PRIME MINISTER'S DEPARTMENT
ECONOMIC PLANNING UNIT

AKADEMI SAINS MALAYSIA

WST 2040

WATER SECTOR TRANSFORMATION

IR4.0 IN THE VARIOUS WATER SUB-SECTORS (IR4.0WS)

(VOLUME IV)

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WATER SECTOR TRANSFORMATION 2040

SUB-SECTORAL FINAL REPORT

IR 4.0 IN THE VARIOUS WATER SUB-SECTORS (IR4.0WS)

(VOLUME IV)

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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 4, "IR 4.0 in the Various Water Sub-sector (IR 4.0WS)", forms part of 9 compendia of reports. Volume 1, which is the Main Report, has summarised the output of Volume 2 to Volume 9. The details in Volume 1, can be found in each of the eight standalone reports.

The emphasis in all these reports is to achieve a secure, sustainable, and vibrant water industry in Malaysia, while forging it into a dynamic, efficient, sustainable, and revenue-generating industry. If the recommendations are implemented, the study will contribute significantly to the national gross domestic product (GDP), create new job opportunities and facilitates the development of science, technology, innovation and economy (STIE). It will 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 and four phases of four five-year Malaysia Plans(MP), starting with the Twelfth Malaysia Plan (12th MP).

The IR 4.0WS study aims to promote integrated, data-driven, and transparent water planning and decision-making, leveraging on big-data analytics, artificial intelligence (AI), IR 4.0 and Research Development and Innovation Centre (RDIC). The data-based evidence shall envision a consistent and high-quality data production for the successful implementation of the integrated water resources management (IWRM) by operationalising of the integrated river basin management (IRBM). The IR 4.0 approach should be used as a strong basis for all aspects of water management, including flood, drought and disaster management support systems, which is a strategic framework that utilises the findings of this study towards realisation of IR 4.0WS in the water sub-sectors.

To achieve this ambition, we have partnered with expert advisors and researchers from multiple organisations led by the Malaysian Water Association (MWA). Leveraging on their knowledge and expertise, to produce outputs and recommendations that, will be a step forward for Malaysia. On behalf of ASM, I would like to take this opportunity to thank the IR 4.0WS team, headed by Datuk Ir. Abdul Kadir Mohd Din 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

The rise of digital water as a transformational pathway for the water sector is undeniably necessary for Malaysia to overcome the declining water quality, and excessive floods occurrence. While Malaysia is fast embracing digital transformation in various sectors, the digitalisation and automation journey for water sub-sectors shall soon push businesses to the forefront of our industrialised world, and set to fast-track the transformation of the sector by contributing to digital economy – allowing us to work smarter, optimising work streams and enabling growth. The transformation road map for the Water Sector Transformation 2040 (WST2040) shall be conducted in four phases, focusing on accelerating the IWRM implementation, water technology innovation, achieving economics of scale and becoming a regional water hub. Strategies and business models of pioneering countries in IR 4.0 implementation, such as Japan, South Korea, Singapore and Germany, have been adopted as the basis for developing a clear framework for change in digitalising the water sector in Malaysia.

In addition, a consolidated matrix highlighting the adoption of "must have, should have and nice-to-have" elements by relevant stakeholders shall support the expected requirements towards a successful IR 4.0 implementation by the water sub-sectors. Langkawi Island was chosen to depict the IT architecture in reflecting the proposed IR4.0 simulation. The existing policies concerning IR 4.0 for water sub-sectors shall be made adaptable to accommodate transformations which aspires to develop an integrated system framework that combines the virtual networking of all supply chain, operators, and end-users of the water sectors.

The policy, despite its focus on transforming the Malaysian manufacturing industry and its related services to be smart, systematic, and resilient, may be used as a guideline to nurture benchmarking criteria for localised water sector transformation agenda. The absence of an international benchmarking criteria for IR 4.0 in the water sub-sectors provides a remarkable opportunity for Malaysia to develop its own standard referencing based on the localised scenario that is of international applicability. Therefore, Malaysia has the opportunity to pioneer the (WST2040) agenda towards the digitalisation of the water sector.

Datuk Ir. Abdul Kadir Mohd Din FASc
Chairperson
IR 4.0 in the Various Water Sub-sectors (IR 4.0WS)

ACRONYMS

IR 4.0	Industrial Revolution 4.0
8i	8i - Internationalisation; Interaction; Institution; Incentives; Infrastructure; Infostructure; Intellectual capital; Integrity
AACB	Advocay, Awareness, Capacity Building
AGC	Attorney General Chamber
AI	Artificial Intelligence
AKSB	Air Kelantan Sdn Bhd
API	Application Programming Interface
AWG	Air Water Generator
BAKAJ	Badan Kawalselia Air Negeri Johor
BBA	Bahagian Bekalan Air
BDA	Big Data Analytics
BI	Business Intelligence
BKSAN	Badan Kawal Selia Air Negeri
BOMBA	Jabatan Bomba dan Penyelamat Malaysia
BPSA	Bahagian Pengairan dan Saliran
CAT	Category
CAT-M1	Category M1
CERT	Computer Emergency Response Teams
CIDB	Construction Industry Board Malaysia
CNII	Critical National Information Infrastructure
COE	Centres of Excellence
CPS	Cyber-Physical Systems
CSIRT	Computer Security Incident Response Team
DID	Department of Irrigation and Drainage
DIPAN	Data Industri Perkhidmatan Air Negara
DLT	Blockchain and distributed ledger technology
DOA	Department of Agriculture
DOE	Department of Environment
DOSM	Department of Statistics Malaysia
DRR	Disaster Reduction
EC	Energy Commission
E-GAN	Evolutionary Generative Adversarial Networks
EoS	Economies of Scale
EQMP	Environmental Quality Monitoring Program
FDS	Forestry Department Sarawak
FGD	Focus Group Discussion
FOIE	Freedom of Information Enactments
FOMCA	Federation of Malaysian Consumer Association
GDP	Gross Domestic Product
GERD	Gross Expenditure on Research & Development
GIS	Geographic Information System
GroW	Big Data Analytics Groundwater

GWP	German Water Partnership
ICT	Information Communications Technology
IoT	Internet of Things
IPTA	Institut Pengajian Tinggi Awam
IPTS	Institut Pengajian Tinggi Swasta
IRBM	Integrated River Basin Management
IT	Information Technology
IWA	International Water Association
IWK	Indak Water Konsortium
IWRM	Integrated Water Resource Management
IWSDC	Integrated Water Sector Data Centre
JANS	Jabatan Air Negeri Sabah
JAS	Jabatan Alam Sekitar
JBALB	Jabatan Bekalan Air Luar Bandar
JBANT	Jabatan Bekalan Air Negeri Terengganu
JKR	Jabatan Kerja Raya
JMG	Jabatan Mineral dan Geosains Malaysia
JPM	Jabatan Perdana Menteri
JPP	Jabatan Perkhidmatan Pembetungan
JPS	Jabatan Pengairan dan Saliran
JPSM	Jabatan Perhutanan Semenanjung Malaysia
JUPEM	Jabatan Ukur dan Pemetaan Malaysia
KADA	Lembaga Kemajuan Pertanian Kemubu
KASA	Kementerian Alam Sekitar dan Air
KDN	Keselamatan Dalam Negara
KEDA	Lembaga Kemajuan Wilayah Kedah
KeTSA	Kementerian Tenaga dan Sumber Asli
KPI	Key Performance Indicator
KPKT	Kementerian Perumahan dan Kerajaan Tempatan
KPLB	Kementerian Pembangunan Luar Bandar
LADA	Langkawi Development Authority
LTE-M	Long Term Evolution for Machine
LUAS	Lembaga Urus Air Selangor
MADA	Muda Agricultural Development Authority
MAFI	Ministry of Agriculture and Food Industries
MaGIC	Malaysian Global Innovation & Creativity Centre
MAMPU	Malaysian Administrative Modernisation and Management Planning Unit
MARDI	Malaysian Agricultural Research & Development Institute
MBOT	Malaysia Board of Technologists
MBSA	Majlis Biodiversiti & Sumber Air Sabah
MCMC	Malaysian Communications and Multimedia Commission
MDEC	Malaysia Digital Economy Corporation
MDM	Master Data Management
MEIO	Malaysian External Intelligence Organisation
MetMalaysia	Metereologi Malaysia

MGTC	Malaysia Green Technology Centre
MICC	Ministry of Information, Communication and Culture
MINDEF (CDOC)	Ministry of Defence Malaysia (Cyber Defence Operation Center)
MITI	Ministry of International Trade and Industry
MKN	Majlis Keselamatan Negara
MNC	Multinational Companies
MOFA	Ministry of Foreign Affairs
MOH	Ministry of Health
MOSTI	Ministry of Science, Technology and Innovation of the government of Malaysia
MOU	Ministry of Utility
MP	Malaysia Plan
MPC	Malaysia Productivity Corporation
MQA	Malaysian Qualifications Agency
MTDC	Malaysian Technology Development Corporation
MyCERT	Malaysian Computer Emergency Response Teams
MyGDI	Malaysia Geospatial Data Infrastructure
MYSA	Malaysian Space Agency
MyWAC	Malaysian Water Engineers Action Committee
MyWI	Malaysian Wellbeing Index
NADMA	National Disaster Management Agency
NaFFWS	National Flood Forecasting and Warning System
NAHRIM	National Hydraulic Research Institute of Malaysia
NALIS	National Library and Information System Authority
NAWABS	National Water Balance Management System
NawDac	National Water Data Centre
NB-IoT	Narrowband Internet of Things
NCSP	National Cyber Security Partnership
NRE	Ministry of Energy and Natural Resoures
NRW	Non-Revenue Water
NWRP	National Water Resources Policy
ODA	Official Development Assistance
OSA	Official Secrets Act
PAAB	Pengurusan Aset Air Berhad
PAIP	Pengurusan Air Paip Pahang
PBAPP	Perbadanan Bekalan Air Pulau Pinang
PDPA	People's Data Protection Act
PoI	Point of Interest
PRABN	Pusat Ramalan dan Amaran Banjir Negara
R&D	Research & Development
RDIC	Research Development and Innovation Centre
RISDA	Rubber Industry Smallholders Development Authority
ROI	Return on Investment
RTSP	Rancangan Tempatan Seberang Perai
RWH	Regional Water Hub
SADA	Syarikat Air Darul Aman Sdn Bhd
SFD	Sabah Forestry Department

SME	Small Medium Enterprises
SPAN	Suruhanjaya Perkhidmatan Air Negara
SPRM	Suruhanjaya Pencegahan Rasuah Malaysia
SPV 2030	Shared Prosperity Vision 2030
SSL	Self-sufficient Service Level
ST	Suruhanjaya Tenaga
STA	Strategic Trade Act
STEM	Science, Technology, Engineering and Mathematics
SWB	Sarawak Water Board
TNB	Tenaga National Berhad
UKAS	Unit Kerjasama Awam Swasta
UPEN	Unit Perancan Ekonomi Negeri
VAICE	Vertical Artificial Intelligence Centre of Excellence
VR/AR	Virtual Reality/ Augmented Reality
WST2040	Water Sector Transformation 2040
WTI	Water Technology Innovation

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ILLUSTRATIONS- BOXES, FIGURES, AND TABLES

APPENDICES

EXECUTIVE SUMMARY

As Malaysia faces mounting water tensions with some areas exposed to vulnerable scarcity, declining water quality, and excessive floods, this study aims to investigate the potential rise of digital water as a transformational pathway to make the sector more resilient to its customer, while fuelling the economic development simultaneously. In a nutshell, businesses may reduce operational cost as IR 4.0 emphasises on streamlining overall business operations by minimising wastage or storage, enhancing supervisory processes and maintenance of machinery, while instilling streamlined security and safety efficiencies in water sub-sectors concurrently. While Malaysia is fast embracing digital transformation in various sectors, the digitalisation and automation journey for water sub-sectors shall soon push businesses to the forefront of our industrialised world, and set to fast-track the transformation of the sector by contributing to digital economy - allowing us to work smarter, optimising work streams and enabling growth. The strategies and business models of countries such as Japan, South Korea, Singapore and Germany have been discussed through organised webinars, signifying a clear framework for the expansion of digital water in Malaysia. For example, Japan is known for its strong ICT capabilities which comprise high-speed Internet infrastructure with 5G deployment. The strong R&D culture in Japan is allowing competitive experimental research via collaboration with universities while allocating a large proportion of gross expenditure on R&D (GERD) by the business sector.

Some data insights were accumulated from the IR 4.0 Readiness Survey targeted to water stakeholders and IR 4.0 Consumer Survey, comprising water, water resource and wastewater, respectively (Appendix S). Based on the overall responses of the IR 4.0 Readiness Survey targeted to water stakeholders, approximately 52% of respondents have not deployed any of the IR 4.0 approaches indicative of 84% respondents having no benchmarking on any global implementation for IR 4.0 in their business. When asked if they are planning to invest in IR 4.0 technologies, 56% stated that they would invest only if it were necessary for the business.

In the next few years, the water sector in Malaysia will continue to embrace and adopt new technologies to help increase visibility in both of the raw production lines and to streamline operational processes. The data matrices presented in this report highly encourage the adoption of "must have, should have and nice-to-have" elements by relevant stakeholders to support the expected requirements towards a successful implementation of IR 4.0 by the water sub-sectors. The consolidated matrix shall be used as development tools for the development of the IT architecture and the works phasing as well as the required budget for IR 4.0 implementation. In this study, the Langkawi Model was chosen to depict the IT architecture, reflecting on the proposed IR 4.0 simulation for the water sub-sectors. In addition, the proposed strategies for sustainability enabler consisted of two key recommendations applicable for the water sector, i.e. reviewing environmental laws and legislation by considering current issues and future challenges and maximising resource utilisation efficiency towards transforming waste production through the concept of circular economy. The embedded circular economy concept will be able to value the operation and income generated from cradle to cradle and waste to wealth.

This study also investigated the existing policies concerning IR 4.0 for water sub-sectors. Thus far, the Industry 4.0 policy addresses many issues concerning manufacturing with regard to hazardous environments, health and safety of human labour, efficiency in managing supply chains, reduction of wastages and savings in time with efficient management of delivery systems, whereby water and

wastewater management are not mentioned as key priorities in the policy document. The policy, despite its main focus on transforming the Malaysian manufacturing industry and its related services to be smart, systematic and resilient may be used as a guideline to nurture benchmarking criteria for localised water sector transformation agenda. In line with the government's direction, the IR 4.0 for water sub-sectors under the (WST2040) study aspires to develop an integrated system framework that combines the virtual networking all supply chains, operators, and end-users of the water sector. The system is expected to be resilient, sustainable, resourceful and user-friendly. The water sector transformation may be achieved through the interaction and resulting convergence of technologies as outlined in the policy, including big data analytics, artificial intelligence, augmented reality, cybersecurity, autonomous robots, cloud computing and the Internet of Things.

Surveys, focus group discussions and workshops which is planned throughout this study would give an understanding of the breadth and depth of the national water sectors in comparison with global standard. Therefore, benchmarking is crucial in establishing appropriate national target based on local ecosystem, talent pool, and sentiment. The virtual workshop and webinars, which were conducted albeit the crucial pandemic, has given a thorough overview on the lack of clear benchmarking criteria to ensure successful implementation of the IR 4.0 for water sub-sectors. The absence of an international benchmarking criteria for IR 4.0 in water sub-sectors, has certainly presented a remarkable opportunity for Malaysia to develop its own standard referencing based on the localised scenario that is of international applicability. Therefore, Malaysia has the opportunity to spearhead the development of these criteria for water sub-sectors leveraging on the (WST2040) agenda which shall include elimination of silo management through data integration.

1.0 Background/ Introduction of Sub-Sectoral Study

Water services infrastructure may still be improved particularly in rural areas and islands, whereby technology adoption is lacking in increasing operational efficiency and fulfilling demand, and thus jeopardising socio-economic growth. In addition, the high non-revenue water (NRW) losses continue to increase mainly due to leakages from the ageing infrastructure, such as pipes and connections coupled with the lack of asset management, establishing an exact location in particular underground pipes. The existing water and sewerage infrastructure, including the irrigation systems, are also underutilised and some are not fully optimised. Generally, infrastructure for resource recovery of water and wastewater treatment by-products is also not ready to support the waste-to-wealth initiatives. The water sector also has not fully leveraged on technological evolutions, which are crucial to efficiently manage water resources and usage. Due to high consumption of water and poor public awareness creation programme and implementation, river pollution threats demand increased attention which subsequently result in a higher cost for raw water services and maintenance.

The availability of water resources continues to be threatened mainly by non-proper land use and climate change. This is coupled with the lack of optimisation of alternative water resources, such as groundwater, lakes and flood ponds, recycled water, rainwater harvesting, air water generators and desalination particularly in water stress areas. Water-related disasters are becoming more intensified and further exacerbated due to the reactive approach in solving the problem.

The proposed strategies for sustainability enabler consisted of two key recommendations applicable for the water sector, i.e. reviewing environmental laws and legislation by considering current issues and future challenges and maximising resource utilisation efficiency through zero waste management concept by adapting the principles of circular economy. As stated in the 12th MP (2021-2025), Chapter 9 on Enhancing Energy Sustainability and Transforming the Water Sector, the circular economy concept will be implemented in the entire water sector value chain, whereby enabling policies and legislations shall be introduced to govern the ecosystem for the circular economy.

The rise of digital water has previously been documented by the International Water Association (IWA), an organisation with membership in 140 countries worldwide. Forming the largest international network of water professionals and aiming towards a water-wise world, IWA discovered the promising opportunity for digital water technologies for water professionals in emerging economies. For example, dynamic and data-driven models may help integrate and optimise smart pumps, valves, sensors and actuators, whereby real-time information may be shared with customers via their smartphones (The Source, 2018). IWA has also published its policy on Digital Water in 2018.

(*Source*: https://iwa-network.org/publications/digital-water/)

As Malaysia faces mounting water tensions with some areas exposed to vulnerable scarcity, declining water quality, and excessive floods, this study investigated the potential rise of digital water as a transformational pathway in making the sector more resilient to its customer, while simultaneously fuel the economic development. This agrees with the aspirations put forward in the 12th MP (2021-2025), whereas the water sector will be restructured to enable it to be a significant contributor to national growth and wealth creation through a twenty-year transformation agenda. The (WST2040) will be developed to set the strategic direction towards positioning the sector as a dynamic growth engine, while ensuring water security for all. By 2040, it is envisaged that Malaysia will become the regional water industry hub.

2.0 Objectives of Sub-Sectoral Study

This study aims to promote integrated, data-driven, and transparent water planning and decision-making, leveraging on big-data analytics, artificial intelligence (AI), IR 4.0 and research development and innovation centre (RDIC). Considering existing challenges, the evidence-based data would be the basis for decision-making under the 12th MP. An integrated database with consistent and high-quality data will provide a stronger basis for the integrated water resource management (IWRM) implementation through operationalising of integrated river basin management (IRBM), considering water-food-energy nexus for future demand of water resources. In addition to data and information collection, in the long-term, this would also be catalyst for national data and technology development ownership line with the IR 4.0 and big data analytics for all aspects of water management, including flood, drought and disaster management support systems.

These aspirations will be realised through the following objectives:

i. To examine the current and past trends of the development of digital water and IR 4.0 initiatives for the water sub-sectors in Malaysia
ii. To set the bench marking and assess the current status of our Malaysia water sector digital water as compared to the developed countries
iii. To identify new potential models to be developed to enhance national development and global competitiveness via adoption of IR 4.0 technologies
iv. To help put in plans for research and development for potential IR 4.0 models
v. To prepare a strategic framework which utilises the findings of this study towards realisation of IR 4.0, big data analytics, AI and RDIC for the water sub-sectors

3.0 Scope of the Sub-Sectoral Study according to the Terms of Reference and with reference to the relevant Study's 8 Foci

The scope of the study according to the terms of reference covers:

i. Undertaking comprehensive reviews and analyses on current policies, literature and expert reports which are related to IR 4.0 in the water sector with a view for improvement;
ii. Undertaking comparative strategy analyses or business models or case study, benchmarking and best practices with other nations
iii. 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
iv. Preparation of a transformation strategy and initiative implementation framework based on secondary data collection from relevant agencies and stakeholders
v. Undertaking consultations with stakeholders and experts with the aim of finalising the proposed strategies and initiatives of Malaysia's IR4.0 initiatives
vi. Preparation of a road map on the National Agenda for the Water Sector Transformation towards achieving the targeted transformation objectives for IR 4.0 in the various water sub-sectors

The scope of the study according to the reference of the relevant 8i STI Ecosystem Enablers are as follows:

i. Infrastructure (Physical & Natural) – Quality and sophistication of the infrastructure that supports the growth and development of industry and the broader economy
ii. Infostructure (Digital Infrastructure) – Digital infrastructure that provides seamless integration of multiple value chains within and across the industries and communities. These systems provide seamless flow of information for market intelligence and strategic decision-making
iii. Intellectual Capital (Talent Stock) – Skills (technical, entrepreneurial and leadership) and knowledge (general and specialised) of the talent stock
iv. Integrity (Good Governance) – Governance systems to manage processes and ensure commitment to continuous improvements and adherence to best practices
v. Incentives (fiscal and non-fiscal) – Incentives to encourage R&D, adoption of new technologies, innovation, commercialisation of local technology, and market expansion, including globalisation of local technology
vi. Institutions (Governance Bodies) – Quality of the institutions of governance (i.e., regulatory bodies, industry associations, institutions of learning / research institutes etc.) that support systematic development of markets, industries, and communities
vii. Interaction (Strategic partnerships) – Level and quality of collaboration, co-creation and knowledge sharing amongst stakeholders
viii. Internationalisation (Global Best Practices and Standards) – Depth and breadth of engagement with global knowledge and innovation networks, institutions of governance and global supply chains

4.0 Sub-sectoral Study Process and impacts, if any, from COVID-19 Pandemic

As the impacts of the novel coronavirus (COVID-19) pandemic continue to expand, the sub-sectoral study on IR 4.0 was struggling with the methodologies of study. Delays were prominent in getting responses from stakeholders as physical workshops were cancelled at final minute due to movement restriction order (MCO) nationwide. Nevertheless, the taskforce team managed to organise several virtual webinars and a virtual workshop with participations from stakeholders. There were some loss in efficiencies as well as in terms of processing of data obtained from the virtual sessions, whereby discussions had to be conducted to ensure that gaps in information gathered were minimised. Cost impacts were significant, whereby costs allocated for workshops and focused group discussion (FGD) were altered to cater for virtual engagements. Other limitations identified as impacting the study process are as follows:

i. Relatively slow adaptability to new norm by those who are less IT-savvy which may have hindered smooth communication and discussion. A new set of virtual culture may be required as pre-requisite factors to allow a more conducive discussion platform.
ii. Additional presentation materials or visual aids/ notes have become inevitable, failing which the team may run into risk of losing interest amongst virtual participants. Effective preparation other than the core topic of discussion may be required to maintain the momentum of online discussion. This required additional time and endurance of the organising team.

iii. The quality of online data collected/gathered via online platform was very much dependent on close monitoring and stringent quality control, failing which may lead to misinterpretation and poor decision-making. Assurance of good quality of data, demanded more time and increased the number of discussion and unplanned meetings required, as well as appreciable level of computer skills.

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

5.1 Scope 1: Review and Analyse Current Policies with a View to Improvement

The first industrial revolution started with the introduction of steam and waterpower, which brings radical changes in manufacturing capabilities and complexity of production processes.

Figure 1 shows a comparison of important industrial revolution developments in various industries and in water management. With regard to the classification of developmental advances in water management; however, there are different possible interpretations and chronological spans from the First Revolution in Water Management until the Fourth Revolution in Water Management.

Based on Figure 1, an important feature of the fourth development stage in both industry and water sub-sectors was the merging of real and virtual worlds into cyber-physical systems (CPS). According to Poljak (2018), this fourth stage describes the linking of sensors, computer models, and a real-time controller with real water systems, with heavy usage of intelligent networks. Cross-sectional technologies allow a holistic consideration of water, regardless of whether it is falling as precipitation, being pumped through a network for supplying drinking water, or being transported to a wastewater treatment plant through a network of channels, whereby it is purified and then reused for irrigation, if applicable, or used in an industrial process as a solvent or cleaning agent or for cooling and heating. These are not stand-alone technologies. Rather, the fourth stage combines processes, measures, and technologies into an Internet-based unit and include classic, tried-and-tested methods as well as new, innovative approaches which reaches the end user such as smart sensoring.

The National Policy on IR 4.0, the Industry Forward, which was published in 2018 by the Ministry of International Trade and Industry (MITI), reflected the Malaysian Government's initiative to stay relevant with the global transformation by utilising IR 4.0. Although the policy is designed to cater for the manufacturing sectors and its related services, it is undeniable that the framework is applicable to other sectors, provided that they define and design their own priorities and action plans. Thus far, the National Policy on IR 4.0 addresses many issues concerning manufacturing with regard to hazardous environments, health and safety of human labour, efficiency in managing supply chains, reduction of wastages and savings in time with efficient management of delivery systems, whereby water and wastewater management are not mentioned as key priorities in the policy document. The policy, despite its main focus on transforming the Malaysian manufacturing industry and its related services to be smart, systematic and resilient may be used as a guideline to nurture benchmarking criteria for localised water sector transformation agenda. In line with the government's direction, the IR 4.0 for water sub-sectors

under the (WST2040) study, aspires to develop an integrated system framework that combines the virtual networking all supply chain, operators, and end users of water sectors. The system is expected to be resilient, sustainable, resourceful and user-friendly. The water sector transformation may be achieved through the interaction and resulting convergence of technologies as outlined in the policy, including big data analytics, artificial intelligence, augmented reality, cybersecurity, autonomous robots, cloud computing and Internet of Things.

Therefore, benchmarking, is crucial in establishing appropriate national target based on local ecosystem, talent pool, and sentiment. Poljak (2018) further defined the concept of IR 4.0 as *"a strategic approach to the integration of advanced internet-based control systems that allow people and machines to connect at anytime, anywhere, with anyone and anything in the unique complex system"*. The fourth industrial revolution, driven by the intense development of IT technologies and telecommunications, was promoted in 2011 at the Hannover Industry and Technology Fair. The policy on Water 4.0 was coined from the Industry 4.0 paradigm shift by the German Water Partnership (GWP) in 2016; and the birth of WATER 4.0 is expected to champion the digital revolution in the water industry (Bufler et al., 2019).

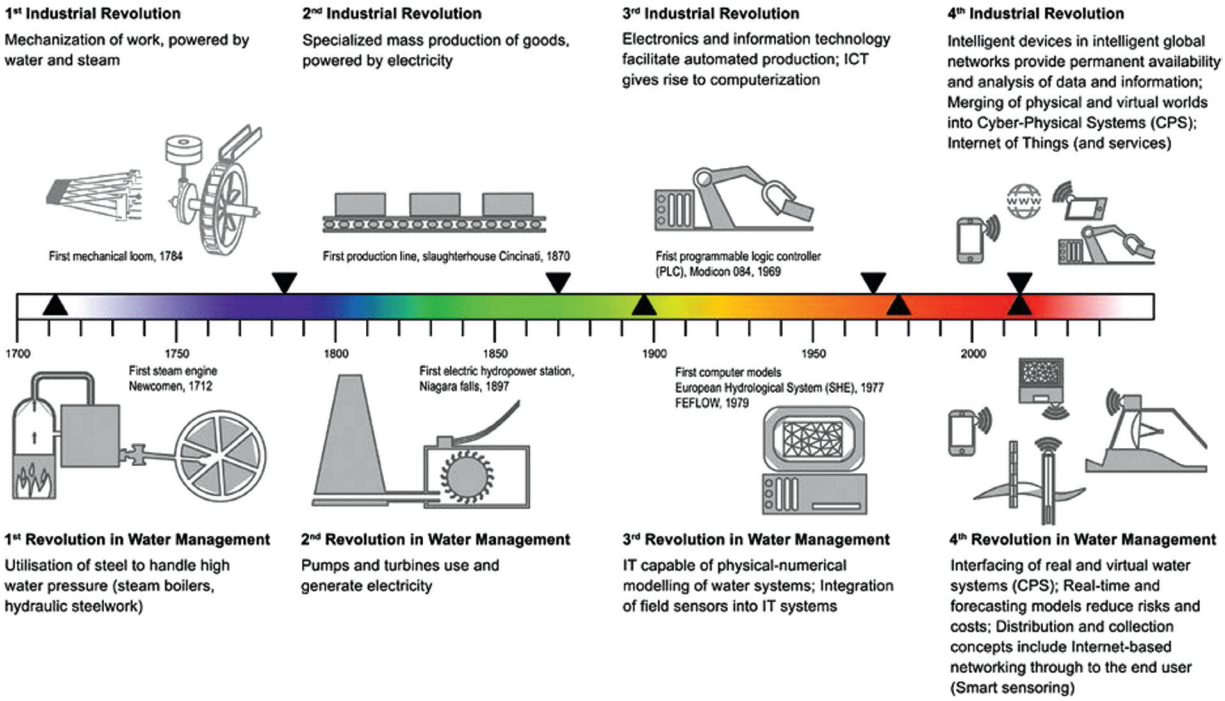

Figure 1: Comparison of important developments in industry and in water management

(*Source*: Poljak, 2018)

The document WATER 4.0 by GWP outlines a holistic approach which lives on and evaluates digital data and inputs into forecasting data from various technical areas, and thus allowing a holistic consideration and sustainable decisions. According to GWP, WATER 4.0 functions does not remain static "in the now". Rather, it follows technical developments and uses the new capabilities that are provided within the systemic environment of the sector. The approach lives on the effect of the entire system and the comparison between virtual and real water systems and less on innovative individual elements. The Box Article 1 illustrates GWP's understanding of Water 4.0.

Box Article 1: WATER 4.0 puts digitisation and automation at the centre of a strategy for resource-efficient, flexible and competitive water management. In doing this, WATER 4.0 incorporates the same main features and terms of the industrial revolution INDUSTRY 4.0, such as "networking of machines, processes, storage systems and resources", "smart grids", "Internet of Things and Services", and bringing them together in a systemic, water management context. In the implementation of WATER 4.0, cyber physical systems (CPS) are drivers of the optimal networking of virtual and real water systems, with planning, construction and operation being largely done by software. This allows the intelligent networking of water users (agriculture, industry, and households) and components in a sustainable water infrastructure with the environment and the water circuit and follows a holistic approach along the value-added chain. Furthermore, WATER 4.0 allows a high degree of transparency for water users, thus covering current needs, and provides opportunities for sustainable, creative activity. areas in water management.

5.1.1 Current Policies Reviewed and Analysed

5.1.1.1 Review on Cybersecurity Guidelines Industry 4.0

Malaysia's development is information and technology-driven. The economy is also knowledge dependent (Abdullah et al., 2018). The launch of Vision 2020 marked the start of the knowledge-based economy in Malaysia (Ariffin, & Letchumanan, 2020). This required a widespread use of information, communication and technology amongst private and public sectors in Malaysia (Abdullah et al., 2018). With an increase in the amount of information being shared over the Internet, the industries became vulnerable to cybersecurity; hence, the need to develop a policy that would help the industries against some of the cybersecurity issues, including intrusion, hacking, harassment, fraud, denial of service attacks and malicious code (Teoh & Mahmood, 2017). This paper reviews Cybersecurity Guidelines for IR4.0 that serves as a reference for manufacturing companies in Malaysia that are moving towards the Industry 4.0 revolution.

The Ministry of Science, Technology and Innovation (MOSTI) of the Malaysian Government conducted a study in 2005 with the aim of developing a cybersecurity policy that would be used in addressing the cyber security challenges that were facing the country; hence, threatening the country's e-sovereignty (Ariffin, & Letchumanan, 2020). The study assessed the prevailing cybersecurity risks situation within the critical national information infrastructure sectors (Teoh, & Mahmood, 2017). The study also ensured that the critical infrastructure was protected to levels that commensurate the risks faced, as well as developed and established a comprehensive action plans and road maps that were to be used to implement the cybersecurity framework. The study results were presented and adopted by the National Information Technology Council on 7 April 2006. This was preceded by the development of the National Cyber Security Guidelines Industry 4.0 (Abdullah et al., 2018).

There are 10 sectors in Malaysia that were considered as the critical national information infrastructure. These include banking and finance, national defense and security, energy, information and communication, water, transportation, government, health services, food & agriculture and emergency services (Ariffin, & Letchumanan, 2020).

The National Cyber Security Guidelines Industry 4.0 was implemented in three phases. The first phase addresses the immediate measures and concerns that were to be taken to implement cybersecurity immediately (Ariffin, & Letchumanan, 2020). These measures include identification of stop-gap measure,s addressing the underlying vulnerabilities of the CNII information security. The second phase concentrates on infrastructure building that is needed for cybersecurity. It also includes the setting up of necessary

processes, systems, mechanisms and standards (Abdullah et al., 2018). The third phase focuses on maintenance of efforts that were presented in the other two phases (Hamzah et al., 2018).

The policy governance structure involved an establishment of the National Cyber Security Coordination Committee, which consisted of the senior security officials from the sectors that were entrusted with the country's CNII operation (Tan et al., 2020). However, the duties of cybersecurity governance were placed under the national security council after the amendment of the duties of theministers. However, the secretariat is controlled by the Cybersecurity Malaysia, coordinating the efforts of NCSP implantation, and proposing the way forward to achieve the objectives (Abdullah et al., 2018). The National Cyber Security Coordination Committee is answerable to the e-Sovereignty committee that is under the leadership of the Deputy Prime Minister. Then, the committee reports to the National IT Council under the leadership of the Prime Minister (Hamzah et al., 2018). The NCSP is isolated into eight regions of centre, which are known as pushed. The following are depictions of the pushes.

5.1.1.2 Viable Governance

The arrangement perceives the reliant idea of the Critical National Information Infrastructure (CNII) that an effect on one area will influence the others. Albeit some advancement was made in making sure about the CNII, still there were difficulties that stay to be survived (Sunkpho et al., 2018).

5.1.1.3 Administrative and Regulatory Framework

This push takes a gander at the lawful territory of the arrangement (Ibrahim et al., 2019). The laws and guidelines are vital to make trust and trust in the CNII. The digital law audit takes a gander at all these laws and gave suggestions on progress that should be made (Hamzah et al., 2018).

5.1.1.4 Digital protection Technology Framework

Data security rules are plentiful inside the public areas in Malaysia (Tan et al., 2020). Notwithstanding, most of these rules are useful in nature and not as giving obligatory or least necessities (Sunkpho et al., 2018).

5.1.1.5 Culture of Security and Capacity Building

This is the one pushed that gives centre around the human part of arrangement (Tan et al., 2020). The proceeding with changes in data innovation requires more prominent accentuation on security by the CNII substances whom create, own, give, oversee, administration and use data frameworks and organisations (Hamzah, et al., 2018). The remote and broadband advances have contributed altogether to the expansion in Internet clients that has expanded the openness of general society to an assortment of dangers and weakness (Sunkpho et al., 2018).

5.1.1.6 Innovative work towards Self Reliance

In accomplishing the target of this push, the CNII of Malaysia is secured by an incorporated innovative work system that centres around innovation with the point of acting naturally dependent (Hamzah et al., 2018). There is a need to have a focal substance to facilitate and focus on the current and future R&D plan

of the country (Teoh & Mahmood, 2017). Considering this, MIMOS an office of MOSTI has been relegated the errand. This organisation will adjust and coordinate R&D projects and activities to evade duplication of endeavours and to support cooperation where fitting (Sunkpho et al., 2018).

5.1.1.7 Consistence and Enforcement

The Ministry of Information, Communication and Culture (MICC) is driving this push. One reason is on the grounds that significant data and correspondence controller, which is the Malaysian Communications and Multimedia Commission and CNII substances, for example, Telekom Malaysia, Maxis, and Jaring are under the domain of this service (Ibrahim et al., 2019).

5.1.1.8 Network safety Emergency Readiness

The Computer Emergency Response Teams (CERT) or the Computer Security Incident Response Team (CSIRT) is an instrumental set up in relieving network safety occurrences. Network safety Malaysia has the Malaysian CERT (MyCERT), which screen the digital protection dangers in the country's digital environment (Ibrahim et al., 2019).

5.1.1.9 Global Cooperation

The digital environment doesn't adjust to the actual limits of the nation's subsequently effective network protection activities require global participation. Sharing insight, research, best work on, talking about difficulties and gaining from different mix-ups just as assisting with figuring and drive worldwide arrangement bearing and activity will assist Malaysia by making sure about the CNIIs (Ibrahim et al., 2019).

In conclusion, as the IT foundation is coming about to the expansion in digital occurrences, it is a correct move for MOSTI to lead an examination on the necessity of a public arrangement to alleviate such rates. The National Cyber Security Partnership (NCSP) targets in upgrading the security, strength and independence of Malaysia's CNII to advance solidness, social prosperity and making abundance (Sunkpho et al., 2018). In actualising the arrangement, the keys to progress include an effective administration and coordination with the foundation of a solitary coordination community such as the CyberSecurity Malaysia.

5.1.2 Proposals for Improvement of Policy (ies)

The National 4IR Policy was recently launched in July 2021, arising from the need to be a technological nation which has prompted the government to draft a relevant policy. The National 4IR Policy sets out to facilitate a technologically enabled public service delivery system and set to give the public the convenience of accessing services within reach of their fingertips.

The National 4IR Policy supports the country's development policies, such as Shared Prosperity Vision 2030 (SPV 2030) and five-year Malaysia Plans. It sets to transform Malaysia into a high-income nation driven by technology and digitalisation. The National 4IR Policy, has four policy thrusts for society, business, and the government, as shown in Figure 2.

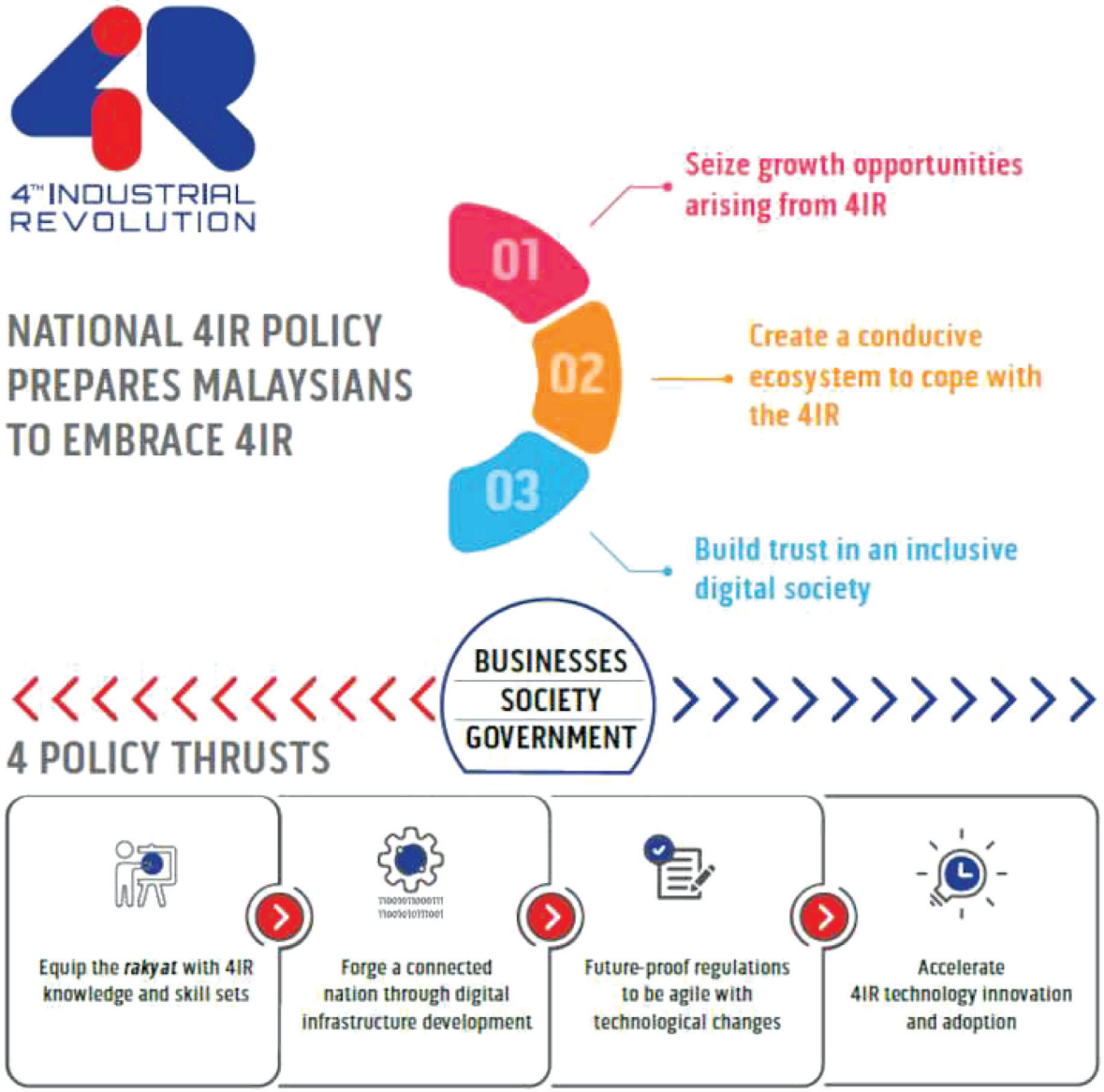

Figure 2. The National 4IR Policy supports the country's development policies such as Shared Prosperity Vision 2030 (SPV 2030) and Five-year Malaysia Plans

(*Source*: National 4IR Policy 2021)

i. First, to equip the people with 4IR related knowledge and skillsets.
ii. Second, to form a nation with connectivity through the development of digital infrastructure.
iii. Third, to provide appropriate rules for future needs, so that they are flexible according to technological changes.
iv. Fourth, to accelerate innovation and adoption of 4IR technology.

The four thrusts involve empowering people with 4IR relevant knowledge and skills; boosting nationwide connectivity through development of digital infrastructures; lay out appropriate rules for future needs that adapt to technological changes, as well as accelerating innovation and adoption of 4IR technologies.

The four thrusts would be implemented based on 16 strategies, 32 national initiatives, and 60 sectoral initiatives that were identified by the government. The four thrusts also intended to reduce the potential social-related risks that could be derived from 4IR, elements of trust, inclusivity, cybersecurity, ethics, and values will be inculcated in all initiatives. At the core of the policy, the 4IR will be driven by five foundational technologies to build local capabilities including:

- Artificial Intelligence (AI)
- Internet of Things (IoT)
- Blockchain and distributed ledger technology (DLT)
- Advanced materials supported by cloud computing
- Big data analytics (BDA)

The National 4IR Policy will lead to better work-life balance, improved convenience, safer streets, value-added jobs, higher incomes, improved social well-being, and more responsible environmental sustainability. Through the adoption of the National 4IR, the Malaysian Well-being Index (MyWI) is projected to climb to 136.5 by 2030, in contrast to 124.4 in 2018. Malaysia is also predicted to remain at the top 20 in the Global Innovation Index by 2030 and expected to achieve an increase of 30% productivity across all sectors as compared to 2020. The implementation of 4IR Policy will have immense benefits for 10 key sectors: manufacturing, transportation and logistics, healthcare, education, agriculture, utilities, finance and insurance, professional, scientific, and technical services, wholesale, and retail trade, as well as tourism.

In addition, the National Water Resources Policy (NWRP) was launched in March 2012. NWRP was developed based on the IWRM approach, with emphasis on the security and sustainability of the nation's water resources. NWRP has three principles, five objectives, four key core areas, nine thrusts, 18 targets and 28 strategies that sets the strategic direction and framework for strategic actions to ensure water resources are used and developed in a sustainable manner based on the collaborative water resources governance amongst all stakeholders through the 69 strategic action plans.

To address water resources related issues in the country by incorporating the IR4.0 for water sub-sectors, the commitment by the government can be seen from the policy statement as stated below:

> *"The security and sustainability of water resources shall be made a national priority to ensure adequate and safe water for all, through sustainable use, conservation and effective management of water resources enabled by a mechanism of shared partnership involving all stakeholders."*

Water resources may also be associated with various aspects that fall within the legislative purview of both the Federal Government and State Government.

The NWRP is constructed based on three principles as follows:

i. Water Resources Security: water resources must be secured to ensure its availability to meet the needs and demands for both humans and nature.
ii. Water Resources Sustainability: water resources are the catalyst for environmental well-being and national development, and thus need to be sustained for present and future uses.
iii. Collaborative Governance: Stakeholders inclusiveness and collaboration are essential towards ensuring the security and sustainability of water resources.

Based on the above principles, nine thrusts were proposed under the NWRP including:

i. Water intelligence
ii. Water resources integrity
iii. Use of alternative water resources and sources
iv. Water related disaster risk reduction, preparedness and response
v. Criteria for water resources characterisation
vi. Conservation and protection of water resources and bodies, both natural and artificial
vii. Stakeholder inclusiveness and engagement
viii. Capacity building and engagement

In achieving the above, a total of 69 strategic action plans were outlined for implementation, whereby NRE and JPS have been appointed as the leading parties. The 69 strategic action plans were first discussed in May 2012 and none of the initiatives discussed for the specific plans of action had addressed the adoption of IR 4.0 for water sub-sectors that shall incorporate integrated water data management particularly on development of innovative technologies for secured database and dissemination, which will help establish a system that will gear water resources towards sustainable usage.

Therefore, it would be of importance for a task force on the establishment of the IR 4.0 for water sub-sector be set up along with the five task force which have already been formed to look into the implementation of specific action plans, which are:

i. Water governance
ii. Water resources information
iii. Investigation and research
iv. Standards and quality
v. Capacity building and awareness

The proposed task force on the development of innovative technology will greatly support the 1st, 2nd and 4th thrust of NWRP on water intelligence and water resources integrity. This will ensure that the policy stays dynamic and flexible to adjust to changing conditions and demands in the water resources management.

Moreover, the NWRP is intended to serve as a directional focal point to help bring together stakeholders, including government agencies, non-government organisations, research institutions, private sectors and communities to help translate the strategic action plans into actions. The time frame for the implementation of the strategic plans ranges from short-term to medium-term, as the policy is expected to be reviewed from time to time.

5.2 Scope 2: Undertake Comparative Strategy Analysis/Business Models with other nations

A series of White Papers have been initiated by organisations such as the International Water Association (IWA), including in Improving Public Health Through Smart Sanitation and Digital Water and Artificial Intelligence Solutions for the Water Sector to help utilities, water professionals and all those interested in water management and stewardship issues to better understand the opportunities of IR 4.0 and digital technologies. Drawing exceptional professionals from over 140 countries, the membership of IWA brings together scientists, researchers, technology companies, and water and wastewater utilities. Nevertheless,

a policy governing water and wastewater sector transformation by using the integration of IR 4.0 for water sub-sectors remain unclear. Criteria benchmarking for digitalization of water and wastewater management is crucial for the implementation of technologies based on localized solutions. Comparative strategy analysis and business models with other nations were studied with countries, including Japan, South Korea, Singapore and Germany. As a well-known international organisation, IWA global membership has served a unique purpose in spearheading the digitalisation of the water sector, which ultimately represents strong collaboration, for example, with Singapore. The road to digitalisation in Singapore began with the confluence of two growing trends. On one hand, Singapore's rising water demand, growing operational costs of supplying water, looming manpower shortages in the water sector, and new challenges such as climate change presented mounting problems in need of solutions. On the other hand, advancements in digital and information communication technologies were transforming the global landscape, and could offer water utilities new methods of enhancing their productivity and efficiency in planning, operations and service delivery without greatly impacting costs. The close cooperation between IWA and Singapore has been documented by IWA in Digitalising Water – Sharing Singapore's Experience (2020).

5.2.1 What were the countries studied and their strategies/Business Models compared to Malaysia's in the sub-sector?

Through the webinars and FGD, it was discovered that the water sector in Malaysia may benefit from a standard benchmarking criterion to ensure successful implementation of IR 4.0 for water sub-sectors. During the webinar engagement with the German counterparts, representatives from Bentley and Siemens, for example, though far advanced in application of IoT, big data analytics and AI technologies, have clarified that most of their initiatives are driven by specific objectives in relation to their business and industrial operations as opposed to the importance of IR 4.0 implementation. However, this does not discount the importance of a holistic and sustainable IR 4.0 water solution to churn the water sector into a new dynamic economic contributing sector. The aspiration requires a strong fundamental benchmarking criterion, which then can be used for assessment of digitisation maturity of ministries/ agencies/ departments and subsequently development and realisation of IR 4.0 for water sub-sectors. The webinars and referential literature have provided a basis for the following summary of observations for countries, including Japan, South Korea, Singapore, and German. In addition, the global organisation IWA is also included based on its contribution to the first white paper signifying a clear framework for the rise of digital water in several country members including Singapore.

- *Japan*
  Japan is known for its strong ICT capabilities, comprising high-speed Internet infrastructure and 5G deployment. Japan promotes its strong R&D culture via competitive national universities while allocating a large proportion of GERD by business sector and emphasising on experimental research. Japan possesses a strong government-driven partnerships and R&D incentives, whereby strong indigenous private sector is supported by MNCs which cover ICT, electronics, and energy. Its global outreach is supported largely by dispatching experts in ODA programmes and conduct international courses.

- *South Korea*
  South Korea has strong ICT capabilities and is supported with 5G infrastructure and dedicated networks for IOT deployment. Its strong R&D culture is supported by policies that encourage STEAM education while maintaining involvement of world-class tertiary institutions. A large proportion of GERD by business sector also support the R&D activities, with specific emphasis on experimental research.

South Korea receives a proactive public governance through government-led and funding for large scale water management projects with 5G infrastructure dedicated networks for IoT deployment. It incorporates the IWRM into existing and future Smart City development with digitalisation of water resource management established. South Korea features its global outreach via K-water global participation through ODA programmes and water management solutions worldwide.

- *Singapore*
  Singapore leads digitalisation of water sector by having 5G deployment and providing nationwide access to high-speed broadband network. Its strong R&D culture is supported via collaborations with top universities consisting of global water experts. Singapore also supports R&D culture with policies, emphasising on STEM education. It has a highly coordinated and self-regulated public water agency which is based on a public driven fiscal and non-fiscal support for private sector and academia water-related development. The IWRM plan is integrated through holistic cross-sectoral policy framework development. Singapore owns over 200 water companies with 25 research centres generating SGD2.5 billion in annual value-add. Its global outreach is driven by the Singapore Water Academy programs and local SMEs international collaborations.

- *Germany*
  Germany is fully equipped with 5G infrastructure and dedicated networks for IoT deployment. Their businesses are supported by top-notch industries and business sectors with collaboration with top universities driving strong R&D culture for IoT in various sectors. In Germany, the government has minimal interference in terms of data ownership. The IWRM plan in Germany is narrow focused on water utilities and providers with minimal mention of the sewerage sector. However, Germany receives strong support from business entities, i.e. Bentley in supporting IR 4.0 implementation throughout their business operations. Their global outreach is led by German Water Partnership, strengthening international collaborations.

A 10-point criterion was derived from the webinar following inputs and critical elements across the various water sub-sectors as proposed by the stakeholders (Appendix A). These criterions were assigned with appropriate weightage to reflect its level of priority among stakeholders. Computation of criteria rating and weightage were then utilised to summarise the status of digitalisation of the participating ministries/agencies/departments, respectively. The absence of an international benchmarking criteria for IR 4.0 in water sub-sectors, has certainly presented a remarkable opportunity for Malaysia to develop its own standard referencing based on the localised scenario that is of international applicability. Based on the countries studies, the criteria for preliminary benchmarking of the IR 4.0 for water sub-sectors and the average scoring derived are summarised in Table 1.

i. Internet accessibility (Scoring: 7.5)
   This criterion aims to access the state of existing coverage of Internet facilities for all that must cover both the urban and rural areas. An average score of 7.5 for Internet accessibility across water stakeholders from various states indicates that Internet coverage in Malaysia is more than 75%; however, less than 100%.

ii. Data centre (Scoring: 3.33)
   A data centre shall be dedicated for the implementation of IR 4.0 for water sub-sectors and shall be completed with IT infrastructures to collect data on the operation of the business on holistic manner, including sharing of information with various stakeholders. An average score of 3.33 indicates that establishment of data centre in water sub-sectors in Malaysia is much localised and not wholesome. Example includes plant monitoring and its related localised operations.

iii. Integrated system (Scoring: 4.17)
All data shall be integrated for business, with other related sectors whether to use as part of the business or contributes as required by other, i.e. water supply may require information from river management. An average score of 4.17 shows that the existing system, might largely measures its own business operations while most probably reaching to a mixed mode of own and other related to business operations.

iv. Guidelines and procedures (Scoring: 3.33)
Availability of risk management, crisis management, mitigation measures and standard operating procedures (SOP) for data management by using IT system. Scoring of 3.33 for guidelines and procedures suggests that the various water stakeholders' guiding documents might be under planning and yet to be implemented.

v. Steering committee/ task force (Scoring: 3.33)
Availability of permanent committee/team that is looking into development of the IR Water 4.0 or similar with vision on adopting the system with target date to implement holistically. Scoring of 3.33 reflects the planning stage for establishment of steering committee or special task force; however, yet to be implemented.

vi. Policy, laws, regulation, guidelines etc. (Scoring: 3.33)
Policy, laws, regulation, act established on data management and IT infrastructure ,which is also outlined in this study. It is clear from the scoring that the water related policy, laws, act & regulation and guidelines are still under planning and yet to be implemented.

vii. Readiness / coordination / adaptability (Scoring: 3.3)
Existing coordination on IR 4.0 for water sub-sectors including readiness to transform and adopt for water transformation, whereby some elements shall be changed or retained accordingly for IR 4.0 implementation in the sector. Not all things need to be changed, some of them will be retained. The average score of 3.3 obtained, points out that the decision makers, management and stakeholders are all having the necessary knowledge of IR 4.0; however' the co-ordination and readiness to transform and adopt are very much dependent on the planning which is underway at present.

viii. Phases and scope (Scoring: 2.5)
In this study, the phases of transformation shall be determined by each sub-sector according to desired scopes of IR 4.0 implementation in the sector. The average score of 2.5 indicates that the phases and scopes are under planning and yet to be implemented.

ix. Readiness of IT infrastructure (Scoring: 3.33)
Completeness of IT Infrastructure, i.e. full facilities, storage, satellite etc. and benefits which shall be reaped from the transformation by stakeholders involved. The scoring suggests that water stakeholders' IT infrastructures completeness is still under planning and yet to be implemented.

x. Communication / interaction systems (Scoring: 7.5)
Availability of mobile apps for water consumers, such as smart phones usage, websites, and transmission to respective stakeholders. Communication/ interaction system scoring of 7.5 illustrates that the existing system of communication with stakeholders from top management to consumers is available at more than 50% and has target for implementation within five years. However, the planning has not been commissioned yet.

Table 1. Preliminary benchmarking criteria assessment by various water sub-sectors and stakeholders

No	Criteria	Description	WATER SUB-SECTORS STAKEHOLDERS											
			JMG	EPU	MOU	PAAB	JBPM	JPS	MARDI	SPAN	KPKT (Bnadaraya)	MIMOS	MyWAC	IWK
1	Readiness/coordination/ adaptability	Measure on coverage on average for whole operational area	5.63	3.75	6.25	15	7.5	7.5	11.25	7.5	8.75	7.5	3.75	7.5
2	Data center	Measure by completeness of data required. More importantly availability of the data center	9.38	3.75	8.5	11.25	11.25	10	5.63	7.5	7.5	7.5	7.5	7.5
3	Integrated system	Measure by completeness of integration system that covers user at all levels etc	7.5	11.25	6.25	11.25	7.5	5.41	2.5	5	5	5	5	7.5
4	Guidelines & Procedures	Measure by the completeness and implementation	6.56	15	5.83	15	15	5	2.5	2.5	1.25	2.5	2.5	3.75
5	Steering Committee/ Task Force	Measure by availabilty of dedicated Committee with clear target to achieve	4.06	7.5	5.83	3.75	7.5	2.08	0.63	1.25	1.25	2.5	1.25	5
6	Policy, Laws, Acts & Regulation, Guidekines etc	Availability of the relevant document for implementation or being planned	10.31	15	6.25	15	15	6.25	5.63	3.75	3.75	7.5	3.75	11.25
7	Readiness/coordination/ adaptabilit	Is current decision maker, management, stakeholders etc practised & implement	5.94	3.75	3.75	0	1	1.25	2.92	1 1.25	1.25	2.5	1.25	2.5
8	Phases and Scope	Planning towards IR Water 4.0	2.5	3.75	2.5	0	7.5	2.92	0	1.25	1.25	2.5	1.25	2.5
9	Readiness of IT Infrastructure	Readiness of IT Infrastructure with proper monitoring	7.5	15	6.25	15	7.5	8.75	5.25	7.5	11.25	7.5	7.5	7.5
10	Communication/interation system	Existing system of communication with stakeholders from top with stakeholders from top	6.25	3.75	7.92	3.75	7.5	6.25	0	5	5	5	5	7.5
		GRAND TOTAL	65.63	75	59.33	83.75	90	57.08	57.08	42.5	46.25	50	38.75	38.75
		STATUS OF IR	IRW2.5	IRW3.0	IRW2.5	IRW3.5	IRW3.5	IRW2.5	IRW2.5	IRW2.0	IRW2.5	IRW2.5	IRW2.0	IRW2.0

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

This Scope of elaborated in Water as an Economic Sector (WES) (Volume IX).

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

WST2040 is the national economic development agenda that will begin in the 12th MP and it will take 20 years. Therefore, a specific study (Implementation & Cost Analysis) under the IRW4.0 sector was made to identify strategies, initiatives, programmes, projects, and activities that need to be implemented to achieve the transformation targets, which is expected in each phase later. The process of preparing the WST2040 road map (IRW4.0) has involved participation from various stakeholders, including ministries, government agencies, NGOs, academics, scientists, industry and the general public. As a result of a series of discussions and workshops, we have successfully developed a transformation plan (implementation & budget) which we believe needs to be implemented accordingly.

The road map forward for IR 4.0 for water sub-sectors are derived from a series of discussion and virtual workshops, involving relevant stakeholders and strategic partners in the sector as depicted in Figure 3 and further elaborated in Table 2, Table 3, Table 4 and Table 5, respectively. A consensus and agreement on a plan and costs required for the period of transformation have been outlined as follows:

i. Preparation of the water sector towards IR 4.0 and the use of smart technology to drive the development of the water sector entirely
ii. Establishment of Centres of Excellence (COE) as the basis for strategic planning and decision making as well as a driver to the development of expertise, local innovation in the water sector
iii. Comprehensive and significant improvement in the concept of Integrated Water Resources Management (IWRM), Water Technology Innovation (WTI), Economies of Scale (EoS), Regional Water Hub (RWH). Here we have agreed to use Artificial Intelligence (AI) technology as the main core in the development and transformation of this water
iv. Sustainable water management with the concept of AI-driven and also be part of the development of Smart Citizen, Smart City & Smart Nation
v. Provision of comprehensive infra-structure and info-structure for current water needs and use by each sector and consumers
vi. Development of a new business model to drive the country's water industry to a viable, attractive, and profitable industry
vii. Implementation of a strategic programme (Private-Public Partnership) to position the water sector as a new economic sector of the country.

Transformation Roadmap (Vision 2040)

Accelerating IWRM Implementation	Water Technology Innovation	Achieving Economics of Scale	Becoming Regional Water Hub
Estimate Total Investment: RM 40 Billion	Estimate Total Investment: RM 45 Billion	Estimate Total Investment: RM 40 Billion	Estimate Total Investment: RM 50 Billion
12th MP (2021 – 2025)	13th MP (2026 – 2030)	14th MP (2031 – 2035)	15th MP (2036 – 2040)

Digitalize all existing manual water ecosystem – Hardware, Software, & Peopleware:
a) Upgrade to full system, application, and technology development (digitalization) like water supply, water treatment, water health, water hazard, water sewerage, ground water, smart meter, GIS, etc
b) Redesign the water ecosystem to be more supportive of digitalisation.

Big Data Analytic & Data Warehouse - Data sharing & Integration Framework:
a) Cloud computing & virtualization platform.
b) Centralize platform and database (Dashboard, KPI Management, Operation Tactical and Planning, Asset Management, Maintenance Planning, Reporting, etc)
c) Optimize the existing system like NAWABS, NaFFWS, etc
d) Business intelligence (BI) tools to improving strategic decision-making and providing a competitive advantage.

Telecommunications & Satellite Technology:
a) Roll out 4G/5G - Improving and expanding network services & coverage.
b) Using Satellite (data) to improve water especially in soil loss and erosion mapping, asset monitoring & maintenance, water quality monitoring, and flood prediction.
c) Smart Connectivity - LTE-M, NB-IOT, CAT, CAT-M1

Blockchain & Artificial Intelligence (Framework):
a) Setup taskforce to draft and develop full framework (end-to-end) using blockchain & AI technology in water ecosystem.
b) Blockchain and AI able to effectively allocate water resources; empower consumers by providing economic and social value, and incentivize conservation and provide positive environmental outcomes.

Establishment of Innovation & Research and Development Centre (Centre of Excellence):
a) Re-skilling & educate business entities to champion IR4.0 in water businesses.
b) Re-skilling & educate industry people to understand water digitalisation.
c) Development of intellectual capital through smart partnerships
d) Information to water stakeholders
e) Setup the National Water Data Centre

Big Data Analytic & Data Warehouse - Data sharing & Integration (Public & Private Sector):
a) Cloud computing & virtualization platform.
b) Improve the Data Hub / Repository for both public & private water sectors and industry.
c) VR/AR augmented workforce.

Telecommunications & Satellite Technology:
a) Review and strengthening the 5G / 6G coverage entire Malaysia
b) Continue to using Satellite technology (data) to improve water especially in soil loss and erosion mapping, asset monitoring & maintenance, water quality monitoring, and flood prediction.
c) Smart Connectivity - LTE-M, NB-IOT, CAT, CAT-M1

Internet of Things (IOT) – Smart Citizen: The Great Urban Challenge:
a) Phase 1 – focusing on the existing occupancies of residents / businesses
b) Installation of smart water devices that enable existing users to self-manage and maintain autonomous water systems at building, community, & cluster level.
c) Provide incentives to citizens to encourage sustainable usage of smart water devices.
d) Provide incentives for marketing of smart water devices and relevant training.

AI-Driven National Smart Water & Operation Centre (Phase 1):
a) Launch Langkawi Project (Live)
b) Focus on the National Project; water quantity & quality, water supply & water demand management, & full water supply chain

Invest in Critical Technology related to Water Recycle and Water Treatment:
Private & Public Partnership – Digital Strategy and Funding (International & Local) especially on Smart Eco Green

Water-Efficient Infrastructure & Water-Smart Cities (Phase 1):
Infrastructure services that enable communities to develop, run and maintain autonomous urban water systems. (Smart City / Smart Home / Smart Building)

Invest in Critical Technology related to Water Operation & Treatment Contributing to GDP and Economics of Scale:
a) Advanced Technology & Innovation. (Nano-Bio Technology & Intelligent Robots)
b) Private & Public Partnership – Digital Strategy and Funding Programme

AI-Driven National Smart Water & Operation Centre (Phase 2):
a) National Project and part of smart cities development
b) Water operator focus on assisting with end-user system design, installation, information, maintenance and emergency response with Smart Meter (AI-Driven Smart Water System)

Smart Water & Smart Cities:
Shift from end users that pay for the delivery of services to those that pay for the cost of installing and maintaining local infrastructure, either individually or collaboratively

Smart Citizen - The Great Urban Challenge (Phase 2):
a) Services and technology that end users able to manage and maintain autonomous water systems at building, community & cluster level.
b) Provide incentives and continue IR4.0 training to public

Smart Water & Smart Citizen (Development Framework):
Smart Home / Building that enable greater autonomy and smaller-scale applications in water collection, storage, treatment and distribution

Water-Efficient Infrastructure & Water-Smart Cities (Phase 2):
a) Technology to monitor and reduce illegal water trade and theft, coupled with a reduction in leakages and wastage across the existing network
b) Also focus on advances in decentralised and centralised water storage solutions, coupled with intelligent demand management and higher water recycling and reuse rates

Invest in Critical Technology related to Water Operation, Supply & Distribution:
a) Expansion of technology and systems to manage and minimise the impact of extreme fluctuations in water availability, including fast shifts from too much water to too little
b) Private & Public Partnership – Digital Strategy and Funding Programme

Establishment of AI-Driven National Smart Water & Smart Cities Hub:
a) Continue the National Smart Water & Smart Cities Development
b) Implementation of differential water pricing and services according to availability of supply, service plans, and customer behaviour (Smart Billing / Prepaid Concept)
c) Centralise (AI-Driven) Water Subsector system

Smart Water, Smart Cities, & Smart Citizen:
a) Autonomous and community-based water systems (Smart City)
b) 70% of self-sufficient service level (SSL) achieved

Smart Citizen - The Great Urban Challenge (Phase 3):
a) Services and technology that end users able to manage and maintain autonomous water systems at building, community & cluster level
b) Provide incentives and continue IR4.0 training to public

Customer Satisfaction Index will increase **25% - 45%**
- Good value for service
- Easy to understand water use
- Save money
- Easy to use water efficiently
- Easy to communicate with provider/utility

ROI
- Assets
- Systems & Process
- People & Culture

- ❑ Up to 50% reduction in unplanned downtime related to assets & parts
- ❑ Up to 40% reduction in inventory costs
- ❑ Up to 35% savings in maintenance and inventory budgets
- ❑ Up to 70% increase in service levels and reduction numbers of incidents
- ❑ Up to 100% project performance and product delivery reliability
- ❑ Up to 40% increase in operational efficiency
- ❑ Up to 30% reduction in water lost before 'reaching' the customer
- ❑ Up to 45% reduction in energy consumption of water supply, wastewater collection, and treatment

Figure 3. Transformation road map framework proposed for the implementation of IR4.0 for water sub-sectors

Table 2. Draft WST2040 strategy plan and implementation road map

Draft WST2040 Strategy Plan and Implementation Road Map										
Focus Area	NIWRMP Strategies			11MP Strategies		WST2040 Strategies				Focus Area
	Water as a Resource/Water Security and Sustainability									
	11MP/12MP/13MP/14MP/15MP									
	Strategy	**Initiatives**	**Programmes/ Activities**	**Hierarchical Level**	**Lead Authority/ Collaborating Partners**	**Implementing Authority**	**Current Status**	**Target Completion**	**Remarks**	
People	1. Establishment of Innovation & Research and Development Centre (Centre of Excellence)	1. Re-skilling & educate business entities to champion IR4.0 in water businesses 2. Re-skilling & educate industry people to understand water digitalisation 3. Development of intellectual capital through smart partnerships 4. Information to stakeholders	1. Create an ecosystem that supports training for IR4.0 amongst industry players (As proposed by AACB) 2. IR4.0 to be inclusive as part of education curriculum (i.e. IPTA/IPTS) in supporting future capacity building for business entities and industries 3. Establish strategic partnerships with entrepreneurs, technocrats via benchmarking exercises	Peninsular, Sabah & Sarawak	KASA & MOU	MOSTI/ MITI, Malaysia Productivity Corporation (MPC), MTDC, UKAS, MQA	On-going	12th MP	Also impacting Water for Livelihood/ water for economic opportunity	People
	2. Malaysia Smart Water & Smart Citizen	1. Smart Citizen - The Great Urban Challenge (Phase 1) i.e., focusing on existing occupancies of residents/ businesses	1. Installation of smart water devices that enable existing users to self-manage and maintain autonomous water systems at building, community & cluster level 2. Provide incentives to citizen to encourage sustainable usage of smart water devices 3. Provide incentives for marketing of smart water devices and relevant training	Peninsular, Sabah & Sarawak	KASA & MOU	MOSTI/MITI, Malaysia Productivity Corporation (MPC), MTDC, UKAS BOMBA, KPKT				
		2. Smart Citizen - The Great Urban Challenge (Phase 2)					On-going	13th MP – 14th MP	Also impacting Water for Livelihood/ water for economic opportunity	

Draft WST2040 Strategy Plan and Implementation Road Map

Focus Area	NIWRMP Strategies		11MP Strategies				WST2040 Strategies		
	Water as a Resource/Water Security and Sustainability								
	11MP/12MP/13MP/14MP/15MP								
	Strategy	Initiatives	Programmes/ Activities	Hierarchical Level	Lead Authority/ Collaborating Partners	Implementing Authority	Current Status	Target Completion	Remarks
People		3. Smart Water & Smart Citizen (Development Framework)	1. Establishment of new policies that govern future smart homes / smart buildings to ensure new development projects that enable adaptation and adoption of greater autonomy and smaller-scale applications in water collection, storage, treatment, and distribution in new development projects	Peninsular, Sabah & Sarawak	KASA & MOU	MOSTI/ MITI, Malaysia Productivity Corporation (MPC), MTDC, UKAS, BOMBA, KPKT	On-going	14th MP	3. Smart Water & Smart Citizen (Development Framework)
		4. Smart Water & Smart Citizen (Implementation Phase)	1. 70 precent of self-sufficient level (SSL) achieved	Peninsular, Sabah & Sarawak	KASA & MOU	MOSTI/MITI, Malaysia Productivity Corporation (MPC), MTDC, UKAS BOMBA, KPKT	On-going	15th MP	4. Smart Water & Smart Citizen (Implementation Phase)

Draft WST2040 Strategy Plan and Implementation Road Map

Focus Area	NIWRMP Strategies			11MP Strategies		WST2040 Strategies				Focus Area
	Water as a Resource/Water Security and Sustainability									
	11MP/12MP/13MP/14MP/15MP									
	Strategy	**Initiatives**	**Programmes/ Activities**	**Hierarchical Level**	**Lead Authority/ Collaborating Partners**	**Implementing Authority**	**Current Status**	**Target Completion**	**Remarks**	
People	1. Establishment of new laws and policies for data sharing 2. Improvement and enhancement of existing laws and policies for data sharing	1. Water to be recognised as a National Security Agenda 2. Amendment of existing laws and policies for data sharing 3. Formulation of Cybersecurity Policy on Data Protection and Data Sharing 4. Data and information on water sector (water resources and water services) to be declared as national security item.	1. Water to be included in National Security Policy 2. Production of Annual Water Security Report 3. Enhancement to PDPA 2010 (Act 709) particularly on (1) the right to access data and data sharing at no costs among government bodies, government agencies and local authorities for national interest and (2) data shared and exchanged amongst the government bodies, government agencies and local authorities must comply with 6 basic lawful rules of information sharing that is necessary, proportionate, relevant, adequate, accurate, timely and secure.	State and National	MKN (JPM)	KASA, DID, DOE, JMG, METMalaysia, MADA, KADA, MOH, MYSA, BBA, JPP, TNB, Water supply operators, IWK, Sewerage Services Operator, DOSM, PLANMalaysia, DOA, JKR, JUPEM, KPLB, KeTSA, JPSM, SFD, FDS, Research institutes Private sectors (e.g. oil palm, rubber estates and sewerage) MINDEF(CDOC), KDN, AGC, MCMC, MOFA, MEIO	On-going	12th MP	As proposed by ISWDC with additional recommendation. Additional Proposal to establish a governing council for quality assurance for IR4.0 IT Architecture Framework.	People
	2. Review of Statistics Act 1965 3. [Amendments to] Statistics Act 1965	1. To propose water and water related data to be included in review of Statistics Act 1965 Amendments to STA 1965 for: 1- inclusion of water related data; 2- development of a systematic mechanism for coordination, reach and cooperation in data sharing; 3- enhancement of existing data for better coordination and readiness of more comprehensive data for the government bodies, government agencies and local authorities to formulate short and long term policies and making decisions for national interest/security.		DOSM (lead)	DOSM (JPM) AGC		1.12th MP	Also impacting Water for Livelihood/ water for economic opportunity	

Draft WST2040 Strategy Plan and Implementation Road Map

Focus Area	Strategy	Initiatives	Programmes/ Activities	Hierarchical Level	Lead Authority/ Collaborating Partners	Implementing Authority	Current Status	Target Completion	Remarks
NIWRMP Strategies / Water as a Resource/Water Security and Sustainability / 11MP/12MP/13MP/14MP/15MP / 11MP Strategies / WST2040 Strategies									
Focus Area: People									
People		4. Freedom of Information Law	1. Establishment of Freedom of Information Law 2. Formulation of Right to Information legislation and repeal of Official Secrets Act (OSA). To have a very clear understanding that certain exemptions in the OSA are incorporated in the Right to Information legislation. 3. Formulating Freedom of Information Enactments (FOIE) which allows anyone to obtain information owned by the respective state governments except for that information which falls under national security.	National	JPM (AGC)	JPM		1.13th MP	
				All States except for Selangor and Penang	State Legal Advisor & AGC				
		5. Review of Fees Act 1951	1. To establish a circular for zero (0) rate fees under the Fees Act 1951 2. To gazette a Warta Kerajaan on no fee for reproduction, scanning, digitizing of data amongst the government bodies, government agencies and local authorities for national interest 3. Overhaul of Fees Act 1951	National	JPM (AGC)	JPM		1.12th MP	As proposed by ISWDC with additional recommendation.
						AGC		2.12th MP	

Draft WST2040 Strategy Plan and Implementation Road Map

Focus Area	NIWRMP Strategies			11MP Strategies			WST2040 Strategies			Focus Area
	Water as a Resource/Water Security and Sustainability									
	11MP/12MP/13MP/14MP/15MP									
	Strategy	**Initiatives**	**Programmes/ Activities**	**Hierarchical Level**	**Lead Authority/ Collaborating Partners**	**Implementing Authority**	**Current Status**	**Target Completion**	**Remarks**	
People	1. Digitalize all existing manual water ecosystem (i.e., hardware, software, peopleware)	1. Upgrade to full system, application, and technology development (digitalization) like water supply, water treatment, water health, water sewerage, ground water, smart meter, GIS, etc. 2. Redesign the water ecosystem to be more supportive of digitilisation	1. Talent grooming programme inclusive of transformational existing talents into roles and functions that support digitilisation at all levels 2. Standardize roll out programme supporting digitilisation	Peninsular, Sabah & Sarawak	KASA & MOU State Legal Advisor & AGC	State Water Operators MITI, MQA, MBOT, CIDB	Ongoing	12th MP - 13th MP	Also impacting Water for Livelihood/ water for economic opportunity	People
	2. Big Data Analytic & Data Warehouse	Data sharing & Integration Framework	1. Cloud computing & virtualisation platform. 2. Centralize platform and database (Dashboard, KPI Management, Operation Tactical and Planning, Asset Management, Maintenance Planning, Reporting, etc) 3. Optimize the existing system like NAWABS, NaFFWS, etc 4. Business intelligence (BI) tools to improving strategic decision-making and providing a competitive advantage.	Peninsular, Sabah & Sarawak	KASA & MOU	MAMPU		12th MP - 13th MP	Also impacting Water for Livelihood/ water for economic opportunity	
	3. Platform for infrastructure (including infostructure) that caters for IR4.0 for water sub-sectors	1. Roll out 4G & 5G for the entire Malaysia in phases to identify, standardize and achieve seamless technological upgrade 2. Cloud computing & virtualization platform 3. Smart Water Management Framework & Integrated Operational Data Centre	1. Review and strengthening the 4G/5G for the nation 2. Improving and expanding network services & coverage 3. Hyper-scale computing infrastructure	Peninsular, Sabah & Sarawak	KASA & MOU	KASA		12th MP		

Draft WST2040 Strategy Plan and Implementation Road Map

Focus Area	Strategy	Initiatives	Programmes/ Activities	Hierarchical Level	Lead Authority/ Collaborating Partners	Implementing Authority	Current Status	Target Completion	Remarks
	NIWRMP Strategies		11MP Strategies					WST2040 Strategies	
	Water as a Resource/Water Security and Sustainability								
	11MP/12MP/13MP/14MP/15MP								
People		4. Roll out 5G & 6G entire Malaysia	1. Establish partnership with local or foreign cloud computing providers 2. Relying on authorised base map produced by JUPEM (rather than too dependent on third party mapping such as Google Map etc.) 3. Initiate collaboration between VAICE as the living lab for IR4.0 in water sub-sectors with institute of higher learning 4. Review and strengthening the 5G / 6G coverage entire Malaysia **Review history of data hub which previously exist including NALIS, NALISA, MyGDI, CASSINI etc.	Peninsular, Sabah & Sarawak	MCMC & MOU State Legal Advisor & AGC	KASA		12th MP	
	4. Blockchain & Artificial Intelligence Framework	1. Setup taskforce to draft and develop full framework (end-to-end) using blockchain & AI technology in water ecosystem. Blockchain and AI able to effectively allocate water resources; empower consumers by providing economic and social value and incentivise conservation and provide positive environmental outcomes.	1. VAICE to monitor, supervise and consult the taskforce for blockchain and AI initiatives in water industry. 2. Provide means for budget allocation/ grant to agencies to adopt blockchain and AI technologies.	Peninsular, Sabah & Sarawak	KASA & MOU	MOSTI, MAMPU		12th MP	
	5. Technology advancement	1. Invest in Critical Technology related to Water Recycle and Water Treatment 2. Invest in Critical Technology related to Water Operation & Treatment	1. Private & Public Partnership – Digital Strategy and Funding (International & Local) 2. Advanced Technology & Innovation. (Nano-Biotechnology & Intelligent Robots) 3. Private & Public Partnership – Digital Strategy and Funding Programme	Peninsular, Sabah & Sarawak	KASA & MOU	KASA		13th MP 14th MP	

Draft WST2040 Strategy Plan and Implementation Road Map

Focus Area										
	NIWRMP Strategies		11MP Strategies				WST2040 Strategies			
	Water as a Resource/Water Security and Sustainability									
	11MP/12MP/13MP/14MP/15MP									
Focus Area	Strategy	Initiatives	Programmes/ Activities	Hierarchical Level	Lead Authority/ Collaborating Partners	Implementing Authority	Current Status	Target Completion	Remarks
Information & RDCI	6. Water Wise & Smart Cities	3. Invest in Critical Technology related to Water Operation, Supply & Distribution	1. Expansion of technology and systems to manage and minimise the impact of extreme fluctuations in water availability, including fast shifts from too much water to too little 2. Private & Public Partnership – Digital Strategy and Funding Programme	Peninsular, Sabah & Sarawak	KASA	MITI, MAMPU, MOFA, MDEC, MaGIC		15th MP	
		1. Water-Efficient Infrastructure & Water-Smart Cities (Phase 1) 2. Water-Efficient Infrastructure & Water-Smart Cities (Phase 2) 3. Shift from end users that pay for the delivery of services to those that pay for the cost of installing and maintaining infrastructures, either individually or collaboratively (**following user income segment)	1. Infrastructure services that enable communities to develop, run and maintain autonomous urban water systems. (Smart City / Smart Home / Smart Building) 2. Technology to monitor and reduce illegal water trade and theft, coupled with a reduction in leakages and wastage across the existing network 3. Development of smart cities shall also focus on advances in decentralised and centralised water storage solutions, coupled with intelligent demand management and higher water recycling and reuse rates	Peninsular, Sabah & Sarawak	KASA & MOU **SPRM to maintain integrity within implementation of projects	MOSTI, KPKT		14th MP	
		2. Autonomous and community-based water systems (Smart City)	1. Initiation of a taskforce team to drive the autonomous community-based water system inclusive of training, talent development etc.	Peninsular, Sabah & Sarawak	KASA & MOU **SPRM to maintain integrity within implementation of projects	MOSTI, KPKT		15th MP	

Table 3. Draft WST2040 budget requirements for water resources

Draft WST2040 Budget Requirements															
Focus Area	NIWRMP Strategies			11th MP Strategies						WST2040 Strategies					Focus Area
	Water as a Resource/Water Security and Sustainability														
	Strategy	**Initiatives**	**Programmes/ Activities**	**Lead Ministry/ Organisation**	**Budget (RM '000,000)**									**Target Completion**	**Remarks**	
					2021	**2022**	**2023**	**2024**	**2025**	**Total 12th MP**	**13th MP**	**14th MP**	**15th MP**			
People	1. Establishment of innovation & Research and Development Centre (Centre of Excellence)	1. Re-skilling & educate business entities to champion IR4.0 in water businesses 2. Re-skilling & educate industry people to understand water digitalisation 3. Development of intellectual capital through smart partnerships 4. Information to stakeholders	1. Create an ecosystem that supports training for IR4.0 amongst industry players (As proposed by AACB) 2. IR4.0 to be inclusive as part of education curriculum (i.e. IPTA/ IPTS) in supporting future capacity building for business entities and industries 3. Establish strategic partnerships with entrepreneurs, technocrats via benchmarking exercises	KASA & MOU	30	50	70	100	150	300	500	500	500	2022: Complete 1 CoE under MOSTI/ ASM 2023 - 2025: Create multiple CoE with different modules and water segment.	Need to allocate some budget to maintain the CoE operation for 13-15MP	Peope

Draft WST2040 Budget Requirements

Focus Area	NIWRMP Strategies			11th MP Strategies	WST2040 Strategies											Focus Area
	Water as a Resource/Water Security and Sustainability															
	Strategy	**Initiatives**	**Programmes/ Activities**	**Lead Ministry/ Organisation**	**Budget (RM '000,000)**									**Target Completion**	**Remarks**	
					2021	**2022**	**2023**	**2024**	**2025**	**Total 12th MP**	**13th MP**	**14th MP**	**15th MP**			
People	2. Malaysia Water Wise & Smart Citizen	1. Smart Citizen - The Great Urban Challenge (Phase 1) i.e., focusing on existing occupancies of residents/ businesses	1. Installation of smart water devices that enable existing users to self-manage and maintain autonomous water systems at building, community & cluster level 2. Provide incentives to citizen to encourage sustainable usage of smart water devices 3. Provide incentives for marketing of smart water devices and relevant training	KASA & MOU							1000			2026 - 2030: Focus on the Phase 1		Peope
		3. Smart Water & Smart Citizen (Development Framework)	1. Establishment of new policies that govern future smart homes / smart buildings to ensure new development projects that enable adaptation and adoption of greater autonomy and smaller-scale applications in water collection, storage, treatment, and distribution in new development projects	KASA & MOU								5000		14th MP-15th MP: National programme - entire Malaysia		

Draft WST2040 Budget Requirements

Focus Area	NIWRMP Strategies			11th MP Strategies							WST2040 Strategies				
	Water as a Resource/Water Security and Sustainability				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
People		4. Smart Water & Smart Citizen (Implementation Phase)	1. 70 precent of self-sufficient level (SSL) achieved	KASA & MOU									5000	14th MP-15th MP: National programme - entire Malaysia	
Information & RDCI	1. Digitalize all existing manual water ecosystem (i.e., hardware, software, peopleware)	1. Upgrade to full system, application, and technology development (digitalization) like water supply, water treatment, water health, water sewerage, ground water, smart meter, GIS, etc. 2. Redesign the water ecosystem to be more supportive of digitilisation	1. Talent grooming program inclusive of transformational existing talents into roles and functions that support digitilisation at all levels 2. Standardize roll out program supporting digitilisation	KASA & MOU	2000	2000	2000	2000	2000	10000	5000	2000	2000	2023	

Draft WST2040 Budget Requirements

Focus Area	NIWRMP Strategies		11th MP Strategies								WST2040 Strategies				
Focus Area	Water as a Resource/Water Security and Sustainability														
	Strategy	Initiatives	Programmes/ Activities	Lead Ministry/ Organisation	Budget (RM '000,000)									Target Completion	Remarks
					2021	2022	2023	2024	2025	Total 12th MP	13th MP	14th MP	15th MP		
People	2. Big Data Analytic & Water Data Bank	Data sharing & Integration Framework	2. Centralize platform and database (Dashboard, KPI Management, Operation Tactical and Planning, Asset Management, Maintenance Planning, Reporting, etc) 3. Optimize the existing system like NAWABS, NaFFWS, etc 4. Business intelligence (BI) tools to improving strategic decision-making and providing a competitive advantage.	KASA & MOU	40	40	40	40	40	200	500			2023	
Peope															

Draft WST2040 Budget Requirements

Focus Area	NIWRMP Strategies	11th MP Strategies	WST2040 Strategies											
Information & RDCI	Water as a Resource/Water Security and Sustainability													
Focus Area	Strategy	Initiatives	Programmes/ Activities	Lead Ministry/ Organisation	Budget (RM '000,000)								Target Completion	Remarks
					2021	2022	2023	2024	2025	Total 12th MP	13th MP	14th MP	15th MP	
Information & RDCI	3. Platform for infrastructure (including infostructure) that caters for IR4.0 for water sub-sectors	1. Roll out 4G & 5G for the entire Malaysia in phases to identify, standardize and achieve seamless technological upgrade 2. Cloud computing & virtualization platform 3. Smart Water Management Framework & Integrated Operational Data Centre	1. Review and strengthening the 4G/5G for the nation 2. Improving and expanding network services & coverage 3. Hyper-scale computing infrastructure 1. Establish partnership with local or foreign cloud computing providers 2. Relying on authorised base map produced by JUPEM (rather than too dependent on third party mapping such as Google Map etc.) 3. Initiate collaboration between VAICE as the living lab for IR4.0 in water sub-sectors with institute of higher learning 4. Review and strengthening the 5G / 6G coverage entire Malaysia **Review history of data hub which previously exist including NALIS, NALISA, MyGDI, CASSINI etc.	MCMC	5066	5066	5066	5066	5066	15200	30500	10000	10000	2025	

Draft WST2040 Budget Requirements

Focus Area	NIWRMP Strategies		11th MP Strategies		WST2040 Strategies										
Focus Area	Water as a Resource/Water Security and Sustainability														
					Budget (RM '000,000)										
Focus Area	Strategy	Initiatives	Programmes/ Activities	Lead Ministry/ Organisation	2021	2022	2023	2024	2025	Total 12th MP	13th MP	14th MP	15th MP	Target Completion	Remarks
Information & RDCI	4. Blockchain & Artificial Intelligence Framework	1. Setup taskforce to draft and develop full framework (end-to-end) using blockchain & AI technology in water ecosystem. Blockchain and AI able to effectively allocate water resources; empower consumers by providing economic and social value and incentivize conservation and provide positive environmental outcomes.	1. VAICE to monitor, supervise and consult the taskforce for blockchain and AI initiatives in water industry. 2. Provide means for budget allocation/ grant to agencies to adopt blockchain and AI technologies.	KASA & MOU	40	40	40	40	40	200				2022	

Draft WST2040 Budget Requirements

Focus Area	NIWRMP Strategies			11th MP Strategies								WST2040 Strategies		
	Water as a Resource/Water Security and Sustainability													
					Budget (RM '000,000)									
Focus Area	Strategy	Initiatives	Programmes/ Activities	Lead Ministry/ Organisation	2021	2022	2023	2024	2025	Total 12th MP	13th MP	14th MP	15th MP	Target Completion	Remarks
Information & RDCI	5. Technology advancement	1. Invest in Critical Technology related to Water Recycle and Water Treatment 2. Invest in Critical Technology related to Water Operation & Treatment 3. Invest in Critical Technology related to Water Operation, Supply & Distribution	1. Private & Public Partnership – Digital Strategy and Funding (International & Local) 1. Advanced Technology & Innovation. (Nano-Biotechnology & Intelligent Robots) 2. Private & Public Partnership – Digital Strategy and Funding Programme 1. Expansion of technology and systems to manage and minimise the impact of extreme fluctuations in water availability, including fast shifts from too much water to too little 2. Private & Public Partnership – Digital Strategy and Funding Programme	KASA & MOU	1000	1000	1000	1000	1000	5000	5000	5000	5000	Information & RDCI

Draft WST2040 Budget Requirements

Focus Area		NIWRMP Strategies		11th MP Strategies	WST2040 Strategies										
						Budget (RM '000,000)									
Focus Area	Strategy	Initiatives	Programmes/ Activities	Lead Ministry/ Organisation	2021	2022	2023	2024	2025	Total 12th MP	13th MP	14th MP	15th MP	Target Completion	Remarks
Information & RDCI	6. Water Wise & Smart Cities	1. Water-Efficient Infrastructure & Water-Smart Cities (Phase 1) 2. Water-Efficient Infrastructure & Water-Smart Cities (Phase 2) 3. Shift from end users that pay for the delivery of services to those that pay for the cost of installing and maintaining infrastructures, either individually or collaboratively (**following user income segment)	1. Infrastructure services that enable communities to develop, run and maintain autonomous urban water systems. (Smart City / Smart Home / Smart Building) 2. Technology to monitor and reduce illegal water trade and theft, coupled with a reduction in leakages and wastage across the existing network 3. Development of smart cities shall also focus on advances in decentralised and centralised water storage solutions, coupled with intelligent demand management and higher water recycling and reuse rates	KASA & MOU								5500	5000	2015	

Draft WST2040 Budget Requirements

Focus Area	NIWRMP Strategies	11th MP Strategies	WST2040 Strategies	Water as a Resource/Water Security and Sustainability												
Information & RDCI	Strategy	Initiatives	Programmes/ Activities	Lead Ministry/ Organisation	Budget (RM '000,000)										Target Completion	Remarks
					2021	2022	2023	2024	2025	Total 12th MP	13th MP	14th MP	15th MP			
Information & RDCI		2. Autonomous and community-based water systems (Smart City)	1. Initiation of a taskforce team to drive the autonomous community-based water system inclusive of training, talent development etc.	KASA & MOU								300	5000		2037	

Table 4. Draft WST2040 strategy plan and implementation road map for water for livelihood

Draft WST2040 Strategy Plan and Implementation Road Map										
Focus Area	**NIWRMP Strategies**			**11MP Strategies**			**WST2040 Strategies**			Focus Area
	Water as a Resource/Water Security and Sustainability									
	11MP/12MP/13MP/14MP/15MP									
	Strategy	**Initiatives**	**Programmes/ Activities**	**Hierarchical Level**	**Lead Authority/ Collaborating Partners**	**Implementing Authority**	**Current Status**	**Target Completion**	**Remarks**	
People	1. Establishment of Innovation & Research and Development Centre (Centre of Excellence)	1. Re-skilling & educate business entities to champion IR4.0 in water businesses 2. Re-skilling & educate industry people to understand water digitalisation 3. Development of intellectual capital through smart partnerships 4. Information to stakeholders	1. Create an ecosystem that supports training for IR4.0 amongst industry players (As proposed by AACB) 2. IR4.0 to be inclusive as part of education curriculum (i.e. IPTA/IPTS) in supporting future capacity building for business entities and industries 3. Establish strategic partnerships with entrepreneurs, technocrats via benchmarking exercises	Peninsular, Sabah & Sarawak	KASA & MOU	MOSTI/ MITI, Malaysia Productivity Corporation (MPC), MTDC, UKAS, MQA	On-going	12th MP	Also impacting Water for Livelihood/ water for economic opportunity	People
	2. Malaysia Smart Water & Smart Citizen	1. Smart Citizen - The Great Urban Challenge (Phase 1) i.e., focusing on existing occupancies of residents/ businesses	1. Installation of smart water devices that enable existing users to self-manage and maintain autonomous water systems at building, community & cluster level 2. Provide incentives to citizen to encourage sustainable usage of smart water devices 3. Provide incentives for marketing of smart water devices and relevant training	Peninsular, Sabah & Sarawak	KASA & MOU	MOSTI/MITI, Malaysia Productivity Corporation (MPC), MTDC, UKAS BOMBA, KPKT				
		2. Smart Citizen - The Great Urban Challenge (Phase 2)					On-going	13th MP – 14th MP	Also impacting Water for Livelihood/ water for economic opportunity	

Draft WST2040 Strategy Plan and Implementation Road Map

Focus Area	NIWRMP Strategies		11MP Strategies				WST2040 Strategies		
	Water as a Resource/Water Security and Sustainability								
	11MP/12MP/13MP/14MP/15MP								
Focus Area	Strategy	Initiatives	Programmes/ Activities	Hierarchical Level	Lead Authority/ Collaborating Partners	Implementing Authority	Current Status	Target Completion	Remarks
People		3. Smart Water & Smart Citizen (Development Framework)	1. Establishment of new policies that govern future smart homes / smart buildings to ensure new development projects that enable adaptation and adoption of greater autonomy and smaller-scale applications in water collection, storage, treatment, and distribution in new development projects	Peninsular, Sabah & Sarawak	KASA & MOU	MOSTI/ MITI, Malaysia Productivity Corporation (MPC), MTDC, UKAS, BOMBA, KPKT	On-going	14th MP	3. Smart Water & Smart Citizen (Development Framework)
People		4. Smart Water & Smart Citizen (Implementation Phase)	1. 70 precent of self-sufficient level (SSL) achieved	Peninsular, Sabah & Sarawak	KASA & MOU	MOSTI/MITI, Malaysia Productivity Corporation (MPC), MTDC, UKAS BOMBA, KPKT	On-going	15th MP	4. Smart Water & Smart Citizen (Implementation Phase)

Draft WST2040 Strategy Plan and Implementation Road Map

Focus Area	NIWRMP Strategies			11MP Strategies			WST2040 Strategies			Focus Area
	Water as a Resource/Water Security and Sustainability									
	11MP/12MP/13MP/14MP/15MP									
	Strategy	**Initiatives**	**Programmes/ Activities**	**Hierarchical Level**	**Lead Authority/ Collaborating Partners**	**Implementing Authority**	**Current Status**	**Target Completion**	**Remarks**	
People	1. Establishment of new laws and policies for data sharing 2. Improvement and enhancement of existing laws and policies for data sharing	1. Water to be recognised as a National Security Agenda 2. Amendment of existing laws and policies for data sharing 3. Formulation of Cybersecurity Policy on Data Protection and Data Sharing 4. Data and information on water sector (water resources and water services) to be declared as national security item.	1. Water to be included in National Security Policy 2. Production of Annual Water Security Report 3. Enhancement to PDPA 2010 (Act 709) particularly on (1) the right to access data and data sharing at no costs among government bodies, government agencies and local authorities for national interest and (2) data shared and exchanged amongst the government bodies, government agencies and local authorities must comply with 6 basic lawful rules of information sharing that is necessary, proportionate, relevant, adequate, accurate, timely and secure.	State and National	MKN (JPM)	KASA, DID, DOE, JMG, METMalaysia, MADA, KADA, MOH, MYSA, BBA, JPP, TNB, Water supply operators, IWK, Sewerage Services Operator, DOSM, PLANMalaysia, DOA, JKR, JUPEM, KPLB, KeTSA, JPSM, SFD, FDS, Research institutes Private sectors (e.g. oil palm, rubber estates and sewerage) MINDEF(CDOC), KDN, AGC, MCMC, MOFA, MEIO	On-going	12th MP	As proposed by ISWDC with additional recommendation. Additional Proposal to establish a governing council for quality assurance for IR4.0 IT Architecture Framework.	People
		2. Review of Statistics Act 1965 3. [Amendments to] Statistics Act 1965	1. To propose water and water related data to be included in review of Statistics Act 1965 Amendments to STA 1965 for: 1- inclusion of water related data; 2- development of a systematic mechanism for coordination, reach and cooperation in data sharing; 3- enhancement of existing data for better coordination and readiness of more comprehensive data for the government bodies, government agencies and local authorities to formulate short and long term policies and making decisions for national interest/security.		DOSM (lead)	DOSM (JPM) AGC		1.12th MP	Also impacting Water for Livelihood/ water for economic opportunity	

Draft WST2040 Strategy Plan and Implementation Road Map

Focus Area	Strategy	Initiatives	Programmes/ Activities	Hierarchical Level	Lead Authority/ Collaborating Partners	Implementing Authority	Current Status	Target Completion	Remarks
NIWRMP Strategies / 11MP Strategies / WST2040 Strategies									
Water as a Resource/Water Security and Sustainability									
11MP/12MP/13MP/14MP/15MP									
People		4. Freedom of Information Law	1. Establishment of Freedom of Information Law 2. Formulation of Right to Information legislation and repeal of Official Secrets Act (OSA). To have a very clear understanding that certain exemptions in the OSA are incorporated in the Right to Information legislation. 3. Formulating Freedom of Information Enactments (FOIE) which allows anyone to obtain information owned by the respective state governments except for that information which falls under national security.	National	JPM (AGC)	JPM		1.13th MP	
				All States except for Selangor and Penang	State Legal Advisor & AGC				
		5. Review of Fees Act 1951	1. To establish a circular for zero (0) rate fees under the Fees Act 1951 2. To gazette a Warta Kerajaan on no fee for reproduction, scanning, digitizing of data amongst the government bodies, government agencies and local authorities for national interest 3. Overhaul of Fees Act 1951	National	JPM (AGC)	JPM		1.12th MP	As proposed by ISWDC with additional recommendation.
						AGC		2.12th MP	

Draft WST2040 Strategy Plan and Implementation Road Map

Focus Area	NIWRMP Strategies			11MP Strategies	WST2040 Strategies					Focus Area
	Water as a Resource/Water Security and Sustainability									
	11MP/12MP/13MP/14MP/15MP									
	Strategy	**Initiatives**	**Programmes/ Activities**	**Hierarchical Level**	**Lead Authority/ Collaborating Partners**	**Implementing Authority**	**Current Status**	**Target Completion**	**Remarks**	
People	1. Digitalize all existing manual water ecosystem (i.e., hardware, software, peopleware)	1. Upgrade to full system, application, and technology development (digitalization) like water supply, water treatment, water health, water sewerage, ground water, smart meter, GIS, etc. 2. Redesign the water ecosystem to be more supportive of digitilisation	1. Talent grooming programme inclusive of transformational existing talents into roles and functions that support digitilisation at all levels 2. Standardize roll out programme supporting digitilisation	Peninsular, Sabah & Sarawak	KASA & MOU State Legal Advisor & AGC	State Water Operators MITI, MQA, MBOT, CIDB	Ongoing	12th MP - 13th MP	Also impacting Water for Livelihood/ water for economic opportunity	People
	2. Big Data Analytic & Data Warehouse	Data sharing & Integration Framework	1. Cloud computing & virtualisation platform. 2. Centralize platform and database (Dashboard, KPI Management, Operation Tactical and Planning, Asset Management, Maintenance Planning, Reporting, etc) 3. Optimize the existing system like NAWABS, NaFFWS, etc 4. Business intelligence (BI) tools to improving strategic decision-making and providing a competitive advantage.	Peninsular, Sabah & Sarawak	KASA & MOU	MAMPU		12th MP - 13th MP	Also impacting Water for Livelihood/ water for economic opportunity	
	3. Platform for infrastructure (including infostructure) that caters for IR4.0 for water sub-sectors	1. Roll out 4G & 5G for the entire Malaysia in phases to identify, standardize and achieve seamless technological upgrade 2. Cloud computing & virtualization platform 3. Smart Water Management Framework & Integrated Operational Data Centre	1. Review and strengthening the 4G/5G for the nation 2. Improving and expanding network services & coverage 3. Hyper-scale computing infrastructure	Peninsular, Sabah & Sarawak	KASA & MOU	KASA		12th MP		

Draft WST2040 Strategy Plan and Implementation Road Map

Focus Area	Strategy	Initiatives	Programmes/ Activities	Hierarchical Level	Lead Authority/ Collaborating Partners	Implementing Authority	Current Status	Target Completion	Remarks
	NIWRMP Strategies		11MP Strategies					WST2040 Strategies	
	Water as a Resource/Water Security and Sustainability								
	11MP/12MP/13MP/14MP/15MP								
People			People						
People	4. Blockchain & Artificial Intelligence Framework	4. Roll out 5G & 6G entire Malaysia	1. Establish partnership with local or foreign cloud computing providers 2. Relying on authorised base map produced by JUPEM (rather than too dependent on third party mapping such as Google Map etc.) 3. Initiate collaboration between VAICE as the living lab for IR4.0 in water sub-sectors with institute of higher learning 4. Review and strengthening the 5G / 6G coverage entire Malaysia **Review history of data hub which previously exist including NALIS, NALISA, MyGDI, CASSINI etc.	Peninsular, Sabah & Sarawak	MCMC & MOU State Legal Advisor & AGC	KASA		12th MP	
		1. Setup taskforce to draft and develop full framework (end-to-end) using blockchain & AI technology in water ecosystem. Blockchain and AI able to effectively allocate water resources; empower consumers by providing economic and social value and incentivise conservation and provide positive environmental outcomes.	1. VAICE to monitor, supervise and consult the taskforce for blockchain and AI initiatives in water industry. 2. Provide means for budget allocation/ grant to agencies to adopt blockchain and AI technologies.	Peninsular, Sabah & Sarawak	KASA & MOU	MOSTI, MAMPU		12th MP	
	5. Technology advancement	1. Invest in Critical Technology related to Water Recycle and Water Treatment 2. Invest in Critical Technology related to Water Operation & Treatment	1. Private & Public Partnership – Digital Strategy and Funding (International & Local) 2. Advanced Technology & Innovation. (Nano-Biotechnology & Intelligent Robots) 3. Private & Public Partnership – Digital Strategy and Funding Programme	Peninsular, Sabah & Sarawak	KASA & MOU	KASA		13th MP 14th MP	

Draft WST2040 Strategy Plan and Implementation Road Map

Focus Area	Strategy	Initiatives	Programmes/ Activities	Hierarchical Level	Lead Authority/ Collaborating Partners	Implementing Authority	Current Status	Target Completion	Remarks
				NIWRMP Strategies / **11MP Strategies** / **WST2040 Strategies**					
				Water as a Resource/Water Security and Sustainability					
				11MP/12MP/13MP/14MP/15MP					
Information & RDCI	6. Water Wise & Smart Cities	3. Invest in Critical Technology related to Water Operation, Supply & Distribution	1. Expansion of technology and systems to manage and minimise the impact of extreme fluctuations in water availability, including fast shifts from too much water to too little 2. Private & Public Partnership – Digital Strategy and Funding Programme	Peninsular, Sabah & Sarawak	KASA	MITI, MAMPU, MOFA, MDEC, MaGIC		15th MP	
		1. Water-Efficient Infrastructure & Water-Smart Cities (Phase 1) 2. Water-Efficient Infrastructure & Water-Smart Cities (Phase 2) 3. Shift from end users that pay for the delivery of services to those that pay for the cost of installing and maintaining infrastructures, either individually or collaboratively (**following user income segment)	1. Infrastructure services that enable communities to develop, run and maintain autonomous urban water systems. (Smart City / Smart Home / Smart Building) 2. Technology to monitor and reduce illegal water trade and theft, coupled with a reduction in leakages and wastage across the existing network 3. Development of smart cities shall also focus on advances in decentralised and centralised water storage solutions, coupled with intelligent demand management and higher water recycling and reuse rates	Peninsular, Sabah & Sarawak	KASA & MOU **SPRM to maintain integrity within implementation of projects	MOSTI, KPKT		14th MP	
		2. Autonomous and community-based water systems (Smart City)	1. Initiation of a taskforce team to drive the autonomous community-based water system inclusive of training, talent development etc.	Peninsular, Sabah & Sarawak	KASA & MOU **SPRM to maintain integrity within implementation of projects	MOSTI, KPKT		15th MP	

Table 5. Draft WST2040 budget requirements for water for livelihood

Draft WST2040 Budget Requirements															
Focus Area	NIWRMP Strategies			11th MP Strategies						WST2040 Strategies					Focus Area
	Water as a Resource/Water Security and Sustainability														
	Strategy	**Initiatives**	**Programmes/ Activities**	**Lead Ministry/ Organisation**	**Budget (RM '000,000)**									**Target Completion**	**Remarks**	
					2021	**2022**	**2023**	**2024**	**2025**	**Total 12th MP**	**13th MP**	**14th MP**	**15th MP**			
People	1. Establishment of innovation & Research and Development Centre (Centre of Excellence)	1. Re-skilling & educate business entities to champion IR4.0 in water businesses 2. Re-skilling & educate industry people to understand water digitalisation 3. Development of intellectual capital through smart partnerships 4. Information to stakeholders	1. Create an ecosystem that supports training for IR4.0 amongst industry players (As proposed by AACB) 2. IR4.0 to be inclusive as part of education curriculum (i.e. IPTA/ IPTS) in supporting future capacity building for business entities and industries 3. Establish strategic partnerships with entrepreneurs, technocrats via benchmarking exercises	KASA & MOU	30	50	70	100	150	300	500	500	500	2022: Complete 1 CoE under MOSTI/ ASM 2023 - 2025: Create multiple CoE with different modules and water segment.	Need to allocate some budget to maintain the CoE operation for 13-15MP	Peope

Draft WST2040 Budget Requirements

Focus Area	NIWRMP Strategies	11th MP Strategies	WST2040 Strategies	Water as a Resource/Water Security and Sustainability												
Focus Area	Strategy	Initiatives	Programmes/ Activities	Lead Ministry/ Organisation	Budget (RM '000,000)										Target Completion	Remarks
					2021	2022	2023	2024	2025	Total 12th MP	13th MP	14th MP	15th MP			
People	2. Malaysia Water Wise & Smart Citizen	1. Smart Citizen - The Great Urban Challenge (Phase 1) i.e., focusing on existing occupancies of residents/ businesses	1. Installation of smart water devices that enable existing users to self-manage and maintain autonomous water systems at building, community & cluster level 2. Provide incentives to citizen to encourage sustainable usage of smart water devices 3. Provide incentives for marketing of smart water devices and relevant training	KASA & MOU							1000			2026 - 2030: Focus on the Phase 1		
		3. Smart Water & Smart Citizen (Development Framework)	1. Establishment of new policies that govern future smart homes / smart buildings to ensure new development projects that enable adaptation and adoption of greater autonomy and smaller-scale applications in water collection, storage, treatment, and distribution in new development projects	KASA & MOU								5000		14th MP-15th MP: National programme - entire Malaysia		

Draft WST2040 Budget Requirements

Focus Area	NIWRMP Strategies			11th MP Strategies								WST2040 Strategies		
				Water as a Resource/Water Security and Sustainability										
						Budget (RM '000,000)								
Focus Area	Strategy	Initiatives	Programmes/ Activities	Lead Ministry/ Organisation	2021	2022	2023	2024	2025	Total 12th MP	13th MP	14th MP	15th MP	Target Completion	Remarks
People		4. Smart Water & Smart Citizen (Implementation Phase)	1. 70 precent of self-sufficient level (SSL) achieved	KASA & MOU									5000	14th MP-15th MP: National programme - entire Malaysia	
Information & RDCI	1. Digitalize all existing manual water ecosystem (i.e., hardware, software, peopleware)	1. Upgrade to full system, application, and technology development (digitalization) like water supply, water treatment, water health, water sewerage, ground water, smart meter, GIS, etc. 2. Redesign the water ecosystem to be more supportive of digitilisation	1. Talent grooming program inclusive of transformational existing talents into roles and functions that support digitilisation at all levels 2. Standardize roll out program supporting digitilisation	KASA & MOU	2000	2000	2000	2000	2000	10000	5000	2000	2000	2023	

Draft WST2040 Budget Requirements																
Focus Area	NIWRMP Strategies			11th MP Strategies						WST2040 Strategies						Focus Area
	Water as a Resource/Water Security and Sustainability															
	Strategy	Initiatives	Programmes/ Activities	Lead Ministry/ Organisation	Budget (RM '000,000)									Target Completion	Remarks	
					2021	2022	2023	2024	2025	Total 12th MP	13th MP	14th MP	15th MP			
People	2. Big Data Analytic & Water Data Bank	Data sharing & Integration Framework	2. Centralize platform and database (Dashboard, KPI Management, Operation Tactical and Planning, Asset Management, Maintenance Planning, Reporting, etc) 3. Optimize the existing system like NAWABS, NaFFWS, etc 4. Business intelligence (BI) tools to improving strategic decision-making and providing a competitive advantage.	KASA & MOU	40	40	40	40	40	200	500			2023		Peope

Draft WST2040 Budget Requirements

Focus Area	NIWRMP Strategies		Water as a Resource/Water Security and Sustainability												WST2040 Strategies	
						11th MP Strategies										
						Budget (RM '000,000)										
Focus Area	Strategy	Initiatives	Programmes/ Activities	Lead Ministry/ Organisation	2021	2022	2023	2024	2025	Total 12th MP	13th MP	14th MP	15th MP	Target Completion	Remarks
Information & RDCI	3. Platform for infrastructure (including infostructure) that caters for IR4.0 for water sub-sectors	1. Roll out 4G & 5G for the entire Malaysia in phases to identify, standardize and achieve seamless technological upgrade 2. Cloud computing & virtualization platform 3. Smart Water Management Framework & Integrated Operational Data Centre	1. Review and strengthening the 4G/5G for the nation 2. Improving and expanding network services & coverage 3. Hyper-scale computing infrastructure 1. Establish partnership with local or foreign cloud computing providers 2. Relying on authorised base map produced by JUPEM (rather than too dependent on third party mapping such as Google Map etc.) 3. Initiate collaboration between VAICE as the living lab for IR4.0 in water sub-sectors with institute of higher learning 4. Review and strengthening the 5G / 6G coverage entire Malaysia **Review history of data hub which previously exist including NALIS, NALISA, MyGDI, CASSINI etc.	MCMC	5066	5066	5066	5066	5066	15200	30500	10000	10000	2025	

Draft WST2040 Budget Requirements

Focus Area	NIWRMP Strategies			11th MP Strategies						WST2040 Strategies					
	Water as a Resource/Water Security and Sustainability														
					Budget (RM '000,000)										
Focus Area	Strategy	Initiatives	Programmes/ Activities	Lead Ministry/ Organisation	2021	2022	2023	2024	2025	Total 12th MP	13th MP	14th MP	15th MP	Target Completion	Remarks
Information & RDCI	4. Blockchain & Artificial Intelligence Framework	1. Setup taskforce to draft and develop full framework (end-to-end) using blockchain & AI technology in water ecosystem. Blockchain and AI able to effectively allocate water resources; empower consumers by providing economic and social value and incentivize conservation and provide positive environmental outcomes.	1. VAICE to monitor, supervise and consult the taskforce for blockchain and AI initiatives in water industry. 2. Provide means for budget allocation/ grant to agencies to adopt blockchain and AI technologies.	KASA & MOU	40	40	40	40	40	200				2022	

Draft WST2040 Budget Requirements

Focus Area	NIWRMP Strategies		11th MP Strategies								WST2040 Strategies				
			Water as a Resource/Water Security and Sustainability												
					Budget (RM '000,000)										
Focus Area	Strategy	Initiatives	Programmes/ Activities	Lead Ministry/ Organisation	2021	2022	2023	2024	2025	Total 12th MP	13th MP	14th MP	15th MP	Target Completion	Remarks
Information & RDCI	5. Technology advancement	1. Invest in Critical Technology related to Water Recycle and Water Treatment 2. Invest in Critical Technology related to Water Operation & Treatment 3. Invest in Critical Technology related to Water Operation, Supply & Distribution	1. Private & Public Partnership – Digital Strategy and Funding (International & Local) 1. Advanced Technology & Innovation. (Nano-Biotechnology & Intelligent Robots) 2. Private & Public Partnership – Digital Strategy and Funding Programme 1. Expansion of technology and systems to manage and minimise the impact of extreme fluctuations in water availability, including fast shifts from too much water to too little 2. Private & Public Partnership – Digital Strategy and Funding Programme	KASA & MOU	1000	1000	1000	1000	1000	5000	5000	5000	5000		
Information & RDCI															

Draft WST2040 Budget Requirements

Focus Area	NIWRMP Strategies			11th MP Strategies								WST2040 Strategies		
Focus Area	Water as a Resource/Water Security and Sustainability													
Information & RDCI	Strategy	Initiatives	Programmes/ Activities	Lead Ministry/ Organisation	Budget (RM '000,000)								Target Completion	Remarks
					2021	2022	2023	2024	2025	Total 12th MP	13th MP	14th MP	15th MP	
	6. Water Wise & Smart Cities	1. Water-Efficient Infrastructure & Water-Smart Cities (Phase 1) 2. Water-Efficient Infrastructure & Water-Smart Cities (Phase 2) 3. Shift from end users that pay for the delivery of services to those that pay for the cost of installing and maintaining infrastructures, either individually or collaboratively (**following user income segment)	1. Infrastructure services that enable communities to develop, run and maintain autonomous urban water systems. (Smart City / Smart Home / Smart Building) 2. Technology to monitor and reduce illegal water trade and theft, coupled with a reduction in leakages and wastage across the existing network 3. Development of smart cities shall also focus on advances in decentralised and centralised water storage solutions, coupled with intelligent demand management and higher water recycling and reuse rates	KASA & MOU								5500	5000	2015	

Draft WST2040 Budget Requirements

Focus Area		NIWRMP Strategies		11th MP Strategies	WST2040 Strategies										
Information & RDCI	Water as a Resource/Water Security and Sustainability	Strategy	Initiatives	Programmes/ Activities	Lead Ministry/ Organisation	Budget (RM '000,000)								Target Completion	Remarks
						2021	2022	2023	2024	2025	Total 12th MP	13th MP	14th MP	15th MP	
Information & RDCI	Water as a Resource/Water Security and Sustainability		2. Autonomous and community-based water systems (Smart City)	1. Initiation of a taskforce team to drive the autonomous community-based water system inclusive of training, talent development etc.	KASA & MOU								300	5000	2037	

5.5 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

The IR 4.0 for water sub-sectors shall be utilised as an economic tool towards transforming the water sector into a dynamic new economic sector capable of driving the Nation's GDP growth in the future. Some examples include measurement of organic loading for environmental tax. Some though process in this regard also include tangible and intangible outputs, whereby cost saving in operations may serve the government some savings for maintenance following the economic drag effect as a return of investment in IR 4.0 and digitalization for the sector. It is projected that by committing Langkawi Island as a whole water catchment will transform the island into an attractive hub for national water balancing model attracting more investment to the area. With water reliability Langkawi Island would be more self-sustenance with projections of downstream and ancillary businesses for water and wastewater sector. These strategies may be enhanced via utilisation of the proposed IR4.0 for the water spectrum.

5.5.1 Provide a Table listing the Ministries, Agencies, CSOs consulted, including dates, venues and attendance (on-line or physical)

Table 6 summarises the consultations undertaken throughout this project thus far.

Table 6. Listing of consultations with stakeholders and experts

No	Description of Activity	Ministry/Agency/CSOs/NGOs	Mode of Activity	Date
1	Data collection and consolidation-Part	Kementerian Alam Sekitar dan Air (KASA) Suruhanjaya Perkhidmatan Air Negara (SPAN) Pengurusan Aset Air Berhad (PAAB) Jabatan Pengairan dan Saliran (JPS) Jabatan Mineral dan Geosains, Malaysia (JMG) Malaysia Green Technology Centre (MGTC) Malaysian Water Engineers Action Committee (MyWAC) Indah Water Konsortium (IWK)	Physical Meeting	24/12/2020
2	Data collection and consolidation-Part 2	Kementerian Alam Sekitar dan Air (KASA) Suruhanjaya Perkhidmatan Air Negara (SPAN) Pengurusan Aset Air Berhad (PAAB) Jabatan Pengairan dan Saliran (JPS) Jabatan Mineral dan Geosains, Malaysia (JMG) Malaysia Green Technology Centre (MGTC) Malaysian Water Engineers Action Committee (MyWAC)	Virtual Meeting	16/2/2021

(*Continued*)

		Indah Water Konsortium (IWK) National Hydraulic Research Institute of Malaysia (NAHRIM) MIMOS Berhad		
3	Presentation on Road map to WST2040 to German Embassy	German Water Partnership	Virtual meeting	3/3/2021
4	Focus Group Discussion with Jabatan Pengairan dan Saliran on NAWABS System	Jabatan Pengairan dan Saliran (JPS) Team	Virtual meeting	11/3/2021
5	Focus Group Discussion with Jabatan Mineral & Geosains, Malaysia on Big Data Analytics Groundwater (GroW)	Jabatan Mineral & Geosains (JMG) Team	Virtual meeting	14/3/2021
6	Presentation on Road map to WST2040 to Regional Director of Internation Water Association	International Water Association (IWA	Virtual meeting	26/3/2021
7	Webinar on IR 4.0 Water for Sub-sectors: An International Water Association Experience	Invitation extended to KASA, SPAN, PAAB, JPS, JMG, NAHRIM, MGTC, IWK, MyWAC, all Task Force Chair and WST2040 Project Management Committee	Virtual meeting	29/4/2021
8	Webinar on IR 4.0 Water for Sub-sectors: The German Experience	Experts from Germany Invitation extended to KASA, SPAN, PAAB, JPS, JMG, NAHRIM, MGTC, IWK, MyWAC, all Task Force Chair and WST2040 Project Management Committee	Virtual meeting	5-7/5/2021
9	Virtual Workshop on IR 4.0 Water for Sub-sectors: Experts Engagement	Kementerian Alam Sekitar dan Air (KASA) Virtual W/shop Suruhanjaya Perkhidmatan Air Negara (SPAN) Pengurusan Aset Air Berhad (PAAB) Jabatan Pengairan dan Saliran (JPS) Jabatan Mineral dan Geosains, Malaysia (JMG) Malaysia Green Technology Centre (MGTC) Malaysian Water Engineers Action Committee (MyWAC) Indah Water Konsortium (IWK) MIMOS Berhad Economic Planning Unit (EPU) Kementerian Pertanian & Industri Makanan (MAFI) Kementerian Utiliti Sarawak (MOU) Kementerian Perumahan dan Kerajaan Tempatan (KPKT) Kementerian Pembangunan Luar Bandar (KPLB) Agensi Pengurusan Bencana Negara (NADMA)	Virtual W/shop	7/6/2021 - 11/6/2021

(*Continued*)

		Jabatan Bomba dan Penyelamat Malaysia (BOMBA) Institut Penyelidikan dan Kemajuan Pertanian Malaysia (MARDI) Kemajuan Pekebun Kecil Perusahaan Getah (RISDA) Rancangan Tempatan Seberang Perai (RTSP) Butterworth Jabatan Pengairan Saliran (JPS) Langkawi Federation of Malaysian Consumer Association (FOMCA)		
10	Focus Group Discussion	Jabatan Pertanian Sabah Jabatan Perikanann Sabah Jabatan Pengairan Sabah	Virtual Meeting	10/5/2021
10	Virtual Workshop on IR4.0 Water for Sub-sectors: Experts Engagement	Kementerian Alam Sekitar dan Air (KASA) Suruhanjaya Perkhidmatan Air Negara (SPAN) Pengurusan Aset Air Berhad (PAAB) Jabatan Pengairan dan Saliran (JPS) Jabatan Mineral dan Geosains, Malaysia (JMG) Malaysia Green Technology Centre (MGTC) Malaysian Water Engineers Action Committee (MyWAC) Indah Water Konsortium (IWK) MIMOS Berhad Economic Planning Unit (EPU) Kementerian Pertanian & Industri Makanan (MAFI) Kementerian Utiliti Sarawak (MOU) Kementerian Perumahan dan Kerajaan Tempatan (KPKT) Kementerian Pembangunan Luar Agensi Pengurusan Bencana Negara (NADMA) Jabatan Bomba dan Penyelamat Malaysia (BOMBA) Institut Penyelidikan dan Kemajuan Pertanian Malaysia (MARDI) Kemajuan Pekebun Kecil Perusahaan Getah (RISDA) Rancangan Tempatan Seberang Perai (RTSP) Butterworth Jabatan Pengairan Saliran (JPS) Langkawi Federation of Malaysian Consumer Association (FOMCA)	Virtual W/shop	7/6/2021 - 11/6/2021
11	Stakeholders' Engagement Sabah &Sarawak-Phase II	Jabatan Perkhidmatan Pembetungan Sarawak (JPP Sarawak) Jabatan Pengairan Saliran (JPS) Sarawak	Virtual Meeting	23/7/2021

(*Continued*)

		Majlis Biodiversiti & Sumber Air Sabah (MBSA) Jabatan Ketua Menteri Jabatan Pengairan Saliran (JPS) Sabah Jabatan Perkhidmatan Pembetungan Sabah (JPP Sabah) Jabatan Bekalan Air Luar Bandar (JBALB Sarawak)		
12	Stakeholders' Engagement IT Personnel	Kementerian Sains, Teknologi & Inovasi Unit (MOSTI) Unit Pemodenan Tadbiran & Perancangan Pengurusan Malaysia (MAMPU) Kementerian Alam Sekitar & Air (KASA) Kementerian Utiliti Sarawak (MOU) Jabatan Pengairan & Saliran (JPS) Jabatan Mineral & Geosains Malaysia (JMG) Indah Water Konsortium Sdn Bhd (IWK) Jabatan Alam Sekitar (JAS) Suruhanjaya Perkhidmatan Air Negara (SPAN) Pengurusan Aset Air Berhad (PAAB) MIMOS Berhad Malaysian Green Technology Corporation (MGTC) National Hydraulic Research Institute of Malaysia (NAHRIM) Syarikat Air Darul Aman Sdn Bhd (SADA) Langkawi Development Authority (LADA) Air Kelantan Sdn Bhd (AKSB) Jabatan Air Negeri Sabah (JANS) LAKU Management Sdn Bhd. Sarawak Perbadanan Bekalan Air Pulau Pinang (PBAPP) Bahagian Bekalan Air (BBA) Labuan Pengurusan Air Paip Pahang (PAIP) Sarawak Water Board (SWB)	Virtual Meeting	28/7/2021
13	Stakeholders' Validation Meeting- Part I: Budget, Costing & Road map	Kementerian Sains, Teknologi & Inovasi Unit (MOSTI) Kementerian Alam Sekitar & Air (KASA) Kementerian Utiliti Sarawak (MOU) Jabatan Pengairan & Saliran (JPS) MIMOS Berhad Jabatan Alam Sekitar (JAS) Langkawi Development Authority (LADA) Air Kelantan Sdn Bhd (AKSB) Perbadanan Bekalan Air Pulau Pinang (PBAPP) Jabatan Air Negeri Sabah (JANS)	Virtual Meeting	26/8/2021
14	Stakeholders' Validation Meeting- Part II: Langkawi IT Model	Kementerian Alam Sekitar & Air (KASA) Kementerian Pertanian & Industri Makanan (MAFI) Bahagian Pengairan dan Saliran (BPSA)	Virtual Meeting	13/9/2021

(*Continued*)

		Jabatan Pengairan & Saliran (JPS) Perlis Jabatan Pengairan & Saliran (JPS) Pulau Pinang Jabatan Pengairan & Saliran (JPS) Langkawi Jabatan Pengairan & Saliran (JPS) Syarikat Air Darul Aman Sdn Bhd (SADA) Langkawi Development Authority (LADA) Lembaga Kemajuan Wilayah Kedah (KEDA) Small Medium Industries Corporation Malaysia (SME Corp)		
15	Stakeholders' Validation Meeting-Part III: IT Infrastructure &Technology	Kementerian Sains, Teknologi & Inovasi Unit (MOSTI) Kementerian Alam Sekitar & Air (KASA) Kementerian Pertanian & Industri Makanan (MAFI) Kementerian Utiliti Sarawak (MOU) Jabatan Pengairan & Saliran (JPS) MIMOS Berhad Jabatan Alam Sekitar (JAS) Pengurusan Aset Air Berhad (PAAB) Suruhanjaya Perkhidmatan Air Negara (SPAN) Jabatan Pengairan & Saliran (JPS) Jabatan Mineral & Geosains Malaysia (JMG) Indah Water Konsortium Sdn Bhd (IWK) Syarikat Air Darul Aman Sdn Bhd (SADA) Langkawi Development Authority (LADA) Air Kelantan Sdn Bhd (AKSB) Perbadanan Bekalan Air Pulau Pinang (PBAPP) Bahagian Bekalan Air (BBA) Labuan Jabatan Bekalan Air Negeri Terengganu (JBANT) Jabatan Air Negeri Sabah (JANS)		

5.5.2 Stakeholders IR 4.0 Readiness Assessment for Water Sub-sectors

The first phase of study recorded a total of 49 respondents for the IR 4.0 readiness assessment questionnaires. To date, 68 responses were received which was an increase of 38.8% feedback, following the stakeholders' consultations initiatives.

From the total respondents it was found that 26.5% were involved in customer services, 22.1% government to business, 25% government to government, and the remaining 26.4% represented various categories, as shown in Figure 4.

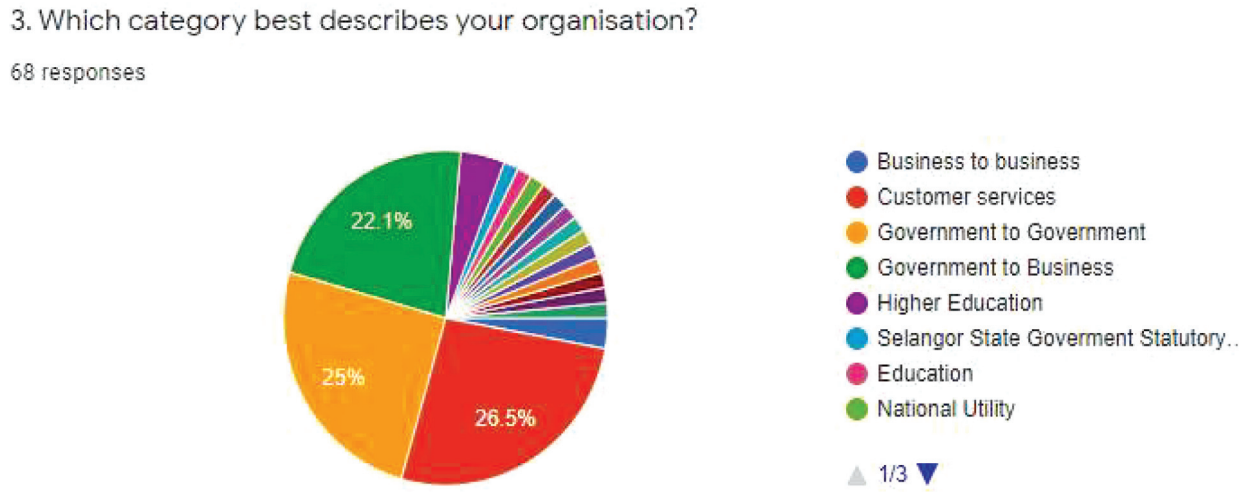

Figure 4. Category best describes the respondents of questionnaires

In terms of readiness, 96% respondents indicated that their organisation has adopted Information Technology (IT) approaches in business practices, whereby the Scada System marked as the highest adopted IT approach at 50.8% followed by telemetry monitoring at 47.6% as demonstrated in Figure 5. This is in agreement with 52.9% of respondents reflected as having moderate understanding on IR 4.0 concept and usage for their business, as shown in Figure 6.

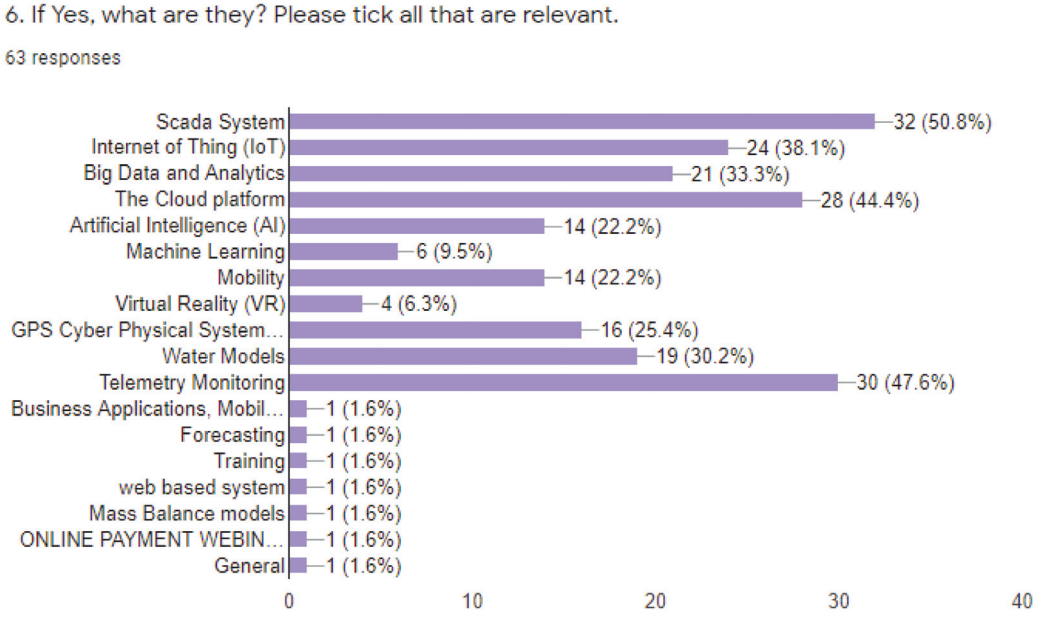

Figure 5. Adopted information technology (IT) approaches in business practices by respondents

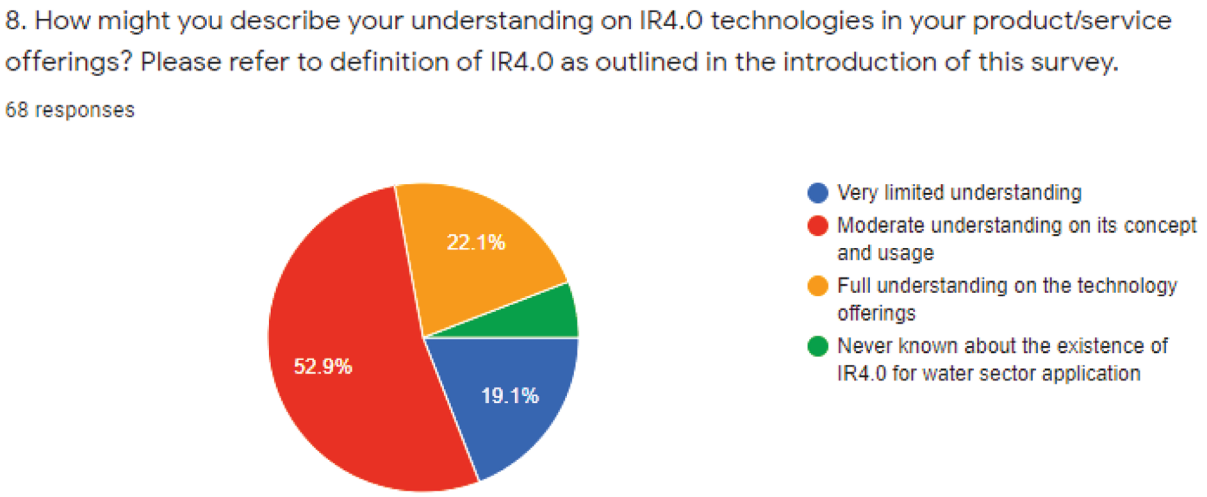

Figure 6. Level of understanding on IR 4.0 technologies in products / service offerings

Based on the overall responses, 52% of respondents have not deployed any of the IR 4.0 approaches indicative of 84% respondents having no benchmarking on any global implementation for IR 4.0 in their business. When asked if they are planning to invest in IR4.0 technologies, 56% stated that they would invest only if it is necessary for the business.

In terms of employees' readiness, 36% stated that no employees possess the skills required to adopt IR 4.0 technologies, while 36% indicated inadequate skills amongs staff. Only 32% of respondents already acquired integrated IT applications while 36% reflected basic IT setup for daily operational system.

5.5.3 Consumer Satisfaction Survey on Raw Water, Wastewater and Water Services in Malaysia

Based on the demographic responses, 68.1% of respondents reside in cities while the rest of communities comprise suburban and rural residents. The "Technology and You" section reflected that over 90% of community is equipped with internet at home while over 80% is receiving public Internet access at their residential areas. In terms of telecommunication services, whereby the Internet Service Provider shall be able to provide reliable internet services, U-Mobile is ranked as the highest subscribed Internet provider at 36.8% followed by companies including Maxis, Telekom Malaysia, DIGI and Celcom. However, only 69% respondents reported the internet coverage as being good and reliable. Only 55% of respondents reported receiving their water bills through online platforms by using mobile phone apps or emails while more than 44% of users remain to use the manual way of receiving water bills, i.e., by mail. Most users are committed to contribute to protecting water bodies for resources, i.e. rivers, rainwater harvesting, sea water etc. The consumers also indicated preference for a mobile app which shall be used for self-monitoring of the safety level of raw water supply and early warning notification in emergency instances at 75% and 72%, accordingly.

More than 95% consumers are receiving wastewater treatment services from Indah Water Konsortium Sdn. Bhd. (IWK) with over 73% are connected to the public sewage treatment plants. Over 60% of consumers demonstrated satisfaction on wastewater services charges provided by the operators.

As for water services, similar percentage of consumers demonstrated of having access to internet services at home or their residential areas. Only 33% of consumers indicated for very satisfied with the water quality that includes odour, colour, volume or amount and taste of water distributed. The water

supply disruption was also investigated, whereby approximately 17% reported two to three days of water supply disruption with 59% of consumers confirming on an unplanned water supply disruptions in their homes or areas. Following this feedback, over 89% of consumers voted for managing their water supply reliability and distribution through mobile apps as one of the key methods for deployment of technology for consumers.

5.5.4 IT Architecture Framework

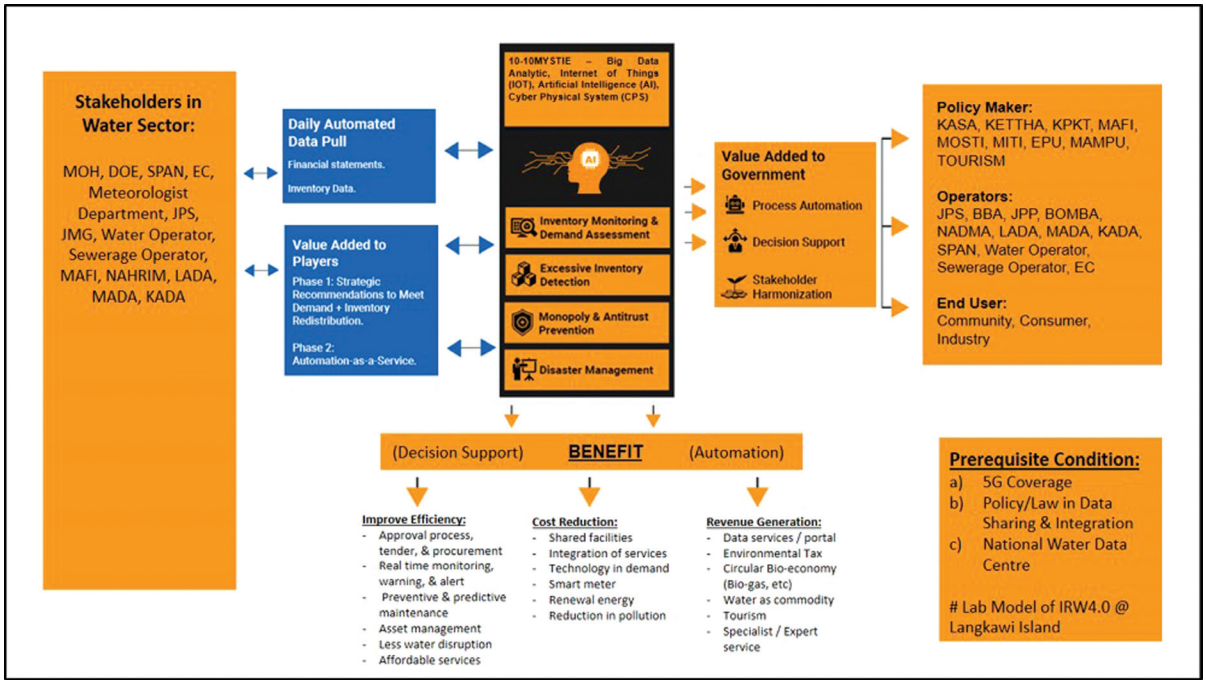

Figure 7. IT architecture framework involving relevant stakeholders and policy makers based on MySTIE

1. IT Architecture Framework

1.1. Summary

In line with the government's intention to transform the water sector into an industry 4.0. There are various efforts that need to be made. Therefore, the government needs to have clear guidelines for this aspiration to be achieved. Therefore, the transformation of the water sector will see from the point of view of IT which will include several important aspects such as key components, standards of procedure, planning, strategies, implementations and testing of the transformation for the improvement.

1.2. Introduction

This framework is designed to support the transformation of the national water sector. It provides a systematic approach to transform Malaysia's water sector into both technology and knowledge-intensive economy. Digital infrastructure such as ICT connectivity, use of big data, AI, seamless integration of multiple digital and data analytic systems amongst others will be introduced. This framework puts digitisation and automation at the centre of a strategy for resource efficient, flexible, and competitive water monitoring and management. It also puts emphasis on the integration of planning and operating processes from user to individual components all the way to the supplier. According to Water 4.0 Made in Germany by the German Water Partnership (GWP), digitalisation in

the water- and wastewater-management sectors holds immense potential. Digital solutions can lead to savings and optimisation in many areas, from data collection, the use of assistance systems, and the networking and integration of individual system components to service decentralisation and even autonomy for whole infrastructure systems.

Digital transformation offers the various water sector and sub-sectors an opportunity to provide reliable and sustainable water supply by optimising distribution systems, treatment efficiency and asset management. It allows the water sub-sectors to explore new ways to enhance productivity and achieve planning and operations efficiency in surface water, groundwater, and wastewater management. Current and future technologies such as data analytics, artificial intelligence and asset management tools can help predict and alert water utilities of potential equipment replacement and rehabilitation issues. Taking preventative actions before equipment failure will minimise total infrastructure lifecycle costs. Working in silos or traditional fragmented approach is no longer viable and a more comprehensive approach of integrated water management is vital. Digital transformation, the implementation of state-of-the art technologies and integration can bring the national water sector to a greater height and drive water as a new growth sector for the country's economy.

Studies conducted by some of the task forces in the various water sub-sectors of the WST2040 found that the use of ICT in Malaysia is low and across many agencies are fragmented. Malaysia does not have a comprehensive approach in water management throughout the water ecosystem. There is limited publicly available water data due to issues with inter-agency data exchange and sharing. Data and statistics collected by Ministries and their respective departments only fulfil their specific functions and operations. There is truly little incentive for cross-organisations data sharing. Despite the Open Data Initiative launched in 2014, there is still a lack of ecosystem for data sharing and data for strategic planning. Users of those data face with issues including outdated data, data provided is not granular and data provided is not always in useful format. This paucity of data impedes financial and investment decision- making where richness of water is not being capitalised and managed for the wealth of the people and nation. Existing water balance management system lacks in essential data such as irrigation demand, domestic water supply demand, mini hydropower requirements, environmental flow, transboundary, and flood mitigation. Inadequate efficient asset management in the custodian of source and treated water with lack of centralised database, resulting in overlapping base map kept by individual agencies has led to poor facility management. Besides, there is also a need for a forecast and early warning system for crisis management and a common GIS platform to promote integration among sectors.

To overcome these problems or challenges a comprehensive, flexible plan and strategy must be made and implemented.

2. Components

Components represent the very building blocks which play major roles for the IT Architecture Framework. Each component dependent to each other and it determine the success of frameworks. The lack of one individual component will affect the framework as a whole and may cripple the whole transformation initiative. Below are the components which already being identified:

i. Stakeholder
ii. Hardware
iii. Software
iv. Data Repository
v. Data Analytic

vi. Data Management
vii. System Integration
viii. IT Architecture
ix. Artificial Intelligence
x. Security
xi. Project Management & Validation
xii. Support & Maintenance
xiii. Policy

2.1. Stakeholder

Stakeholder refers to an individual or organisation that has interest in water sector transformation and they either can affect or be affected with the transformation. Figure 8 gives the types of stakeholders involved:

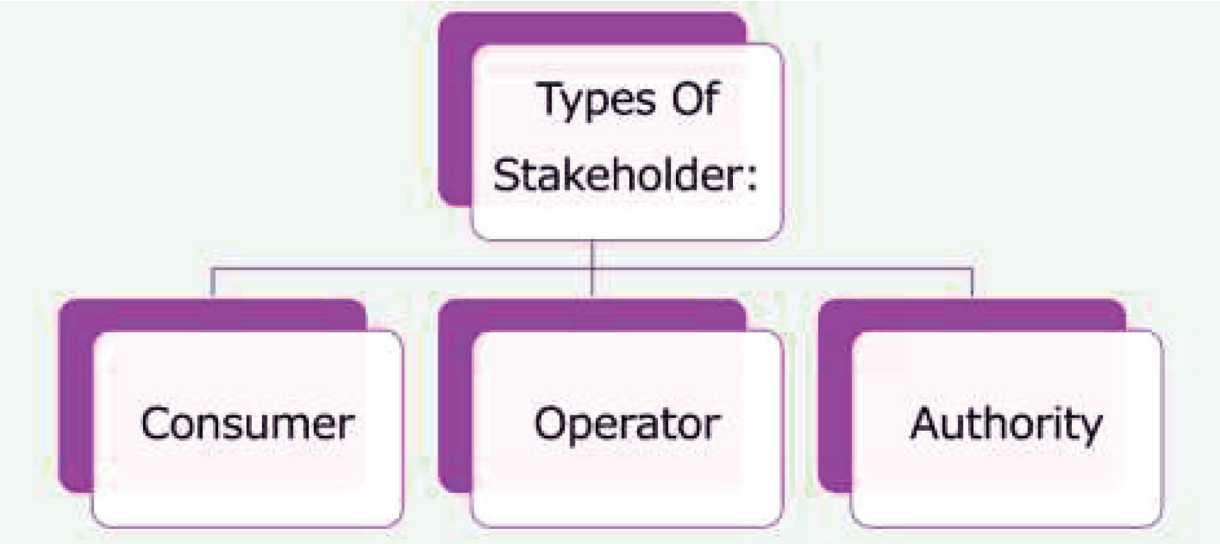

Figure 8.Types of water stakeholder

2.1.1. Consumer

A consumer is a stakeholder who consumes the output of the water sector transformation. There are two type of consumer which are

a. Water and Wastewater Customer which is divided into the following categories:-
   i. Residential
   ii. Commercial / Industry
   iii. Government
b. Any parties that use the output of the water sector to complete a service or product delivery
   i. Government Entities
   ii. Private Sectors

2.1.2. Operator

The operators are the main contributors and consumers of the water transformation sector. There are three types of operator:-

a. Entities that are involved in the management of the water sources such as LUAS, BAKAJ etc. and JPS

b. Entities that are involved in the treatment, production, and distribution of drinking water such as Syarikat Air Darul Aman and Pengurusan Air Selangor
c. Entities that are involved in the treatment of wastewater which are Indah Water Konsortium Sdn. Bhd. (IWK), Jabatan Pembetungan Sabah, and Jabatan Pembetungan Sarawak.

2.1.3. Authority

Authority is the stakeholder that is involved in the policing and regulating of the water and wastewater industry, as well as all the other government entities that manages the other parts of the industry including the management of natural water resources.

2.2. Hardware

Hardware refers to the physical infrastructure installed to a certain location for an operational used. This infrastructure can be divided into two types of infrastructures, and they are:

2.2.1. Water Infrastructure

Water infrastructures such as monitoring stations, water meter, level sensors, piping, valves, well, storage shall be used for water management and monitoring.

2.2.2. IT Infrastructure

IT Infrastructure in water sector is used for the water operation, information storage and for data recording. Such as sensors, servers, smartphones, computers, etc.

2.3. Software

Software is a tool used for operational usage, data monitoring, data recording, and data logging. Software helps ease the task of operational tasks by simplifying existing procedure, there are two types of software, and they are:

2.3.1. Firmware

Firmware is a set of software that come pre-installed in the applications or hardware. This type of software help user to navigate and ease the user operating the machine

2.3.2. System and application

System and application are a third-party application also used to ease the operational task. This type of software is either buy out of the box or customer development based on the current requirements.

2.4. Data Repository

i. Data repository is the component in which all the water related data will be stored. Examples of existing data repository include digital innovation based on existing digital approach in Malaysia i.e. NAWABS, PRABN, DIPAN, BDA and EQMP. The data gathered from the data suppliers will be stored in 3 different type of storage and they are:

- Data Lake – for storing raw unstructured data which is fresh from the source
- Water Data Bank – for storing structured data which can be used for analytic purposes
- Compiled data – for storing pre-process data that can be used for the future operations.

2.5. Data Analytic

Data analytic is a technique where data will be processed to extract latest information that is needed. Data analytics also serves to see patterns that cannot be seen with the naked eye. Below is the list of data analytic techniques:

- Descriptive analysis
- Prescriptive analysis

- Predictive analysis
- Diagnostic analysis.

2.6. Data Management

Data Management is a set of discipline and technique used to ensure the validity of data. There are two techniques used for data management including master data management as shown in Figure 9 and data broker.

- Master Data Management (MDM)

Figure 9. Master data management

- Data Broker

  Data Broker is a mechanism adopted to gather information from various sources; process to enrich, purify or analyse it; and before sharing the data to other agencies.

2.7. System Integration

System integration is one of the most crucial parts of the component as this would allow data from the various sources to be collected and consolidated into the system, as well as to allow the data to be shared to all its stakeholders. The system integration must be capable of interfacing with all the current system that is being used by the various stakeholders that might be communicating in multiple protocols and languages.

The system integration must also be developed using an open standard protocol and to allow ease of integration to the external systems owned by the stakeholder without compromising on security. The system integration will be using API (application programming interface) as its main standard for data sharing with the various stakeholders.

It is where all the data sharing occurred. System integration most of the time was done using Application Programming Interface or called **API.** This **API** is needed at the system which supplies the data.

2.8. IT Architecture

IT Architecture is a component whereby network, system, security, database, and data blueprint will be designed and implemented. This architecture is crucial to determine the robustness of proposed solutions before it is implemented. Type of IT Architecture:

- System Architecture
- Network Architecture
- Data Architecture
- Security Architecture
- Database Architecture

2.9. Artificial Intelligence

Artificial intelligence is a tool used to substitute for human intelligence in performing task. This technology learns from a set of data until it can make its own decision. There are four types of artificial intelligence as shown in Figure 10.

- Reactive AI
- Limited Memory
- Theory of Mind
- Self-aware

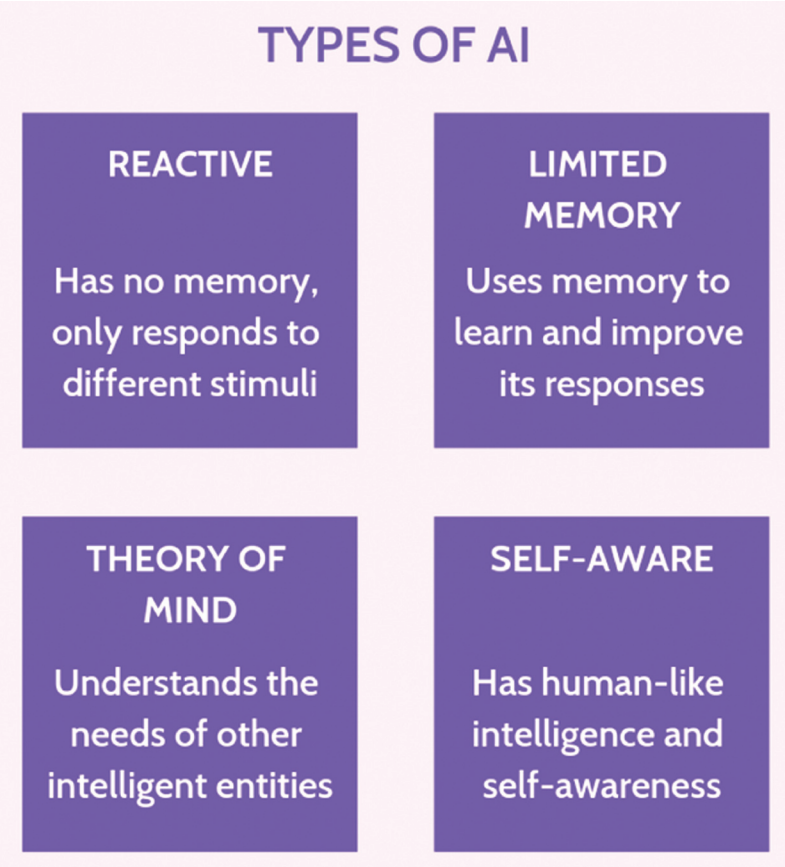

Figure 10. Types of artificial intelligence (AI)

2.10. Security

Water is one of the most important aspects of national security, and the highest standards must be in place to protect this asset especially when industry is going through rapid digitisation under the water transformation sector initiative. This component is further divided into the following:-

- **Cyber Security** – Network security, data protection, system security.
- The parties involved, and the system itself must be developed incompliance with ISO 27001, and other security standard set up by MAMPU.

- **Asset Security** – The protection of asset such as water treatment plant, water damn, piping from threat.
- **Economic Security** – The protection of industry or businesses from foreign takeover either using buyouts or bankruptcy.
- **Personnel Security** – The protection of everyone that involved with the water sector transformation, especially to those that has direct access to the system and data.

2.11. Project Management & Validation

The project management and validation processes include the following components as shown in Figure 11. Table 7 gives the processes description for the project management and management validation processes, respectively.

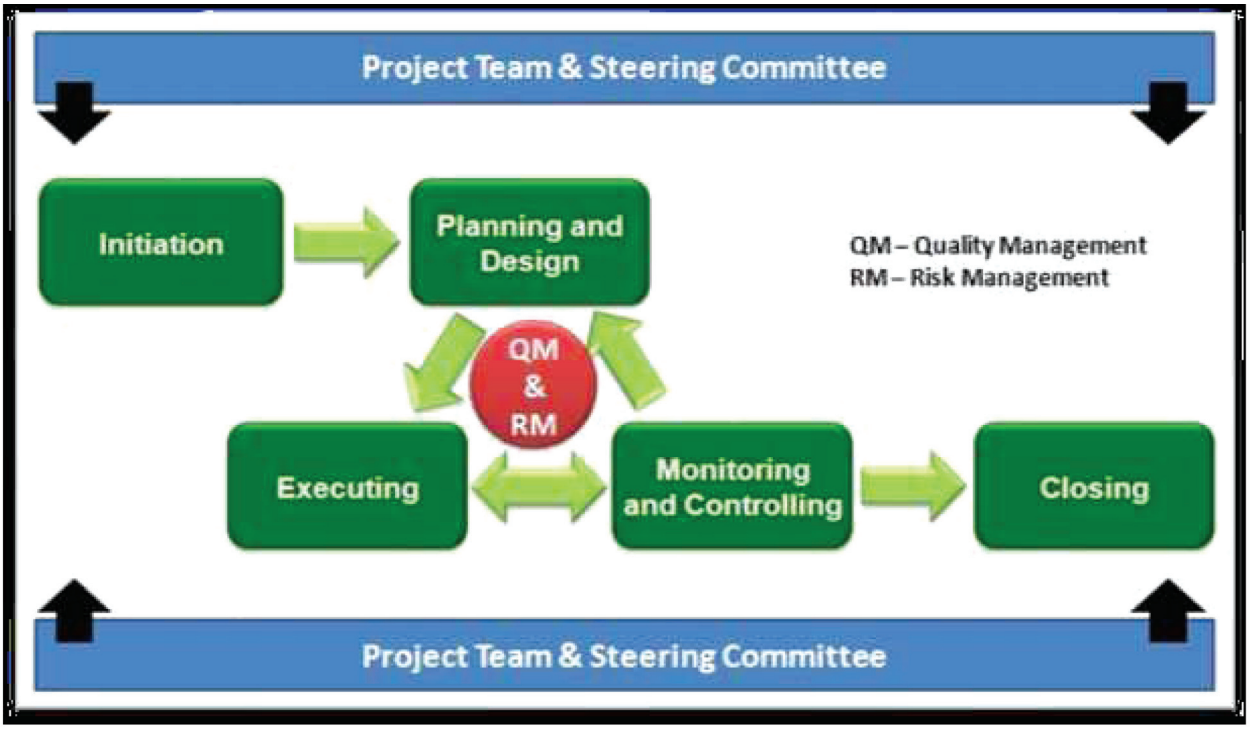

Figure 11. Project management and validation components

2.12. Support & Maintenance

By leveraging the existing experience on existing technologies as well as other technologies along with cost-effective support, this proposed framework will provide the results you expect that is an ICT infrastructure that operates and operates around the clock, is well -managed, secure and more efficient.

The government needs to provide full maintenance and support services, ranging from remedial maintenance, preventive maintenance, telephone support, web-based support, email support, remote support and even specialized maintenance. It is very important to provide excellent support and maintenance services as ensuring the successful operation of all these proposed Information Technology (IT) solutions.

2.13. Policy

Government should focus on the new policy or improve the current policy about the data sharing and integration.

Table 7. Processes description for the project management and management validation processes

Proses	Description
Initiating	The initiation process will determine the nature and scope of the project. This is the stage where the team will analyze and confirm the work required to accomplish the project by defining and agreeing the objectives, scope, and benefits. These are documented in the Project Charter along with the implementation approach, high-level estimates, resources, and infrastructure required to conduct the project.
Planning	At this stage the project is planned to an appropriate level of detail. The main purpose is to plan time and resources adequately to estimate the work needed and to effectively manage risk during project execution.
Executing	Executing consists of the processes used to complete the work defined in the project management plan to accomplish the project's requirements. Execution process involves coordinating people and resources, as well as integrating and performing the activities of the project in accordance with the project management plan.
Monitoring and controlling	Monitoring and controlling consists of those processes performed to observe project execution so that potential problems can be identified in a timely manner and corrective action can be taken, when necessary, to control the execution of the project. This is achieved through both iterative processes (e.g., monthly status reporting) and continuous processes that require attention in a non-scheduled manner. The key benefit is that project performance is observed and measured regularly to identify variances from the project management plan. Monitoring and Controlling includes: • Measuring the ongoing project activities ('where we are'); • Monitoring the project variables (cost, effort, scope, etc.) against the project management plan and the project performance baseline (where we should be); • Identify corrective actions to address issues and risks properly (How can we get on track again); • Influencing the factors that could circumvent integrated change control so only approved changes are implemented This is a key process throughout the implementation project and the expected outputs from this process are: • Bi-Weekly status report • Monthly management report • Minutes of meeting for key project meetings 
Closing	Closing includes the formal acceptance of the project and the ending thereof. Administrative activities include the archiving of the files, documenting lessons learned and transition of project deliverables to operations, disbanding the project and conducting post-implementation reviews.

3. Framework Guideline

Framework guideline is a set of principles to follow when transforming the Water Sector Transformation. It is crucial to ensure that all techniques, methods, and solutions used for the implementation of water sector transformation to adhere to this principle for it to sustain successfully. Below is the list of guidelines:

3.1. Standardisation

One must ensure that all applicable idea, solutions, techniques, method, information, and data are standardised. Due to a lot of integration of the system, infrastructure, network, software, data from difference source into a single platform. Therefore, this will lead to chaos if there is no standardisation.

3.2. Seamless

As there is a lot of integration for the water sector transformation, frictionless transformation is needed to make sure there is no problem that can cause malfunction or severity to the water sector transformation.

3.3. Improvement

Every technique, requirement, solution, implementations, and method should be improvement from the previous one if there is any. This improvement is required for the transformation to be succeed so that it can eliminate all the previous weaknesses.

3.4. Modular

All the solution, techniques, implementation, and method needed to be modular. This is ensured that each component can be easily replaced if there is a need.

3.5. Continuous

All the solution, technique, method, and implementation must have a continuity in mind. With this continuity, each aspect in water sector transformation will have room for improvement and can evolved into something which could benefit the nation.

3.6. Validated

Before implementing solutions to the problem, all solution must undergo reviews and proofing to ensure all solution are validated and can solve the given problem.

3.7. Optimized

When proposing a solution, it is a must ensure that the solution is optimised and does not require excessive amounts of resources, performance to operate. This is to eliminate wastage.

3.8. Phases

Phases is to ensure that each implementation is broken down into small task which can be easily managed or controlled. By having a phase for every implementation, a study could conduct on previous phase for further improvement and new requirements.

3.9. Transparency & Quality

Since for the transformation of water sector consist of multiple stakeholders, hardware, software, data, etc. Transparency is required to ensure that all implementor, stakeholders to get the truthful information. Any entity withholding information or hide information could jeopardise the water sector transformation.

3.10. Robust

Robustness ensures the all the solutions, techniques, method used can withstand any circumstances. This is to ensure any given implementation can work well under all conditions.

3.11. Objective Oriented

Any solution, method, technique, or implementation must be realized objectively. By doing so, all progress of the implementation can be tracked.

3.12. Realistic & Holistic

All implementation, planning, strategy, and test must be able to be executed in the current circumstances (budget, time, and workforce). This is to eliminate underestimate or overestimate the situation.

4. Proposal

4.1. Summary

This section aims to explain about the proposed data sharing platform with the components involved and the architecture that will be built. This document will also describe the data security, systems, and networks that will be built develop during implementation.

This section consists of:

- Stakeholder requirements
- Scope of development and implementation
- Description of the platform to be developed.

4.2. Introduction

4.2.1. Understanding the needs of the government

In line with the intention of the Government vision to transform the national water sector by using the latest information system that can collect, manage, analyse, process and share data to respective agencies and organisations, respectively.

The implementation of the platform can be divided into five cores components, namely:

- Data Hub
- Data Repository
- Registry
- Criteria and Guideline
- Platform Development
- Virtualisation
- Technology

4.3. National Water Data Centre (NawDac) Platform Proposal

To realise the desire to build a data sharing platform between government agencies, a centralised system should be built to connect between government agencies. The platform that needs to be built must use web -based technology, which will make it easier for the system to be accessed through several types of devices at any time.

This platform will act as an **Integrator Application**, where this platform will communicate with other systems using the Application Programming Interface (**API**) as shown in Figure 12 below:

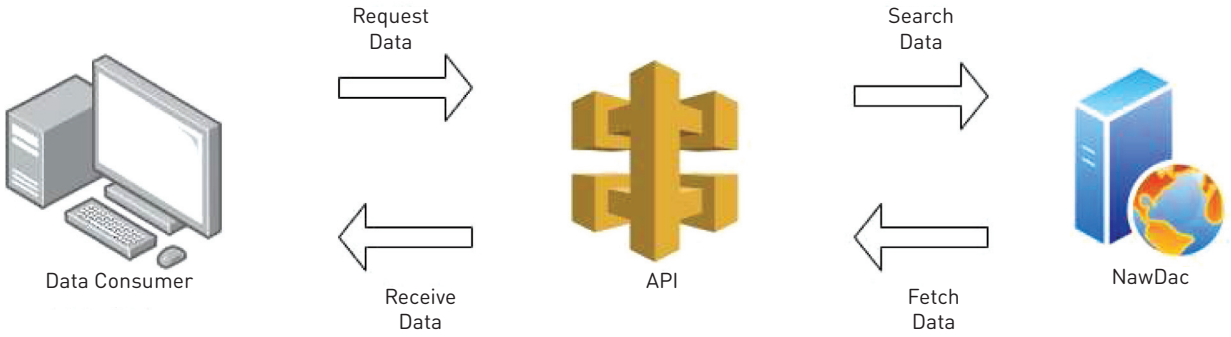

Figure 12. National Water Data Centre (NawDac) Platform Proposal

The main purpose of this platform needs to relate to other systems is to make this Platform as a Data hub, whereby this platform will be the main source of for data collection by government agencies where the data has:

- Data Integrity
- Data Accuracy
- Data validity
- Latest Data
- Real time Data
- Unified Data
- Assisted Decision Making
- Data Pattern
- Data Visualisation

For the development of the National Water Data Centre (**NawDac)**, there are four (4) key thrusts identified as follows:

i. Big Data Analytic
   - Data Hub
   - Data Repository
   - Registry
   - Criteria and Guideline

ii. Artificial Intelligence
   - Reactive AI
   - Limited Memory
   - Theory of Mind
   - Self-aware

iii. Internet of Things (IoT)

iv. Cyber Physical System

NawDac is proposed to be located at the proposed Water Hub as visioned in 15th MP which can be located at NAHRIM. In addition, formation of a dedicated taskforce / steering committee is highly recommended to monitor the development of the IR 4.0 Water Sector Architecture system until the envisioned 15th MP is successfully achieved, including the implementation of IR 4.0 for water sub-sectors.

4.4. Big Data Analytic

4.4.1. Introduction

Big data is a term used to describe a huge volume of data which stored in both structured and unstructured manner. Big data are known as for it 3 v's. Which are:

- Volume – represent the number of data
- Velocity – represent the speed of data growth
- Variety – represent the multitude of data stored in term of format and data type

4.4.2. Data Hub

Data Hub is a platform where all data sharing takes place between agencies under the state of Selangor, these agencies will communicate with each other through the **NawDac** for the purpose of obtaining data as shown in Figure 13 below.

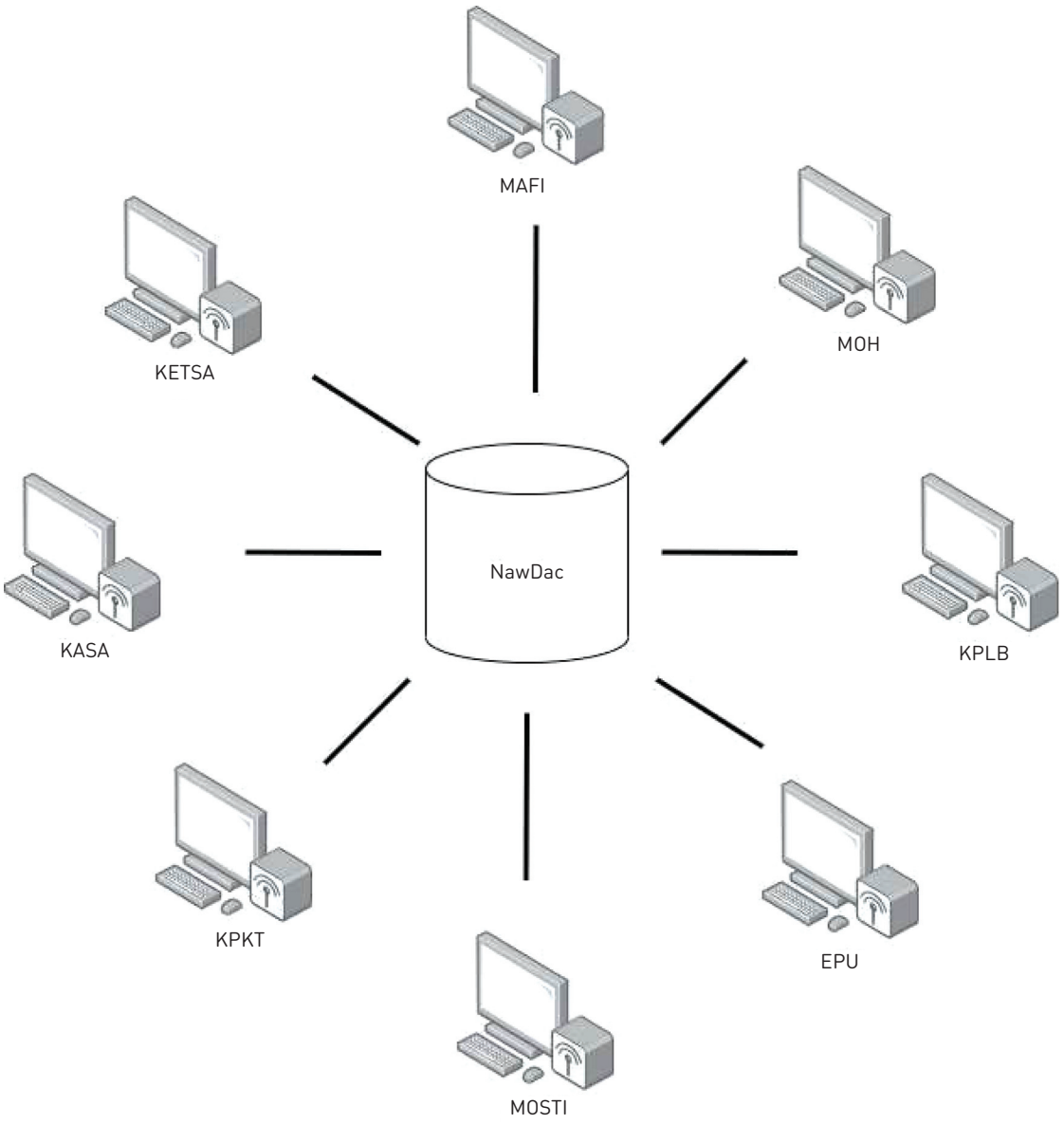

Figure 13. Data Hub as a data sharing platform for water agencies whereby data may be obtained through NawDac

Therefore, the relation between these users can be categorised into two main categories of users, namely:

1. Data Supplier

The user is responsible for supplying the data to the system

2. Data Consumer

Agencies that use the data contained in NawDac

A user can simultaneously be a supplier or consumer according to current needs.

NawDac may be used as a platform for Data Hub and data sharing by incorporating the following components:

1. Information Portal

Information portal is a portal used for the purpose of delivering information on the NawDac system such as:

- About NawDac
- FAQ
- Catalog
- System Documentation
- Contact us
- Announcement

2. Management Portal

- Application and management of data acquisition
- Data Monitoring
- Asset Monitoring
- Agency Management
- Helpdesk
- System Integration Application
- Customer Service

3. Master Data Management

Master Data Management (**MDM**) is one of the techniques required to ensure the validity of data in the NawDac . This technique includes 7 main components as shown in Figure 14, namely:

a. Vision
   Ensure that all planning and processes used must be in line with the main purpose of the NawDac.
b. Strategy
   Have action plans that can ensure that the identified vision can be achieved.
c. Governance
   To ensure that all implementation management can be achieved well and have a long-term effect
d. Roles
   Provide roles and groups that will process MDM based on the planning that has been made.

e. Process
Provide some actions that need to be adopted based on the planning that has been made

f. Technology
Identify the architecture and the list of hardware and software that will be used during the implementation process

g. Metric
Metrics are some of the criteria that will be used to assess all processes during MDM. These metrics will be identified during before, during, and after MDM implementation. This is intended to ensure the quality of the data available in the NawDac.

Figure 14. Master Data Management (**MDM**) is one of the techniques required to ensure the validity of data in the NawDac

4. Data Broker

Data Broker is a mechanism adopted to gather information from various sources; process to enrich, purify or analyse it; and before sharing the data to other agencies.

For data collection, there are several methods that will be used, namely:

a. Retrieve data directly from the system via API.
b. Upload data through documents such as excel documents.
c. Obtain data using a web-crawler for systems that do not have an API

While for the purpose of sharing, the data is shared either by using the API provided or downloading the data in the form of documents (pdf, excel).

5. Data Monitoring

Data monitoring is the process by which were taken out will be monitored by the system. The purpose of monitoring this data is to ensure that the data is successfully retrieved or failed to be retrieved or shared to other users If there are difficulties during data retrieval or data sharing. All log information for reference

4.4.3. Data Repository

Data Repository is one of the places where all data storage applies. The data taken will be categorized into four categories of data:

- Raw Data
  Raw Data is taken from other user systems either by using the API or the data upload process. The data in this condition still retains the original format and no modification of the data has been made.
- Uniform Data
  Uniform data is raw data that has been standardised. This data has undergone a data transformation process where the format of this data is aligned as what has been set in the system
- Pre-process Data
  Pre-process data is a data that has been processed initially by the system for user purposes. The purpose of this data is in the early process so that it can improve system performance by reducing data related processes first.
- Metadata
  Metadata is data used for the purpose of referring to future data or data that is being stored in the system. This metadata is the data type of a parameter taken from an external source.

4.4.4. Data Registry

Information registry is one of the cores where all information related to documentation and API will be located. This information registry will make it easier for users to obtain information because it will serve as a reference point. All documentation will be stored here and it is:

- API documentation
- System Integration documentation
- Data sharing guidelines documentation
- Catalog service
- Data service

4.4.5. Criteria and Guidelines

This thrust is intended to be used to ensure that all processes related to data, APIs (Application Programming Interface) and documentation will follow the policies and guidelines that have been set. These policies will cover all processes holistically to reduce the problem of data related matters as well as the relationship between NawDac and other systems. This Guideline will cover the process:

- Data Storing
- Data Sharing
- Data Processing
- Data Uniformity
- API Management
- Documentation Management

By implementing these Criteria and Guidelines, it can maximize all data usage processes where the data can be reused because it is reliable, comprehensive, and interoperable.

4.5. Artificial Intelligence

4.5.1. Introduction

Artificial Intelligence (AI) is branch of computer science which enable machine to perform task and make decision. Therefore, NawDac can employ an Artificial Intelligence that can be

used to help ease the workload of human counterpart by doing task which is menial and less prioritised. By doing this, the humans can focus on what task really important to them and it can lead to increase work efficiency and operational time reduction.

Artificial Intelligence also enable machine to learn and improve over period. There are 4 main types of AI:

- Reactive Machines
- Limited Memory
- Theory of Mind
- Self-Awareness

AI can be divided into 4 approaches which are:

- Thinking Humanly
- Thinking Rationally
- Acting Humanly
- Acting Rationally

4.5.2. Reactive Machine

Reactive Machine is a type of AI that perceive to it surrounding and respond to it accordingly. This type of AI does not have previous memory as it does not require pass experience to decide. Such AI are Google AlphaGo & IBM Deep Blue.

4.5.3. Limited Memory

Limited Memory is a type of AI that has ability to store previous memory and used it either for prediction or decision making. There are 3 categories for this AI:

- Reinforcement Learning
  Learn making decision and prediction with repeatedly using try and error principle
- Long Short-Term Memory
  Use previous set of data to predict the next set of data can be produced
- Evolutionary Generative Adversarial Networks (E-GAN)
  The AI evolve over time based on previous data and generate new decision for it to make.

4.5.4. Theory of Mind

Theory of mind is a concept which artificial intelligence are able to understand that many living things such as humans and animal have their decision making by using their thoughts and emotions. This said that AI knows through self-reflection and determination, human and animal will utilise it information and make decision.

4.5.5. Self-Awareness

Self-awareness is a concept, whereby an AI are self-conscious about itself and understand its own existence in the world. This kind of AI have human level consciousness.

4.6. Internet of Things

4.6.1. Introduction

Internet of things is a concept, whereby any devices relate to each other through internet. These devices are connected through a manager-asset concept.

- Manager
  Manager is an application, system or platform used to manage day to day operation, Asset management and data repository. User will use the platform to get the overview details on the asset status, data management, data pattern and data monitoring.
- Asset
  Assets are device which is used to collect data from sources. The data sent to the manager through Internet

Internet of things can be a momentous change for the NawDac platform as it can be a tool for day-to-day operation for its users such as managing water-reservoir operation, managing water treatment PH levels, etc.

4.6.2. Architecture

IoT (Internet of Things) architecture represent the phase of IoT architecture in this framework from data collection until the processing phase. In general, the use of satellite is very important in this framework development. Data from satellite is part of data resource, whereby satellite can be used to monitor and provide good information related to temperature and also ocean/water topography. The phases of IoT are as follows and is further simplified in Figure 15.

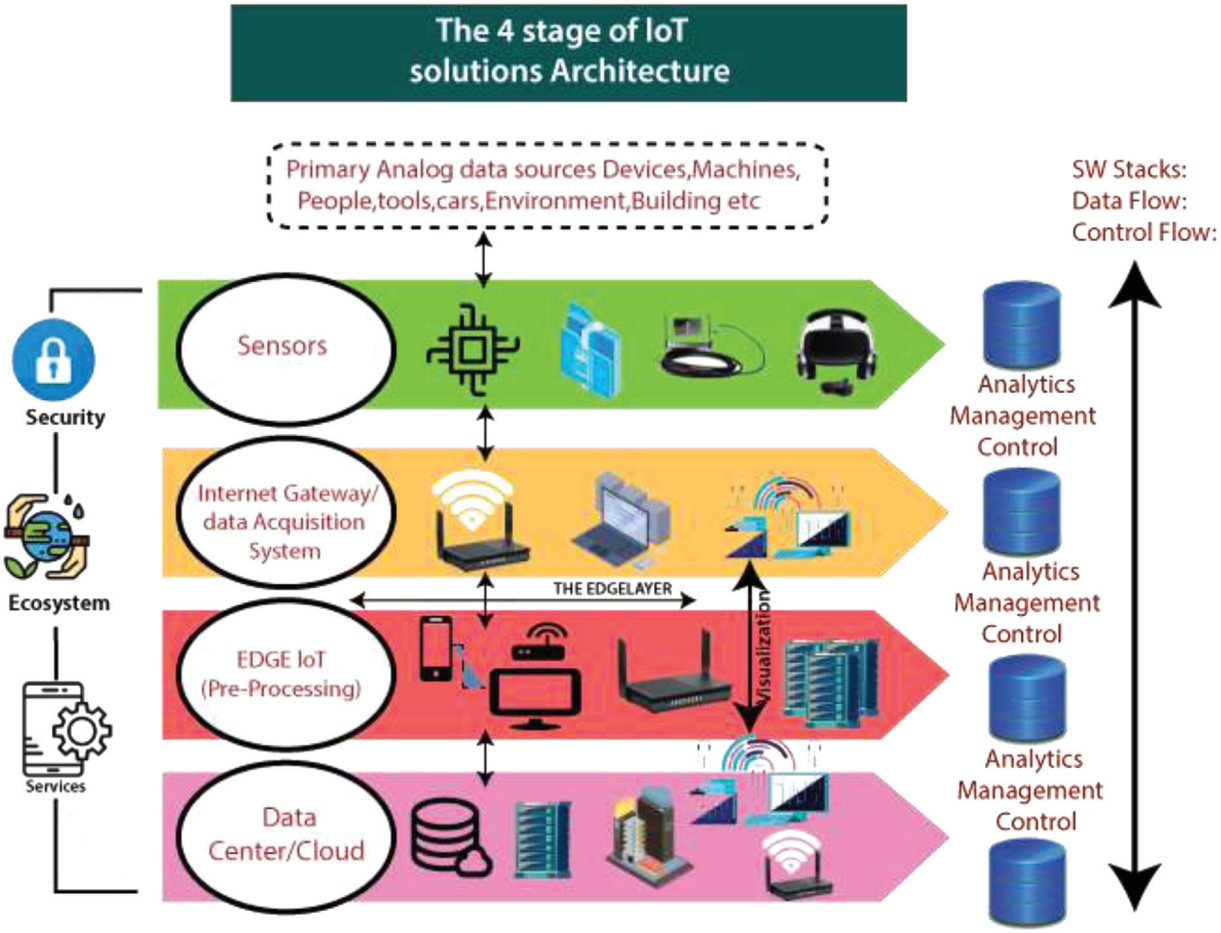

Figure 15. The 4 stages of IoT solutions architecture

(*Source*: https://www.tutorialandexample.com/iot-architecture/ Retrieved on 19 October 2021)

- Sensing
  An object to that equipped with sensors to collect the data and send it through the network either for data storing or perform tasks.
- Internet Gateway
  A mechanism which task to filter incoming traffic from the sensors to the system. The gateways also redirect traffic to its targeted destination i.e., data processing, and data retrieval)
- Edge Analytic
  Edge analytic is where the NawDac platform located at. It operates and manages the sensing activities as well as conduct on the processing and analysis of the data gathered.
- Data Centre
  Data Centre is where all the data is stored after it was collected and pre-processed by NawDac. This Data Centre will act as data repository for the national water sector.

4.7. NawDac Architecture

4.7.1. Technical Structure

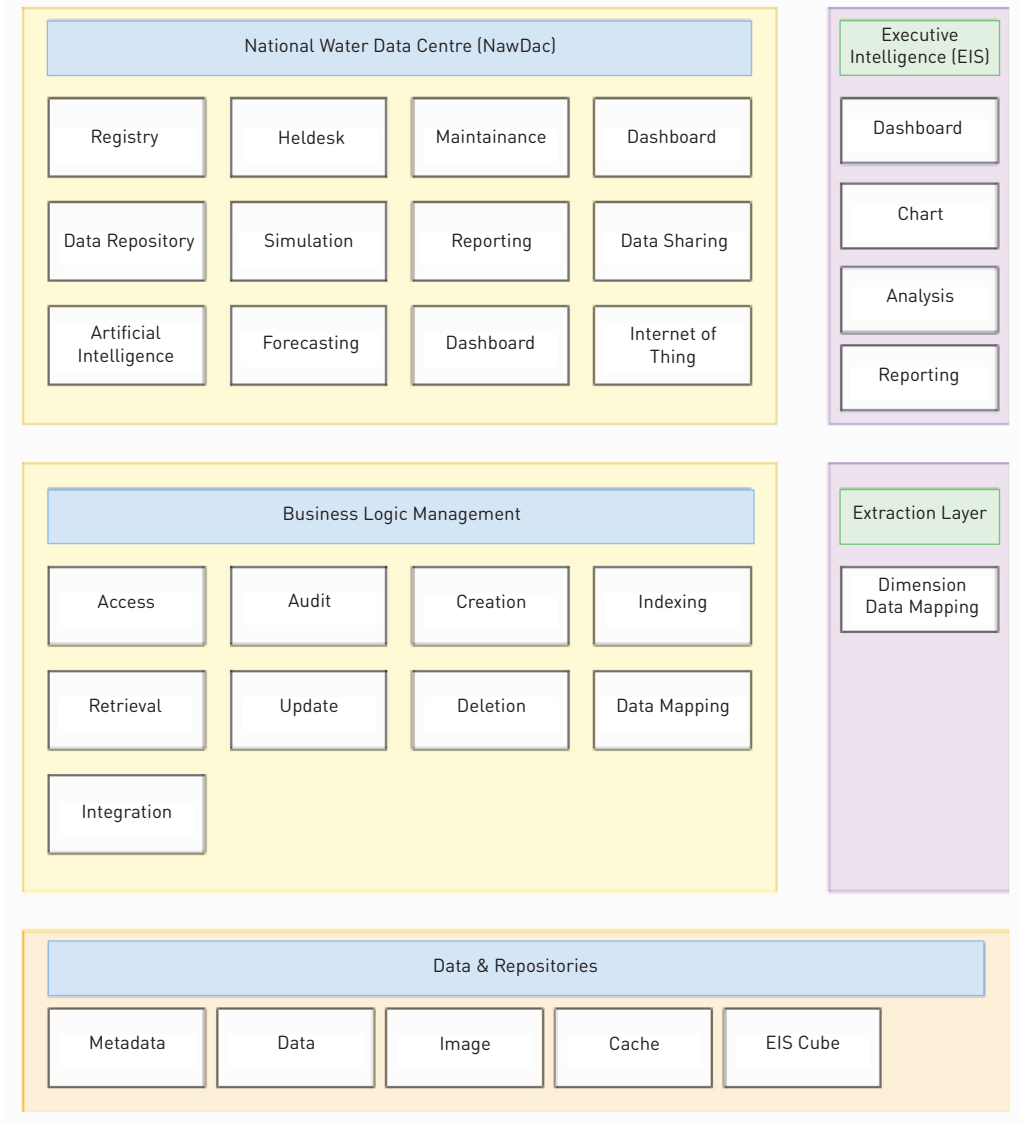

Figure 16. Technical structure of the SELGDX System application

Figure 16 shows the technical structure of the SELGDX System application to be developed. It is divided into 3 main components including:

i. Modules
ii. Business Logic and Management
iii. Data and Repositories

Each of the above components is modular and dynamic to ensure that the modules developed can meet the needs of future users.

4.7.2. Context Diagram

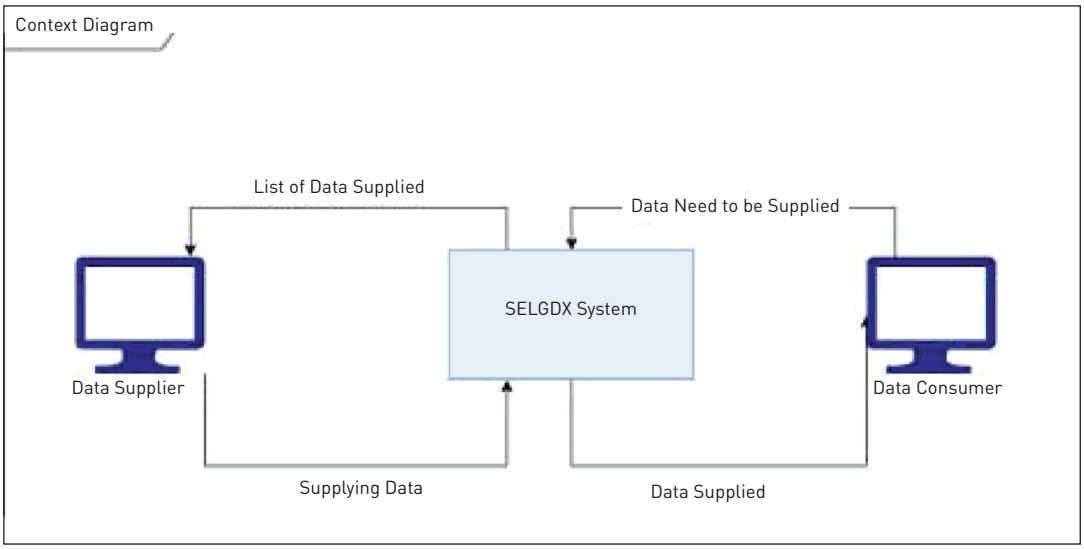

Figure 17. Context Diagram

The table below describes the functions of the parties described in the Context Diagram of the NawDac System.

No	User	Details
1	Data Supplier	Users who supply data to the system. Supplier data consists of: • Government Agency • Statutory body • Private Sector
2	Data Consumer	Users who use data supplied by the Data Supplier. Users consist of • Government Agency • Statutory body • Private Sector • Public

4.7.1. NawDac System Architecture

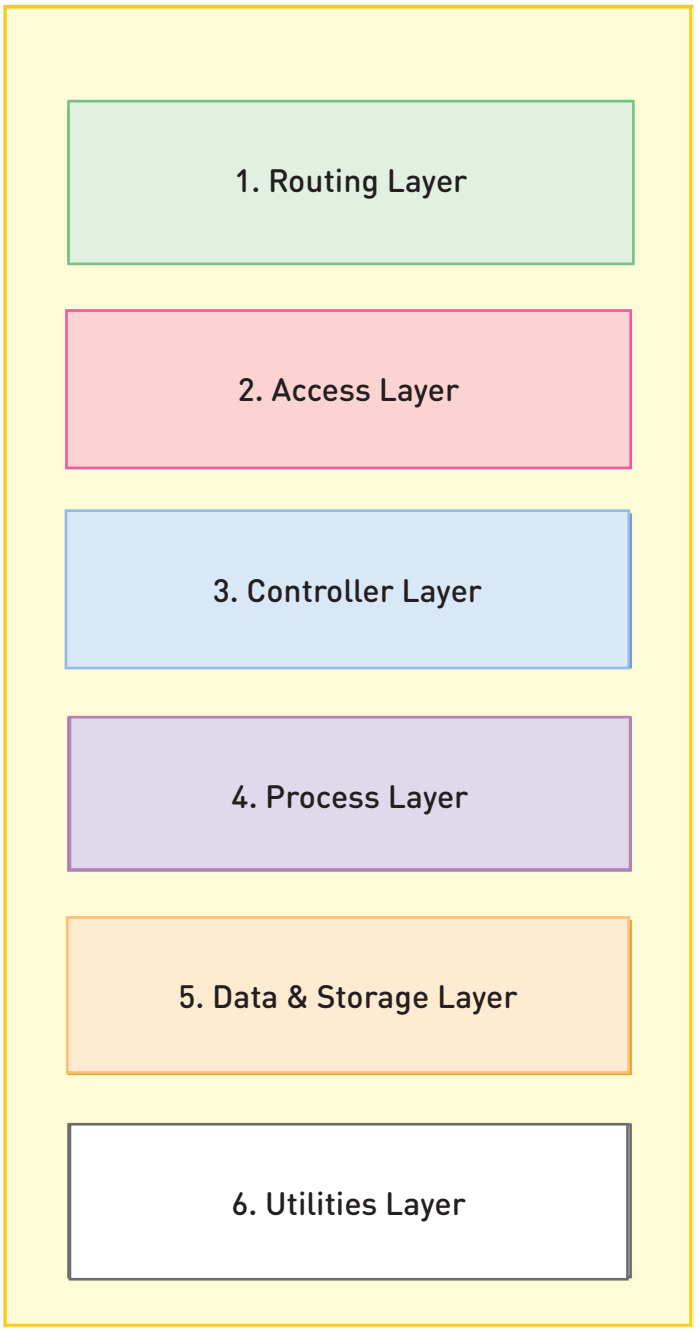

Figure 18. NawDac system architecture depicting layers required for the system

4.7.2. Routing Layer

The Routing Layer is responsible for the flow of traffic in and out of the system by using HTTP as well as HTTPS Protocol. Routing will be combined with the access layer and controller layer to set the user's direction in the system.

4.7.3. Access Layer

The Access Layer is responsible for ensuring that users only get access assigned to their role. This process occurs in application middleware that will frequently check for up -to -date user access so that they cannot get information that they do not have access to.

4.7.4. Controller Layer

The controller layer is responsible for connecting the user's will with the resources it needs.

4.7.5. Processing Layer

Processing Layer is a service where all requests made by users will be processed and sent back to the user. In this processing layer, data from the database will be taken and given to the user or used for system processes. Services in this processing layer will be built dynamically and use the **SOLID** Principle as a reference.

4.7.6. Data & Storage Layer

All data management and updating will take place at this stage. At this stage, all file management also takes place.

4.7.7. Utilities Layer

Utilities layer is a layer where all the basic information is stored. All settings and configuration information will be saved. In addition, all reference and basic information will be cached at this stage.

5.5.4.1 Strategies

i. Digitalisation

Digitalisation must be done in every aspect of the water sub-sectors. It covers from water sources or resources, water management, water operations and water controls for surface water, groundwater and wastewater. Involvement of all water players such as the Malaysia water body regulators, water utilities, water companies, consumers, other government agencies and non-government agencies. Figure 19 shows the coverage of the whole water ecosystem.

Figure 19. Coverage - From source back to source covers the whole water ecosystem

(*Source*: SIEMENS)

- Implementation of digitalisation

The way to realise the digitalisation process is by incorporating the latest technologies in every aspect of the water management and water operations. Examples of the technologies that can be considered are:

- o Sensors
- o Drones
- o Satellite
- o Mobile applications
- o Web- based Applications
- o Water Data Bank
- o Business Intelligence tools

In the latter sections we will discuss the incorporation and implementation of the ten science and technologies drivers put forth by the 10-10 Malaysian Science, Technology, Innovation and Economy (MySTIE) Framework.

- Benefits of digitalisation

- o These are some other benefits of digitalisation apart from that have been mentioned earlier.
- o Real time control on water management
- o Real time monitoring in each aspect of management and processes
- o Water management process is automated
- o Digital measurement of water consumption
- o Operational real-time control and warning system
- o Cost reduction
- o Generation of income
- o Improved service efficiencies

The proposed framework for Langkawi Island as the pilot site aims to connect water players and stakeholders via a single platform for collaborative implementation of the IR4.0 for water sub-sectors. All data and information will be collectively shared amongst the players and stakeholders to help them make an informed decision. Through IR 4.0 and digitalisation of water sector, this may be achieved provided that each section of water processes is monitored and recorded therefore shared data may be visualised in a in a manner that is easy for the stakeholders and water players to understand. Eventually it is envisioned that the whole of Langkawi Island can be a converted into a water catchment through initiation of the IR Water 4.0 model for the island which emulates a concept similarly adopted for the development of Marina Barrage in Singapore. The following framework is proposed based on the work conducted by the German Water Partnership on Water 4.0 and examples brought forward by Japanese experts during the Water Sector Transformation 4.0 webinar.

Thus, there will be 5 separate parts required for the proposed water framework including:

a. Data Gathering
b. Data Storage
c. Data Visualisation
d. Data process – Artificial Intelligence (AI)
e. Dissemination & sharing
f. Cyber-physical system (CPS)

a. Data Gathering

Data gathering is a process which all the needed data is collect from the database, sensors, and files. This data then later will be stored within the modelling and simulation own database as currently practised by agencies such as NAWABS, PRABN, DIPAN, BDA and EQMP. There are two types of data gathering and they are:

i. Real-Time data gathering
ii. Recorded data gathering

i. Real-Time data gathering

Real time data gathering is a technique used to monitor real data came from the sensors installed in respective locations. These sensors will record all the data from the sensor within the given timeframe (i.e., 5 min) and sent it to the server to be stored. Real-time data gathering shall require a shared basis facility i.e., monitoring station.

ii. Recorded data gathering

Recorded data gathering is a process in which the data is gathered from the machine/device used by the water agencies with integration of existing and old data. This data can be gathered as follows:

- System Integration
  - This process can only be achieved if the current system has an Application Program interface (API) which the modelling and the simulation can connect to retrieved data. This simulation will retrieve the data from the system database and store it to the modelling database for its usage.
- 3rd Party integrator
  - Some systems do not have an API and also cannot be connected with other systems. But the system has a database that can be used. So, in order for that data to be retrieved, a separate integrator application will be developed and installed to the water player system to retrieve the data. The 3rd party integrator is by using an external API for the simulation to retrieve the water player data.
- Manual upload
  - From the site visits, it is noted that some monitoring devices does not connect to the existing system and databases. Thus this becomes a problem when the crucial data cannot be used by the simulations and can impact the decision making of the stakeholders this can be achieved by having a user interface within the platform whereby the water player need to upload it manually. This process is not recommended because it can affect data integrity because during the uploading process.

b. Data Storage

Data storage is a place where all the data is retrieved and then stored. This data storage can be used for processing, visualization and also record purposes. All the data retrieved from different sources have their own data structure and format. Each data needs to be trimmed and converted into a single format that can easily be used by the modelling and simulations. Even so, the original format of the data won't be discarded but it will be recorded also so that it can be used when the time comes. The data storage is proposed to be made under the auspices of the National Water Data Centre. Below is the list of data storage types:

i. Raw data storage

This type data storage is used to store the data in its original format. This data only used for the recorded purposes. This type of data is stored either in Water Data Bank or data lake.

ii. Converted data storage

This type data is similar to the data that is stored in raw data storage but the format of the data is converted into standard data format. Unlink raw data, which the data can have multiple format due to the format came from different resources. The converted data format will have the same format and data type. Therefore, with this standardisation, we can conclude any data produce from this storage has data integrity.

iii. Compiled converted data storage.

Compiled converted data storage is type of storage this is used to store all the processed data retrieved form converted data storage. This storage is used as a cache storage for the modelling and application. Therefore, the same generated data would not be processed over and over again, and this JPS not affect the performance of the simulation and modelling due to processing a data consumes a lot of computer resources.

a. Data Visualisation

Data Visualisation is a section in which all the data is processed and displayed to the stakeholders and players in the form of "Must Have", "Would Like To Have" and "Nice To Have", respectively. Each stakeholder and players will be able to view information related to its organisation. Within this visualisation, data visibility hierarchy is established based on the level authoritativeness of and organisation and individuals. Every member in a single organisation would not be able to view the same data because the data they use might be different because of the responsibility that they played within the organisation.

b. Data Process – AI

Data process is a phase where the stored data is processed to generate new information or new data. The data that is used for data processing is either converted data or compiled converted data. Raw data can also be used in this process when the data needed does not exist in converted data, but it exists raw data due to data standardisation process. The data process usually used for data forecasting, pattern recognition, and also data anomaly recognition. This can help to increase process efficiency through data, process optimisation and also process cost saving through data.

c. Dissemination

Data dissemination is a process where the data can be viewed either by stakeholders, players and public users. This data dissemination is directly correlated with data visualisation , whereby some information can only be viewed by personal authority. This data can be retrieved either through downloading the materials, application program interface (API) and also through electronic files such as;

i. Excel files
ii. Words document
iii. PDF document
iv. Images

To connect all water players and stakeholders in a single platform which they can monitor the water status stem from gathering the water from its resources until it is discharged by the water treatment. This water framework also used to optimise and improve water processes to make it efficient, cost savings, and renewable. This can only be achieved through digitalisation. Table 2 shows planned activities from November 2020 to June 2021 for development of IR 4.0 for water sub-sectors.

That digitalization consist of several phases as follows:

a. Requirement Phase
b. Development/Implementation Phase
c. Execution Phase
d. Improvement Phase

a. Requirement Phase

This phase is where all the study, research, information gathering, design, and planning were done. Within this phase, all the needed information is properly documented so that it can be used during the development phase. Within this phase, many outputs will be produced such as:

- System architecture
- System design
- User Interface prototype
- System requirement
- Business process

b. Development / Implementation Phase

During this phase, the simulation and modelling is being developed. The progress of the development within this phase should be shown once in two weeks so that the development will not go astray from what it is intended to. It is expected that some new information will be gathered here that is not visible during the requirement phase. Usually, stakeholders and players don't really know what they want until it is shown to them.

c. Execution Phase

This phase is used to gather the feedback and new requirement from the stakeholders and players. This phase only consists of 2 -3 weeks. During this phase, users will be able to use the finished products, thus they will know what other section within this simulations and modelling can be improved such that it can deliver more value.

d. Improvement Phase

This last phase is where the modelling and simulation will be improved with the latest feedback and requirement from the stakeholders and the players. This phase usually lasts 2 - 3 months and it can be longer based on the number of new requirements from the player and stakeholders.

Table 8 shows completed activities from November 2020 to October 2021 for development of IR4.0 for water sub-sectors.

Table 8. Planned activities for development of IR 4.0 for water sub-sectors

Items	Start Date	Due Date	2020/2021							
			11	12	01	02	03	04	05	06
Requirement Phase	02/11/2020	31/12/2020								
Development/ Implementation Phase	01/01/2021	31/03/2021								
Execution/Testing Phase	01/04/2021	16/04/2021								
Improvement Phase	19/04/2021	11/06/2021								

Figure 20 summarises the conceptual framework for contributions of each stakeholder from sources to services based on the seven taps resources of water, including river, dams/lakes, groundwater, recycled water, rainwater, AWG and desalinated water, which is extracted following the site visit to Langkawi Island. This conceptual framework will be used to update and finalise the proposed mind-map for strategising the water sector transformation agenda perusing the IR 4.0 for water sub-sectors which will include Sabah and Sarawak. Table 9 summarises the Langkawi model gap analyses extracted from discussions made with the stakeholders during the site visit from 15 until 17 December 2020. This will represent a model that can be upscaled for implementation of the IRW4.0 for water sub-sectors while simultaneously emulate the existing systems monitored by NAWABS, PRABN, DIPAN, BDA and EQMP. This model will be used as a pilot testing project for the nationwide implementation of IRW4.0 towards 15th MP.

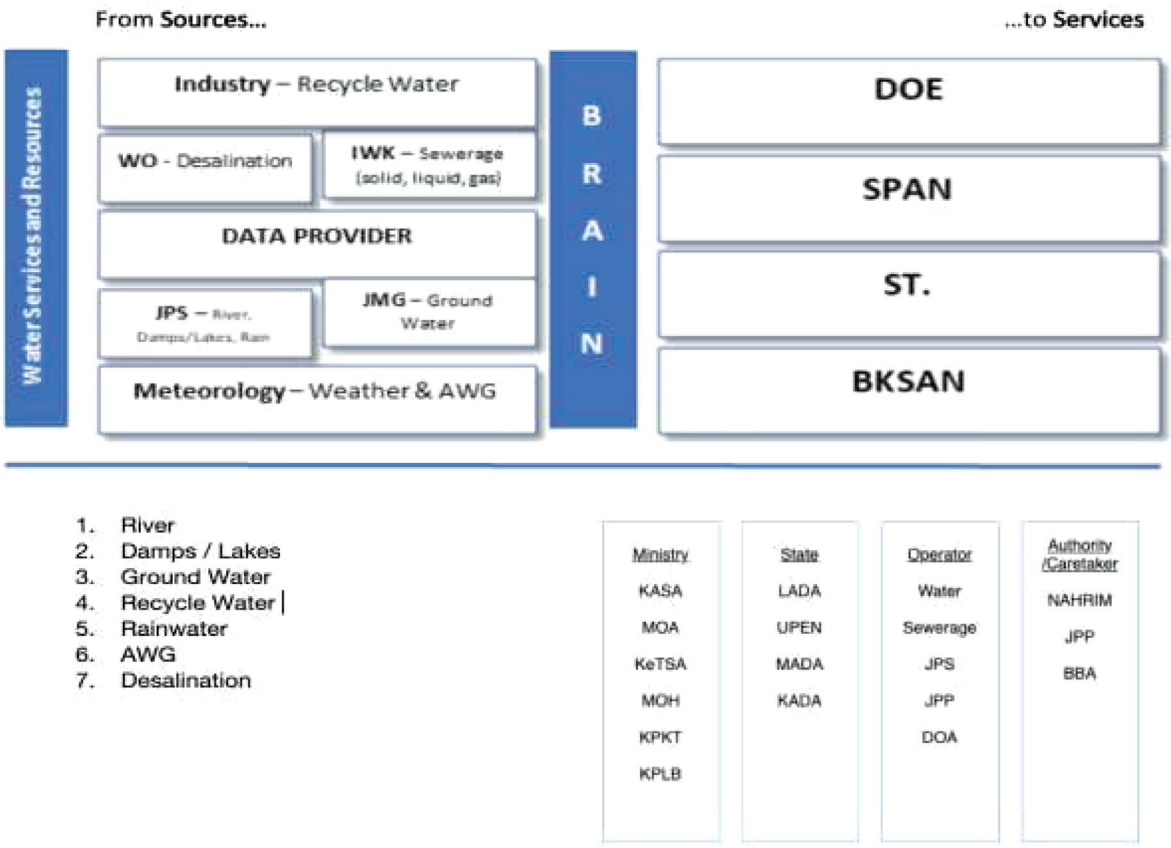

Figure 20. Conceptual framework for contributions of each stakeholder from sources to services

Table 9. Langkawi model gap analyses (Appendix R)

Langkawi Model Gap Analysis

AGENCIES	FOCUS AREA	DESIRED FUTURE STATE	CURRENT STATE	IDENTIFIED GAP	ACTION PLAN
LADA	*IR4.0 For Water Sub-Sectors*	Digitisation and automation as hub for resourceefficient, flexible and competitive water and wastewater management. Measured by: Cyber-Physical Systems (CPS): An intelligent and diversified system as cyberspace for water data integration accessible to stakeholders.	- LADA implies that integration between water players and stakeholders may still be improved to a better scale. - Misinformation on water data which may lead to uninformed decisions. - Weak approach towards water data management system.	More than 90% from the desired future state.	Requires an application system which is able to provide precision water data enabling prediction and forecasting of water availability.
JPS			- JPS monitors their operation through SCADA and by using sensors and telemetry system are in place. Some equipment is outdated and requires updating. - Big Data and AI approaches are lacking	Need more than 30% to achieve the desired future state.	Acquires sensors / probes to provide data through up-to-date telemetric system or state of the art technology for realtime monitoring Integration of IR 4.0 approaches ensuring digitalisation of water data to enable informed and accurate decisions.
SADA			- SADA acts as the main provider for data accuracy and plays key role in determining providence of water data to the stakeholders in Langkawi.	Need more than 30% to achieve the desired future state.	- NRW monitoring - Pollution control - Identify alternative sources
IWK			- IWK has an up-to-date waste water treatment system. - Early warning system and SCADA are in place. The only drawback is that the tools and system used are in silos.	Need about 20% more in order to achieve the desired future state.	- Need to integrate all the systems together. Need to put intelligence into the system. This will enable IWK in making quick and good decisions.
Local Authorities/ Tourism			- Water demand needs to be quantified to ensure digitization and automation system are reflected in water supply & demand	The gaps are yet to be identified	Zero management concept

5.5.5. IR 4.0 Technology Implementation for Water Sub-Sectors

The German Water Partnership stated that Water 4.0 should not remain static or remain "in the now" but rather should follow the technical developments and uses the new capabilities that are provided. Malaysian water industry should embrace and increase the use of IT, sensors technologies, Internet of Things (IoT), big data analytics, artificial intelligence (AI), modelling applications and other innovative current and future networked technologies. The emergence of cloud-computing technologies should also be used for example to enable the implementation of the cyber-physical system (CPS) which is the fusion of the physical or real and virtual worlds. The Malaysian water industry should describe a holistic approach that covers the entire water ecosystem. This will enable the creation of an intelligent network that links the various water sub-sectors, the stakeholders and the users within a sustainable water infrastructure.

To be aligned with the national aspiration put forward by the 10-10 Malaysian Science, Technology, Innovation and Economy (MySTIE) Framework, the Malaysian water industry shall incorporate the ten elements of the science and technology drivers in its IT framework. The following Figure 21 consist of the 10 drivers.

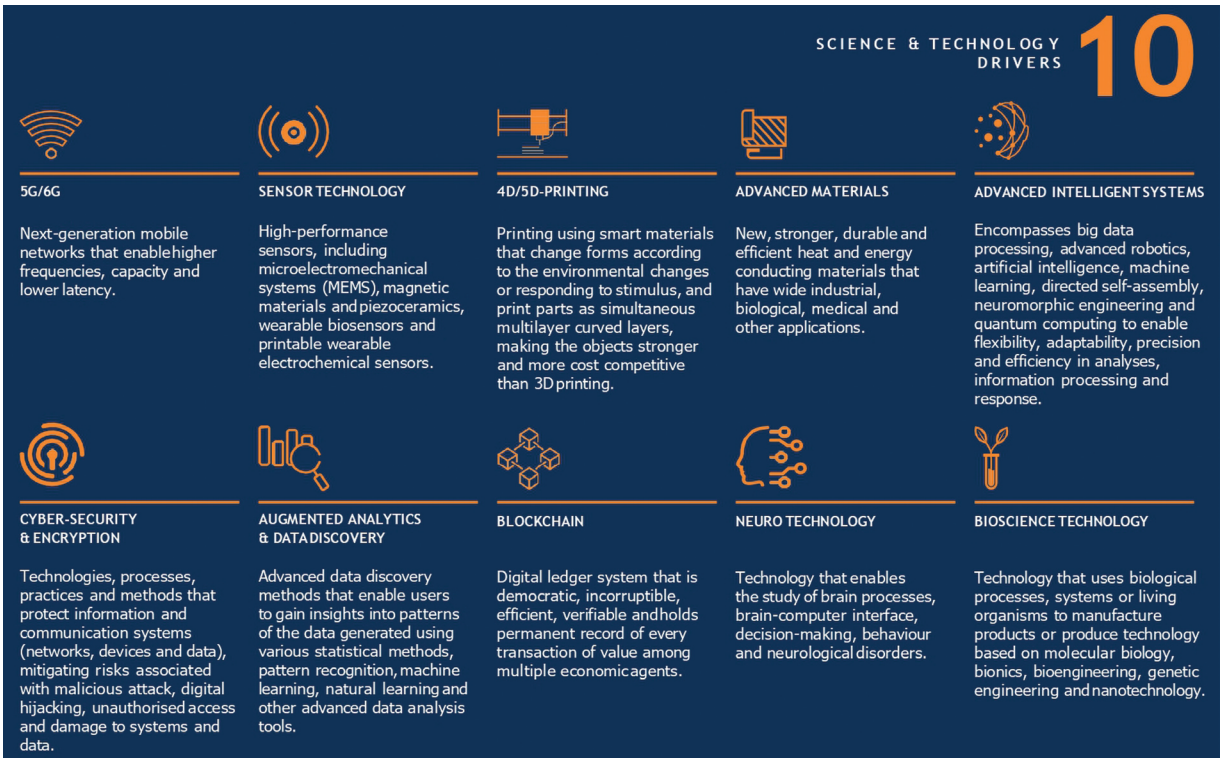

Figure 21. 10-10 Malaysian Science, Technology, Innovation and Economy (MySTIE) Framework (Source: Akademi Sains Malaysia, 2020)

5.6 Scope 6: Prepare a Complete Road map 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

As per TOR Scope 4 above, the Road map Framework has been prepared. The relevant Focus Areas' need to be populated by every sub-sector for all the four phases.

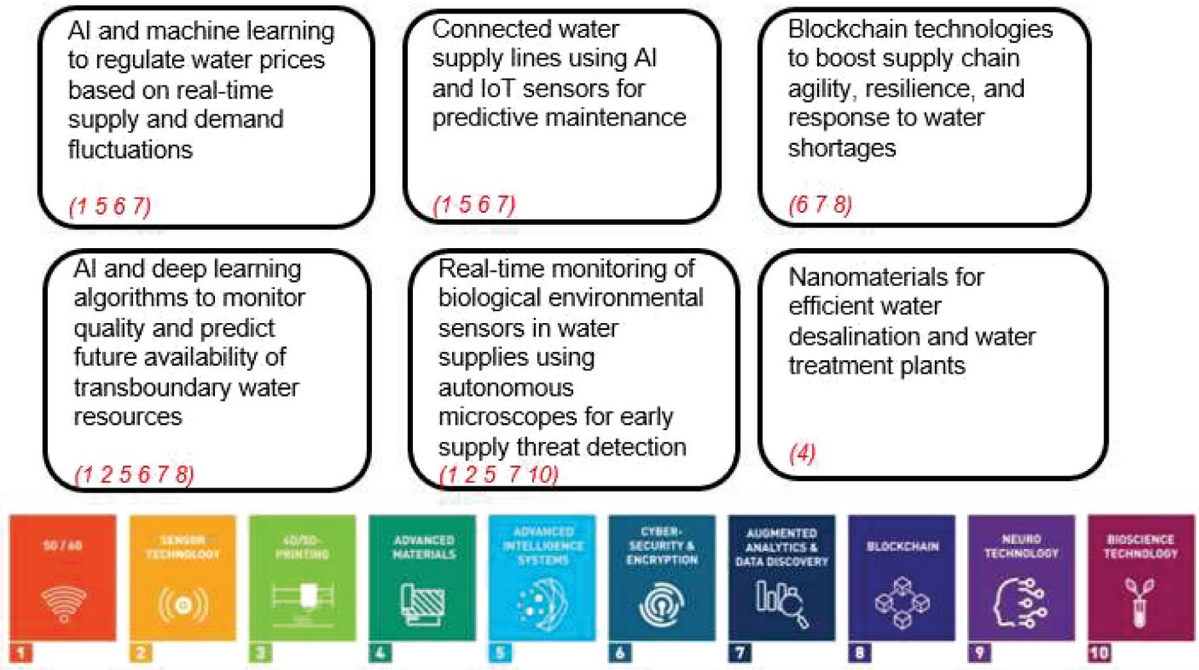

Figure 22. Example implementation of science and technology drivers to water industry

(Source: Adapted from Akademi Sains Malaysia, 2020)

As water and wastewater utilities continue to mature into the digital era, smoother transition to digitalisation is needed to ensure adequate services and maintenance throughout the IR4.0 for water sub-sectors implementation. Figure 23 outlines the proposed road map to transform water sector via adoption of IR 4.0 for water sub-sectors. To aid this transformation, we tapped into the knowledge and experience of stakeholders by conducting surveys and global benchmarking with global utilities in selected countries, including German and Japan.

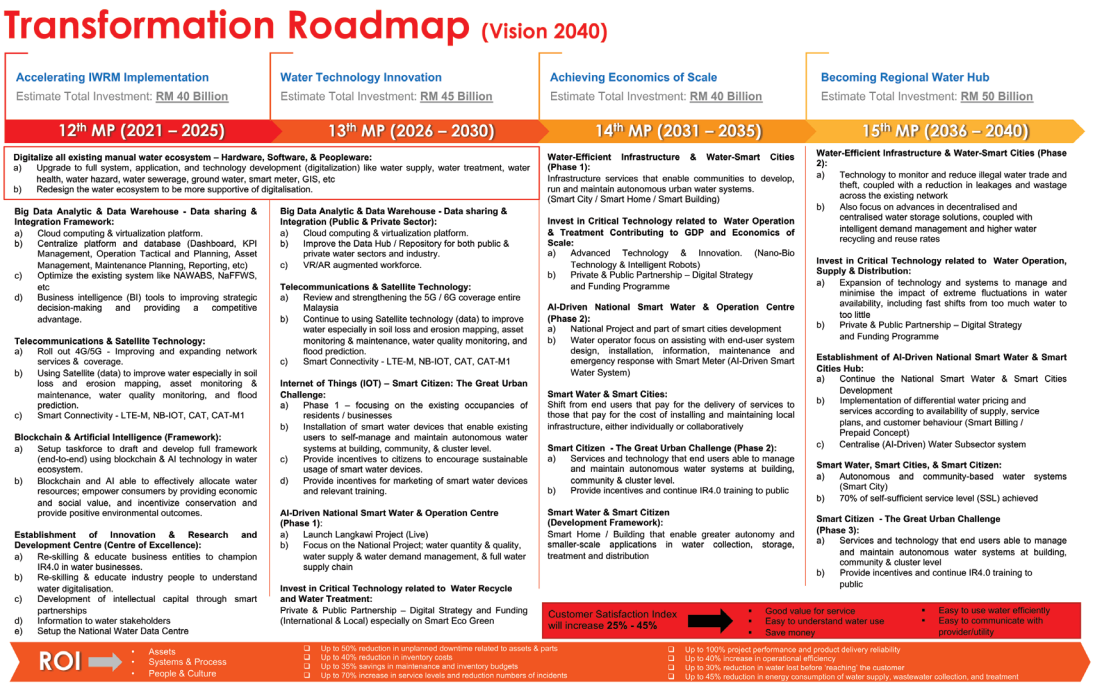

Figure 23. Proposed road map to transform water sector via adoption of IR 4.0 for water sub-sectors

Figure 24, Figure 25 and Figure 26 outline the application of MySTIE as embedded into the potential implementation of IR 4.0 for water sub-sectors transformation.

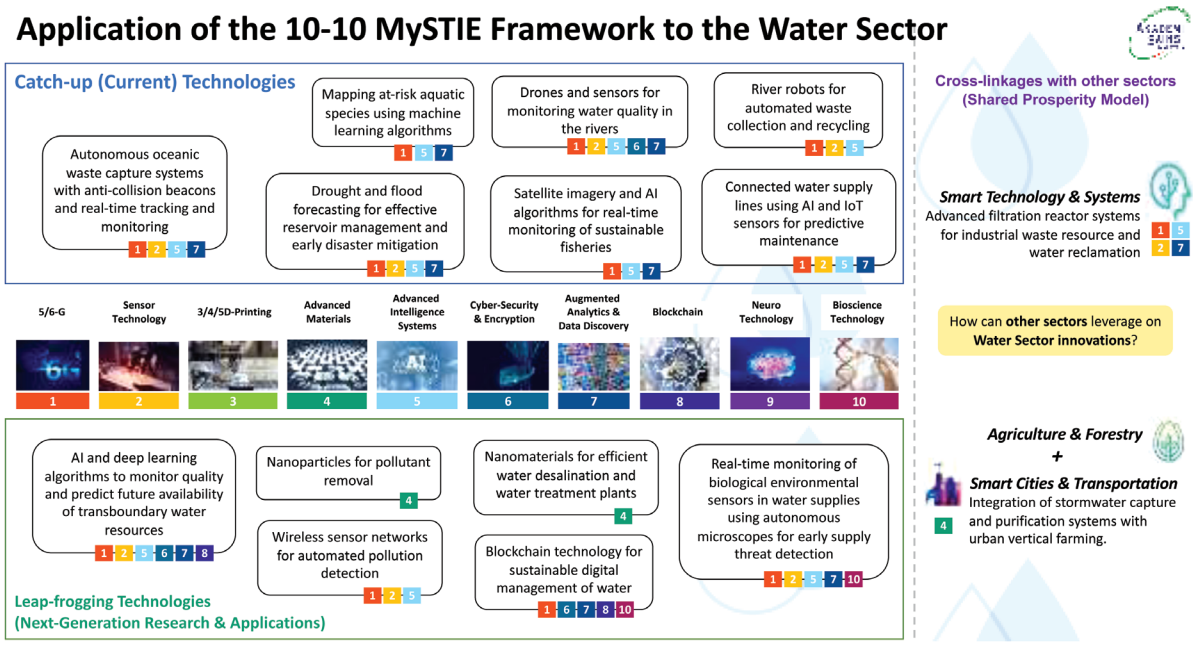

Figure 24. Application of the 10-10 MySTIE Framework for water sub-sectors

(*Source*: Adapted from Akademi Sains Malaysia, 2020)

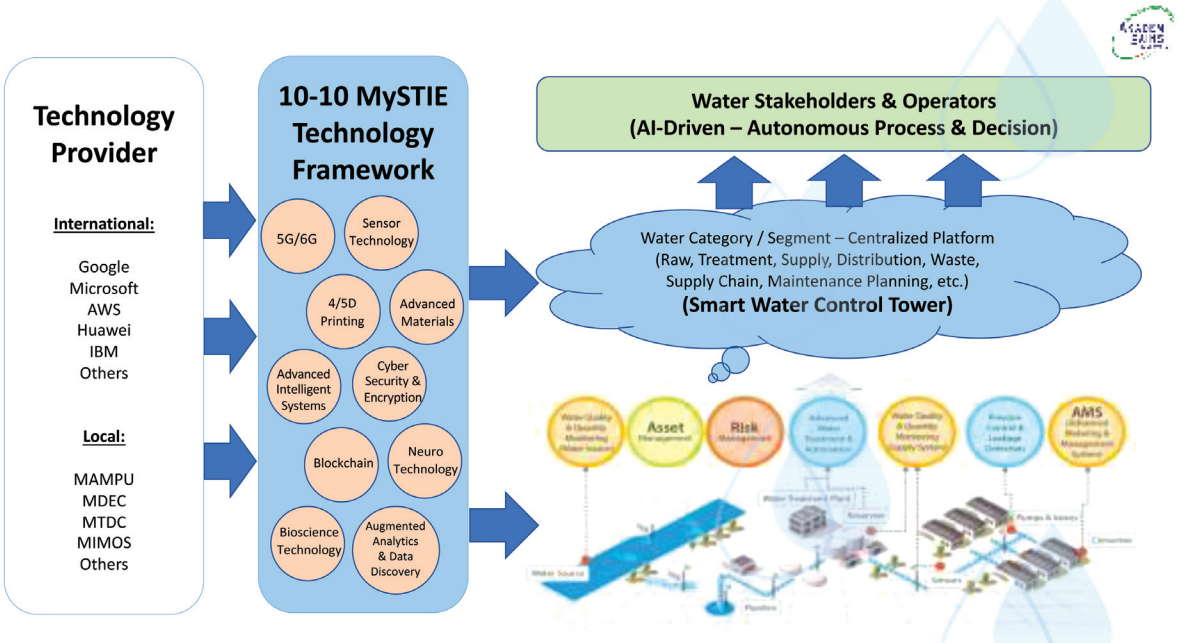

Figure 25. AI driven autonomous process and decision based on MySTIE

(*Source*: Adapted from Akademi Sains Malaysia, 2020)

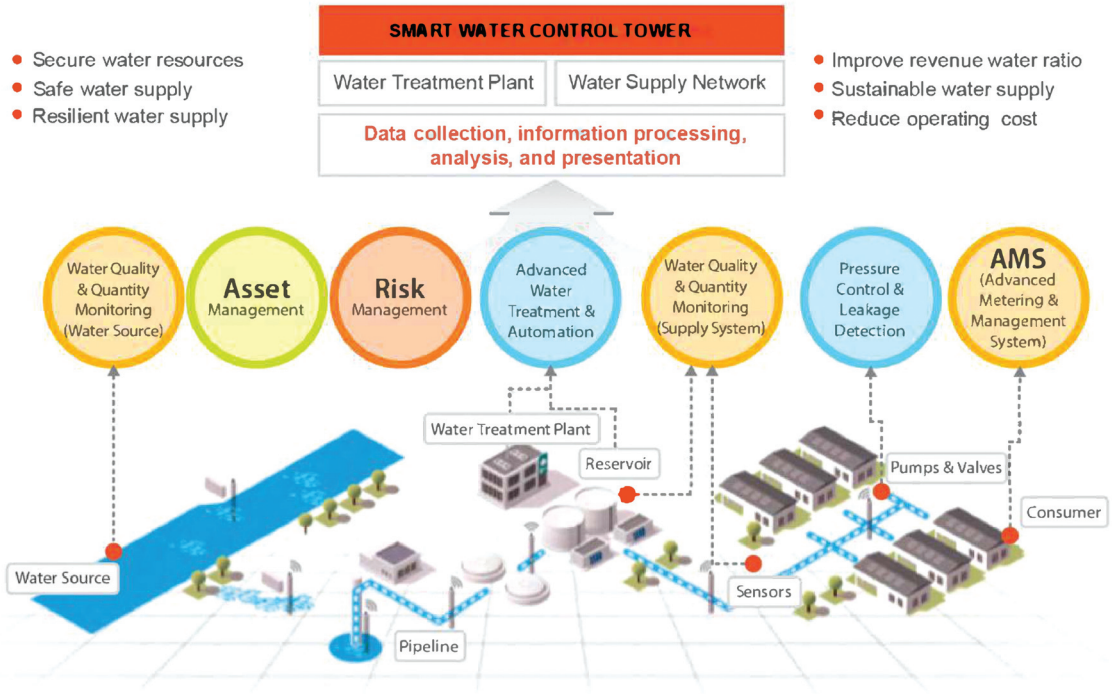

Figure 26. Proposed smart water control tower with IR 4.0 elements embedded into the system

6.0 Way Forward – 8i Ecosystem Approach

The 10-10 Malaysian Science, Technology, Innovation and Economic (*My*STIE) Framework is an integration of 10 key Malaysian socio-economic drivers with 10 global leading science and technology drivers aligned to our strengths and needs. The framework provides a systematic approach to transform Malaysia into a knowledge-intensive economy by design. Water and food as one of the socio-economic drivers are core to the sustainable development of communities across the globe. This demands a well-integrated ecosystem to ensure water and food security to address the challenges of rising population, urbanisation, climate change and economic disparities.

The IR4.0 for water sub-sectors shall focus on the following 8i Ecosystem Analyses:

i. **Infrastructure** (Physical & Natural) – Quality and sophistication of the infrastructure that supports the growth and development of the industry and the broader economy

- **Challenges**
  Ageing facilities coupled with impractical approaches to cope with recurring incidents of floods and droughts, exposes the public to water related disasters. Absence of tailored mitigation in water balance management in tackling both excessive and deficient water supply conditions is still scarce within the country. Further challenges include limitations in IR 4.0 technology adoption, Wi-Fi coverage both in urban and rural areas for public access, telecommunication infrastructures, readiness capacity and connectivity and operating costs for IR4.0 technological implementation.
- Proposed Solution
  Increasing IR 4.0 compatible infrastructure to manage extreme conditions of water supply during flood and dry spell, including IoT and big data analytic technologies for optimised solutions that provide co-benefits to financial returns such as Return on Value and Return on Investment (ROI).

ii. Infostructure (Digital Infrastructure) – Digital infrastructure that provides seamless integration of multiple value chains within and across the industries and communities. These systems provide seamless flow of information for market intelligence and strategic decision-making.

- Challenges

  Existing water balance management system lacks in essential data such as irrigation demand, domestic water supply demand, mini hydropower requirements, environmental flow, transboundary, flood mitigation etc. Inadequate and inefficient asset management in the custodian of source and treated water with lack of centralised database resulting in overlapping base map kept by individual agencies has led to poor facility management. Existing forecast and early warning systems available as a mitigation plan and crisis management however remain limited within an organisation and fragmented.

- Proposed Solution

  Integrating existing systems across various water sectors to develop a common open-source data hub which serves multiple functions. The development of IT framework should incorporate the 10-10 Malaysian Science, Technology, Innovation and Economic (*My*STIE) Framework for 10-10 *My*STIE a cohesive development and modernise digital ecosystem for the water sector.

iii. Intellectual Capital (Talent Stock) – Skills (technical, entrepreneurial and leadership) and knowledge (general and specialised) of the talent stock.

- Challenges

  Lack of technology know-how on the fundamental items that define the IR 4.0 itself such as cloud technology, IoT, big data, Al etc. Skills shortage in areas including cybersecurity i.e., handling cyberattacks and the ability to generate useful business insights from data and by using the insights to improve operational efficiencies. Lack of data security and skillsets needed in digitising various processes.

- Proposed Solution

  There is a need to invest in multidisciplinary talent that will provide the manpower needs of the water sector. Reskilling of talents are required to accommodate experts and skills required for IR4.0 implementation

iv. Integrity (Good Governance) – Governance systems to manage processes and ensure commitment to continuous improvements and adherence to best practices.

- Challenges

  Weak enforcement of the relevant governing acts and regulations for the various water sub-sectors. The level of access to strategic data and information is still limited, whereby specific legal and institutional framework are not in place to support these needs. Additionally, there is also an absence of SOP for risk and mitigation towards prevention and better forecasting, including Crisis Management.

- Proposed Solution

  A more systematic development of the IR4.0 is needed (prevent ad-hoc and piece-meal approach) that is geared towards enabling more effective planning, monitoring and refining existing policies and strategies. Key regulator reforms and policies need to be in place for data sharing amongst the different agencies and ministries. Use of digital governance systems will go a long way to help address complexities of multiple stakeholder management.

v. Incentives (fiscal and non-fiscal) – Incentives to encourage R&D, adoption of new technologies, innovation, commercialisation of local technology, and market expansion, including globalisation of local technology.

- Challenges
  Development of IR 4.0 oriented solutions requires high investment levels. However, there is a lack of funding for implementation of infrastructures and infostructures, preventing the water sector from quantum leap towards achieving long term sustainability. Existing good equipment has been left in poor conditions due to lack of maintenance.
- Proposed Solution
  Incentive compatible schemes must be put in place to foster public-private partnership to develop new innovations and applications in IR 4.0 area for the industry. Improve incentive schemes (tax & subsidies) for SMEs in the industry to adopt IR 4.0.

vi. Institutions (Governance Bodies) – Quality o the institutions of governance (e.g. regulatory bodies, industry associations, institutions of learning / research institutes etc.) that support systematic development of markets, industries and communities.

- Challenges
  Functional focus of water players largely remains in silos despite cross-cultural and inter-organisation collaboration with an excessive overlapping of functions/authority that are neither coordinated nor geared towards a stringent schedule for the future. Instead of plug-in and improvise, adding values and knowledge transfer to the stakeholders, water companies often start off as digital novices lengthening their path to IR 4.0 revolution.
- Proposed Solution
  Establish an integrated data hub which allows for data sharing amongst water sub-sectors with relevant policies to govern consents of data sharing.

vii. Interaction (Strategic partnerships) – Level and quality of collaboration, co-creation and knowledge sharing among stakeholders.

- Challenges
  Awareness creation is still lacking concerning the importance of eco-hydrology, disaster reduction (DRR) preparedness, enforcement of the relevant governing acts and regulations for the various water sub-sectors. Lacking knowledge and engagement amongst public on their waterdissemination point of interest (PoI), i.e from water treatment plant to taps at home, water treatment processes and general knowledge of good consumer habits.
- Proposed Solution
  Preparation of data matrix to provide scenario-based solutions focusing on "Must Have", "Should Have" and "Nice-to-Have" options by stakeholders (Refer Appendices B – M).

viii. Internationalisation (Global best practices & standards) - Depth and breadth of engagement with global knowledge and innovation networks, institutions of governance and global supply chains.

- Challenges
  Lack of benchmarking criteria for implementation of IR 4.0 for water sub-sectors
- Proposed Solution
  Organising webinars and knowledge transfer program with leading countries in IR 4.0 for water sector i.e., Germany, Japan, and working closely with organisation such as International Water Association (IWA).

7.0 Conclusions and Recommendations of the Sub-Sectoral Study: proposed Mission Critical Projects in line with the Roadmap requirements, including KPIs and targets (for every strategy) and immediately implementable proposals / projects for each subsector, to be achieved during each Phase and the implementation time frames

Conclusion

The **IR 4.0 in the Various Water Sub-sectors** addressed crucial aspects of three major national water sectors, namely Raw water, Water Supply services and Sewerage services, such as raw water source taps and conservation, pollution to the water source, interruption to water supply, high Non-Revenue Water (NRW) losses; insufficient water services infrastructure particularly in rural areas and islands; underutilisation of water and sewerage infrastructure, precision farming and irrigation systems; unreadiness of infrastructure for water and wastewater treatment resource recovery of by-products; underleveraged emerging IR4.0 technological evolution for operational efficiency and financial independence. The development of resilient, sustainable, resourceful, and user-friendly integrated IT system framework that combines the virtual networking all of water sectors' supply chain, operators, and end users by adopting IR 4.0 fundamentals such as big data analytics, Internet of Things, artificial intelligence, augmented reality, cybersecurity, autonomous robots, cloud computing and Internet of Things is vital in transforming the national water sector to dynamic new economic driver by 2040.

The key to unlocking the potential of IR4.0 for water sub-sectors is by ensuring that Malaysia's digital infrastructure provides ubiquitous, reliable and ultrafast broadband Internet service. Malaysia has made substantial progress in connecting people to basic internet services. Nearly 80 % of the population is online, primarily through a competitive mobile telecoms market.

Based on the IR 4.0 Readiness Survey (Refer Appendices N-O), more than 50 % of respondents have not deployed any of the IR 4.0 approaches indicative of 84% respondents having no benchmarking on any global implementation for IR 4.0 in their services and/or businesses. When asked if they are planning to invest in IR 4.0 technologies, 56% stated that they would invest only if it is necessary for the business.

The benchmarking criteria include the followings:

i. Internet accessibility
ii. Data center
iii. Integrated system
iv. Guidelines and procedures
v. Steering committee / task force
vi. Policy, Laws, Acts & Regulations, Guidelines etc.
vii. Readiness / Coordination /Adaptability
viii. Phases and scope
ix. Readiness of IT Infrastructure
x. Communication/ Interaction System

This study aims to understand the digital maturity in the water and wastewater sectors, by eliciting insights through a detailed survey process. The IR4.0 adoption study in water sub-sectors shall provide a means for assessment where they are in their digital maturation and to have a general roadmap on where to head next.

Implementation of IR4.0 for water sub-sectors may be used as one of the key drivers for policy change i.e., no chemical fertilizers to be used on island for agricultural activities, proper determination of custodian for water resources, monitoring of river reserves, enforcement on polluters, creation of water catchment for island, assist implementation of efficient integrated billing and charging system etc. whereby IR4.0, will be an informative concept of tools. IR 4.0 renders its fullest support to the development of River Basin model however its details will be covered in a separate study as the scope is limited by TOR of this current study.

Recommendations based on the five Pillars of WST2040 agenda the recommendations shall leverage on the five key factors of Malaysia Digital Economy Blueprint: MyDigital to attract investments enabling the formation of a digital ecosystem in Malaysia. These are:

i. Availability of digital infrastructure such as connectivity, cloud and 5G.
ii. Market opportunities to sell their products and services, to make a profit.
iii. Availability of local talent and ability to bring in foreign talent.
iv. A supportive regulatory framework.
v. An avenue to raise alternative financing beyond bank-backed financing such as the venture capital matching programme as per Dana Penjana initiative (under the Ministry of Finance).

The CoE for water sub-sectors transformation shall focus on re-skilling and education of business entities to champion IR 4.0 in water businesses through the establishment of National Water Data Centre (NAWDAC).

a. People as the Key Driver in Water Sector Transformation

i. **Intensify Strategic partnerships** through quality collaboration between various level, co-creation and knowledge sharing among stakeholders incorporating the use of IR4.0 infrastructure and digital apps. Awareness creation is still lacking concerning the importance of eco-hydrology, disaster reduction (DRR) preparedness, revision to the existing policy and acts, enforcement of the relevant governing acts and regulations for the various water sub-sectors. Lacking knowledge and engagement among public on their water dissemination point of interest (PoI) i.e. from water treatment plant to taps at home, water treatment processes, sewage treatment and effluent discharges, including recycle and general knowledge of good consumer habits based on Customer Satisfaction Index. Preparation of data matrix to provide scenario-based solutions focusing on Must Have, Should Have and Nice-to-Have options by stakeholders is a collaborative measure in establishing transparency of roles and responsibilities and improved decision-making.
ii. **Strengthening talent stock** within the operational agencies for water digitisation technology and management, fundamentals of IR 4.0 such as cloud technology, IoT, big data, Al etc., cybersecurity crisis handling, business insights generation and operational improvement from data analysis. Lack of data security and skillsets needed in digitising various processes and sharing of data in the proposed National Data Bank. There is a need to invest in multidisciplinary talent that will provide the manpower needs of the water sector. Reskilling of talents are required to accommodate experts and skills required for IR 4.0 implementation.

iii. **Emulate innovation culture by utility operators**, IT staff, technologists, engineers and particularly water and wastewater operators for identifying new technologies and embracing digital innovation based on existing digital approach in Malaysia i.e. NAWABS, PRABN, DIPAN, BDA and EQMP.

b. Strengthening governance of water sector at federal and state levels

i. **Good Governance systems** ensures reliable process management, commitment to continuous improvements and adherence to best practices. Weak enforcement of the relevant governing acts and regulations for the various water sub-sectors were recognised. The level of access to strategic data and information is still limited, whereby specific legal and institutional framework are not in place to support these needs. Additionally, there is also an absence of SOP for risk and mitigation towards prevention and better forecasting, including Crisis Management. A more systematic development of the IR4.0 is needed (prevent ad-hoc and piece-meal approach) that is geared towards enabling more effective planning, monitoring, and refining existing policies and strategies. Key regulator reforms and policies need to be in place for data sharing among the different agencies and ministries. Use of digital governance systems will go a long way to help address complexities of multiple stakeholder management.

ii. **Adopt the use of IR4.0** to enhance enforcement and transparency for effective management of water sector.

iii. **Quality of the governance bodies** (i.e., regulatory bodies, industry associations, institutions of learning / research institutes) that support systematic development of markets, industries, and communities. Functional focus of water players largely remains in silos despite cross-cultural and inter-organisation collaboration with an excessive overlapping of functions/ authority that are neither coordinated nor geared towards a stringent schedule for the future. Instead of plug-in and improvise, adding values and knowledge transfer to the stakeholders, water companies often start off as digital novices lengthening their path to IR 4.0 revolution. Establish an integrated data hub which allows for data sharing amongst water sub-sectors with relevant policies to govern consents of data sharing

c. Strengthening financial capability to support water sector transformation

i. **Incentives which include fiscal and non-fiscal** encourages Research & Development (R&D), adoption of new technologies, innovation, commercialisation of local technology, and market expansion, including globalisation of local technology. Development of IR 4.0 oriented solutions requires high investment levels. However, there is lack of funding for implementation of infrastructures and infostructures, preventing the water sector from quantum leap towards achieving long-term sustainability. Existing good equipment has been left in poor conditions due to lack of maintenance. Incentive compatible schemes must be put in place to foster public-private partnership to development new innovations and applications in IR 4.0 area for the industry. Improve incentive schemes (tax & subsidies) for SMEs in the industry to adopt IR4.0.

ii. **Utilise IR4.0 to monitor** return on investment (ROI) and performance of implementation strategies of WST2040.

iii. **Implement conceptualisation** of the principles of circular economy in water sector value chain.

iv. **Utilise the seven taps** as alternative water sources and effective management of water resources.

d. Enhancing data-driven decision-making for sustainability

i. **Digital infrastructure** that provides seamless integration of multiple value chains within and across the industries and communities. These systems provide seamless flow of information for market intelligence and strategic decision making. Existing water balance management system lacks in essential data such as irrigation demand, domestic water supply demand, mini hydropower requirements, environmental flow, transboundary, flood mitigation etc. inadequate efficient asset management in the custodian of source and treated water with lack of centralised database resulting in overlapping base map kept by individual agencies has led to poor facility management. Besides, there is also a need for a forecast and early warning system for crisis management and a common GIS platform to promote integration among sectors. There is a need to invest in advanced technology (10-10MySTIE) and a more cohesive development plan to modernize the digital ecosystem of the water sector.

ii. **Global best practices & standards** need to be established through rigorous engagement with global knowledge and innovation networks, institutions of governance and global supply chains. Absence of international standard reference for benchmarking criteria of IR4.0 implementation, present a huge opportunity for Malaysia to develop localized criteria of international standard. Organising webinars and knowledge transfer programme with leading countries in IR 4.0 for water sector i.e., Germany, Japan, and working closely with organisation such as International Water Association (IWA).

iii. Establish water and wastewater hub for developing countries.

e. Developing sustainable water infrastructure with cost-effective technology

i. **Quality and sophistication of the infrastructure (physical and natural)** that supports the growth and development of the industry and the broader economy. Water related disasters due to excessive water causing floods or during shortage periods causing droughts whereby tailored mitigation for both circumstances are still scarce without the support of mature facilities and impractical approaches for the public to cope with recurring incidents. Limitations in IR 4.0 technology implementation i.e., Wi-Fi coverage availability in common, including rural areas for public access, telecommunication infrastructures, readiness capacity and connectivity and operating costs for IR 4.0 technological implementation. There is a serious need to modernise the infrastructure with advanced technology (IR 4.0) to increase the return of value & ROI of the infrastructure, avoiding silo management and absence of one stop centre for data repository system.

ii. **Overcome insufficient ICT infrastructure** to support the digitalisation transformation.

The roadmap forward for IR4.0 for water sub-sectors are summarized as follows:

i. **Set the transformational road map at management level:** Water leaders agreed that having the support and leadership of the management team is an important accelerator to the implementation of IR 4.0 for water sub-sectors. Malaysia is not a water stress country. Hence, the implementation of IR4.0 in water sub-sectors shall help to improve water management and increase its efficiencies.

ii. **Build a holistic digital road map** based on Langkawi Island case which includes mobile and website application as a pilot-based transformation model for other stakeholders. This will be up scale for application nationwide.

iii. **Emulate innovation culture by utility operators**, IT staff, technologists, engineers and particularly water and wastewater operators for identifying new technologies and embracing digital innovation based on existing digital approach in Malaysia i.e., NAWABS, PRABN, BDA, DIPAN, Environmental Quality Monitoring Program (EQMP) eliminating silo in management of water sub-sectors.

iv. **The pilot project in Langkawi Island will serve as a platform** to explore new technologies, build momentum, and create a holistic understanding of their physical and financial effects on operations prior to implementation of IR 4.0 for water sub-sectors on a larger scale.

v. **Develop architecture for Water Data Bank for water sector**, whereby operational data sets may be used to cultivate digital ecosystem to benefit people, operational, financial and resilience while simultaneously generate exponential values for utilities via the establishment of a National Water Data Centre which shall be situated at the water hub.

Development of policy supporting the IR 4.0 for water sub-sectors to facilitate a technologically enabled water service delivery system which shall be governed by laws and regulations for reinforcement and set to give the public the convenience of accessing services within reach of their fingertips.

The KPIs and targets (for every strategy) and immediately implementable proposals / projects for IR4.0 for water sub-sectors are summarised in Tables 10 and 11, respectively.

Table 10. KPIs and targets (for every strategy) and immediately implementable proposals / projects for IR 4.0 for water sub-sectors

Focus areas	No	Transformation Item	Measurement	Target	Baseline	Phase I		Phase II	Phase III	Phase IV
						2022	2025	2030	2035	2040
People	1	Establishment of Innovation & Research and Development Centre (Centre of Excellence) i.e. VAICE	Number of talents produce by the centre	200 000 workforce in water sector	0	10,000 pax	90,000 pax	35,000 pax	35,000 pax	30,000 pax
	2	Develop Malaysia Smart Water & Smart Citizen	Number of Smart Device per premise -50% urban & rural, 25% government building, 20% commercial, 5% universities	11.35 million Premises are equipped with Smart Meters, Smart App, Billboard & Information kiosk at strategic locations	0	-	350k premises	1Mlill premises	5Mill premises	5Mill premises
Governance	3	Establish new Cyber security Law addressing water sector industry and improve the existing PDPA to address data sharing in water sector	Completion of water study and Approval of the Cybersecurity guideline and PDPA	1 Water Study Improvement on PDPA 1 Cyber security Law	0	100% 100% 100%	-	-	-	-
Information & RDCI	4	Digitalize all existing manual water ecosystem (i.e., hardware, software, peopleware)	Percentage of digitalisation (transformation)	100% digitalisation transformation in water sector	30%	-	70%	-	-	-
	5	Develop Big Data Analytic & Water Data Bank	Numbers of ministries/agencies/NGO in water sector	All stakeholders in water sector	0	30%	40%	10%	10%	10%
	6	Establish Platform for infrastructure (including infostructure) that caters for IR4.0 for water sub-sectors	Numbers of ministries/agencies/NGO in water sector	All stakeholders in water sector	30%	-	70%	-	-	-
	7	Develop Blockchain & Artificial Intelligence Framework	Development phases for BC & AI in: a) Langkawi (as a model) b) National Water Data Centre (NAWDAC)	a)100% completion of Langkawi Model b) Improvise & strengthen existing water data centre functions & facilities	0	100%	50%	25%	20%	5%
	8	Enhance Technology advancement	Number of technology adoption Based on identified 10-10 MYSTIE	Meeting 10-10 MYSTIE Roadmap	0	-	4	3	3	-
	9	Implement Water Wise & Smart Cities	Percentage of identified potential sites / cities	14 Capital Cities	0	-	2	5	5	5

Note
1) The quantification of KPI percentage (%) shall be determined during the detailed study upon implementation of relevant strategies.
2) Estimated 200 000 workforce Per MP will be trained & retrained.

Table 11. Immediately implementable projects for IR 4.0 for water sub-sectors

No	IR Water 4.0 Sub Sector	Remarks
1	Change of policy and governance for IR4.0 implementation for water sub-sectors	Improvement to existing key policies and governance as recommended in our report submission have to firstly be in placed to govern and guide the implementation of IR Water 4.0 moving forward. A more simplified approval authority and structure for governance would also help to expedite the improvement process towards smooth and successful implementation of IR Water 4.0.
2	Telecommunications & Satellite Technology	The recent news published on 29 September 2021 announced that the Malaysian government's 5G wholesale network operator Digital Nasional Berhad (DNB) has struck a 10-year partnership with Swedish telco equipment vendor Ericsson in helping to make DNB's stated target of bringing 5G coverage to 80 % of the country's population by 2024 a reality. The Malaysia's first 5G network is expected to be launched in Kuala Lumpur, Putrajaya and Cyberjaya in the initial phase of the rollout. Therefore, establishment of telecommunications and satellite technology incorporating IR4.0 shall focus on: i. Roll out 5G - Improving and expanding network services & coverage. ii. Using Satellite (data) to improve water sub-sectors, especially in soil loss and erosion mapping, asset monitoring & maintenance, water quality monitoring, and flood prediction. iii. Smart Connectivity systemic approach including Long Term Evolution for Machine (LTE-M), narrowband internet of things (NB-IOT), Category (CAT), Category M1 (CAT-M1) etc.
3	Establish Langkawi Island as the pilot project for IR4.0 for water sub-sectors implementation	Langkawi being the first UNESCO Global Geopark in Southeast Asia and also nation's aspiration in making the island one of the top 10 world's tourism destination, has rendered all qualifying criteria to be adopted for IR4.0 pilot project. This model will serve as an ideal simulation platform for seamless execution for bigger framework later. The model shall include: i. Establishment of Innovation & Research and Development Centre (Centre of Excellence) i.e. Vertical AI Centre of Excellence (VAICE) The establishment of CoE dedicated shall leverage on the five key factors of Malaysia Digital Economy Blueprint: MyDigital to attract investments enabling the formation of a digital ecosystem in Malaysia. The CoE for water sub-sectors transformation shall focus on re-skilling and education of business entities to champion IR 4.0 in water businesses through the establishment of National Water Data Centre (NAWDAC). i. Digitalization all existing manual water ecosystem – Hardware, Software, & Peopleware ii. Inclusion of Big Data Analytic & Water Data Bank - Data sharing & Integration Framework iii. Blockchain & Artificial Intelligence (Framework)

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APPENDIX A
Benchmarking scoring and criteria (con't)

No	Criteria	Description	Scoring					Sub Total Score	Priority	Weightage (%)	Total Score	Remark
			0	2.5	5	7.5	10					
	Internet accessibility	Measure on coverage on average for whole operational area										
1	Accessing the state of existing coverage of internet facility for all. This must cover both urban and rural areas.	0 - no coverage or less than 25%										
		2.5 - coverage is more than 25% but less than 50%										
		5.0 - coverage is more than 50% but less than 75%										
		7.5 - coverage is more than 75% but less than 100%										
		10.0 - coverage is more than 100%										
2	Data center	Measure by completeness of data required. More importantly availability of the data center										
	Dedicated and complete with IT infrastructure to collect data on the operation of the business on holistic manner including sharing of info with the various stakeholders	0 - No established data center										
		2.5 - localised data center eg monitoring only the plant										
		5.0 - mixed of localised and central collection										
		7.5 - Central collection but incomplete data for holistic process and reporting										
		10.0 - Complete data center										
3	Integrated system	Measure by completeness of integration system that covers user at all levels etc										
	All data integrated for the business, with other related sectors whether to use as part of the business or contribute as required by others. E.g. Water supply require info from rivers etc	0 - No system and operate manually										
		2.5 - system only measure own business										
		5.0 - mixed of own system and also other related to business										
		7.5 - Central collection but incomplete data for holistic process and reporting										
		10.0 - Complete data centre with full IT infrastructure										
4	Guidelines & Procedures	Measure by the completeness and implementation										
	Availability of 1) risk management, crisis management, 2) mitigation measures and 3) Standard Operating Procedure for data management using IT System	0 - None										
		2.5 - Under planning but yet to implement										
		5.0 - Developed 50% and target to complete within 5 years										
		7.5 - Completed but not implemented/enforced										
		10.0 - Complete guidelines & procedure and implemented										
5	Steering Committee/Task Force	Measure by availability of dedicated Committee with clear target to achieve										
	Availability of permanent committee/team that is looking into development of the IR Water 4.0 or similar with vision on adopting the system with target date to implement holistically	0 - None										
		2.5 - Under planning but yet to implement										
		5.0 - Developed 50% and target to implement within 5 years										
		7.5 - Planned but not commissioned										
		10.0 - Available and action being takento meet with target										

Benchmarking scoring and criteria (continued)

No	Criteria	Description	Scoring					Sub Total Score	Priority	Weightage (%)	Total Score	Remark
			0	2.5	5	7.5	10					
	Policy, Laws, Acts & Regulation, Guidelines etc	Availability of the relevant document for implementation or being planned										
6	Policy, laws, regulation, act established on data management and IT infrastructure	0 - no coverage or less than 25%										
		2.5 - coverage is more than 25% but less than 50%										
		5.0 - coverage is more than 50% but less than 75%										
		7.5 - coverage is more than 75% but less than 100%										
		10.0 - coverage is more than 100%										
7	Readiness / coordination /adaptability	Is current decision maker, management, stakeholders etc practised & implement										
	Existing coordination on IR Water 4.0 including readiness to transform and adopt. Not all thing need to be changed, some of them will be retained. Can those retain adapt when the IR4.0 is implemented	0 - no coverage or less than 25%										
		2.5 - localised data center eg monitoring only the plant										
		5.0 - mixed of localised and central collection										
		7.5 - Central collection but incomplete data for holistic process and reporting										
8	Phases and Scope	10.0 - Complete data center										
	How many phase needs to undergo for this transformation to success. What is the scope of each phases and what is the duration for each phases. Which entity involve in each phases	Planning towards IR Water 4.0										
		0 - No system and operate manually										
		2.5 - system only measure own business										
		5.0 - mixed of own system and also other related to business										
		7.5 - Central collection but incomplete data for holistic process and reporting										
		10.0 - Complete data centre with full IT infrastructure										
9	Readiness of IT Infrastructure	What is ready and has been used with proper monitoring										
	Completeness of IT Infrastructure eg full facilities, storage, satellite etc and benefits etc enjoyed	0 - None										
		2.5 - Under planning but yet to implement										
		5.0 - Developed 50% and target to complete within 5 years										
		7.5 - Completed but not implemented/enforced										
		10.0 - Complete guidelines & procedure and implemented										
10	Communication/interaction systems	Existing system of communication with stakeholders from top management to consumers										
	Availability Mobile App for Water consumers e.g. smart phone, website, transmission to respective stakeholders	0 - None										
		2.5 - Under planning but yet to implement										
		5.0 - Developed 50% and target to implement within 5 years										
		7.5 - Planned but not commissioned										
		10.0 - Available and action being taken to meet with target										

APPENDIX B

Matrix 1: Data Generated By Water Stakeholders

No	Organisation	Data Repository – available and ready to be shared with others										
		Rainfall	Surface Water (Quantity)	Surface Water (Quantity)	Groundwater (Quantity)	Groundwater (Quantity)	Storage Dams/ Ponds/ TAPS	IWK STP Location	IWK Sewer Mapping	NRW	Water Supply (Quantity)	Water Supply (Quantity)
MINISTRY OF ENVIRONMENT AND WATER												
1	Meteorology	√	x	x	x	x	x	x	x	x	x	x
2	DID (Federal)	√	x	√	x	x	√	x	x	x	x	x
3	DID (States)	√	√	√	x	x	√	x	x	x	x	x
4	JAS	x	x	√	x	√	x	x	x	x	x	x
5	JPP	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
6	NAHRIM	√	√	√	x	x	√	x	x	x	x	x
7	MGTC	x	x	x	x	x	x	x	x	x	x	x
8	PAAB	x	x	x	x	x	x	x	x	x	x	x
9	BBA	x	x	x	x	x	√	x	x	√	√	√
10	SPAN	x	x	x	x	x	√	x	x	x	x	x
11	IWK	x	x	x	x	x	x	√	√	x	x	x
MINISTRY OF AGRICURAL AND FOOD INDUSTRIES												
12	MADA	√	√	√	x	x	√	x	x	x	x	x
13	KADA	√	√	√	x	x	√	x	x	x	x	x
14	IADA	√	√	√	x	x	√	x	x	x	x	x
15	FISHERIES (STATES)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
MINISTRY OF ENERGY AND NATURAL RESOURCES												
16	FORESTRY (STATES)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
17	JMG	x	x	x	√	√	x	x	x	x	x	x
18	ENERGY COMMISSION	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
WATER OPERATORS / REGULATORY / AUTHORITY (STATES)												
19	Water Operators (States)	x	x	x	x	x	√	x	x	√	√	√
20	LAKU	√	√	√	x	x	√	x	x	√	√	√
21	AKSB	x	x	√	x	√	x	x	x	√	√	√
22	BAKAJ	x	x	√	x	x	√	x	x	x	x	x
23	LAP	x	√	√	√	√	√	x	x	√	√	√
24	PBAPP	x	x	x	x	x	√	x	x	x	√	x
NON-GOVERNMENTAL ORGANISATIONS (WATER RELATED)												
25	MWA	x	x	x	x	x	x	x	x	x	x	x
OTHERS												
26	Consumer	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Footnote:

"√" Data generated and ready to be shared with others "x" Data not generated "NA" Data not available

APPENDIX C
MATRIX 1: DATA REQUIRED FROM OTHERS BY WATER STAKEHOLDERS

No.	Organisation	Data required from others							
		Rainfall	Surface Water (Quantity)	Surface Water (Quantity)	Groundwater (Quantity)	Groundwater (Quantity)	Storage Dams/ Ponds/TAPS	IWK STP Location	IWK Sewer Mapping
MINISTRY OF ENERGY AND NATURAL RESOURCES									
1	Meteorology	NA	NA	NA	NA	NA	NA	NA	NA
2	DID (Federal)	√	√	√	√	√	√	x	x
3	DID (States)	x	x	x	x	x	x	x	x
4	JAS	√	√	x	√	x	√	x	x
5	JPP	NA	NA	NA	NA	NA	NA	NA	NA
6	NAHRIM	√	√	√	√	√	√	x	x
7	MGTC	√	√	√	√	√	√	x	x
8	PAAB	x	x	x	x	x	x	x	x
9	BBA	√	√	√	√	√	√	x	x
10	SPAN	√	√	√	√	√	√	x	x
11	IWK	√	x	√	x	x	x	x	x
MINISTRY OF AGRICULTURAL AND FOOD INDUSTRIES									
12	MADA	√	√	√	√	√	√	x	x
13	KADA	√	√	√	√	√	√	x	x
14	IADA	√	√	√	√	√	√	x	x
15	FISHERIES (STATES)	NA	NA	NA	NA	NA	NA	NA	NA
16	FORESTRY (STATES)	√	x	x	x	x	x	x	x
17	JMG	√	√	√	√	√	√	x	x
18	ENERGY COMMISSION	NA	NA	NA	NA	NA	NA	NA	NA
WATER OPERATORS / REGULATORY / AUTHORITY (STATES)									
19	Water Operators (States)	√	√	√	√	√	√	x	x
20	AKSB	√	√	√	√	√	√	x	x
21	BAKAJ	√	√	√	√	√	√	x	x
22	LAP	√	√	√	√	√	√	x	x
NON-GOVERNMENTAL ORGANISATIONS (WATER RELATED)									
23	MWA	x	x	x	x	x	x	x	x
OTHERS									
24	Consumer	NA	NA	NA	NA	NA	NA	NA	NA

Footnote:

"√" Data required from others "x" Data not required "NA" Data not available

APPENDIX D

MATRIX 1: ADDITIONAL DATA (TECHNICAL) REQUIRED FROM OTHERS BY WATER STAKEHOLDERS

No.	Organisation	Additional Data Required from Others – Technical Data												
		Locality and Zoning of Areas (Industry, Commercial, Residential, etc)	Others Utility Underground Mapping (Water, Electric, etc)	Water Demand (historical and projected)	Satelite Image	Landuse Map	Climate data (forecast and realtime)	Radar Data	GIS (Soil Map, Forest Area, Present Landuse, Future Landuse, Landcover, etc)	Local Authorities (OSC / Pipe Laying Approval etc)	JKR Approval	Asset Management System	JUPEM Map	Underground Water Profile From JMG
MINISTRY OF ENVIRONMENT AND WATER														
1	Meteorology	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2	DID (Federal)	√	√	√	√	√	√	√	√	x	x	x	√	√
3	DID (States)	x	x	√	√	√	√	√	√	x	x	x	x	x
4	JAS	√	√	x	√	√	√		√	x	x	x	√	√
5	JPP	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
6	NAHRIM	x	x	x	x	x	x	x	x	x	x	x	x	x
7	MGTC	x	x	x	x	x	x	x	x	x	x	x	x	x
8	PAAB	x	x	x	x	x	x	x	√	√	√	√	√	√
9	BBA	√	x	√	x	√	x	x	x	x	x	x	x	x
10	SPAN	x	x	x	x	x	x	x	x	x	x	x	x	x
11	IWK	√	√	x	x	x	x	x	x	x	x	x	x	x
MINISTRY OF AGRICURAL AND FOOD INDUSTRIES														
12	MADA	x	x	x	x	x	x	x	x	x	x	x	x	NA
13	KADA	x	x	x	x	x	x	x	x	x	x	x	x	NA
14	IADA	x	x	x	x	x	x	x	x	x	x	x	x	NA
15	FISHERIES (STATES)	x	x	x	x	x	x	x	x	x	x	x	x	NA
MINISTRY OF ENERGY AND NATURAL RESOURCES														
16	FORESTRY (STATES)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
17	JMG	√	√	√	√	√	√	√	√	√	√	x	√	x
18	ENERGY COMMISSION	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
WATER OPERATORS / REGULATORY / AUTHORITY (STATES)														
19	Water Operators (States)	x	x	x	x	√	√	x	√	√	x	x	x	√
20	LAKU	√	√	x	√	√	√	√	√	√	√	x	√	√
21	AKSB	√	√	√	√	√	√	x	√	√	√	√	√	√
22	BAKAJ	√	x	√	√	√	√	x	√	√	x	x	√	√
23	LAP	√	√	√	√	√	√	x	√	√	√	√	√	√
24	PBAPP	x	√	x	√	√	√	√	x	x	x	√	√	√
NON-GOVERNMENTAL ORGANISATIONS (WATER RELATED)														
25	MWA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
OTHERS														
26	Consumer	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Footnote:

"√" Additional data required from others

"x" Additional data not required from others

"NA" Data not available

APPENDIX E

MATRIX 1: ADDITIONAL DATA (TECHNICAL) REQUIRED FROM OTHERS BY WATER STAKEHOLDERS

No.	Organisation	Additional Data Required from Others									
		Technical Data									
		Underground Water Profile From JMG	Water Resource / Capacity from BAKAJ, LUAS etc	River Cross Section	River Monitoring System	Total Maximum Daily Load	Geotechnical Data	Lidar Survey/ IFDA Survey	Ministry of Health (MOH)	Ministry of Education (MOE)	Inventori Pencemaran
MINISTRY OF ENVIRONMENT AND WATER											
1	Meteorology	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2	DID (Federal)	√	√	√	√	√	√	√	x	x	√
3	DID (States)	x	x	x	x	x	x	x	x	x	x
4	JAS	√	√	√	√	√	√	√	√		√
5	JPP	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
6	NAHRIM	x	x	x	x	x	x	x	x	x	x
7	MGTC	x	x	x	x	x	x	x	x	x	x
8	PAAB	√	√	x	x	x	x	x	x	x	x
9	BBA	x	√	√	√	x	x	x	x	x	x
10	SPAN	x	x	x	x	x	x	x	x	x	x
11	IWK	x	x	x	x	x	x	x	x	x	x
MINISTRY OF AGRICURAL AND FOOD INDUSTRIES											
12	MADA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
13	KADA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
14	IADA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
15	FISHERIES (STATES)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
MINISTRY OF ENERGY AND NATURAL RESOURCES											
16	FORESTRY (STATES)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
17	JMG	x	√	√	√	√	√	√	√	√	√
18	ENERGY COMMISSION	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
WATER OPERATORS / REGULATORY / AUTHORITY (STATES)											
19	Water Operators (States)	√	x	√	√	√	√	√	x	x	√
20	LAKU	√	√	√	√	√	√	√	x	x	√
21	AKSB	√	√	√	√	x	√	√	√	x	√
22	BAKAJ	√	x	√	√	x	x	√	√	x	√
23	LAP	√	√	x	√	x	√	√	√	x	x
24	PBAPP	√	√	x	√	x	√	√	x	x	√
NON-GOVERNMENTAL ORGANISATIONS (WATER RELATED)											
25	MWA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
OTHERS											
26	Consumer	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Footnote:

"√" Additional data required from others

"x" Additional data not required from others

"NA" Data not available

APPENDIX F

MATRIX 1: ADDITIONAL DATA (NON-TECHNICAL) REQUIRED FROM OTHERS BY WATER STAKEHOLDERS

No.	Organisation	Non-Technical Data			
		International Market (MITI)	Kepuasan Pelanggan	Teknologi Baru Oversea	Benchmarking Water Operator
MINISTRY OF ENVIRONMENT AND WATER					
1	Meteorology	NA	NA	NA	NA
2	DID (Federal)	x	x	x	x
3	DID (States)	x	x	x	x
4	JAS	x	x	√	x
5	JPP	NA	NA	NA	NA
6	NAHRIM	x	x	x	x
7	MGTC	x	x	x	x
8	PAAB	x	x	x	x
9	BBA	x	x	x	x
10	SPAN	x	x	x	x
11	IWK	x	x	x	x
MINISTRY OF AGRICURAL AND FOOD INDUSTRIES					
12	MADA	x	x	x	x
13	KADA	x	x	x	x
14	IADA	x	x	x	x
15	FISHERIES (STATES)	x	x	x	x
MINISTRY OF ENERGY AND NATURAL RESOURCES					
16	FORESTRY (STATES)	NA	NA	NA	NA
17	JMG	x	x	√	√
18	ENERGY COMMISSION	NA	NA	NA	NA
WATER OPERATORS / REGULATORY / AUTHORITY (STATES)					
19	Water Operators (States)	√	√	√	√
20	LAKU	√	x	√	√
21	AKSB	x	√	√	√
22	BAKAJ	x	x	√	x
23	LAP	√	√	√	√
24	PBAPP	x	x	√	x
NON-GOVERNMENTAL ORGANISATIONS (WATER RELATED)					
25	MWA	NA	NA	NA	NA
OTHERS					
26	Consumer	NA	NA	NA	NA

Footnote:
"√" Additional data required from others
"x" Additional data not required from others
"NA" Data not available

APPENDIX G
MATRIX 2: DEVELOPMENT TOOLS REQUIRED BY WATER STAKEHOLDERS

No.	Organisations	SCADA	PLC	Telemetry/ Adv Sensors	Modelling/ Simulation	IoT	Big Data Analytics	Drone and Autonomous vehicle	Smart Phone Apps	Cloud computing	Cloud Storage	Artificial Intelligent	Pipe Burst Indicator	Automated Dam Gate Control (for multi-purposed dams)	Raw Water / Ground Water Monitoring	Water Supply (Production)	Water Supply (Quality)
MINISTRY OF ENVIRONMENT AND WATER																	
1	Meteorology	NA															
2	DID (Federal)	√	√	√	√	√	√	√	√	√	√	√	x	√	√	√	x
3	DID (States)	√	√	√	√	√	√	√	√	√	√	√	x	√	√	√	x
4	JAS	√	√	√	√	√	√	√	√	√	√	√	x	x	√	x	√
5	JPP Sabah	√	√	√	√	√	√	√	√	√	√	√	√	x	x	x	x
6	NAHRIM	√	x	√	√	√	x	x	√	x	x	x	x	x	x	x	x
7	MGTC	x	x	x	√	√	x	x	√	x	x	x	x	x	x	x	x
8	PAAB	x	x	x	x	x	√	√	√	√	√	x	x	x	x	x	x
9	BBA	√	x	√	x	√	x	x	√	x	x	x	√	√	x	x	x
10	SPAN	x	x	x	√	√	√	x	√	√	x	x	x	x	x	x	x
11	IWK	√	√	√	x	√	√	x	√	√	√	x	x	x	x	x	x

Footnote:
- √ - must have data
- √ - should have data
- √ - nice to have data
- "x" - not required
- NA - not available

APPENDIX H

MATRIX 2: DEVELOPMENT TOOLS REQUIRED BY WATER STAKEHOLDERS

No.	Organisations	Customer Services Management	Reservoir / Aquifer Level Monitoring	Pressure Management	Water Supply (Advance Pressure Management)	Web base System monitoring	Geographical Information System	Water Supply (Critical Point Monitoring)	Ground Water / Hydraulic Monitoring	Early Warning System (River / Settlement Rate)	River / Groundwater Monitoring System	Rainfall Data	Human Resources Training Development	NRW / Groundwater Infiltration Monitoring System	Water Supply (Benchmarking)	Ground Settlement (Benchmarking)	Smart Phone Apps	IoT for Pump Operation	Slope Monitoring
MINISTRY OF ENVIRONMENT AND WATER																			
1	Meteorology	NA																	
2	DID (Federal)	x	x	x	x	√	√	x	√	√	√	√	x	x	x	x	√	x	x
3	DID (States)	x	x	x	x	√	√	x	√	√	√	√	x	x	x	x	√	x	x
4	JAS	√	x	x	x	√	√	x	x	√	√	√	√	x	x	x	x	x	x
5	JPP Sabah	√	x	√	x	√	√	x	x	√		√	x	√	x	x	x	x	x
6	NAHRIM	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
7	MGTC	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
8	PAAB	x	x	x	√	√	x	x	x	x	x	x	√	x	x	x	x	x	x
9	BBA	x	x	x	x	x	x	x	x	x	x	x	x	√	x	x	x	x	x
10	SPAN	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
11	IWK	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x

Footnote:

- √ - must have
- √ - should have
- √ - nice to have
- "x" - not required
- NA - not available

APPENDIX I
MATRIX 2: DEVELOPMENT TOOLS REQUIRED BY WATER STAKEHOLDERS

No.	Organisations	Software (Intergrated)	Data Analyses/ Programmer	Real Time Monitoring / Prediction	Water Supply (Leakage Sensoring)	Command Centre Monitoring	Centralise Maintainance Management	Prepaid Meter	Smart Meter / RFID	Infrastructure for Smart Meter	Infrastructure for smart sensor (auto sampling)	E-Book (Technical References)	Asset Management System	Online Approval Status	System Integration	Application Integration	Effluent/ Sewage Real-time discharge monitoring	Discharged Treated Waste Water Monitoring	Waste Water (Benchmarking)
MINISTRY OF ENVIRONMENT AND WATER																			
1	Meteorology	NA																	
2	DID (Federal)	x	x	x	x	x	x	x	x	x	x	x	x	√	√	x	x	x	x
3	DID (States)	x	x	x	x	x	x	x	x	x	x	x	x	√	√	x	x	x	x
4	JAS	x	√	√	x	√	x	x	x	x	√	x	x	x	x	√	√	x	x
5	JPP Sabah	x	√	√	x	√	x	x	x	x	√	√	√	x	x	x	√	√	√
6	NAHRIM	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
7	MGTC	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
8	PAAB	√	x	x	x	x	x	x	x	x	x	x	√	x	√	x	x	x	x
9	BBA	x	x	x	√	x	x	x	x	x	x	x	x	x	x	x	x	x	x
10	SPAN	x	x	x	x	x	x	x	x	x	x	x	x	x	√	x	x	x	x
11	IWK	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x

Footnote:
- √ - must have
- √ - should have
- √ - nice to have
- "x" - not required
- NA - not available

APPENDIX J
MATRIX 2: DEVELOPMENT TOOLS REQUIRED BY WATER STAKEHOLDERS

No.	Organisations	SCADA	PLC	Telemetry/ Adv Sensors	Modelling/ Simulation	IoT	Big Data Analytics	Drone and Autonomous vehicle	Smart Phone Apps	Cloud computing	Cloud Storage	Artificial Intelligent	Pipe Burst Indicator	Automated Dam Gate Control (for multi-purposed dams)	Raw Water / Ground Water Monitoring	Water Supply (Production)	Water Supply (Quality)
1	JMG	√	√	√	√	√	√	√	√	√	√	√	√	x	√	x	x

No.	Organisations	Customer Services Management	Reservoir / Aquifer Level Monitoring	Pressure Management	Water Supply (Advance Pressure Management)	Web base System monitoring	Geographical Information System	Water Supply (Critical Point Monitoring)	Ground Water / Hydraulic Monitoring	Early Warning System (River / Settlement Rate)	River / Groundwater Monitoring System	Rainfall Data	Human Resources Training Development	NRW / Groundwater Infiltration Monitoring System	Water Supply (Benchmarking)	Ground Settlement (Benchmarking)	Smart Phone Apps	IoT for Pump Operation	Slope Monitoring
		MINISTRY OF ENERGY AND NATURAL RESOURCES																	
1	JMG	x	√	x	x	√	√	√	√	√	√	√	√	√	x	√	√	√	√

No.	Organisations	Software (Intergrated)	Data Analyses/ Programmer	Real Time Monitoring / Prediction	Water Supply (Leakage Sensoring)	Command Centre Monitoring	Centralise Maintainance Management	Prepaid Meter	Smart Meter / RFID	Infrastructure for Smart Meter	Infrastructure for smart sensor (auto sampling)	E-Book (Technical References)	Asset Management System	Online Approval Status	System Integration	Application Integration	Effluent/ Sewage Real-time discharge monitoring	Discharged Treated Waste Water Monitoring	Waste Water (Benchmarking)
		MINISTRY OF ENERGY AND NATURAL RESOURCES																	
1	JMG	√	√	√	√	√	√	x	x	x	√	√	√	√	√	x	x	x	x

Footnote:
- √ - must have
- √ - should have
- √ - nice to have
- "x" - not required
- NA - not available

APPENDIX K
MATRIX 2: DEVELOPMENT TOOLS REQUIRED BY WATER STAKEHOLDERS

No.	Organisations	SCADA	PLC	Telemetry/ Adv Sensors	Modelling/ Simulation	IoT	Big Data Analytics	Drone and Autonomous vehicle	Smart Phone Apps	Cloud computing	Cloud Storage	Artificial Intelligent	Pipe Burst Indicator	Automated Dam Gate Control (for multi-purposed dams)	Raw Water / Ground Water Monitoring	Water Supply (Production)	Water Supply (Quality)
WATER OPERATORS / REGULATORY / AUTHORITY (STATES)																	
1	Water Operators (States)	√	x	√	x	x	x	x	x	x	x	x	x	x	√	√	√
2	AKSB	√	√	√	√	√	√	√	√	x	√	√	√	√	√	√	√
3	BAKAJ	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
4	BBAL	√	√	√	√	√	√	√	√	√	√	√	√	x	√	√	√
5	LAP	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
6	PBAPP	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
7	LAKU	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√

Footnote:

√ - must have

√ - should have

√ - nice to have

"x" - not required

NA - not available

APPENDIX L

MATRIX 2: DEVELOPMENT TOOLS REQUIRED BY WATER STAKEHOLDERS

No.	Organisations	Customer Services Management	Reservoir / Aquifer Level Monitoring	Pressure Management	Water Supply (Advance Pressure Management)	Web base System monitoring	Geographical Information System	Water Supply (Critical Point Monitoring)	Ground Water / Hydraulic Monitoring	Early Warning System (River / Settlement Rate)	River / Groundwater Monitoring System	Rainfall Data	Human Resources Training Development	NRW / Groundwater Infiltration Monitoring System	Water Supply (Benchmarking)	Ground Settlement (Benchmarking)	Smart Phone Apps	IoT for Pump Operation	Slope Monitoring
WATER OPERATORS / REGULATORY / AUTHORITY (STATES)																			
1	Water Operators (States)	√	√	√	√	√	√	√	√	√	√	√	√	√	√	x	√	√	√
2	AKSB	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
3	BAKAJ	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
4	BBAL	√	√	√	√	√	√	√	x	x	x	√	√	√	x	x	x	√	√
5	LAP	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
6	PBAPP	√	√	√	√	√	√	√	√	√	√	√	√	√	x	x	√	√	x
7	LAKU	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√

Footnote:

√- must have

√- should have

√- nice to have

"x" - not required

NA - not available

APPENDIX M

MATRIX 2: DEVELOPMENT TOOLS REQUIRED BY WATER STAKEHOLDERS

No.	Organisations	Software (Intergrated)	Data Analyses/ Programmer	Real Time Monitoring / Prediction	Water Supply (Leakage Sensoring)	Command Centre Monitoring	Centralise Maintainance Management	Prepaid Meter	Smart Meter / RFID	Infrastructure for Smart Meter	Infrastructure for smart sensor (auto sampling)	E-Book (Technical References)	Asset Management System	Online Approval Status	System Integration
WATER OPERATORS / REGULATORY / AUTHORITY (STATES)															
1	Water Operators (States)	√	√	√	√	√	√	√	√	√	√	x	x	x	x
2	AKSB	√	√	√	√	√	√	√	√	√	√	√	√	√	√
3	BAKAJ	√	√	√	√	√	√	√	√	√	√	√	√	√	√
4	BBAL	√	√	√	√	√	√	x	√	√	√	√	√	√	√
5	LAP	√	√	√	√	√	√	√	√	√	√	√	√	√	√
6	PBAPP	√	√	√	x	√	√	x	√	√	√	√	√	√	√
7	LAKU	√	√	√	√	√	√	√	√	√	√	√	√	√	√

Footnote:

√ - must have

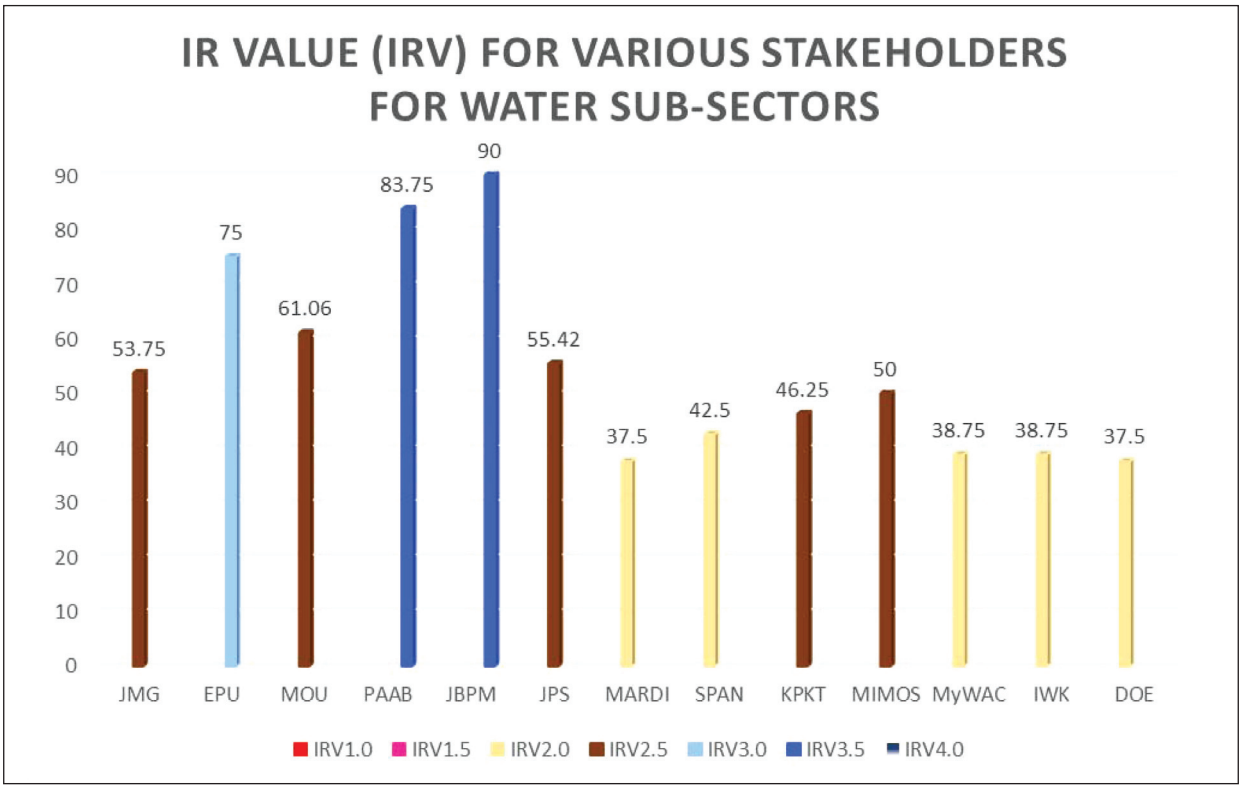
√ - should have

√ - nice to have

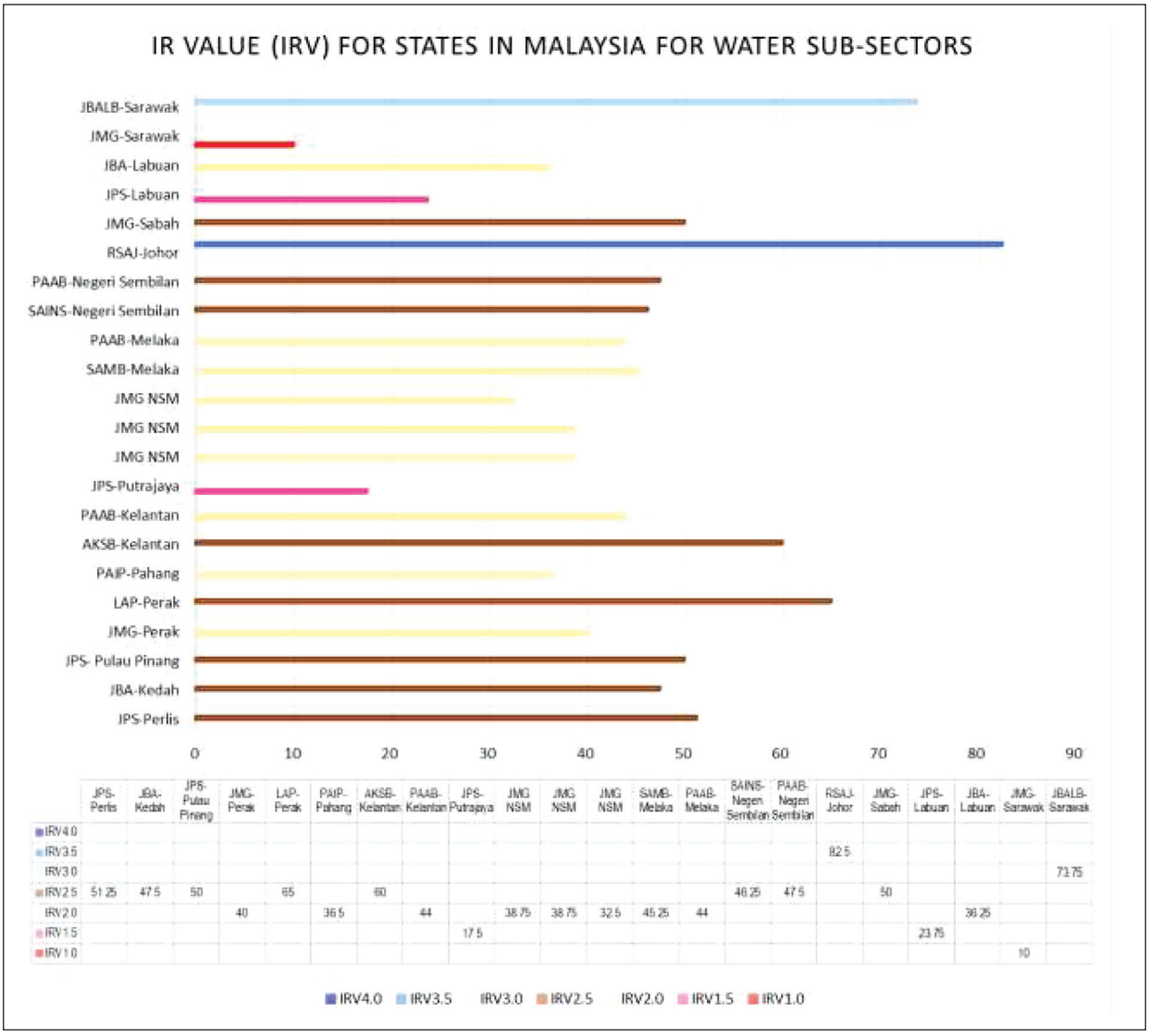
"x" - not required

NA - not available

APPENDIX N
IR VALUE (IRV) FOR VARIOUS STAKEHOLDERS FOR WATER SUB-SECTORS



APPENDIX O
IR VALUE (IRV) FOR STATES IN MALAYSIA FOR VARIOUS WATER SUB-SECTORS



	JPS-Perlis	JBA-Kedah	JPS-Pulau Pinang	JMG-Perak	LAP-Perak	PAIP-Pahang	AKSB-Kelantan	PAAB-Kelantan	JPS-Putrajaya	JMG NSM	JMG NSM	JMG NSM	SAMB-Melaka	PAAB-Melaka	SAINS-Negeri Sembilan	PAAB-Negeri Sembilan	RSAJ-Johor	JMG-Sabah	JPS-Labuan	JBA-Labuan	JMG-Sarawak	JBALB-Sarawak
IRV4.0																						
IRV3.5																	82.5					
IRV3.0																						73.75
IRV2.5	51.25	47.5	50		65		60								46.25	47.5		50				
IRV2.0				40		36.5		44		38.75	38.75	32.5	45.25	44						36.25		
IRV1.5									17.5										23.75			
IRV1.0																					10	

APPENDIX P

SUMMARY REPORT OF VALIDATION ENGAGEMENTS

Executive Summary:

WST2040 is the national economic development agenda that will begin in the 12MP and it will take 20 years. Therefore, a specific study (Implementation & Cost Analysis) under the IRW4.0 sector has been made to identify strategies, initiatives, programs, projects, and activities that need to be implemented to achieve the transformation targets which expected in each phase later. The process of preparing the WST2040 Roadmap (IRW4.0) has involved participation from various stakeholders including ministries, government agencies, NGOs, academics, scientists, industry and the general public. Amongst whom present includes representatives from MOSTI, MAMPU, KASA, MOU, IWK, JPS, JMG, JAS, PAAB, NAHRIM, MIMOS, MGTC, SADA, LADA, AKSB, JANS, PBAPP, BAKAJ, BBA Labuan, PAIP, LAKU and SWB. As a result of a series of discussions and workshops, we have successfully developed a transformation plan (implementation & budget) which we believe needs to be implemented accordingly.

Discussion:

We have conducted a series of discussions as well as workshops with all stakeholders as well as relevant strategic partners in the water sector. For each discussion and workshop that has been implemented, we have reached a consensus and agreed on a transformation plan and also the costs that need to be prepared during the period. Among the activities we do are as follows:

a) Review and analyse current policies and suggest improvements that need to be made for the benefit of the national water sector.
b) Perform comparative analysis of strategies and business models implemented in other countries such as Korea, Singapore, Germany, United States, Denmark, and others.
c) To study the direction and potential of the country's water sector industry by taking into account the current world market value to make the country's water sector a new economic sector, dynamic, and able to drive the country's GDP growth in the future.
d) Prepare a framework for the implementation of strategies and initiatives for the transformation of the national water sector for the four phases (12th MP – 15th MP) along with implementation proposals, allocation estimates and key achievement targets based on the analysis carried out.
e) Conduct consultation sessions with each stakeholder and expert team for the purpose of finalizing the implementation framework of strategies and initiatives for the transformation of the country's water sector.
f) Provide complete documents as reference and guidance by various ministries and agencies to implement projects/programs and activities towards achieving the targeted transformation goals.

Conclusions & Recommendations:

As a result of each of the discussions and workshops we have conducted, we have formulated a direction that the government and ministries need to take seriously with each of the programs and frameworks we have proposed. Here we list some of the main thrust and transformation agenda that need to be done during the four phases:

a) Preparation of the water sector towards IR4.0 and the use of smart technology to drive the development of the water sector entirely.
b) Establishment of Centres of Excellence (COE) as the basis for strategic planning and decision making as well as a driver to the development of expertise, local innovation in the water sector.
c) Comprehensive and significant improvement in the concept of Integrated Water Resources Management (IWRM), Water Technology Innovation (WTI), Economies of Scale (EoS), Regional Water Hub (RWH). Here we have agreed to use Artificial Intelligence (AI) technology as the main core in the development and transformation of this water.
d) Sustainable water management with the concept of AI-Driven and also be part of the development of Smart Citizen, Smart City & Smart Nation.
e) Provision of comprehensive infra-structure and info-structure for current water needs and use by each sector and consumers.
f) Development of a new business model to drive the country's water industry to a viable, attractive, and profitable industry.
g) Implementation of a strategic program (Private-Public Partnership) to position the water sector as a new economic sector of the country.

Attachment:

The roadmap that has been agreed by all stakeholders is as attached and we hope the government and ministries will take this proposed transformation plan seriously.

APPENDIX Q

Transformation Roadmap as Proposed by IR4.0 and Agreed by Stakeholders

Transformation Roadmap (Vision 2040)

Accelerating IWRM Implementation	Water Technology Innovation	Achieving Economics of Scale	Becoming Regional Water Hub
Estimate Total Investment: RM 40 Billion	Estimate Total Investment: RM 45 Billion	Estimate Total Investment: RM 40 Billion	Estimate Total Investment: RM 50 Billion
12th MP (2021 – 2025)	13th MP (2026 – 2030)	14th MP (2031 – 2035)	15th MP (2036 – 2040)

Digitalize all existing manual water ecosystem – Hardware, Software, & Peopleware:
a) Upgrade to full system, application, and technology development (digitalization) like water supply, water treatment, water health, water hazard, water sewerage, ground water, smart meter, GIS, etc
b) Redesign the water ecosystem to be more supportive of digitalisation.

Big Data Analytic & Data Warehouse - Data sharing & Integration Framework:
a) Cloud computing & virtualization platform.
b) Centralize platform and database (Dashboard, KPI Management, Operation Tactical and Planning, Asset Management, Maintenance Planning, Reporting, etc)
c) Optimize the existing system like NAWABS, NaFFWS, etc
d) Business intelligence (BI) tools to improving strategic decision-making and providing a competitive advantage.

Telecommunications & Satellite Technology:
a) Roll out 4G/5G - Improving and expanding network services & coverage.
b) Using Satellite (data) to improve water especially in soil loss and erosion mapping, asset monitoring & maintenance, water quality monitoring, and flood prediction.
c) Smart Connectivity - LTE-M, NB-IOT, CAT, CAT-M1

Blockchain & Artificial Intelligence (Framework):
a) Setup taskforce to draft and develop full framework (end-to-end) using blockchain & AI technology in water ecosystem.
b) Blockchain and AI able to effectively allocate water resources; empower consumers by providing economic and social value, and incentivize conservation and provide positive environmental outcomes.

Establishment of Innovation & Research and Development Centre (Centre of Excellence):
a) Re-skilling & educate business entities to champion IR4.0 in water businesses.
b) Re-skilling & educate industry people to understand water digitalisation.
c) Development of intellectual capital through smart partnerships
d) Information to water stakeholders
e) Setup the National Water Data Centre

Big Data Analytic & Data Warehouse - Data sharing & Integration (Public & Private Sector):
a) Cloud computing & virtualization platform.
b) Improve the Data Hub / Repository for both public & private water sectors and industry.
c) VR/AR augmented workforce.

Telecommunications & Satellite Technology:
a) Review and strengthening the 5G / 6G coverage entire Malaysia
b) Continue to using Satellite technology (data) to improve water especially in soil loss and erosion mapping, asset monitoring & maintenance, water quality monitoring, and flood prediction.
c) Smart Connectivity - LTE-M, NB-IOT, CAT, CAT-M1

Internet of Things (IOT) – Smart Citizen: The Great Urban Challenge:
a) Phase 1 – focusing on the existing occupancies of residents / businesses
b) Installation of smart water devices that enable existing users to self-manage and maintain autonomous water systems at building, community, & cluster level.
c) Provide incentives to citizens to encourage sustainable usage of smart water devices.
d) Provide incentives for marketing of smart water devices and relevant training.

AI-Driven National Smart Water & Operation Centre (Phase 1):
a) Launch Langkawi Project (Live)
b) Focus on the National Project; water quantity & quality, water supply & water demand management, & full water supply chain

Invest in Critical Technology related to Water Recycle and Water Treatment:
Private & Public Partnership – Digital Strategy and Funding (International & Local) especially on Smart Eco Green

Water-Efficient Infrastructure & Water-Smart Cities (Phase 1):
Infrastructure services that enable communities to develop, run and maintain autonomous urban water systems.
(Smart City / Smart Home / Smart Building)

Invest in Critical Technology related to Water Operation & Treatment Contributing to GDP and Economics of Scale:
a) Advanced Technology & Innovation. (Nano-Bio Technology & Intelligent Robots)
b) Private & Public Partnership – Digital Strategy and Funding Programme

AI-Driven National Smart Water & Operation Centre (Phase 2):
a) National Project and part of smart cities development
b) Water operator focus on assisting with end-user system design, installation, information, maintenance and emergency response with Smart Meter (AI-Driven Smart Water System)

Smart Water & Smart Cities:
Shift from end users that pay for the delivery of services to those that pay for the cost of installing and maintaining local infrastructure, either individually or collaboratively

Smart Citizen - The Great Urban Challenge (Phase 2):
a) Services and technology that end users able to manage and maintain autonomous water systems at building, community & cluster level.
b) Provide incentives and continue IR4.0 training to public

Smart Water & Smart Citizen (Development Framework):
Smart Home / Building that enable greater autonomy and smaller-scale applications in water collection, storage, treatment and distribution

Water-Efficient Infrastructure & Water-Smart Cities (Phase 2):
a) Technology to monitor and reduce illegal water trade and theft, coupled with a reduction in leakages and wastage across the existing network
b) Also focus on advances in decentralised and centralised water storage solutions, coupled with intelligent demand management and higher water recycling and reuse rates

Invest in Critical Technology related to Water Operation, Supply & Distribution:
a) Expansion of technology and systems to manage and minimise the impact of extreme fluctuations in water availability, including fast shifts from too much water to too little
b) Private & Public Partnership – Digital Strategy and Funding Programme

Establishment of AI-Driven National Smart Water & Smart Cities Hub:
a) Continue the National Smart Water & Smart Cities Development
b) Implementation of differential water pricing and services according to availability of supply, service plans, and customer behaviour (Smart Billing / Prepaid Concept)
c) Centralise (AI-Driven) Water Subsector system

Smart Water, Smart Cities, & Smart Citizen:
a) Autonomous and community-based water systems (Smart City)
b) 70% of self-sufficient service level (SSL) achieved

Smart Citizen - The Great Urban Challenge (Phase 3):
a) Services and technology that end users able to manage and maintain autonomous water systems at building, community & cluster level
b) Provide incentives and continue IR4.0 training to public

Customer Satisfaction Index will increase **25% - 45%**

- Good value for service
- Easy to understand water use
- Save money
- Easy to use water efficiently
- Easy to communicate with provider/utility

ROI

- Assets
- Systems & Process
- People & Culture

- ❑ Up to 50% reduction in unplanned downtime related to assets & parts
- ❑ Up to 40% reduction in inventory costs
- ❑ Up to 35% savings in maintenance and inventory budgets
- ❑ Up to 70% increase in service levels and reduction numbers of incidents
- ❑ Up to 100% project performance and product delivery reliability
- ❑ Up to 40% increase in operational efficiency
- ❑ Up to 30% reduction in water lost before 'reaching' the customer
- ❑ Up to 45% reduction in energy consumption of water supply, wastewater collection, and treatment

APPENDIX R

SUMMARY OF VALIDATION REPORT FOR LANGKAWI MODEL

User Engagement Validation Report

1. Introduction

   Akademi Sains Malaysia (**ASM**) currently conducting research regarding the transformation of water sector to IR4.0. For this research, there is a need for modelling to simulate the real scenario. Thus, Langkawi was chosen for a pilot project. The pilot projects focus on unified all the water sector stakeholders into one single platform whereby all information were shared and can be easily accessed by stakeholders. For this purpose, IR4.0 Taskforce has engaged various stakeholders for information collection and validations

2. Method

   IR 4.0 taskforce has formulated sequence of method for requirement collection and validation. Those method are:

   1. Site visit.
   2. Prototyping
   3. Workshop
   4. Regular Meeting

   2.1 Site Visit (Refer Appendix T)

   Early 2021, Group of 5 member of taskforce was flown to Langkawi for site visit and to understand the whole situation happened. The taskforce was taken to visit Jabatan Saliran dan Pengairan (**JPS**). Langkawi Authority Development Agency (**LADA**), Syarikat Air Darul Aman (**SADA**). During those meeting, the taskforce was shown the equipment, infrastructures, systems, and the current situation happening on Langkawi. The stakeholder also stated their desire for the water sector transformation.

   2.2. Prototyping

   With the all the information gathered during the site visit, the taskforce IR 4.0 has concluded that there is a need to bridging each stakeholder into one single platform due to every stakeholder working in a silo and there is no coherent working between them. Thus, there is not data sharing between them. This platform prototype was build using web-based technology. This prototype was developed based on the information gathered from stakeholders. This prototype focus on core functionality and they are:

   a. Data monitoring
   b. Data analytic
   c. Asset monitoring
   d. Asset management
   e. Data hub.
   f. General information
   g. Reporting
   h. Helpdesk

2.3. Workshop

On second week of June 2021, the taskforce conducted a 5-day workshop with the stakeholder for the data validation. On the fifth day, the modelling was presented to the stakeholders for their feedbacks, improvement, and suggestions. The stakeholder consist of existing stakeholder during the Langkawi site visit and new stakeholders each stakeholder was group into 4 difference group for a discussion. A lot of new input and perspective was brought up by each group. Overall, the prototype validated and accepted by the stakeholders.

2.4. Regular Meeting

After the workshop, the taskforce regularly conducts a meeting with the stakeholder to get feedback and validation on the amendment from previous meeting. Besides that, new stakeholder was onboard onto the regular meeting to get new insight which is not shed previously. This is important to solidify the proposed model for Langkawi.

3. Summary

Based on the information gathered throughout the research process, the information gathered during the site visit was verified during the workshop presentation. Any changes on the proposed prototype were verified in the next meeting with the stakeholder after the amendments were made. This is to ensure any new feedback, improvement, and changes was verified.

APPENDIX S
Consumer Survey Report For Various Water Sub-sectors Services In Malaysia

CONSUMER SATISFACTION SURVEY IN VARIOUS WATER SUB-SECTORS IN MALAYSIA												
Demographic	Raw water services				Water supply				Waste water services			
Residence	Kedah	WP Kuala Lumpur	Perak	Others (36.8%)	Kedah	Perak	WP Kuala Lumpur & Putrajaya	Others	Kedah	Perak	WP Kuala Lumpur & Putrajaya	Others
	43.20%	26.50%	5.40%	36.80%	34.60%	15.40%	14.30%	35.70%	36.70%	15%	12.7	
Community type	Urban	Suburban	Rural		Urban	Suburban	Rural	Others	Urban	Suburban	Rural	
	68.10%	26.50%	5.40%		67.50%	24%	7.80%	0.70%	72.70%	21.30%	6%	
Gender	Male	Female			Male	Female			Male	Female		
	59.50%	40.50%			58%	42%			56.20%	43.80%		
Age	18-44	45-64	65 & Above		18-44	45-64	65 & Above		18-44	45-64	65 & Above	
	63.80%	34.60%	1.60%		69.20%	29.10%	1.70%		66%	33.70%	0.30%	
Level of Education	High School	Bachelor's	Master's	Others	High School	Bachelor's	Master's	Others	High School	Bachelor's	Master's	Others
	25.90%	48.10%	18.40%	7.60%	9.80%	56.00%	25.40%	8.80%	31.10%	48.30%	13.90%	6.70%
Relationship status	Single	Married	Others		Single	Married	Others		Single	Married	Others	
	21.1%	78.4%	0.5%		16.10%	82.90%	1%		18.40%	80.10%	1.50%	
Employment status	Employed (Full time & Part time)	Self-employed	Not-employed	Others	Employed (Full time & Part time)	Self-employed	Not-employed	Others	Employed (Full time & Part time)	Self-employed	Not-employed	Others
	93.50%	2.70%	0.50%	3.30%	84.50%	6.20%	3.10%	6.20%	95.50%	1.50%	3.00%	
Average household income	< RM5000	RM5000 - RM10 000	> RM10 000		< RM5000	RM5000 - RM10 000	> RM10 000		< RM5000	RM5000 - RM10 000	> RM10 000	
	43.20%	30.80%	25.90%		26%	36.80%	37.30%		45%	32.60%	22.50%	
No.of family members	< 5	> 5			< 5	> 5			< 5	> 5		
	66.50%	33.50%			62.70%	37.30%			68.20%	31.80%		

Figure S1. Demography summary for various water sub-sectors

TECHNOLOGY AND YOU	YES			NO			OTHERS		
	Raw water services	Water supply	Wastewater services	Raw water services	Water supply	Wastewater services	Raw water services	Water supply	Wastewater services
Internet accessibility at home	91.90%	94.30%	91.40%	8.10%	5.70%	8.60%	NA	NA	NA
Free internet at their area	9%	13.50%	19.50%	87%	85%	80.50%	3.80%	1.50%	NA
Availability of smartphone	100%	99%	99.60%	0%	1%	0%	NA	NA	NA
Usage of smart phone for internet banking?	93%	90.70%	91.80%	73%	9.30%	8.20%	NA	NA	NA
Reliability of internet coverage	69.70%	76.70%	73%	20.50%	18.10%	19.50%	9.70%	5.20%	7.50%
Usage computer at home	83.20%	89.10%	81.30%	16.80%	10.90%	18.70%	NA	NA	NA
Receival of water bills through any online platform i.e. smartphone apps, email etc.	44.30%	52.80%	52.40%	55.70%	47.20%	47.60%	NA	NA	NA

Figure S2. Technology and You

Technology and You	Raw water services	Water supply	Wastewater services
Which telecommunication services or Internet Service Provider that you subscribed for home use?			
Maxis	20.50%	20.20%	21%
Celcom	20%	19.20%	20.20%
Telekom Malaysia	36.80%	44.60%	34.80%
DIGI	10.80%	8.30%	14.20%
U-mobile	11.90%	7.80%	9.70%
How do you normally pay your water bill?			
Online transfer-bank account	NA	74.10%	67.80%
Online transfer-credit card	NA	4.10%	2.20%
Mobile transaction	NA	7.80%	5.20%
Pay by cash	NA	8.30%	16.80%
Other e-payments method	NA	1.60%	1.90%
How much do you pay your water bill on average in a month?			
< RM20	NA	39.20%	72.70%
RM20-RM50	NA	41.50%	16.50%
> RM50	NA	19.20%	4.90%
Others	NA	0.40%	5.90%
Given the choice, what is your preferred mode of payment?			
Online transfer-bank account/credir card	NA	82.90%	77.90%
Mobile transaction	NA	10.40%	10.50%
Other e-payments method	NA	2.50%	4.90%
Pay at counter	NA	5.20%	6.70%
Compared to other states or countries, what do you think of the charges of your Water Utility Company?			
About the same	NA	26.40%	33.70%
Less expensive	NA	32.10%	39%
More expensive	NA	13%	4.50%
Others	NA	28.50%	22.80%

Figure S3. Technology and You

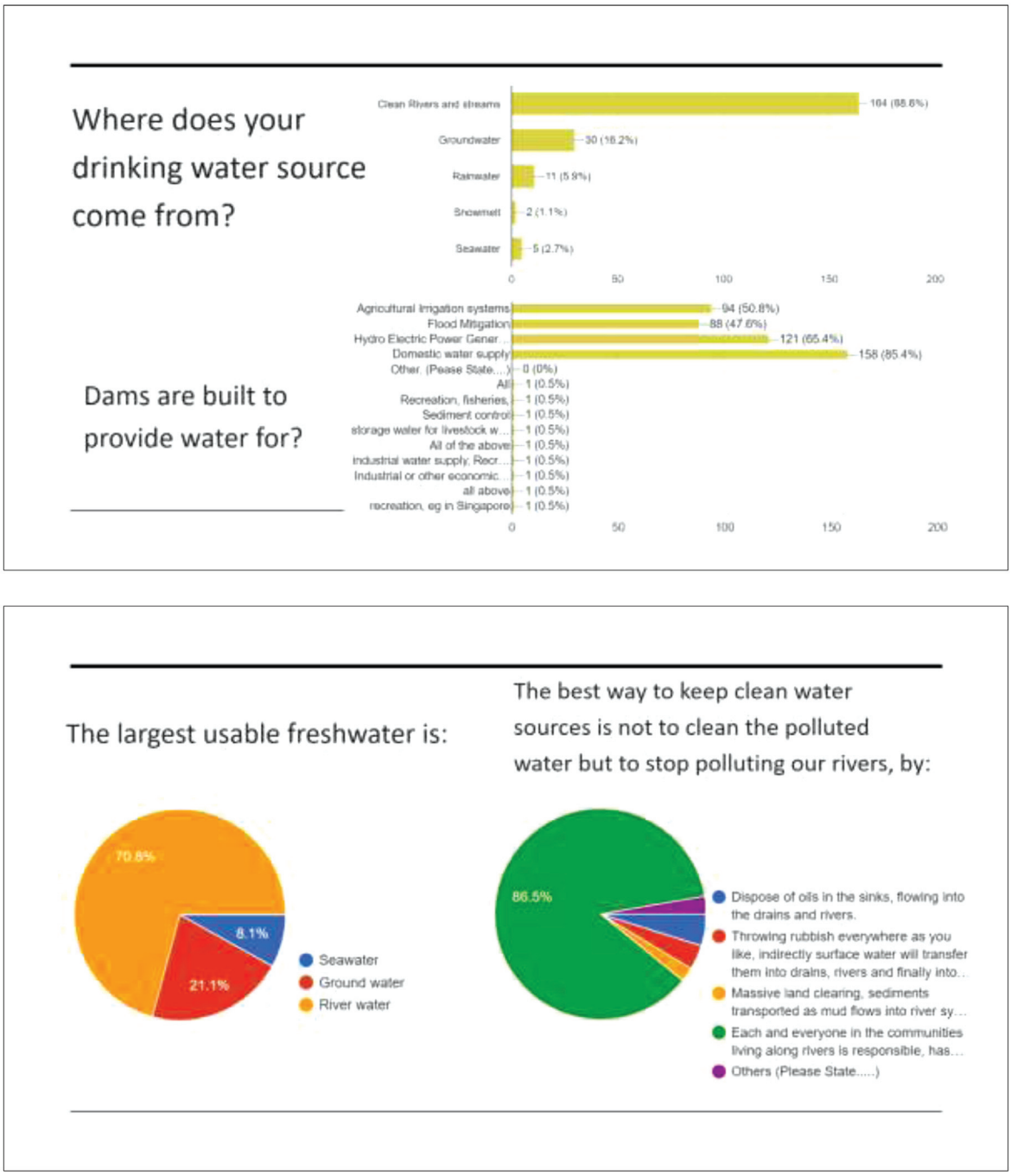
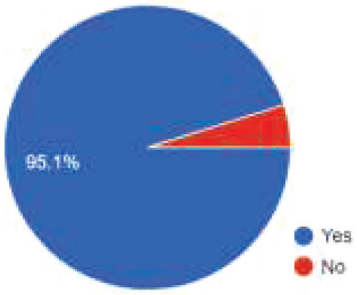
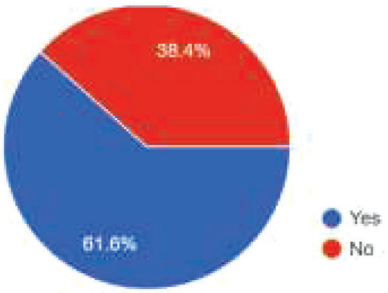


Figure S4. Survey summary for raw water services

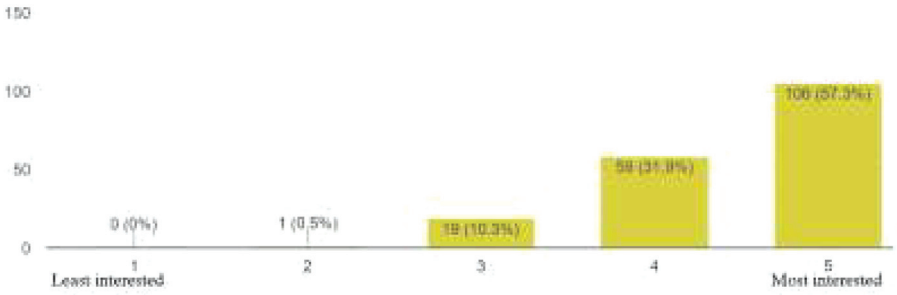
Are you aware the garbage nearby your residential area could be one of the polluting factor to raw water?



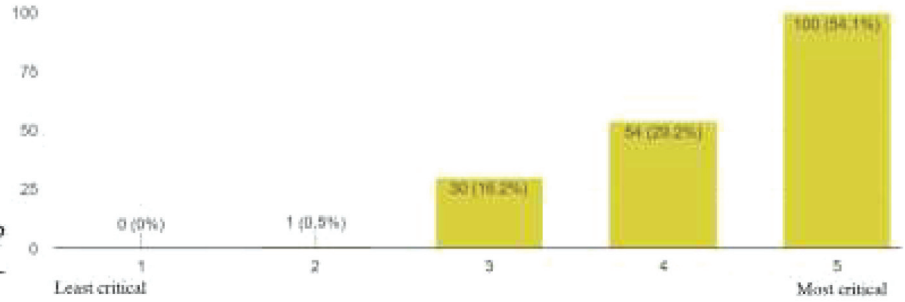
Are you aware which river is supplying drinking water to your home?

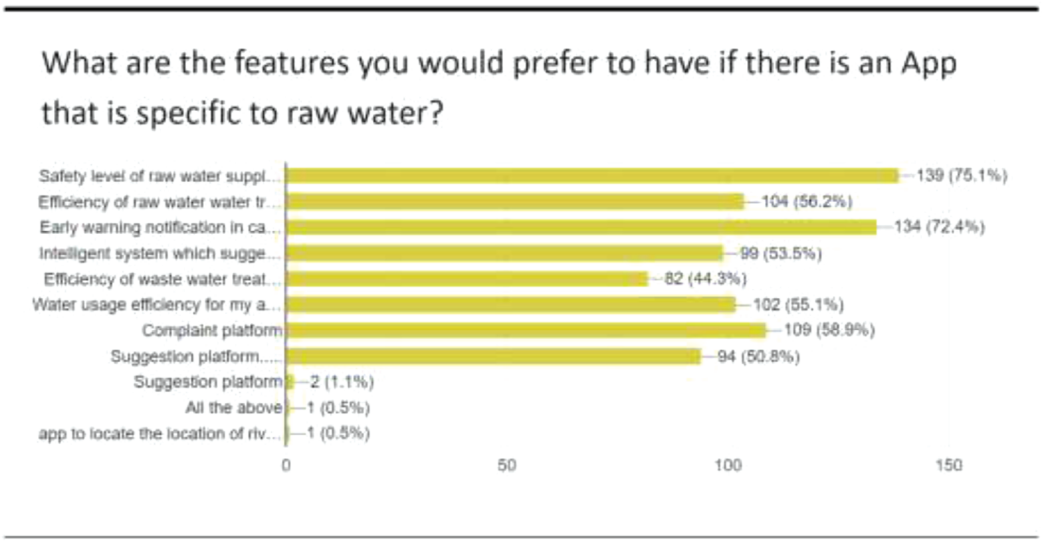


How interested are you to know how clean/polluted your water sources are?



Do you think that it is crucial that each customer/consumer of water should have an app that alert them on potential water crisis and options of solution?





Please choose the water company that treats your water or wastewater

Water supply	Air Selangor	LAP	SADA	PBAPP	AKSB	SAP	SATU	PAIP	SAMB
	54.40%	5.20%	5.70%	4.10%	4.10%	1%	2.10%	0.50%	4.10%
	SAINS	SAJ	KWB	LAKU	Sabah Water Department	FT Labuan Water Supply	Others		
	3.10%	5.20%	1%	1%	0.50%	2.10%	5.90%		
Wastewater services	IWK	Others							
	95.10%	4.95							

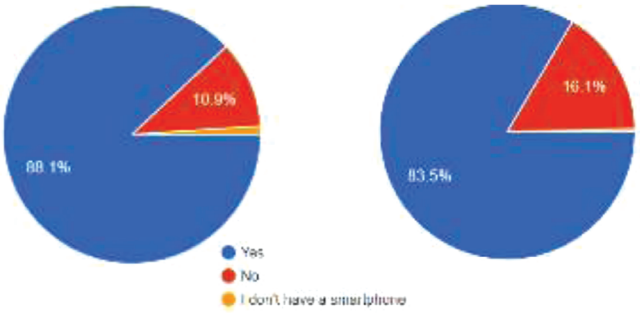
Service delivery- Quality	Water supply	Sewerage water
Taste of tap water i.e. for daily usage including brushing teeth, ablution etc.		
Excellent	33.70%	NA
Good	37.80%	NA
Neutral	21.80%	NA
Poor	3.60%	NA
Very poor	3.10%	NA
Colour (clarity) of tap water or effluent		
Excellent	33.75%	26.60%
Good	38.90%	39.70%
Neutral	19.20%	25.50%
Poor	7.30%	4.90%
Very poor	1%	3.40%
Odour of tap water or effluent		
Excellent	32.60%	27.70%
Good	44%	36.30%
Neutral	15.50%	25.10%
Poor	5.20%	7.10%
Very poor	2.60%	3.70%
Volume of water you receive		
Excellent	37.30%	NA
Good	38.90%	NA
Neutral	18.70%	NA
Poor	4.70%	NA
Very poor	0.50%	NA
Pressure of water you receive		
Excellent	32.60%	NA
Good	34.70%	NA
Neutral	21.80%	NA
Poor	9.30%	NA
Very poor	1.60%	NA
Would you like to manage the above qualities via an Application (App) on your smartphone?		

Figure S5. Service delivery (Quality) of various water sub-sectors in Malaysia

Service delivery- Reliability

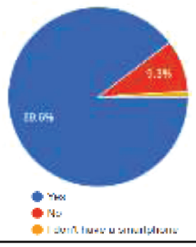
	Water suply		Wastewater
Frequency of water disruption		Current sewerage system	
Less than once in every 6 months	50.30%	Connected to public sewerage plant	73.80%
More than once in every 6 m	36.30%	Individual septic tank	36.30%
Never	13.50%	Others	13.50%
No. of water disruption in a week		Frequency of desludging sewerage system	
Usually have supply	69.40%	Yearly	10.50%
2-3 days	17.60%	Once every 2 years	16.50%
More than 3 days	4.10%	Once every 5 years	7.50%
Others	8.90%	Others	75.50%
Receive notification via electronic media in cases of water disruption		Receive notification for desludging	
Yes	67.90%	Yes	9.70%
No	32.10%	No	73.40%
		Don't know	16.90%
		Method of notification	
		Company website	27.30%
		Mobile Apps	21.10%
		Radio/TV announcement	11.70%
		Others	39.90%
Any experience led to water cut due to major UNPLANNED water disruption		Any experience that led to manholes or toilet overflow due to sewer pipe blockages	
Yes	59.10%	Yes	24.70%
No	31.10%	No	70.40%
Not sure	9.80%	Not sure	4.90%
		Service provider you contact in cases of blockages	
		Local wastewater service provider	62.00%
		Private contractor	19.30%
		Others	18.70%
Duration needed to restore water supply after breakdown		Duration needed by local wastewater service provider to	
Within 24 hours	50.80%	Within 24 hours	62.20%
Within 48 hours	22.80%	Within 48 hours	21.20%
Within 72 hours	18.70%	Within 72 hours	2.80%
Others	7.70%	Others	13.80%
Rate of satisfaction on restoration		Rate of satisfaction on restoration	
Very satisfied	13.80%	Very satisfied	27.70%
Satisfied	34.60%	Satisfied	40.40%
Neutral	38.80%	Neutral	28.50%
Poor	10.60%	Poor	2.20%
Very poor	2.10%	Very poor	1.10%
Handling of water-related conflicts		Handling of water pollution-related conflicts	
They send mobile tankers	22.60%	Sufficient resources	52.40%
Keep posted the situation on social media	46.30%	Efficient feedback platform for public complaints	30.70%
Increase helpdesk assistance	6.80%	They increase helpdesk assistance	5.60%
They leave it as it is	16.30%	They leave it as it is	5.20%
Others	8.00%	Others	6.10%
Would you like to manage the above via Apps in your smart phone?		Would you like to manage the above via Apps in your smart phone?	

Figure S6. Service delivery (Reliability) of various water sub-sectors in Malaysia

Service delivery- The Company	Water supply	Wastewater
Provides timely services		
Very satisfied	18.70%	32.60%
Satisfied	44.60%	39.30%
Neutral	32.10%	23.20%
Poor	3.60%	3.40%
Very poor	1%	1.50%
Reliable services		
Very satisfied	26.90%	34.10%
Satisfied	45.60%	42.70%
Neutral	25.90%	18.40%
Poor	1%	3.40%
Very poor	0.50%	1.50%
Procedures of serving its customers/consumers		
Very satisfied	19.70%	31.30%
Satisfied	43.50%	41.90%
Neutral	30.10%	22.10%
Poor	5.20%	3.40%
Very poor	1.60%	1.50%
Compliant to their promises		
Very satisfied	16.60%	31.10%
Satisfied	41.50%	41.60%
Neutral	35.20%	23.20%
Poor	5.20%	2.60%
Very poor	1.60%	1.50%
Transparency at handling customers/consumers		
Very satisfied	19.20%	31.10%
Satisfied	40.90%	41.20%
Neutral	31.10%	22.50%
Poor	5.20%	4.10%
Very poor	3.60%	1.10%
Timely response to letters and email inquiries		
Very satisfied	14%	32.20%
Satisfied	29.50%	38.60%
Neutral	45.10%	24.70%
Poor	5.20%	3.40%
Very poor	6.20%	1.10%

Service delivery- The Company	Water supply	Wastewater
Timely response to customer/consumer complaints and		
Very satisfied	15.50%	31.80%
Satisfied	35.20%	41.20%
Neutral	38.30%	22.50%
Poor	5.70%	3.40%
Very poor	5.20%	1.10%
Information provided on company website		
Very satisfied	15%	32.20%
Satisfied	45.10%	39.70%
Neutral	30.60%	23.60%
Poor	4.10%	3%
Very poor	5.20%	1.50%
The appearance and maintenance of facilities (buildings,		
Very satisfied	14.50%	28.50%
Satisfied	39.40%	39.70%
Neutral	35.80%	25.80%
Poor	6.70%	3.70%
Very poor	3.60%	2.20%
Level of preparedness in handling future water needs /		
Very satisfied	15.00%	35.20%
Satisfied	37.80%	40.10%
Neutral	32.10%	21%
Poor	8.30%	2.20%
Very poor	6.70%	1.50%
Level of dedication in maintaining water system or		
Very satisfied	17.10%	33.30%
Satisfied	41.50%	42.70%
Neutral	33.20%	19.50%
Poor	4.70%	2.60%
Very poor	3.60%	1.90%

Figure S7. Service delivery (Company) of various water sub-sectors in Malaysia

Service delivery-Billing	Water supply	Wastewater
Service charges		
Very satisfied	23.30%	37.50%
Satisfied	32.10%	34.50%
Neutral	34.70%	24.70%
Poor	7.80%	1.90%
Very poor	2.10%	1.50%
The ease of understanding your bill		
Very satisfied	29%	36.30%
Satisfied	41.50%	36%
Neutral	22.30%	24.30%
Poor	5.20%	1.50%
Very poor	2.10%	1.90%
The service information provided on your bill		
Very satisfied	25.90%	31.10%
Satisfied	40.90%	39.30%
Neutral	26.90%	25.50%
Poor	4.70%	2.60%
Very poor	1.60%	1.50%
The accuracy of the bill		
Very satisfied	25.40%	36.30%
Satisfied	35.80%	38.60%
Neutral	32.60%	21.70%
Poor	4.10%	1.90%
Very poor	2.10%	1.50%
The number of days you're given to pay your bill		
Very satisfied	31.10%	39.70%
Satisfied	40.40%	36.70%
Neutral	24.90%	21.30%
Poor	2.60%	1.50%
Very poor	1.00%	0.70%
The variety of bill payment options available (in person, by mail, bank draft, online, and phone system)		
Very satisfied	35.20%	42.30%
Satisfied	38.30%	35.60%
Neutral	21.80%	19.50%
Poor	1.60%	1.50%
Very poor	3.10%	1.10%

	Water supply	Wastewater
Ease of using the payment portal service		
Very satisfied	26.90%	38.20%
Satisfied	37.80%	37.10%
Neutral	29%	23.30%
Poor	2.60%	0.70%
Very poor	3.60%	0.70%
Ease of using the phone payment service		
Very satisfied	24.90%	37.80%
Satisfied	37.80%	34.50%
Neutral	29.50%	25.80%
Poor	3.60%	0.70%
Very poor	4.10%	1.10%
Overall, satisfaction level of the services		
Very satisfied	20.20%	38.20%
Satisfied	44.60%	40.40%
Neutral	28.50%	18%
Poor	6.20%	2.20%
Very poor	0.50%	1.10%

Figure S8. Service delivery (Billing) of various water sub-sectors in Malaysia

Deployment of Technology in Water Sector	Water supply	Wastewater
Kindly check ALL the methods of communication below that you would prefer to use to receive NON-EMERGENCY information.		
Water bill insert message	46.60%	53.90%
Company website	52.80%	48.70%
Email	54.40%	51.30%
Newspaper, TV or radio advertisement	32.60%	45.30%
Text messages	62.70%	50.20%
Social media	63.70%	59.90%
Kindly check ALL the methods of communication below that you would prefer to use to receive EMERGENCY information.		
Company website	45.10%	59.20%
Text messages	87%	68.50%
Call water treatment customer service	26.90%	44.20%
Automated phone calls to customers	35.20%	36.30%
Social media	67.90%	56.90%
In the areas where you are dissatisfied, what is/are the cause of your		
Lack of information	22.80%	29.60%
Low water pressure	20.70%	12.40%
Water rationing	9.80%	4.10%
High tariff	9.30%	4.10%
Others	37.40%	49.80%
How keen are you to know which treatment plant is treating your raw water or wastewater?		
Most keen	52.80%	42.30%
Keen	25.90%	37.80%
Neutral	15.50%	17.60%
Uninterested	2.60%	0.70%
Least keen	3.10%	1.50%

Deployment of Technology in Water Sector	Water supply	Wastewater
How interested are you to know which river flows to your treatment plant or where your wastewater being discharged?		
Very interested	57.50%	48.30%
Interested	27.50%	33%
Neutral	11.90%	16.50%
Uninterested	1.60%	1.50%
Least interested	1.60%	0.70%
In your opinion, which type of water treatment is more expensive?		
Raw water treatment	25.40%	18%
Wastewater treatment	63.70%	73.80%
Rainwater treatment	2.10%	1.90%
Groundwater treatment	5.70%	6%
Others	3.10%	0.40%
Do you think that it is crucial that each customer/consumer of water		
Most crucial	57%	46.10%
Crucial	31.60%	30.70%
Neutral	8.30%	21%
Unimportant	2.10%	1.50%
Least crucial	1%	0.70%
What are the features you would prefer to have if there is an App that is specific to water?		
Safety level of raw water supply near m	64.20%	61.80%
Efficiency of raw water treatment plant	56.50%	43.40%
Early warning notification of potential c	88.60%	67.40%
Intelligent system to provide solution	53.40%	40.80%
Efficiency of wastewater treatment plar	44.60%	46.10%
Water usage efficiency	50.80%	39.70%
Complaint platform	65.30%	53.60%
Suggestion platform	57%	45.30%

Figure S9. Deployment of Technology in various water sub-sectors in Malaysia

APPENDIX T
Site visit to Langkawi (December 2020)

Collaborative visit to Lembaga Pembangunan Langkawi (LADA)

Collaborative visit to Lembaga Pembangunan Langkawi (LADA)

Collaborative visit to Jabatan Pengairan dan Saliran Langkawi (JPS)

Site visit to Empangan Bukit Malut with JPS and SADA

Site visit to Loji Air Bukit Saga