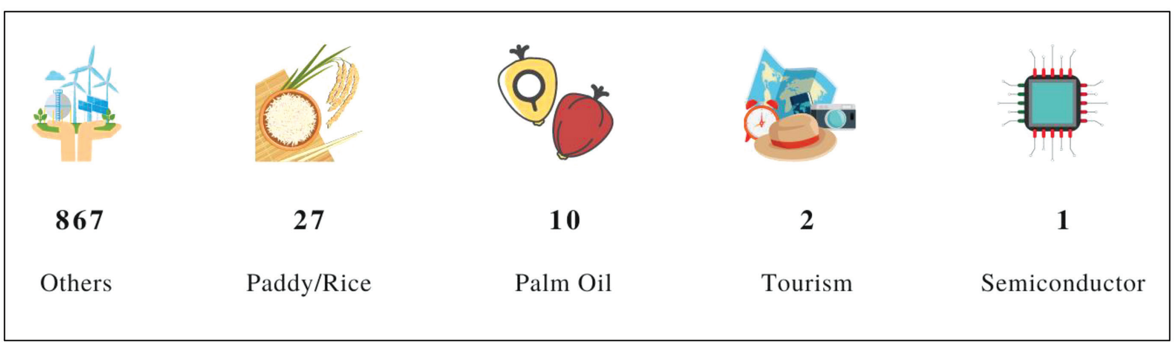

Figure 4.2. Number of Global WF Publications in Selected Sectors (2015–2020)

An area that has received scarce attention is the rubber sector. Currently, there are less than five articles that focus on the WF of rubber. There is also little explanation on how WF assessment is performed for rubber. Studies on WF of rubber are not stand-alone assessments. Instead, WF assessment of rubber is typically found in studies that combine rubber with other crops. Seminal work in this area was conducted by Mekonnen and Hoesktra (2011), who focused on quantifying green, blue, and grey WF of global crop production from 1996 to 2005. However, as the article was published before 2015, it could not be included in the current analysis. Another study that analysed rubber tree cultivation, transportation, and production could not be included in the analysis, as it is written in the Thai language.

Another area that is understudied is the WF of rubber gloves. Relatively, no studies have explored the concept of WF in the rubber gloves sector. Consequently, the study on LCA is taken as a point of reference. Although an LCA study's purpose and inventory method are different, some of the data can be used, as LCA is also one of the approaches utilised for WF studies.

Figure 4.3 shows the correlations between the number of publications and the number of authors and citations for the top ten institutions shown in the diagram. The University of Twente leads the WF research with 72 publications, and 1,848 citations, followed by the Chinese Academy of Sciences with 63 publications. The size of the bubbles indicates the number of institutional citations for all authors. It was observed that the number of citations did not correlate with the number of publications. For example, the National University of Singapore has 37 publications. However, it has a high number of citations (770) compared to Hohai University, which has 44 publications with only 324 citations. The number of citations per document might suggest that either an article is more relevant and frequently referred to, or that it has a higher number of authors per article.

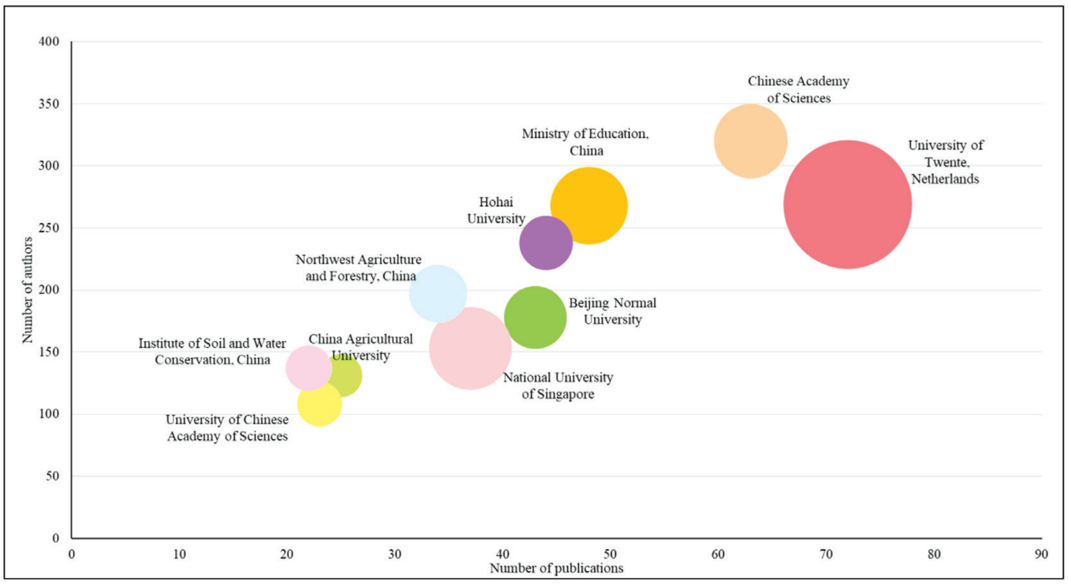

Figure 4.3. Correlation between the Number of Publications with the Number of Authors and Citations (2015–2020)

Malaysia had published 21 papers on WF from 2015 to 2020, which rendered the country amongst the top 20 countries globally as far as the number of publications is concerned. Therefore, Malaysia could further mark its presence in this area, and become the top ten countries globally by collaborating with other active nations, including China, Germany, the Netherlands, and the US.

Figure 4.4 depicts the networking in WF of the top five countries, namely China, the US, the Netherlands, Italy, and the United Kingdom (UK), with other countries including Germany, Singapore, Japan, Australia, France, and others. The line's width represents the intense collaboration (i.e., number of co-

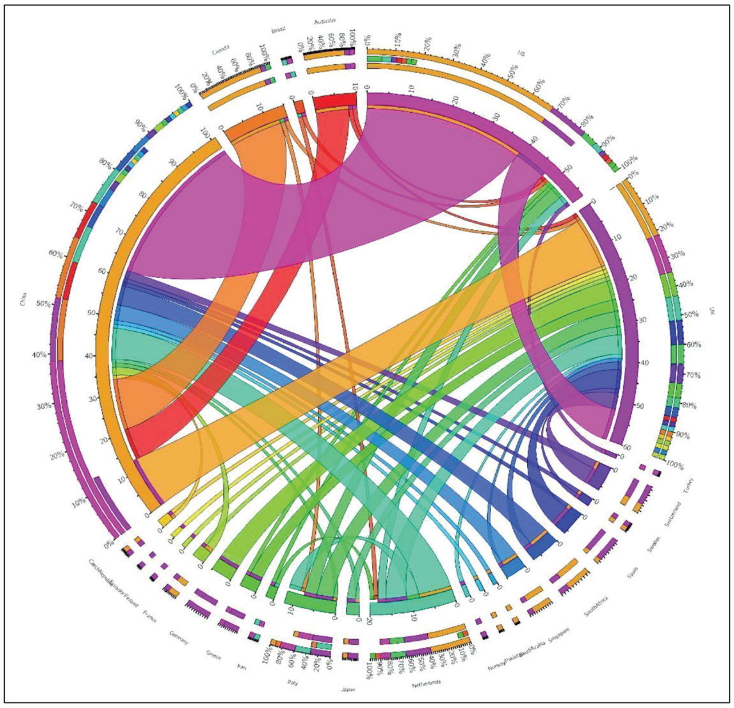

Figure 4.4. Collaboration between Other Countries and Top 5 Countries on WF Publications

(*Note*: The width of the line indicates the degree of collaboration intensity between the two countries.)

authored papers) that have been established between the countries. For example, China had co-authored 39 publications with authors from the US, and thus generated a broad line compared to their collaboration with co-authors from the Netherlands, which only led to eight publications, and subsequently generated a narrower line (see Figure 4.4). Since WF research and its initiatives are still emerging, Malaysia, which has shown tremendous potential in expanding WF-related publications, should seize the opportunity to play a more active role, especially in intensifying its network and collaboration with other global players, such as China, the US, the Netherlands, and the rest of the world.

4.2 Global WF Policy and Initiatives

VW&WF have been used as novel quantitative methods to assess water resources in livestock and food production globally. Research on VW&WF has been extensively done in many countries, especially to investigate VW&WF using local data. The findings demonstrated that VWWF are significant to be included in the national policy, not only for the water sector, but across other economic sectors.

Embedding the VW&WF concept as a policy requires a thorough understanding of the impact, and interactions amongst major stakeholders in the water sector, taking into account its economic, environmental, and cultural implications. Several countries have placed this concept as a market-mediated mechanism, which enabled water-scarce regions, such as the Middle East and North African countries to cope with water scarcity over the past few decades without implicating significant changes and reforms in water allocation, management, and policy (Allan, 2003; Antonelli et al., 2014).

Since VW&WF concepts are relatively new, especially in the water sector, globally the governance of this concept is still at the methodological and framework stages. Many researchers have focused their efforts on developing the WFA method in several water-intensive sectors, such as food and agriculture, with the highest water consumption recorded during the value chain process. Currently, most countries are at the research-based level, whereby local researchers work together with their respective government agencies to establish an accurate assessment of VW&WF for several economic sectors.

Based on the literature, China and Spain are the most proactive countries championing the VW&WF agenda. These two countries have been characterised by a significant water endowment variation, especially food imports. For example, China has established a water pollution discharge permit system to account for grey water in WF. Furthermore, China has implemented the water usage cap in five provinces, namely Ningxia, Shandong, Jiangsu, Shanghai, and Beijing. Moreover, the International Finance Corporation (IFC) and the China National Standardisation Institute (CNIS) have started WFA to China's first-ever sector in breeding and distribution of pigs. This project is under collaboration with Muyuan Foodstuff Company, Ltd. in China.

Spain has also been actively promoting the VW&WF agenda in the economic sector. To ensure systematic management in Spain's water resource management, Spain is the first country in Europe to implement WF in government policy for various socio-economic sectors. The country has established WF in assessing VW in agricultural production. This programme is known as the H3 certification scheme. Under this scheme, agricultural growers will receive a certificate, indicating the WF of each crop using a methodology, known as "Precision Agriculture as a Competitive Advantage" of the fruit and vegetable sector. Spain is one of the few countries in the world that has established a National Water Footprint. This policy also aligns with the EU initiative for WF known as "The Water Framework Directive"[2].

Sweden has also taken a proactive initiative to implement VW&WF. Sweden imports food in abundance, including fruits, vegetables, coffee, and tea. Under the initiative of the Pan-European Atlas of Urban Water Management of the European Commission, the Joint Research Centre has proposed WF analyses related to food consumption. As a result, Sweden has proposed to adjust national policies to shift towards VW trade in food production, trade, and subsidies. These initiatives also involve other Nordic countries, such as Finland, Denmark, Norway, and Iceland.

The initiative on VW&WF has also spread to other continents, such as Canada. Canada is known as the most agriculturally productive with crop production in the Northern American region. In particular, the state of Alberta has taken the initiative to introduce Agro-hydrological models to assess WF of barley by simulating future crop yield (Y) and consumptive water use (CWU). In addition, the Soil and Water Assessment Tool (SWAT) was also used to develop rainfed and irrigated barley simulation models. As a result, the state government predicts that the volume of irrigated barley will likely decrease in the future. Like other countries that attempted to implement WF, especially in agricultural products, the challenge to embed WF policy is to control water use patterns with strong support from the government in terms of policies. This will ensure that future water policies at the local and global levels can be developed to support the sustainable economy, and improve human and environmental well-being.

The US currently has the highest WF due to its large production of goods and services (Marston et al., 2018). Nevertheless, to date, the US has inconsistent information on water use and consumption trends in its economic sectors. As part of the effort to assess WF in economic sectors, the United States Geological Survey (USGS) had taken the initiative to calculate the use of water known as "Estimated Use of Water". This practice has become a national benchmark to analyse WF in the US economic sectors. Such information is crucial to help each state in the US to calculate WF, which has started in the food industry. However, to date, there is also no clear evidence of the country's effort to incorporate WF into its policy and regulation.

[2] Refers to the European Union's Water Framework Directive 2000/60/EC that commits the European Union member states to achieve satisfactory qualitative and quantitative status of all water bodies by 2015.

Another country that leads global trade is the United Kingdom (UK). Although the UK has already ratified the withdrawal agreement with the European Union (EU), water management in the UK is highly influenced by EU's initiatives, known as the 'Water Framework Directive' (WFD). This is seen as a step forward for the UK and all EU countries to initiate a joint policy on VW&WF. Currently, the policy and initiative of VW&WF are indirectly taken from the WFD without clear indication on the policy, which could act as a guideline for all relevant stakeholders. There is an urgent need for the UK to revise its current water policy due to several events that could jeopardise the UK's water supply. Currently, in the UK, the implementation of WFD has not been fully materialised. Therefore, based on these factors, it is pertinent that the prospect of WF should be addressed immediately to avoid further crisis.

While the US and European countries have some clear directions in addressing VW&WF agendas, countries in other continents have increased awareness to implement VW&WF strategies in their economic sectors. The Middle East countries, such as Yemen, the United Arab Emirates (UAE), Saudi Arabia, and Iraq face severe water scarcity that requires global and immediate attention. These countries rely heavily on imported products, especially food and agriculture, due to a lack of water supply access. For example, the UAE has allocated generous government subsidies in the water sector, and are energy-intensive to develop more local products. The future of local trade in the UAE requires both consumers and producers to be more flexible. With the scarcity of water resources, UAE has formulated the Habitat Directive Policy to govern the river exclusively for sustainable use. The UAE and other Middle East countries require water resources and suitable land to create a more sustainable food and agricultural industry. From VW&WF's perspective, these countries need to import products from countries with abundant water resources to ensure global water sustainability in the future. Therefore, VW&WF's policy in the UAE and other Middle East countries should consider these fundamental issues. Despite establishing the water sector-related policy, at present, the Middle East countries have not devised a clear policy on VW&WF.

South American countries, namely Mexico, Chile, Argentina, Colombia, and Peru have taken proactive steps to implement the WF concept not just on its methodological approach, but also into the government's policy. In recent years, investment and attention to achieve sustainable water use have increased for these countries. It started in 2015 when these countries took steps in the public sector to participate in the WF network. Several projects had been initiated with significant fundings from the Swiss Development Corporation (SDC). For instance, in Colombia, Good Stuff International and Technology Antiochia (CTA) made an initiative to examine all river basins' WF in Colombia, supported by the Institute of Hydrology Meteorology and Environmental Studies (IDEAM). As a result, most municipalities in Colombia have started the WF assessment in all river basins within their jurisdiction.

In Chile, Fundacion Chile has taken proactive action to establish WFA at the river basin scale, and was piloted in the Rapel River Basin. In addition, Universidad Mayor and Agrosustentable have conducted WFA of agricultural production and industrial processes for wine production. The project's impact brought new technology to determine the optimal irrigation scheduling to reduce water consumption.

In Mexico, at the government level, policy on WF has been implemented to measure water efficiency. The Mexican Water Commission (CONAGUA) adopted the blue WF per product unit to quantify WF on a product to measure water use efficiency. This new regulation is a methodology to determine the volume of efficient water use, the coefficient of efficient water use, and the direct blue WF. This government fiscal policy is expected to generate significant benefits to Mexican water users.

Argentina is another South American country that is actively involved in implementing VW&WF policy and activities. Buenos Aires has started to apply legislation that uses grey WF in determining wastewater fees, known as Arroyo Conchitas-Canal Platanos. Since 2006, Argentina has significantly improved water infrastructure throughout the country, leading to increased water tariffs, and high cost of financing the infrastructure. Consequently, it also impacts the sectors that rely on water, such as food and agriculture, which need to impose wastewater fees to integrate with WF policy. Currently, the Argentinian government is revamping the water sector policy to certain economic sectors in line with the WF framework.

Peru is one of the largest avocado exporters, and this crop has been known to use abundance of water, even higher than the water volume consumed by paddy. Another essential crop that generates income for Peru is asparagus, which is mainly exported to European countries. There has been concern about this crop due to an unsustainable planting system. According to a Peruvian Centre for Rural Development (CEPES), and Water Witness International, the extent of damage done by the asparagus plantation is at the stage of overexploitation of the aquifer that will eventually exhaust the groundwater. Therefore, the country has taken initiatives to reduce WF in avocado and asparagus planting. Like other Latin American countries, WF activities and financing mostly came from the Swiss Development Corporation and local governments.

Countries from other continents have also begun to promote WF, especially in food, agriculture, and commodities. Malawi, Bangladesh, and Turkey have started to include WF in their sustainable development strategy. As the global leading silk exporter, Malawi has taken steps to calculate WF in the production stage. The Malawian government has taken the initiative in diversifying the agricultural portfolio towards boosting overall productivity and exports. As a result, Malawi's high dependency on silk production decreased, which eventually lowered the WF in silk production.

Bangladesh is another country that has embarked on WF implementation in its major commodity. Bangladesh has been recognised as a major textile manufacturer, and a major hub for textile production. Textile is one of the industries with the highest WF. Therefore, the Bangladeshi government has taken the initiative to establish data and evidence-based WFA at one of the textile productions in the Konabari Textile Cluster. The WFA cluster will provide the local context within the buyers' and mills' WF and the impacts on water resources, environment, and local communities. As for India, the government has already included the VW&WF agenda as part of an important policy to revamp the national water sector. WF has been incorporated in India's New Water Policy, emphasising the WF assessment, and analysis across all sectors. Furthermore, it is aimed to promote and incentivise efficient use of water.

Most countries have concentrated in the food and agricultural sectors to implement the VW&WF agenda. Only a few countries have placed manufacturing as an economic sector to highlight WF's importance in the supply chain process. Besides Bangladesh, which has started calculating WF in the textile industry, Turkey has also begun a WF initiative in the manufacturing sector. For instance, a water risk assessment framework has been implemented in the Yasar Group, whose main businesses vary from agriculturally based, food, and trade. R&D has been made in the packaging facility to reduce WF, and WF calculation in all productions in this company. Additionally, VW&WF have been included in the company's policy throughout the value chain process of manufacturing.

In the Oceania continent, New Zealand (NZ) seems to have taken active measures to include VW&WF in its policy. Based on international guidelines, the NZ government has recognised ISO 14046 Environment Management-Water Footprint, which explains principles, requirements, and guidelines that allow all kinds of organisations, from industry to government and NGOs, to measure its WF and the potential environmental impact of water use and pollution. NZ industry players have one standard guideline for assessing WF in several important sectors, such as food, agriculture, and manufacturing through this standard.

As for Australia, the guidelines of VW&WF are still vague. WF's element only appears in Australia Vision 2020, an initiative of Horticulture Innovations Australia (HIA) to create 20% more green space in Australia's urban areas by 2020. The role of WF in this vision is to increase blue water resources for irrigation. Although there are many studies on VW&WF in Australia, to date, it is still at the research-based findings stage without a clear direction on how they can be embedded into policy and regulations.

Nevertheless, the awareness of VW&WF amongst the Australian industry players is relatively high. For instance, the awareness of water stewardship highlights the company's value chain in controlling pollution, especially to the Murray-Darling River, one of Australia's major river basins.

In conclusion, although VW&WF are relatively new concepts, especially in their implementation in the water and economic sectors, several countries have been proactive in looking and progressing in these concepts, whether at the research level, methodological development, or as part of the government's policy. Countries from various continents have started to enforce VW&WF policy although its implementation is limited to several sectors. Initially, the focus was only on food and agricultural industries, which later developed into a national policy. Table 4.1 provides a summary of the worldwide country-level initiatives and implementation of VW&WF.

Table 4.1. Worldwide Country-Level Initiatives and Implementation of VW&WF

No.	Country	Activities
1.	China 	• Establishment of 'water pollution discharge permit system' (grey WF permit) (Liao, 2019). • Implementation of water usage cap in five provinces (Ningxia, Shandong, Jiangsu, Shanghai, and Beijing) (Leong, 2013; WFN, 2020; Cao et al., 2018). • International Finance Corporation (IFC), and the China National Standardisation Institute (CNIS) on Muyuan Foodstuff Company, Ltd. in China. The company, which is principally engaged in the breeding and distribution of pigs, has launched the first-ever sector-wide Water Footprint Assessment (Guoping, 2013).
2.	Spain 	• WF for agricultural production (Nieuwsberich, 2020). • H3 certification scheme (EU Fleght, 2020). • Precisions agriculture as a competitive advantage of the fruit and vegetable sector (Aldaya et al., 2019). • Establishment of the National Water Footprint. • First European country to implement WF in different socio-economic sectors (Carlos, 2018).
3.	Sweden 	• Assessment of WF in the food industry (Sweden Environmental Protection Agency, 2011). • Pan-European Atlas of Urban Water Management of the European Commission (Sweden • Environmental Protection Agency, 2011). • Global collaborative in 'Water Framework Directive' as a beginning to introduce WF initiatives (Vanham et al., 2017).
4.	Denmark 	• Establishment of the Pan-European Atlas of Urban Water Management of the European Commission (Venham et al., 2017). • Global collaborative in 'Water Framework Directive' as a beginning to introduce WF initiatives Venham et al., 2017).
5.	Finland 	• Pan-European Atlas of Urban Water Management of the European Commission (Venham et al., 2017). • Global collaborative in 'Water Framework Directive' as a beginning to introduce WF initiatives (Venham et al., 2017).
6.	Iceland 	• Pan-European Atlas of Urban Water Management of the European Commission (Venham et al., 2017). • Establishment of 'Water Framework Directive' as a beginning to introduce WF initiatives, such as water penalty and water cap (Venham et al., 2017).
7.	Canada 	• Use of Solid and Water Assessment Tool (SWAT) to assess the water footprint in agricultural products (Masud et al., 2018).
8.	United States 	• USGS released Estimated Use of Water in the United States (every five years), a national benchmark report to analyse WF (Rushforth and Ruddel, 2017). • Data in food transfer is also able to help the calculation of WF in each state (Norgaard et al., 2015; Dang et al., 2018).

No.	Country	Activities
9.	United Kingdom	• Global collaborative in 'Water Framework Directive' as a beginning to introduce WF initiatives, such as water penalty and water cap. (Tsolakis et al., 2018; Chapagain & Orr, 2008).
10.	UAE	• Preferred local dairy products compared to the Europeans due to high WF (The National News, 2020). • Establishment of Habitat Directive Policy to govern the river through sustainable use (The National News, 2020).
11.	Peru	• Reduction in WF in avocado planting, as it is one of the major export food products to Northern America (Water Footprint Network, 2015).
12.	Colombia	• Good Stuff International (GSI), and the Centre for Science and Technology Antiochia (CTA) assessed the water footprint of all river basins in a project that supported the National Institute of Hydrology, Meteorology and Environmental Studies (IDEAM), which was funded by the Swiss Development Corporation (SDC), and the CTA (Good Stuff International, 2015; Swiss Development Corporation, 2014; Water Footprint Network, 2015).
13.	Chile	• Fundacion Chile developed a methodology for WFA at the river basin scale, and piloted it in the Rapel River Basin (Good Stuff International, 2015). • WFA of agricultural production and industrial processes for wine production (Swiss Development Corporation, 2014; WFN, 2015).
14.	Mexico	• The Mexican Water Commission (CONAGUA) adopted the blue WF per product unit to measure water use efficiency. The new regulation establishes a methodology to determine the volume of efficient water use, the coefficient of efficient water use, and the direct blue WF, resulting in fiscal benefits for efficient users (Good Stuff International, 2015; Swiss Development Corporation, 2014; WFN, 2015).
15.	Argentina	• The province of Buenos Aires started to apply legislation that used the grey WF in wastewater fees by piloting projects in the Arroyo Conchitas-Canal Platanos (Good Stuff International, 2015; Swiss Development Corporation, 2014; WFN, 2015).
16.	Malawi	• WF in silk production (Hogeboom et al., 2017).
17.	EU	• Establishment of 'Water Framework Directive' as a start to introduce WF initiatives (European Commission, 2000). • Water Stewardship Programme setting international standards, such as the International Organisation for Standardisation (ISO) 14046 WF, or encouraging WF (European Commission, 2000).
18.	Bangladesh	• Development and completion of WFA of the Konabari textile cluster based on data and evidence (Islam et al., 2012). • The WFA cluster will provide the local context, whereby the buyers' and mills' WF occur, and the impacts on water resources, environment, and local communities (Islam et al., 2012).
19.	Turkey	• Establishment of water risk assessment framework for the Yaşar Group (Manufacturing) (Yasar Group, 2012).
20.	Australia	• Setting the National 2020 Vision Plan on Green City implies increasing blue water resources to irrigate green water (Miller and Peacock, 2015).
21.	India	• Inclusion of WF in India's National Water Policy (Wichelns, 2014).
22.	New Zealand	• WF in several important sectors, such as food, agriculture, and manufacturing.

4.3 Malaysia's WF Policy and Initiatives

As with other countries worldwide, WF is considered a relatively new concept in Malaysia. Although research publications on WF by Malaysian researchers can be traced back as early as 2014 (Muaz et al., 2014), the concept has yet to be embedded in any water-related policy or regulation.

In 2012, the National Water Resources Policy (NWRP) was formulated, and endorsed by the Malaysian government in response to the increasing water crises, such as water mismanagement and relatively water scarcity. The NWRP is a comprehensive document that provides the basis to support and strengthen sustainable water resources management by focusing on four pillars: water for people, water for food and rural development, water for economic growth, and water for the environment. However, there is no single mention of WF, although elements to support WF initiatives are already in place. The National Water Balance System (NAWABS) is established directly from the NWRP's vision (Muizan et al., 2017). Furthermore, the system has been proposed as a comprehensive river basin management instrument that can facilitate a coordinated planning approach to water resources development as well as provide the river basin management with a means to operate the river basin in short- to medium-term more effectively. The Malaysia Drainage and Irrigation Department is the implementing agency for NAWABS, and has selected the water-stressed Muda River basin in Kedah as the first to be incorporated into the new system. Since then, many other river basins have been included under the system.

The NAWABS comprises two main stages, which are:

i. An initial water balance study, whereby the main modelling will be developed to quantify the overall resource availability, and assess existing and future demands, including environmental needs.
ii. Incorporating developed models with a decision support system (DSS) framework, and linking to real-time, and forecast data sources provides an operational water management tool for the river basin managers.

The Water Balance Study was supported by several sub-studies, namely:

i. Demand Management Study – investigating current water use efficiencies, and how demands are influenced by economic, climate, and other factors (should include a comprehensive assessment on all water demands);
ii. Water Resources Conservation Plan – investigating how land use, and water supply/demand are linked. Recommend a land-use map (with catchment protected areas);
iii. Environmental law study – to determine environmental law requirements; and
iv. Water, energy, food nexus study – to determine the relationships between food, energy, and water in the river basin, and to determine specific WF sectors within the river basin.

An example of WFA that has been conducted as part of NAWABS was a study conducted for the Kedah river basin. Under this study, the WF of paddy cultivation was performed to provide inputs for DID on how water resources from this river basin could be appropriately managed and allocated in the future to ensure the sustainability of food-based crops. In this study, WF is related to water availability under NAWABS' scope, as shown in Figure 4.5.

The NAWABS' study, which has nine scopes, ranging from resources assessment to water allocation and utilisation, is instrumental in strengthening the water resources management, as stated under strategy B2 in Chapter 9 of the 12MP[3]. In addition, NAWABS's study scope is proposed to be broadened to provide comprehensive real-time data to assess, and balance the current and future water demand and supply (strategy B3).

[3] Strategy B2 – Strengthening governance at all levels is outlined under Priority Area B Transforming the Water Sector (12MP, p.9–18) that looks into an improvisation of integrated and effective water management at the federal, state and district levels.

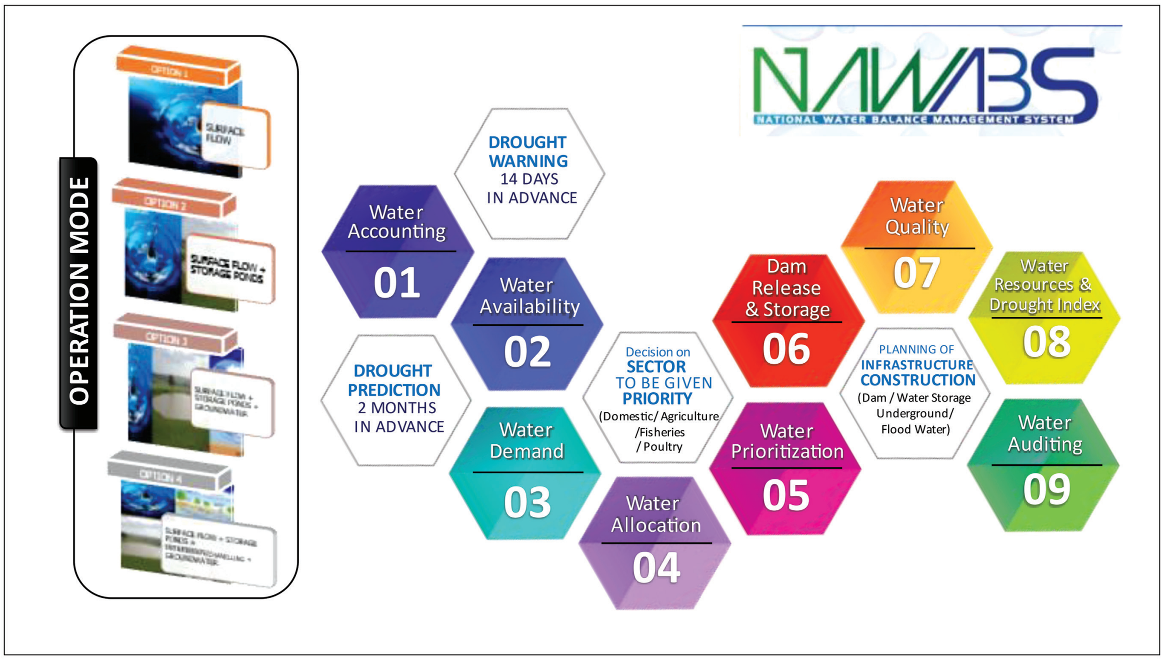

Figure 4.5. Scope of the NAWABS' Study

Besides NAWABS, WF initiatives in Malaysia could also be seen in Malaysia's involvement as an international committee that finalised and endorsed the WF Standard ISO14046 (ISO 14046, 2020). SIRIM Bhd. has set a committee comprising WF experts from various universities and institutions in Malaysia. The international standard, officially endorsed and confirmed in 2020, outlines the principles, requirements, and guidelines for assessing and reporting WF. This standard applies to products, processes, and organisations based on life cycle assessments. The ISO 14046 provides requirements and guidance for calculating, and reporting a WF as a standalone assessment, or as part of a more comprehensive environmental assessment. Following the endorsement of the ISO standard, SIRIM has also developed a Malaysian Standard for WFA, which is an identical version of the ISO 14046: 2014. However, the former is mainly intended for SIRIM's commercial use purposes. According to Ms. Isnazunita Ismail, the General Manager of SIRIM (personal communication, 25 May 2021)[4], SIRIM have developed a WF calculator that considers water scarcity index elements, and climate change parameters. By definition, the water stress index (WSI) is one of the methodologies used to evaluate the ratio of water withdrawal that deprives other water users in the same watershed area. WSI has been expanding the methodology proposed by Pfister et al. (2009), as a screening indicator or characterisation factor (CF) for water withdrawal in the Life Cycle Impact Assessment (LCIA) to measure the potential environmental, or human health damages caused by excessive water withdrawal.

Another initiative is the inclusion of WF in the National Sustainable Consumption and Production (SCP) Blueprint 2016–2030. The Pathways for SCP in Malaysia (Pathway 9, page 11), as shown in Figure 4.6 calculates WF for food and beverages. This Pathway 9 highlights the SCP communication, education, and public awareness (CEPA), and aims to develop further understanding and recommended action through these efforts.

[4] This communication took place during the "*Bengkel Cadangan Penambahbaikan Polisi & Akta untuk Menerapkan Konsep VW&WF*" on 6th April 2021 at Bangi Resort Hotel.

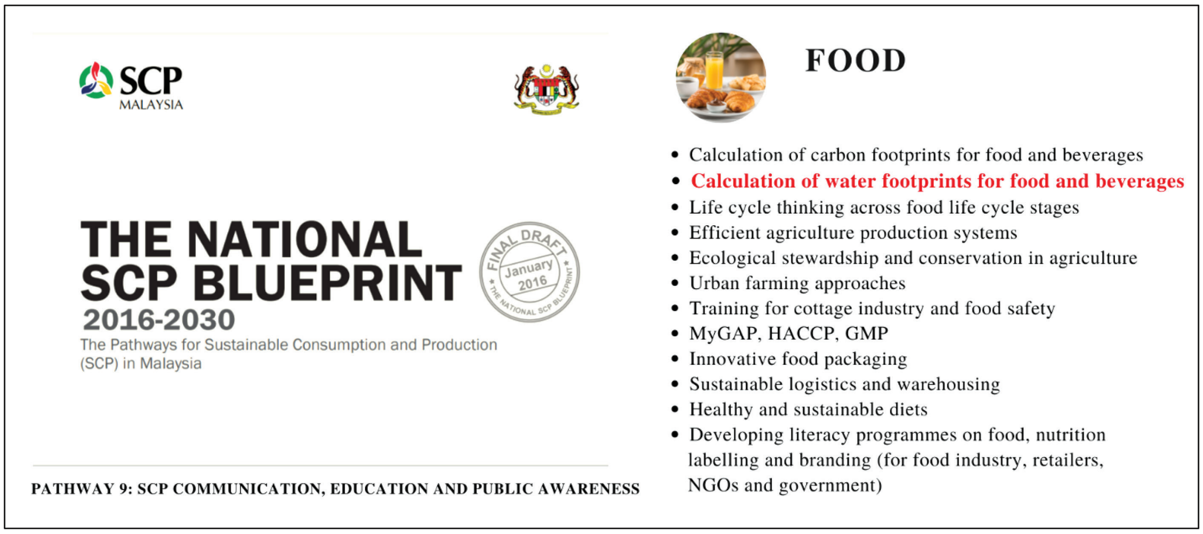

Figure 4.6. Content of Water Footprint in the National SCP Blueprint Document

4.4 Current Legislation (Federal and States) Review to Implement Water Footprint (WF) Law or Policy

The WF approach has been a part of the water policy process. Based on the growing body of literature, despite the lagging of its sustainability evaluation, WF accounting has progressed significantly in recent years. The suitability of WF in directing water management and planning has been questioned for this and other reasons. As a result of anthropogenic climate change, the rising demand for food, and the worsening of energy services, water-related problems will likely become more prominent in the global spotlight in the coming decades. They will inevitably dominate the political agenda in many countries. Almost all economic activities, and human development depend on water resources management, which should therefore be sustainable and effective. It has been agreed that the WF definition will play a constructive role in addressing global water issues, taking into account how human behaviour and consumption habits affect the planet's precious and scarce resources. In this context, the main goal of this report is to propose an alternative strategy for the WFN methodology sustainability assessment process. To that end, this report provides a comprehensive review, and suggestions to include WF as part of the current law and enactments under the federal government and state governments. There are ten federal government acts, and 23 enactments/ordinances that have been reviewed in the report for possible WF inclusion. A summary of these acts and enactments/ordinances are presented in Table 4.2.

4.4.1 Federal Government Laws

Table 4.2 reviews ten laws under the jurisdiction of the federal government that relates to WF. Laws and regulations under the federal government are mostly related to major Malaysian commodities, such as rubber, palm oil, manufacturing, tourism, and agriculture. Several laws specifically focus on major commodities, such as rubber, palm oil, and paddy. Nevertheless, these laws aim to establish organisations that manage specific commodities, such as the Malaysian Rubber Board (LGM- *Lembaga Getah Malaysia*) and the Malaysian Palm Oil Board (MPOB). Therefore, the authority under these laws is quite limited. Currently, it is challenging for the WF policy to be included in these laws.

Table 4.2. Review on Acts, Enactments, and Ordinances

No	Acts/ Enactments/ Ordinances	Review on Acts/ Enactments/Ordinances	Recommendations
1.	Malaysia Rubber Board Incorporation (1996)	1. No specific green policy in LGM Act 1996. 2. All items related to water fall under *Akta Alam Sekeliling*, acts related to *Jabatan Belan Air* (JBA) and Indah Water. 3. Currently, LGM is doing research on LCA and carbon footprint, extension of WF research can be adopted. 4. The concern is on lack of WF expertise.	1. MITI has the power for industries to put WF as part of the water management. 2. Suggestion to add WF element in regulators act, which relates to water.
2.	Malaysian Palm Oil Board 1998	VW&WF concepts could be implemented in palm oil production by establishing a special committee to assess the calculation of VW&WF in oil palm production. This committee will act as an advisor in the palm oil industry for water consumption and research purposes.	1. MPIC & MITI has the power for industries to put WF as part of the water management. 2. Suggestion to add WF element in regulators act, which relates to water.
3.	Control of Paddy and Rice Act 1994	Estimation of WF on rice is needed to evaluate the national WF in Malaysia, given the low food self-sufficiency, and high water use in agriculture. Since rice absorbs a large portion of water in Malaysia, tracing the WF of rice products, including international trade, is critical for developing a national water management policy.	1. The current act did not mention any terms of water consumption in paddy and rice in Malaysia. 2. MITI, MAFI, and local authorities will be able to put in the water consumption policy for rice production industry. 3. Suggestion to add WF element in regulators act, which relates to water.
4.	Tourism Industry Act 1992	1. My Tourism Quality Assurance: Sustainability Practices (Rainwater Harvesting). 2. National Ecotourism Plan (NEP) collaborates with NRE (*Dasar Biodiversiti Kebangsaan*). 3. National Tourism Policy 2020–2030 (sustainability and responsible tourism). 4. To encourage tourism operators to promote water tag campaigns by giving incentives, such as tax deduction, subsidy and promotion.	1. Part II Section 5. By using licensing mechanisms, the government have the power to impose virtual water calculations within the tourism industry, such as hotels, transportation and food. 2. Section 34. Power of Minister to introduce regulations. The Minister could put the WF element as part of the policy in the tourism industry.

No	Acts/ Enactments/ Ordinances	Review on Acts/ Enactments/Ordinances	Recommendations
5.	Malaysian Standard Act 1996	1. SIRIM has conducted a project on Water Stress Index (WSI) by the sub-districts level, which was funded by MOSTI in 2014. 2. A WF calculator for the agriculture sector, building (shopping malls), and industry (glove) have been developed through the project. 3. NQI Elements (Standardisation, Accreditation, Conformity Assessment, Metrology & Market Surveillance). 4. The need to have a roadmap to implement VW&WF in a complete ecosystem (government directives and governance, regulatory functions, standards, accreditation of WF certification scheme by JSM, the establishment of WF certification programme and certification bodies, testing, inspection, promotion, awareness, capacity building, incentives, and government assistance (tax exemption). 5. National Malaysian Standard. 6. Three categories of standards i. Total adoption ii. Modification (based on environment, needs) iii. Adoption from international standards MS ISO 14046:2017 (published) is readily available	1. To add WF element in regulators act, which relates to water. 2. To add a provision, the need to develop training modules on WF. 3. To review VW&WF as a complete ecosystem through National Quality Infrastructure (NQI).
6.	Water Services Industry Act 2006	1. The government has approved the terms of references (ToR) for the National Water Policy. 2. New National Water Policy will also include water management from resources to resources. 3. There are urgent needs for water management in Malaysia to put water lifecycle as part of holistic management. 4. Jurisdiction of water management is under the state government. Therefore, any amendments will need state governments' approval. 5. Water institutions in each state are different. 6. This act only has limited power on water management. 7. SPAN is a body that prepares water usage for MITI under its agency, MIDA. 8. It has been suggested that in the future, it will be centralised wastewater for new industrial areas.	1. A useful indicator, incorporating direct and indirect water scarcity into volumetric WF accounting in the water supply. 2. WF that is related to reservoir included all steps of the supply chain. The total WF should subsequently be attributed to derived products and services based on their economic values. A reservoir generally serves multiple purposes, the most common of which are hydroelectricity generation, supplying water for residential and industrial use, supplying irrigation water, regulating the flow of rivers to prevent flooding, and enabling inland navigation. 3. To put wastewater as part of the legal terms in the acts, or enactments/ordinances. 4. Wastewater needs to be put as part of the water resources under the states' jurisdiction

No	Acts/ Enactments/ Ordinances	Review on Acts/ Enactments/Ordinances	Recommendations
		9. Water tariff is currently under the federal government's monitoring. Nevertheless, it depends on the states to implement it.	5. Reuse wastewater needs to be used by companies, whereby the terms need to be included under the states' enactments/ordinances terms. 6. WF can be put under the policy as part of the terms. 7. In preparing the acts or enactments, each relevant agency needs to put the water footprint element under its regulations. 8. Suggestion to put WF provision in Section 4: water supply, sewerage system, or any part of the system. 9. Suggestion to Section 20: requirement for a class license for water supply, sewerage system, or any part of the system. 10. Suggestion to put the element under the current provision provided under Part IV: provisions relating to the water supply system, water supply services, sewerage systems, and sewerage services.
7.	Environmental Quality Act 1974	1. The Minister may, after consultation with the Council, by order prescribe the vehicle or ship used for the movement, transfer, placement, or deposit of wastes. The use of which by any person shall, unless he is the holder of a license issued in respect of the prescribed conveyance, be an offence under this Act. 2. Notwithstanding any other provisions to the contrary, the Director-General may, by notice, direct the owner or occupier of any vehicle, ship, or premises, or aircraft to emit, discharge, or deposit environmentally hazardous substances, pollutants or wastes during such periods of the day as he may specify, and may generally direct the manner in which the owner or occupier shall carry out his trade, industry or process, or operate any equipment, industrial plant, or control equipment therein. 3. The Minister may, after consultation with the Council, by order published in the Gazette specify the circumstances, whereby the Director-General may issue a prohibition order to the owner or occupier of any industrial plant or process to prevent its continued operation, and release of environmentally hazardous substances, pollutants or wastes either absolutely or conditionally, or for such period as he may direct, or until requirements to make remedy as directed by him have been complied with.	1. The implementation of VW in this act is from the aspect of VW flows from and to Malaysia. 2. Input-output approach to evaluate the WF.

No	Acts/ Enactments/ Ordinances	Review on Acts/ Enactments/Ordinances	Recommendations
		4. Any person who contravenes this section shall be guilty of an offence and shall be liable to a fine not exceeding one hundred thousand ringgit, or imprisonment for a period not exceeding five years or both, and to a further fine of one thousand ringgit for each day the offence is continued after a notice by the Director-General, requiring him to comply with the act specified therein has been served upon him.	
8.	Waters Act 1920 (Amendment 1989)	1. Water scarcity problems at various scales and levels of governance. 2. Economic principles like pricing and cost recovery. 3. Moving water to people (infrastructure), moving people to the water (zoning, resettlement), importing food (virtual water), and demand management (saving water). 4. Water management in the face of the growing regional water shortages.	1. To include WF provision under the current water supply provision provided in Part IV (Provision relating to water supply, services, sewerage systems, and sewerage services) Section 45 – 51.
9.		SPAN, Act 654	Suggestion to include WF provision under these sections: 1. Section 15 (b) - Functions of the Commission. To implement and enforce the water supply and sewerage services laws, and to consider and recommend reforms to the water supply and sewerage services laws; 2. Section 15 (c) To ensure the productivity of water supply services and sewerage services industry, and monitoring of operator compliance with stipulated service standards, contractual obligations, and relevant laws and guidelines; 3. Section 26 The Commission may, with the approval of the Minister, adopt with such modifications as it deems fit any regulations, rules, policies, circulars, and directives enacted, or issued by the federal government in relation to any matter under this Part.

No	Acts/ Enactments/ Ordinances	Review on Acts/ Enactments/Ordinances	Recommendations
			4. Section 15 (c) To ensure the productivity of water supply services and sewerage services industry, and monitoring of operator compliance with stipulated service standards, contractual obligations, and relevant laws and guidelines; 5. Section 26 The Commission may, with the approval of the Minister, adopt with such modifications as it deems fit any regulations, rules, policies, circulars, and directives enacted, or issued by the federal government in relation to any matter under this Part.
10.	Town and Country Planning Act 1976	Water provision is only emphasised in the following statements: 1. Land covered by water 2. Term for utilities, including water. 3. Definition of land, which also includes water. 4. Water bodies for development proposal report.	1. A closely related concept is the WF, which is the total VW content of products consumed by an individual, business, town, city, or country. 2. The WF based on environmental input and output analysis (EIOA) can be used as a means to identify the 'hidden' water consumers along the whole supply chain, and for balancing the supply and demand of water resources. 3. Scaling of WF amongst cities under local authorities. 4. The knowledge gathered can be used by regional policymakers to develop efficient and practical approaches to mitigate water scarcity, ensure safe water supply use, and ensure food security. 5. To add water provision under planning control, which was provided under Part IV. 6. To add WF provision under Section 21A (Development Proposal Report).

No	Acts/ Enactments/ Ordinances	Review on Acts/ Enactments/Ordinances	Recommendations
11.	Natural Resources and Environment Ordinance 1993 (Amendment 2019) (Sarawak)	1. Water resource in state constraint for future socioeconomic development and eco-environmental conservation. The severe water pollution and inadequate wastewater, and sewage processing facilities will result in intense pressure on sustainable utilisation. 2. Capacities of wastewater treatment plants are insufficient to treat entering rainwater and excess wastewater, unforeseen nonpoint source pollution occurs, and rivers and lakes are exposed to existing endogenous pollution.	1. To include WF definition and concept in Section 5 of the function and powers of the Natural Resource Board.
12.	Conservation of Environment Protection Enactment 2002 (Sabah)	Encouraged conservation tillage practices, or the set-aside of arable land, and maintained food production without intensifying the land use.	Suggestion to include WF terms and definition under Part II (Conservation of Improvement of Natural Resources).
13.	Sabah Town and Country Planning Ordinance Caption 141 (Amendment 2019)	Most relevant with States Planning Scheme, which is under the purview of local authorities	1. Elements of WF could be added under Section 4C (Sabah Cap. 141).
14.	Sarawak Local Authorities Ordinance 1996	Most relevant with States Planning Scheme, which is under the purview of local authorities	1. To add a definition of WF under the current Section 139 (Environment and Landscaping). 2. To empower local authorities to control water consumption amongst industries.
15.	i. Selangor Mining Enactment (2000) ii. Kedah Mining Enactment 2003 iii. Kelantan Mining Enactment 2001 iv. Perak Mineral Enactment 2003 v. Johor Mineral Enactment 2003 vi. Terengganu Mineral Enactment 2002 vii. Melaka Mineral Enactment 2002 viii. Pahang Mineral Enactment 2001	In mineral processing, quantification of blue and grey WF is useful for effective management of direct and indirect water use across the supply chain. In particular, WF analysis is required to reduce water consumption and improve the mining industry's perception of the water value.	1. To add WF terms under Part VII (Water Provision) (Selangor). 2. To add WF terms under Part VIII (Water Provision) (Kedah). 3. To add WF terms under Part VII (Water Provision) (Kelantan). 4. To add WF terms under Part VIII (Water Provision) (Perak). 5. To add WF terms under Part VII (Water Provision) (Johor). 6. To add WF terms under Part VIII (Water Provision) (Terengganu). 7. To add WF terms in Part VIII (Water Provision) (Melaka). 8. To add WF terms in Part VIII (Water Provision) (Pahang).

No	Acts/ Enactments/ Ordinances	Review on Acts/ Enactments/Ordinances	Recommendations
16.	i. Johor Water Supply Enactment (1993) ii. Kedah Water Resources Enactment (2008) iii. Sabah Water Supply Enactment 1998 iv. Sarawak Water Ordinance 1994 v. Penang Water Supply Enactment 1998 vi. Negeri Sembilan Water Supply Enactment 1997 vii. FMS Water Supply Enactment (Cap 203) (Pahang) viii. Terengganu Water Supply Enactment 1998 ix. Kelantan Water Supply Enactment 1998 x. Water Supply (Federal Territory of Kuala Lumpur) Act 1998	1. Responsibility for water resources. 2. Control of use and flow of water. 3. Licensing, as a controlling method. 4. Water costing/charging. 5. Management plan. 6. Control demand management.	Johor In the process of upgrading to the state water board. Kedah Expand the definition of water in Part V (Water Consumption) by adding the WF terms and definitions. Pahang Part IX (*Pelbagai*) by adding WF terms and definitions.
17.	Enactment Selangor Water Management Corporation (Enakmen Lembaga Urus Air Selangor) (Amendment 2020)	1. Responsibility for water resources. 2. Control of use and flow of water. 3. Licensing, as a controlling method. 4. Water costing/charging. 5. Management plan. 6. Control demand management.	Section 40 (1) Notwithstanding anything contained to the contrary in any other written law, the Authority shall be responsible for the regulation and control of all water sources, including but not limited to the sustainable development, management, use, and conservation of the water sources. Section 40 (2) Where any other public authority or private operator has been given any task or responsibility similar to subsection (1) by the State Authority, or under any other law, it shall continue to exercise its functions, but to coordinate its activities with the Authority. Section 41 (1) Notwithstanding anything contained to the contrary in any other law, the Authority shall exercise, and flow supervision and control over the use and flow of water in any water source, and whether occurring naturally on the surface or subsurface of the ground.

No	Acts/ Enactments/ Ordinances	Review on Acts/ Enactments/Ordinances	Recommendations
			Section 41 (3) (a to i) In the exercise of the powers conferred by subsection (1), the Authority may take such measures as it thinks fit for: a) the conservation, replenishment, and supply of water. b) the equitable distribution of water. c) the beneficial use of water. d) the protection of water from pollution, and the improvement of its quality. e) preventing any unauthorised interference with the flow, or availability of water. f) preventing the unauthorised obstruction of a water source, or the diversion of the course of a watercourse. g) preventing the carrying out of any unauthorised works. h) in consultation with the relevant public authority, the mitigation and control of flooding. i) protection of the environment. Section 44 (1) The Authority may, with approval of the State Authority, by notification in the Gazette, impose a charge on: a) the use of water, or any other resource from any water source, including but not limited to the abstraction, extraction, discharge, drainage, diversion, and impoundment of such water, or other resources, and b) the return of water or discharge of waste, effluent or any polluting matter into any water source. Section 46 (1) Notwithstanding anything to the contrary contained in any written law, the Authority: a) may draw up and implement an integrated management plan for the conservation and sustainable development of any water source.

No	Acts/ Enactments/ Ordinances	Review on Acts/ Enactments/Ordinances	Recommendations
			b) shall advise any public authority, within which jurisdiction any water source or part thereof occurs, on matters pertaining to the management, conservation, and development of the water source. c) shall report annually to the State Authority on the status of compliance with federal and state laws, and regulations and plans on all water sources in the state. d) may establish local area management committees and stakeholder groups to work with the authority. e) advice the State Authority on the demarcation of river reserves and other zones of protection. f) may regulate the development of any dam, reservoir, or impoundment on any water source. Section 49 (1) Notwithstanding anything to the contrary contained in any written law, the Authority may, by notice in writing, order any person or public authority to: a) prevent water taken from a water source from being wasted or improperly used; and b) take, within a specified time, specified measures, or precautions to protect the quality of water in the water source. Section 127 The Authority may, with the approval of the State Authority, by notification in the Gazette, make such rules or regulations, as may appear to be necessary or expedient for carrying out the provisions of this enactment, and without prejudice to the generality of the foregoing, for all or any of the following matters: Sub-section g: Measures for efficient management practices in conserving, augmenting, and distributing resources. Sub-section h: Resource use efficiency and conserving. Sub-section m: Recycling of water.

Nevertheless, some efforts could be initiated in several industries under the purview of these acts. For instance, under the Malaysian Rubber Board Incorporation Act (1996), the green policy covering all sustainability elements could be embedded in future act amendments. However, for a short-term strategy, the research could be undertaken as part of the research activity in the Malaysian Rubber Board agency. Currently, research has only been limited to LCA and carbon footprint, and this is due to the lack of the countries' expertise in WF research area. Therefore, WF research could be undertaken under the Malaysian Rubber Board's research activity.

Consequently, it will help to strengthen the effort to implement WF policy under the Malaysian Rubber Board Incorporation Act (1996). In addition, the rubber industry, one of the major commodities in Malaysia, has accelerated the growth of rubber factories. These factories are under the jurisdiction of the Ministry of International Trade and Industry (MITI). MITI authorises manufacturing license (ML), policy on import of tyres, tax exemption under the Promotion of Investment (PIA) and Income Tax 1967, and import duty exemption. Furthermore, these factories are also under the monitoring of local authorities (LAs), which can control the general water consumption. Therefore, MITI could play its role in water management, while WF could be part of the significant area observed under water management for factories. MITI's policies, such as ML, could be imposed on the factories, mainly to put WF as part of the manufacturing process requirement. Even though the natural rubber industry can generate substantial income, several different natural resources are needed for resource provision and water consumption along the life cycle chain from the plantation to the final product. The WF of rubber products has never been calculated. Therefore, the WF of rubber products should be increased to help the growth of the rubber industry in the long run.

Another industry that contributes significantly to Malaysia's economic growth is palm oil. Similar to the rubber industry, the palm oil industry's current law aims to establish the governance aspect of MPOB. Nevertheless, the effort to increase WF awareness can be achieved under the current act. Under the current act, several terms, such as oil palm product, conveyance, machinery, contrivance, and equipment could relate to putting WF as part of the process.

VW&WF concepts could be implemented in palm oil production by setting up a special committee to assess the calculation of VW&WF in palm oil production. This committee will act as an advisor in the palm oil industry for water consumption and research purposes. Palm oil WF accounting and irrigation management indicators can be used as a diagnostic tool to identify the hotspots of irrigated palm oil plantation systems. Specific actions also need to be defined to improve water use efficiency and reduce water abstractions, and polluted water returns while maintaining production rates. In the palm oil industry, the Ministry of Plantation Industries and Commodities (MPIC) also has its legislation for palm oil production in Malaysia, especially for its milling process. MPIC, together with MITI, could embed the WF concept in the palm oil production process.

The paddy industry has become the most important industry in Malaysia due to its position as food security. Therefore, implementing the WF concept in rice production is essential to ensure the industry's sustainability. In Malaysia, the paddy industry is under the control of the Padi and Rice Act 1994. In general, this act allocates the authority for the federal government to take action on any misconduct in rice supply as well as marketing, demand and supply, anti-monopoly control, and sales. An estimation on the WF of rice is needed to evaluate the national WF in Malaysia, given the low food self-sufficiency, and high proportion of water use in agriculture. Since rice absorbs a large portion of water in Malaysia, tracing the WF of rice products, including international trade, is critical for developing a national water management policy. Like other major commodities' acts in Malaysia, no single area mentions the WF concept or general water consumption. Therefore, for WF to be included in the current act, general water consumption allocation terms need to be highlighted. In this case, several agencies can play a major role in the Ministry of Agricultural and Food Industry (MAFI), local authorities, and MITI, whether to amend the current act or put in the policies. For instance, incentives to use capital on higher-value crops and more productive manners can be included in the policy.

Furthermore, water allocation and management institutions that are functional and effective are expected to put adequate strategies into effect. Both MITI and MAFI could put this under each jurisdiction in the paddy and rice production. Paddy farmers need to be aware of water consumption, which consequently WF concept could take effect. If farmers are not aware of this or the intricacies of the process, encouraging them to do so with accurate information and infrastructure are essential to water management and policy interventions.

Another sector contributing significantly to Malaysia's economic growth is the service sector, particularly the tourism industry. Being the third biggest GDP contribution to the local economic growth, the tourism industry will play a role in participating on awareness of the WF policy in the industry. The Malaysian tourism industry operation is under the purview of the Ministry of Tourism, Arts and Culture (MOTAC) under the Tourism Industry Act 1992. This act allocates the Ministry in terms of tourism licensing, hotel operators, tourist operators, registration, accommodation, and tourism training institutions. MOTAC also has several policies, namely My Tourism Quality Assurance, National Ecotourism Plan (NEP) (in collaboration with the Department of Environment, Ministry of Environment and Water), and National Tourism Policy 2020–2030 (sustainability and responsible tourism). Therefore, the term WF could be put as part of the statement under these policies. For example, in My Tourism Quality Assurance, the rainwater harvesting concept has been implemented to create awareness in terms of water consumption amongst tourism operators. Another measure to put WF in the act or policies is by using licensing mechanisms. The government would have the power to impose VW calculations within the tourism industry, such as hotels, transportation, and food.

Given the rising resource demand and increasing water scarcity, water usage and management are critical concerns for any country. Water management is essential at the local, regional, and global levels, requiring a standardised assessment method. The Malaysian Standards (MS) current practice is based on the following categories:

a) Total adoption
b) Modification (based on environment, needs)
c) Adoption from international standards

The ISO 14046 is a modern WF standard that will offer clarity and integrity of WF performance based on the international standard that lays out the standards, criteria, and guidelines for calculating and reporting WF. Based on life cycle evaluations, this will refer to goods, systems, and organisations. As a stand-alone assessment, or as part of a more extensive environmental assessment, the ISO 14046 can provide criteria and recommendations for measuring and disclosing a WF. Being one of the agencies that monitor MS, SIRIM has conducted a Water Stress Index project at the sub-districts level funded by the Ministry of Science, Technology and Innovation (MOSTI) in 2014. This project developed the water footprint calculator (WFC) for the agricultural sector, shopping malls, and glove industry. Despite this, the project did not identify WF under the different WF categories, namely blue water, green water, and grey water. The current ISO 14046 on WF is sufficient for local industries to implement WF in the industry. Nevertheless, some activities need to be supported to ensure all stakeholders can comprehend the standard. This includes establishing training modules for WF based on the ISO 14046 as well as certification programmes.

Furthermore, it is also necessary to devise a roadmap to implement WF in a complete ecosystem. The ecosystem involves government directives and governance, regulatory functions, standards, accreditation of WF, certification scheme by Malaysian Standard Department (JSM), the establishment of

WF certification programme by certification bodies, testing, inspection, promotion, awareness, capacity building, incentives, and government assistance, such as tax exemption incentive. In addition, there is also a need to preview WF as a complete system through the National Quality Infrastructure (NQI). The main trusts are standardisation, accreditation, conformity assessment, metrology, and market surveillance. Competitiveness in national and foreign markets is ensured by quality certification, the price of goods and services, and how they are delivered. Malaysian industries will retain their national markets by remaining competitive. It is believed that WF will complement the current role of standards in NQI in an effort for our industries to become more competitive.

From the perspective of legislation allocation for environmental protection and water industry and sustainability, Malaysia has already committed to championing this agenda. Several acts relating to the environment include the Environmental Quality Act 1974, Water Service Industry Act 2006 and Water Act 1920 (Amendment 1989). For instance, the Environmental Quality Act has put aside allocations to the ministry from all aspects of the environment from factories, transportation, plant and machinery, industrial plants, and waste. The relationship between WF and the environment is very high. Environmental acts can be used to measure in aggregated metric, which is a rough measure of the effect of human consumption on the natural water climate. For example, one should consider what constitutes blue versus green water use, as blue water use often has a more significant environmental impact than green water use. Therefore, as the Environmental Quality Act is under the federal government's jurisdiction, the amendment of this act is from the aspect of VW flows from and to the country to measure the input-output approach, especially in evaluating WF. In Malaysia, the Water Act 1920 (Amendment 1989) aims to provide for rivers and streams. Under this act, all properties in and the power over all rivers in any state is and shall be exclusively vested in the ruler of that state. As a result, the act provides for the restoration of river banks in private property intervention. Water extraction from rivers for private, domestic, commercial, or other purposes, or rice farming, and any other action affecting rivers, are both prohibited. This act is essential for WF due to the rising number of violation cases on environmental flows of natural freshwater ecosystems. Assessing WF at the river basin level is a crucial step in understanding how human activities affect natural water cycles, and a foundation for integrated water resource management and sustainable water usage.

Another act related to the country's water management is the Water Services Industry Act 2006 and SPAN Act 654. These acts allocate the authority of water operators, which belong to the states. This act seeks to establish a licensing and regulatory system for regulatory activity in the water supply and sewerage services industries to promote national policy objectives. Peninsular Malaysia, as well as the Federal Territories of Putrajaya and Labuan, are covered. The act establishes the standards and procedures applications for individual, or class licenses, and the licensee's duties and obligations. Owners of public water supply and sewerage systems as well as those who provide treated water, or sewerage services to the public, are issued individual licenses. However, owners of private water supply and sewerage systems as well as those who provide treated water, or sewerage services for personal use only, are issued class licenses.

Furthermore, this act establishes guidelines for managing Malaysia's water supply and sewerage systems and facilities. It empowers the Malaysian National Water Services Commission to supervise and control these services. The act also covers consumers' rights, dispute resolution, rates, costs, and deposits for water supply and sewerage facilities, the creation of an Appeal Tribunal, establishing a Water Industry Fund and a Sewerage Capital Contribution Fund as well as other provisions. The suggestion to improve these acts that are closely relevant to water, highlights the importance of water scarcity problems at various scales and levels of governance. Furthermore, this act also could highlight several aspects of water, such as moving water to people (infrastructure), moving people to the water (zoning, resettlement), importing food (virtual water), and demand management (saving water). Most importantly, this act also emphasises on economic principles, such as pricing and cost recovery, and waste management in the face of the growing regional water shortages.

VW has a significant impact on other aspects of economics, such as business and finance. For instance, the Companies Act 2016 covers all aspects of company law in Malaysia. Under this act, the government could impose a VW&WF calculator for companies under several categories identified to consume lots of water in the products, such as in food-based companies. The WF allows examining water consumption habits and converting them into more environmentally friendly water practices. WF resources help to understand better on the relationship between water use, economic growth, and social and environmental issues. However, since WF is a relatively new research area, most people are unfamiliar with the term.

Another aspect of water management is the role of local authorities (LAs) in Malaysia. As water demand is highly related to the communities, therefore the role of LAs is very significant. Therefore, the Town and Country Planning Act (1976) was able to play an important role in putting WF elements that can directly target communities. Under this act, a closely related concept is the WF, the total virtual water content of products consumed by an individual, business, town, city, or country. For LAs, it can identify hidden water consumers along the whole supply chain, especially under LAs jurisdiction. LAs can also be used under this act to identify, whereby local water resources are used through food trade networks and scaling of WF amongst cities. The knowledge gathered can be used by regional policymakers to develop more efficient and practical approaches to mitigate water scarcity, thereby ensuring safe water supply use and food security.

4.4.2 Enactments/Ordinances Reviews - States

The responsibility of water management in Malaysia is under the jurisdiction of each state in Malaysia. Article 74 of the Federal Constitution empowers the federal government to pass legislation relating to the Federal List, part of the Federal Constitution's Ninth Schedule. Clause 11 specifically gives the federal government authority over water sources, rivers, and canals, while excluding matters relating to one state or governed by an agreement between all the states concerning development, distribution, and water supply. This law limits the federal government's authority over water that falls through two or more states (Kader 2004). Furthermore, the federal government's authority is limited to cases involving shared waterways, with interference permitted only when the states' negotiations have reached a stalemate.

Under Clause 6 of the State List in the Ninth Schedule of the Federal Constitution, state governments are given equal legislative authority. In view of Article 74 of the Federal Constitution, this includes water (including rivers and canals, but excluding water sources and services), management of silt, and riparian rights, all of which are subject to the Federal List. If the power supply is entirely within the territory of a state, the state has complete control over the water. Furthermore, the Concurrent List empowers the federal and state governments to pass legislation relating to drainage and irrigation, and water sources and utilities, subject to the Federal List.

Sabah and Sarawak Ordinances have their own ordinance, which slightly differs from other states in Malaysia. For instance, the Sarawak's Natural Resources and Environment Ordinance 1958 (Amendment 2005) and Sabah's Conservation of Environment Enactment 2002 differ from Malaysia's ordinance. This ordinance is aimed to protect the environment in Sarawak, including several related environmental issues, such as conservation, pollution, recycling, sewage, waste, and emission. WF could be embedded in this ordinance under water resources in both states with constraints for future socioeconomic development and eco-environmental conservation. WF in grey water also relates to the pollution resulting from inadequate wastewater and sewage processing facilities, resulting in severe pressure on sustainable utilisation. In addition, capacities of wastewater treatment plants are insufficient to treat entering rainwater excess, unforeseen non-point source pollution occurs, and rivers and lakes will be exposed to existing endogenous pollution. Consequently, it will affect the blue water, which is an essential component in WF. This act could also relate to WF from the perspective of food security, which can strengthen the conservation tillage practices, or the set-aside of arable land and maintain the food production without intensifying land use.

State's water enactments are the most significant legislation to implement the WF agenda. These enactments are directly involved with WF activities and policies. In Peninsular Malaysia, some enactments that relate to water are as follows:

i. Selangor Water Management Authority Enactment (1999)
ii. Pahang Rivers Enactment
iii. Kedah Water Resources Enactment (2008)
iv. Penang Water Supply Enactment (1998)
v. Negeri Sembilan Water Supply Enactment (1997)
vi. Johor Water Supply Enactment (1993)
vii. Terengganu Water Supply Enactment (1998)
viii. Water Supply (Federal Territory of Kuala Lumpur) Act (1998)

These enactments are very significant to water resources, especially under the blue WF initiative. In addition, these enactments control the use and flow of water in each state. In scientific communities, new paradigms, and methods, such as WF and green and blue water, have emerged to encourage effective, equitable, and sustainable water use. These paradigms are thought to break new grounds for water resource planning and management. Therefore, the advancement of the WF definition has been a significant step forward in this direction. However, current methodologies focus mainly on the quantity of water used rather than its associated impacts. Therefore, refinement on the enactments can allow the authority to control the use and flow of water. To strengthen this act, the revised enactments should highlight licensing as a controlling method of water use, especially to water operators. These companies need some management plan and control demand management plan to ensure the agenda of water sustainability can be achieved, and thus leading to positive impacts on the WF agenda.

Changes in the resource's quality or quantity are the root of water-related business risks. Risks are then manifested in reputational harm, costs, regulatory adjustments, and eventually, the bottom line. Water is not only used at the primary production site, but it also has varying degrees of strength across the entire supply chain. Currently, all water enactments have similar contents, which aim to establish water management in each state. Therefore, the WF elements could be added under the water provision depending on each state's enactment section in the enactments. Amongst all states in Malaysia, Selangor has the most comprehensive water enactment, which covers the dynamics of Selangor water management, including water resources in terms of taking responsibility for water use and flow, licensing as a controlling method, water costing/charging, management plan and control demand management. Under this enactment, the WF provision could also be added in other sections, including Section 40, Section 44, Section 46, Section 49, and Section 127 (Table 4.2).

Water, along with agriculture, forestry and property, is included in the State List. As a result, the state authority becomes the supreme authority on all matters relating to water. Local government is a subject covered by the State List, giving the state authorities the power to organise local councils and public services. Local councils in Malaysia, which are established under the Local Government Act 1976 (Act 172), Sabah Town and Country Planning Ordinance Caption 141 (Amendment 2019) and Sarawak Local Authorities Ordinance 1996, are primarily responsible for the health, sanitary conditions, services and general well-being of their residents as well as the administration of other environmental matters under the powers conferred by Act 172, such as environmental pollution. Despite their reliance, the management of the planning system and development regulation is solely the responsibility of the state and local government. The state authorities are in charge of organising local government and municipal services and they serve as the local central government. In Malaysia, the local authority is the primary government body with the power to exercise control at the local level. Additionally, Act 172 stated that the goal of fostering uniformity is by putting a heavy burden on the federal government for funds and other resources in the planning law in the West Peninsular Malaysian states, however there is a lack of uniformity in the administration of town and country planning laws in the states of Malaysia.

Concerning the WF, local authorities can play a role in the development plan, whereby it can avoid any development that could jeopardise the water resources areas and negatively impact the environment. Another perspective from the local authorities concerning the inclusion of WF in the policies or laws is the authorisation to control water consumption amongst industries in the local authorities' jurisdiction area. This measure will allow local authorities to obtain data regarding water consumption amongst industries. In addition, local authorities can also incorporate the water provision, which includes WF, within the process to get any development approval, especially for commercial and industrial projects.

Forest management is also under the jurisdiction of the states in Malaysia. Although each state has the authority to establish its own forestry laws, Malaysia has two major forest policies governing forestry activities; the National Forestry Act 1984 and the National Forestry Policy 1978 and all subsequent amendments. These measures are intended to protect forest management areas from illegal logging, unauthorised settlement and other prohibited activities. Different laws represent the need to protect forest management areas from unauthorised activities in different states, namely Sabah and Sarawak. Knowing the laws and policies of Sabah and Sarawak is recommended since they are the two largest states and have the most forest coverage. The prevailing state laws in Sabah are the State Forest Policy 1954 and the Forest Enactment Policy 1968. The Sarawak Statement of Forest Policy 1954 as well as the Forests Ordinance 1954 (Chapter 126, Part II [Forest Reserves] and Part III [Protected Forests]), regulate the forestry operations.

Concerning the WF, some of the main commodity products are based on forest-based products. Therefore, it is significant to impose a mechanism on water requirements by incorporating blue and green water components under these acts. This mechanism will further improve conservation measures, demand management on forest-based products and improve water use. In addition, green water management needs to be taken into consideration when developing water conservation strategies. By incorporating blue and green water components of the hydrologic cycle and the efficiency of the water management system to determine water requirements, it will assist in the production and consumption of forest-based products within and between regions in the state. Furthermore, the green water system in WF includes water consumption of forests, which is deemed necessary to maintain a terrestrial ecosystem in a forest ecosystem.

Mining is also under the state's jurisdiction. All states in Malaysia have their own mining enactment, which generally follows the National Mineral Policy. Regardless, it is critical to note the minor differences between the small and medium-sized enterprises (SMEs), especially in the operational and administrative aspects. The State Director of the Lands and Mines Department, a sub-division of each state land office, is responsible for issuing licenses and mining leases. In mineral processing, blue WFs can quantify direct and indirect water use across the supply chain. Therefore, tailored management of water resources is required to reduce water consumption and further develop the mining industry's perception on the value of water. Furthermore, water supplies are recognised as one of the most critical resource forms in the past and for the future. The best way to ensure water supply security is to look at water use at the state and national scales. Overall, the ten federal government acts and 23 enactments/ordinances have been reviewed and Figure 4.7 illustrates the different sectors in which WF can be incorporated.

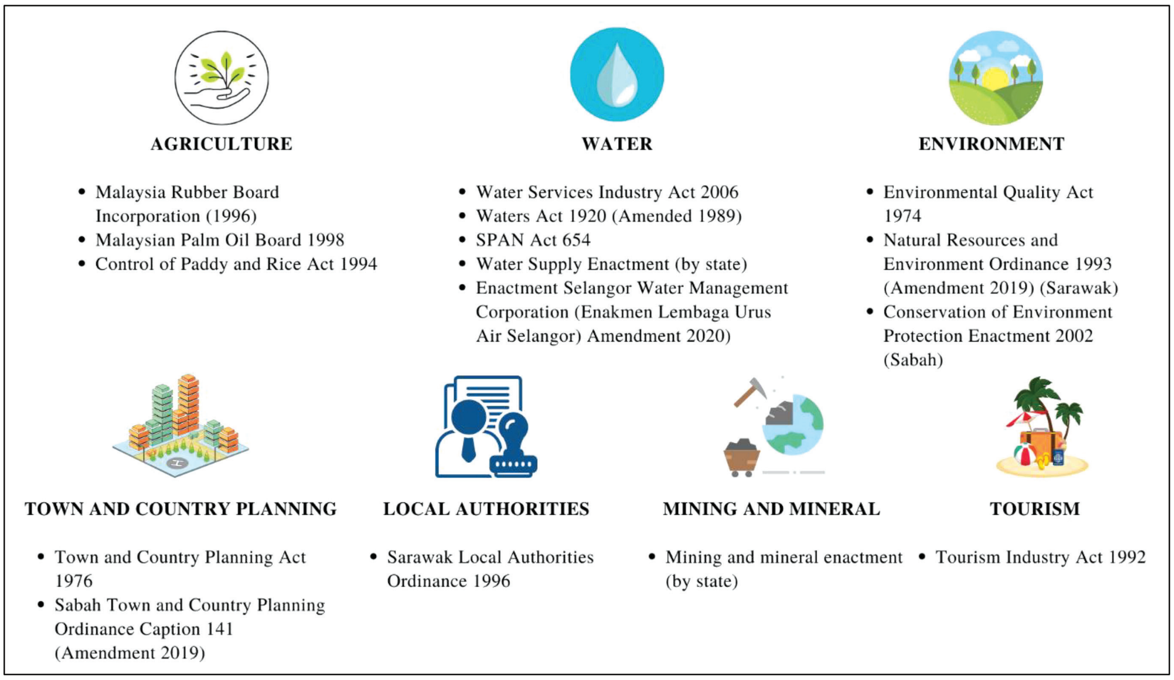

Figure 4.7. Possible Inclusion of WF Accounting in Various Sectors

As shown in Figure 4.7, there are six sectors in which WF accounting can be incorporated, including agriculture, water, environment, town and country planning, mining and mineral and tourism as well as the governance from local authorities. Now, more than ever, there is a compelling case to be made for a holistic approach to water management that addresses internal processes and supply chains and the population and ecosystems in which these activities connect. Businesses will make better management decisions and work with a broader range of stakeholders to solve problems beyond their immediate sphere of control if they are mindful of and appreciate the water challenges they face. The national policy has always been very supportive of the development of related industries. However, a better understanding of WF values of rice production in Malaysia is now critical to inform policy decisions about water management.

5.0 The Economic Aspects of Virtual Water (VW) and Water Footprint (WF)

The need for water demand has increased due to the rapid growth of the agricultural, manufacturing and tourism sectors. These are the major sectors in Malaysia that have contributed to Malaysia's economic growth for several decades. The export and import values for major commodities in Malaysia are illustrated in Figure 5.1. It is anticipated that export growth in Malaysia will accelerate as Malaysia's economy is still less diversified in terms of the domestic economy. Malaysia's export commodities should be diversified to develop greater social and economic cooperation with the rest of the world (Arip, 2010). For instance, processed palm oil products are still underexplored due to a small domestic market in the palm oil sector. According to Lebdiou (2020), efforts to promote value addition through palm oil refining were met with considerable market barriers favouring the status quo and discouraging domestic value addition. Besides, in the dynamic industry growth, palm oil products still require more time to materialise. For this reason,

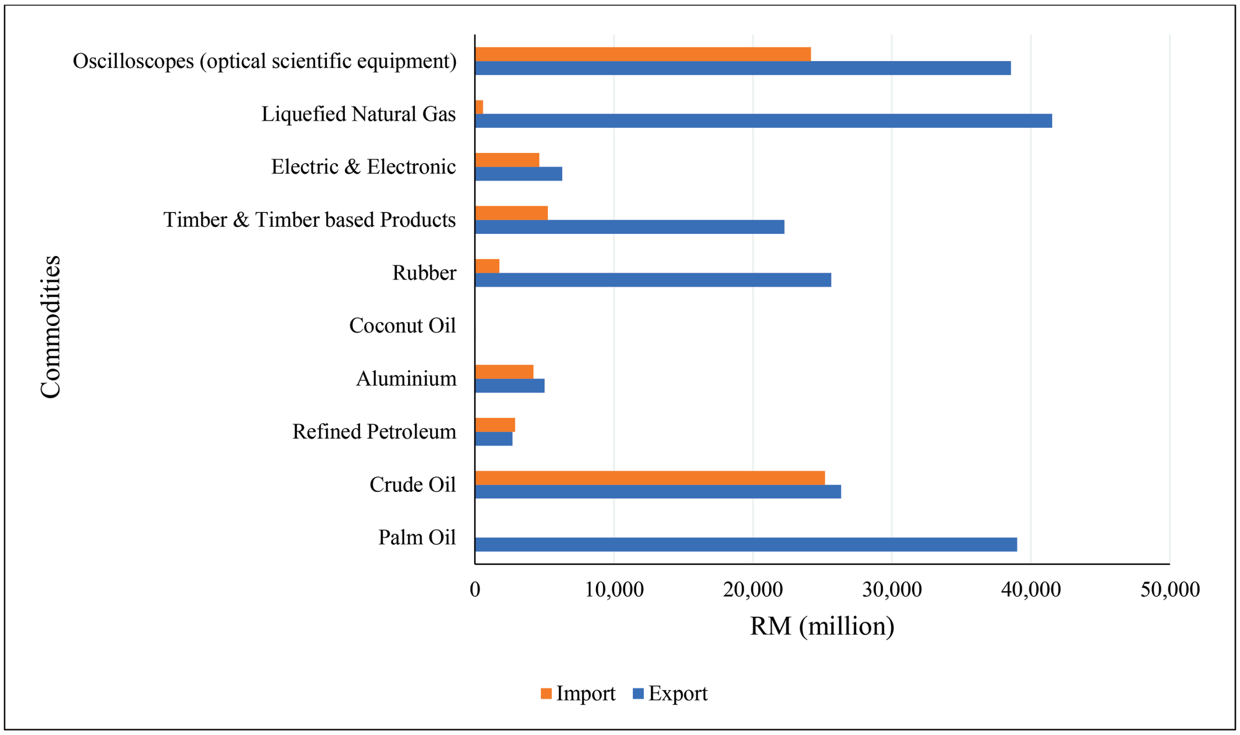

Figure 5.1. Export and Import Values of Major Commodities in Malaysia for the Year 2019

Source: Authors' compilation from DOSM, MPOB, World Bank and OECD (2019)

along with high population growth and socio-economic development, a further increase in water demand is expected.

To ensure the sustainability of the Malaysian industry, a comprehensive study on VW&WF is needed. The study's findings will enable the industrial sector to better understand future water challenges requiring stern action, such as water scarcity mitigation and systematic water distribution. Furthermore, VW transfer has been identified as one of the mechanisms to match the demand for water-intensive products, especially in water-rich countries like Malaysia. Although Malaysia is under the category of a water-abundant country, it is important to examine VW&WF due to Malaysia's high intensity of export products, especially in the manufacturing sector. In the international market, Malaysia contributes between 1.1% and 1.3% of the global trade market. The global concern on water resources has led to the concern on the concept of VW. VW transfer occurs when products made in one region using its local water resources are exported to another region for consumption (Zhang et al., 2019). Apart from the term VW or embedded water introduced by Allan (1998), other studies (Dietzenbacher & Velazquez, 2007) have also referred to VW flows as the water resources that are virtually transferred through trade between regions. According to Hassan et al. (2017), agricultural products have the highest water volume in production. Therefore, a country that exports agricultural commodities has the highest VW. This is because VW in agricultural products has been extracted from domestic sources, especially during the phase, whereby products are getting ready to be exported.

Countries that import water-embedded products are very likely to purchase water in virtual form when the water could have been used for other purposes (Gawell & Bernsen, 2011). A suggestion has also been proposed by Hassan et al. (2017), who advocated that VW trading should be encouraged to promote global water redistribution. Chen and Chen (2013) also acknowledged that trade plays a significant role in redistributing water resources between countries because VW embodied in international trade is equivalent to nearly one-third of global water withdrawal.

Data on VW&WF will provide information for Malaysia in terms of VW&WF profiles for major commodities and the impact on water management. The commodities input and output will create a network and the water input data, namely the water flow of the export and import destinations. This includes trade structure, especially for water-scarce countries, to increase water-intensive import to reduce local freshwater dependency. Consequently, it can also strengthen the water sector in Malaysia as a new economy that can create more job opportunities in the future.

5.1 Economic Indicators

An economic indicator is a piece of economic data, typically at a macroeconomic scale, that analysts use to analyse current and prospective investment opportunities. These metrics can also be used to assess an economy's overall health. Economic indicators are important economic statistics that can indicate where the economy is heading. Water productivity is a notion that is strongly related to WF. The rising shortage of fresh water and the critical role that water plays in economic sector production necessitates optimising water use in all human activities in Malaysia's primary water-using sector. In an evaluation based on a comprehensive global poll of risk perception amongst representatives from business, academia, civil society, governments and international organisations, the World Economic Forum (WEF) has identified water shortages as one of the three global systemic risks of greatest concern. Freshwater shortage expresses itself in diminishing groundwater levels, decreasing river flows, diminishing lakes and highly contaminated waterways as well as rising supply and treatment costs, sporadic supplies and water-related disputes. Water shortage may worsen in the future due to various factors, including population and economic expansion, rising demand for animal products and biofuels and climate change. Therefore, it is crucial to identify the major sectors that contribute significantly to the country's economy. These are the factors that are believed to be contributing to the water production. The following figures and tables are the indicators of major economic sectors in Malaysia, which have been identified in assessing WF production.

Economic activities are typically divided into three categories (Table 5.1). The primary economic sector, which extracts or harvests items from the earth, has the highest WF on the planet. Agriculture, forestry, fishing, aquaculture, mining and quarrying are all part of this industry. The primary sector is nearly totally dominated by humanity's green WF. Agriculture alone is believed to account for approximately 92% of humanity's blue WF (WEF, 2020). The secondary sector encompasses the production of goods in the economy and the processing of primary-sector inputs. Construction and public utility businesses of electricity, gas and water are also included, as they generate utilities (electricity, gas, purified water) and distribute them to clients. The public utility industries are sometimes included in the tertiary (service) sector (as a service). Because part of the business is abstraction of water from the environment, water utilities may fall under the primary sector (rivers, lakes and groundwater). Water utilities are responsible for water collection, purification, distribution, supply, wastewater collection (sewerage), treatment, materials recovery and disposal. It is rather typical to lump the entire water utility industry under the secondary sector. The tertiary sector is the service industry, including corporate and consumer services. Retail and wholesale sales, transportation and distribution, entertainment, restaurants, clerical services, media, tourism, insurance, banking, health care, defence and law are all part of this sector. Activities connected to governance, culture, libraries, scientific research, education and information technology can be listed, even if they are sometimes classified as part of another quaternary sector. The WFs in the secondary and tertiary industries are significantly lower than in the primary sector.

Table 5.1. Classification of Economic Sector for Water Products

Economic Sector	Water Use Category	Remarks
Primary sector	• Crop Farming • Pasture • Animal Farming	Direct (green and blue WF) and indirect (green, blue and grey WF)
Secondary sector	Industry	Direct and indirect (blue and grey WF)
Tertiary sector	Service industry indirect (green, blue and grey WF)	Direct (blue and grey WF) and

(*Sources*: Hoekstra and Mekonnen (2012), UN (2008), FAO (2014))

Malaysia has been a trading country and plays a significant role in global trade activities. Export trade is important as it is the main indicator of economic growth and Malaysia has one of the world's highest sustained growth rates over the last three decades. Malaysia's experience is precious for a variety of reasons. To begin with, it has a lengthy history of primary commodity trade, as do many developing countries with a colonial past. The government's emphasis moved from import substitution to export expansion beginning in 1971, after ten years of import substitution following independence in 1957. Furthermore, with an average yearly growth rate of 7.5% over the last three decades, Malaysia is a country in which the export and growth history is worth studying. Recent data has shown that Singapore, the US and China are the top three countries with the highest value export trade, as depicted in Figure 5.2. Other countries, such as Japan, Hong Kong, Thailand, South Korea, Australia and Indonesia are also listed as export trade countries with Malaysia.

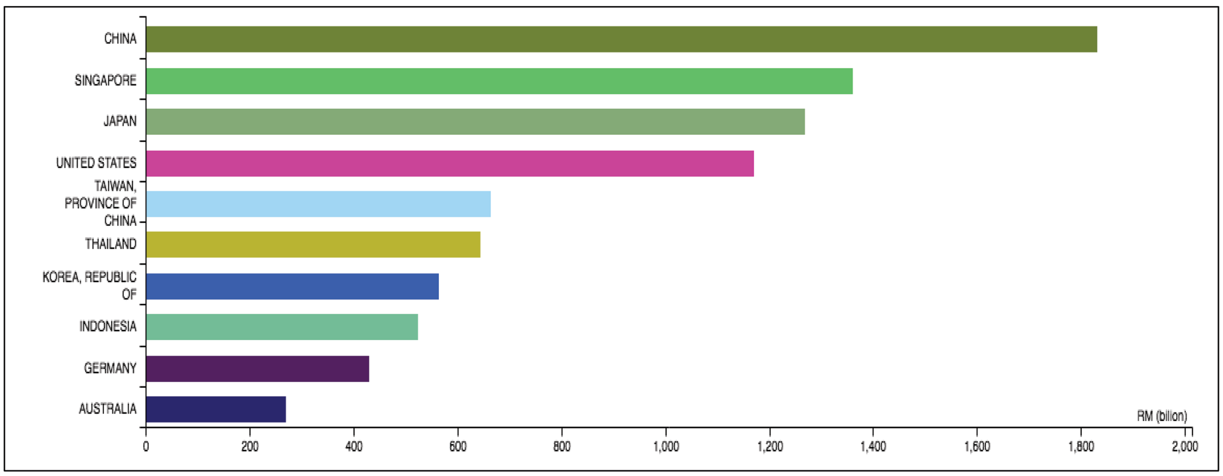

Figure 5.2. Malaysia Major Export Countries: 2020

The Malaysian economy is heavily reliant on international trade. Malaysia has steady trade surpluses since 1998, owing to an increase in the export of electrical and electronic items. Hong Kong, Singapore, Japan and the US had the largest trade surpluses in 2015, while China and Taiwan had the largest trade deficits. Despite these unusual circumstances, Malaysia's foreign trade functioned admirably, with exports returning in the second half of 2020 after a period of negative growth in the first half. This can be linked to the economy's gradual liberalisation and the gradual revival of external demand. The December exports were the highest monthly total for 2020. In 2020, exports to China reached a new high. The US experienced a similar uptick, with the highest value in prior decade. Rubber, electrical and electronic (E&E) products, palm oil and palm oil-based agriculture products saw significant exports increase. Figure 5.3 to Figure 5.9 illustrate some major indicators of the Malaysian trade balance from several periods.

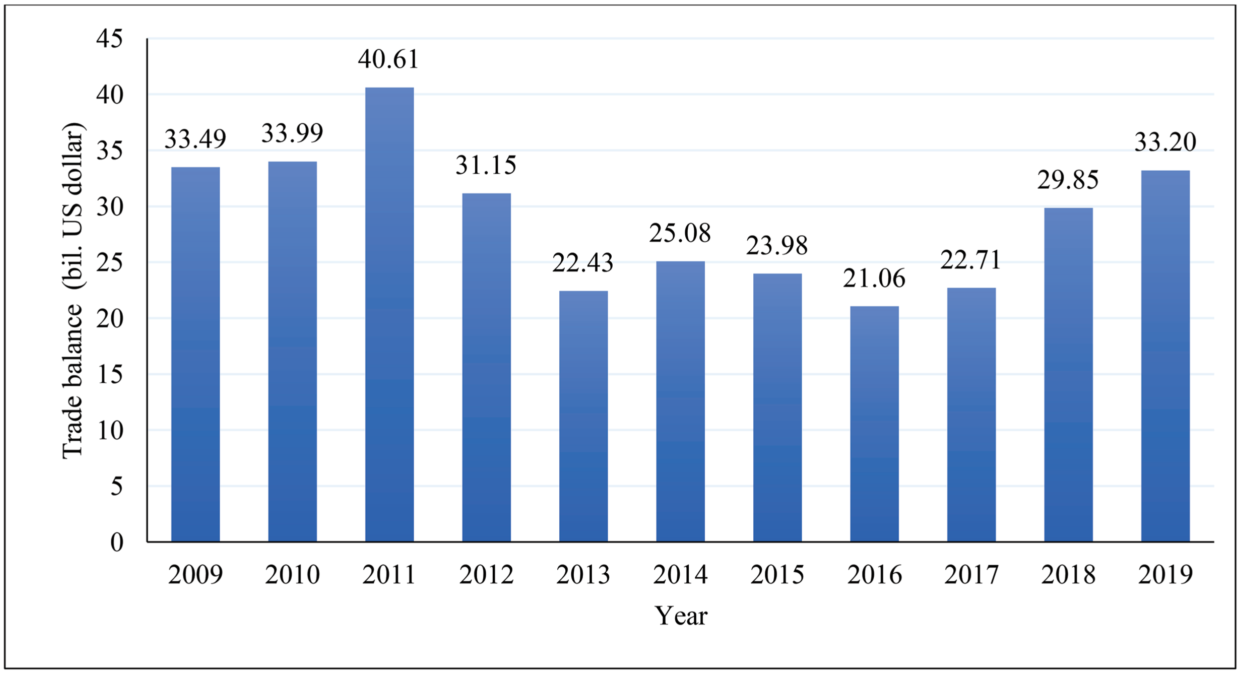

Figure 5.3. Malaysia Trade Balance (2009-2019)

Source: WTO, Statista (2021)

Malaysia's economy proliferated for more than a decade, from the 1985 recession until the 1997 financial crisis, averaging 7.8% each year. Malaysia's GDP increased at a rate of more than 9% yearly in the mid-1990s, leading up to the Asian financial crisis of 1997. However, considering the global financial crisis of 2008, Malaysia's GDP growth rate has nearly halved from 1997. Furthermore, Malaysia's GDP share has continued to shrink, and private investment has remained flat due to various issues. In several industries, government and government-linked companies (GLCs) have deterred private investment. Throughout the period, private investment has swiftly returned to a significant level, as last seen in 1997, accounting for over one-fifth of GDP by 2020, up from around one-tenth in 2010. Furthermore, in the mid-1990s, Malaysian investment accounted for 40% of GDP. It had continuously declined since 1997, reaching just 20% of GDP before the global financial crisis in 2008. However, investment in China, Vietnam and Indonesia had approached or exceeded pre-1997 peaks. To make matters worse, what little life exists in the Malaysian investment is due to the government policy rather than personal strength: private investment as a percentage of GDP fell to less than one-third of its pre-1997 peak in the decade after 1997.

Like most East and Southeast Asia countries, Malaysia has suffered the effects of the global economic and financial crisis primarily through a reduction in aggregate demand induced by a drop in exports to the US, either directly or indirectly. As a result, the GDP growth slowed to 0.1% in the fourth quarter of 2008 and decelerated by -6.2% and -3.9% in the first two quarters of 2009. The Malaysian economy, which was already weakening, had been worsened by this recession. Compared to other developing market countries, Malaysia has performed exceptionally well in recent years, rapidly catching up to OECD living standards. Malaysia's resilience to external shocks has improved due to the diversification of export items and better macroeconomic discipline. Export activities have grown from commodities to manufacturers, mainly electrical and electronic items, because of integration into the global supply chain. As a result, Malaysia's GDP has shown significant growth in the post-global financial crisis (GFC) period through 2020 (Figure 5.4).

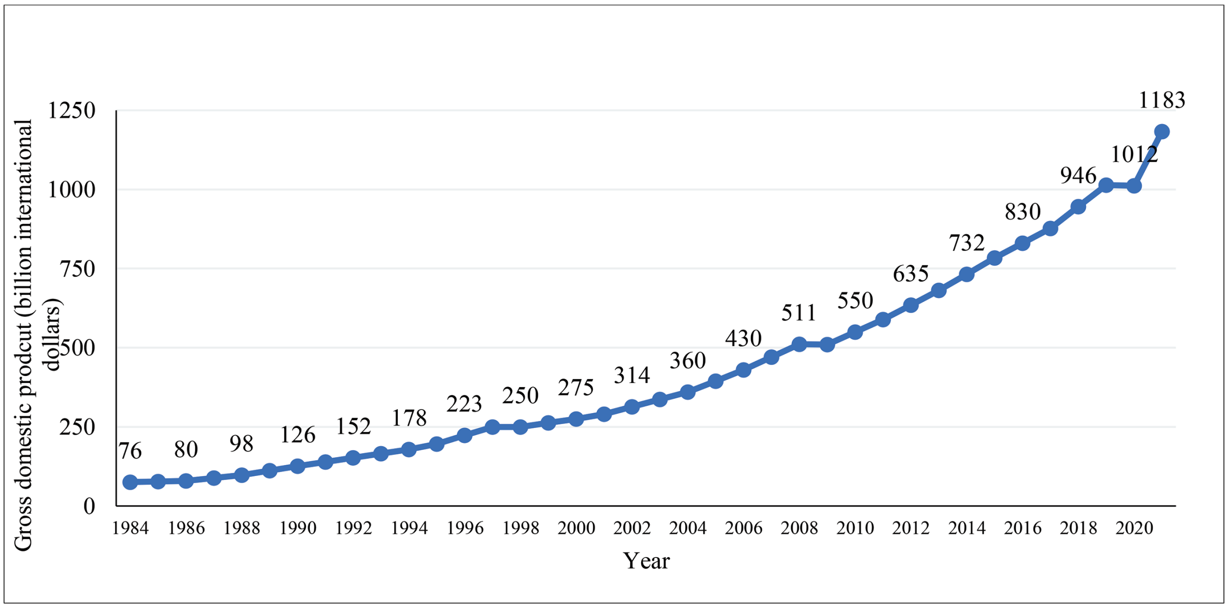

Figure 5.4. Malaysia Gross Domestic Product (GDP) (1984-2020)

Source: WTO, Statista (2021)

Natural rubber is grown in Malaysia for more than three decades. It is one of the country's most important industries. Malaysia's export revenues climbed from RM2,571 million in 2000 to RM7,026 million in 2013, as shown in Figure 5.4. As a result, natural rubber is regarded as one of Malaysia's most significant agricultural commodities. However, due to several problems, such as land scarcity and uneven production patterns, the production of this export crop has decreased in recent years. Malaysian rubber is exported to more than 200 nations. The US and the European Union (EU27) were the primary markets for Malaysian rubber products, accounting for a combined 55% of total rubber exports. Demand variables, such as rubber land conversion to other types of developments and increasing demand due to the rapid growth of the automobile industry led to the increasing and decreasing trend from 2000 to 2010. In recent years, the total rubber export has seen a descending movement. Despite this, Malaysia continues to be the world's biggest provider of medical gloves (examination and surgical gloves), meeting more than half of global demand. Nevertheless, Malaysia still imports rubber from the international market due to several factors, such as low rubber prices and declining harvesting area and production (Ali et al., 2021). Figure 5.5 and Figure 5.6 show Malaysia's total rubber export and import from 2000 to 2019.

For many years, Malaysia's palm oil sector held the world's most significant market share. The oil palm sector's success has made Malaysia's oil palm industry one of the most important contributors to the country's GDP, foreign exchange gains and job creation. The sector contributes 5% to 7% of the country's GDP on average, with export earnings averaging RM64.24 billion per year during the last five years. Due to Malaysia's limited population, the palm oil business was mostly an export-oriented industry. Over the past six years, the total value of palm oil and palm-based products have shown stable growth between RM64 billion to RM67 billion (Figure 5.7 and Figure 5.8). The fluctuating global palm oil price trend has resulted in the unparalleled indicator between total volume and total export value.

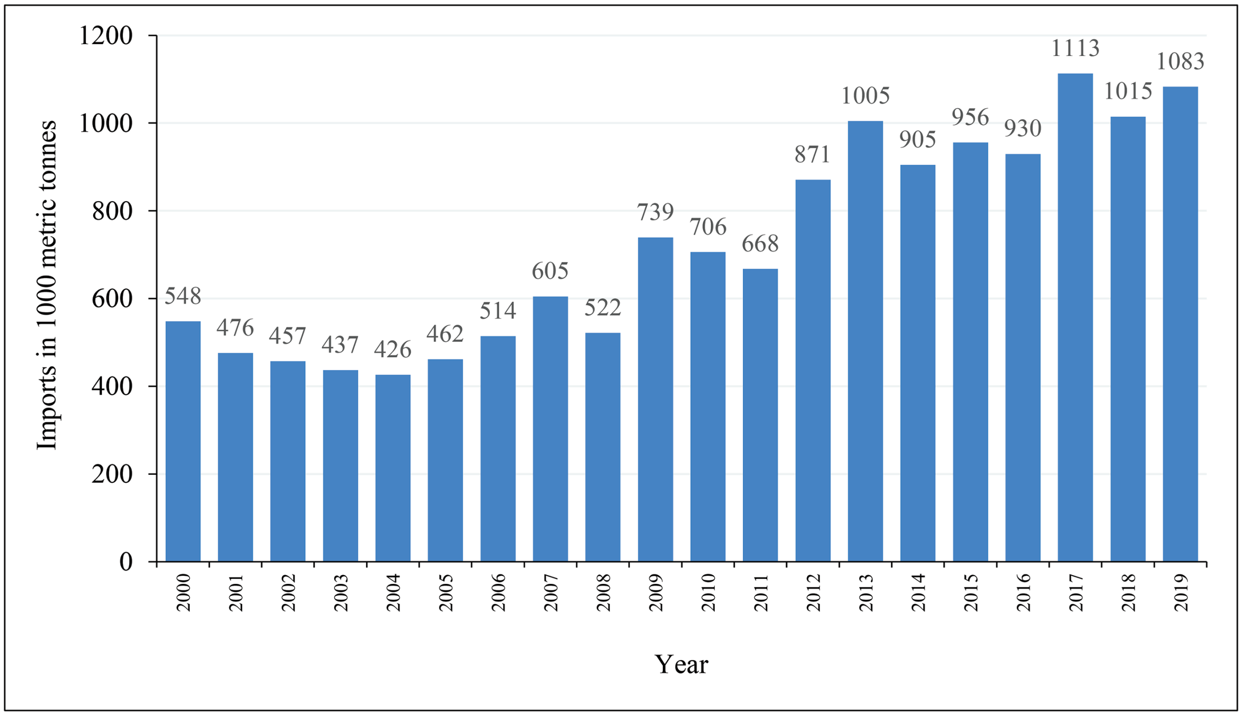

Figure 5.5. Malaysia Total Rubber Import (2000–2019)

(*Source*: International Rubber Study, Statista (2021))

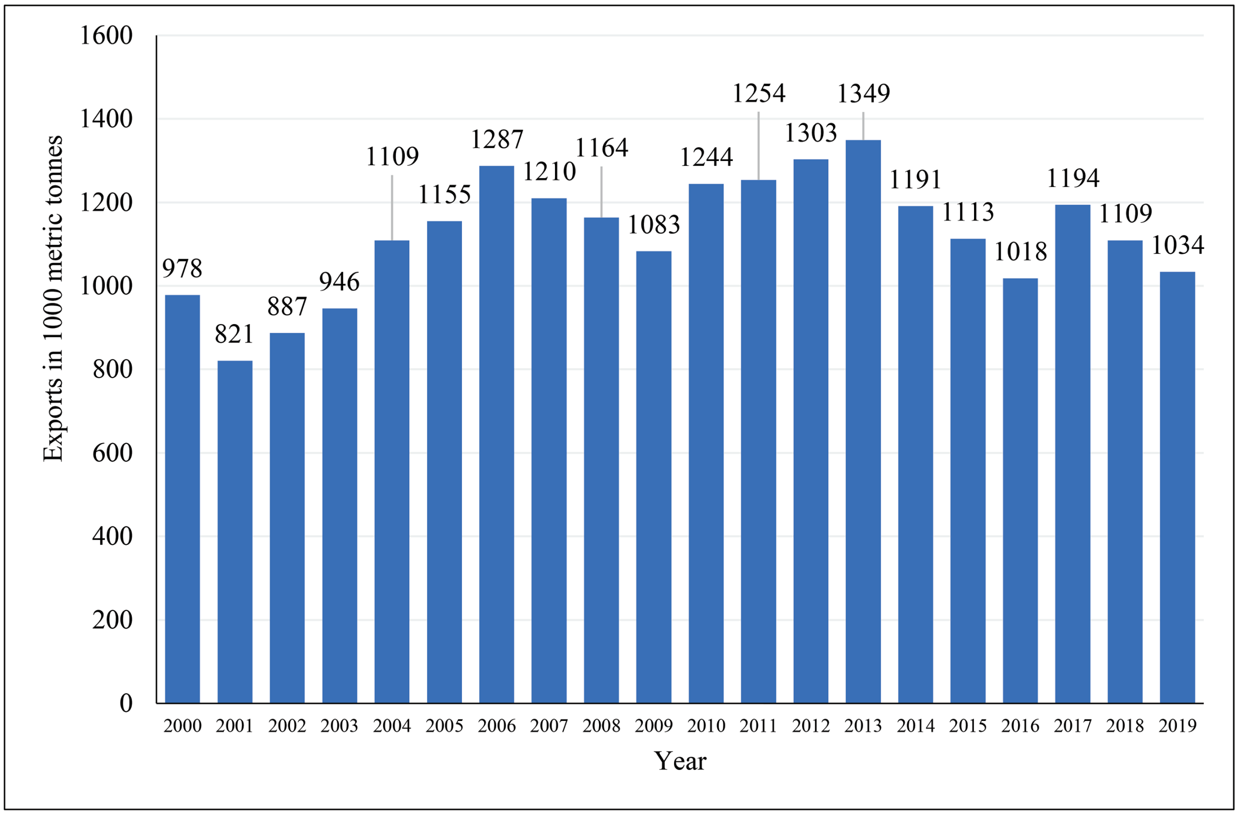

Figure 5.6. Total Rubber Export (2000–2019)

(*Source*: Statista, 2020)

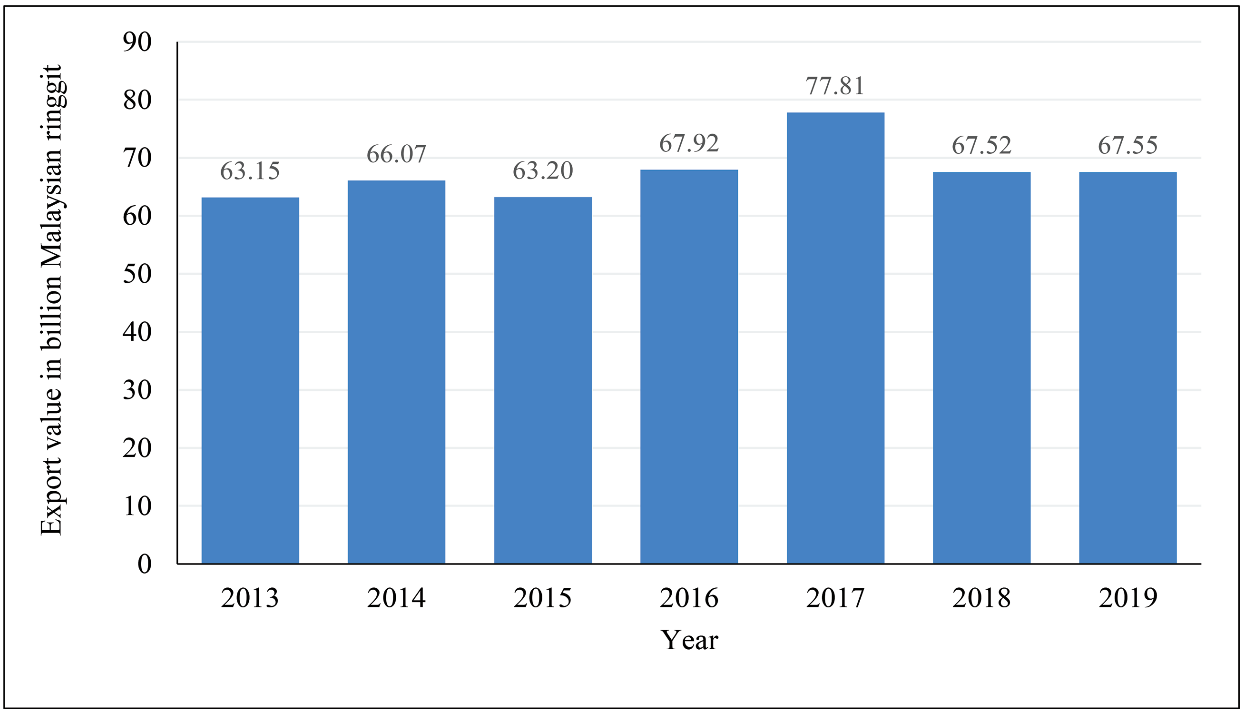

Figure 5.7. Malaysia Export Value Palm-Oil and Palm-based Product (2013–2019)

(*Source*: DOSM, 2021)

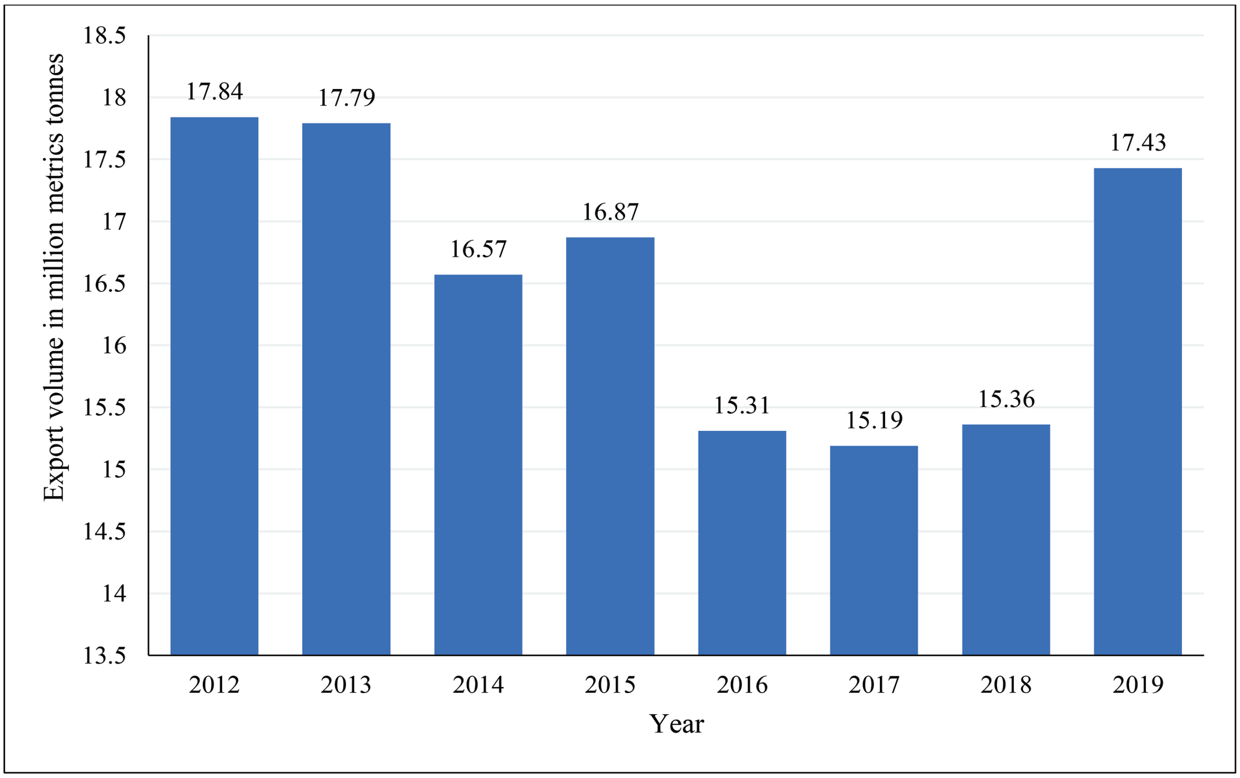

Figure 5.8. Malaysia Export Volume of Palm Oil (2012–2019)

(*Source*: DOSM, 2021)

Malaysia is a net importer of rice because its production falls short of market demand. Figure 5.9 demonstrates Malaysia's import and export values from 2000 to 2019. The rice export and import values patterns show that Malaysia continues to export rice to other nations despite importing a higher percentage of market demand. Imports account for more than a quarter of the country's rice needs. Imports of rice are critical in determining the country's food security. The company's import strategy, which has exclusive import rights, significantly impacts various economic, political and societal stability. The difference between domestic supply and demand should be addressed with imported rice, given the country's rice production and consumption trends. The estimated import value, which is higher than the export value, demonstrates this. Because rice is a staple food for Malaysians, a heavy reliance on imported rice will negatively impact the economy.

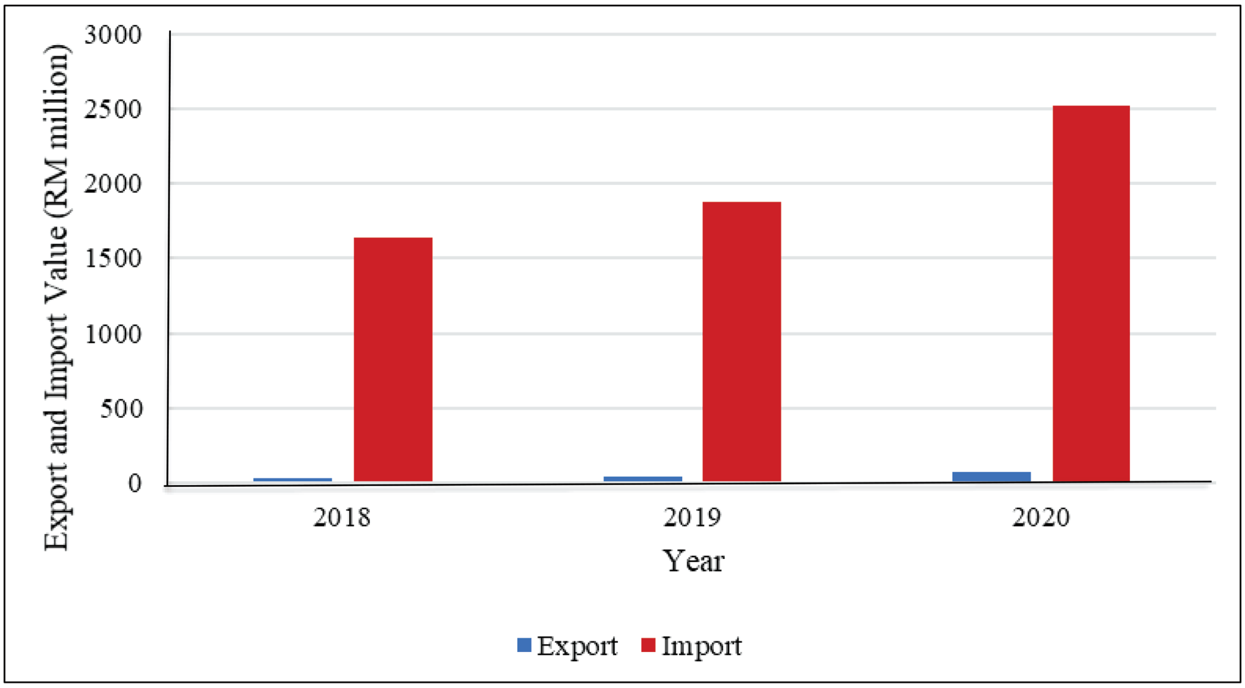

Figure 5.9. Malaysia Rice Export and Import Value (2018–2020)

(*Source*: Malaysia's External Trade Statistics Database)

6.0 Sub-sectoral Study Process and Impacts from COVID-19 Pandemic

The Coronavirus disease (COVID-19) started in 2019, whereby the first place to be infected was in Wuhan, China. However, the virus transmitted through respiratory droplets and airborne particles, has affected most countries globally, particularly the socio-economy. This project, which started in May 2020 and is scheduled to be completed by December 2020, has been positively and negatively affected by the COVID-19 pandemic in certain aspects as discussed in the following subsections.

6.1 Positive Impacts

The COVID-19 pandemic has disrupted various aspects of human lives. Most importantly, amidst the global health crisis, digital transformation and technology have been accelerated due to the movement and travelling restrictions imposed locally and globally. The COVID-19 situation is said to speed up the digital economy and transformation, which coincidentally aligns with Malaysia's aspirations to embrace the Fourth Industrial Revolution. The advent of 21st-century technologies, including artificial intelligence (AI), the Internet of Things (IoT), augmented reality (AR), virtual reality (VR), drones and digital learning platforms have increased accessibility for better communication, both for personal and business interactions.

Existing trends, such as digital transformation have been tremendously accelerated due to the COVID-19 pandemic. These rapid changes can be seen in communications, whereby virtual meetings have been replaced with face-to-face meetings and the advancement in the delivery system and data repository. In this study, most of the team meetings and focus group discussions are required to be conducted online due to the movement control order (MCO) imposed in the country. Despite the lesser physical interactions that can be held, this study has successfully accelerated discussions, which helps to fulfil some aspects of the study completion. Besides, the travelling restrictions and limiting physical contacts imposed during this period have saved time and travelling costs. In addition, various parties have the flexibility of attending virtual meetings, which leads to increased participation from stakeholders and fruitful discussions on decision-making. The MCO imposed by the government on the movement restrictions of persons and vehicles has no doubt halted many economic activities. However, the positive outcomes from this pandemic are the significant reduction of carbon emissions and air pollution (Dasgupta and Srikanth, 2020; Shakil et al., 2020) and the decrease in fuel and electricity consumption (Eufemia and Hussein, 2020).

In addition to this impact in terms of travel restrictions, the amount of stress was lessened in several tourism destinations. Through this, the busiest and most crowded tourist places were restored, resulting in lower environmental impacts because fewer people contributed to water pollution than the business-as-usual circumstances. This was proven based on the Department of Statistics Malaysia (2021) data, which showed a decrease of 83.4% of international tourists in 2020. The total number of international tourists who arrived in 2019 was 26.1 million. Additionally, facilities such as swimming pools and spas were prohibited from operating to minimise infectious transmission rate and control in communities, resulting in less direct water and energy consumption.

At the outset of this study, the selection of case studies was based on factors, such as contribution, in terms of value towards Malaysia's GDP, food security and water consumption in product manufacturing. This led to the decision to select the rubber gloves and semiconductor industries for the manufacturing sector. During this pandemic, these industries benefitted greatly from increasing demands, particularly personal protective equipment (PPE) and work-from-home essential gadgets, although manufacturing and production industries have been known to decline sharply. Production of gloves in Malaysia alone surged by around 85% in 2020 (Statista, 2021). Electrical and electronic products have increased to 13.8%, contributing to the manufacturing sector's growth of 12.7% in March 2021 for a one-year time frame (DOSM, 2021). This can be viewed positively by relating current pandemic trends to the WF gained from the study via the changing patterns in direct and indirect water consumption of the three chosen sectors and can be applied as the benchmark or living documents for future exploration. Figure 6.1 summarises the positive impacts brought about by the COVID-19 pandemic.

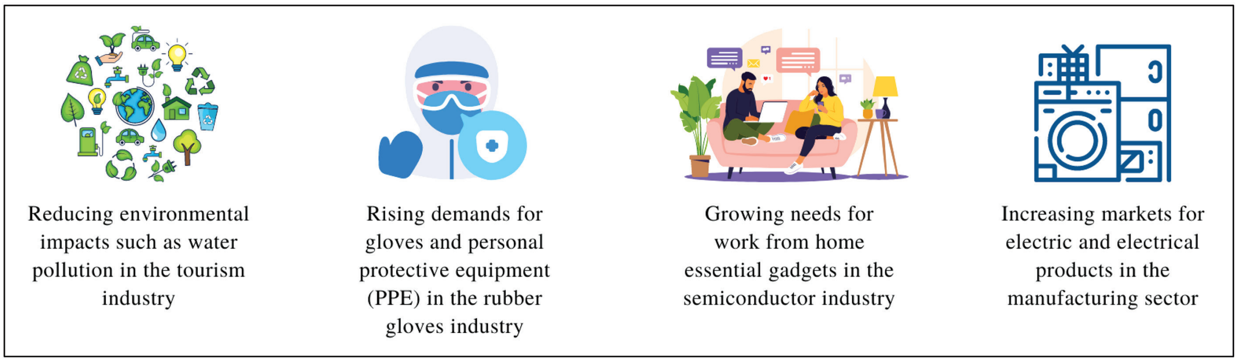

Figure 6.1. Positive Impacts on Sub-sectoral Study during COVID-19 Pandemic Period

6.2 Negative Impacts

Although there are positive effects of the COVID-19 pandemic, the restrictions imposed have also negatively impacted several aspects of human lives. In this section, the negative impacts of COVID-19 concentrate on the direct impact of the pandemic, particularly those related to the economic sectors understudied, as shown in Figure 6.2. The following is the focus on the sectors being studied.

Palm oil production is essential to Malaysia's economy, as the country is the world's second-largest producer, behind Indonesia. Due to the prolonged drought and COVID-19 epidemic and strict MCO imposition, palm oil production fell in 2020. According to the MPOB report, the global spread of the COVID-19 epidemic made 2020 a challenging year for Malaysia's oil palm industry. The industry's export demand and prices dropped in 2020 by 19.14 million tonnes, or 3.6% compared to 19.86 million tonnes in 2019 (MPOB, 2020). Due to the pandemic, the rubber industry showed the same pattern of declining production, exports and imports in 2020. Moreover, the industry imports fell by 4.0% to 21.5 million tonnes, down from 22.4 million tonnes in 2019.

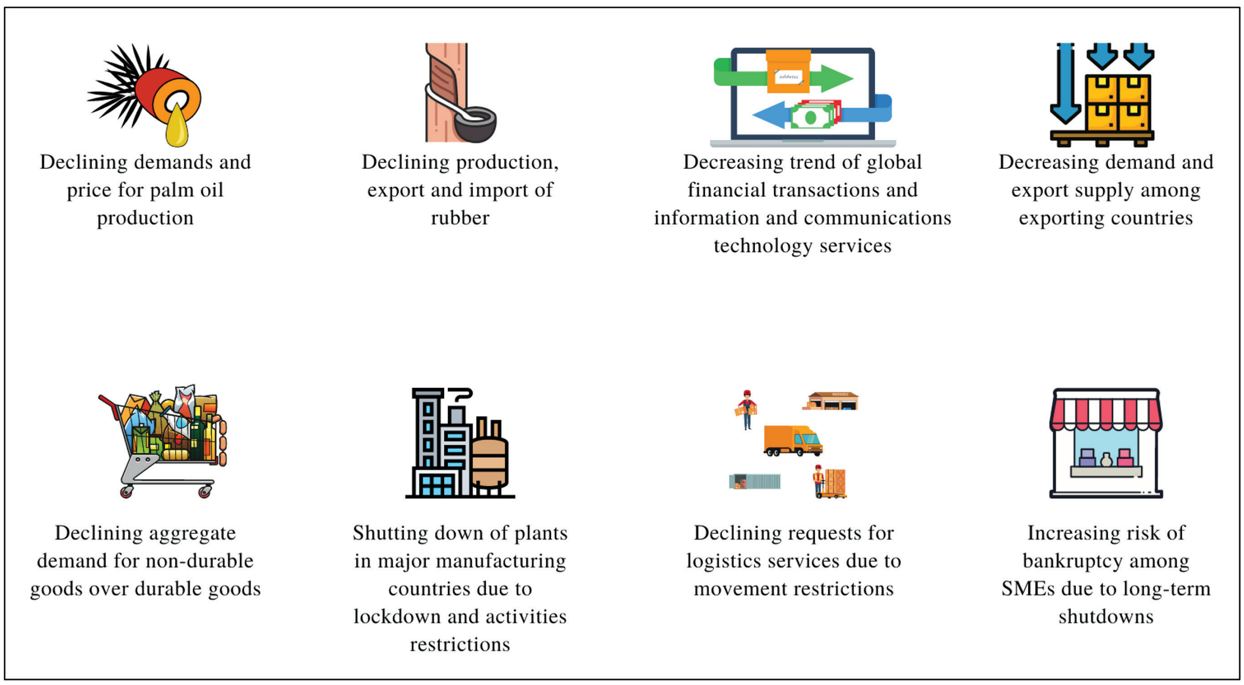

Figure 6.2. Negative Impacts on Sub-sectoral Study during COVID-19 Pandemic Period

Meanwhile, the export value decreased by 2.1% with 20.8 million tonnes in 2020 and 21.3 million tonnes in 2019 (MRC, 2020). With the outbreak of the COVID-19 virus, there has been a soaring demand for rubber gloves worldwide. To maintain the glove production, Malaysia's main producers faced several challenges, as the closing of borders resulted in a shortage of workers to keep the production lines running.

The COVID-19 pandemic has severely impacted global trade, affecting both the supply and demand of the economy. The government has forced the temporary shutdown of non-essential manufacturing facilities. In contrast, several companies have either adopted such measures willingly due to labour shortage, or merely reduced production due to supply chain disruptions. The COVID-19 pandemic influence, on the other hand, is most evident in the international service industry. The principal casualties are international tourism, passenger air travel and container transportation.

Financial transactions on a global scale and information and communication technology services have decreased dramatically. The COVID-19 pandemic is projected to have a significant impact on international trade in a variety of ways, according to theory. Naturally, a larger COVID-19 pandemic burden in an exporting country reduces production size, resulting in a reduction in export supply. Exports will fall, especially in industries and countries, whereby remote work/operations are challenging. The impact of the COVID-19 pandemic burden in an importing economy is mainly attributable to a reduction in aggregate demand. Reduced demand will result from lower incomes and fewer visits to retail stores. The COVID-19 pandemic load in surrounding countries may have an impact on a country's international trade. Reduced exports from an impacted country, for example, provide an export opportunity for its neighbours. Negative production shocks caused by the COVID-19 pandemic in one nation, on the other hand, may lower production in nearby countries via supply-chain networks.

The impact of the COVID-19 pandemic burden on commerce in an importing country will mainly be due to a reduction in aggregate demand in that country. Lockdowns that affect the entire city or country, lower individuals' earnings from businesses, resulting in a drop in aggregate demand unless the government offers enough subsidies to compensate for lost wages. Even if the individuals' salaries remain stable, their fear of infection reduces their trips to retail outlets and supermarkets, resulting in lower demands. Negative demand shocks may reduce durable goods spending more than non-durable goods spending. Uncertainty about the future, or 'panic buying' may, on the other hand, raise demand for non-durable goods. Furthermore, increased demand for items that protect against COVID-19 infection may raise import demand for sanitation products, such as face masks and hand sanitisers.

The COVID-19 pandemic has caused plants shutdown in major manufacturing countries due to lockdown, flight stop, outside activities restrictions, etc. The manufacturing supply chain has been, or about to be interrupted for some products in industries, such as automobile, electronics and pharmaceutical industries. In addition, market demand has shown great uncertainty and cannot be satisfied because of the logistics setbacks. Moreover, many SMEs are at a higher risk of bankruptcy than ever. A global supply chain has been formed for many manufacturing industries with enterprises closely connected. China, the US and Germany have become regional manufacturing centres for North Asia, North America and West Europe.

Meanwhile, South Korea, Japan and Singapore have been important members of the global value chain due to their industry or geographic advantages. Logistics has become the weak spot for the manufacturing industry after the breakout of the COVID-19 pandemic. As for domestic logistics in Malaysia, highway control mainly affects long-distance road transportation. The demand for logistics services has dropped severely in a short time because of the pandemic. More importantly, the quarantine policy has led to the supply decrease of drivers and trucks since the primary source is from several major ports, such as Klang, Johor and Penang. Furthermore, many SMEs have struggled in recent years due to the global economic slump. These businesses are at a greater danger of insolvency due to the COVID-19 outbreak.

For starters, obtaining a permit to resume production is more difficult for SMEs. Because of the high standard required for the facility and working conditions, which many SMEs cannot fulfil, the recovery rate for SMEs is relatively lower than that of large corporations. Due to their limited working capital reserve, long-term shutdowns will harm SMEs' operations and may result in bankruptcy.

The supply networks have been put to the test by the COVID-19 pandemic. COVID-19 pandemic consequences on agriculture, like any other industry have yet to be fully realised, and a second wave of the virus is currently affecting numerous countries. The general population's panic shopping and stockpiling of durable food, such as rice and other agricultural products had significant impacts on the food system thus far. As a result, supermarket shelves were left empty. Some countries were wary of running out of domestic resources and blocked their borders. For example, Vietnam, Thailand and China have temporarily restricted the export of critical staple items. Similarly, the EU countries, such as France have proposed sealing Europe's border. According to the Food and Agricultural Organisation of the United Nations (FAO), the international prices of important staple commodities, such as wheat and maize have declined since the beginning of May 2020. Conversely, rice is the only basic necessity, whereby the price has increased. This is due to export limitations imposed by Vietnam, an important supplier. Furthermore, major disruptions in supply chains due to population 'lockdowns' have resulted in a global drop in demand in the food service sector, including restaurants, open markets, catering and hotels. Food service segment closures have significantly impacted all companies in the supply chain, including farmers that source the primary product. To make matters worse, transportation restrictions have limited the ability of farmers and fishermen to access markets, restricting their productive capacities. Disturbances downstream from farms can also lead to accumulative surpluses, putting additional strain on storage facilities, particularly perishable goods.

Meanwhile, the rubber glove business in Malaysia is experiencing a massive rise in demand due to the COVID-19 pandemic, producing a new crop of producers and creating new millionaires in the process. Although the rubber glove industry's exceptional success received significant attention, increased worldwide attention has also brought awareness on the industry's darker side, which has sparked criticism from labour unions and civil society organisations. The rubber glove industry is part of a national economy that relies primarily on low-wage, unskilled labour and it is overseen by organisations that do not routinely monitor and implement regulations. While the number of COVID-19 infected individuals continues to rise, global vaccination campaigns are gaining traction. As a result, manufacturing timetables are becoming increasingly stringent, with pressure coming from unexpected places. While glove demand will continue to rise, supply will not be able to keep up. According to the Malaysian Rubber Glove Manufacturers Association (MARGMA), the global rubber glove scarcity will extend into 2023. Glove dipping is a time-consuming operation that cannot be scaled up overnight. Unexpected challenges, like the COVID-19 epidemic at glove companies and shipping container constraints, have compounded the problem. Orders are currently expected to take six to eight months to complete, with demand from desperate governments driving up average selling costs.

Although Malaysian palm oil exports have plummeted, the industry remains a lifeline for the country's economy in the face of global uncertainties caused by the epidemic since it continues to contribute positively. However, the palm oil export market should be a source of concern. Some export destination countries, including China, the EU, India, Africa and Pakistan, the world's major vegetable oil purchasers, have imposed economic limitations. The pandemic in 2020 resulted in a considerable drop in worldwide trade of between 13% and 32%, affecting economic activity (WTO, 2020). From an economic standpoint, the palm oil business will be adversely impacted by a reduction in chain management performance. The disturbance in supply chain components, such as procurement, production, distribution and logistics caused this drop. Demand concerns create supply challenges, which significantly impact supply chain management and distribution networks. Demand-side shocks, supply constraints and transportation issues wreak havoc on processing, retail and agricultural distribution stakeholders.

6.3 Post-pandemic Adaptation

The COVID-19 pandemic has accelerated three tendencies that may remain at varying degrees after the pandemic, each with its own set of work consequences, as shown in Figure 6.3. Firstly, a hybrid remote work might continue to be executed, which may likely be performed by those whose work can be accessed or performed remotely through computers. As more people may likely work from home, the demand for commuters, restaurants and retail in metropolitan areas could potentially be reduced. In addition, organisations have deployed automation and artificial intelligence (AI) to deal with the COVID-19 pandemic disruptions. Adoption may accelerate in the coming years, allowing for more self-service customers or a virtual home office. Most organisations have stayed focused on short- and medium-term profits, anticipating that business conditions to remain stable. The COVID-19 pandemic has signalled the need for a new approach. The digital revolution has brought about tremendous growth in data availability, connectivity and decision-making speed. While these changes have transformative potential, they also carry the risk of large-scale failure and security breaches as well as rapid cascading repercussions. While the use of digital technology may accelerate a company's reputation amongst its stakeholders, companies should also be vigilant in using these technologies, which require them to have a better understanding of resilience by considering the increased risk of massive technical failure and cyber attacks that could harm those who rely heavily on technology.

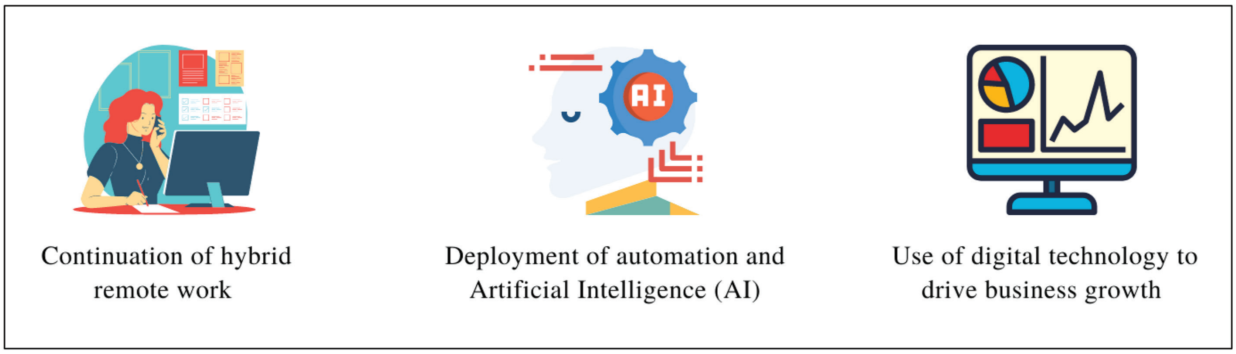

Figure 6.3. Post-pandemic Adaptation

7.0 Report on Findings based on each Scope of the Sub-sectoral Study as required by the Terms of Reference (TOR)

7.1 Scope 1: Review and Analyse Current Policies with a View for Improvement

As WF is a new and emerging industry in Malaysia, there is currently a shortage of talent, competence and investment in the field. The lack of WF specific training programmes contributes to poor expansion of intellectual capital in this field. In the 12th MP[5], one of the strategies under B1 in Chapter 9 is to implement

[5] Under Strategy B1 of the 12th MP (Twelfth Malaysia Plan, p. 9-18), structured modules will be developed for specific target groups to enhance understanding of the IWRM.

comprehensive awareness, advocacy and capacity-building programmes. In addition, under strategy B3[6], there is a need to enhance the capacity of water industry players and the scientific community to transform the water sector. The current ISO 14046 on WF provides appropriate guidance for local industries to incorporate WF in their operations. However, specific efforts should be encouraged for all stakeholders to understand the standard. This includes producing ISO 14046 based training modules and certification programmes for WF. By taking training and earning a certificate in water management, industries may compete and expand their business to an international level. Several colleges offer the Certified Water Management Programme, including the California Landscape Contractors Association (CLCA) and Arizona State University (ASU).

Aside from the US and Europe, the Middle East countries, including Yemen, the United Arab Emirates (UAE), Saudi Arabia and Iraq have increased understanding on the need to apply VW&WF strategies in their economic sectors. Due to their water scarcity concerns, they have raised their awareness and established a more sustainable food and agriculture sector, necessitating the most effective use of water resources. For example, UAE has formulated the Habitat Directive Policy to govern the river exclusively for sustainable use. Despite numerous studies conducted on VW&WF in Australia, the country is still at the research-based findings stage with no clear direction on how these concepts might be incorporated into Australia's policy and legislation. Nonetheless, there is a high level of knowledge about VW&WF amongst Australian industry players. For instance, the awareness of water management highlights the company's value chain in controlling pollution, especially to the Murray-Darling River, one of Australia's major river basins. As in Malaysia, since water is still abundant in some areas, the level of awareness in implementing water-saving amongst the industrial players is inadequate. Nevertheless, various policies and actions can be utilised to incorporate WF as part of an effort to raise WF awareness as spelt out under the strategy expanding community-driven conservation programmes of the 12th MP (Chapter 9: B1)[7].

Some countries have set up WF research centres to garner more buy-in from government departments and provide an institutional level platform for industries. China is regarded as one of the most proactive countries advocating the VW&WF agenda. The Chinese government has devised a sustainable agricultural blue water use strategy known as the 'three red lines', aiming at total maximum national blue water consumption. Sweden has likewise taken a proactive approach to VW&WF implementation. For instance, under the initiative of the Pan-European Atlas of Urban Water Management of the European Commission, the Joint Research Centre has proposed WF analyses related to food consumption. These initiatives also involved other Nordic countries, such as Finland, Denmark, Norway and Iceland. In Colombia, a collaboration has been established between the Good Stuff International (GSI) and the Centre for Science and Technology Antiochia (CTA) to assess the WF of all river basins. This project was supported by the National Institute of Hydrology, Meteorology and Environmental Studies (IDEAM) and was funded by the Swiss Development Corporation (SDC) and the CTA. However, no institution has been designated as a WF centre in Malaysia to develop, integrate and coordinate WF implementation. To aid WF implementation at all levels and to foster worldwide collaboration amongst WF players, a one-stop WF centre should be built to raise WF awareness and understanding. Therefore, the proposed establishment of a single water

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[6] The capacity of water industry players and the scientific community will be improved to enable data-driven decision-making in embracing the 4th Industrial Revolution (4IR) as well as efforts in providing competency certification and relevant education programmes to increase competency of water-related professionals in public and private sectors.
[7] Under this strategy, community-driven conservation programmes will be heightened to empower people to protect and conserve water resources and create socioeconomic activities through campaigns and environmental-relation education programmes through various collaborations amongst educational institutions, government agencies, private sectors and other organisations.

management agency to strengthen the water data and research centre under the 12th MP (Chapter 9: B2 and B3)[8] is very much lauded.

During the Climate Change E-Colloquium 2021 on 3rd August, the Ministry of Environment and Water (*Kementerian Alam Sekitar dan Air* [KASA]) had announced the Intended Nationally Determined Contribution (NDC) for reducing the intensity of greenhouse gas (GHG) emission to 45% by 2030. Malaysia's commitment to climate change is also shown in the development of the Malaysian Climate Change Action Council (MyCAC), which acts as an ultimate platform for setting the direction, discussing climate change policies and actions, driving green economic growth, catalysing green technology and low-carbon growth at all levels, particularly in the federal and state governments. Unlike carbon footprint, there is no requirement for industries to declare their water consumption of the processes, products, or businesses. For example, every five years, the US has reported their estimated use of water as a national benchmark report to analyse WF. In 2014, the ISO 14046 was launched and officially endorsed in 2020. This standard includes requirements and guidance for calculating and reporting a WF as a standalone assessment, or as part of a more comprehensive environmental assessment. Following the endorsement of the ISO standard, SIRIM has also developed a Malaysian standard for WF assessment, which is an identical version of the ISO 14046:2014. On the other hand, the former is primarily meant for SIRIM's commercial interests and has not been well embraced or implemented by Malaysia's industrial players. One of the initiatives that can be taken to strengthen the industrial water report is to incorporate the WF element into existing industry assessments. If properly executed, these initiatives will facilitate the implementation of the circular economy concept in the entire water sector value chain (Chapter 9: B5)[9] and improve the design and process of products and services (Chapter 8: A2)[10] in the 12th MP.

7.1.1 Local Policy

Knowledge of VW&WF is still a new venture and the present work mainly focuses on developing scientific methodology and collecting data for detailed analysis. Ten policies at the federal level related to water, environment, climate change and natural resources are comprehensive enough to cover various aspects of water to support sustainable use under two broad categories: water as a resource and water for livelihood. Although some of the provisions and statements in the existing policies are relevant to support WF initiatives, VW&WF are not mentioned explicitly. The only policy document highlighting WF is the National Sustainable Consumption and Production (SCP) Blueprint 2016–2030, under pathway 9, which requires a WF calculation for food and beverage.

Possibly the most related policy that can incorporate WF definition and requirement is the National Water Resource Policy (NWRP), endorsed by the federal government in 2012. The NWRP comprises four tenets: water for people, water for food and rural development, water for economic development and

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[8] The capacity of water industry players and the scientific community will be improved to enable data-driven decision-making in embracing the 4th Industrial Revolution (4IR) as well as efforts in providing competency certification and relevant education programmes to increase competency of water-related professionals in public and private sectors.

[9] Under this strategy, community-driven conservation programmes will be heightened to empower people to protect and conserve water resources and create socioeconomic activities through campaigns and environmental-relation education programmes through various collaborations amongst educational institutions, government agencies, private sectors and other organisations.

[10] Strategy B2 includes strengthening governance at all levels, strengthening water resources management mitigating water pollution and institutionalising the water-energy-food nexus approach, while Strategy B3 includes enhancing capability in data-driven decision-making, strengthening water data and research centre and enhancing capacity of water industry players and the scientific community (Twelfth Malaysia Plan, pp. 9-18 – 9-19).

water for the environment. This policy also outlines nine thrusts that elaborate further on strategies and strategic action plans. As the NWRP policy focuses on resources, the thrusts mainly hinge on water availability, alternative resources, disaster risk and reduction, conservation, stakeholder engagement and awareness. The existing NWRP can be strengthened by incorporating WF definition and requirements, especially under thrust number 2 (water resources integrity) and thrust number 9 (capacity building and awareness).

It is encouraging to note that KASA is in the process of awarding a contract to develop the National Water Policy (NWP). The formulation process of NWP requires comprehensive review and assessment of existing policies, especially the NWRP 2012, regulatory impact analysis, identification of current and emerging issues, standard benchmarking in water management and practices, IR 4.0 and comprehensive management approach and practices (resource, supply and sewerage). This opportunity is possibly the best platform for water professionals and agencies to suggest the inclusion of VW&WF in the upcoming NWP to strengthen water resources management, as stated in Chapter 9 strategy B2 of the 12th MP[11].

In addition to reviewing the existing local policies, this study had reviewed ten federal government acts and 23 enactments/ordinances that indirectly support WF initiatives. However, to make them legally binding, it is necessary to include WF definition and specific provisions into the existing laws and enactments. The summary of these acts and enactments/ordinances are presented in Table 4.2.

7.1.2 International Policy

Benchmarking with countries on existing WF-related policies is essential to ensure consistency and not to overlook on crucial elements. In this regard, two policies, namely Spain's WF policy and China's Three Red Line Policy were reviewed, and the summary is presented in Table 7.1. Spain was the first EU country to include WF analysis into its government policy. The Spanish Water Directorate General, which is under the Ministry of Environment, Rural and Marine Affairs, approved a regulation in September 2008 that includes an analysis of the WF on different socio-economic sectors, as a technical criterion for the development of River Basin Management Plans, which all EU Member States should complete by 2010 (Official State Gazette, 2008). Regional disparities in the availability of green and blue water resources characterise the Spanish setting. VW studies, which consider green and blue (ground and surface) water systems and trade policies, can help improve integrated water resource management.

China has also made a significant step in putting WF on the water sector agenda. The Chinese government aims for self-sufficiency in major staple food (wheat, rice and maize) and has established the 'three red lines' policy on sustainable agricultural blue water use, including targets for total maximum national blue water consumption. While future water consumption and accompanying water stress in major water-exporting provinces, such as Xinjiang and Heilongjiang strongly depend on the complete execution of water use and economic development policy plans. Given China's large proportion of infrastructure investment in GDP, assessing the infrastructure-water nexus and its future performance under existing policies is crucial to comprehend the interdependencies of infrastructure growth and the environmental repercussions.

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[11] The 12th MP outlines the implementation of circular economy in the water sector throughout the entire water sector value chain. This will be done through enabling policies and legislations, and strategic collaborations and RDCI activities to provide the ecosystem for the circular economy.

Table 7.1. Review on International WF Policy and Initiatives

No.	Policies	Reviews	Recommendations for Malaysia Water Sector
1.	Spain National Water Footprint	i. The H3+ certificate guarantees that the grower applied an excellent crop irrigation scheme. ii. Growers received the WF of each product using a standard calculation and subsequently received a certificate showing their crop's WF. iii. Farmers who choose to certify both the implementation of these tools and methodologies will obtain an additional WF certificate (the H3+), which guarantees that the producer is practising excellent irrigation management. iv. These techniques have incorporated more technology, allowing high frequency localised irrigation, computer-controlled and sensor application to the crops. This efficiency in the use of water in Almería, Spain, is shown through the depreciable WF.	i. The legal aspect should be initially tackled to ensure that the WF&VW agenda will significantly benefit the water sector. The WF certification programme is an essential milestone in the roadmap, which indicates the success of the programme. ii. Position the agricultural sector as a priority sector, to be a central focus for the WF programme. iii. To allocate research funds for invention in WF technology. iv. Training needs for WF certification initiative in Malaysia.
2.	China's Three Red Line Policy	i. China has placed its WF policies under its provinces. The strategy, known as the 'Three Red Lines' establishes targets for total water usage, water efficiency and ambient water quality for a number of benchmark years up to 2030. ii. These goals will subsequently be broken into the province and country-level goals, to be incorporated into the officials' performance objectives. iii. The 'Three Red Lines' programme is an excellent example of policy formulation in China's fragmented system. Its scope and potential roadblocks illustrate issues that will challenge effective water administration in the coming years, not just in China. One approach that could help ease water stress at the provincial level is a 'Virtual Water Strategy'. iv. On the one hand, it will alleviate the water problem in receiving provinces; on the other hand, it will put pressure on providing provinces via their supply chains, particularly in water-stressed areas. v. As a result, monetary compensation from net water-receiving provinces to water-supplying regions could be considered in the context of meeting water-management goals.	i. Suggestion for local authorities in Malaysia to play a major role in water administration through provisions to control water usage, water efficiency and water quality. ii. As WF deals with micro-managing, the empowerment of local authorities in Malaysia is crucial in knowledge, workforce and strengthening law enforcement capacity.

7.2 Scope 2: Undertake Comparative Strategy Analysis/Business Models with Other Nations

Research on VW&WF has been extensively done in many countries based on WF strategies and activities in several water-intensive sectors, such as food, agriculture and manufacturing. China, Sweden, New Zealand and Canada are amongst the countries involved. Other countries have embarked on WF implementation in their major commodity, such as WF in silk production in Malawi and WF in textile production in Bangladesh. Countries such as Chile and Colombia have taken the initiative to start WFA at the river basin scale. At present, most countries are at the research-based level, whereby local researchers work together with their respective government agencies to establish an accurate assessment of VW&WF for several economic sectors.

The findings had demonstrated that VW&WF are significant to be included in the national policy, not only for the water sector, but across other economic sectors. For example, Spain is the first country in Europe to implement WF in its government policy at various socio-economic sectors and established a National Water Footprint. This policy also aligned with the EU initiative for WF, known as 'The Water Framework Directive'[12]. As for India, WF had been incorporated in India's New Water Policy, which emphasised the WFA and analysis across all sectors.

WF tools is one of the components included as a WF initiative at the international level. A few countries, such as Germany and the US have developed their web analysis, such as WF calculator. In Germany, the industrial ecology research group of the Chair of Sustainable Engineering (SEE) from Technical University Berlin had developed a Water Footprint Toolbox web analysis, which was supported by the German Environment Agency (UBA). This toolbox consisted of standards, databases, concepts, data sets, tools and impact assessment concerning the environmental impacts and sustainability performance, including WF. The interface of the Water Footprint Toolbox is shown in Figure 7.1.

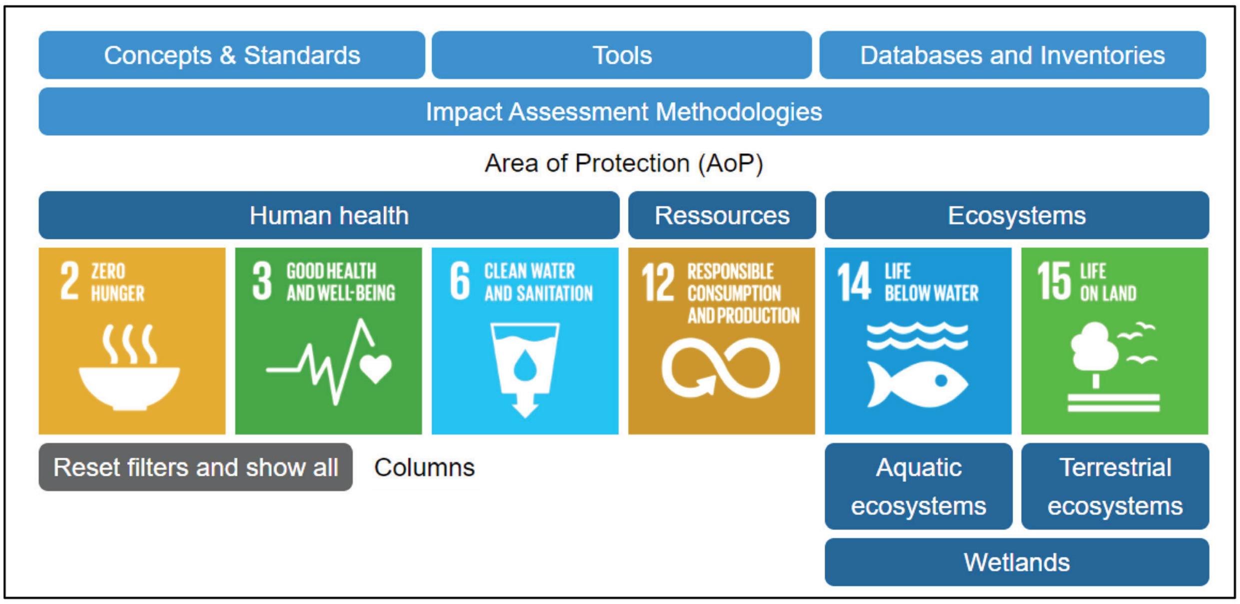


Figure 7.1. Interface of Water Footprint Toolbox by Technical University of Berlin

(*Source*: https://wf-tools.see.tu-berlin.de/wf-tools/waterfootprint-toolbox/)

[12] The 12th MP highlights the key roles of design of products and services in determining resource efficiency and promoting the circular economy. One way of doing this is to uptake recognised green labelling, whereby relevant policies and legislations will be reviewed to incorporate eco-design requirements.

The US has launched a WF calculator by GRACE Communications Foundation (GRACE). GRACE is a non-profit organisation dedicated to creating a more sustainable food system to raise awareness about how people in the US use water throughout their day. This tool is free and available in the English and Spanish languages and illustrates the impacts of water use on everyday actions, from washing dishes to watering the lawn to buying groceries. Figure 7.2 illustrates a screenshot of the water calculator homepage, allowing users to calculate their WF**.**

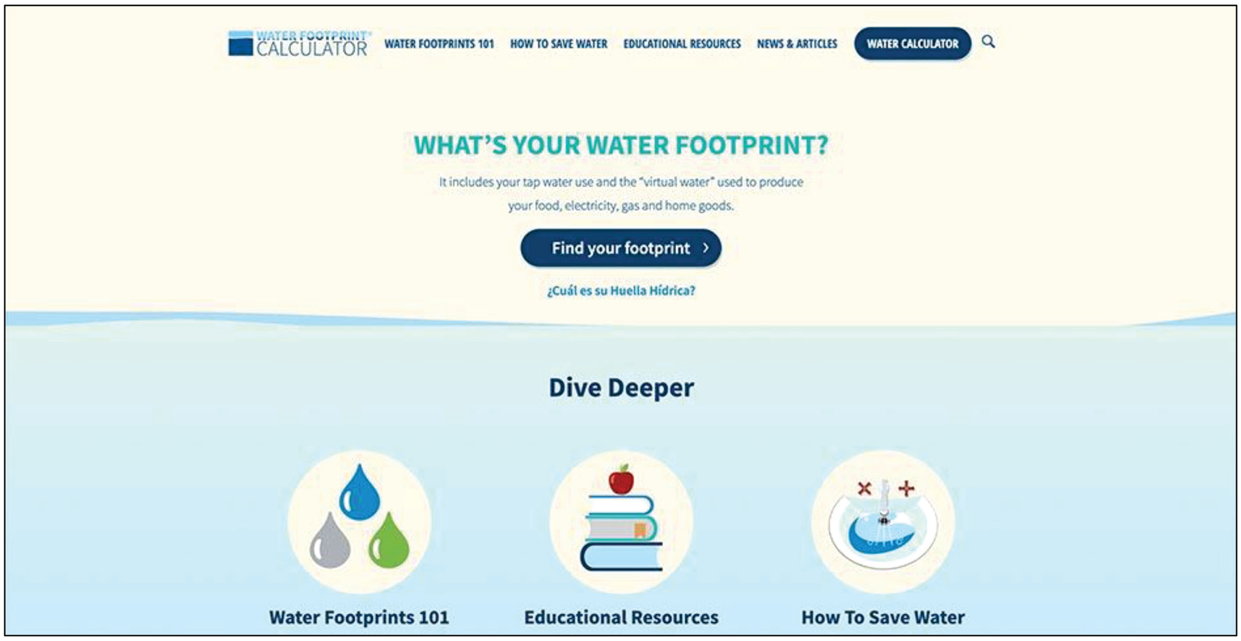


Figure 7.2. WF Calculator Established by GRACE, United States

(*Source*: https://www.watercalculator.org/)

Therefore, there is a need to establish a WF database that consists of a comprehensive WF study of major river basins and selected sectors at the national level. The WF database will help raise awareness amongst the public, inform public policies and business strategies amongst industry players, and provide essential input for future WF research projects in Malaysia. WaterStat (https://shift.tools/resources/1763) is an example of a comprehensive WF database, whereby the datasets are based on peer-reviewed research and the Global Water Footprint Assessment Standard.

Figure 7.3 shows the worldwide country-level initiatives and implementation of VW&WF based on global collaborative, implemented WF agenda, or elements as part of an important policy and regulation, WFA and tools.

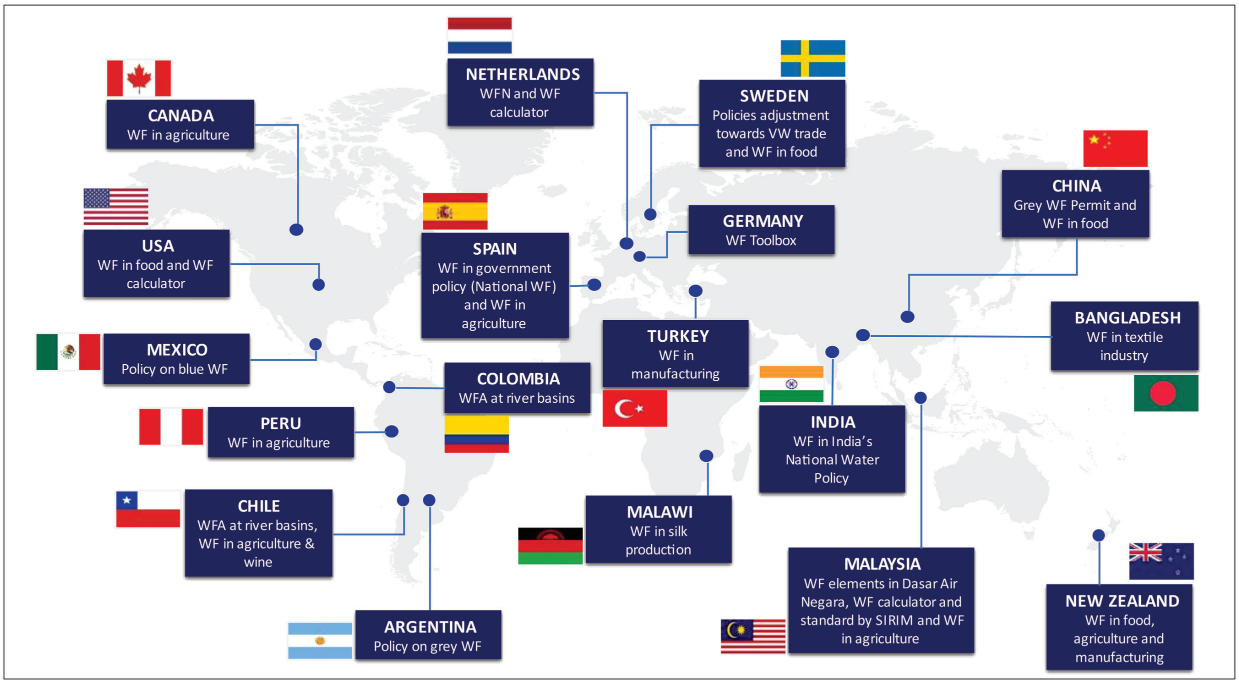


Figure 7.3. Country-level Initiatives and Implementation of VW&WF

7.3 Scope 3: Study Potential of the Nation's Water Sector Industry Taking into Consideration Current Global Markets towards Making the Water Sector as a Dynamic New Economic Sector Capable of Driving the Nation's GDP Growth in the Future

Due to the rapid growth of several sectors, the need for water demand has increased. Amongst major sectors that contribute to Malaysia's economic growth are agriculture, manufacturing and tourism. To ensure the sustainability of the Malaysian industry, a comprehensive study on VW&WF is needed. The study's findings will enable the industrial sector to better understand future water challenges requiring stern actions, such as water scarcity mitigation and systematic water distribution. Furthermore, VW transfer is one mechanism to match water-intensive products, especially water-abundant countries like Malaysia. Although Malaysia is considered a water-abundant country, it is crucial to examine its VW&WF due to Malaysia's high intensity of export products, especially manufacturing.

In the international market, Malaysia contributes between 1.1% and 1.3% of the global trade market. According to Zhang et al. (2019), VW transfer occurs when products made in one region using its local water resources are exported to another region for consumption. Agricultural products have the highest volume of water embedded in the production (Hassan et al., 2017). Therefore, a country that exports agricultural commodities are perceived to have the highest VW, as VW in agricultural products has been extracted from domestic sources, especially during product preparation for export use.

Consequently, results on VW&WF would provide information for Malaysia regarding WF&VW profiles for major commodities and the implications to water management. This includes trade structure, especially for water-scarce countries to increase water-intensive import to reduce local freshwater dependency. As a result, it can also strengthen the water sector in Malaysia as a new economy, which can create more job opportunities in the future.

Based on the WF mapping using Scival, it is found that the institutions from China had dominated the WF publications from 2015 to 2020 with eight out of ten institutions. Since 2006, China has already been researching on WF and has been involved in WF-related research. China has conducted geographic WF studies since the country has vastly different internal water resources. In China, business models should also evolve since WF is incorporated in the supply chain process in the textile sector. Based on the Made in China 2025 strategy, textiles are not a strategic industry, as its contribution to China's GDP is declining. Therefore, brands use innovative circular technologies and business ideas to decrease WF to stay competitive.

From the perspective of a pioneer in the WF concept, the Netherlands, joining forces is integral to strengthen the WF concept and its implementation. The Netherlands focus is on the high VW import dependency quantification and impact assessment, whereby they identified the most critical regions worldwide concerning external WF. Additionally, the first rough analysis had been done for the Netherlands external WF, whereby the grey WF component of main imported products was included.

Germany is further enhancing the WF to perform the Sustainable Development Goals (SDGs). Consequently, several research projects have been done using and improving the WF concept as part of the Federal Ministry of Education and Research initiative, including water as a global resource. The goal is to identify places where water is used inefficiently and put practical measures to improve the situation. Furthermore, the study which focused on high VW import dependency was initiated in Germany. Besides, it is crucial to recognise Germany as the country which applied WF using Life Cycle Assessment and embarked on ISO 14046. Germany has also developed a toolbox that enables researchers to refer to information on WF.

The 12th MP emphasised the need to intensify strategic collaboration amongst scientists at regional and international levels (Chapter 9: B3)[13]. Therefore, the next step to be taken by Malaysia is to establish WF research collaboration with these countries to strengthen Malaysia's position in WF globally. Furthermore, with the current requirement in the global reporting, which is to include the WF element, this would be a key value for industries to be fulfilled. Regarding VW trade, countries such as the Netherlands and Germany have started studying the significance and dependency of VW import dependency to measure its impact throughout the globe and devise future trade strategies.

7.3.1 International Trade Agreement

All major industries will go through the trade process, whereby the concept of WF is being implemented through 'water trade'. VW 'trade' (VWT) represents the amount of water embedded in traded products. Although VWT evaluations have involved countries or even bigger regions as trading partners, the concept can also be applied within countries. From a water resources perspective, the analysis of potential gains from local trade should take into consideration socio-economic and policy conditions, in addition to the spatial and temporal variations of blue and green water.

The VWT mechanism will encourage more countries to acknowledge the amount of water being exported or imported in the agricultural and industrial commodities trade. Most scholars acknowledged and emphasised the use of VWT, as one way of managing water resources and offered numerous solutions to accomplish it. As a result, economic optimisation of VWT, or the balance between export and import of

[13] In the 12th MP, strategic collaboration amongst scientists at regional and international levels are encouraged to be intensified through development of home-grown and innovative water technologies that are on par with international standards (Twelfth Malaysia Plan, p. 9–19).

VW, is required to maintain the level of goods and services of producers' income as well as to take into account the environmental and social concerns towards improving the efficacy of this concept in managing water resources crisis (Hejabi & Akhoondzadeh, 2019).

In many water-scarce countries, non-renewable groundwater from deep aquifers is increasingly being used to grow crops that are then marketed internationally aside from green water, or renewable blue water. Therefore, continued depletion and over-exploitation of non-renewable groundwater have severe regional and global consequences, including land subsidence, salt water intrusion and deterioration of water quality. From 2010 until the end of the century, virtual green water and virtual blue water exports are expected to be tripled due to the driving factors of population growth and water demand (Graham et al., 2020). Therefore, VWT plays a critical role in alleviating water shortages in virtual water-importing countries. Simultaneously, it has resulted in a rapid decline in the water availability per capita for net virtual water-exporting nations, such as India, which is already water limited. Thus far, VWT has been utilised as a mechanism for the globalisation of fresh water resources, sharing fresh water resources and improving the water resource management.

The US and China are both water net importers. Agriculture VW is imported mainly by China, whereas industrial VW is primarily imported by the US. As China is facing water scarcity issues, importing a significant amount of agricultural VW can help ease the country's water crisis. However, due to economic and technological limitations, some countries water systems are increasingly stressed, causing them to export water-intensive items, such as agricultural products. Therefore, these countries should take drastic measures, including changing their industrial structures, learning industrial technology from industrialised countries and changing their industrial VW export system (Fu et al., 2021). It is anticipated that to make this work on a global scale, respective governments and policymakers should pay close attention to this issue and prioritise it through a policy.

At the moment, two major international trade agreements between Malaysia and the global partners are the Asian Free Trade Agreement (AFTA) and the Trans-Pacific Partnership (TPP) (Table 7.2). These international agreements are significant to WF policy from the perspective of VWT connections. The inclusion of WF in the agreement would link international water trade concerning all major export and import commodities. For instance, international VW flows is related to trade agricultural and industrial products. The WF in the trade agreement can be used by applying the mechanism in collecting various details of VW intensity and trade volume of specific merits of the bottom-up approach, which provides details on the commodity information. As a result, it will indicate the VW flows embodied in the international commodity trade, which is evaluated as the magnitude of VW required to produce traded commodities.

The international VWT is a weighted and guided network, in which link weights are the volumes of VW exchanged between countries, and link direction is determined by trade direction (i.e., from exporting to importing country). If a trade relationship is driven from a relatively more efficient country of production into a relatively less efficient country of production, it could lead to global water savings. In this context, the World Trade Organisation (WTO) has started VW initiatives under the global trade agreement (Manson & Epps, 2014). A white paper on this initiative has been prepared and discussions on this matter amongst country leaders are still ongoing.

Table 7.2. International Trade Agreements between Malaysia and Global Partners

No.	Trade	Summary	Suggestion/Recommendation
1.	ASEAN Free Trade Area (AFTA)	1. The governments of Brunei Darussalam, the Republic of Indonesia, Malaysia, the Republic of the Philippines, the Republic of Singapore and the Kingdom of Thailand, Member States of the Association of South East Asian Nations (ASEAN): Mindful of the Declaration of ASEAN Concord signed in Bali, Indonesia on 24 February 1976, which provides that Member States shall cooperate in the field of trade in order to promote development and growth of new production and trade; Recalling that the ASEAN Heads of Government, at their Third Summit Meeting held in Manila on 13-15 December 1987, declared that Member States shall strengthen intra-ASEAN economic cooperation to maximise the realisation of the region's potential in trade and development; Noting that the agreement on ASEAN Preferential Trading Arrangements (PTA) signed in Manila on 24 February 1977 provides for the adoption of various instruments on trade liberalisation on a preferential basis; Adhering to the principles, concepts and ideals of the framework agreement on Enhancing ASEAN Economic Cooperation signed in Singapore on 28 January 1992; Convinced that preferential trading arrangements amongst ASEAN Member States will act as a stimulus to the strengthening of national and ASEAN economic resilience and the development of the national economies of Member States by expanding investment and production opportunities, trade and foreign exchange earnings; Determined to further cooperate in the economic growth of the region by accelerating the liberalisation of intra-ASEAN trade and investment with the objective of creating the ASEAN Free Trade Area using the Common Effective Preferential Tariff (CEPT) Scheme; Desiring to effect improvements on the ASEAN PTA in consonance with the ASEAN international commitments; Have agreed as follows: Article 1. 2. The members of the Association of South-East Asian Nations; Inspired to maintain, further develop and strengthen friendly relations and cooperation between their countries; Reiterating their commitment to foster smooth, rapid and efficient movement of goods, First ASEAN Informal between and amongst Contracting Parties; Recalling the decisions of the Summit held on 30 November 1996 in Jakarta and the Second ASEAN Informal Summit held on 15 December 1997 in Kuala Lumpur, to cooperate in the area of facilitation of goods in transit and to expeditiously study the necessary measures to facilitate the transportation of goods both in transit and inter-state, covering land, maritime and air links, respectively; Noting Article V of the General Agreement on Tariffs and Trade (GATT 1994) on 'Freedom of Transit' and other relevant international conventions on goods in transit; Agreeing that the ASEAN Framework Agreement	1. Virtual water trade (VWT) connections. 2. International water trade concerning all major export and import commodities. 3. Relationship between water scarcity and foreign water dependency regarding food-based VWT.

No.	Trade	Summary	Suggestion/Recommendation
		on the Facilitation of Goods in Transit provides the most effective arrangement for facilitating inter-state traffic and transit transport amongst ASEAN countries; Undertaking to encourage and facilitate inter-state traffic and transit transport amongst the Contracting Parties; Have agreed as follows: Objectives i. The Contracting Parties shall recognise periodic inspection certificates of road vehicles used for transit transport issued by the other Contracting Parties, following the Agreement on the Recognition of Commercial Vehicle Inspection Certificates for Goods Vehicles and Public Service Vehicles Issued by ASEAN member countries signed in Singapore on 10 September 1998. ii. The Contracting Parties shall establish sanitary and phytosanitary measures to be specified in Protocol 8 to facilitate movement of goods in their territories and ensure compliance with the laws and regulations, which the relevant authorities are responsible for enforcing. iii. The Contracting Parties endeavour to harmonise and simplify their rules, regulations and administrative procedures related to transit transport in accordance with the provisions of this Agreement. iv. The Contracting Parties shall ensure transparency of its respective laws, regulations and administrative procedures, which affect the facilitation of transit transport of goods under this Agreement and its Protocols. v. Protocol 1 – Designation of Transit Transport Routes and Facilities, Protocol 2 – Designation of Frontier Posts, Protocol 3 – Types and Quantity of Road Vehicles, Protocol 4 – Technical Requirements of Vehicles, Protocol 5 – ASEAN Scheme of Compulsory Motor Vehicle Third-Party Liability Insurance, Protocol 6 – Railways Border and Interchange Stations, Protocol – 7 Customs Transit System, Protocol 8 – Sanitary and Phytosanitary Measures, and Protocol 9 – Dangerous Goods.	
2.	Trans-Pacific Partnership (TPP)	1. The TPP is an initiative to establish a comprehensive Free Trade Agreement (FTA). 2. The chapters are Sanitary and Phytosanitary (SPS), Customs, Cross-Border Trade in Services, Telecommunications, Temporary Entry, Government Procurement, Labour, Cooperation and Capacity Building, Competitiveness and Business Facilitation, Development, Small and Medium-sized Enterprises, Regulatory Coherence, Initial and General Definitions and Administrative and Institutional Provisions.	1. International VW flows related to trade in agricultural and industrial products. 2. Collects dispersive details (e.g., VW intensity and trade volume of specific commodity) and aggregates them into the global or regional profiles. One of the most attractive merits of the bottom-up approach, which provided detailed commodity information.

No.	Trade	Summary	Suggestion/Recommendation
		3. The government views the TPP as an important initiative, as Malaysia seeks to expand market access opportunities, enhance the competitive advantage, build investor confidence in the country, which draws foreign investments and builds capacity through FTAs. Consultations with various stakeholders have revealed an increasing need by their own companies for more open markets and trade facilitation measures. 4. Malaysian companies are increasingly becoming global investors and they require a level of transparency and predictability that can only be guaranteed effectively through binding agreements like FTAs. There is interest from foreign companies in non-TPP countries that are increasingly exploring Malaysia, as a base of their operations to enjoy the benefits of the TPP. 5. The government has been engaging stakeholders, both from the business sector and NGOs to update and explain the positions taken, and how Malaysia is dealing with the concerned issues in the negotiations. 6. To continue the trade and investment liberalisation efforts undertaken through WTO and FTA initiatives of each TPP member country in the region. 7. Some of the key issues for Malaysia are enforcement, whereby forestry, biodiversity, water and land are under the state jurisdictions; elimination of fisheries and fossil fuel subsidies, adopting stronger provisions in conservation, binding all the commitments in Multilateral Environmental Agreements (MEAs) under this chapter, and subjecting the environment chapter to dispute settlement mechanism. 8. On the issue of ISDS, foreign investors are drawn to Malaysia by economic incentives and a transparent and predictable investment regime that allows recourse in the event of disputes. 9. Apart from the need to comply with the confidentiality requirement, as provided by Malaysia's domestic law, Malaysia also owes a duty of care to preserve and protect its positions as well as the positions of other countries from being exposed during the negotiations. 10. Other ministries and agencies involved in the negotiations, such as the Ministry of Finance, Ministry of Domestic Trade, Consumerism and Cooperatives, Ministry of Human Resource, and the Ministry of Natural Resource and Environment have continuously undertaken consultations with their stakeholders.	3. International VW trade indicates the VW flows embodied in international commodity trade, which is evaluated as the magnitude of VW required to produce the traded commodities.

7.4 Scope 4: Prepare a Transformation Strategy and Initiative Implementation Framework for each of the 4 Phases including the Implementing Agencies, Estimated Budgets and Main Target Achievements Based on the Analyses Undertaken and Expert Reviews

The details of the Roadmap can be referred to in Section 7.6.

7.5 Scope 5: Undertake Consultations with Stakeholders and Experts with the Aim of Finalising the Proposed Strategies and Initiatives of the Nation's Water Sector Transformation

Various consultation sessions with stakeholders and experts have been conducted to propose the strategies, initiatives, programmes and activities under the VW&WF study. Table 7.3 summarises the engagement sessions with stakeholders and experts throughout the study's project.

Table 7.3. Activities with Stakeholders and Experts to Finalise Proposed Strategies and Data Collection

No.	Activity	Ministries/Agencies/ Organisations	Date	Venue (Live/Zoom)
1.	VW&WF Task Force Members Meeting	MPOB, MADA, MARDI, UM, LGM, INTEL, NREB, DOSM, MITI, MIDA, KASA, SIRIM	10 Aug 2020	ASM
2.	VW&WF Task Force Meeting (Definition and Concept)	MPOB, UM	3 Sept 2020	Zoom
3.	VW&WF Task Force Members Meeting	MPOB, MADA, MARDI, UM, LGM, INTEL, DOE, NREB, EPD Sabah, Top Glove	3 Nov 2020	Zoom
4.	FGD Paddy	MADA, KADA, IADA, MARDI, DOE, BERNAS, Faiza Sdn. Bhd., NREB, EPD Sabah, MAFI	26 Jan 2021	Zoom
5.	FGD Tourism	Hotels (Terengganu, JB, KL, Selangor, Pahang, Sabah, Sarawak), DOSM, MOT, MAFI, MAH, MOTAC	22 Feb 2021	Zoom
6.	FGD Rubber	FELCRA, FELDA, LGM, LIGS, UM, NAFAS	1 Mar 2021	Zoom
7.	Meeting for Semiconductor Sector	Micron Semiconductor Sdn. Bhd.	3 Mar 2021	Zoom
8.	*Bengkel Cadangan Penambahbaikan Polisi & Akta untuk Menerapkan Konsep VW&WF*	KASA, SPAN, LGM, IPASA, UTM, MOTAC, JPS, NAHRIM, FMM, LESTARI, UM, LUAS, EPU, DOE, JSM, SIRIM, BAKAJ	6 Apr 2021	Bangi Resort Hotel
9.	*Kajian Pembangunan Roadmap WST2040 bagi VW&WF*	LGM, MOSTI, ASM, GEC, MOHE, MOE, MOF, KASA, JPS, UTM, UM, SIRIM	7 Apr 2020	Bangi Resort Hotel

No.	Activity	Ministries/Agencies/ Organisations	Date	Venue (Live/Zoom)
10.	Meeting on Roadmap	JSM	3 Mar 2021	Zoom
11.	*FGD Cadangan Penambahbaikan Polisi & Akta untuk Menerapkan Konsep VW&WF (Sabah dan Sarawak)*	JPS Sabah, JTU Sabah, DOA Sabah, JPBW Sabah, DOA Sarawak, JTS Sarawak, SEDC, NREB, KWB, KASA, JPS	6 Apr 2021	Zoom
12,	*Mesyuarat Pemurnian Kajian Pembangunan Roadmap WST2040 bagi VW&WF*	KASA, JPS, DOE, JSM, MOTAC, LGM, BAKAJ, LUAS, LESTARI UKM, RISE UTM, UM, NAHRIM, SIRIM, SPAN, ASM, GEC, MOHE, MOE, MOF, MPOB, EPD Sabah, BPEN Kedah, UPEN Kelantan, UPEN Terengganu, JBA Terengganu, LAUT	25 May 2021	Zoom
13.	*Mesyuarat Pemurnian Kajian Pembangunan Roadmap WST2040 bagi VW&WF*	MITI	2 Sept 2021	Zoom

7.6 Scope 6: Prepare a Complete Roadmap for the National Agenda on the Water Sector Transformation 2040 for various Ministries and Agencies Information and Guide for the Implementation of Programmes and Activities towards Achieving the Targeted Transformation Objectives

Table 7.4 and Table 7.5 illustrate the proposed Water Sector Transformation 2040 (WST2040) for various ministries and agencies towards water security and sustainability and the economic sector. Table 7.6 and Table 7.7 show the proposed WST2040 roadmap budget framework for water security, sustainability and the economic sector.

Table 7.4. Proposed WST2040 Roadmap Framework towards Water Security and Sustainability

Draft VW&WF for WST2040 Strategy Plan and Implementation Road Map										
Focus Area	**NIWRMP Strategies**			**11th MP Strategies**			**WST2040 Strategies**			**Focus Area**
People	Heightening VW&WF awareness amongst the public and industry	**Public**								**People**
		Conducting awareness programmes and knowledge dissemination for the public	Roadshow to get buy-in from federal agencies and state governments.	National	• KASA • MOE • MOHE • State Agencies, e.g., Sarawak Natural Resources & Environmental Board (NREB), Sabah Natural Resource Office • WF Centre	• KASA • MOSTI • MOE • MOHE • State Agencies • DID • KKMM • DOE • Local Authority • KPKT • NGOs		2022 - 2040	Proposed KPIs: Awareness programme for roadshow will start from 2022.	
			WF highlights during National Environment Day.						Proposed KPIs: Articles on WF to be published on popular media targeted for the general public.	

Draft VW&WF for WST2040 Strategy Plan and Implementation Road Map

Focus Area	NIWRMP Strategies			11th MP Strategies			WST2040 Strategies			Focus Area
			Participating in programmes under IHP-UNESCO and DID.						Proposed KPIs: WF elements to be included in the programme to start in 2023.	
			WF awareness programmes through social media (Facebook, YouTube, Instagram, Twitter, LinkedIn) and other mass media.						Proposed KPIs: 1) WF related content on social media updated on a daily basis starting from 2022. 2) New content created on a weekly basis in a dedicated YouTube channel starting from 2022.	
			Workshops and webinars on WF awareness.						Proposed KPIs: Biennial WF workshop to be organised beginning 2023.	

Draft VW&WF for WST2040 Strategy Plan and Implementation Road Map										
Focus Area	NIWRMP Strategies			11th MP Strategies			WST2040 Strategies			Focus Area
			Inclusion of WF in exhibitions and awareness programmes to the parliamentary special committee and state assemblymen.						Proposed KPIs: Awareness programme with members of parliament and state assemblymen conducted every two years starting from 2024.	
			Promoting local food - lower WF.	National	Government Agencies/EPU	EPU/Government of Malaysia Circulations, KASA			Proposed KPIs: List of alternative local food with low WF to replace imported food starting from 2023.	
			Personal Approach	Personal	Public/local communities	Personal			Proposed KPIs: Online customised individual WF calculator is available for local use starting from 2023.	

Draft VW&WF for WST2040 Strategy Plan and Implementation Road Map										
Focus Area	NIWRMP Strategies			11th MP Strategies			WST2040 Strategies			Focus Area
		School and University								
		Conducting awareness programmes and knowledge dissemination for schools and universities.	Introducing WF concept in co-curriculum activities amongst school children.	National		• KASA • MOSTI • MOE • MOHE • State Agencies • DID • KKMM • DOE • WWF • NGOs • Influencer • Animation company		2022 - 2040	Proposed KPIs: 1) Incorporation of WF concept in the school environmental club activities by 2025. 2) Content and materials for WF activities for school and university students developed by 2024.	
			WF awareness programmes through social media (Facebook, YouTube, Instagram, Twitter) and other mass media (DidikTV).			• MOE • KKMM			Proposed KPIs: WF-related content for school and university students on social media to be updated on a daily basis starting from 2022.	

Draft VW&WF for WST2040 Strategy Plan and Implementation Road Map										
Focus Area	NIWRMP Strategies			11th MP Strategies			WST2040 Strategies			Focus Area
			Organising competition on WF related themes during the National Science Week.			• MOSTI • MOHE • MOE			Proposed KPIs: One WF competition programme per year.	
			Highlighting WF concept during the World Water Day.						Proposed KPIs: Article on WF to be published on popular media targeted for the general public.	
			Conduction of awareness programmes on Water Conservation initiatives during the World Water Day.		MOE, MOHE, *Pusat Sains Negara*, DOE *Sekolah Lestari*, SPAN	• EPU • MOE • MOHE • GEC			Educational institutions have the allocation for water conservation efforts in their schools/institutions (compulsory).	
			Incorporating WF elements from the DrH2O programme developed from the national pilot project funded by HSBC.			• MOE • GEC • NGOs			Proposed KPIs: Co-organise activity with GEC using the DrH2O kit (water savings kit, checklist, water audit, water conservation module).	

Draft VW&WF for WST2040 Strategy Plan and Implementation Road Map										
Focus Area	**NIWRMP Strategies**			**11th MP Strategies**			**WST2040 Strategies**			**Focus Area**
		Industry								
		Conducting awareness programmes and knowledge dissemination for industry.	Establishing networking with industries to disseminate progress on WF initiatives and success stories.	National		• KASA • KPKT • WF Centre • MOF • MITI • MICCI	In-planning	2022 - 2040	Proposed KPIs: Database of industries and WF association established by 2023.	
			Educating via training and awareness programmes for setting up the economic return framework of products.						Proposed KPIs: Economic module for economic return framework developed by 2025.	
			Including WF elements, as one of the assessment criteria in the Prime Minister's Hibiscus Award.			MICCI			Proposed KPIs: Element of WF to be included in the Prime Minister's Hibiscus Award by 2025.	

Draft VW&WF for WST2040 Strategy Plan and Implementation Road Map

Focus Area	NIWRMP Strategies			11th MP Strategies			WST2040 Strategies			Focus Area
Governance	Enhancement of policy and law to support WF initiatives.	Incorporating WF components in Dasar Air Negara (DAN)	Deliberation with KASA to have WF components included in DAN.	National	KASA	• KASA • MITI • JSM • MPC • MAFI		2022	Proposed KPIs: Inclusion of VW&WF elements and requirements in the Dasar Air Negara (DAN) by the end of 2022.	Governance
	Mainstreaming WF in business.	Establishing requirements for water accounting report.	Incorporation of WF in water accounting report.	National	KASA/ EPD Sabah/ NREB Sarawak/ state government	• KASA • JSM • MITI • MPC • MAFI		2022 - 2030	Proposed KPIs: 1) Requirement for water accounting report by industry in 2030. 2) WF elements are incorporated in water accounting reporting by 2030.	
		Strengthening water accounting report.	Reviewing reports submitted by the industries, identify gaps and suggestions for improvement.		KASA/ EPD Sabah/ NREB Sarawak/ state government	• KASA • JSM • MITI • MPC • MAFI		2026 - 2040	Proposed KPIs: Water accounting report is fully implemented to major water user industries by 2040.	

Draft VW&WF for WST2040 Strategy Plan and Implementation Road Map

Focus Area	NIWRMP Strategies			11th MP Strategies			WST2040 Strategies		Focus Area
	Becoming global champion.	Positioning Malaysian WF experts at the international platform.	Collaboration with researchers from China, the Netherlands and Germany.	National	• MITI • MOSTI	• MITI • MOSTI		2031 - 2035	Proposed KPIs: 1) MoU on WF collaboration with China, the Netherlands and Germany to be signed by 2033. 2) Framework for benchmarking with global best players developed by 2032.
		Elevating Malaysia's role as a major player in the global WF initiative.	Increasing WF related outputs in terms of publications, joint research and capacity building.	National	• MOHE • MOSTI			2022 - 2040	Proposed KPIs: 1) To increase the number of publications in high impact journals (2022 - 2040). 2) Increased number of citations on VW&WF publication (2022 - 2040)

Draft VW&WF for WST2040 Strategy Plan and Implementation Road Map

Focus Area

NIWRMP Strategies			11th MP Strategies			WST2040 Strategies		
	Exporting WF knowledge.	Development of module and conducting training in WF in Southeast Asia countries.	National	WF centre (MyWaFA)			2036 - 2040	Proposed KPIs: 1) Training module to be accepted and implemented in selected Asian countries, namely Indonesia, Vietnam, and the Philippines (2036 - 2040). 2) Two WF training conducted in selected Asian countries per year (2036 - 2040).
Establishing WF governance.	Creation of task force and guidelines.	1) Establishing a national task force on VW&WF. 2) Formulating guidelines on WF implementation.	National	KASA			2022 - 2024	Proposed KPIs: WF task force established by 2022. Guidelines on WF implementation completed by 2024.
Enhancing global trade.	White paper on VW for the purpose of international trade agreement.	Establishing committee members to prepare the white paper.	National	• MITI • EPU	• MITI • EPU		2031 - 2035	Proposed KPIs: A white paper of VW will be presented in the Malaysian Parliament by 2035.

Focus Area

Draft VW&WF for WST2040 Strategy Plan and Implementation Road Map										
Focus Area	NIWRMP Strategies			11th MP Strategies			WST2040 Strategies			Focus Area
		Optimising global water management through VWTunder several trade agreements.	Formulating terms and conditions on VW for mutual trade.	National	• MITI • EPU • MFA	• MITI • EPU • MFA		2031 - 2040	Proposed KPIs: Trade agreement involving VW to be signed with major trade partners under AFTA and TPP members, and other trade partners and economic blocks (e.g., EU, North American Free Trade Agreement, and Australia) by 2040.	
		Inclusion of VW in an international trade agreement.	Forming VW caucus for trade negotiation.	National	• MITI • EPU	• MITI • EPU		2036 - 2040	Proposed KPIs: 1) VW caucus amongst member countries to be established by 2037. 2) Trade agreement incorporating VW to be signed by 2040.	
Information & RDCI	Enhancing R&D in WF	Incorporation of WF in NAWABS within the river basin framework.	Conduction of comprehensive WF study for selected river basins.	National	DID	• DID • EPU • MAFI • State agency (SUK)		2022 - 2040	Proposed KPIs: Completion of WF studies for 56 river basins in Malaysia (as listed by DID) by 2040.	Information & RDCI

Draft VW&WF for WST2040 Strategy Plan and Implementation Road Map

Focus Area

NIWRMP Strategies			11th MP Strategies			WST2040 Strategies		
	WF study for selected sectors.	Involvement of local authorities in the water planning at river basin level.						Proposed KPIs: Guideline on the involvement of local authority in WF implementation to be drafted by 2026.
		Analyse and calculate WF for major products and services.	National	• EPU	• EPU • MIDA/MITI • Universities • MPOB		2023 - 2040	Proposed KPIs: Completion of 20 WF studies of products and services (2023-2040).
		WF study for textiles.					2023	
		WF study for automotive.					2024	
		WF study for energy.					2025	
		WF study for vegetable farming.					2026	
		WF study for cocoa beans.					2026	
		WF study for livestock.					2027	

Draft VW&WF for WST2040 Strategy Plan and Implementation Road Map										
Focus Area	**NIWRMP Strategies**			**11th MP Strategies**			**WST2040 Strategies**			**Focus Area**
			WF study for food industry.					2027		
			WF study for mining.					2028		
			WF study for waste.					2029		
			WF study for aquaculture.					2030		
			Another ten products/services to be determined for the 14th MP and 15th MP.					2031 - 2040		
		Enhancing global trade. Initiating tax incentives upon completion of water reporting.	Comprehensive studies on global economic opportunities, drivers and impacts of VW.	National	• MITI • EPU			2031 - 2035	Proposed KPIs: Studies on global economic opportunities, drivers and impacts of VW to be completed by 2035.	
Finance	Provision of financial rewards and incentives.		Drafting of financial rewards in the form of tax incentives.	National	MOF	• MOF • LHDN		2027	Proposed KPIs: Tax incentive programme ready to be implemented by 2027.	**Finance**

Table 7.5. Proposed WST2040 Roadmap Framework towards Water as an Economic Sector

Draft WST2040 Strategy Plan and Implementation Road Map											
Focus Area	NIWRMP Strategies			11th MP Strategies				WST2040 Strategies			Focus Area
	Water for Livelihood/Water as an Economic Opportunity										
	11th MP / 12th MP / 13th MP / 14th MP / 15th MP										
	Strategy	Water User Category	Initiatives	Programmes/ Activities	Hierarchical	Lead Authority/ Collaborating Partner	Implementing Authority	Current Status	Target Completion	Remarks	
People	Enhancing WF competency.		Development of training modules and attainment of recognition by certification bodies (Statutory/ Private).	Series of meetings with government, certification agency and industrial players.	National	• KASA • NREB • EPD Sabah	• KASA • MITI • Standards Malaysia • SIRIM		2022	Proposed KPIs: Accredited WF assessment training modules for industry ready to be utilised by the end of 2022.	People
				Establishment of the accreditation body (to be decided by the national task force on WF).					2023	Proposed KPIs: Accredited WF auditing training modules for auditors ready to be utilised by June 2023.	
Governance	Mainstreaming WF in businesses.		Promotion of WF labelling scheme amongst local producers.	i. Updating water scarcity index (WSI) with climate change scenario at the district level. ii. Preparing and disseminating information on the benefits of WF labelling.	National	SIRIM	• SIRIM • NAHRIM • JPS • SPAN • Standards Malaysia	i. WSI projection until 2030 available in SIRIM GIS Portal ii. WF profiling for agriculture, building services and glove industry.	2024	Proposed KPIs: The WF labelling scheme will be available by 2024.	Governance

Draft WST2040 Strategy Plan and Implementation Road Map											
Focus Area	NIWRMP Strategies			11th MP Strategies				WST2040 Strategies			Focus Area
	Water for Livelihood/Water as an Economic Opportunity										
	11th MP / 12th MP / 13th MP / 14th MP / 15th MP										
	Strategy	**Water User Category**	**Initiatives**	**Programmes/ Activities**	**Hierarchical**	**Lead Authority/ Collaborating Partner**	**Implementing Authority**	**Current Status**	**Target Completion**	**Remarks**	
			Development of WF calculator for the industrial sector.	Identification of suitable online domain, theme and big data compilation.	National	• KASA	• EPU • KASA • MITI • MOSTI • Standards Malaysia • SIRIM		2025	Proposed KPIs: WF calculator to be developed by June 2025.	
				Inclusion of WF inventory from case studies.					2022 - 2040	Proposed KPIs: Completion of WF database for 26 various products/ services (2022 - 2040).	
	Enhancing WF competency.	Water professionals (e.g., industrial players, consultants, researchers, government officers).	Conduction of competency training programmes for water managers.	Conduction of the trainers training programme.	National	• KASA • NREB • EPD Sabah	• KASA • MITI • Standards Malaysia		2023 - 2040	Proposed KPIs: 1) WF competency programme ready to be implemented by 2023. 2) 100 trained water managers per year beginning from 2023.	

Draft WST2040 Strategy Plan and Implementation Road Map											
Focus Area	NIWRMP Strategies			11th MP Strategies				WST2040 Strategies			Focus Area
	Water for Livelihood/Water as an Economic Opportunity										
	11th MP / 12th MP / 13th MP / 14th MP / 15th MP										
	Strategy	**Water User Category**	**Initiatives**	**Programmes/ Activities**	**Hierarchical**	**Lead Authority/ Collaborating Partner**	**Implementing Authority**	**Current Status**	**Target Completion**	**Remarks**	
Focus Area	Strengthening Institutional setup.		Establishment of a model river basin to fully implement the WF concept.	1) Setup criteria for river basin selection. 2) Prioritise potential river basin.	National	• DID • State Water Authorities	• DID • State Water Authorities		2026 - 2035	Proposed KPIs: A pilot project on WF implementation at the river basin scale to start in 2026 and should be in line with the River Basin Authority (RBA) initiative.	Focus Area
Finance	Mainstreaming WF in businesses.		Incorporating WF components in the environmental, social and governance (ESG) initiatives.	Engagement with Bursa Malaysia to discuss on the ESG reporting.	National	Bursa Malaysia	• Bursa Malaysia • SC		2025 - 2040	Proposed KPIs: 1) WF information under water provision in ESG by 2025. 2) Participation of public listed companies in the new provision of ESG by 20% in 2040.	Finance
Infrastructure & Technology	Strengthening institutional set-up.		Setting up WF centre.	Identification of location, establishment of a physical centre, and recruitment of experts and staff.	National	• KASA • MOHE	• KASA • MOHE • Universities • NAHRIM		2023 - continuous	Proposed KPIs: National WF centre will be set up by 2023.	Infrastructure & Technology

Table 7.6. Proposed WST2040 Roadmap Budget Framework towards Water Security and Sustainability

Draft VW&WF for WST2040 Budget Requirements																
Focus Area	**NIWRMP Strategies**			**11th MP Strategies**						**WST2040 Strategies**						**Focus Area**
People	Heightening VW&WF awareness amongst the public and industries.	Conduction of awareness programmes and knowledge dissemination for the public, industries, schools and universities.	**Public** • Roadshow to get buy-in from agencies and state governments. • WF highlights during the National Environment Day. • Participating in programmes under IHP-UNESCO and DID. • WF awareness programmes through social media (Facebook, YouTube, Instagram, Twitter, LinkedIn) and other mass media. • Workshops and webinars on WF awareness • Inclusion WF in exhibitions and awareness programmes to the parliamentary special committee and state assemblymen. • Promote local food – lower WF • Personal Approach	KASA, MOE, MOHE, State agencies, e.g., Sarawak Natural Resources & Environmental Board (NREB), Sabah Natural Resource Office, WF Centre		0.7	0.2	0.2	0.2	**1.3**	0.5	0.5	0.5	2022 - 2040	The budget is for an awareness programme amongst the public, schools, universities and industries.	**People**

Draft VW&WF for WST2040 Budget Requirements																
Focus Area	**NIWRMP Strategies**			**11th MP Strategies**						**WST2040 Strategies**						**Focus Area**
			School and University • Co-curriculum activities amongst school children. • WF awareness programmes through social media (Facebook, YouTube, Instagram, Twitter) and other mass media (DidikTV). • Organise competition on WF related theme during the National Science Week. • Highlighting WF concept during the World Water Day. • Conduction of awareness programmes on water conservation initiatives during the World Water Day. • Incorporating WF elements from the DrH2O programme developed from the national pilot project funded by HSBC.			0.5	0.2	0.2	0.2	**1.1**	0.3	0.3	0.3			

Draft VW&WF for WST2040 Budget Requirements																
Focus Area	NIWRMP Strategies			11th MP Strategies						WST2040 Strategies						Focus Area
			Industry • Establishing networking with industries to disseminate progress on WF initiatives and success stories. • Educating via training and awareness programmes for setting up the economic return framework of products. • Inclusion of WF elements, as one of the assessment criteria in the Prime Minister's Hibiscus Award.			0.3	0.1	0.1	0.1	**0.6**	0.2	0.2	0.2			
Governance	Enhancement of policy and law to support WF initiatives.	Incorporation of WF components in Dasar Air Negara (DAN).	Deliberation with KASA to have WF components included in DAN.	KASA										2022		Governance
	Mainstreaming WF in businesses.	Establishing requirements for the water accounting report.	Incorporation of WF in water accounting report.	KASA/ EPD Sabah/ NREB Sarawak/ State government		0.4	0.2	0.2	0.2	**1.0**	1.0			2022-2030		

Draft VW&WF for WST2040 Budget Requirements

Focus Area	NIWRMP Strategies		11th MP Strategies							WST2040 Strategies				Focus Area
	Strengthening the water accounting report.	Reviewing reports submitted by industries, identify gaps, and suggestions for improvement.	KASA/ EPD Sabah/ NREB Sarawak/ state government							0.3	0.2	0.2	2026-2040	
Becoming global champion	Positioning Malaysian WF experts at the international platform.	Collaboration with researchers from China, the Netherlands and Germany.	MITI, MOSTI								15		2031-2035	
	Elevating Malaysia's role as a major player in global WF initiatives.	Increasing WF related output in terms of publications, joint research and capacity building.	MOHE, MOSTI		1	0.5	0.5	0.5	**2.5**	2	2	2	2022-2040	
	Exporting WF knowledge.	Conducting training modules, certification programmes, WF calculator and WF reporting in Southeast Asia countries.	WF centre (MyWaFA)									25	2036-2040	
Establishing WF governance.	Creation of task force and guidelines.	1) Establishing a national task force on VW&WF. 2) Formulating guidelines on WF implementation.	KASA		0.3	0.2	0.2		**0.7**				2022-2024	

Draft VW&WF for WST2040 Budget Requirements

	NIWRMP Strategies			11th MP Strategies					WST2040 Strategies								
Focus Area																	Focus Area
Focus Area	Enhancing global trade.	White paper on VW for the purpose of international trade agreement.	Establishing committee members to prepare the white paper.	MITI, EPU								0.2		2031-2035		Focus Area
Focus Area	Enhancing global trade.	Optimising global water management through VWT under several trade agreements.	Formulation of terms and conditions on VW for mutual trade.	MITI, EPU, MFA								1	1.5	2031-2040		Focus Area
Focus Area	Enhancing global trade.	Inclusion of VW in an international trade agreement.	Forming VW caucus for trade negotiation.	MITI, EPU									1	2036-2040		Focus Area
Information & RDCI	Enhancing R&D in WF.	Incorporating WF in NAWABS within the river basin framework.	1) Conduction of comprehensive WF study for selected river basins. 2) Involvement of local authorities in the water planning at river basin level.	DID		0.2	0.4	0.4	0.4	**1.4**	1.8	1.5	0.4	2022-2040	Budget for VW&WF study only. The final cost for NAWABS may need to include the cost from other task forces.	Information & RDCI
Information & RDCI	Enhancing R&D in WF.	Conducting WF study for selected sectors.	Analysing and calculating WF for major products and services (20 selected case studies).	EPU			0.5	0.5	0.5	**1.5**	3.5	2.5	2.5	2023-2040		Information & RDCI

Draft VW&WF for WST2040 Budget Requirements																
Focus Area	**NIWRMP Strategies**			**11th MP Strategies**						**WST2040 Strategies**						**Focus Area**
	Provision of financial rewards and incentives	Enhancing global trade	Comprehensive studies on global economic opportunities, drivers and impacts of VW.	MITI, EPU								0.2		2031-2035		
Finance		Initiate tax incentive upon completion of water reporting	Drafting of financial rewards in the form of tax incentives.	MOF							0.5			2027		**Finance**

Table 7.7. Proposed WST2040 Roadmap Budget Framework towards Water as an Economic Sector

Draft WST2040 Budget Requirements																
Focus Area	NIWRMP Strategies			11th MP Strategies					WST2040 Strategies							Focus Area
	Water for Livelihood/Water as an Economic Opportunity															
	Strategy	Initiatives	Programmes/ Activities	Lead Ministry/ Organisation	Budget (RM '000,000) 2021	2022	2023	2024	2025	Total 12th MP	13th MP	14th MP	15th MP	Target Completion	Remarks	
People	Enhancing WF competency.	Development of training modules and attainment of module recognition by certification bodies (Statutory/ Private)	1) Series of meetings with government, certification agency, and industrial players 2) Establishment of the accreditation body (to be decided by the national task force on WF)	• KASA • NREB • EPD Sabah		0.2	0.1			**0.3**				2023		People
Governance	Mainstreaming WF in businesses.	Promotion of WF labelling scheme amongst local producers.	i. Updating water scarcity index with climate change scenario at the district level ii. Preparing and dissemination information on the benefit of WF labelling	SIRIM			1.5			**2**				2024		Governance

Draft WST2040 Budget Requirements																
Focus Area	**NIWRMP Strategies**			**11th MP Strategies**						**WST2040 Strategies**						**Focus Area**
	Water for Livelihood/Water as an Economic Opportunity															
					Budget (RM '000,000)											
	Strategy	**Initiatives**	**Programmes/ Activities**	**Lead Ministry/ Organisation**	**2021**	**2022**	**2023**	**2024**	**2025**	**Total 12th MP**	**13th MP**	**14th MP**	**15th MP**	**Target Completion**	**Remarks**	
Governance		Development of WF calculator for the industrial sector.	1) Identification of suitable online domain, theme and big data compilation. 2) Inclusion of WF inventory from case studies.	KASA		0.3	0.25	0.25	0.2	**1**	0.5	0.5	0.5	2040		**Governance**
	Enhancing WF competency.	Conduction of competency training programmes for water managers.	Conduction of the trainers training programme.	• KASA • NREB • EPD Sabah			0.2	0.1	0.1	**0.4**	0.5	0.5	0.5	2023-2040		
	Strengthening institutional setup.	Establishment of a model river basin to fully implement the WF concept.	1) Setting up criteria for river basin selection. 2) Prioritising potential river basins.	• DID • State Water Authorities							50	20		2026-2035		

Draft WST2040 Budget Requirements

Focus Area	NIWRMP Strategies			11th MP Strategies						WST2040 Strategies					Focus Area
	Water for Livelihood/Water as an Economic Opportunity														
	Strategy	Initiatives	Programmes/ Activities	Lead Ministry/ Organisation	Budget (RM '000,000) 2021	2022	2023	2024	2025	Total 12th MP	13th MP	14th MP	15th MP	Target Completion	Remarks
Finance	Mainstreaming WF in businesses.	Incorporating WF component in ESG initiatives.	Engagement with Bursa Malaysia to discuss ESG reporting.	Bursa Malaysia					0.1	**0.1**	0.5	0.5	0.5	2025-2040		Finance
Infrastructure & Technology	Establishment of WF Centre.	Setting up WF centre.	Identification of location, establishment of physical centre, and recruitment of experts and staff.	• KASA • MOHE			2.5	2	2	**6.5**	10	10	10	2023 - continuous	• Initial cost is for the establishment of the centre. • The annual cost is the cost to run the centre, but once the centre is in full operation, it will be able to generate income and be partially self-sustained. • Using the existing national training centre.	Infrastructure & Technology

8.0 Virtual Water and Water Footprint Case Study Approach

8.1 Selection of Case Studies

The study assessment parts are divided into two main categories; assessment of selected sectors based on a set of criteria and WF inventory assessment of several important sub-sectors.

For the past few decades, Malaysia has transitioned from merely agriculture-based to an industrialised country. This change has resulted in a significant industrialisation process, which increases the water demand. Due to the high volume of outputs, Malaysia's major commodities, which constituted major GDP, such as manufacturing, consumed significant amount of water. During the rapid growth of industrialisation, export has played a major role in the economy's major contribution to trade balance, which recorded USD2.61 billion surpluses in 2018. However, as Malaysia's economy is relatively small due to its small market size, the aim to be a developed country needs to be realised through international trade.

Due to several factors, including time and financial constraints, this study only undertakes several of Malaysia's vital sectors to perform WFA. Therefore, case studies on the selected sectors are strategically chosen to be highlighted at this stage. These case studies, which will give valuable inputs to the next stage of WFA, are chosen based on two main criteria, namely:

i. Contribution in terms of value towards Malaysia's GDP
ii. Consumption of water to produce product outputs

Using these criteria as the guidelines, sectors that fulfil these criteria are selected. Next, several sub-sectors under these different sectors are picked as case studies based on the same criteria – contribution to the country's GDP and water consumption. Although rice production (from paddy cultivation) does not fit the first criteria, this water-intensive food crop is chosen because it is considered a critical commodity from the food security aspect. In recent years, sectors, such as services and manufacturing have contributed significantly to Malaysia's GDP (56.7% and 22.4%, respectively). Conversely, the agriculture sector only contributes 7.6% of Malaysia's GDP. However, this sector is strategic and important for the nation's food security purposes.

Food and agriculture are the largest water consumers compared to domestic and industrial needs. Up to 70 % of the total water demand goes into irrigation, about 10% is used in domestic applications and 20% in industries (Chen & Chen, 2017; Curmi et al., 2013). Studies by Dietzenbacher and Velázquez (2006) and Zhao et al. (2009) have also identified water embodied in food commodities, as having a large share of water withdrawal. Considering our low food self-sufficiency level (SSL) and a large amount of water is used for paddy plantation, estimation of WF for rice is essential for national WF accounting. According to Morano and Filippi (2015), the rice trade significantly impacts VW since it is one of the largest water consumers. Therefore, paddy is chosen to be one of the case studies for the agriculture sector.

Palm oil is another sub-sector under the agriculture sector chosen as a WF case study since Malaysia is currently the world's largest exporter of palm oil and the second-largest producer after Indonesia. With over 5.7 million hectares covered by oil palm trees in the country, the total water requirement for palm plantation and palm oil processing is tremendous, and this requires urgent improvement on the current water management practices (Subramanian & Hashim, 2018).

Manufacturing has also contributed significantly to Malaysia's economic growth, especially in the electrical and electronic sectors. Compared to the agricultural sector, manufacturing requires less water. However, the sector contributes to the highest volume in production. Additionally, manufacturing activities are responsible for most transportations related to economic transactions, contributing to the environmental impacts (Egilmez & Park, 2014). The electrical and electronic sector particularly withdraws more water (in high quality) than the rest. This sector is also highly vulnerable to water resource changes, especially from potential climate change (Macknick et al., 2011). Besides, this sector requires more energy resources, which consequently needs significant quantities of freshwater. Therefore, the electrical and electronic industry is selected as a case study under the manufacturing sub-sector.

The sectors selected for this study are depicted in Figure 8.1, while the sub-sectors selected for the VW&WF assessment in Malaysia are presented in Figure 8.2.

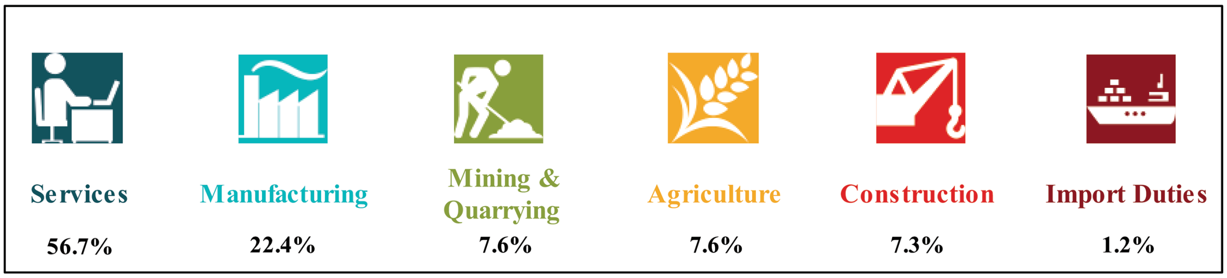


Figure 8.1. Breakdown of Different Sectors Contribution to Malaysia's GDP for 2019

(*Source*: DOSM, 2020)

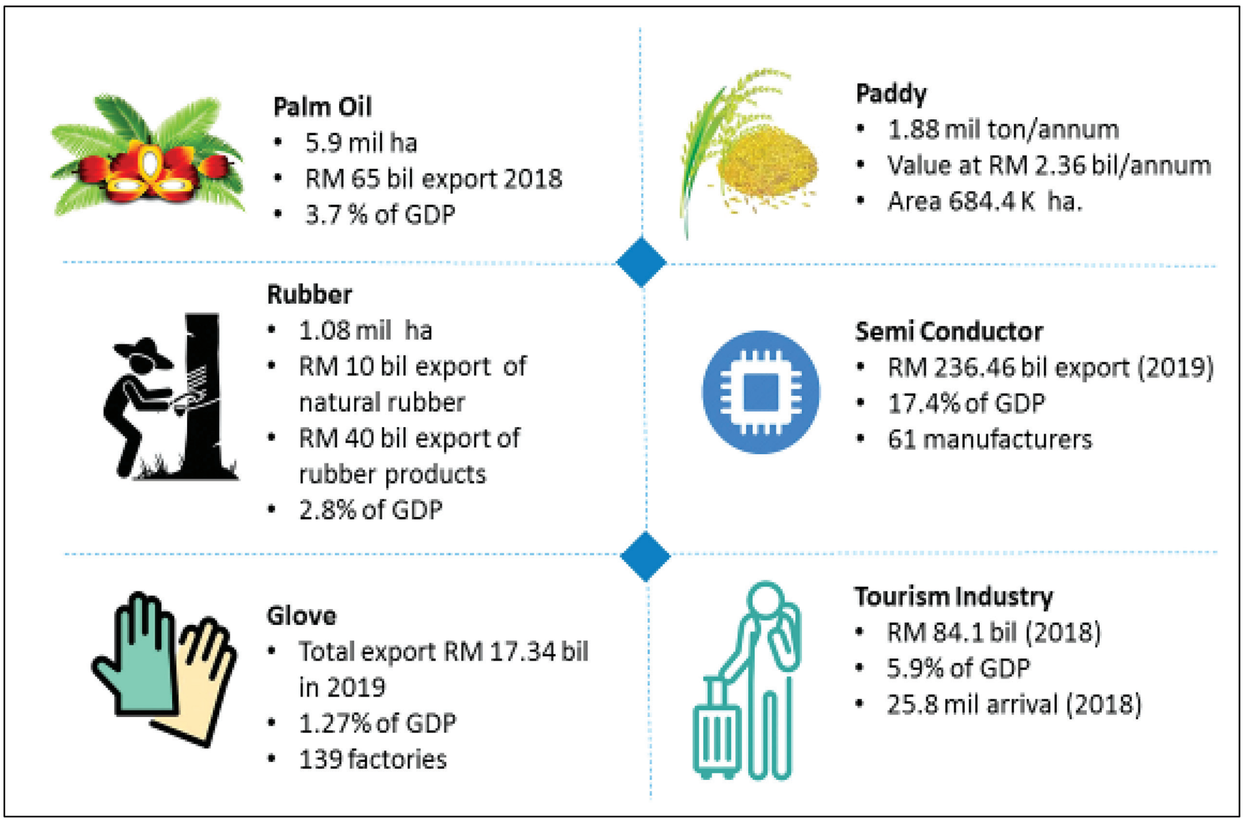


Figure 8.2. Selected Sector for Virtual Water and Water Footprint Assessment in Malaysia

Figure 8.3 shows Malaysia's GDP from 1961 to 2019. Since 1961, Malaysia has enjoyed significant growth, especially during the 90s, which describes the country's positive economic development from various sectors. Nevertheless, Malaysia has experienced a contraction growth impact from the Asian Financial Crisis (AFC) in 1997–1998. During this period, all industries were impacted by the crisis, including the value of the Malaysian Ringgit. However, Malaysia has swiftly recovered from the crisis, as illustrated by the positive growth in 2001 until 2018. Malaysia experienced negative growth again in 2009, which resulted from the Global Financial Crisis (GFC). Once again, Malaysia recovered the economic growth post-GFC period until the recent years, which gradually grew between 4% and 5%.

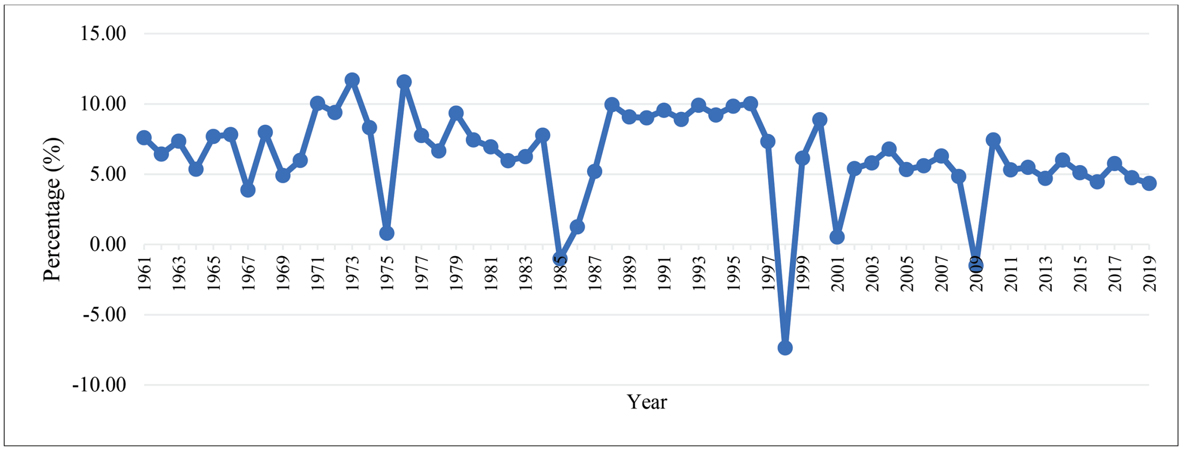


Figure 8.3. Malaysia's GDP (1961 – 2019)

Figure 8.4 represents the export and import of food products from 1990 to 2020 (RM billion). It could be seen that the balance of export and import of food products in Malaysia have shown an imbalance trend since 1990. The food import to Malaysia has seen significant increases and peaking in more recent years. Nevertheless, the export has also shown remarkable growth over this period, indicating the significance of the food industry.

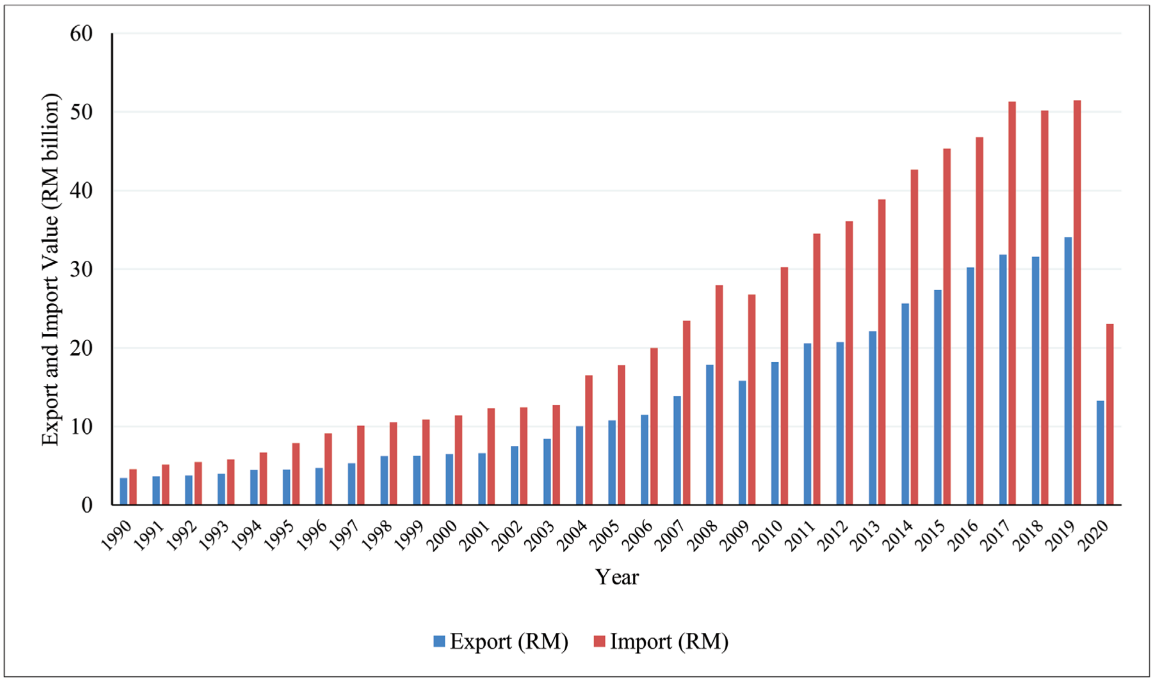


Figure 8.4. Export and Import of Food Products (1990 – 2020)

(*Note*: Data for 2020 is until June)

Figure 8.5 illustrates Malaysia's export and import of chemical and chemical products from 1990 to 2020. In this sector, an imbalance between export and import trade since 1990 can be seen, in which import is higher than export with a slight margin. Overall, the trend of imports is steadily increasing except during the GFC in 2008 – 2009. Similar to import, chemical and chemical products' export of Malaysia has seen an upward trend that indicates the strength of this sector to contribute to the economic growth.

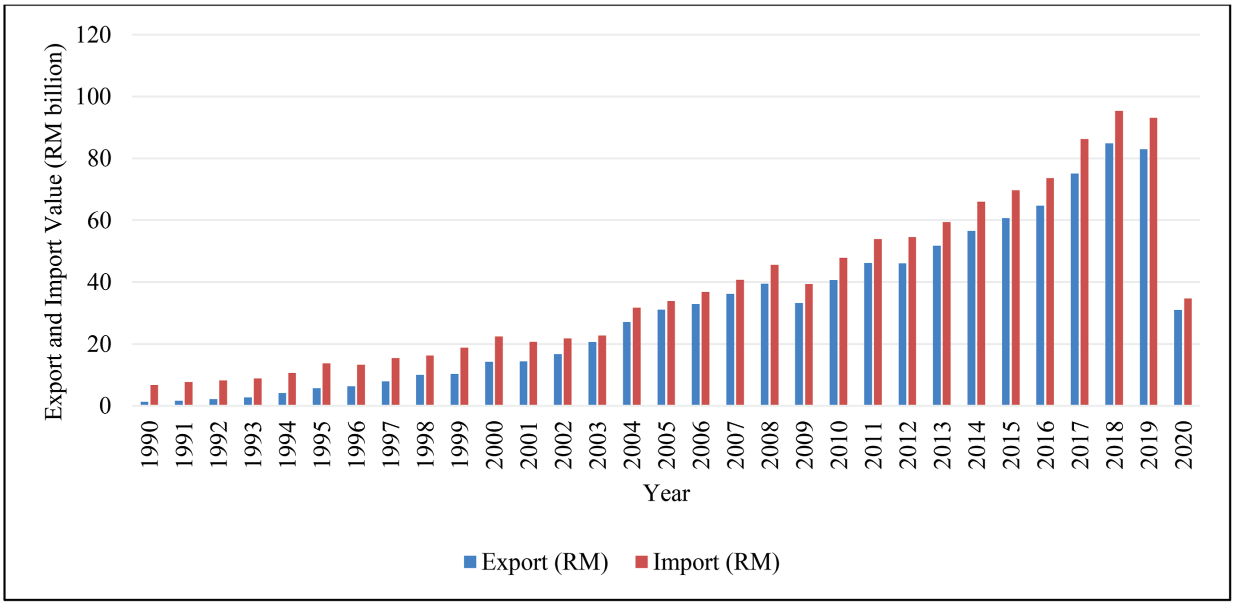


Figure 8.5. Export and Import for Chemical and Chemical Products (1990 – 2020)

(*Note*: Data for 2020 is until June)

8.2 Case Studies

WF studies may have various purposes and be applied in different contexts. Each purpose requires its scope of analysis and will allow for different choices when making assumptions. The main purpose of this study is to raise awareness. Therefore, the national or global average estimates for the WF of products were used (Hoekstra, 2009). WF can be assessed at different levels of spatiotemporal details, as presented in Table 4.13. At the lowest level of detail, the WF is assessed based on global average WF data from an available database. At the highest level of details, WF accounts are geographically and temporally explicit, based on precise data on inputs used and authentic sources of those inputs.

The WF of a product is estimated by considering water consumption and pollution in all production chain steps. Detailed explanation of methods for selected commodities will be discussed in the following section.

For the agricultural sector, palm oil, rubber and paddy have been chosen to assess water use from the nursery stage until the production of the products, including crude palm oil, rubber gloves and rice. Furthermore, rubber gloves and semiconductor products were chosen for case studies in the manufacturing sectors. The study also includes tourism to represent the services industry.

Table 8.1. Spatiotemporal Explication in Water Footprint Accounting

Hierarchy	Spatial Explication	Temporal Explication	Source of Required Data of Water Use	Typical Use of the Accounts
Level A	Global average	Annual	Available literature and database on typical water consumption and pollution by product or process.	Awareness-raising, rough identification of components contributing mostly to the overall water footprint, development of global projections of water consumption.
Level B	National, regional, or catchment specific	Annual or monthly	As above, but the use of nationally, regionally or catchment specific data.	Rough identification of spatial spreading and variability, knowledge-base for hotspot identification and water allocation decisions.
Level C	Locally, site and field-specific	Monthly or daily	Empirical data, or (if not directly measurable) best estimates on water consumption and pollution, specific by location and over the years.	Knowledge-base for carrying out a water footprint sustainability assessment, formulation of a strategy to reduce WFs and associated local impacts.

8.2.1 Case Study 1: Crude Palm Oil Production

According to MPOB, oil palm plantations have steadily increased from 2013 to 2018. In 2019, the plantation areas of oil palm seemed to have decreased by 10.8 % compared to the previous year. The highest oil palm plantations were achieved in 2018 with 5.85 million ha in Malaysia, with plantations from Sabah and Sarawak contributing the most with 3.12 million ha, while Peninsular Malaysia contributed 2.73 million ha in Figure 8.6. Sarawak had the highest planted area in 2019 with 1.57 million ha, followed by Sabah with 1.54 million ha. While in Peninsular Malaysia, the biggest planted area was from Pahang by 0.77 million ha. The smallest planted area was in Perlis, with 891 ha (MPOB, 2019).

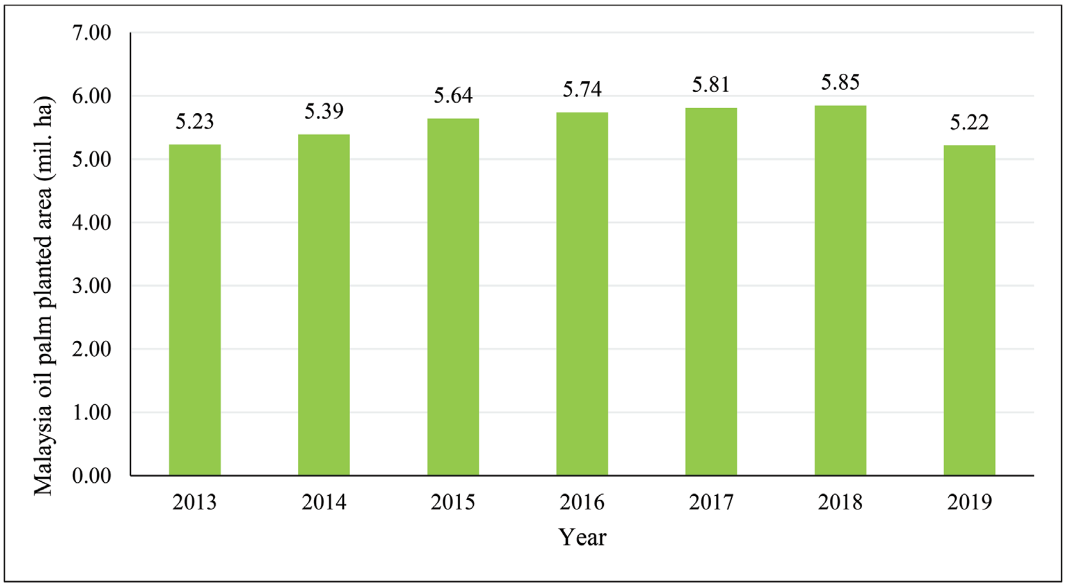


Figure 8.6. Malaysia Palm Oil Planted Area (2013 – 2019)

(*Source*: MPOB, 2019)

In calculating WF for palm oil, the process stages can be divided into the nursery, young trees, matured trees and crude palm oil (CPO) production at the mill. The functional unit for WF of palm oil is the volume of water (m^3) used to produce 1 ton of CPO, as mentioned in Box 8.1. The total WF of the crop in the plantation and the other processes is the sum of green, blue and grey water components. The green and blue WF of growing a crop or tree are calculated by Equation 1, the grey component by Equation 2, and Equation 3 for the grey water as proposed by Hoekstra et al. (2011). The total WF for producing CPO from the nursery, plantation and mill is the sum of green, blue and grey water to be determined using Equation 4.

BOX 8.1

Description of Oil Palm Plantation and Crude Palm Oil Production

Sector : Agriculture
Measuring : VW&WF for oil palm plantation and crude palm oil (CPO) production
Unit : m^3/tonne
Data Sources : Malaysia Palm Oil Board (MPOB), Department of Statistics Malaysia (DOSM)
Data Requirement:

i. Nursery and plantation stage
- Land area (ha)
- Yields (tonne)
- Type and amount of fertilisers (kg/ha)
- Type and amount of pesticides (kg/ha)
- Diesel consumption (L)
- Electricity consumption (kWh)
- Crop coefficient (Kc)
- Evapotranspiration (ET) (mm/day)
- Rainfall (mm/day)
- Soil series

ii. Milling stage
- Water for processing (m3/tonne)
- Steam input (tonne)
- Diesel consumption (L)
- Electricity consumption (kWh)
- Palm oil mill effluent (tonne)

iii. Net virtual water (NVW)
- Export products (tonne)
- Import products (tonne)

$$WF_{green/blue} = \frac{CWU}{Y} = \frac{10 \times \sum_{d-1}^{lgp} ET}{Y} \qquad \text{Eq. 1}$$

where;

$WF_{green/blue}$ = Green/blue water footprint of growing a crop or a tree, *m³/tonne*

CWU = Crop water use, *m³/ha*

$\sum_{d-1}^{lgp} ET$ = Accumulation of daily evapotranspiration, *mm/day*

Y = Crop yield, *ton/ha*

$$WF_{grey} = \frac{(\alpha \times AR)/(C_{max} - C_{min})}{Y} \qquad \text{Eq. 2}$$

Where;

WF_{grey} = Grey water footprint of growing a crop or a tree, *m³/tonne*

AR = Chemical application rate per hectare, *kg/ha*

α = Times leaching fraction

C_{max} = Maximum acceptable concentration, *kg/m³*

C_{min} = Minimum concentration for the pollutant considered, *kg/m³*

Y = Crop yield, *ton/ha*

$$WF_{greymill} = \frac{C_{effl} - C_{act}}{C_{max} - C_{min}} \qquad \text{Eq. 3}$$

Where;

$WF_{greymill}$ = Grey water footprint from mill, *m³/tonne*

Effl = Effluent volumme, *volume/time*

C_{effl} = Concentration of pollutant, *mass/volume*

C_{act} = Actual concentration of the intake water, *mass/volume*

C_{max} = Maximum concentration allowed, *mass/volume*

C_{min} = Concentration in natural form, *mass/volume*

$$WF = WF_{green} + WF_{blue} + WF_{grey} + WF_{greymill} \qquad \text{Eq. 4}$$

There are limited studies that explore WF for palm oil industries in Asia. Mungkalasiri et al. (2015) evaluated oil palm fresh fruit bunches (FFB) in two regions: Pathumthani and Chonburi in Thailand. Silalertruksa et al. (2017) also studied the environmental sustainability of oil palm cultivation in different Thailand regions. In Indonesia, Herda et al. (2017) estimated the WF of palm oil production in South Sumatera. In contrast, Safitri et al. (2018) described the oil palm root architecture at different growth stages, soil type and vulnerability to drought. The pioneer studies on WF and the life cycle of the palm oil industry in Malaysia were conducted by Vijaya et al. (2018) and Zulkifli et al. (2014).

To calculate the WF of oil palm, evapotranspiration (ET) determination is the initial step. For ET in the nursery, the value is equivalent to 3.64 mm/day. During the plantation stage, the average ET estimated for all states in Malaysia is 5.1 mm/day. Figure 8.7 displays results from the WF analysis of every state in Malaysia. Penang has the highest WF value of 9,911 m^3/t of crude palm oil and 2,200 m^3/t of FFB. In contrast, the WF value in Negeri Sembilan is the lowest, with 4,447 m^3/t crude palm oil and 986 m^3/t of FFB. The average WF in Malaysia analysed from this study was 5,794 m^3/t of CPO and 1,285 m^3/t of FFB. The present value of WF is comparable with the analysis done by Vijaya et al. (2014) of 5,836 m^3/t of CPO, as shown in Figure 8.8.

The variation in WF values is due to applying specific ET rates for each state influenced by the different climatic conditions, especially the temperature, sunshine radiation and wind speed. Moreover, according to Herda et al. (2017), the differences in farming practices and the technology used also influenced the palm oil yield per unit area. By comparison, the site in South Sumatera, as reported by Herda et al. (2017), yields the lowest WF of 3,819 m^3/t of CPO. Therefore, it is worth noting that this study evaluated only one plantation, which is the largest plantation and possibly the most productive in South Sumatra. As such, the low WF may not represent the regional values.

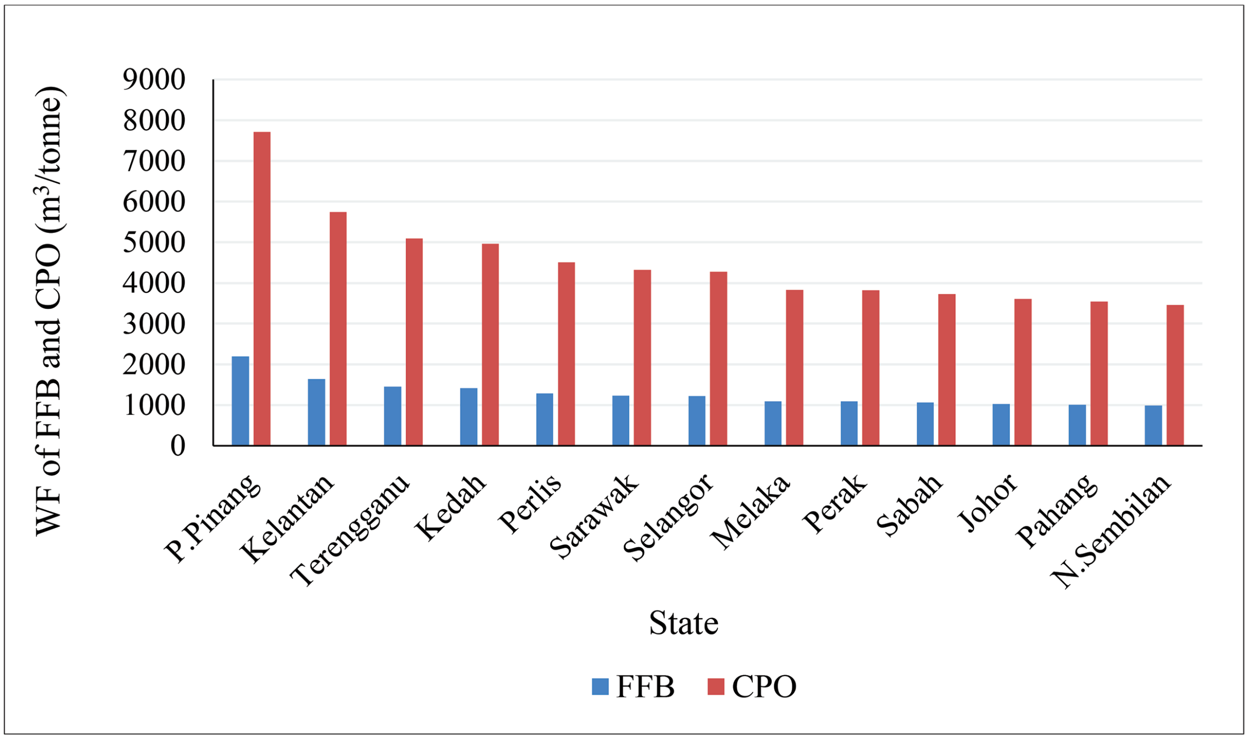


Figure 8.7. Water Footprint per Tonne of Fresh Fruit Bunches and Crude Palm Oil at Each State in Malaysia

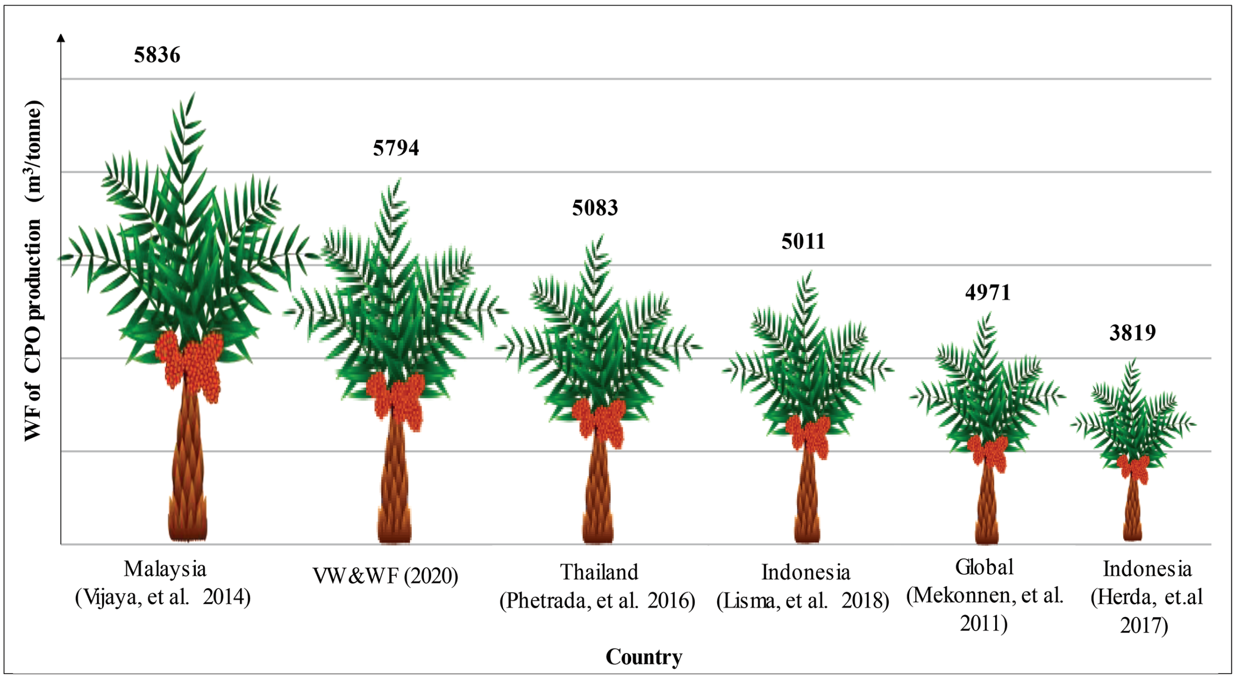


Figure 8.8. Comparison of Water Footprint per Tonne of Crude Palm Oil with Several Countries

In Thailand, Suttayakul et al. (2016) found that WF for producing CPO is approximately 5,083 m^3/t. This study evaluated the average WF from several plantations in southern and eastern Thailand, including seven mills using a wet extraction process located at Krabi (2 mills), Suratthani (2 mills), Chumphon (2 mills) and Chonburi (1 mill). In Central Borneo, Lisma et al. (2018) obtained WF of 1,002 m^3/t of FFB and 5,011 m^3/t of CPO.

Several factors may affect the WF for crude palm oil production, which are summarised below:

- Climatic conditions, especially the temperature varies between states and significantly influence the ET rates.
- Soil properties and depth determine the site ability to store soil moisture. In general, less sandy soil has a larger capacity to hold soil moisture. Therefore, more water can be transpired through stomata that account for green water.
- Application of fertilisers, herbicides and pesticides can give different amount of indirect blue water and grey water.
- Palm oil mills with new technology can produce more CPO per tonne of FFB. Additional savings can be achieved by installing a more efficient water use system and devices.

8.2.2 Case Study 2: Rubber

The global demand for natural rubber in Malaysia and Indonesia has increased more than 100% in the last 15 years (Davide et al., 2018). However, some studies suggested that rubber plantations could pose environmental risks, such as deforestation, loss of biodiversity, loss of soil productivity, water quality and quantity (Ahrends et al., 2015; Chen et al., 2016). Table 8.2 shows the yield and hectares of rubber plantations from 2010 to 2019 (DOSM, 2019). In 2010, the yield production for natural rubber was 920 t/ha, while in 2019, the yield dropped by almost 64% with 590 t/ha. However, there is an increase in plantation hectarage from 2010 to 2019 from 1.02 mil. ha to 1.08 mil. ha.

Table 8.2. Yearly Production of Natural Rubber Production (2010 – 2019)

Year	Production (t)	Hectarage (mil. ha)	Yield (t/ha)
2010	939,241	1.02	920
2011	996,210	1.03	970
2012	922,798	1.04	886
2013	826,421	1.06	781
2014	668,613	1.07	626
2015	722,122	1.07	672
2016	673,513	1.08	625
2017	740,138	1.08	684
2018	603,329	1.08	557
2019	639,830	1.08	590

(*Source*: DOSM, 2019) (Source: DOSM, 2019)

Data collection for rubber plantations are from Lembaga Getah Malaysia (LGM), Lembaga Getah Sabah (LGS), FELCRA Berhad and RISDA. During the nursery stage, young buddings are planted in polybags for two years before being planted in the fields. According to RISDA, there were about 400 rubber trees per hectare, and LGM stated that there were 500 trees per hectare. This study used about 450 trees per hectare in calculating the WF. The calculation of WF for rubber plantation and concentrated latex was determined by Equation 1 and Equation 2. Box 8.2 displays the stages of rubber tree growth and latex production, and the data requirements for calculating WF.

BOX 8.2

Stages in Concentrated Latex Production

Sector : Agriculture

Measuring : VW&WF for rubber plantation and concentrated latex production

Unit : m^3/t

Data Sources : Malaysian Rubber Board (LGM), Lembaga Industri Getah Sabah (LGIS), RISDA, FELCRA Berhad, Department of Statistics Malaysia (DOSM)

Data Requirement:

i. Nursery and plantation stage
- Land area (ha)
- Yields (tonne)
- Type and amount of fertilisers (kg/ha)
- Type and amount of pesticides (kg/ha)
- Diesel consumption (L)
- Electricity consumption (kWh)
- Crop coefficient (Kc)
- Evapotranspiration (ET) (mm/day)
- Rainfall (mm/day)
- Soil series

ii. Milling stage
- Water for processing (m^3/t)
- Diesel consumption (L)
- Electricity consumption (kWh)
- Amount of wastewater (m^3)

iii. Net virtual water (NVW)
- Export products (tonne)
- Import products (tonne)

WF for rubber is divided into three stages: nursery, plantation and at the mill until the production of concentrated latex. Like palm oil, the unit of WF is m^3 of water used to produce 1 tonne of natural rubber and concentrated latex. The WF green and blue water components were calculated using Equation 1, the grey water component using Equation 2 and the grey WF from the mill using Equation 3. Therefore, the total WF is the sum of green, blue and grey water components, calculated using Equation 4. Consequently, the net virtual water (NVW) trade for rubber production was obtained using Equation 5 to Equation 7.

The WF for rubber has only been done by Kaanita et al. (2017) in Thailand. It was found that WF of rubber sheets in the Northeastern region of Thailand was 17,970 m^3/t. Of these, 8,174 m^3, 6,975 m^3 and

2,821m^3 are green, blue, and grey WF, respectively. On the other hand, the Southern region's WF was significantly lower, 11,417 m^3/t of rubber sheet, whereby 8,631 m^3 was green water, 858 m^3 was blue water and 1,928 m^3 was grey WF. Thus far, no reported study on rubber WF was found for Malaysia.

To calculate the WF of rubber plantations, it is crucial to determine the value of ET at the nursery and plantation stages. Table 8.3 shows the value of ET from different countries. This study used ET value by Haridas (1980) to calculate WF at the nursery and plantation stages. The value of ET may vary due to annual rainfall distribution.

Table 8.3. Value of ET from Different Countries

Country	ET (mm/yr)	ET (mm/day)	Annual rainfall (mm/yr)	Reference
Malaysia	1606	4.4	2961	Haridas, 1980
Cambodia	1459	4.0	1545	Thomas et al., 2015
Thailand	1211	3.3	2020	Thomas et al., 2015
Thailand	1317	3.6	1250	Kaanita et al., 2017

There is a lack of studies on WF for natural rubber production. However, Figure 8.9 shows WF for producing per tonne of latex for different states in Malaysia, ranging from 9,060.21 m^3/t to 22,875.65 m^3/t. The lowest WF for latex production comes from the northern region (Kedah and Perlis) with 9,060 m^3/t. Followed by the central region (Selangor, N. Sembilan and Melaka) with 10,768 m^3/t. The highest WF result was from the eastern region (Kelantan and Terengganu). In calculating WF at the mill for concentrated latex production, the data was provided by LGS, and the value of WF was 37.5 m^3/t of concentrated latex.

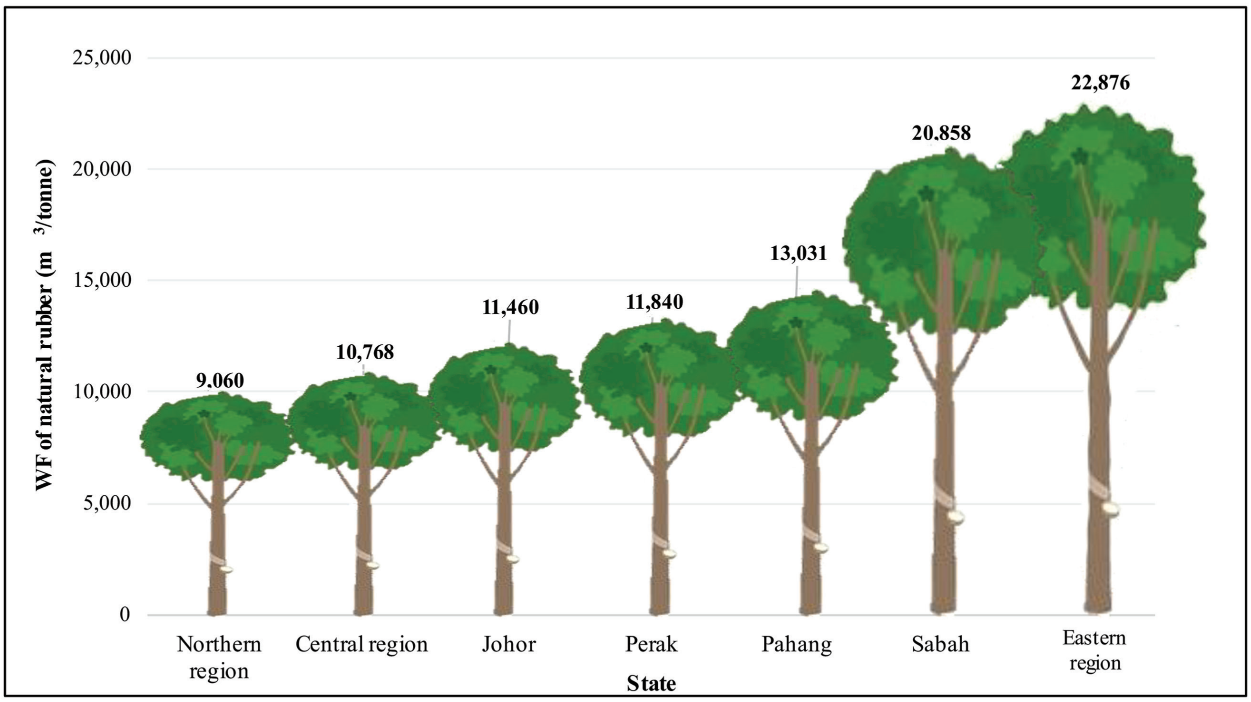


Figure 8.9. WF of Latex for Various Regions in Malaysia

The highest water consumption is from the green water component, representing 99% of the total WF per tonne of latex. The blue water component is only used during the nursery stage. According to Zameri et al. (2017; 2018), the total river water used per one polybag of two young whorl budding is 0.223 m^3/yr. During plantation at the field, the water source mainly comes from rainwater. Besides, the global WF for natural rubber production is 13,748 m^3/t (Mekonnen & Hoekstra, 2011). The variation in WF values might be due to the yield of natural rubber, which correlates with the price of rubber. WF results could also be influenced by soil conditions at the rubber plantation and plantation management input and practices, such as fertilisers, pesticides and herbicides.

8.2.3 Case Study 3: Paddy

Paddy cultivation is one of the most essential activities in the Malaysian agriculture sector and it is recognised as Malaysia's most important food crop to ensure its food security (Mohd et al., 2013). As a staple food in Malaysia, rice consumption in 2018 was estimated at 2.8 million tonnes per year, equivalent to 80.6 kg per capita (OECD/FAO, 2019). According to the Department of Agriculture (DOA), Malaysia has produced 1.7 million tonnes of rice in 2018, 35% less than the total paddy production due to the removal of husk, spoilt, stone and mud during the rice milling process. Figure 8.10 shows Malaysia's paddy production and harvested area from 2015 to 2018.

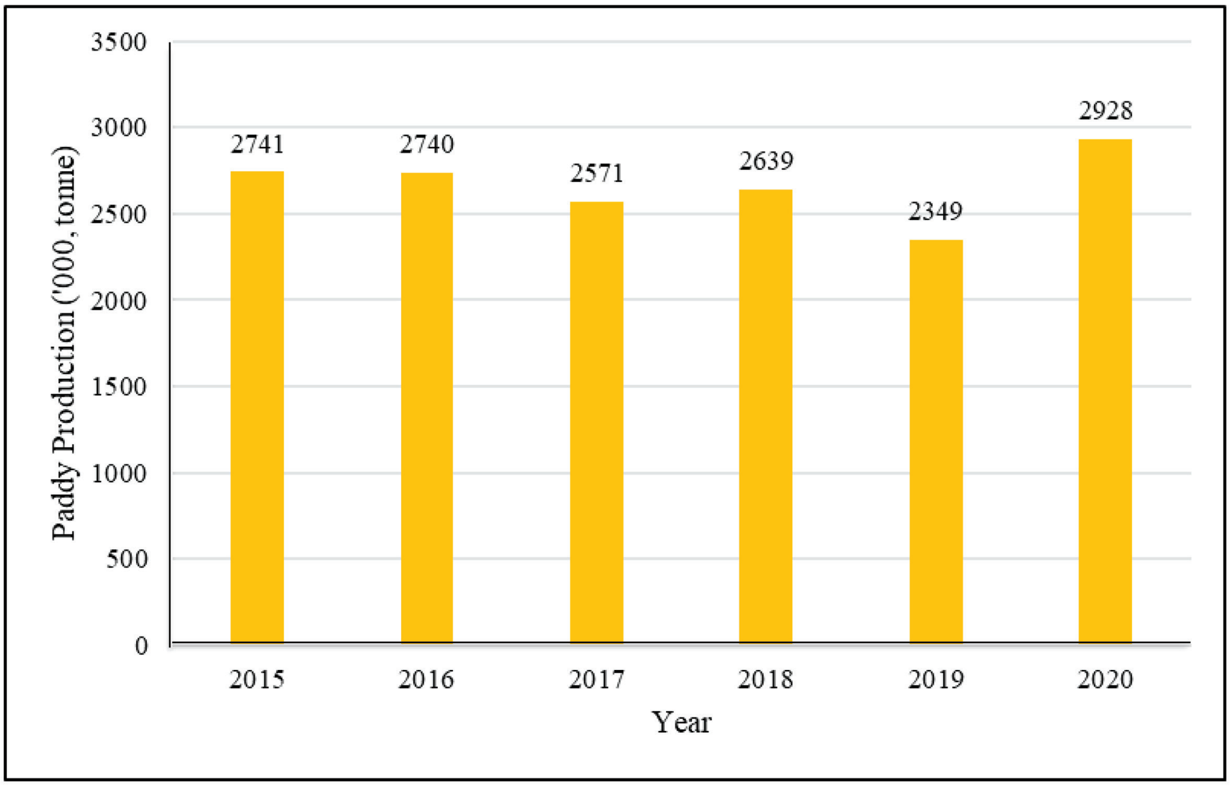


Figure 8.10. Paddy Production and Harvested Area in Malaysia (2015–2018)

Paddy farming area is divided into two major sections; the granary area and the non-granary area. The government recognises the granary area as the main paddy production area, and the non-granary area is the opposite of this recognition. There are 12 granary areas in Malaysia: ten in Peninsular Malaysia, one in Sabah and one in Sarawak, as shown in Figure 8.11. The total planted areas in 2018 was 699,960 ha, with 62% from non-granary and 38% from granary areas. Kedah, which is known as the 'Rice Bowl of Malaysia', has the most extensive planted areas (201,324 ha), and it is all under the management of the Muda Agriculture Development Authority (MADA). Meanwhile, Sarawak has the second biggest planted area with 135,426 ha. However, only 1,121 ha (0.8%) were granary areas under the management of Integrated Agricultural Development Area (IADA) Batang Lupar.

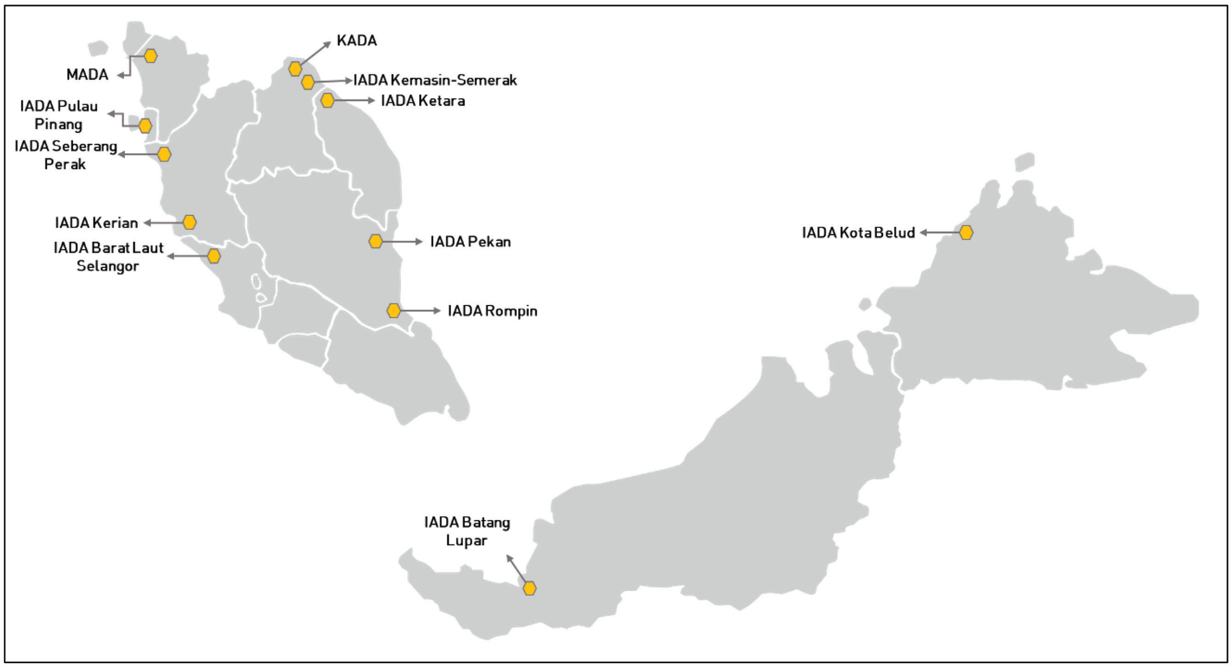


Figure 8.11. Granary Areas in Malaysia

Paddy cultivation needs relatively high-water inputs, especially irrigation water in the dry season. Several factors, which affect productivity are:

i. Irrigation efficiency and agricultural production technologies;
ii. Water management and land preparation;
iii. Field conditions, such as drainage, field road, water retaining boundaries and field dryness before harvesting (Ibrahim & Mook, 2014);
vi. Climate factors, such as temperature, sunshine duration and intensity, humidity and wind speed.

Therefore, rice production is not correlated with the planted area. Figure 8.12 shows the rice yield based on the total planted area (non-granary and granary) and rice production in each state in 2018.

Box 8.3 shows the various stages of paddy cultivation and the data needed to calculate WF for paddy and rice. There are two planting seasons in paddy cultivation, whereby each season takes around 105–120 days to harvest/mature. Therefore, the WF was calculated based on direct and indirect water consumption at each growth stage and the mill. The quantity of water needed is supplied throughout the growing stage by rainfall (precipitation), irrigation, or both to maintain optimal water level for growing paddy. Meanwhile, the indirect water consumption at the rice milling process is from electricity or fuel needed to run the machines for the main processes, such as paddy cleaning, whitening, water polisher and colour sorter.

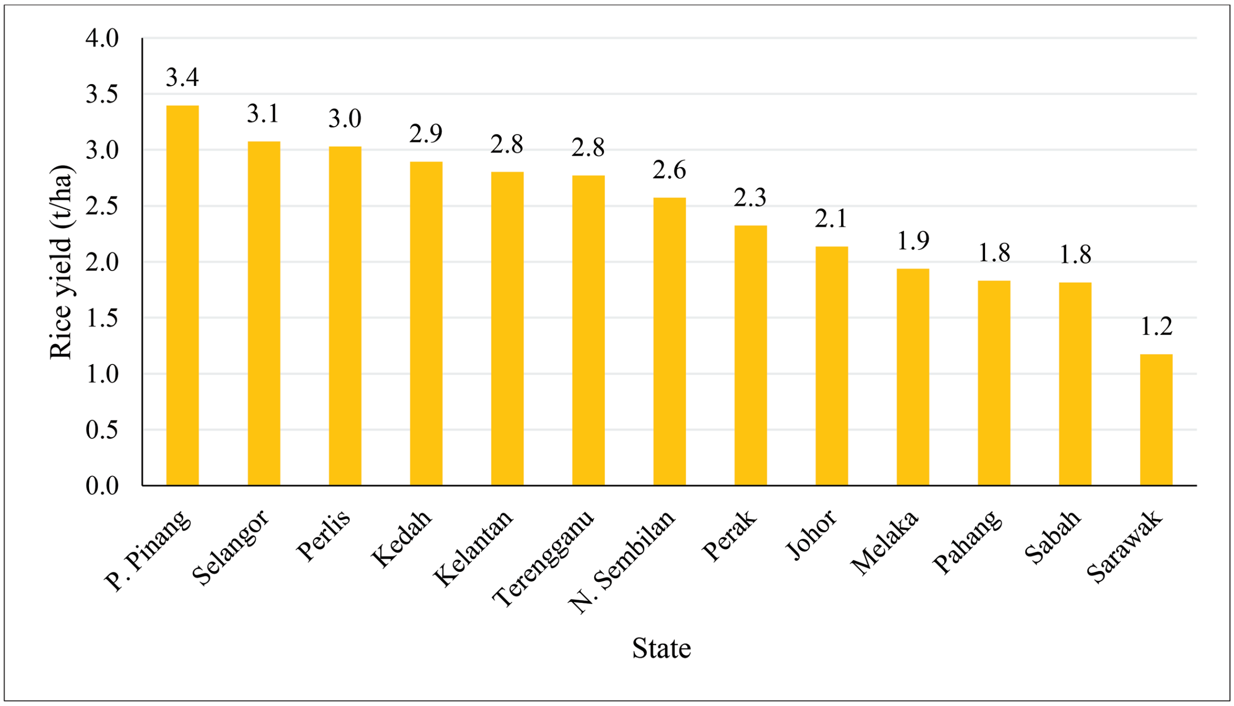


Figure 8.12. Rice Yield (t/ha) in Malaysia (2018)

The calculation for the green water component for paddy is similar to oil palm and rubber, but different for the blue and grey water components. The WF calculation of paddy cultivation and rice production per season was determined by Equation 1 to Equation 6. The data required for these calculations are water consumption from rainfall, dam, river water and recycled pump water (m^3), total planted area (ha), evapotranspiration (ET, mm/day), rice yield (t/ha), amount of fertilisers (kg/ha) and electricity consumption (kWh). Figure 8.13 depicts the process flow of WF calculation for paddy cultivation and rice production.

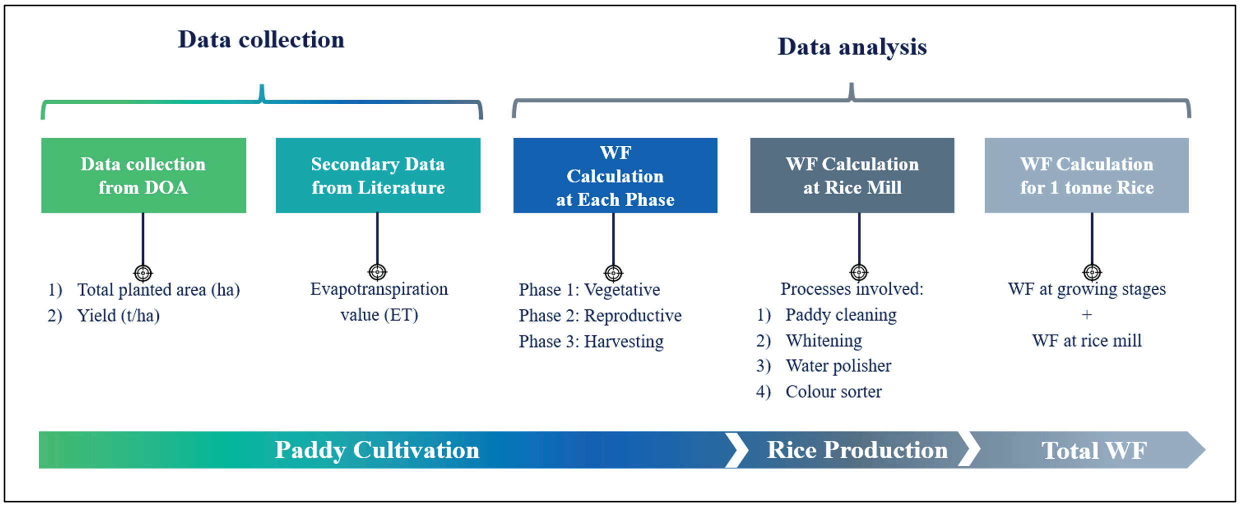
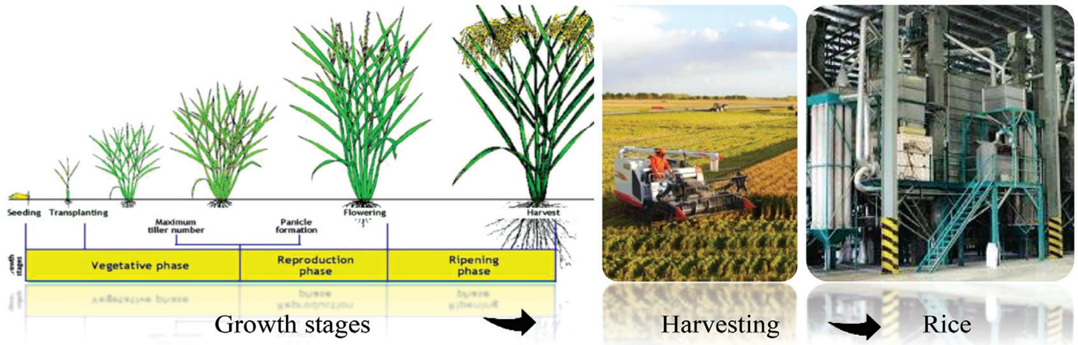


Figure 8.13. Process Flow and Steps for WF Calculation of Paddy Cultivation and Rice Production

BOX 8.3

Paddy Cultivation and Rice Production



Stage 1: 0 - 10 (10 days)	Vegetative phase: 0 – 35 (35 days)
Stage 2: 11 – 45 (35 days)	Reproductive phase: 36 – 75 (40 days)
Stage 3: 46 – 55 (10 days)	Mature/harvest: 76 – 105 (30 days)
Stage 4: 56 - 95 (40 days)	76 – 95 (20 days (irrigation))

Sector : Agriculture

Measuring : VW&WF for rubber plantation and concentrated latex production

Unit : m^3/t

Data Sources : Department of Agriculture (DOA)

Data Requirement:

i. Paddy field stage
- Irrigation system
- Irrigation water requirement (mm/day/ha)
- Rainfall (mm/day)
- Type and amount of fertilisers (kg/ha)
- Type and amount of pesticides (kg/ha)
- Diesel consumption (L)
- Source of water for irrigation
- Crop coefficient (Kc)
- Evapotranspiration (ET) (mm/day)

ii. Milling stage
- Water for processing (m3/t)
- Diesel consumption (L)
- Electricity consumption (kWh)
- Amount of wastewater (m3)

iii. Net virtual water (NVW)
- Export products (tonne)
- Import products (tonne)

The green water component for paddy was calculated using Equation 1, while the blue and grey water components were calculated using Equation 5 and Equation 6. The total WF of paddy cultivation and rice production was the sum of green, blue and grey water components (Equation 5).

$$WF_{blue} = A \times IWR \quad \text{Eq. 5}$$

Where;

WF_{blue} = Blue water footprint of growing a crop or a tree, m^3/*tonne*

A = Actual crop area, *ha*

IWR = Crop irrigation water requirement, *mm*

$$WF_{grey} = \frac{\alpha - C_A}{C_{max} - C_{min}} \quad \text{Eq. 6}$$

Where;
WF_{grey} = Grey water footprint, $m^3/tonne$
α = Leaching runoff fraction
C_A = Rate of chemical application to the field, *kg/ha*
C_{max} = Maximum acceptable concentration, kg/m^3
C_{min} = Concentration of chemical in natural water, *kg/m3*

The determination of ET is crucial to estimate the WF for crops, or other agriculture products. ET can be obtained by many estimation methods (e.g. Penman-Monteith, Thornthwaite and Pan Evaporation). Some of these methods need extensive climatic parameters as inputs, while others are simpler and less data demanding. Major factors, which commonly influence ET are temperature, sunshine duration, short wave and long wave radiation, humidity and wind speed. Table 8.4 shows the ET values from other case studies conducted by Malaysian researchers using different estimation methods.

Table 8.4. ET Value for Paddy Using Different Estimation Methods

Case Study	ET Value (mm/day)	Method	Reference
Seberang Perak	3.152 3.229 3.276 3.989 4.329 4.486 4.454 3.550	Penman-Monteith Pan Evaporation Blaney-Criddle Kimberly-Penman Priestley-Taylor Hargreaves Samani-Hargreaves Penman	Lee et al. (2004)
Tanjung Karang	3.2 - 5.8 (off-season, main season) 3.15 - 5.72 (calculate using weather parameters)	Using NOAA satellite and CROPWAT	Hilmi (2005)
Tanjung Karang	3.2 - 5.8 4.04 - 6.54	Lysimeter Satellite data	Hassan et al. (2008)
Tanjung Karang	4.8 - 6.2	Micro-lysimeter	Abdullahi et al. (2013)
Tanjung Karang	4.1 (Feb 2012) 3.9 (March 2012) 4.0 (April 2012)	Microflex-C sensors	Maina et al. (2014)
KADA irrigation scheme	ET_e: 3.69 (for 21 days) ET_m: 4.8 (tillering stage) ET_m: 5.7 (mid-growth stage)	Micro-lysimeter	Rowshon et al. (2014)

Based on the data provided by DOA in the Crop Statistics Report for 2015 to 2020, the average total WFs for producing 1 tonne of rice in Malaysia ranged between 975 m^3/t and 2,641 m^3/t with 37.4% for green WF, 56.25 for blue WF and 6.4% for grey WF. At the state level, the lowest WF was recorded for Selangor with 921 m^3/t in 2015, while Sarawak had the largest WF with 2,698 m^3/t in 2018. Figure 8.14 presents the range of WF for each state in Malaysia.

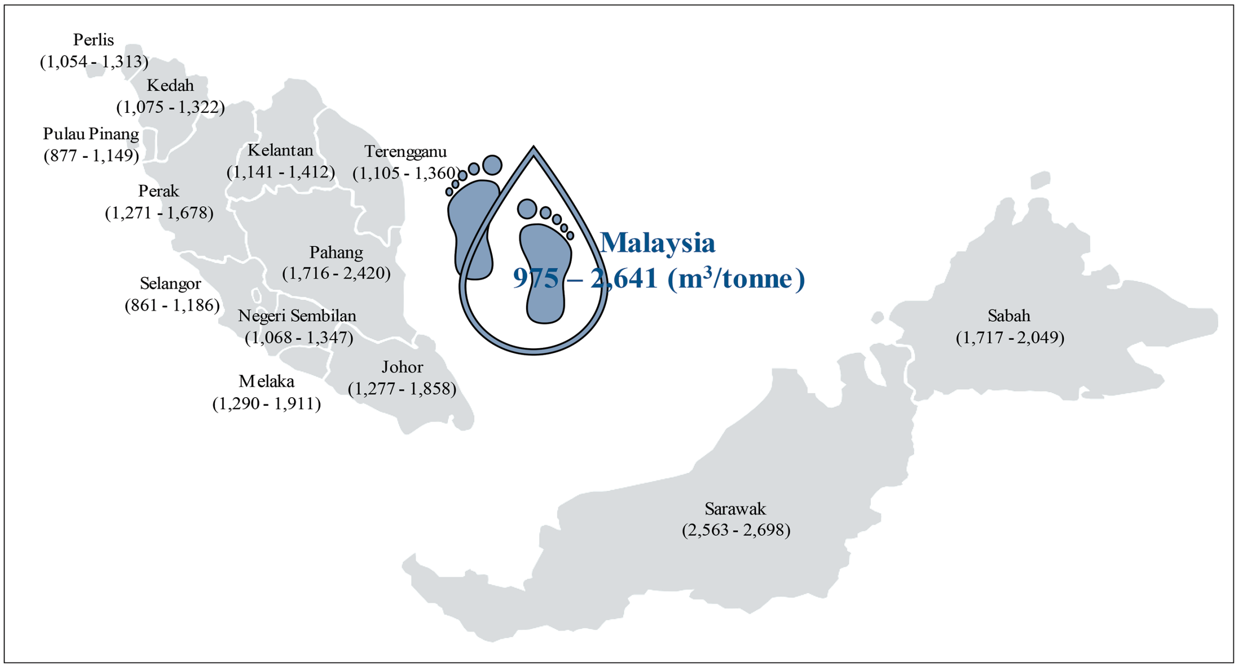


Figure 8.14. WF for Paddy and Rice in Malaysia (2015–2020)

On average, 2,500 m^3 of water is needed (from rainfall and/or irrigation) in the field to produce one tonne of paddy (Mahmod et al., 2014). Figure 8.15 compares the WF values for producing one tonne of rice from different countries and the global average. In Nepal, Shrestha et al. (2014) found WF for paddy of 3,483 m3/t, the highest ever reported. This could be due to poor agricultural productivity, inefficient water use and ageing, or outdated infrastructures. According to Bulsink et al. (2010), the WF for paddy is the highest compared with other primary crops in Indonesia, such as maize, cassava and soybeans. These differences could be due to climatic variation and agricultural practices. Thailand had the lowest WF, which was 2,005 m3/t. A study by Gheewala et al., (2014) only referred to rice growing during the wet season (May – October). Therefore, with adequate rainfall and the lowest irrigation water demand, WF rice in Thailand is much lower than in other countries.

The average WF of rice differs significantly for non-granary and granary areas across certain states. In general, WF of rice at the granary area is better than WF at the non-granary area. For example, IADA Pulau Pinang recorded the lowest WF for the granary area with an average of 975 m^3/t. In comparison, IADA Pekan had the largest WF with an average of 2,402 m^3/t. Figure 8.16 shows the comparison between WF of rice at non-granary and granary areas in 2018.

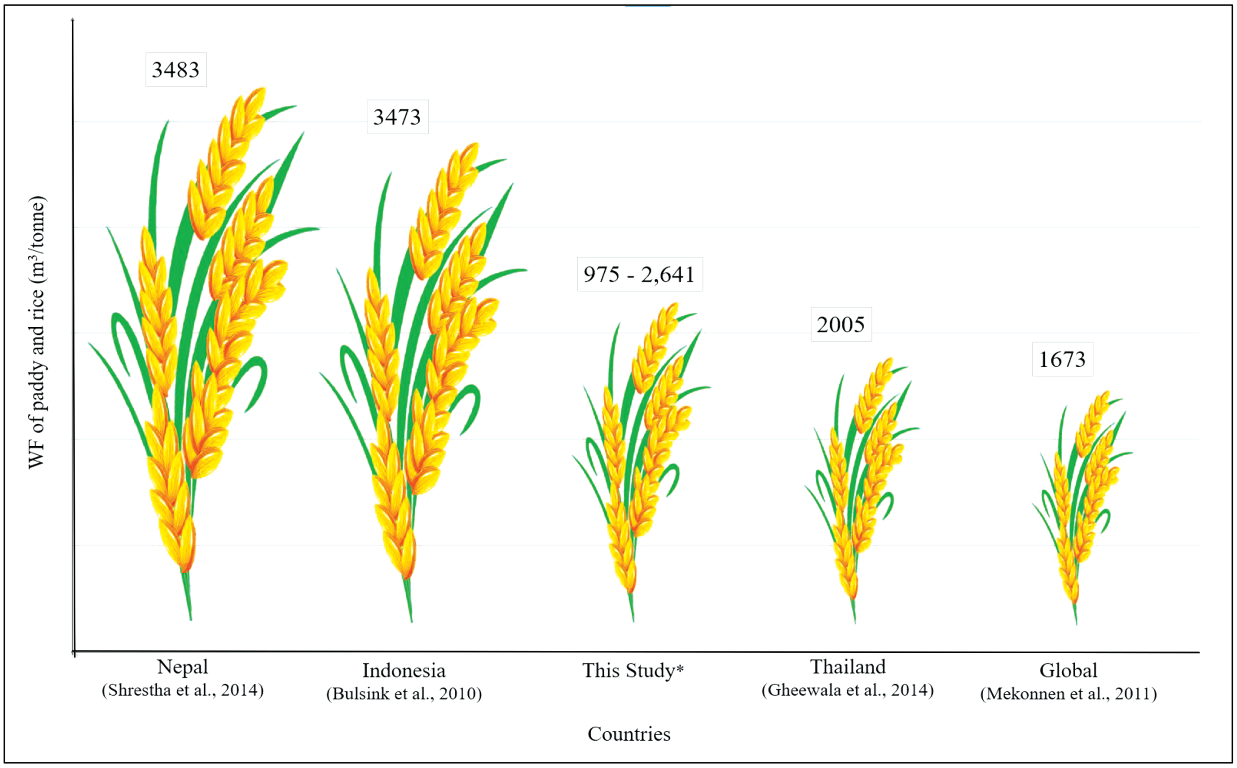


Figure 8.15. Comparison between WF of Rice with Other Countries

(*Note*: * Range for 13 states in Malaysia)

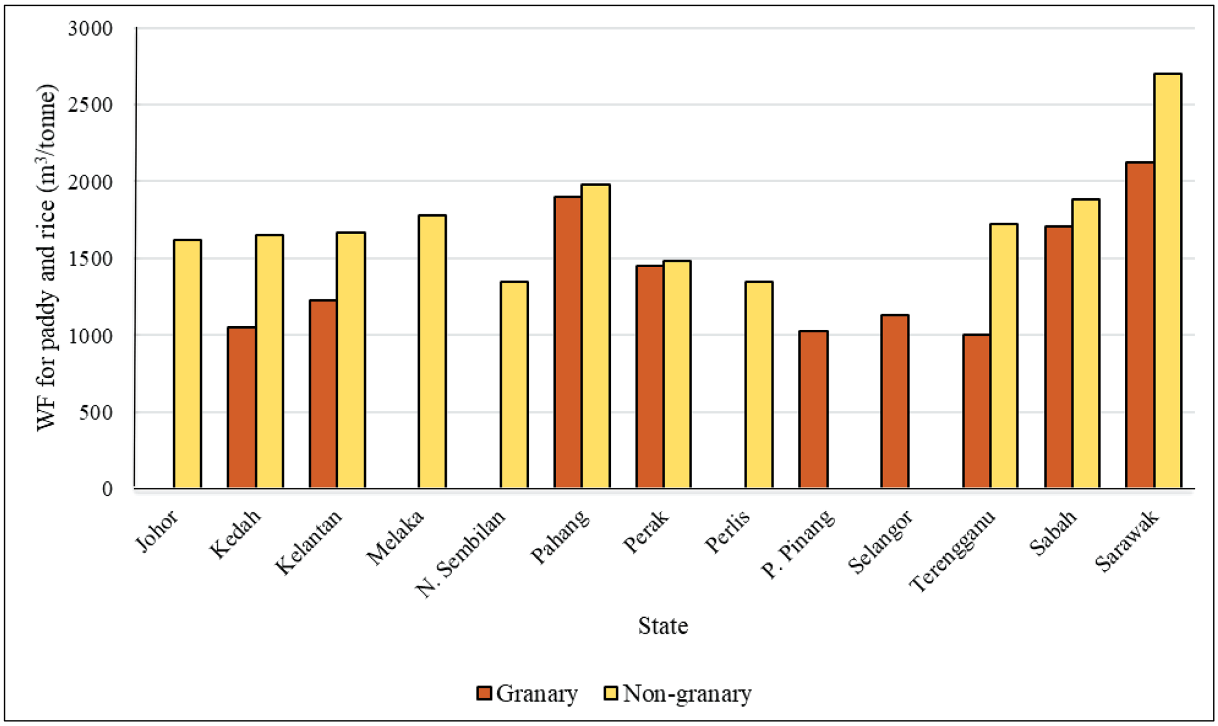


Figure 8.16. Comparison between WF of Rice at Non-granary and Granary Areas (2018)

Based on the results presented thus far, it could be concluded that rice production is relatively better, particularly in granary areas, because of the support system by the government and expert management, such as:

i. farming infrastructures (irrigation systems and dams)
ii. technical advice for farmers, including land preparation, planting and harvesting
iii. government incentive (subsidies for fertilisers and pesticides)
iv. technological advancement (upgrade machinery)
v. provides training and gives advisory services to paddy farmers

8.2.4 Case Study 4: Rubber Glove

The total rubber production was about 523.2 thousand tonnes in the first three quarters of 2020, consisting of natural and synthetic rubber (MRC, 2021). The sales value of the locally manufactured rubber gloves was about 80.9% in 2020, as illustrated in Figure 8.17, which showed that it was the most dominant product compared to other rubber products produced in the same year (DOSM, 2020), with an export value of RM4.6 billion as at December 2020 (DOSM, 2021). According to the Malaysian Rubber Board (2018), synthetic rubber, which comprised characteristics such as low-temperature flexibility and low cost with good heat resistivity, increased significantly in terms of consumption compared to natural rubber.

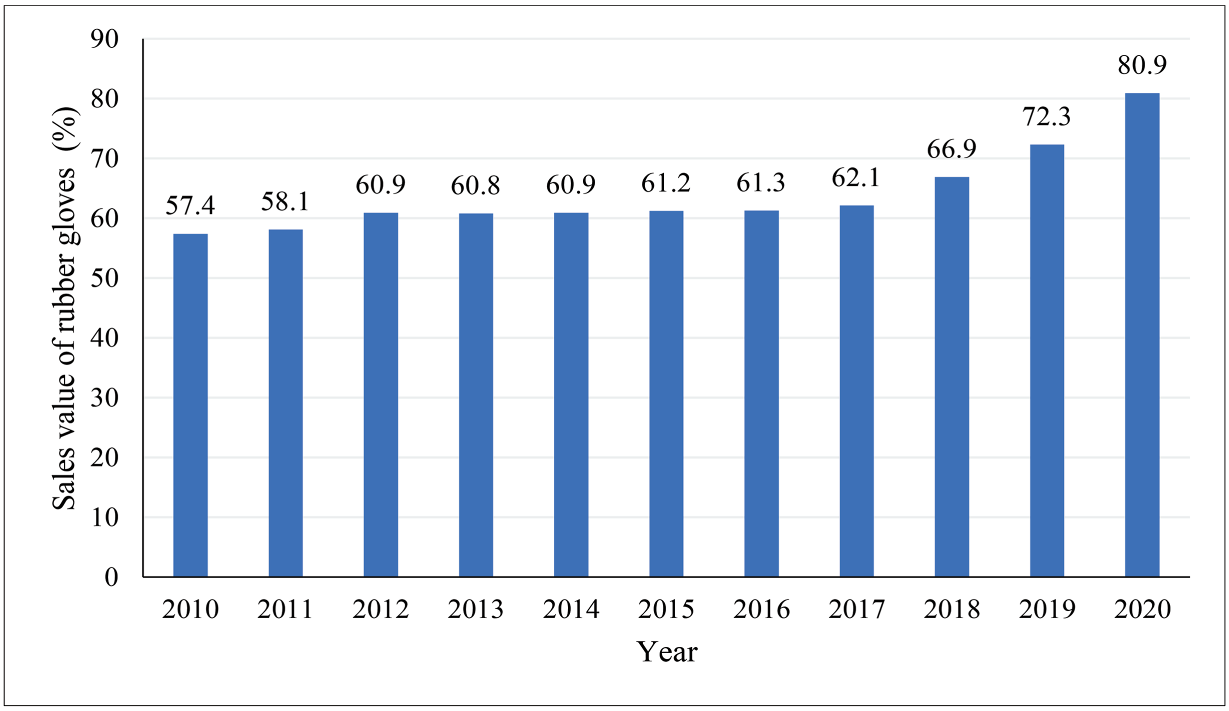
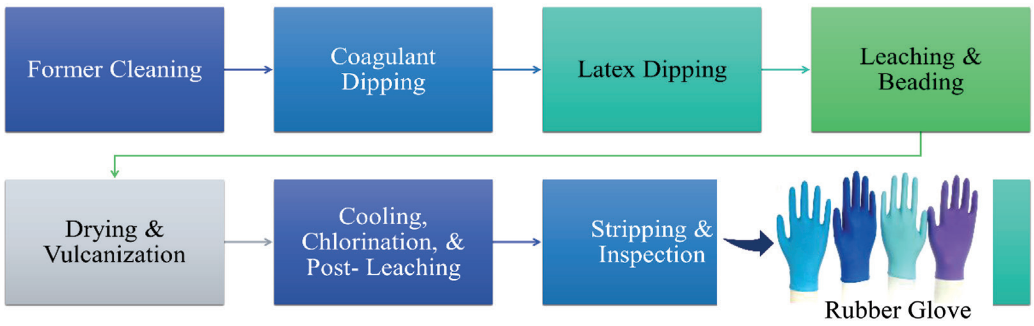


Figure 8.17. Percentage of Sales Value of Rubber Gloves (2010–2020)

There are different purposes for rubber gloves, whether it is from natural or synthetic rubber. As stated by the Malaysian Rubber Council (2021), Malaysia had exported non-surgical rubber gloves that accounted for almost 86% of total selected rubber products in 2020. Therefore, this study only focused on WF analysis of non-surgical gloves.

BOX 8.4

Description of Rubber Glove Production



Sector : Manufacturing
Measuring : VW&WF for rubber glove production
Unit : m^3/1000 pcs
Data Sources : Top Glove, Malaysian Rubber Board (LGM), Department of Statistics Malaysia (DOSM)

Data Requirement:

i. Processing of rubber gloves
- Total number of gloves produced monthly
- Average weight of 1 pc of rubber glove
- Amount of direct water used (m^3)
- Electricity consumption (kWh)
- Amount of wastewater (m^3)
- Type and amount of chemicals used (L)
- Diesel consumption (L)
- Raw material (rubber) used (kg)
- Wastewater characteristics (BOD, COD, Zinc)

A few information has been gathered thus far on WF for rubber glove production since there is no specific study on WF of rubber gloves. It is evident that besides requiring a large amount of water in the manufacturing process, the glove industry also generates large volumes of wastewater with high organic load (Pendashteh et al., 2017).

The process flows in rubber glove production are crucial because it defines the amount of water consumed. Generally, WF in the manufacturing industry is calculated as follows:

$$WF = DWC + VWC \quad \text{Eq. 7}$$

Where;

DWC = Direct water consumption

VWC = Virtual water consumption

The main sources of indirect water for manufacturing are energy calculation in fuel consumption, electricity and transportation (Mekonnen et al., 2015). The calculation for electricity used in the production chain consists of fuel supply, construction and operation. For electricity, a unit conversion of 1TJ = 277.78 MWh is used. Data requirements can be referred to in Box 8.4.

The production of rubber gloves used both direct and indirect water. The chemicals and energy used along with the processes also contribute to indirect water. The process of making gloves starts with using the raw material, which is from synthetic rubber. As depicted in Box 8.4, the most critical step in rubber gloves production is the dipping process (Rattanapan et al., 2012). In most cases, the cleaned formers are entered into a coagulant dipping tank. It is crucial to know that the amount of coagulant used in the process is mainly dependent on the glove's thickness. A dryer is then used in this process to partially dry water at 70°C. Also, an oven is used for the vulcanisation process, whereby the temperature is set to 140°C. This is where electricity is used, and it is the indirect source of water consumption.

The WF analysis for the rubber gloves was emphasised on the gate-to-gate boundary since there was limited data to analyse the whole supply chain, namely raw material acquisition. Therefore, the analysis is only conducted on natural rubber gloves (NRG) and synthetic rubber gloves (SRG). Data were collected from four different production plants consisting of two plants, with the inclusion of wastewater generated from the production in each type. At this point, Top Glove is withdrawing water from ponds, rainwater, groundwater and recycled water to complement the main supply from Air Selangor.

As stated earlier, the blue water element includes both direct and indirect water. The calculation of grey water requires data on wastewater quality and volume. The wastewater should be treated and complied with the existing regulatory standards. For example, the final discharge of chemical oxygen demand (COD) should be less than 50 mg/L and zinc concentration should be less than one mg/L (Abdul Kadir Bakti & Lim, 1999). Therefore, Equation 10 can be referred to for the calculation.

Based on the analysis, WF for NRG ranged from 1.3 to 3.4 m^3/1000 pcs, while WF for SRG ranged from 1.9 to 6.0 m^3/1000 pcs, as depicted in Figure 8.18. Although the raw material used was identical, the WF result varied by production plants. This could be caused by the type of technology used in the production. This involved electricity consumption, the different number of gloves produced according to plant and different amount of wastewater generated. Furthermore, the indirect water consumption in the analysis caused a high value of WF compared to direct water consumption.

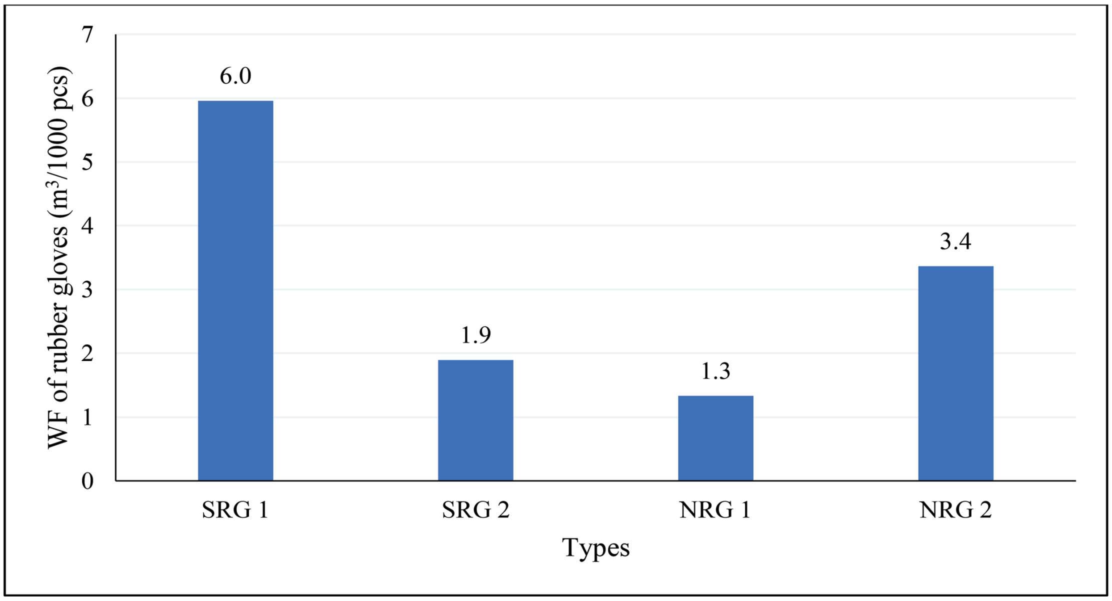


Figure 8.18 WF of Natural and Synthetic Rubber Gloves Production

In conclusion, WF can be lowered when the direct and indirect water consumption for rubber gloves production is reduced. This can be achieved using water-efficient technologies, advancing water training by including the WF elements for technical and administrative staff and strategised wastewater treatment plants.

8.2.5 Case Study 5: Semiconductor

The semiconductor sector has contributed significantly to Malaysia's economy over the previous decades. The semiconductor sector has shown a steady increase in production except during the Global Financial Crisis (GFC) in 2015. Nevertheless, the production has recovered since 2017 and continuously showed positive growth until 2019. Figure 8.19 depicts the number of semiconductors production from 2013 to 2019. Semiconductor fabrication is classified as a water-intensive process. Therefore, it consumes massive amount of water through its supply chains, such as raw materials production, transportation involved and electricity consumption. In Malaysia, electronic, electrical and optical products are amongst the highest export earners, with RM361.8 billion per year export value, or about 28.4% of the nation's GDP (DOSM, 2018). Given the high and sustained export value of semiconductor products, it is imperative to have a systematic assessment of its WF to ensure the sustainability and competitiveness of the industry globally.

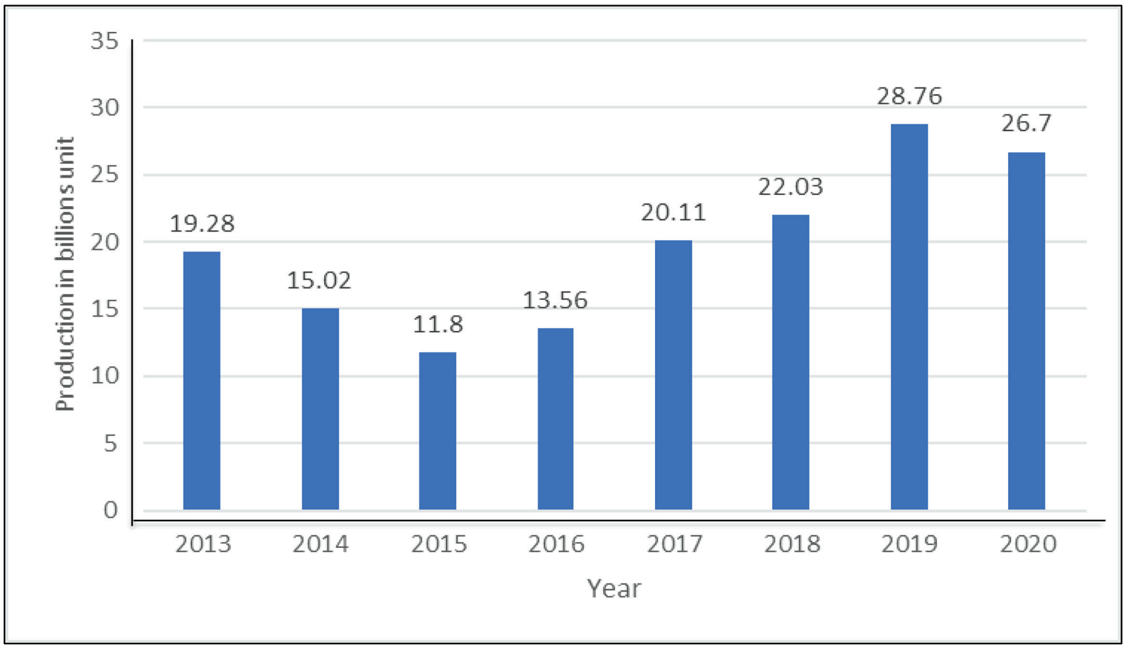


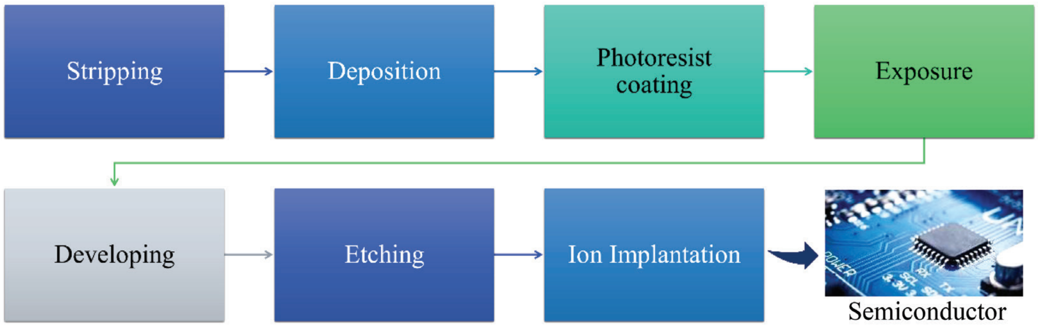
Figure 8.19. Production of Semiconductors in Malaysia (2013–2019)

The process flows in the semiconductor components production are crucial in defining the water consumed. Generally, the WF in the manufacturing industry is calculated based on Equation 7. The main sources of indirect water for manufacturing are energy calculation in fuel consumption, electricity and transportation (Mekonnen et al., 2015). For electricity, a unit conversion of 1TJ = 277.78 MWh was used. Data requirements and general process flow for wafer fabrication can be referred to in Box 8.5.

Semiconductor manufacturing uses materials and energy with embedded water to be quantified, such as in the wafer fabrication process. This direct and indirect blue water consumption has been influenced by the technologies utilised in the wafer fabrication. According to Schischke et al. (2001), the wafer fabrication used 70 materials and energy categories. Figure 8.20 is an example of the fabrication model, whereby the inputs and outputs are clearly illustrated.

BOX 8.5

Stages in Semiconductor Production



Sector : Manufacturing
Measuring : VW&WF for semiconductor production
Unit : m^3/cm^2 of wafer
Data Sources : Micron, Department of Statistics Malaysia (DOSM)
Data Requirement:

i. Processing of semiconductor
   - Types of product and total product produced in one month
   - Electricity consumption (kWh)
   - Amount of direct water (m^3)
   - Amount of wastewater (m^3)
   - Weight of 1 pc of product (g)
   - Surface measurement of 1 pc of product (cm^2)
   - Type and amount of chemicals used (L)
   - Wastewater characteristics (BOD, COD, TSS, etc.)

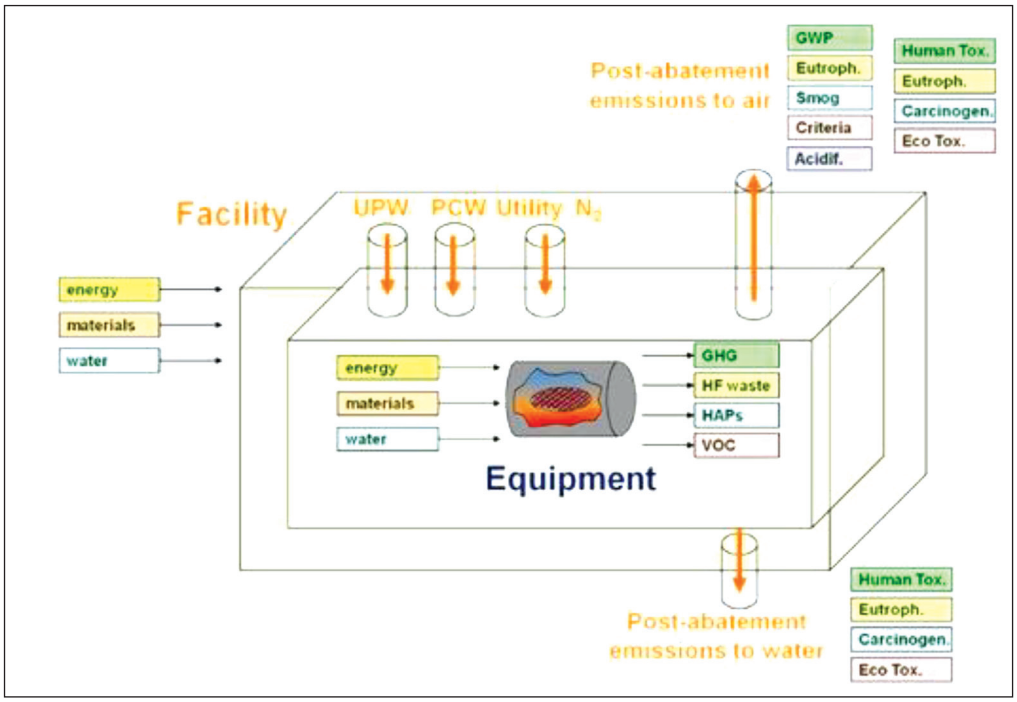


Figure 8.20. Common Processes in Wafer Fabrication

(*Source*: Boyd, 2009)

Water is being used intensively in this fabrication and the industry has acknowledged this issue. Therefore, it is considered a factor in any decisions related to its physical, regulatory and reputational risk (Frost & Hua, 2017). A study by Frost and Hua (2017) showed that the water used by semiconductor manufacturers, including electricity in the calculations, was about 21,785 x 10^6 m^3/yr. China has the highest water use with 11,888 x 106 m^3/yr, representing 27.3% of the total water used. Another study by Cooper et al. (2011) conducted a WF assessment that focused on direct water consumption of the manufacturing facilities, water used in producing the Intel's electricity consumed for manufacturing and water used within the supply chain. The findings came out with the water inventory footprint, revealing that the water used at Intel's manufacturing had the highest WF value, with 97.26%. Therefore, water use efficiency and the type of technologies utilised in the industry are the factors that affect the amount of water used.

WF calculation for semiconductor products from secondary data by Frost and Hua (2019) was done with only the major categories that have been considered, such as logic, memory, flash and others. Besides, Micron Semiconductor Malaysia Sdn. Bhd., which specialises in producing memory and storage products, shared data on one of the products made. Table 8.5 shows the different product categories calculated based on two distinct data sources and the WF results for each category. However, the calculation only considers direct water and electricity consumption on data from Frost and Hua (2019). In contrast, data considered from the respective company is provided with further information on wastewater.

Table 8.5. Product Category and Amount of WF

Categories in wafer	WF (m^3/cm^2 of wafer)	Source
Logic (CMOS, Bipolar, MEMs)	0.0090	Frost and Hua (2019)
Memory (RAM, DRAM, MRAM)	0.0202	
Flash (CMOS, NAND)	0.0115	
Other (GaAs, Sapphire, MEMs, Indium)	0.0076	
Flash (NAND)	0.0024	This study

WF calculation from Frost and Hua (2019) showed that the memory had the highest WF. Other categories have the lowest WF with 0.020 m^3 and 0.008 m^3, respectively. NAND products from the flash category had a WF of 0.002 m^3. The difference in the WF results was due to the assumption that the products produced have various types of technology nodes. The total water withdrawal from the production was assumed through the production capacity. The product with a high value of WF and component that consumed more water could be detected from the findings. This will help the industry to recheck the supply chain and propose countermeasures, such that water consumption can be reduced by using water-saving technologies and reducing electricity consumption.

8.2.6 Case Study 6: Tourism

The Malaysian government has recognised tourism as one of the major sectors that can generate significant economic growth. This can be seen from the rapid growth of the tourism industry. During the 90s, tourism contributed about 3.8% of GDP and has increased significantly to 16.1% in 2014. The expenditure of tourists stimulates economic activity and creates an additional business turnover, employment, household income and government revenue in the host destination (Dwyer et al., 2015). Although tourism has been regarded as the main driver for economic growth, tourists' water consumption needs to be assessed due to sustainability efforts at tourist spots.

Several previous researchers have established procedures and methods to quantify WF focusing on the tourism industry. These findings concentrated on the case study method, which covered certain countries, namely China (He-Zhang, 2017; Li, 2017; Mingyu et al., 2011), Spain (Cazcarro et al., 2014), Taiwan (Sun & Hsu, 2018) and Croatia (Grofelnik, 2017) are used as a basis to establish a WF methodological approach for tourism case studies in Malaysia.

BOX 8.6

Description of Tourism Sector

Sector	:	Tourism
Measuring	:	VW&WF for tourist per visitation day
Unit	:	m^3/tourist/day
Data Sources	:	Hotel operators, Hotel's property managers, Ministry of Tourism and Culture (MOTaC), Ministry of Transport (MOT), Land Public Transport Agency, Malaysia Association of Hotel (MAH), Malaysia Association Tour Agency (MATA)

Data Requirement:

i. Direct water use per tourist:
   - Water bill (m^3)
   - Number of tourists

ii. Indirect water use per tourist:
   - Energy fuel consumption (transport and electricity)
   - WF for food

The calculation of VW&WF in the tourism industry relies on data in tourism activities. Similar to the calculation in major economic commodities, the input-output table is vital. Therefore, the following data used in the model to assess WF&VW for the tourism industry in Malaysia can be referred to Box 8.6:

i. Direct water use per tourist
ii. Energy-related footprint (transport and electricity)
iii. Amount of food consumed by tourists per day

Based on the model developed by Mingyu et al. (2011), the equations to calculate WF accounting are as follows:

i. Estimation of the direct component of footprint (W_{direct}) or, in other words, direct water use per tourist was calculated using Equation 8:

$$W_{direct} = \sum_{i=1}^{n} (V_d)\, i \qquad \text{Eq. 8}$$

where;

V_d = Average volume of water directly used from the tourism points, such as hotels motels, guesthouses per visitation day

ii. Energy-related footprint (EF) can be further broken down, consisting of two main parts: WF to produce fuel for powering accommodation and travel-related transport ($W_{electric}$) and WF associated with long-distance travel from and to tourists' places of origin, using different energy-consuming transport modes ($W_{transport}$).

Estimation of the indirect food component of the footprint (W_{food}). This model will require two datasets: local food daily consumed by tourists and the associated amount of green water used to grow and produce local food.

Therefore, the equation will be as follows:

$$W_{food} = \sum_{i=1}^{n} (\bar{f}) \times (v_g) i \qquad \text{Eq. 9}$$

where;
$\bar{f}$ is the average amount of food consumed by a tourist per day through local catering services. While v_g represents green water used to grow and produce food *i*.

iii. Estimation of the total WF of a tourist per day is summarised by adding Equation 8, Equation 9 and EF, which is as follows:

$$WF = W_{direct} + W_{energy} + W_{food} \qquad \text{Eq. 10}$$

Rather than employing the standard production (supply) perspective, the WF evaluation approach measures human water demand from the consumer's perspective. Given adequate consumption data, a WF can be determined for any individual, community, nation, or corporation (Chapagain et al., 2006; Chapagain & Hoekstra, 2007). With a growing interest in the relationship between a country's economic development and water use and the various ways this link may be expressed, WF can be used as an index number. This is included in the tourism sector. The strategy is based on WF accounting, a new tool for analysing the human impact on water resources (Hoekstra & Chapagain 2008). This method is used to identify water usage patterns by local tourists and estimate the amount of direct and indirect water use.

The calculation of the WF of tourism may not have significant implications for calculating the WF in certain nations. However, it does in Malaysia, which receives over 26 million tourists each year. Moreover, tourism accounts for over 13% of Malaysia's GDP in 2019. In order to explore policy implications for enhancing Malaysian tourist-related WF, this study examines the water impacts of tourism, concentrating mainly on agrifood production processes. The importance of analysing the WF of tourism is emphasised by demonstrating that water consumption by foreign tourists in Malaysia through the purchase of products and services cannot be attributed to Malaysian locals, and it is significant in the overall WF. Politically, it can also be claimed that internalisation of social costs does not occur solely through the price mechanism of products and services, making the costs of tourist activities particularly relevant (Green et al., 1990). The total food WF of Malaysian hotels could be reduced by adjusting the diet structure and reducing WF per unit of food. In the case study locations, hotels and restaurants should take the initiative to limit meat sales and enhance vegetable and fruit sales. Additionally, the information on WF per unit of goods will give public awareness to minimise the intake of products with a greater WF.

Tourists seek various goods and services (accommodation, meals, travel services, souvenirs), all of which require inputs from other sectors of the economy. As a result, consumption in each key area should be considered. These activities contributed to the water consumption for each tourist. The analyses comprised several water consumption components, such as direct water, electricity, fuel and food. This study provided a comprehensive estimate of tourist water consumption in several Malaysian states and territories. The strategy was based on WF accounting, a new tool for analysing the human impact on water resources (Hoekstra & Chapagain 2008). This method is used to identify water usage patterns by local tourists and estimate the quantity of direct water use. The findings assisted Malaysian policymakers in developing appropriate water and tourism policies.

To assess WF in the tourism industry, this study has assessed several components in the tourism industry that contributed to the calculation of WF. A survey was conducted based on the 2019 data to ensure data consistency due to the COVID-19 pandemic**.** Figure 8.21 presents findings on the mode of transportation for local tourists.

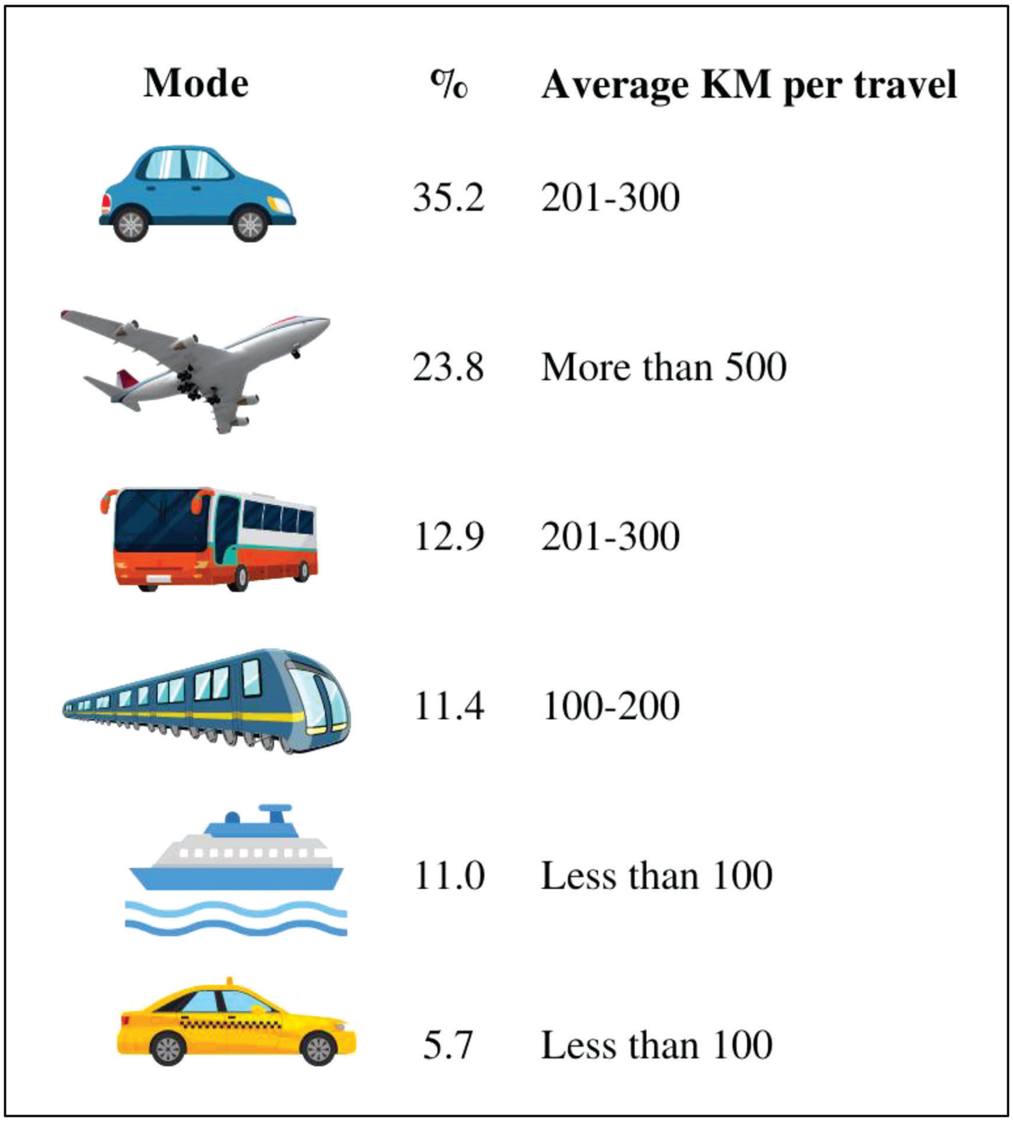


Figure 8.21. Mode of Transportation for Local Tourists (from Home to Hotel)

As shown in Figure 8.21, the primary transportation mode amongst tourists includes cars (32% with an average of 201 km to 300 km per travel) when travelling from their home to the hotel, followed by flights and buses (23.8% and 12.9%, respectively). The results also indicated that due to the advancement of the Malaysian transportation system, only a small percentage of tourists chose taxis to travel from their home to the hotel.

Another significant component in assessing WF in the tourism industry is the electrical usage of hotel accommodations. Based on the tourist stay data in 2019, the results indicated tourists mainly used appliances including air-conditioning, fan and lamps ranging between 12 and 14 hours per day. In Malaysia's dry climate, an evaporative air conditioner consumes roughly 60 litres per hour, or between 2% and 10% of typical Malaysian households' total yearly water usage (Hamid et al., 2014). Other major appliances, such as televisions and laptops also have high electrical usage during tourist's stay in the hotel. WF calculation tools can therefore be used to calculate the impact of human activities through electrical appliances. This indicator is a useful tool to estimate WF in the tourism sector since it calculates the actual amount of water used, which is important when producing energy-efficient appliances in a more efficient and environmentally responsible manner, and therefore contributing to cost reduction, water conservation and sustainable environment. Figure 8.22 shows the average daily usage of electrical appliances at hotels.

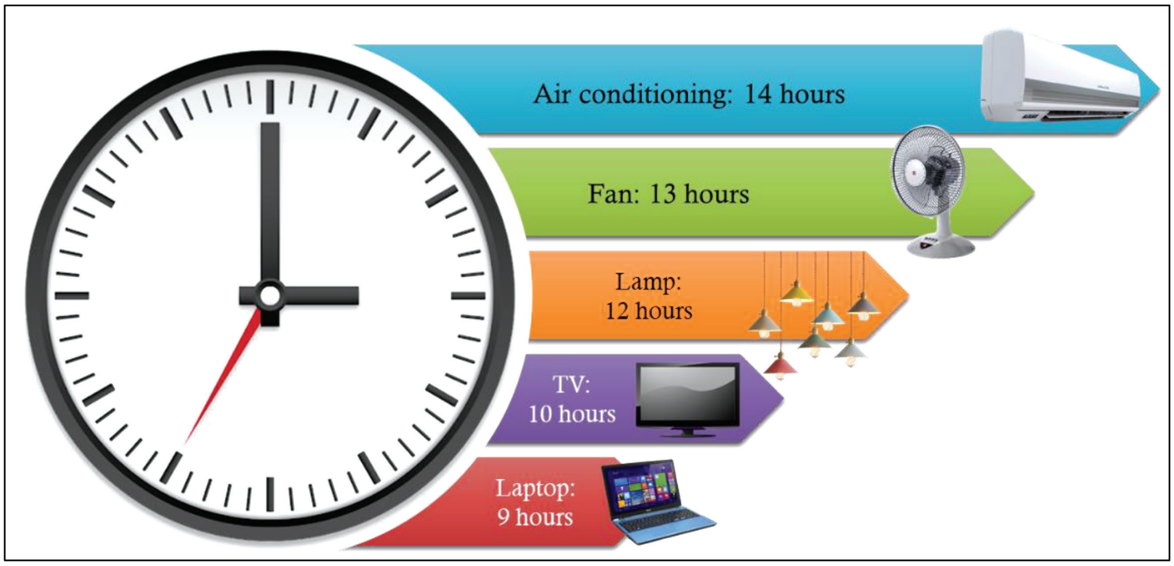


Figure 8.22. Average Daily Usage of Electrical Appliances at Hotels

In assessing WF in the tourism industry, four major elements have been identified to suit the case study on the Malaysian tourism industry. The elements comprise direct WF, which assesses the direct water consumption such as shower, toilet and swimming pool; WF fuel, which examines the average kilometres for travelling by car from home to hotel; WF electric, which assesses the average electricity usage, such as air conditioning, fans, lamps, televisions and laptops; and WF food, which investigates the daily food consumptions based on the main ingredients, such as rice, noodles, chicken, beef, vegetable and drinking water. The total WF can be defined as the water required to create the goods and services used by visitors based on their WF. It takes into account both the direct and indirect WF. The direct WF is primarily concerned with direct water usage and pollution, referring to actual water. The VW incorporated in tourism meals, supplies and energy is referred to as the indirect WF. These elements can be referred to in Table 8.6, with the total WF for one tourist per day was 4.89 m^3. The results indicated that food had the highest WF, which was 4.33 m^3/tourist/day. This was followed by direct WF with 0.40 m^3/tourist/day.

Table 8.6. WF Calculation in Malaysian Tourism Industry based on WF Elements

No.	WF Element	Details	WF (m^3/tourist/day)
1	WF direct	Direct water consumption: shower, toilet, swimming pool, etc.	0.40
2	WF fuel	Average kilometres for travelling by car from home to hotel.	0.11
3	WF electricity	Average electricity usage: air conditioning, fan, lamps, television, and laptop.	0.05
4	WF food	Daily food consumption (main ingredient): rice, noodles, chicken, beef, vegetable and drinking water.	4.33
		Total WF	**4.89**

Table 8.7 compares the findings of this study with WF in China's tourism sector. The previous findings revealed different outcomes based on different case studies in China. For instance, Zhang et al. (2017) found 3.39m^3/tourist for the case study in Mount Huangshan, comprising accommodation, management, sewage, food and transportation elements. Another study in China was done by Yang et al. (2017). Their findings showed that every tourist in the Liming Valley, Yunnan Province, recorded 5.2m^3. The different value was due to diet and the effective use of energy and water.

Table 8.7. Comparison of WF Calculation for Tourism in China and Malaysia

Study	Tourist WF (m^3)	Elements	Reference
China (Mount Huangshan) (Huangshan City, south of Anhui Province)	3.39	Accommodation, Management, Sewage, Food, Transportation	Zhang et al. (2017)
China	1.92	Accommodation, Food, Transportation	Hoekstra & Chapagain (2017)
China (Liming Valley, Laojun Shan, Yunnan Province)	5.2	The difference may be caused by diet, number of tourists and the way and degree of effective use of energy and water.	Yang et al. (2011)
Malaysia	4.89	Accommodation, Food, Electricity, Fuel	This study

Tourism businesses are slow to deploy water-saving and recycling equipment, offering only a little balance to the high demand for water. Since tourism industries are experiencing a fundamental change of adding more water-intensive amenities onsite, such as spa, swimming pool, in-room jacuzzi, or sports and health centre, relying solely on water-saving equipment or water-conscious consumers is insufficient to compensate for increased water demand. If information about water use is needed to be published in the future, such as footprint labelling, tourism businesses will be forced to choose between attracting environmentally conscientious customers and entertaining visitors drawn to luxury and water amenities. Tourism services have increasingly relied on foreign suppliers, particularly for agriculture and forestry products in Taiwan, reflecting the rise of global value chains. This dependency relieves home water stress, particularly during droughts or monsoons, and allows businesses to profit from product specialisation, cost efficiency and flexibility when launching new products or expanding volume.

8.3 Virtual Water Trade

In VWT, when products and services are transferred, embedded water is also shared. VW's biggest net exporters are North and South America (the US, Canada, Brazil and Argentina), Southern Asia (India, Pakistan, Indonesia, Thailand) and Australia. On the other hand, the biggest net VW importers are North Africa and the Middle East, Mexico, Europe, Japan and South Korea. Even though Malaysia is a water-rich country, it is critical to study its VW due to its high intensity of export items. Therefore, this study analyses the VWT for the agriculture sector through export and import for CPO, rubber and rice. Net VW (NVW) trade of CPO, rubber and rice are obtained by subtracting the virtual water exported (VWE) from the virtual water imported (VWI). VWE was calculated using Equation 11, and VWI and NVW trade used Equation 12 and Equation 13, respectively.

$$VWE = Export\ product\ \times WF\ for\ product \qquad \text{Eq. 11}$$

$$VWI = Import\ product\ \times WF\ for\ product \qquad \text{Eq. 12}$$

$$NVW = VWE - VWI \qquad \text{Eq. 13}$$

The palm oil sector is one of the most important contributors to our country's GDP. According to DOSM, oil palm contributed 37.7% of the agriculture sector's value-added in GDP in 2020 (DOSM, 2020). While Malaysia is the second largest exporter of palm oil products, we are also importing small amounts of CPO as shown in Figure 8.23.

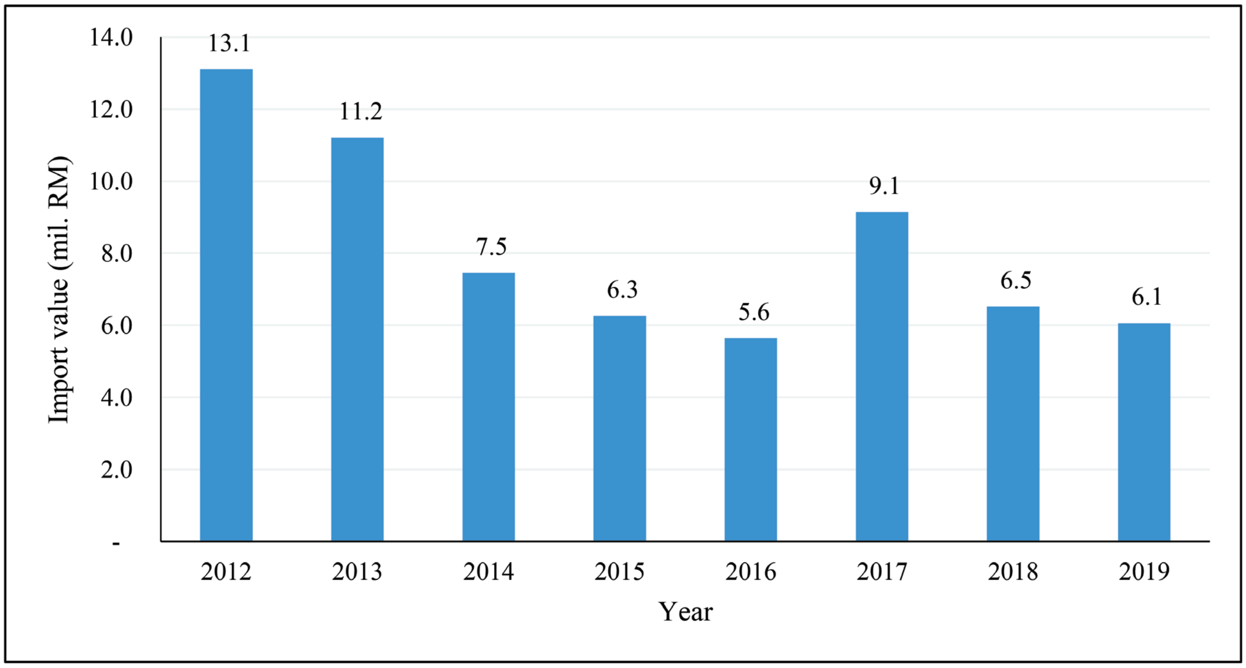


Figure 8.23. Import Value of CPO in Malaysia (2012–2019)

Malaysia generated roughly 0.6 to 0.9 million tonnes of natural rubber per year between 2010 and 2019. Thailand, Cote D'Ivoire, the Philippines, Vietnam and Myanmar were the top importers of natural rubber. Figure 8.24 shows the total value of rubber imports.

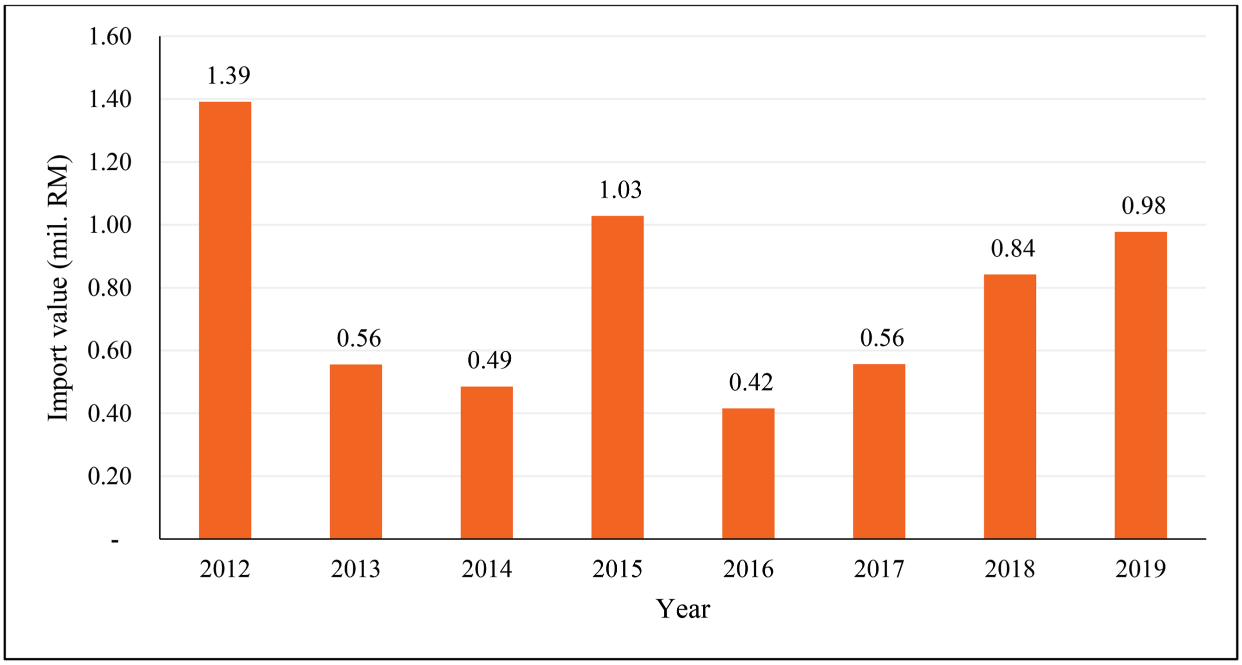


Figure 8.24. Import Value of Natural Rubber in Malaysia (2012–2019)

Malaysia has imported 38% of rice to meet the demand of approximately RM1.87 billion (Statista, 2021). The value of rice imports ranges between RM1.49 billion and RM2.08 billion, as shown in Figure 8.25.

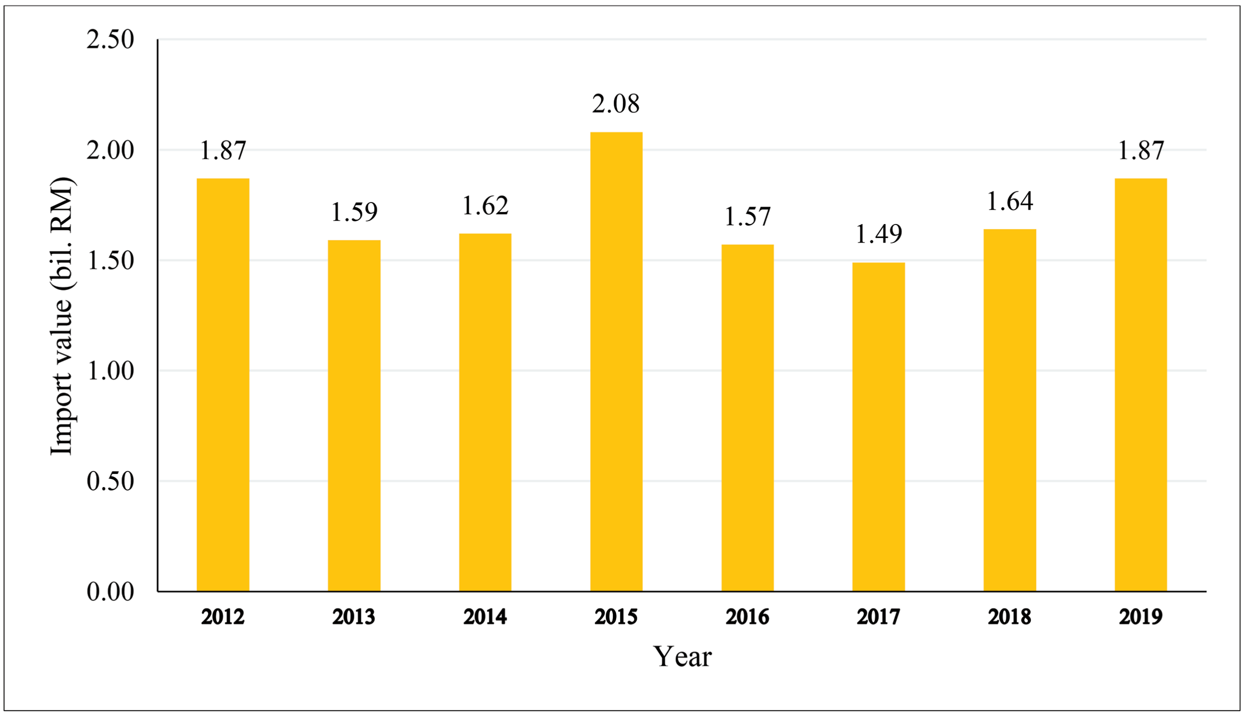


Figure 8.25. Import Value of Rice in Malaysia (2012–2019)

Based on the most recent data, NVW trade for CPO was 101.36 billion m^3 in 2019, rubber was -0.70 billion m^3 in 2019, and rice was -1.46 billion m^3 in 2018. The value of the NVW trade was positive due to the higher value of VWE and vice versa. Figure 8.26 to Figure 8.28 illustrate the VW of CPO, rubber and rice-based on VW trade between Malaysia and the main exporter and importer countries.

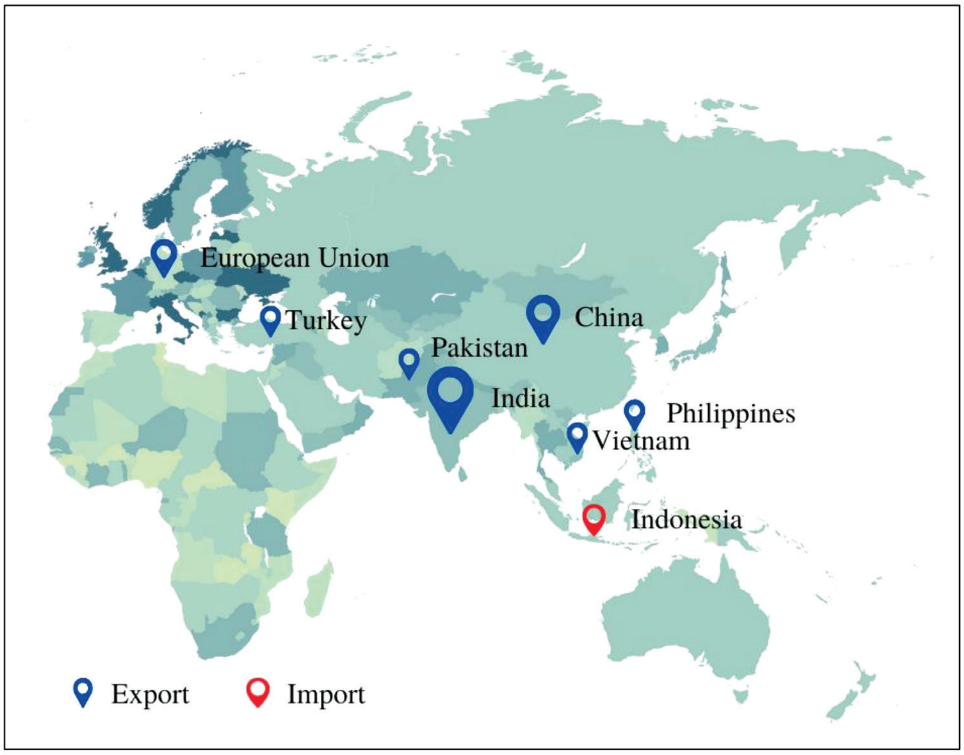


Figure 8.26. VW of Crude Palm Oil (2019)

In Figure 8.26, the VW of CPO for 2019 is presented. CPO was mainly imported from Indonesia (5.7 billion m^3) and Malaysia exported CPO to several countries, including India, China, EU, Pakistan, Turkey, the Philippines, Vietnam and other countries with a total of 107 billion m^3 with the highest range of 37.5 billion m^3 and the lowest range of 3.4 billion m^3.

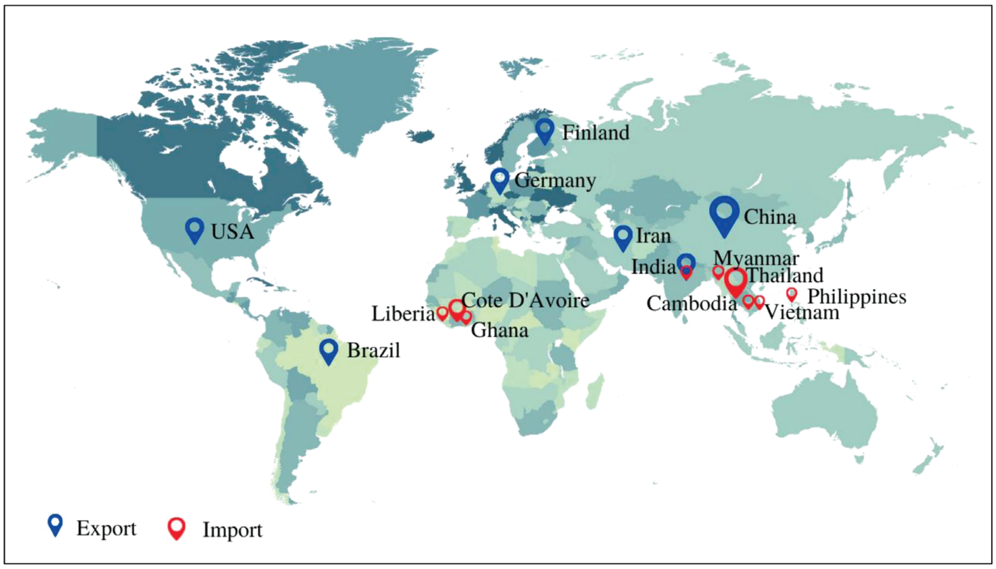


Figure 8.27. VW of Natural Rubber (2019)

The VW of natural rubber for 2019 is presented in Figure 8.27. Malaysia had a balanced import and export of natural rubber with a total import of 15.46 billion m^3 with the highest range of 6.94 billion m^3 and the lowest range of 0.10 billion m^3. Meanwhile, the export value of natural rubber was 14.75 billion m^3, with the highest range of 10.16 billion m^3 and the lowest range of 0.20 billion m^3. Natural rubber was mainly imported from Thailand, Cote d'Ivoire, the Philippines, Vietnam, Myanmar, Liberia, Ghana, Cambodia, Sri Lanka and India. Natural rubber was exported to several countries, including China, Germany, Finland, Iran, the USA, India and Brazil.

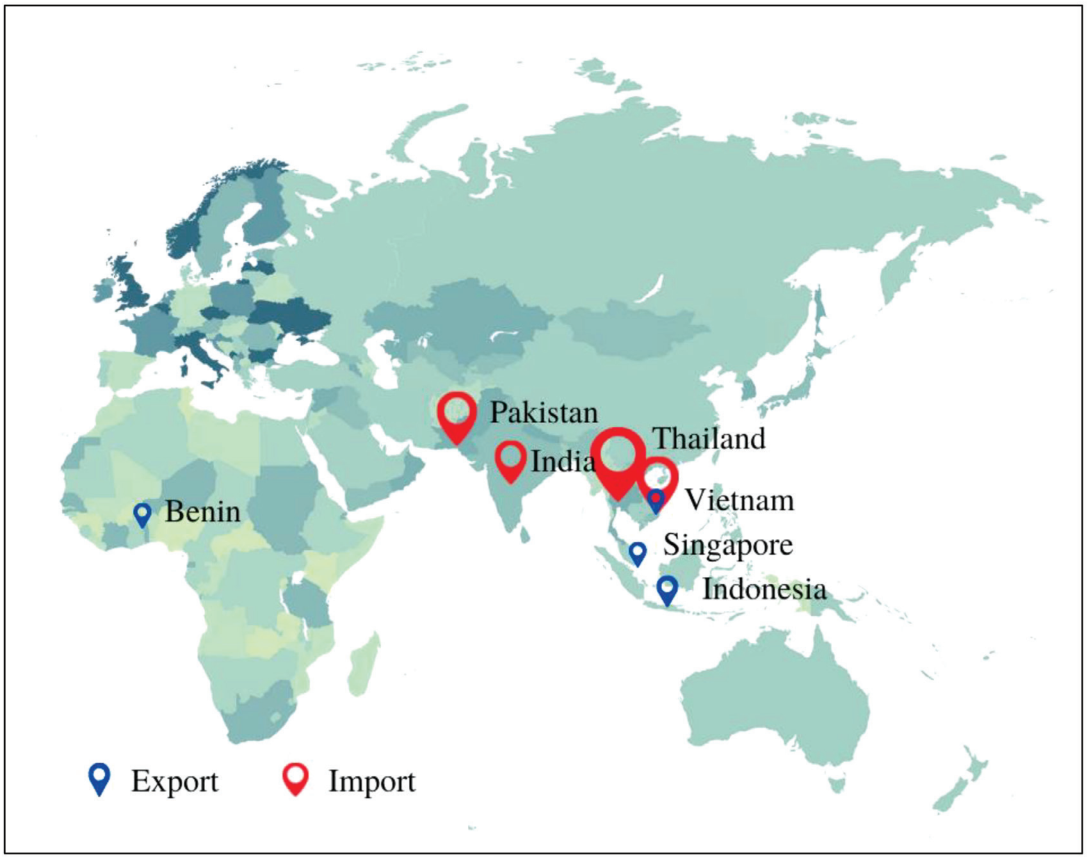


Figure 8.28. VW of Rice (2018)

The VW of rice is shown in Figure 8.28 for 2018. Malaysia recorded 1,481.6 million m^3 for rice imported from Thailand, Vietnam, Pakistan and India, with the highest range of 765.8 million m^3 and the lowest range of 69.6 million m^3. Meanwhile, Malaysia also exported rice with 22.7 million m^3 to Benin, Singapore, Vietnam and Indonesia, with the highest range of 20.3 million m^3 and the lowest range of 0.2 million m^3.

8.4 Summary Results

As shown in Figure 8.29, the sub-sectors selected for this study are palm oil, rubber, paddy, glove, semiconductor and tourism. The calculated WF values ranged from 4,447 to 9,911 m^3/t for crude palm oil, 9,060 to 22,876 m^3/t for rubber, and 975 to 2,641 m^3/t for paddy. The WF of synthetic rubber glove ranged from 1.9 to 6.0 m^3/1000 pcs of gloves and 1.3 to 3.4 m^3/1000 pcs for natural rubber gloves. The WF value for NAND Flash, representing the semiconductor sector was 0.002 m^3/cm^2, while the WF for tourism was 4.89 m^3 (tourist/day).

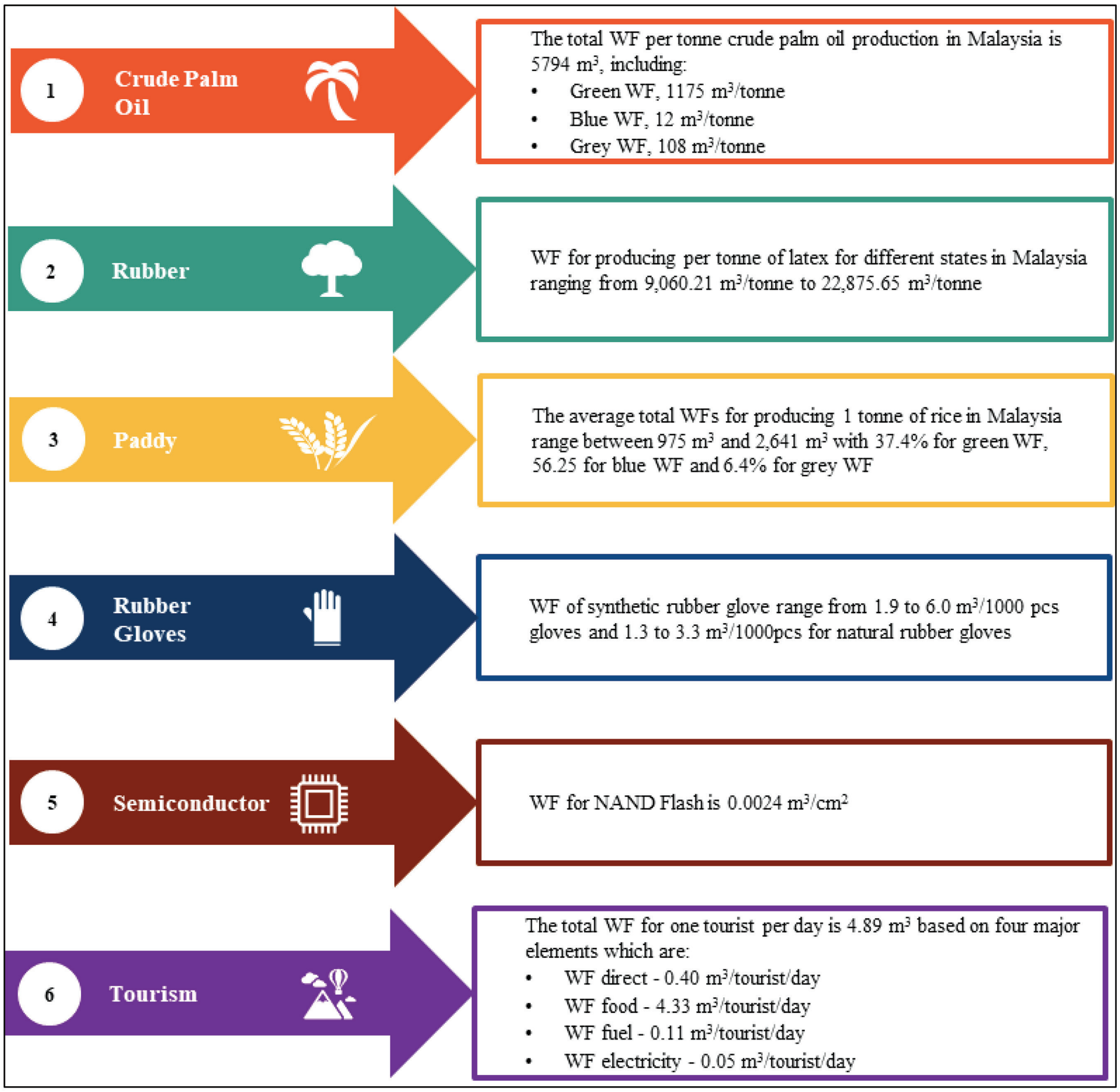


Figure 8.29. Summary of Case Studies Findings

8.5 Issues and Challenges

WF is a relatively new research area in Malaysia. Therefore, several challenges may arise during the study, mainly since this study commenced in May 2020 and should be completed after only 20 months. Technically, different methodology in applying WF leads to different WF results since there are two main approaches for WF assessment and no standardisation of using WF definitions. Therefore, it is agreeable that this study implements a hybrid approach to complement the advantages of both methods. The next biggest challenge is data accessibility.

Several industries are very reluctant to share water quality data, as it will reveal the actual conditions of the respective company or industry. Furthermore, if it involves third-party companies, it poses further challenges to create data inventory. Since sufficient and reliable data are needed to obtain the precise value of WF, awareness of the WF concept should be introduced, and knowledge on WF should be disseminated amongst the government, industries and the public. Besides, data is scattered under different types of governance. This is due to the nature of Malaysia's water sector, which is diverse from the perspectives of services and water players themselves. Another main constraint when doing the WF assessment in the agricultural sector is a lack of climatic data and soil data variability. Consequently, the assessment results may not be accurate because the WF approach is spatial and temporal. Moreover, limited data access and coordination may also lead to obstacles in assessing the WF and comparing the study's results. In manufacturing, the processes involved may differ even if it is in the same field, leading to different datasets. Plenty of data is required in each step of production, complicating the water footprint assessment of this sector. Since water is still abundant in some areas, the level of awareness in implementing water-saving amongst the industrial players is inadequate.

As WF is relatively a new research endeavour in Malaysia, several challenges may arise during the study, as demonstrated in Figure 8.30.

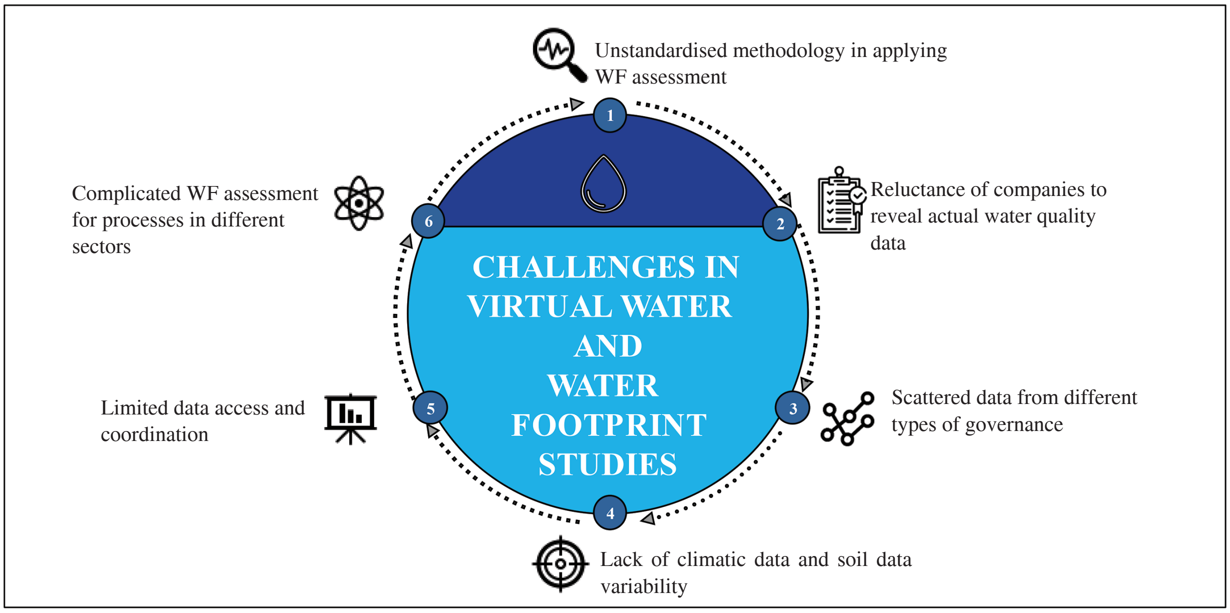


Figure 8.30. Challenges in Water Footprint Study

9.0 Way Forward – 8i Ecosystem Approach

VW&WF concepts have not been widely understood with regard to the sustainable use of freshwater resources by various sectors and the community. More aspects of VW&WF need to be explored, particularly those concerning the 8i ecosystem framework: infrastructure, infostructure, intellectual capital, integrity, incentives, institution, interaction and rationalisation, as illustrated in Figure 9.1.

In terms of infrastructure, the water use in irrigation is inefficient and that there are also poor applications of recycling and reuse technologies in industries. It has to be highlighted that, at present, many industries seem quite reluctant to invest in water-efficient technology due to the low water tariff in Malaysia. The problem is made worse with water loss caused by water leakage due to ageing and poorly maintained water infrastructures. Some preventive measures that can be taken are introducing a more efficient irrigation technology, growing more drought-resistant crops such as paddy and employing more water-efficient planting techniques. Industries may also opt to invest in water-saving technology, especially in manufacturing, agriculture and mining. The government can also proactively provide incentives and

Internationalisation

Challenges: 1) Lack of mechanism to realise WF as a trading element. 2) Insufficient funding for internationalisation effort. 3) Non-existence of VW trading agreement.

Solutions: 1) Formation of alliances with international players. 2) Becoming global leader in WF initiative. 3) Allocation of resources. 4) A white paper on VW for the purpose of international trade agreement. 5) Comprehensive studies on global economic opportunities, drivers, and impacts. 6) WF as a mechanism to optimize global water direct/indirect consumption.

Interaction

Challenges: 1) Lack of coordinated effort between the Federal and State governments. 2) Lack of mechanism to foster the government-industries initiative on WF.

Solutions: 1) Provide WF platform between the Federal and State governments through IRBM initiative. 2) Inclusion of WF definition in laws and regulations. 3) Establishment of national taskforce on WF research and implementation.

Institutions

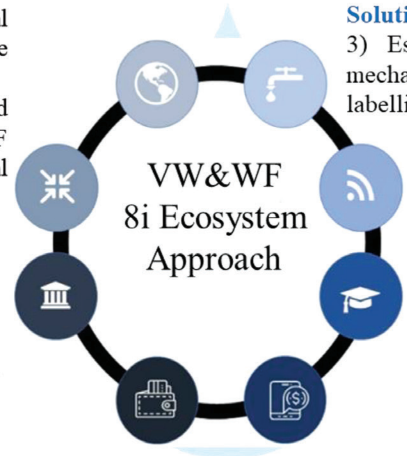
Challenges: 1) No dedicated institution to derive WF initiative. 2) Lack of awareness and knowledge. 3) Slow respond of State government to new initiatives. 4) State government has limited capacities to encourage industries participation. 5) Water is a state matter.

Solutions: 1) Establishment of one stop centre for WF. 2) The WF Centre to transfer knowledge to stakeholders. 3) Conduction of competency program. 4) KASA to administer and facilitate interactions with various parties.

Incentives

Challenges: 1) Lack of R&D in WF. 2) Lack of reward and regulations on water recycling and reuse technology.

Solutions: 1) To include WF in the current ESG initiative under Bursa Malaysia. 2)Provision of financial rewards. 3) Review water tariff. 4) Introduction of incentives and penalty to support water demand management.



Infrastructure

Challenges: 1) Low irrigation efficiency. 2) Unwillingness of industry to invest. 3) Ageing water infrastructures.

Solutions: 1) Improvement of irrigation technology. 2) Develop drought resistant crops. 3) Provide incentive to encourage industry to invest on water saving technology. 4) Promote water demand management. 5) Water tariff rationalisation.

Infostructure

Challenges: 1) Lack of WF data. 2) Data inaccessibility. 3) Lack of driver for implementing WF.

Solutions: 1) WF R&D for priority sectors. 2) Strengthen NAWABS. 3) Establishment of a model river basin. 4) Establish data sharing mechanism. 5) Government incentive for industries to participate in WF labelling scheme. 6) Public awareness programs.

Intellectual Capital

Challenges: 1) Lack of talents, experts, and funding in WF research. 2) Low number of WF publication by Malaysians. 3) Local researchers are not focus on WF. 4) WF is not listed under the national research priority. 5) Lack of training on WF.

Solutions: 1) Development of WF training module as part of water manager competency program. 2) Promote WF as a priority research area.

Integrity

Challenges: 1) Different school of thoughts (WFN vs ISO14046). 2) WF is not a priority issue for industry. 3) Lack of concern by the industry. 4) Lack of data sharing and transparency. 5) No water accounting reporting. 6) Inadequate policy to support WF.

Solutions: 1) Adoption of hybrid method for WF analysis. 2) Setting up of appropriate policy and regulation on WF. 3) Water manager certification. 4) Establishment of water accounting report which incorporates WF element. 5) Conduction of awareness program. 6) Inclusion of WF components in Dasar Air Negara

Figure 9.1. 8i Ecosystem Framework

impose penalties to promote demand management and water use efficiency, including rationalising the current water tariff.

In terms of infostructure, insufficient WF data has affected planning at the river basin scale and difficulty in accessing industry data hampered essential WF data to be gathered. Readily available WF data sources are often scattered, with no proper data repository for VW&WF studies due to the lack of a coordinating mechanism to document the data. Another contributing factor to the limited access to infostructure is the limited pushing factor in terms of enforcement, incentive, laws and regulations for industries to participate in the WF labelling scheme. To support WF implementation in Malaysia, a WF study for priority sectors needs to be carried out to address the scarcity of WF data. In addition, NAWABS's role in implementing WF at the river basin scale is crucial to strengthen and widen the existing efforts. This can be implemented by conducting WF analysis within the boundary of the selected river basin and establishing a model river basin to fully implement the WF concept. In addition, a mechanism to facilitate data sharing should be initiated, which can be accelerated through the development of WF. The development of WF could accelerate the data sharing process. The government should provide incentives to industries that participate in the WF labelling scheme and promote public participation through public awareness programmes.

Another gap in the VW&WF study is found in the area of intellectual capital. Malaysia is currently facing a shortage of talent, expertise and investment in WF, since WF is a new and emerging field in Malaysia. In this area, contributions from Malaysian researchers are marginally small (2.3%) compared to the total WF-related publications across the globe. WF is not a key focus area amongst local researchers, as it is yet to be listed in the national research priority. The limited training programmes on WF further contributes to the slow growth of intellectual capital in this area. A WF training module for the water manager competency programme should be developed along with capacity building for WF competency to mitigate this problem. Above all, promoting WF as a priority research area with a clear socioeconomic outcome is of utmost importance.

The need to address the issue of integrity is also pertinent in the area of VW&WF. To date, WF research has a different school of thought (WFN and ISO 14046) which could be counter-productive. WF may not be seen as a priority issue for industry players as they are also dealing with other basic water issues, resulting in the lack of industry buy-in to apply the ISO 14046 and implement the WF labelling scheme. It has not been established whether there is transparency in the WF reporting as data sharing is limited. Other issues concerning integrity include lack of data sharing and transparency, incomprehensive reporting and inadequate policy supporting WF implementation in Malaysia. One of the possible ways to tackle integrity issues is to accommodate different schools of thought in WF. This can be done by adopting a hybrid method supported by appropriate policies, incentives and penalties for WF implementation. Other initiatives, such as implementing water manager certification, incorporating WF elements into the industry's existing assessment for water accounting reports and instigating awareness programmes to get buy-in from industries, policymakers and other stakeholders can also be established. Essentially, the inclusion of WF components in Dasar Air Negara and continuous improvement of the WF accounting report could further expedite WF implementation in Malaysia.

Another issue regarding the VW&WF is the perceived limited incentives that could be gained from WF. Due to the limited WF research and development conducted, researchers will not gain financial assistance, or incentives that could help boost WF implementation. The lack of reward and regulations on water recycling and reuse technologies make it more difficult for those involved to value the importance of WF. Therefore, it is recommended that the WF element should be included in the current ESG initiative under Bursa Malaysia. Another important factor that needs to be considered is the provision of financial rewards in the form of tax incentives. Apart from rewarding incentives, there should also be a review on water tariffs for the industries as well as a penalty to be imposed to support water demand management.

Institutions are also key players that play a significant role in the VW&WF implementation. However, no institution has been assigned to derive, integrate and coordinate WF implementation in the country due to the lack of awareness and knowledge of WF. The response by the state government to new policies and initiatives by the federal government is generally relatively slow. In addition, the state government also faces some limitations to encourage more participation from industries. As water is a state matter, it has resulted in non-uniformity in regulations and practices. To assist the WF implementation at various levels, a one-stop centre for WF should be established to convey awareness and knowledge of VW&WF. The centre can act as a vehicle to get a stronger buy-in from state agencies. Apart from that, a collaboration with the Department of Standards Malaysia should also be established immediately to run the competency programme and set up a platform for industries to participate at the institutional level. Above all, KASA needs to administer the coordination with various agencies to as far as possible uniformise regulations and practices with regards to water.

Another gap in the study of VW&WF is the limited interaction between researchers and industry players. There is a lack of coordination amongst the state governments and territories in Malaysia, and no partnership has been established between the industries and government due to the inexistence of a dedicated platform for collaboration amongst stakeholders on WF. Therefore, any existing interaction between these parties is mainly based on individual initiative. Consequently, there is a the need to strengthen coordination between the federal and state government through the IRBM initiative and establish interaction between the government WF professionals in incorporating WF definition in laws and regulations. A national task force also needs to be set up to conduct and implement WF research. The involvement of government agencies in incorporating the WF agenda in laws and regulations is also pertinent in rationalising WF implementation in Malaysia.

The final concern of the VW&WF study is with regard to rationalisation. Calculating the WF can be as important as tracking the carbon footprint, which can be used as a free tariff element for future trade. However, Malaysia's participation in WF studies is marginal compared to other countries, such as China, the Netherlands, the USA and Singapore. The lack of available funding often hinders continuous and active participation by Malaysian researchers at global WF platforms, such as WFN and LCA, and thus limiting Malaysia's potential involvement as a global player in WF studies. In addition, there is also a limited mechanism and mutual agreement on VW trading with selected countries, causing further gaps in the VW&WF studies. To overcome this issue, Malaysia needs to strengthen its WF programme position by forming alliances with major international players, such as WFN and the UN. Consequently, Malaysia should also assume a leading role in the global WF initiative. Sufficient resources should therefore be allocated to achieve this goal. The way forward to rationalise VW trading is to prepare a white paper on VW international trade agreement purposes. A comprehensive study should also be undertaken to explore global economic opportunities, drivers and impacts of VW. Optimisation of global water management/ consumption through VW trade can be reached if all participating countries seek common ground on water trading.

9.1 Immediate Implementable Projects

A total of ten strategies, 22 programmes/initiatives and 45 activities has been proposed in the VW&WF study concerning water as resources and as livelihood. These projects address five focus areas (people, governance, information and research, development, innovation and commercialisation [RDIC], finance and infrastructure), which act as catalysts for developing a roadmap for the National Agenda on the WST2040, to be considered for implementation through the 12th MP to 15th MP. The immediate implementable projects are presented in Table 9.1.

Table 9.1. Immediate Implementable Projects for the 12th MP

Focus Area	Strategy	Initiative	Starting Year
People	Heightening VW&WF awareness amongst the public and industry.	Conduction of awareness programmes and knowledge dissemination for the public, younger generations and industries.	2022-2040
	Enhancing WF competency.	Development of training modules and attainment of recognition by certification bodies (Statutory/Private).	2022 - 2023
Governance	Enhancement of policy and law to support WF initiatives.	Incorporation of WF component in Dasar Air Negara (DAN).	2022
	Becoming global champion. Establishing WF governance.	Elevating Malaysia's role as a major player in the global WF initiative.	2022 - 2040
	Mainstreaming WF in business.	Creation of task force and guidelines.	2022 - 2024
	Enhancing WF competency.	Establishing requirements for water accounting report.	2022 - 2030
		Promotion of WF labelling scheme amongst local producers.	2024
		Development of WF calculator	2025
Information and RDCI	Enhancing R&D in WF.	Conduction of competency training programmes for water managers.	2023 - 2040
		Incorporation of WF in NAWABS within the river basin framework.	2022 - 2040
		WF study for selected sectors.	2023 - 2040
Infrastructure and Technology	Strengthening institutional setup.	Setting up WF centre.	2023 - continuous

As shown in Table 9.1, there are two immediately implementable projects under people, which include heightening VW&WF awareness amongst the public and industries and enhancing WF competency amongst water managers. The VW&WF awareness programmes and knowledge dissemination initiatives amongst the public, younger generations and industry players will start from 2022 until 2040. Meanwhile, enhancement of WF competency amongst water managers will be conducted by developing training modules and attainment of recognition by certification bodies starting from 2022 to 2023.

In terms of governance, five projects have been proposed, including enhancement of policy and law, which supports WF initiatives. The VW&WF study proposes incorporating the WF component in the Dasar Air Negara (DAN) to be implemented in 2022. In addition, another immediately implementable project is ensuring that Malaysia becomes a global champion through uplifting Malaysia's role as a global player in the WF initiative through the 2022–2040. Another project that can be implemented is through the establishment of WF governance through the creation of WF guidelines and the formation of the

WF task force from 2022 to 2024. Another project to be conducted is to mainstream WF in businesses by establishing requirements for water accounting reports through a nine-year period (2022–2030), promoting a WF labelling scheme amongst local producers by 2024 and developing a WF calculator by 2025. The final project that has been outlined under this focus area is the enhancement of WF competency through the conduction of training programmes for water managers, which are proposed to be conducted from 2023 to 2040.

Under the information and RDCI focus area, this study proposes that an enhanced R&D in WF should be conducted immediately by incorporating WF in NAWABS within the river basin framework starting from 2022 to 2040 and the conduction of WF study in selected sectors from 2023 to 2040. Finally, the fifth project proposed in this study to be readily implemented is by strengthening institutional set-up by establishing a WF centre starting from 2023 to address the focus area concerning infrastructure and technology. These immediately implementable projects can help drive the water transformation agenda outlined in the 12th MP. The following section thoroughly outlines the targets and KPIs that have been set throughout the 12th MP – 15th MP to achieve this aim.

9.2 Strategies, Targets and KPIs over the 12th – 15th MP

The strong emphasis on the water sector transformation agenda has driven the motivation for the VW&WF study to propose relevant strategies, addressing priority areas included in Chapter 8: Advancing Green Growth for Sustainability & Resilience and Chapter 9: Enhancing Energy Sustainability & Transforming the Water Sector of the 12th MP. To reiterate, ten strategies, 22 programmes/initiatives and 45 activities have been proposed concerning water as resources and as livelihood that fall under five focus areas (Section 9.1), which form the basis for developing a roadmap for the National Agenda on WST2040 to be considered for implementation through the 12th MP to 15th MP. The timeline to achieve these aims are shown in Table 9.2 to Table 9.5. Table 9.2 presents the strategies, targets and KPIs proposed to be achieved for the 12th MP.

Table 9.2. Strategies, Targets and KPIs for the 12th MP

12th MP				
Strategies	**Targets**	**KPIs**	**Lead Agency**	**Budget Estimated (RM million)**
Heightening VW&WF awareness amongst the public and industries.	Conduction of awareness programmes and knowledge dissemination for the public.	• Awareness programmes for roadshows will start from 2022. • Articles on WF to be published in popular media targeted for the general public. • WF element included in the programme to start in 2023. • WF related content on social media updated on a daily basis starting from 2022. • New content created on a weekly basis in a dedicated YouTube channel starting from 2022. • Biennial WF workshop organised beginning from 2023. • Awareness programmes with members of parliament and state assemblymen are conducted every two years starting from 2024.	• KASA • MOE • MOHE • State agencies, e.g., Sarawak Natural Resources & Environmental Board (NREB), Sabah Natural Resource Office • WF Centre	1.3

12th MP				
Strategies	**Targets**	**KPIs**	**Lead Agency**	**Budget Estimated (RM million)**
		• List of alternative local food with low WF to replace imported food starting from 2023. • Online customised individual WF calculator to be available for local use starting from 2023.		
	Conduction of awareness programmes and knowledge dissemination for schools and universities.	1. Incorporation of WF concept in the activities of school environmental club by 2025. 2. Content and materials for WF activities for school and university students developed by 2024. 3. WF-related content for school and university students on social media to be updated on a daily basis starting from 2022. 4. One WF competition programme per year. 5. Article on WF to be published in popular media targeted for the general public. 6. Educational institutions to have allocation for water conservation efforts in their schools/ institutions (compulsory). 7. Co-organise activity with GEC using the DrH2O kit (water-saving kits, checklist, water audit, water conservation module).	• KASA • MOE • MOHE • State agencies, e.g., Sarawak Natural Resources & Environmental Board (NREB), Sabah Natural Resource Office • WF Centre	1.1
	Conduction of awareness programmes and knowledge dissemination for industries.	1. Database of industry and WF association to be established by 2023. 2. Economic module for economic return framework to be developed by 2025. 3. Element of WF to be included in the Prime Minister's Hibiscus Award by 2025.	• KASA • MOE • MOHE • State agencies, e.g., Sarawak Natural Resources & Environmental Board (NREB), Sabah Natural Resource Office • WF Centre	0.6
Enhancing WF competency.	Development of training modules and attainment of recognition by certification bodies (Statutory/Private).	1. Accredited WF assessment training modules for industries ready to be utilised by the end of 2022. 2. Accredited WF auditing training modules for auditors by June 2023.	• KASA • NREB • EPD Sabah	0.3

12th MP				
Strategies	**Targets**	**KPIs**	**Lead Agency**	**Budget Estimated (RM million)**
	Conduction of competency training programmes for water managers.	1. WF competency programmes ready to be implemented by 2023. 2. 100 trained water managers per year beginning from 2023.	• KASA • NREB • EPD Sabah	0.4
Enhancement of policy and law to support WF initiatives.	Incorporating WF component in Dasar Air Negara (DAN).	Inclusion of VW&WF elements and requirements in the Dasar Air Negara (DAN) by the end of 2022.	• KASA	–
Becoming global champion.	Elevating Malaysia's role as a major player in the global WF initiative.	1. Increasing the number of publications in high impact journals (2022 - 2040). 2. Increasing the number of citations on VW&WF publications (2022 - 2040).	• MOHE • MOSTI	2.5
Establishing WF governance.	Creation of task force and guidelines.	1. WF task force to be established by 2022. 2. Guidelines on WF implementation to be completed by 2024.	• KASA	0.7
Strengthening institutional setup.	Setting up WF centre.	National WF centre will be set up by 2023.	• KASA • MOHE	6.5
Enhancing R&D in WF	Incorporation of WF in NAWABS within the river basin framework.	1. Completion of WF studies for 56 river basins in Malaysia (as listed by DID) by 2040. 2. Guidelines on the involvement of local authorities in WF implementation drafted by 2026.	• DID	1.4
	WF study for selected sectors.	Completion of 20 WF studies of products and services (2023 – 2040).	• EPU	1.5
Mainstreaming WF in businesses.	Establishing requirements for water accounting report.	1. Requirement for water accounting report by industry in 2030. 2. WF elements are incorporated in water accounting reporting by 2030.	• KASA • JSM • MITI • MPC • MAFI	1.0
	Promotion of WF labelling scheme amongst local producers.	The WF labelling scheme will be available by 2024.	• SIRIM	2.0
	Development of WF calculator.	1. WF calculator to be developed by June 2025. 2. Completion of WF database for 26 various products/services (2022 - 2040).	• KASA	1.0
	Incorporation of WF component in ESG initiatives.	1. WF information under water provision in ESG by 2025. 2. Participation of public listed companies in the news.	• Bursa Malaysia	0.1

As knowledge of VW&WF concepts amongst the public is still in its infancy, the 12th MP has the highest number of targets and KPIs to be achieved to kickstart the water sector transformation agenda. A total of eight strategies, 15 targets and 39 KPIs to be conducted by various leading agencies have been outlined to be implemented for the 12th MP with a total budget allocation of RM20.4 million, as shown in Table 9.2. These strategies include enlightening the public, younger generations and industry players on the VW&WF concepts through awareness programmes and knowledge dissemination activities. Enhancing WF competency amongst the water managers is also a central concern for the 12th MP and the enhancement of policy and law that helps to support WF initiatives. Empowering Malaysian WF experts and providing avenues for WF researchers to become global champions in WF are also the key strategies to be achieved under the 12th MP. Besides empowering people, establishing better WF governance should also be done to ensure the WF initiatives could materialise in the country. Apart from that, strengthening institutional setup through establishing a WF centre is also proposed for the 12th MP. In order to get a wider perspective on the WF implementation in the country, enhanced R&D in WF has also been proposed to be materialised under the 12th MP through the incorporation of WF in NAWABS within the river basin framework as well as through conduction of WF study for selected sectors. Finally, it is also suggested that mainstreaming WF in business through requirements of water accounting report by industry and incorporating WF elements in water accounting reporting should also be initiated under the 12th MP. The strategies, targets and KPIs to be achieved for the 13th MP is presented in Table 9.3.

Table 9.3. Strategies, Targets and KPIs for the 13th MP

13th MP				
Strategies	**Targets**	**KPIs**	**Lead Agency**	**Budget Estimated (RM million)**
Mainstreaming WF in businesses.	Strengthening water accounting report.	Water accounting report is fully implemented to major water user industries by 2040.	• KASA • JSM • MITI • MPC • MAFI	0.3
Provision of financial rewards and incentives.	Initiating tax incentives upon completion of water reporting.	Tax incentive programme ready to be implemented by 2027.	• MOF • LHDN	0.5
Strengthening institutional set-up	Establishing a model river basin to fully implement the WF concept.	A pilot project on WF implementation at the river basin scale to be started in 2026 and should be in line with the River Basin Authority (RBA) initiative.	• DID • Water State Authorities	50.0
Continuation of initiatives from the 12th MP				20.8

A total proposed budget of RM71.6 million has been proposed for the activities outlined for the 13th MP, as shown in Table 9.3, with an allocation of RM20.8 million proposed to support the initiatives previously targeted under the 12th MP. Three key strategies have been outlined: continuation of mainstreaming WF in business to be conducted by leading agencies, such as KASA, JSM, MITI, MPC, and MAFI to implement the water accounting report. Another strategy is through the provision of financial rewards and incentives, which will be championed by MOF and LHDN to initiate tax incentives for those who successfully submit the water accounting report. The final strategy under the 13th MP is to strengthen institutional set up by establishing a model river basin that implements the WF concept. The strengthening of institutional setup takes up the most significant budget allocation, with RM50 million allocated to realise this aim. The strategies, targets and KPIs for the 14th MP are outlined in Table 9.4.

Table 9.4. Strategies, Targets and KPIs for the 14th MP

14th MP				
Strategies	**Targets**	**KPIs**	**Lead Agency**	**Budget Estimated**
Becoming global champion.	Positioning Malaysian WF experts at the international platform.	1. MoU on WF collaboration with China, the Netherlands and Germany to be signed by 2033. 2. Framework for benchmarking with global best players to be developed by 2032.	• MITI • MOSTI	1.5
Enhancing global trade.	White paper on VW for the purpose of international trade agreement.	A white paper of VW will be presented in the Malaysian Parliament by 2035.	• MITI • EPU	0.2
	Optimising global water management through VW trade under several trade agreements.	Trade agreement involving VW to be signed with major trade partners under AFTA and TPP members and other trade partners and economic blocks (e.g., EU, North American Free Trade Agreement, and Australia) by 2040.	• MITI • EPU • MFA	1.0
Enhancing R&D in WF.	Enhancing global trade	Studies on global economic opportunities, drivers and impacts of VW to be completed by 2035.	• MITI • EPU	0.2
Continuation of initiatives from the 12th and 13th MPs				38.7

The strategies, targets and KPIs set for the 14th MP has the second-highest budget allocation to implement the water transformation agenda concerning the VW&WF agenda (RM41.6 million). These allocations are proposed to achieve three strategies, four targets and five KPIs. The strategies include positioning Malaysian WF experts to become global champions through collaborations with other countries, enhancing global trade through international trade agreements, enhancing R&D in WF through global trade and conducting studies related to VW&WF concepts. Apart from these strategies, the initiatives outlined in the 12th MP and 13th MP will continue to be carried out with a budget allocation of RM38.7 million. The strategies, targets and KPIs for the 15th MP, which marks the final phase of the water transformation agenda under the WST2040, are highlighted in Table 9.5.

For the final phase of the WST2040, two main strategies, two targets and four KPIs have been outlined for the 15th MP as shown in Table 9.5. The first strategy is to continue the target of becoming a global champion in WF by exporting WF knowledge through the implementation of training modules in selected Asian countries. The second strategy is by enhancing global trade by including VW in the international trade agreement. Amongst the leading agencies proposed to champion these agendas are MITI, EPU and the WF centre (MyWaFA). A total budget of RM3.5 million has been proposed to carry out these strategies under the 15th MP, with RM19.1 million allocated to continue the initiatives proposed for the 12th MP – 14th MP.

Table 9.5. Strategies, Targets and KPIs for the 15th MP

15th MP				
Strategies	**Targets**	**KPIs**	**Lead Agency**	**Budget Estimated**
Becoming global champion.	Exporting WF knowledge.	1. Training module to be accepted and implemented in selected Asian countries, namely Indonesia, Vietnam, and the Philippines (2036 - 2040). 2. Two WF trainings to be conducted in selected Asian countries per year (2036 - 2040).	WF centre (MyWaFA)	2.5
Enhancing global trade.	Inclusion of VW in international trade agreement.	1. VW caucus amongst member countries to be established by 2037. 2. Trade agreement incorporating VW to be signed by 2040.	• MITI • EPU	1.0
Continuation of initiatives from 12th, 13th, and 14th MPs				19.1

Overall, a total budget of RM156.2 million has been proposed to drive Malaysia's VW&WF agenda throughout the 12th MP to 15th MP to realise the national agenda on the WST for 2022–2040. To materialise this aim, several strategies, targets and KPIs have been proposed, each of which requires leading agencies to play their respective roles in transforming the water sector in Malaysia. These strategies have also been aligned with the MPs and addressed the five key focus areas; people, governance, information and RDIC, finance and infrastructure. The final section of the report highlights the outcomes of the VW&WF study and presents recommendations to drive the VW&WF initiatives under the water sector transformation in Malaysia.

10.0 Conclusion and Recommendations

The VW&WF study sets out to quantify Malaysia's VW and establish a WF inventory of the country's three top economic sectors, namely agriculture, manufacturing and services. Therefore, six case studies were conducted to assess the specific industries' WF values under these sectors: palm oil, rubber, paddy, rubber glove, semiconductor and tourism. The calculated WF values ranged from 4,447 to 9,911 m^3/t for crude palm oil, 9,060 to 22,876 m^3/t for rubber and 975 to 2,641 m^3/t for paddy. The WF of synthetic rubber glove ranged from 1.9 to 6.0 $m^3/1000$ pcs for gloves and 1.3 to 3.4 $m^3/1000$ pcs for natural rubber gloves, NAND Flash representing the semiconductor sector was 0.002 m^3/cm^2, while the WF for tourism was 4.89 m^3 (tourist/day).

In realising Malaysia's aim under the 12th MP[14] under Theme 3 – Advancing Sustainability, this study seeks to achieve a more coherent and standardised implementation of policies and governance that can help transform the water sector. This study hopes to raise awareness on the importance of WF accounting

[14] Theme 3 – Advancing Sustainability concerns with advancing green growth and enhancing energy sustainability and transforming the water sector. Two game changers will be implemented under Theme 3; embracing the circular economy and accelerating adoption of the IWRM.

amongst decision decision-makers that may lead to better water allocation and consumption decisions. It is essential to estimate direct and indirect water consumption and water trading within and outside of the country to ensure Malaysia's water resources remain secure and sustainable both in quality and quantity for the sovereignty of future generations and economic growth. This study may help provide inputs towards the improvement of existing policies and the drafting of new ones as well as setting priorities for the years ahead to achieve sustainable and equitable use of the country's water resources. A total budget of RM156.2 million has been proposed to drive the VW&WF in Malaysia (RM20.4 million for the 12th MP, RM71.6 million for the 13th MP, RM41.6 million for the 14th MP and RM22.6 million for the 15th MP), with a readily implementable roadmap for the National Agenda on the WST for 2022–2040. A total of ten strategies, 22 programmes/initiatives and 45 activities have been proposed to drive the water sector transformation, covering five key focus areas; people, governance, information and RDIC, finance and infrastructure with a total of 50 KPIs set out to drive the VW&WF initiatives under the water sector transformation in Malaysia. The following are the overall plans that are recommended to be carried out:

I. Empowering People to Drive Water Sector Transformation

Under this focus area, a total of 21 KPIs have been outlined to empower three main target groups: the public, younger generations and industry players. Some of the activities proposed to empower the public are awareness programmes through roadshows that will be initiated starting from 2022. Empowerment through reading materials will also be planned through article publications on WF in popular media targeting the general public, especially during special events, such as the National Environment Day. Joint programmes with IHP-UNESCO and DID incorporating WF elements will also be initiated starting from 2023. Social media platforms and mass media will also be utilised to educate the public on WF through daily postings on WF-related content starting from 2022. In addition, weekly content will also be posted on dedicated YouTube channels starting 2022. Biennial WF workshops will also be organised beginning 2023. Apart from that, awareness programmes will also be conducted for members of parliament and state assemblymen every two years starting from 2024. Besides, the public will also be educated on making a better decision to opt for local food over imported food. This will be done by providing them with a list of alternative local food with low WF to replace imported food starting from 2023. An online customised WF calculator will be made available for local use starting from 2023.

At Malaysian schools and universities, the WF-related concept will be incorporated through the environmental clubs by 2025. The required content and materials for WF-related activities to educate the younger generations at schools and universities will be uploaded daily on social media platforms starting from 2022 and fully developed by 2024. More significant projects will also be planned, such as conducting competition programmes every year on WF-related themes during the National Science Week. Publications on WF will also be made available to the younger generations, particularly through popular media during special events, such as the World Water Day. In conjunction with special events, such as the World Water Day, awareness programmes will also gauge their interests. Other activities include incorporating WF elements through joint activity with GEC using the DRH20 kit (water-saving kits, checklist, water audit, water conservation module).

To increase awareness amongst industry players, several KPIs have been devised. One of the proposed activities is to enhance WF competency through accredited WF assessment training modules for industry players. The training modules would be ready to be utilised by the end of 2022. Accredited WF auditing training modules for auditors are also expected to be ready by June 2023. To empower industry leaders in incorporating WF accounting, the database of industry and WF association is also projected to be established by 2023, with an additional economic module for the economic return framework expected to be developed by 2025. Finally, to get stronger buy-ins from industry players, elements of WF will also be included in prestigious awards, such as the Prime Minister's Hibiscus Award by 2025.

II. Strengthening Governance of Water Sector at All Governmental Levels

The second focus area relates to concerted efforts to strengthen the governance of the water sector at all governmental levels. To initiate this plan, enhancement of policy and law to support WF initiatives are proposed by including VW&WF elements and requirements in the Dasar Air Negara (DAN) by the end of 2022. Mainstreaming WF in business will also be conducted through the requirement of the water accounting report by industry in 2030. Therefore, WF elements will be incorporated in the water accounting reporting by 2030 and will be fully implemented in major water user industries by 2040. Besides, the WF labelling scheme will be available by 2024 through this strategy. Also, the WF calculator will be developed by June 2025 with the completion of the WF database of 26 various products and services by 2040. Several KPIs have been outlined to establish Malaysia as a global champion in WF. These include signing MoU on WF collaboration with key global WF players, such as China, the Netherlands and Germany by 2033. A framework for benchmarking Malaysia with the rest of the global players will also be developed by 2032. In elevating Malaysia's role as a major player in the global WF initiative, the increment in the number of publications in high impact journals and citation on VW&WF publications are targeted by 2040. Furthermore, Malaysia needs to develop training modules that are accepted and ready to be implemented in selected Asian countries, including Indonesia, Vietnam and the Philippines, starting from 2036 to 2040, with two WF training proposed to be conducted in selected Asian countries yearly in order to export WF knowledge.

Another KPI that need to be achieved are establishing the WF task force by 2022 with complete guidelines of WF implementation by 2024 as part of the strategy in establishing WF governance. To enhance global trade, several KPIs have been outlined. First is drafting a white paper on VW, which will be presented in the Malaysian Parliament by 2035. Second is by formulating terms and conditions on VW for mutual trade in which a trade agreement can be signed and established involving VW with major trade partners under AFTA and TPP members as well as other trade partners and economic blocks, including the EU, North American Free Trade Agreement and Australia by 2040. In addition, a VW caucus amongst member countries should also be established by 2037 and the trade agreement incorporating VW to be signed by 2040. To enhance WF competency, the KPIs targeted are to have the WF competency programmes ready for implementation by 2023 and to train 100 water managers per year starting in 2023. Finally, in this focus area, a pilot project on WF implementation at the river basin scale should be started in 2026 and should be in line with the River Basin Authority (RBA) initiative to strengthen institutional setup.

III. Strengthening Financial Capability to Support Water Sector Transformation

The next focus area addresses strategies to strengthen the financial capability to support water sector transformation. Under this area, three KPIs have been outlined. The first KPI is through the provision of financial rewards and incentives, whereby tax incentives programmes should be ready to be implemented by 2027. Mainstreaming WF in businesses should also be conducted in which WF information under the water provision in ESG should be incorporated by 2025 as well as through participation of public listed companies in the new provision of ESG by 20% in 2040.

IV. Enhancing Data-Driven Decision-Making for Sustainability

Another focus area is the enhancement of data-driven decision-making for sustainability. Under this focus area, the inclusion of WF in NAWABS should be conducted within the river basin framework with the completion of WF studies for 56 river basins in Malaysia (as listed by DID) by 2040. In addition, a guideline on the involvement of local authorities in WF implementation should also be drafted by 2026. While the VW&WF study provided case studies for six sectors, another WF study should also be conducted for selected sectors, including the completion of 20 WF studies of selected products and services from 2023 to 2040. Finally, enhancement of global trade can also be done through comprehensive studies on global economic opportunities, drivers and impacts of VW, which should be completed by 2035.

V. Developing Sustainable Water Infrastructure with Cost-effective Technology

The final focus area highlighted in this study looks into developing sustainable water infrastructure with cost-effective technology. Under this area, one KPI has been outlined to strengthen institutional set-up: establishing a national WF centre that is proposed to be ready by 2023. The setting up of the WF centre may help water professionals to orchestrate a more systematic way of delivering and achieving the WST targets outlined throughout this study.

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