PRIME MINISTER'S DEPARTMENT
ECONOMIC PLANNING UNIT

AKADEMI SAINS MALAYSIA



WST 2040

WATER SECTOR TRANSFORMATION

INTEGRATED WATER SECTOR DATA CENTRE (IWSDC)

(VOLUME III)



PRIME MINISTER'S DEPARTMENT
ECONOMIC PLANNING UNIT

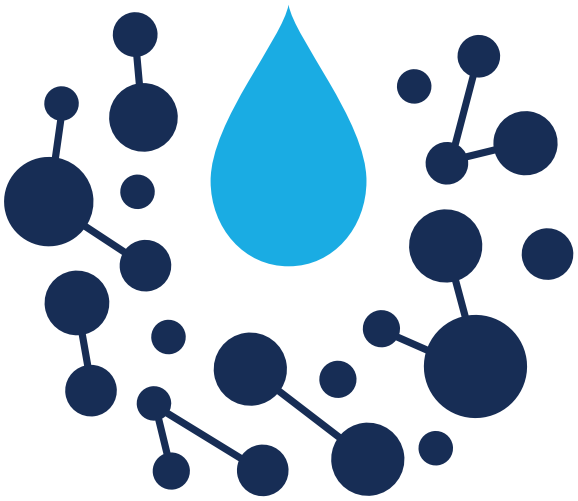
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SUB-SECTORAL FINAL REPORT

INTEGRATED WATER SECTOR DATA CENTRE (IWSDC)

(VOLUME III)



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INTEGRATED WATER SECTOR DATA CENTRE (IWSDC) (VOLUME III)

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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 3, "Integrated Water Sector Data Centre (IWSDC)", forms part of 9 compendia of reports. Volume 1, the Main Report, summarised the output of Volume 2 to Volume 9. The details in Volume 1, can be found in each of the 8 standalone reports.

The emphasis in all these reports is on achieving a secure, sustainable, and vibrant water industry in Malaysia, to forge it into a dynamic, efficient, sustainable, and revenue-generating industry. The Study, if the recommendations are implemented, will contribute significantly to the national gross domestic product (GDP), create new job opportunities and facilitates the development of science, technology, innovation and economy (STIE), and 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 2 decades and 4 phases of four 5-year Malaysia Plans (MP), starting with the 12th MP.

The IWSDC is anticipated to transform current data management and sharing ecosystem in the country into one that is more integrated, accessible, standardised, and beneficial to all users and stakeholders. It will also establish a platform for Water Research Collaboration which will eventually lead to the formation of a Water Research Consortium. Good decision making, especially in the public sector, is highly dependent on science-based recommendations, and scientific endeavours, in turn, are highly dependent on reliable data and information. The establishment of IWSDC will indeed be a significant step in guiding our nation-building efforts towards a more systematic and objective approach.

To achieve this ambition, we have partnered with expert advisors and researchers from multiple organisations led by RPM Engineers Sdn. Bhd, and leverage on their knowledge and expertise, we were able to produce outputs and recommendations that, we believe, will improved and provide reliable data and information for Malaysia. On behalf of ASM, I would like to take this opportunity to thank the IWSDC team headed by Datuk Ir. Mohd Adnan Mohd Nor, FASc, for all their dedication, hard work, and commitment.

Thank you.

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Preface

The Water Sector Transformation 2040 (WST2040) recognises that accessibility to a reliable and trustworthy data for all water stakeholders are important to accelerate the implementation of the Integrated Water Resources Management (IWRM), empowering the public in water management, inspire home grown technology and services in Research, Development, Innovation and Commercialisation (RDIC) that are of international significance and propelling the Nation's water management to higher levels of governance and security. Equally important is to achieve the aspiration to "Manage our Wealth of Water for the Wealth of the Nation". Thus, the establishment of the Integrated Water Sector Data Centre (IWSDC) is a Game Changer in the WST2040.

The IWSDC aims to be a one-stop centre for integrating data and information accessible to all stakeholders; without replicating the role of Ministries and organisations that have long-established systems. It will also establish a platform for Water Research Collaboration involving local and international RDIC players. This platform is a precursor to the formation of a Water Research Consortium.

The output of this Centre is envisioned to fill in the gaps in the current water management spectrum such as reports on water security, water for environment, water accounting and water auditing. It is also envisioned that the IWSDC shall also support and encourage Open Science initiatives amongst the general population. The IWSDC would also provide opportunities for new and high-value jobs within the digital economy. It will also aim to adopt the applications of high-end technology, particularly space technology in water management. In the long run, the IWSDC would not just facilitate higher levels of water management but also provide an ecosystem for new science-based businesses in the Water Sector.

Thank you.

IWSDC Sub-Sectorial Study Chairperson
Datuk Ir. Mohd Adnan Mohd Nor, FASc

List of Abbreviation and Acronyms

AACB	Advocacy, Awareness, Capacity Building and public participatory platforms
AI	Artificial Intelligence
AiS	*Pengurusan Air Selangor Sdn Bhd*
AKSB	*Air Kelantan Sdn Bhd*
API	Application Programming Interface
ASM	Academy of Sciences Malaysia
ASMA	*Alam Sekitar Malaysia Sdn Bhd*
AWAS	Australian Water Accounting Standard
AWRIS	Australian Water Resources Information System
BBA	*Bahagian Bekalan Air, KASA* (Water Supply Division)
BSAH	*Bahagian Pengurusan Sumber Air dan Hidrologi* (Water Resources Management and Hydrology Division)
BPSP	*Bahagian Pengairan dan Saliran Pertanian, MAFI* (Irrigation and Agriculture Drainage Division, MAFI)
CCIA	Climate Change Impact and Adaptation
CDP-PvC	Cloudera Data Platform Private Cloud
CGSO	Chief Government Security Officer
CSO	Civil Society Organisation
CSV	Comma-Separated Value
DB	Development Bank
DIPAN-SMI	*Data Industri Perkhidmatan Air Negara Berserta Spatial Mapping Yang Interaktif*
DMMS	Decision-Making Support System
DOA	Department of Agriculture
DOE	Department of Environment
DOSM	Department of Statistics Malaysia
DRM	Disaster Risk Management
DTSA	*Data Terbuka Sektor Awam* (Public Sector Open Data)
EO	Earth Observation
EPU	Economic Planning Unit (formerly known as Ministry of Economic Affairs, MEA)
ERAS	Earth Resources and Sustainability Centre
ESA	Environmentally Sensitive Area
FAO	Food and Agriculture Organisation of the United Nations
FAIR	Findable, Accessible, Interoperable and Reusable
FDS	Forest Department Sarawak
FGD	Focus Group Discussion
FRIM	Forest Research Institute Malaysia
Gbps	Gigabit Per Second
GCF	Green Climate Fund
GDP	Gross Domestic Product
GEC	Global Environmental Centre
GIS	Geographic Information System
HDFS	Hadoop Distributed File System

IADA	Integrated Agricultural Development Area
ICT	Information and Communications Technology
IoT	Internet of Things
IR4.0	Industrial Revolution 4.0
IT	Information Technology
IWK	*Indah Water Konsortium*
IWRM	Integrated Water Resources Management
IWSDC	Integrated Water Sector Data Centre
JANS	*Jabatan Air Negeri Sabah* (Sabah State Water Department)
JBLB	*Jabatan Bekalan Air Luar Bandar, Sarawak* (Sarawak Rural Water Supply Department)
JKR	*Jabatan Kerja Raya* (Public Works Department)
JLM	*Jabatan Laut Malaysia* (Marine Department Malaysia)
JMG	*Jabatan Mineral dan Geosains* (Department of Mineral and Geoscience)
JPP	*Jabatan Perkhidmatan Pembetungan* (Sewerage Services Department)
JPS	*Jabatan Pengairan dan Saliran* (Department of Irrigation and Drainage)
JPSM	*Jabatan Perhutanan Semenanjung Malaysia* (Forestry Department of Peninsular Malaysia)
JUPEM	*Jabatan Ukur dan Pemetaan Malaysia* (Department of Survey and Mapping Malaysia)
KADA	Kemubu Agriculture Development Authority
KASA	*Kementerian Alam Sekitar dan Air* (Ministry of Environment and Water)
KEGA	Key Economic Growth Activities
KeTSA	*Kementerian Tenaga dan Sumber Asli* (Ministry of Energy and Natural Resources, formerly known as Ministry of Natural Resources and Environment, NRE)
KKR	*Kementerian Kerja Raya* (Ministry of Works)
KPKT	*Kementerian Perumahan dan Kerajaan Tempatan* (Ministry of Housing and Local Government)
KPLB	*Kementerian Pembangunan Luar Bandar* (Ministry of Rural Development)
KSN	*Ketua Setiausaha Negara* (Chief Secretary to the Government of Malaysia)
KWB	Kuching Water Board
LAKU	Lembaga Air Kawasan Utara (LAKU) Management Sdn Bhd
LAP	*Lembaga Air Perak* (Perak Water Board)
LEO	Littoral Environment Observation
LLM	*Lembaga Lebuhraya Malaysia* (Malaysian Highway Authority)
LSANK	*Lembaga Sumber Air Negeri Kedah* (Kedah State Water Resources Board)
LSD	Land Survey Datum
LUAS	*Lembaga Urus Air Selangor* (Selangor Water Management Authority)
LWD	Labuan Water Department
MADA	Muda Agricultural Development Authority
MAFI	Ministry of Agriculture and Food Industries (formerly known as Ministry of Agriculture (MOA))
MAHB	Malaysia Airports Holdings Bhd
MAMPU	Malaysian Administrative Modernisation and Management Planning Unit
MAN	*Majlis Air Negara* (National Water Council)
MARDI	Malaysian Agricultural Research and Development Institute
MASTIC	Malaysia Science and Technology Information Centre
MCMM	Ministry of Communications and Multimedia Malaysia
MCO	Movement Control Order
MDEC	Malaysia Digital Economy Corporation
METMalaysia	Malaysian Meteorological Department
MIGHT	Malaysian Industry-Government Group for High Technology

MKN (NSC)	*Majlis Keselamatan Negara* (National Security Council)
MOE	Ministry of Education
MOF	Ministry of Finance
MOF (Inc.)	Ministry of Finance (Incorporated)
MOH	Ministry of Health
MOSP	Malaysia Open Science Platform
MOSTI	Ministry of Science, Technology, and Innovation
MOT	Ministry of Transport
MPOB	Malaysian Palm Oil Board
MPRC	MicroPollutant Research Centre
MSDN	*Majlis Statistik dan Data Negara* (National Statistics and Data Council)
MyDIGITAL	Malaysia Digital Economy Blueprint
MyGDI	Malaysia's Geospatial Data Infrastructure
MyGDX	Malaysian Government Central Data Exchange
MYSA	Malaysian Space Agency
MySTIE	Malaysian Science, Technology and Innovation and Economy 10-10 Framework
NADMA	National Disaster Management Agency
NaFFWS	National Flood Forecasting and Warning System
NAHRIM	National Water Research Institute of Malaysia
NAWABS	National Water Balance System
NCIA	Northern Corridor Implementation Authority
NCER	Northern Corridor Economic Region
NDSP	National Data Sharing Policy
NGO	Non-Government Organisation
NMC	National Management Committee
NPCC	National Physical Planning Council
NSDI	National Spatial Data Infrastructure
NSP 2021-2025	National Security Policy 2021-2025
NSP2030	National Space Policy 2030
NSTIP	National Science, Technology, and Innovation Policy
NWIR	National Water Innovation Roadmap
NWQS	National Water Quality Standards
NWRP	National Water Resources Policy
NWRS	National Water Resources Study
NEQMP	National Environmental Quality Monitoring Programme
ODB	Open Data Barometer
ODI	Open Data Index
OGC	Open Geospatial Consortium
OGP	Open Government Partnership
OLP	Online Analytical Processing
ORS	Off-river Storage
OSA	Official Secrets Act 1972
PAC	Public Accounts Committee
PADRN	*Pusat Analitik Data Raya Negara* (National Big Data Analytic Centre)
PAIP	*Pengurusan Air Pahang* Bhd (Pahang Water Management Bhd)
PBAPP	*Perbadanan Bekalan Air Pulau Pinang* (Penang Water Supply Corporation)
PDF	Portable Document Format
PHN	*Pusat Hidrografi Nasional* (National Hydrographic Centre)

PLANMalaysia	Urban and Rural Planning Department of Peninsular Malaysia
PORIM	Palm Oil Research Institute of Malaysia
PORLA	Palm Oil Registration and Licensing Authority
PRAB	*Program Ramalan dan Amaran Banjir* (National Flood Forecasting and Warning Programme)
QA/QC	Quality Assurance/Quality Control
RBMU	River Basin Management Unit
RBO	River Basin Organisation
RDIC	Research, Development, Innovation, and Commercialisation
REDAC	River Engineering and Urban Drainage Research Centre
RHN	*Rangkaian Hidrologi Nasional* (National Hydrological Network)
RHEL	Red Hat Enterprise Linux
12th MP	12th Malaysia Plan
RRIM	Rubber Research Institute Malaysia
SAINS	*Syarikat Air Negeri Sembilan*
SADA	*Syarikat Air Darul Aman*
SAJ	*Syarikat Air Johor*
SAMB	*Syarikat Air Melaka Bhd*
SAP	*Syarikat Air Perlis*
SATU	*Syarikat Air Terengganu*
SDG2030	Sustainable Development Goals 2030
SFD	Sabah Forestry Department
SME	Subject Matter Expert
SIRIM	Standards and Industrial Research Institute of Malaysia
SMSA	*Sistem Maklumat Sumber Air* (Water Resources Information System)
SOP	Standard Operating Procedure
SPAN	*Suruhanjaya Perkhidmatan Air Negara* (National Water Services Commission)
SPV2030 (WKB2030)	Shared Prosperity Vision 2030 (*Wawasan Kemakmuran Bersama* 2030)
STI	Science, Technology and Innovation
STP	Sewage Treatment Plant
SWB	Sibu Water Board
TB	Terabyte
TNB	*Tenaga Nasional Berhad*
TNC	Third National Communication
TNBR	Tenaga Nasional Research Sdn Bhd
UiTM	Universiti Teknologi MARA
UN	United Nations
UNESCO	United Nations Educational, Scientific and Cultural Organisation
UNITEN	Universiti Tenaga Nasional
UniMAP	Universiti Malaysia Perlis
UKM	Universiti Kebangsaan Malaysia
UMP	Universiti Malaysia Pahang
UMS	Universiti Malaysia Sabah
URND	UNITEN Research and Development Sdn Bhd
USGS	U.S. Geological Survey
USM	Universiti Sains Malaysia
UTHM	Universiti Tun Hussein Onn Malaysia
UTP	Universiti Teknologi PETRONAS

UUM	Universiti Utara Malaysia
WFE	Water-Food-Energy
WFEN	Water-Food-Energy Nexus
WHO	World Health Organisation
WRC	Water Research Consortium
WSIA	Water Service Industry Act
WST2040	Water Sector Transformation 2040
WSP	Water Safety Plan
WTP	Water Treatment Plant
WUG	Water User Group

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Executive Summary

Chapter 1: Malaysian Water Sector – Data Management Perspective

1.1 Overview

The 12th Malaysia Plan 2021-2025 (12th MP) affirms the Government's commitment to transform the Water Sector from one that is merely providing a supporting role to all economic and social activities to one that is vibrant as an economic sector whilst ensuring high levels of water security for a sustainable development and growth. This transformation will continue until 15th MP Malaysia Plan as envisaged in the WST2040. Under 12th MP, one of the targets is the establishment of the Integrated Centre for Water Data and R&D&C&I by 2025.

The idea of establishing an Integrated Water Data Centre (IWSDC) is for it to be a precursor towards the formation of two institutions stated under WST2040, namely Strategy C1: *Towards the establishment of an independent water data and information statutory body* and Strategy C2 – *Integrating research on water through the establishment of the Water Research Consortium*. At the onset, IWSDC will be structured to provide the environment to initiate and encourage water research consortium.

1.2 Data Lessons from Covid-19 Pandemic

One of the major lessons learned from the Covid-19 pandemic management is the need for rapid exchange of reliable, accurate and trusted data for decision-making not only by the Government but also by the industries and businesses as well as the community and even the individuals.

Overall, the Covid-19 pandemic experience should dispel the notion that severe control of data by the respective custodians is necessary to prevent a crisis or to strengthen security. Instead, the opposite is true. Prudent data sharing between all parties is necessary to manage national security, manage the situation when crisis occurs and to rapidly develop recovery strategies.

1.3 The Current State of Water and Land Data

The reluctance to share data is the biggest barrier to an integrated water data management in the country. The sectorial governance is the strongest reason behind this reluctance as well as the management approach which has been embedded in the country since its inception. This sectorial governance and management approach is compounded by restrictive data sharing laws inherited from colonial times, shaped during the nation's more tumultuous past, where data restriction was seen as crucial to national security.

The following are the current state of water and land data according to the WST2040 Framework:

a. **Governance**

The current fragmented water data governance and management in the water sector has resulted in an environment where the sectorial approach is now fully entrenched in the country's governance system. The strictly functional nature of government department operations in the country has resulted in gaps within the water management spectrum. This is compounded by restrictive data sharing laws, enacted during colonial times, which has subsequently instilled data protectiveness culture amongst the custodians. These two factors have stifled IWRM development in this country, where critical issues related to water security such as water quality are still being managed and resolved in an ad-hoc manner.

b. **Information and RDIC**

In terms of information system development, there have been positive steps towards water data integration in the country, such as the development of *Sistem Maklumat Sumber Air* (SMSA) by JPS and *Data Industri Perkhidmatan Air Negara berserta Spatial Mapping yang Interaktif* by KASA. However, there is room to further integrate all the water and water related databases in the country, and subsequently establish a platform to share this integrated database and encourage collaborative efforts in RDIC.

The current state of RDIC in Malaysia is still fragmented and unfocussed. Most RDIC efforts are dominated by higher learning institutions and there is limited involvement of private sector. There is also too much focus on 'basic and applied' research activities but limited engagement in 'experimental development' in RDIC, which results in limited commercial successes.

c. **People**

Public participation and empowerment in IWRM are also still very limited since the public are neither equipped with detailed and granular data and information on the status of water sector nor do they have a formal national-level platform to take part in deliberations and decision-making process.

d. **Infrastructure**

Presently, each department oversees its own data and information infrastructure. The infrastructure development for data collection by each department is designed to serve their respective functions. Thus, there is little interoperability between the infrastructure setups of these departments.

Moreover, data collected also follows standards and nomenclature set by the respective departments and there is limited data collection quality assurance. There is also evidence that water data collection infrastructure is slowly deteriorating due to lack of funding and lack of capacity building programme.

e. **Finance**

In terms of financial incentives, the current fees imposed on data acquisition by the public is a barrier against seamless data sharing, and efforts should be made to reduce this financial cost to boost the data sharing ecosystem in the country.

1.4 The Challenges and Need for an Integrated Water Sector Data Centre

The need to establish an integrated water sector data centre is driven by five main challenges, namely, to meet the demands of:

a. Achieving national aspirations and policies such as WKB2030, SDG2030, National Security Policy 2021-2025 and MyDIGITAL 2030.
b. Increasingly challenging Water Demand Management. As the nation progresses and population increases, demand for water will increase and inter-sector water resources management balance such as the Water-Food-Energy Nexus will become more intense.
c. Disaster risk reduction management exacerbated by the impacts of climate change.
d. Managing water for wealth. While Malaysia is rich in water, the water sector is seen mostly as a supporting service for other sectors and there have been only limited efforts to utilise this water abundance into economic wealth.
e. Empowering the public through participation and engagement. While public participation and empowerment are an important component of national level water-related policy and act, it has yet to achieve widespread support and has not been systematically adopted.

An integrated water sector data centre is needed to meet the unique challenges presented above since these challenges require more precise and reliable data and information for decision making.

Moreover, having a dedicated organisation will also provide few strategic advantages in terms of sustainability in achieving short-term and long-term objectives, developing multi-disciplinary talents as well as continuous career development.

Chapter 2: Integrated Water Sector Data Centre – The Game Changer

2.1 IWSDC's Concept

IWSDC is to be established a single-point, independent and dedicated reference centre for water and land data and information. It shall not duplicate the functions and services of existing Government Departments particularly with respect to water and land data collection.

It shall provide services that are cross-sectorial and independent in nature and shall also undertake support services for additional elements to the present water management spectrum such as Water Security, Water Accounting and Water Auditing tools and system, which would strengthen information and reports for decision-making.

IWSDC shall also provide a platform for Water Research Collaboration – encouraging and facilitating inter-Government, Public-Private Sector, including the Academia and their students, research collaboration as well as provide opportunities for Open Science for the public with a view to translate outcomes as of significant value for business development and commercialisation.

The establishment of IWSDC is planned to be in tandem with MYSA's high resolution (0.5m x 0.5m) satellite launching planned for 2025. Preparations for capacity building for applications of remote sensing technology for water management shall be timed such that it will be ready to be fully activated when the Malaysian satellite is launched. Simultaneously, pilot projects in selected RBMUs should be activated. These should be seriously considered as Immediately Implementable Projects (IIPs) under 12th MP.

2.1.1 Responding to Lessons from the Covid-19 Pandemic

The design of the IWSDC shall be based on the lesson learnt from the Covid-19 experience that emphasised the need for timely exchange of good, reliable, trusted data and information for sound decision-making. The "Whole-of-Nation" approach that involves the collaborative efforts of the Government and society in water management is also needed for water security and transforming water into an economic opportunity.

Transformation here and in the context of WST2040 is taken as increasing the rate of change, accelerating change. As a Game Changer in this Transformation, IWSDC will need to be the catalyst to intensify and converge the focus, direction, and dynamics of data management by the many water players that would excite all other stakeholders and attract them to actively participate in water management as well benefit from the opportunities provided by the Sector.

Thus, the structure of IWSDC is also designed such that the data and information sharing is systematically organised to be made available beyond sectorial boundaries. This by itself is a strategy to accelerate IWRM through data and information integration. With this, all Federal-State, State-State, Inter-Sector and public participation and decision-making shall be based on a common set of mutually agreed data and information.

2.1.2 Water Research Collaboration Platform

The water sector RDIC is guided by the Malaysian Science, Technology and Innovation and Economy (MySTIE) 10-10 Framework. The framework lays out a detailed plan to turn Malaysia into a knowledge-intensive economy. Several collaborative efforts could be developed between IWSDC and research players. These include providing data and information access and an open platform for hackathon competitions in water sector. The proposed areas of focus under the National Water Innovation Roadmap (NWIR) could also be encouraged by applying similar collaborative approach.

2.1.3 The Outcome of IWSDC and WRC

The outcomes of IWSDC and WRC are based on the overall WST2040 Framework under 12th MP, namely the objectives of: (1) water security and sustainability, and (2) water as an economic opportunity. In addition, the framework also consists of people as the driver; as well as enablers consisting of governance, information and RDIC, finance, and infrastructure and technology.

For the objectives, the IWSDC would be able to support rapid exchange of data and information and produce strategic reports and support decision-making towards increasing the confidence level of the public on water security and for managing the wealth of water for the wealth of the nation.

Supporting the driver, high levels of data and information accessibility will empower people and encourage a meaningful participation in water management. This can be accomplished by providing a formal stakeholder engagement platform which could be institutionally linked to the National Water Council (MAN) and the respective State Water authorities.

As enablers, the IWSDC shall develop quantitative tools for governance in the form of water accounting and water auditing system. In addition, IWSDC shall drive for the introduction of related data and information sharing policies and laws.

Apart from enhancing capacity in data-driven decision-making, the IWSDC will provide the Water Research Collaboration platform to strengthen the RDIC linkages and facilitate public-private collaboration with opportunities for innovations and new businesses. This platform will be a precursor to the eventual establishment of a Water Research Consortium.

IWSDC will provide continuous good, reliable, trusted data for sustainable financing with the ability to develop more better project evaluation analysis, towards higher returns on investments and varied options for integrated water projects not only for water projects, but also beyond the sector such as water and tourism, water and environment, and water and energy.

Similarly, IWSDC will play an active role to support more water efficient designs and operations and maintenance for existing and future infrastructure particularly with applications of space technologies.

Chapter 3: IWSDC – The Structure

The overall IWSDC's framework comprises input, systems architecture, output and services, support, and enablers.

a. **Input**
   IWSDC's input comprises primary and secondary data necessary to support water management. Primary data inputs are common water data for use by water managers, the industry, and the public.

Secondary data inputs are those needed to complement the primary water data in decision-making such as policy development, disaster risk management and public participation.

b. **Systems Architecture**

The IWSDC's core system architecture comprises eight components which will form the technical information technology backbone of IWSDC. This includes components such as physical and virtual machine setup, cloud storage and big data analytics platform, data ingestion, data management and data governance, data processing, data visualisation, blockchain and artificial intelligence. Moreover, the core systems architecture will be supported by data standards, good practices in data management and data quality control and data quality assurance as well as data security practices.

c. **Output and Services**

The output and services of IWSDC comprise strategic reports, IWSDC water data platform, water research collaboration (RDIC), as well as applications using big data analytics, blockchain and artificial intelligence.

The publication of Strategic Reports is designed to fill in the gaps in the water management spectrum. The IWSDC will produce these reports to service end users that include Federal and State Governments, Water Operators, Research Institutions, Universities, Private Sector, and the public.

IWSDC Water Data Platform serves IWSDC's function as a one-stop centre for water and land data for all stakeholders in the water sector. Users of these data include government institutions, students, consultants, industries, researchers, NGOs, and the public.

Under Water Research Collaboration Platform (RDIC), the overall objective of IWSDC's roles is to become a catalyst in completing the R->D->I->C chain. This will be done via a combination of in-house RDIC activities as well as providing a water research collaboration platform for all RDIC institutions. This collaboration platform will be a precursor to the establishment of a Water Research Consortium as envisaged in the Strategy Paper No. 16.

The IWSDC will also develop applications supported by the latest advanced data technology, for example water utility monitoring using AI and water identity using blockchain technology.

d. **Support**

The support structure for IWSDC comprises technology, institutional structure, finance, and human resources.

The IWSDC will be developed with built-in capabilities in latest data technologies such as big data analytics, artificial intelligence and blockchain. The IWSDC will also utilise space technology in water management in coordination with MYSA, which is planning to launch a high-resolution satellite of (0.5m x 0.5m) in 2025.

To successfully establish the IWSDC as a one-stop centre for water data, there must be linkages between IWSDC and institutions that collect these data throughout the country. However, linkages with IWSDC will not interrupt the current operations of various data collecting institutions in the government.

The IWSDC also requires financial support to institutionalise its establishment as well as to sustainably operate and maintain the organisation. It will also require multi-disciplinary and cross-sectorial experts

and researchers in various fields of science and social science to conduct in-house RDIC activities and coordinate external research efforts, as well as assist in space-based data analysis for water sector.

e. **Enablers**
The enablers for IWSDC are policy and legal foundations which shall enhance the source of authority for IWSDC to operate. The proposed policy and legal arrangements for IWSDC include the following:

i. Data sharing agreements with data collectors and providers
In the interim, data sharing agreements with data collectors will be made on a bilateral or multi-lateral basis, where IWSDC will sign agreements with various data providers including Federal, Sabah, Sarawak, and State agencies.

ii. National Data Sharing Policy and National Data Sharing Law
In the long term, a national data sharing policy and a national data sharing law are needed to fully support seamless data sharing in the country. Currently, a national data sharing policy is being drafted, and this is a positive first step towards the eventual establishment of a national data sharing law in the country.

Chapter 4: Roadmap

4.1 Roadmap

The IWSDC roadmap and implementation plan is divided into four stages according to the four MPs under WST2040. It is also designed based on the five focus areas under the WST2040 Phase 1 Framework. The IWSDC's strategies under the WST2040 Roadmap are as the following:

a. Establishment of an Integrated, Single-Point Reference Centre
b. Publication of Strategic Reports on Water Management
c. Establishment of a Water Data and Search Engine Platform (IWSDC's Water Platform)
d. Establishment of a RDIC Collaboration Platform (as a precursor to a Water Research Consortium)
e. Enhancing Seamless Data Sharing
f. Tools to Quantify and Assess Water Governance
g. Establishment of a Public Participation Platform
h. Capacity Building and Talent Development
i. Establishment of a Water Hub

The immediately implementable projects and initiatives for IWSDC (in 12th MP) include:

a. The establishment of IWSDC
b. Water platform pilot projects in Sungai Perak River Basin
c. Data sharing initiatives and incentives
d. Development of governance tools and systems (water accounting and water auditing)

4.2 Implementation Plan

The criteria for establishing IWSDC's implementation structure is based on the Strategy Paper No. 16, which states that IWSDC should be an independent statutory body. The most appropriate custodian for IWSDC is the Ministry of Environment and Water (KASA) since it is the leading ministry in water management in the country. The options for IWSDC's institutional set-up are as the following:

a. To establish IWSDC as an agency under KASA in 12th MP
b. To form IWSDC as a government-owned company under the Minister of Finance (Incorporated) [MOF (Inc.)] but administrated by KASA (13th MP onwards).

It is recommended that the IWSDC is eventually established as a Government Owned Company under MOF (Inc.) and administrated by KASA. Setting up IWSDC as a company under MOF (Inc.) will give it the independence and flexibility to pursue projects and programmes that require public-private partnerships, investment from private sector, as well as those requiring multi-disciplinary and multi-sectorial collaborations.

NAHRIM, which was rebranded as the National Water Research Institute of Malaysia on 20 January 2021, is recommended to develop the idea of establishing a Water Research Consortium as envisaged under WST2040 Strategy C2 – *Integrating Research on Water through the Establishment of the Water Research Consortium,* that is proposed here to be implemented under 13th MP.

4.3 Immediately Implementable Projects

The immediately implementable projects for IWSDC under 12th MP include:
a. Establishment of IWSDC
b. Commencement of IWSDC Water Platform pilot projects
c. Implementation of data sharing initiatives and incentives
d. Development of water governance tools (water accounting and water auditing)

4.4 IWSDC Water Platform Pilot Projects

IWSDC will develop an IWSDC Water Platform for data and information sharing that is open to the stakeholders. This platform will serve as a search engine for stakeholders to use the available data to develop ideas, business opportunities, and many more. It will also serve as a public participation platform for water management, a platform for water research collaborations, Open Science and crowdsourcing for information and even funding.

As proof of concept, pilot projects are proposed for four river basins under 12th MP. The main objective of these pilot projects is as a proof-of-concept on the role and function of IWSDC and the Water Research Collaboration platform, as well as a start-up for the IWSDC Water Platform.

The four river basins proposed for the pilot projects are Sg Perak (Perak), Sg Linggi (Negeri Sembilan/ Melaka), Sg Padas (Sabah) and Sg Miri (Sarawak). These four river basins are selected based on the IRBM Masterplan prepared by JPS.

The pilot project shall cover the following scope:

a. Primary and secondary data sharing arrangements
b. Data collection, processing, storage, and distribution
c. System architecture designs
d. Data and information sharing system
e. Water Research Collaboration initiation
f. Public participation and Open Science
g. Preparation of selected strategic reports
h. Remote Sensing applications for water management (in collaboration with MYSA)

4.5 IWSDC Water Platform Pilot Project Pre-Test

Under this Study, a Pilot Project Pre-Test was initiated for Sg. Perak. The idea of this pre-test is as a pre-proof of concept to obtain some preliminary results of the expected output of the IWSDC Water Platform pilot projects proposed. The preliminary outputs include:

a. Data structure for river basin management
b. Stakeholder Management data structure
c. Disaster risk reduction management data structure
d. WFE Nexus management data structure

Chapter 5: Costing

The total estimated capital expenditure and operating expenditure for IWSDC (12th MP to 15th MP) are RM 405.52 million and RM 1.745 billion, respectively. The capital expenditure under 12th MP is RM 219.82 million.

Chapter 6: Conclusion and Recommendations

The main reason why water and water related in Malaysia is in such a fragmented state is due to the sectorial governance and management approach, coupled with a lack of affirmative data sharing policy and law. The water sector RDIC scenario in the country is also limited by lack of coordinated strategic approach, lack of access to data, and lack of funding, which ultimately results in Malaysia's inability to turn water wealth into economic wealth.

In-line with WST2040, and as mandated by 12th MP, the IWSDC shall be designed as a Game Changer in water management. It shall integrate data collection and processes in-line with common standards and good practices. The IWSDC shall aim to feed "trusted" data to all end-users and be used as a basis for science-based decision-making and negotiations. It shall facilitate the empowerment of the public in water management and be a catalyst to spur a prolific RDIC and invigorate the water business and industry. Ultimately, it will support the achievement of national aspirations, development plan and blueprints such as the WKB 2030, 12th MP, the 10-10 MySTIE Framework and the MyDIGITAL 2030, and global targets under SDG2030.

The following are the summary of recommended actions as the way forward for IWSDC under the WST2040 plan based on the following 5 focus areas:

1. People
    a. The IWSDC will propose a formal, national-level stakeholders engagement platform which will provide a stage for the public to participate in decision-making process in the water sector.
    b. The IWSDC will also support to expand the public participation in water sector through participation of people through establishment of Open Science concept and Crowdsourcing.
    c. The IWSDC will plan, design, and conduct systematic capacity building and training programme in water management, space technology and advanced data technology.

2. Governance
    a. The IWSDC will develop and propose a data sharing agreement with all primary and secondary water data providers at Federal, Sabah, Sarawak, and states levels as well as with private sector and NGOs.
    b. The IWSDC will subsequently propose the establishment of a 'Data Sharing Policy' and the subsequent 'Data Sharing Law' as the final step towards raising data sharing in this country on par with international standards and practices.

c. The IWSDC will propose to DOSM on the possibility of including water and land data collection in its proposed amendments of Statistics Act 1965. The IWSDC will also propose for it to be part of the MSDN and PADRN organisation set-up.
d. The IWSDC will also produce Annual Water Security report to support decision making on national water security for the MKN.
e. The IWSDC will also produce an independent, annual water accounting report which will become the most essential water governance quantifying tool in this country.
f. The IWSDC will publish strategic reports, such as virtual water and water footprint report and Water-Food-Energy Nexus report, to enhance data-driven decision-making process and complete the water management spectrum.
g. The IWSDC will propose for Malaysia to become a member of an international open data alliance such as Open Government Partnership or Open Data Charter.

3. Information and RDIC
   a. The IWSDC will be established as a single-point, independent statutory body in-line with the goal under WST2040 and 12th MP.
   b. The IWSDC will establish a research collaboration platform which will link RDIC institutions from government, institutions of higher learning and private sector to collaborate on novel and advanced solutions in the water sector. This is a precursor to the eventual development of a water research consortium.
   c. The IWSDC will establish a water data platform which will host a complete database of the RBMUs in Malaysia, and enhanced by space technology, as a reference and collaborative platform for users from various sectors.

4. Infrastructure and Technology
   a. The IWSDC will assist in the masterplan study to identify a water hub in the country.
   b. The IWSDC will provide access to high quality data as well as provide new tools which will facilitate the development of options in planning, design, operations, maintenance, and performance evaluations of water systems.
   c. The IWSDC will also venture and upscale into space technology applications in water sector and this will be complemented with big data analytics, artificial intelligence, and blockchain. This technology will support IWSDC's output such as strategic reports as well as RDIC activities.

5. Finance
   a. The IWSDC will propose measures to incentivise the free sharing of data and information that is already being continuously collected and available and unlock their values. This could be accomplished by reviewing the Fees Act 1951.
   b. IWSDC will provide data and information for managing the wealth of water in the nation through the development of better options for investment decisions and strategies through supporting data and information (annual strategic reports).

Chapter 7: Closing Statement

The IWSDC is envisioned as a Game Changer in the National Water Sector Transformation 2040. A game changer can be demonstrated in transformative projects such as the mission to the moon. In highlighting the enormous task faced by the Americans, President Kennedy mentioned that

"*We choose to go to the Moon in this decade and do the other things, not because they are easy, but because they are hard; because that goal will serve to organise and measure the best of our energies and skills, because that challenge is one that we are willing to accept, one we are unwilling to postpone, and one we intend to win, and the others, too." (Boyd, 2012)*

As the country progresses, the challenge is to manage water scarcity events such that would ensure sustained comfort of life and living whilst managing the wealth of water and biodiversity for the wealth of the nation; both in situations of uncertainties induced by the climate change.

This requires a good, reliable, and trusted common data, the prerequisites, not only for precise water management, but for qualitative Federal-State, State-State and inter-sector negotiations on water use priorities in various scenarios and needs. IWSDC is the facilitator.

Beyond data management, IWSDC is designed to be a catalyst to accelerate IWRM, to unlock the value of data, empowering people for meaningful participation, providing high-value jobs and business opportunities in a digital economy, connecting RDIC seamlessly and, propelling national capacity in STI through applications of space technology.

Ultimately, IWSDC is to support IWRM in realising the vision of "Clean, Living, Vibrant and Spiritually-enriching rivers and river basins".

Chapter 1
Malaysia Water Sector – Data Management Perspective

1.1 Overview

The Twelfth Malaysia Plan 2021-2025[1] (12th MP) affirms the Government's commitment to transform the Water Sector from one that is merely providing a supporting role to all economic and social activities to one that is vibrant as an economic sector whilst ensuring high levels of water security for sustainable development and growth. This transformation is set to continue through the 13th, 14th, and the 15th Malaysia Plans as envisaged in the Water Sector Transformation (WST2040). The themes of this WST2040 over the respective Malaysia Plans are as shown in **Figure 1.1.**

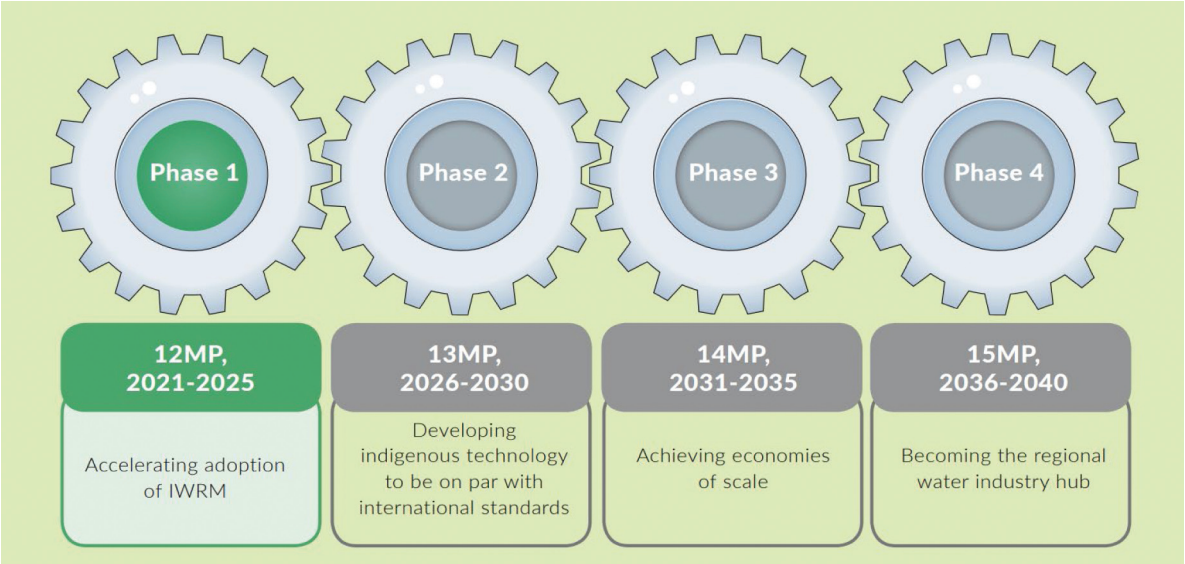


Figure 1.1: WST2040 Themes
(Economic Planning Unit, 2021)

Under this Twelfth Malaysia Plan, one of the targets under the WST2040, and in line with SDG Goal No. 6: Clean Water and Sanitation, is the establishment of the Integrated Centre for Water Data and R&D&C&I by 2025, as shown in **Figure 1.2**.

The long-term plan is related to Strategy C1: *Towards the establishment of an independent water data and information statutory body* and Strategy under Focus Area C – *Enhancing the Data-driven Decision-making for Sustainability* of Phase 1 of the WST2040 (Ministry of Economic Affairs, 2019). Another strategy is Strategy C2 – *Integrating research on water through the establishment of a Water Research Consortium*.

The idea of establishing IWSDC is for it to be a precursor towards the formation of those two institutions stated under strategies C1 and C2. At the onset, IWSDC will be structured to provide the environment to initiate and encourage Water Research Consortiums.

In establishing this IWSDC, it is necessary to appreciate the present key characteristics of water data management practices that requires special attention for the role of IWSDC as a Game Changer in the WST2040.

[1] Economic Planning Unit. (2021, September). Rancangan Malaysia Kedua Belas 2021-2025, https://rmke12.epu.gov.my/en

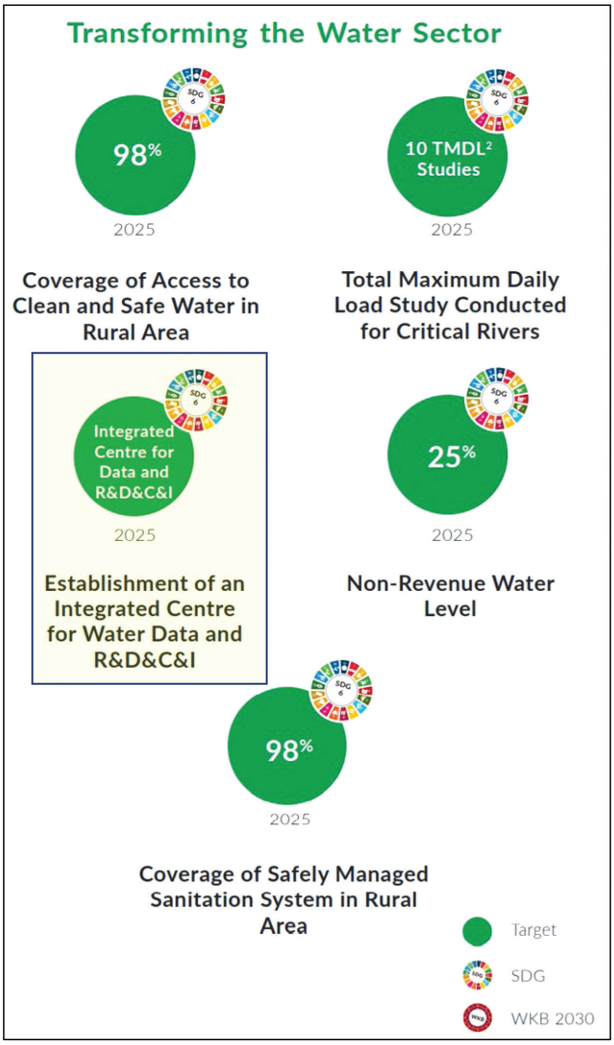


Figure 1.2: Integrated Centre for Water Data and R&D&C&I under 12th MP (Economic Planning Unit, 2021)

1.2 The Need to Transform the Water Sector Data Management

1.2.1 Lessons Learnt from the Covid-19 Pandemic

One of the major lessons learned from the Covid-19 pandemic management is the need for a rapid exchange of reliable, accurate and trusted data for decision-making not only by the Government but also by industries and businesses as well as the community and even by individuals.

The types and sources of data are numerous and from national and international levels involving the Government, Non-Government organisations, private sector, communities, and individuals. Those decisions made have then to be communicated quickly and effectively to the implementing agencies and to the public. Ensuring effective data collection, storage, processing and transmission requires reliable technologies operated and maintained by well-qualified human resources.

The rapid flow of data exchange has assisted in making dynamic yet strategic decisions. For example, data has been crucial in the decision to impose total Movement Control Orders (MCO) before the availability of vaccines, to partial MCO strategies for balancing economic needs with herd immunity policy target, and subsequent change of policy to accept Covid-19 as endemic and rapid MCO relaxations to support quick economic recovery as the population of vaccinated people increases.

Overall, the Covid-19 pandemic experience should dismiss the notion that severe control of data by the respective custodians is necessary to prevent a crisis or to strengthen security. Instead, the opposite is true. Prudent data sharing between all parties are necessary to manage national security situation when crisis occurs and to rapidly develop recovery strategies.

The same is relevant to the Water Sector. While water stress situations now are sporadic, localised, and over short durations (mostly less than one month for both flood, landslides, and drought events), the impact can be severe in terms of economic and social losses not just during the event, but also in the long term, where such incidents cause loss of confidence and disquiet amongst the society and investors.

Climate change impacts such as changing rainfall patterns as well as increasing frequency, extent, duration, and severity of water stress events such as floods and droughts, will require changes in disaster risk management approach. Such climate-change induced events could lead to other consequential disasters such as dam breaks, landslides, discontinuity of agriculture produce and water-dependant manufacturing. Moreover, another lesson from the Covid-19 experience is that the pandemic impacted supply chains, and this affected industries not just locally but also internationally.

Box 1.1: Seven Lessons Covid-19 Has Taught About Data Strategy

Data drives better decisions. Governments are not new to data-driven decision-making—their efforts to use data to replace intuition with objectivity span decades. In the current Covid-19 crisis, governments have quickly reacted to available data and developed strategies to combat the effects of the virus on people, governments, and the economy. Using data, analytics, and emerging technologies, governments made informed policy decisions to enforce restrictive protocols to reduce the spread of the virus. In addition, data allows informed policy decisions around the release of economic aid, reopening of cities, improving public health capacity, and much more.

The following seven lessons have emerged post coronavirus:

1) Real-time data is key to resilience
2) Data presentation is most effective when it is centred on users
3) Cloud converts data from a luxury to a utility
4) Data governance is crucial
5) A data strategy is incomplete without privacy and security
6) Data-sharing enables innovation
7) Identifying and addressing data issues can strengthen decision-making

Source: Deloitte, 2021

The WST2040 is not just about managing for water stress situations. It includes the objective of managing the wealth of water for economic growth. Data integration and accessibility are especially crucial in wealth management. The IWSDC therefore would play a significant role to support the WST2040 twin objectives of achieving higher levels of Water Security and for Water as an Economic Opportunity. It will also be the fundamental input for Strategy B4 – Strengthening Disaster Risk Governance, Strategy C4 – Upgrading of Disaster-Related Decision-making, and Strategy D5 – Develop Water as One of the KEGA under the WKB2030.

1.2.2 Current State of Water Data, Water Related Data and RDIC

The reluctance to share data is the biggest barrier to an integrated water data management in the country. The strongest reason behind this reluctance to share is the sectorial governance and management approach which has been embedded in the country since its inception. This sectorial governance and management approach is compounded by restrictive data sharing laws inherited from colonial times, shaped during the nation's more tumultuous past, where data restriction was seen as crucial to national security.

Box 1.2: Tragedy of the Commons

The Tragedy of the Commons refers to a situation in which individuals with access to a shared resource (also called a common) act in their own interest and, in doing so, ultimately deplete the resource.

The concept originated in an essay written in 1833 by the British economist William Forster Lloyd, who used a hypothetical example of the effects of unregulated grazing on common land (also known as a "common") in Great Britain and Ireland.

Source: Harvard Online Business School, 2019

Water resources, meanwhile, is a common element in management for different sectors. Without data integration and sharing, the current sectorial approach will lead to the 'Tragedy of the Commons', where each sector manages water resources for its own functions, without looking at the sustainability of water resources being used. Eventually, this will lead to the deterioration of water security in the nation.

The lack of data sharing has also cost the nation missed opportunities, especially in developing water as an economic opportunity. RDIC efforts in water sector for example, requires enormous amount of precise, consistent, and reliable data, and this data could only be provided by the government. If more data had been freely shared by data providers in the country, more RDIC efforts and the subsequent potential commercial enterprises could have been developed in the country.

Nevertheless, there have been efforts to integrate water governance in the country through legal reform such as the Water Service Industry Act (WSIA) 2006 and combination of water sub-sectorial functions through formation of KASA.

Integration has also occurred naturally through pressure to satisfy inter-sectorial demands. Dams that were originally built to serve agricultural water resources needs and functions for example, now must also serve domestic, industrial and energy demands.

The following is the detailed analysis of current state of water data, water related data and RDIC based on the WST2040 Framework (Governance, People, Information and RDIC, Infrastructure and Technology, and Finance).

1. Governance (Laws, Policies, Tools, Institutions, and Internationalisation)

a. Governing Institutions

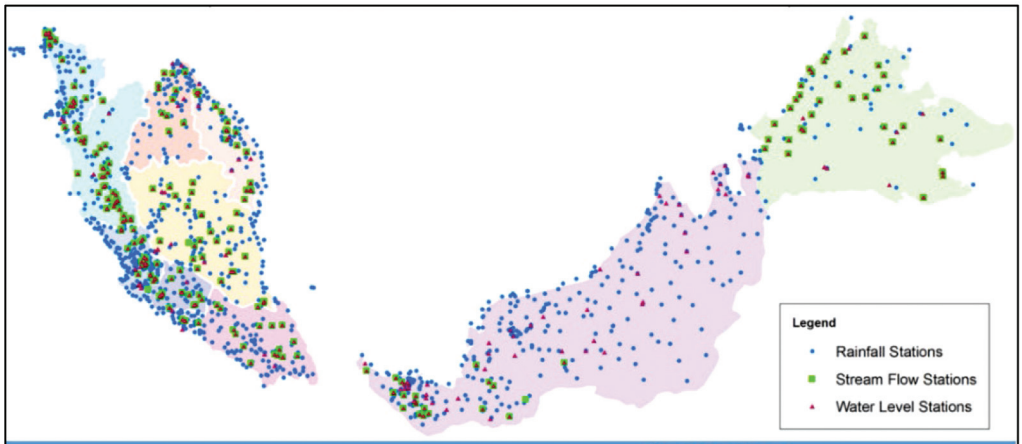
Systematic water data collection can be said to begin since the formation of various Government Departments in the country. Early data collection was focussed on the need to plan and design basic infrastructure for the early stages of the country's development. This includes infrastructure development for water resources, water supply, transportation, and communication.

Box 1.3: Establishment of Departments and Organisations Collecting Water and Land Data

Year	Department/Organisation	Water Data Collection
Late 1800s	Rubber Estates	Rainfall, Weather
1872	JKR	Water quality, Water supply (Until 1990s)
1879	METMalaysia	Meteorology, Climate
1880s	Hospital and Public Health (later MOH)	Water quality, Water safety (health)
1885	JUPEM	Topography, Land use, River alignments
1890s	Sewerage (Sanitary Boards)	Sewerage
1903	Geological Office (later JMG)	Groundwater
1905	DOA	Rainfall, Weather, Land use, Wells
1921	JPBD/PLAN Malaysia	Geospatial
1932	JPS	Hydrology
1949	DOSM	Demographics, Statistics
1970	MADA	Hydrology, River flow
1972	KADA	Hydrology, River flow
1975	DOE	Water quality
1993	MYSA	Remote Sensing for monitoring and surveillance
2007	SPAN (Water Operators)	Water quality

As the country progresses and the investments in infrastructure increases, the need for data is extended into those required for operations and maintenance. Technological advancement has also caused data collection process to gradually progress from manual to automatic. For example, there are now more than 1,000 hydrological stations managed by the Department of Irrigation and Drainage (JPS) in the country, as shown in **Figure 1.3**. More of these stations as well as other related infrastructure are expected to be built as the need for wider coverage and greater data accuracy increases.

However, the installation of these stations by the respective departments is to serve their main functions, but not specifically for sharing or serving the needs of other departments and end-users. This is because in the early stages of national development, water supply was far more than demand, and there was no urgent need for any meaningful multi-sectorial demand analysis. This traditional sectorial approach is now well-embedded in the nation's approach to water management. Subsequently, the departments' data and statistics management systems were also developed mainly to deliver their expected internal organisational roles and functions and with very little meaningful cross-sectorial considerations. The Ministerial Functions Act 1969, which defines the boundaries within which each Ministry and its departments should operate, further reinforces this sectorial approach.



No	States	No. of Stations			
		Rainfall	Streamflow	Water Level	TOTAL
(1)	(2)	(3)	(4)	(5)	(6)=(3)+(4)+(5)
1	Perlis	20	10	13	43
2	Kedah	55	5	20	80
3	Pulau Pinang	24	6	12	42
4	Perak	96	35	39	170
5	Selangor	131	15	44	190
6	Wilayah Persekutuan Kuala Lumpur	35	9	18	62
7	Negeri Sembilan	53	16	18	87
8	Melaka	27	4	10	41
9	Johor	229	14	29	272
10	Pahang	130	6	43	179
11	Terengganu	76	18	28	122
12	Kelantan	76	12	16	104
13	Sabah	53	32	64	149
14	Sarawak	340	20	161	521
15	Wilayah Persekutuan Labuan	4	20	Nil	24
	TOTAL	**1349**	**222**	**515**	**2086**

Figure 1.3: Map of JPS's Hydrological Stations in the Country (RPM Engineers Sdn. Bhd.)

Processed data produced by water related departments are shared in the form of information for the public such as flood warning system by JPS, weather services by Malaysian Meteorological Department (METMalaysia) and pollution reports by the Department of Environment (DOE). Not all data collected are readily accessible to the public and external end-users such as government research agencies,

universities, and the private sector. The overall water data collection and management in Malaysia is shown in **Figure 1.4**.

Nonetheless, the data collection, distribution and processing in the country has become more sophisticated in line with the progress in science and technology. However, there are also areas of duplications that could be removed to have a more efficient, complete, and standardised water data sets. Rainfall data for example is collected by JPS, METMalaysia, Muda Agricultural Development Authority (MADA), Kemubu Agricultural Development Authority (KADA), research institutions, water and sewerage services operators and the private sector (oil palm and rubber estates). The DOE collects water quality data just as JPS, water and sewerage services operators do but for different purposes. Closely related to water quality is the water health and safety data collected by Ministry of Health (MOH).

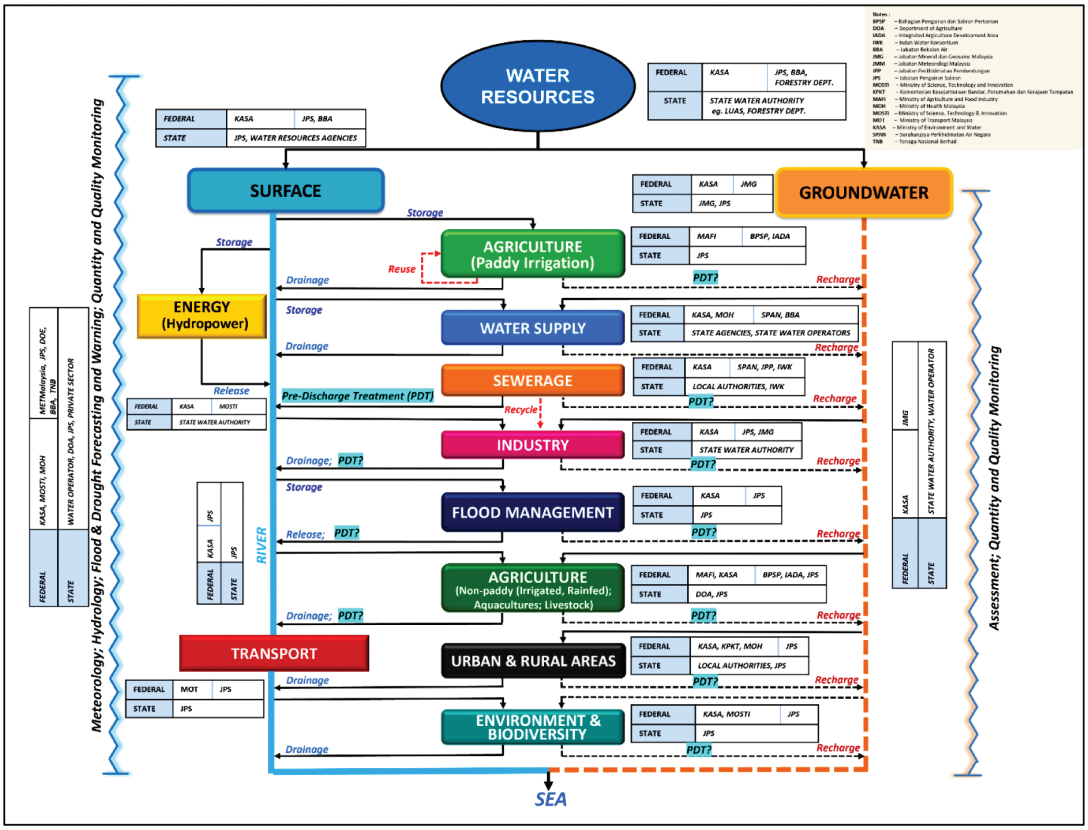


Figure 1.4: Water Data Collection and Management in Malaysia
(RPM Engineers Sdn. Bhd.)

Data collection by the various organisations and government departments can be broken down into two, Primary data and Secondary data. Primary data with regards to the formation of IWSDC relates to water data. Currently, water data collection encompasses surface water, groundwater, and coastal information. Primary data collected varies from department and organisation, but as mentioned previously, certain data collected overlaps in function. Primary data alone cannot fully satisfy operational use. This is where secondary data serves to complement the water data in its use for water management. Secondary data includes land use, demography, and other non-water information.

Given that the sectorial approach is very well embedded in the country's water management and development system, an institutional integration approach would not be well received by the individual water management organisations. These organisations have developed and strengthened over the years

since the early days of the country's development when water resources supply far exceeded demand. This inevitably has also resulted in the responsible water developers and managers, mainly from the Food (agriculture), Water Supply and Sewerage and Energy Sectors, to form distinctly rigid sectorial and organisational boundaries. And, to a certain extent, even physical operational boundaries.

The strategy for "physical" institutional integration over the last few years was to form new Ministries housing the selected relevant water managers. The latest is the formation of the Ministry of Environment and Water (KASA) comprising DOE, JPS, Water Supply Division (BBA), Sewerage Services Department (JPP), METMalaysia and the National Water Research Institute Malaysia (NAHRIM) as well as the National Water Services Commission (SPAN). There is also a recent announcement by the Minister of KASA that the Ministry is in the final stages of forming a *Jabatan Air Negara*, which will combine the functions of three departments, namely JPS, BBA and JPP (Muhamad, 2021).

Whilst this is a significant move towards the IWRM approach, it is still incomplete in other ways. The groundwater management aspect, for example, is not included and so are aspects related to land use planning that is integral to IWRM. Moreover, crossing functional boundaries is still limited, certain duplications of activities have occurred (e.g., water data collection, common public participation platform and target group) and there are gaps in the spectrum of water management necessary for present and future situations (e.g., water security, water for the environment and biodiversity, water for wealth management).

The pressures on the need to integrate is increasing. As the country progresses, water demand gradually exceeds supply and this in turn has induced increasing pressures on the traditional sectorial boundaries. More and more sectorial boundaries are being forced to be porous and even breached to accommodate the needs of other sectors and to satisfy its own sectorial demands.

There are already a series of such occurrences. The MADA irrigation system network was initially developed and managed almost exclusively for the Food (agriculture) sector (paddy), but now must significantly serve the Water Supply, Energy and environmental (flood management) sectors. It also functions as an inter-State water resources transfer scheme.

Similarly, the Kerian Granary irrigation network now must serve the Water Supply sector and in addition to this, its complementary Bukit Merah reservoir is now challenged with the need to serve the Tourism, Environmental (Flood) and Transport (Railway) Sectors.

Further inter-Sector pressure is already on the Energy Sector (Sungai Perak hydroelectric generation dams) with the request for the Perak-Penang Water Transfer to relieve the already stressed Muda River as the traditional "River of Life" to support and sustain development in the Northern Corridor Economic Region (NCER).

Apart from inter-sector water boundary management issue. There are also intra-State and inter-State transboundary pressures as well as a possible inter-regional water management challenge for the future. Furthermore, these boundary management issues will have to be observed and respected in terms of the States' sovereign rights and balancing the decisions from the perspectives of National interests and the States' interests.

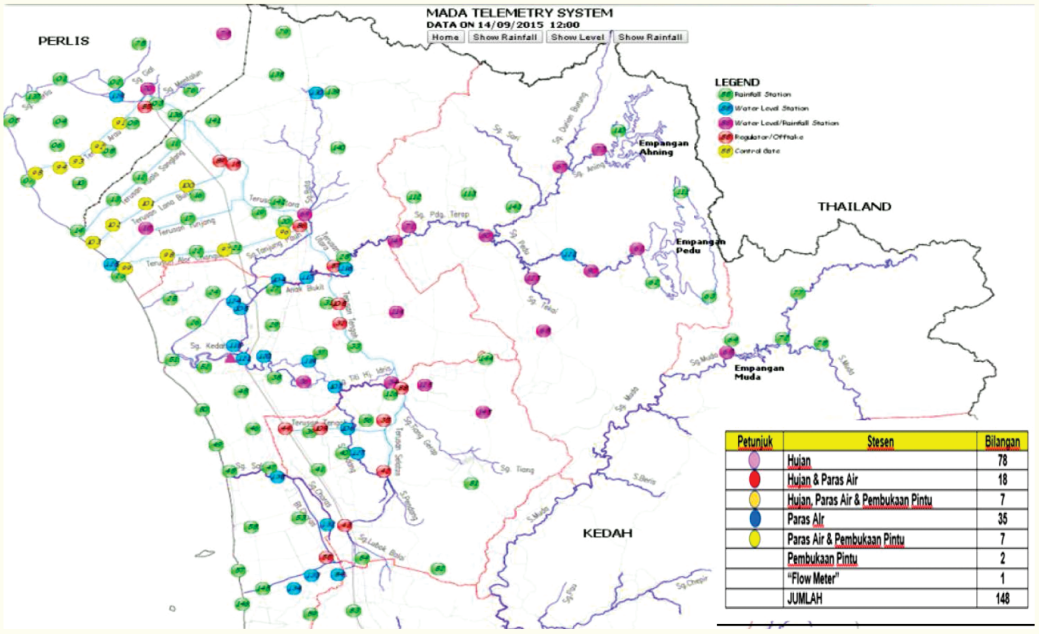
Boundary management by itself is a complex problem. Exacerbating this are inherent as well as emerging water management issues in relation to laws, rules and regulations, policies, and practices. Of concern

Box 1.4: The MADA Granary Data and Information Management System

The MADA Granary (100,685 ha.) water management system is one of the most complex in the country. Initially designed exclusively for irrigation and drainage, it is now extended for flood management and inter-sector (domestic and industrial water supply, energy) and inter-State (Kedah, Perlis, Pulau Pinang) water demand management. The backbone of this system is the extensive hydrological telemetric and communications network that transmits data and information to the computerised central control station for rapid decision-making in moving water for timely irrigation and drainage, for safety (as in floods) and for storage to avoid wastages and water quality management when the need arises. The key to the consistent success in water management and therefore paddy production is the system ability to manage high utilisation of effective rainfall first (40% of total water for paddy) and uncontrolled flow in rivers (18%), before recycling (10%) and then only dam (Pedu, Muda, Ahning) water releases (32%).

This system now comprises 148 telemetric stations. There are however still certain data such as planting and field water status, reservoir levels and water quality that are still manually collected. Many of the control structures are still manually operated. There is also concern on the limited data and information availability for dam catchment monitoring and surveillance. The plan is for all the data management and selected structures (15 Main Irrigation and 2 Main Drainage Control Structures) to be fully automated, a move to IR4.0 applications.

MADA shares all its telemetric hydrological data daily and automatically with JPS Malaysia that in turn add these to the national hydrological management system including for real-time flood information service for the public.



is the ever-increasing impacts of factors such as climate change, pollution, floods and droughts on the expanding economy and on the already affluent social well-being.

With the increasing complexities of water management and the inherent threat to development sustainability, the need to accelerate IWRM approach is therefore a priority now.

The NCER region is a good example of complexities of water management. This is a water-stressed region that depends on intensive water resources development and extensive water distribution system for growth sustainability. This situation is exacerbated as the population increases and development intensifies. Under the circumstance, water resources allocation becomes an issue between the State

Governments and between sectors and stakeholders. Resolving this requires negotiations between parties and agreed set of common data is necessary as the basis of agreements.

More importantly, since the governance system within the various government institutions have developed according to functional basis of the respective organisations, there are gaps of services within the spectrum of water management and in data and statistic collection. At present there is no assigned responsible organisation for water security and sustainability, for water governance compliance, for water data and statistics standards, for monitoring and strategising water wealth management for wealth creation and for other support services such as the Water-Food-Energy Nexus management and virtual water monitoring. Also lacking is a responsible organisation for public participation in the water industry. Another major gap in the national water management system is the lack of a responsible organisation for managing water for the environment although it is well accepted that this is a critical water sub-sector to protect the richness in biodiversity and for ensuring sustainability.

All these support services are necessities for the acceleration of IWRM approach as well as to have affirmative programmes and directions to achieve the Sustainable Development Goals (SDG2030), WKB2030, the 12th MP plans and the WST2040 ambitions. Again, an organised and integrated water data and statistic management system is a necessity to achieve all these.

As mentioned above, the reluctance of data sharing by Government departments is caused by the desire to preserve traditional hierarchy and authority structure under the Ministerial Functions Act 1969. However, history shows that the Government has taken affirmative actions to remove or separate specific functions from a particular department and create another function-specific department or authority when it is in the nation's interests to do so. Some examples of these organisations are shown in **Table 1.1**. The creation of these new institutions has given them the necessary focus and independence to elevate their delivery and productivity to a new level and enable the growth of specific products and services such as highway administration, paddy production and palm oil industry. Similar approach could also be made to integrate water data sharing and enhance water sector in the country.

Table 1.1: New Bodies Created to Serve New Strategic Functions

No.	New Department/ Year Body/ Authority	Created	Function	Original Department
1.	Malaysian Highway Authority (LLM)	1980	Highway Authority	Public Works Department (JKR)
2.	MADA	1970	Irrigation water resources and paddy production management	Ministry of Agriculture (MoA)
3.	Malaysian Palm Oil Board (MPOB)	2000	Promotion and development of the palm oil industry	Palm Oil Research Institute of Malaysia (PORIM) and the Palm Oil Registration and Licensing Authority (PORLA)
4.	NAHRIM	1995	Water related research	Staffed with Officers from JPS

b. Laws

The analysis on the legal landscape with regards to data collection, data sharing and RDIC has concluded that three laws are most relevant to these issues, namely the Official Secrets Act (OSA) 1972, the Ministerial Functions Act 1969 and the Statistics Act 1965.

i. The OSA 1972

More than the actual threat of OSA, the mere 'perceived threat' of OSA impedes the fluidity of data sharing in Malaysia, since just about any government document could be classified as a secret. Even though there is a government circular (Jabatan Perkhidmatan Awam, 2018) which provides guidelines to public servants on managing government records, most Government departments prefer to be on the safe side of the law and are only willing to release limited data to the public. Over time, this perception and wariness have developed into an entrenched culture, where sharing of data is seen as something that could be considered detrimental to national security. Thus, data security concerns have developed into a sense of data insecurity amongst the data custodians.

Box 1.5: OSA 1972

The OSA's schedule defines official secret as the cabinet documents, records of decisions and deliberations including those of Cabinet committees; the State Executive Council documents, records of decisions and deliberations including those of State Executive Council committees; and the Documents concerning national security, defence, and international relations.

OSA defines "document" as any map, plan, model, graph or drawing; any photograph; any disc, tape, soundtrack or other device in which sound or other data (not being visual images) are embodied so as to be capable (with or without the aid of some other equipment) of being reproduced therefrom; and any film, negative, tape or other device in which one or more visual images are embodied so as to be capable (as aforesaid) of being reproduced therefrom.

Any document could be declared a "Top Secret", "Secret ", "Confidential" or "Restricted" by a Minister, the *Menteri Besar* or Chief Minister of a State or such public officer appointed under section 2B of the Act. The penalty for violations of the Act ranges from a fine of not exceeding RM2,000 for making a false declaration in obtaining a permit to life imprisonment for spying.

ii. Ministerial Functions Act 1969

The Ministerial Functions Act 1969 establishes the assignment of each Ministry and its respective departments to a Minister. While this delineation is necessary for administrative cohesion and fluidity of the government, it has also led to setting up of rigid boundaries between organisations. Any data or information collected by a department or agency, for example, is solely for the purpose of fulfiling the department or agency's roles and functions, hence, not designed to be shared with other institutions. The act limits the data sharing even amongst Government departments and agencies and does not lend to a conducive data sharing environment. This limited accessibility has also subsequently impacted the full implementation of the RDIC chain since many RDIC players could only initiate their RDIC efforts by having seamless access to the massive data routinely collected, processed, and stored by Government agencies.

Box 1.6: Ministerial Functions Act 1969

Section 2 declares the functions of Ministers and the Ministry, as well as the departments assigned to each Minister.

Source: Government of Malaysia, 2013

iii. Statistics Act 1965 (amended 1989)

The Statistics Act 1965 is currently being reviewed for an amendment, with the aim of strengthening Department of Statistics Malaysia's (DOSM) roles in data and statistics collection. This amendment will also align DOSM's roles in-line with the proposed establishment of *Majlis Statistik dan Data Negara* (MSDN) and *Pusat Analitik Data Raya Negara* (PADRN).

This development presents an opportunity to strengthen water data and statistics collection in the country, by including water data and statistics as an item under the proposed Statistics Act amendment.

Box 1.7: Statistics Act 1965 (amended 1989)

Section 2 of the Statistics Act 1965 (amended 1989) provides the source of authority to DOSM to collect and interpret statistics for the purpose of furnishing information required in the formation or carrying out of Government policy in any field or otherwise required for Government purposes or for meeting the needs of trade, commerce, industry, or agriculture (including forestry, fishing, and hunting).

Source: Government of Malaysia, 2020

iv. Summary

It can be concluded that the legal landscape related to water data sharing in Malaysia is still very restrictive and sectorial in nature. This is because Malaysia does not have a National Data Sharing Law or a Freedom of Information Law that not only would oblige government departments to share data with each other, but also to the public. Such law would also facilitate the process of data sharing, such as establishing simple protocol, standardisation of data format and nomenclature as well as ensuring data interoperability.

Nevertheless, there is now an effort by the government to facilitate a more conducive data sharing ecosystem whereby the National Data Sharing Policy Paper has been prepared for the Cabinet. This Policy is developed by Ministry of Communications and Multimedia Malaysia (MCMM), Malaysian Administrative Modernisation and Management Planning Unit (MAMPU), Chief Government Security Officer (CGSO), Malaysia Digital Economy Corporation (MDEC) and other agencies involved in data sharing. The scope of this policy covers the government, the private sector and the public to ensure the formation of a more conducive data sharing ecosystem.

The Draft National Data Sharing Policy (NDSP) is a long-term strategic document and ongoing efforts designed to create a holistic, conducive, and inclusive data ecosystem to support the country's socio -economic development agenda. Data is a national asset that serves as a major catalyst to the digital economy and the Fourth Industrial Revolution (IR4.0). Furthermore, this policy also realises the desire to make Malaysia a data-driven decision-making country. (MAMPU, 2021).

The NDSP is the right step towards promoting a free data sharing society in Malaysia. However, the NDSP is currently designed as a set of guidelines to facilitate data sharing and it is not an affirmative policy that will oblige data sharing by all sectors. Nevertheless, this policy is a move in the right direction, which will hopefully lead to the establishment of a Data Sharing Law the country.

c. Policy/Blueprint/Initiative/Framework

An extensive list of policies, guidelines, masterplans, standards, frameworks, and circulars has also been reviewed to identify current policies involving water data governance and RDIC, and the most relevant policies are as the following:

i. National Security Policy 2021-2025

The newly updated National Security Policy (NSP) 2021-2025 has developed a thorough national security analysis through the development of a Comprehensive Security Matrix (**Figure 1.5**). Water security has been listed as a national security item under the core value of 'sustainable development'. The highlighted core values in **Figure 1.5** shows how IWSDC can support the NSP 2021-2025, in areas such as water security and data governance.

Box 1.8: Water Security

Water security is defined by UN Water Security and Global Water Agenda Brief as the "capacity of a population to safeguard sustainable access to adequate quantities of acceptable quality water for sustaining livelihoods, human well-being, and socioeconomic development, for ensuring protection against water-born pollution and water related disasters, and for preserving ecosystems in a climate of peace and political stability."

Source: UN Water, 2013

The NSP 2021-2025 is a significant policy document since it clearly states, for the first time, that water security is now an explicit part of the national security agenda. This pronouncement by the NSP 2021-2025 means that there is now an urgent need to develop tools to clearly report the state of water security in the country.

The IWSDC could play a role in ensuring the successful implementation of the NSP 2021-2025 by producing Annual National Water Security Reports for the National Security Council (MKN). This report will provide information on the level of confidence in our nation's water security in terms of water quantity, water quality and water safety status. Furthermore, the proposed water accounting report by IWSDC could also provide detailed information on the nation's overall water assets, supply and demand, analogous to financial accounting reporting. Meanwhile, through water auditing report, a proper mapping of the nation's water management and governance, including legislations and institutions, can be established.

ii. National Water Resources Policy 2012

The National Water Resources Policy (NWRP) has several strategies and action plans that are relevant to integrated water data collection and sharing. One of the strategies under the NWRP is to create a database framework and establish information networks on water resources. It also plans for this database to establish communication framework between key stakeholders.

The NWRP also outlines the requirements to identify existing scientific and technical data available related to water, water resources, use and users. Furthermore, it calls for national standards as well as uniform measures, terms and guidelines for water resources characterisation.

Overall, the NWRP is a positive step towards integrating water data collection, standardisation and sharing. However, being a water resources only policy, it does not comprise other sectors in the water industry such as water supply and sewerage services. More specifically, its implementation is limited by the Ministerial Functions Act 1969, which restricts its authority to agencies under KASA. This is a particularly crucial limitation when it comes to data collection and data sharing, since water and water related data are collected across several ministries (such as irrigation, groundwater, and health) as well as by private institutions.

iii. Digital Economy Blueprint 2021

The Government recently announced the launch of Malaysia's Digital Economy Blueprint (MyDIGITAL). MyDIGITAL (EPU, 2021) is a national initiative to successfully transform Malaysia

Matriks Keselamatan Negara (National Security Matrix) : Sembilan Nilai Teras Keselamatan Negara & Keselamatan Menyeluruh

9 NILAI TERAS KESELAMATAN NEGARA

	1	2	3	4	5	6	7	8	9
	Kedaulatan dan Keutuhan Wilayah	Kestabilan Sosio-Politik	Kesepaduan Nasional	Tadbir Urus Yang Baik	Keutuhan Ekonomi	Keadilan Sosial	Pembangunan Mampan	Keselamatan Rakyat	Pengiktirafan Antarabangsa
STRATEGIK	Kepentingan Nasional	Perlembagaan Persekutuan Malaysia	Integrasi Nasional	Pencegahan Rasuah dan Pengukuhan Integriti	Nexus Ekonomi-Keselamatan	Kedaulatan Undang-undang	Keselamatan Air	Keselamatan Dalam Negeri	Dasar Luar Malaysia
STRATEGIK	Ciri-ciri sifat geografi wilayah	Ehwal Raja-Raja Melayu	Kontrak Sosial	Pengurusan Perubahan Nasional	Impak Globalisasi / De-Globalisasi	Sosio-Budaya & Identiti Nasional	Sekuriti Makanan (Food Security)	Ketenteraman Awam	Hubungan Diplomatik Antarabangsa
STRATEGIK	Pengukuhan Kawasan Negara	Sistem Persekutuan	Kepentingan Persekutuan	Pengurusan Dasar Merentas Sektor	Keutuhan Ekonomi	Kewarganegaraan	Pengurusan Perubahan Iklim	Ekstremisme / Keganasan / Ajaran Sesat / Ideologi Baharu	Komitmen Institusi Antarabangsa
STRATEGIK	Perisikan / Penyuluhan Perisikan Balas / Penyuuhan Balas	Pengasingan Kuasa	Kepentingan Negeri	Indeks Keselamatan Kebangsaan	Pengurusan Sumber Pendapatan Negara	Hak Asasi Manusia mengikut Perlembagaan	Strategi Pembangunan Revolusi Industri ke-4	Jenayah Berkaitan Gangsterism	Keselamatan Geo-Strategik - ASEAN
STRATEGIK	Domain Angkasa Lepas	Keselamatan Politik	Semangat Kenegaraan	Pengurusan Sumber Negara	Pengurusan Keselamatan Tenaga	Isu Kumpulan B40, M40 & T20	Infrastruktur Strategik Keselamatan	Jenayah Berkaitan Dadah	Keselamatan Geo-Strategik – Asia Pasifik
OPERASIONAL	Domain Daratan	Demokrasi Berpelembagaan	Perpaduan Masyarakat	Integrasi Dasar & Operasi	Pengurusan Infrastruktur Kritikal Negara	Isu Bandar & Luar Bandar	Projek Pembangunan Keselamatan Khas	Pendatang Asing Tanpa Izin	Keselamatan Geo-Strategik - Antarabangsa
OPERASIONAL	Domain Maritim	Perjanjian Malaysia 1963	Semangat Patriotisme	Peruntukan Belanjawan Sektor Keselamatan	Pembangunan Infrastruktur Negara	Pengurusan Sistem Pendidikan Kebangsaan Secara Menyeluruh	Pembangunan Kapasiti & Kompetensi Nasional	Penguatkuasaan Undang-undang	Konvensyen Antarabangsa Disertai Malaysia
OPERASIONAL	Domain Udara	Keseimbangan Hak Majoriti Dan Hak Minoriti	Sensitiviti Toleransi (&Non-Toleransi)	Pengurusan Teknologi Keselamatan	Pembangunan Sosio-Ekonomi Sempadan	Isu Migran & Migrasi	Impak Pembangunan Bandar & Luar Bandar	Pengurusan Krisis Keselamatan	Komitmen Antarabangsa
OPERASIONAL	Pengukuran & Penandaan Sempadan	Sensitiviti Perkauman	Hubungan Persekutuan-Negeri	Pengurusan Komunikasi Keselamatan	Keutuhan Matawang	Kesetaraan Gender	Perumahan Rakyat & Kemampuan Pemilikan	Pengurusan Pandemik & Keselamatan Kesihatan	Kerjasama Bilateral / Multilateral
OPERASIONAL	Keupayaan Cegah Rintang Konprehensif	Sensitiviti Agama	Hubungan Berbilang Kaum	Pengurusan Teknologi Maklumat	Pemulihan Pasca-Krisis Pandemik	Tingkah Laku Sosio-Budaya	Pemuliharaaan Alam Sekitar	Pengurusan Bencana	Pengurusan Keselamatan Sempadan Bersama
TAKTIKAL	Pengukuhan Pengurusan Pintu Masuk Darat, Laut & Udara	Sensitiviti Institusi Negara	Pengukuhan Patriotisme	Akauntabiliti, Kompetensi dan Kapasiti Jentera Kerajaan	Ancaman Ketirisan Hasil Negara	Pemuliharaan Fabrik Sosial	Pengurusan Sumber Asli Negara	Keselamatan Makanan (Food Safety)	Diplomasi Pertahanan
TAKTIKAL	Pengurusan Aset Keselamatan Negara Secara Komprehensif	Membudaya Persekitaran Politik Sihat dan Matang	Perkongsian Kemakmuran yang Adil, Menyeluruh & Berkekalan	Pengurusan Peluang Pekerjaaan Warga Tempatan	Pemilikan Ekuiti Strategik Negara	Akses Pendidikan Kepada Semua	Memelihara dan Mempertahan Infrastruktur kritikal negara	Pusat Rujukan Berisiko	Diplomasi Ekonomi
TAKTIKAL	Pencerobohan & Pembolosan Sempadan	Pengurusan Kebebasan Media	Hubungan Berbilang Agama	Sistem Kewangan Kerajaan	Ancaman Penyeludupan	Memelihara Golongan Rentan	Pengurusan CBRNE (Chemical/Biological/Radioactive/ Nuclear/Explosive)	Pengukuhan Kesihatan Minda dan Ketahanan Rakyat	Evakuasi Warganegara di Luar Negara
Keselamatan Siber & Teknologi	Peperangan Siber	Pemantauan Media Sosial	Budaya Digital Malaysia	Pengurusan Teknologi Geo-Dataraya	Infrastruktur Digital	Pengurusan Jurang digital	Teknologi Pemusnah / *Destructive Technology*	Jenayah Siber	Integrasi Komuniti Keselamatan Siber Antarabangsa
Keselamatan Siber & Teknologi	Domain Siber dan Elektromagnetik	Pencegahan Berita Palsu	Pemantauan Naratif & Naratif-Balas	Kerajaan Digital	Pengurusan eko-sistem Ekonomi Digital Malaysia	4IR & Impak Sosial , Budaya, Identiti dan Jatidiri Malaysia	Akses Digital	Pengurusan Keselamatan Data Menyeluruh	Perundangan Siber Antarabangsa
Keselamatan Siber & Teknologi	Pertahanan Siber Aktif (Active Cyber Defence)	Pembudayaan Ruang Siber Yang Sihat dan Selamat	Pengukuhan Minda dan Patriotisme Komuniti Siber	Tadbir Urus dan Pengurusan Berkesan Domain Siber	Ancaman Manipulasi Teknologi Digital	Memperkukuh Rangka Kerja Perundangan & Penguatkuasaan	Pembangunan Kesedaran, Keupayaan dan Pendidikan	Memperkukuh Rangka Kerja Perundangan & Penguatkuasaan	Memperkukuh Kerjasama Global
Komunikasi Strategik	Gerak Saraf & Perang Saraf	Propaganda & Propaganda-Balas	Operasi Jiwa Murni (Hearts & Minds)	Strategi Komunikasi Kerajaan	Kandungan Digital	Perubahan Corak Sosio-Budaya	Kesedaran Keselamatan Negara	Kesedaran Peranan Masyarakat	Imej dan Status Negara

Figure 1.5: The National Security Policy Matrix
(Majlis Keselamatan Negara, 2021)

into a digitally driven, high-income nation and a regional leader in digital economy. The Blueprint mentions data utilisation as one of the key aspects in driving digital transformation of public sector. One of the key aspects of this transformation is through the Malaysian Government Central Data Exchange (MyGDX). MyGDX will increase its service catalogues to include all ministries and government agencies to enable more data sharing. The various Ministries and agencies are obliged to generate their own open Application Programming Interface (API) to share real-time and aggregated data.

The implementing agency, MAMPU is aiming for 50% of the data shared to be machine-readable and accessible through APIs, and for all ministries and agencies to use MyGDX by 2025. Through better data sharing, authorities can integrate more data in their assessment and development of future policies.

However, currently there is not enough commitment to open data environment nationally, especially in terms of reviewing current laws stifling open data sharing, and this situation will limit MAMPU's ability to properly execute the implementation of MyGDX (Shaharudin, 2020). For example, individual government agencies have wide discretionary authority under the OSA to determine what data can be exchanged. As a result, MAMPU currently has very little authority to mandate open data by default across all agencies (Lim, 2021).

Both digital policies and "non-digital" policies shape open government data. While the MyDIGITAL mentions proposals to make government data available by default, the lack of a Data Sharing Law means that agencies are currently not required to share its data (Shaharudin, 2020).

iv. Government Open Data Initiative 2014

The Public Sector Open Data (*Data Terbuka Sektor Awam, DTSA*) portal was developed by MAMPU to support the open data initiative. The portal allows the government open data to be easily accessed centrally from an official source (MyGovernment, 2019).

Its objectives include:

- To promote data sharing between the public and private sector agencies, and the public,
- To increase the quality and transparency of the government's service delivery through online sharing of open data,
- To promote digital economy output through the creation of new industries or innovation with the involvement of public and private industries.

Despite this initiative, there are still several problems faced by users when obtaining data and information from the Government. Despite the Open Data Initiative (ODI), users of Government's data still face several issues (Lim, 2020), including:

- Outdated data. Data stored and provided to the public could be as old as 10 years. This hampers users such as researchers and journalists who depend on the latest data for their work.
- Data provided is also not granular, i.e., not detailed enough. Some of the data provided, for example demographics data, is only available at district level, and not at sub-district level, where it is more useful. Advanced countries, such as the United States for example, provide granular data down to street or block level, with added granular breakdown such as gender, age, and income level.

- Data provided is not always in useful format. Some of the government data provided to users, can only be downloaded in Portable Document Format (PDF), which cannot be immediately processed. A database provided in raw data format such as Comma-Separated Values (CSV) and available via an API would be more useful and less costly to researchers and other users to process.

v. National Science, Technology, and Innovation Policy (NSTIP) 2021-2030

The NSTIP2021-2030 sets the target of Malaysia attaining a high-tech nation status by the year 2030. Several strategies and initiatives under the NSTIP are relevant to the overall objectives of IWSDC.

Under Initiative A4, the NSTIP aims to create an independent body that is responsible for planning, managing, evaluating, and monitoring the country's RDIC activities. This includes formulating national RDIC direction, managing funds, monitoring direction, and reviewing performance.

Under Strategy D, the NSTIP encourages Open Data Sharing to drive national innovation through collaboration and reduction of overlap in RDIC activities.

Meanwhile, under Initiative D1, the NSTIP supports the establishment of Malaysia Open Science Platform (MOSP) to encourage data, information and resources sharing amongst RDIC players. Furthermore, under Initiative E2, the NSTIP plans to intensify the integration of knowledge and technological innovation development through cross-disciplinary research efforts.

Finally, the NSTIP also plans to establish an 'STIE Surge Program'. This will be accomplished through the creation of a Digital Tsunami via increased R&D activities in IR4.0 technology.

All strategies and initiatives mentioned above are in-line with the ones proposed under WST2040 IWSDC sub-sectorial study. Efforts should be made to align WST2040 RDIC planning, coordination, and management with the NSTIP 2021-2030. This includes:

- Linking WST2040's Water Research Consortium with the national RDIC body.
- Enhance adoption of open data sharing and Open Science in water sector.
- Encourage cross-disciplinary and cross-sectorial collaborative RDIC efforts between water sector and others.

vi. 10-10 Malaysian Science, Technology, Innovation and Economy (MySTIE) Framework

The 10-10 MySTIE Framework is an integration of 10 key Malaysian socio-economic drivers with 10 global leading science and technology drivers aligned to Malaysia's strengths and needs. It provides a systematic approach to transform Malaysia into a knowledge-intensive economy by design.

'Water and food are listed as one of the key socio-economic drivers under the Framework. Opportunities in water sector RDIC laid-out under the 10-10 MySTIE Framework include:

- Connected water supply lines using Artificial Intelligence (AI) and Internet of Things (IoT) sensors for predictive maintenance,
- Drought and flood forecasting for effective reservoir management and early disaster mitigation,
- AI and deep learning algorithms to monitor quality and predict future availability of transboundary water resources for the food industry,

- Real-time monitoring of biological environmental sensors in water supplies using autonomous microscopes for early supply threat detection, and
- Nanomaterials for efficient water desalination and water treatment plants

The water sector RDIC opportunities identified under 10-10 MySTIE Framework should be a guide for developing RDIC efforts under WST2040.

vii. National Space Policy (NSP) 2030

The NSP2030 aims for the dominance of space towards securing national sovereignty and becoming a sustainable high-income country. Some areas under the NSP2030 that are relevant to the IWSDC are as the following:

- Thrust 2 of the NSP2030 focusses on space technology, infrastructure and applications that are of significant and critical importance to the country including planning and management of natural resources and the environment and disaster management.
- Thrust 3 meanwhile, focusses on driving the development of space science and technology as well as building local expertise to:
  - Understand and manage natural and man-made phenomena such as climate change, natural disasters, and unsustainable development.
  - Develop RDIC activities, industry development, and infrastructure utilisation.
- Thrust 4 aims to contribute to the economy by providing access to space technology and applications for other sectors.

The NSP2030 sets the overall way forward for space technology to become a key component to nation building, including resource planning, management and monitoring as well as enhancing RDIC activities. It is recommended that space technology becomes a cornerstone technology for WST2040 in areas such as water resources planning, management and monitoring as well as RDIC related activities.

viii. Summary

Efforts made by the government to share data through the Open Data Initiative have seen only limited success due to the stifling secrecy laws as well as the sectorial nature of governing institutions in this country. Furthermore, the MyDIGITAL blueprint, which is another step forward towards creating a digital economy in the country, also require seamless data accessibility for stakeholders from various sectors. Ultimately, Malaysia still lacks a Data Sharing or Rights to Information law which would establish access to data and information as a right of every citizen. As of May 2019, 93 countries in the world have enacted the Rights to Information Law, and Malaysia is not one of them (Right2Info, 2019).

Nevertheless, policies such as the NWRP 2012 have seen some successes in integrating water resources data in the country and should be further integrated. The integrated data should also be accessible to all stakeholders to unlock its value in terms of ensuring national water security and developing water as an economic opportunity.

Furthermore, with water becoming a national security item under the NSP 2021-2025, it is essential that the water security status in Malaysia is comprehensively quantified and regularly reported to assist decision makers in the country. This can only be accomplished through data integration and data sharing across sectors.

The NSTIP2030 is an important policy in relation to RDIC efforts in the country. Many of the strategies and initiatives established under the policy are relevant to IWSDC's RDIC strategies and efforts should be made to align WST2040's RDIC efforts to the NSTIP2030.

Finally, the NSP2030 outlines strategies and initiatives to make space technology as a key tool in nation-building. Space technology should become the cornerstone technology of WST2040 not just to manage water security but also to develop new applications which could generate economic opportunities.

Box 1.9: Water Accounting

Water accounting can be defined as the systematic quantitative assessment of the status and trends in water supply, demand, distribution, accessibility and use in specified domains, producing information that informs water science, management and governance to support sustainable development outcomes for society and the environment.

Source: FAO, 2016

Box 1.10: Water Auditing

Water auditing can be referred to as a process to report the findings, outputs and recommendations of water accounting that covers governance, institutions, public and private expenditure, legislation, services delivery, and political economy of specified domains. As such, the focus is to assess and understand the broader societal context of water management, water supply or water services delivery.

Source: FAO, 2016

d. Governance Tools

Malaysia also lacks any comprehensive governance tools to viably quantify water sector governance at a more detailed level. One of the most basic statement in management is that 'you cannot plan and manage what you cannot measure'. In terms of water governance, the World Bank states that one of the main challenges in water governance is the 'uncertainty about the amount and quality of water available from year to year, in terms of both stocks and flows' (FAO, 2018).

The Food and Agriculture Organisation (FAO) of the United Nations also states that water accounting is an essential tool in quantifying governance in water sector. Water accounting is about recognising the hydrological cycle, evaluating spatial and seasonal variations in rainfall with erratic extremes of floods and droughts. It must recognise the medium and long-term changes in demand across all water users, and advise water infrastructure investment in pumping, storage, and planning for climate change (FAO, 2018).

Meanwhile, water auditing, also known as water governance assessment, goes beyond water accounting by examining changes in water supply, demand, accessibility, and use in the context of governance, institutions, public and private spending, legislation, and the larger political economy of water in specific areas (FAO, 2016).

Currently, Malaysia still lacks any comprehensive water accounting and water auditing reports that could assist the country in quantifying water governance. Moreover, some of the water status reports being used for the nation's decision-making in water sector are also not regularly updated. The National Water Resources Study (NWRS) for example, is perhaps the most important reference for both the government and private sector, and yet it was last reviewed in 2012.

Thus, decisions related to water security in the country are being made without the support of strategic reports which would have given the decision makers a more complete picture of the country's state

of water sector. This includes issues such as cross-sector and inter-state transboundary water management, transparency, and integration.

e. Internationalisation

Malaysia is still lagging when it comes to international benchmarking of data and information. A report by Global Open Data Index (ODI) in 2016 showed that Malaysia is ranked 87 out of 94 countries surveyed in Global ODI, with a score of only 10% (Open Knowledge Foundation, 2016).

Overall, Malaysia still lags other countries in providing an open data ecosystem. The lack of a Data Sharing Law as well as the lack of commitment to international data sharing and open data initiatives have contributed to this present status. Free flow and sharing of information are keys to spurring economic and democratic growth. The leaders of the Global ODI illustrate how open data are related to economic and political growth. The top five countries on the ODI list are as the following:

i. Taiwan
ii. Australia
iii. Great Britain
iv. France
v. Finland

These countries also happen to be some of the most advanced countries in the world, both economically and politically. Malaysia will have to loosen up the barriers on data and information sharing and embrace the global commitment to open data if it harbours any intention of joining the advanced and developed world.

One of the initiatives under the recently launched MyDIGITAL is to enhance cross-border transfer. To successfully achieve this initiative, Malaysia will have to commit to international data sharing partnerships. However, Malaysia is currently not a member of any data sharing partnerships such as Open Government Partnership (OGP) or the Open Data Charter (ODC) (Lim, 2021). Membership in these organisations would compel Malaysia to share more data internationally and be part of the open data global society.

Open Science is another concept which is still in infancy in Malaysia. United Nations Educational, Scientic, and Cultural Organisation (UNESCO) defines the term 'Open Science' (UNESCO, 2020) as:

"*An umbrella concept that combines various movements and practices aiming to make scientific knowledge, methods, data and evidence freely available and accessible for everyone, increase scientific collaborations and sharing of information for the benefits of science and society, and open the process of scientific knowledge creation and circulation to societal actors beyond the institutionalised scientific community.*"

It consists of major components illustrated in **Figure 1.6** such as open data, open access, open-source software and open hardware, open science infrastructure, open evaluation, open educational resources, open engagement of societal actors and openness to diversity of knowledge.

One of the key areas under Open Science is Open Data. Open Data means data can be freely used, reused, and redistributed by anyone, subject only, at most, to the good practice of acknowledgement, attribution, and citation. It is necessary that data and databases, as appropriate, to be clearly described as 'in the public domain', assigned a public domain waiver, or an open license, to ensure the openness of



Figure 1.6: The Components of Open Science (UNESCO, 2020)

Box 1.11: FAIR Principles

FAIR stands for Findable, Accessible, Interoperable, Re-usable principles. The FAIR Data principles are the basis for international guideline for high quality data stewardship.

The FAIR principles are designed to support knowledge discovery and innovation both by humans and machines, integration of support data and knowledge, promote sharing and reuse of data, be applied across multiple disciplines and allow data and metadata to be 'machine readable', support new discoveries through the harvest and analysis of multiple datasets and outputs.

Source: FORCE11 in AIMS – FAO, 2018; Australian Research Data Commons, 2021

data. Data should be available in a human- and machine-readable and modifiable format, in accordance with principles of good data governance, such as for example the FAIR principles.

Open Science also adopts the concepts of crowdsourcing as well as citizen science, where the public is encouraged to participate in the scientific process, such as data collection and observation and reporting of current events (such as flash floods), as well as imparting their localised knowledge related to water.

2. Information and RDIC

a. Infostructure Status Report

There are currently efforts by the government at integrating the infostructure related to water and water-related data and information. These include the *Sistem Maklumat Sumber Air* (SMSA) by JPS, *Data Industri Perkhidmatan Air Negara berserta Spatial Mapping yang Interaktif* (DIPAN-SMI) by KASA, HydroDat and GroW by JMG, as well as MyGDI by National Geospatial Centre (PGN).

Box 1.12: SMSA

SMSA is a system to assist JPS in managing water resources information by integrating data from various sources into a solid database to provide business intelligence insights to JPS. The SMSA study began in 2016 and it is still in the system development phase. The water resources data collected by JPS, agencies under KASA, as well as 18 internal and external stakeholders will be consolidated in SMSA. SMSA also plans to utilise crowdsourcing as a source of data in areas such as flood management.

Source: JPS, 2020

i. Sistem Maklumat Sumber Air (SMSA)

SMSA structured data includes rainfall, water level, river flow, soil moisture, evaporation rate, sediment, water quality, tidal water level, dam storage, and dam level. Meanwhile, unstructured data includes videos, images, plans, studies, reports, and drawings. JPS also plans to integrate the various data gateways for its applications such as *InfoBanjir, InfoKemarau, Program Ramalan dan Amaran Banjir* (PRAB), and *Rangkaian Hidrologi Nasional* (RHN) into a single gateway in SMSA (JPS, 2017). SMSA is a step forward in integrating JPS's vast data sources, as well as data from external agencies. It will enhance the department's overall data management, processing, and distribution. **Figure 1.7** shows the systems architecture of SMSA.

ii. *Data Industri Perkhidmatan Air Negara berserta* Spatial Mapping *yang Interaktif* (DIPAN-SMI)

The DIPAN-SMI is an on-going project by KASA (KASA, 2021) to develop an integrated dashboard consisting of data on:

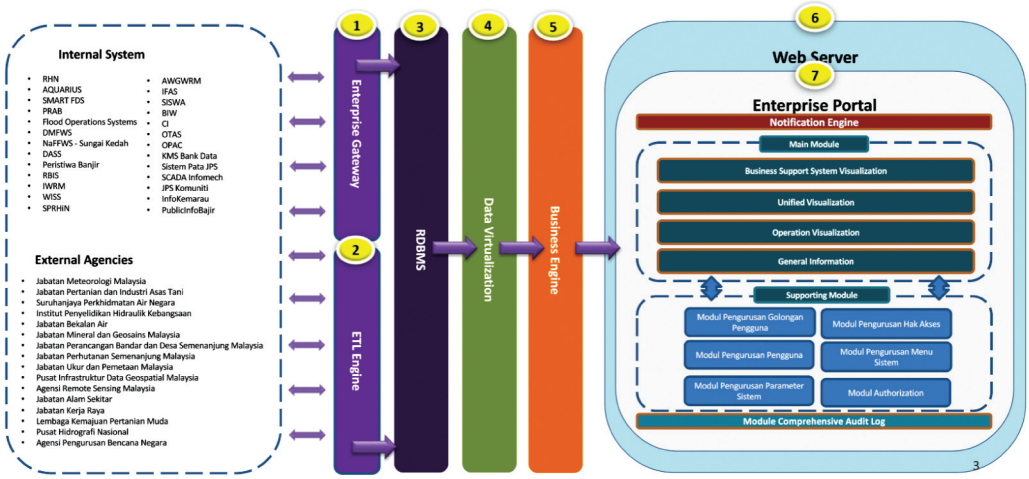


Figure 1.7: The Systems Architecture of SMSA
(Jabatan Pengairan dan Saliran Malaysia, 2020)

- water resources (water resources locations, water quality, water intake information and groundwater information),
- water supply (Water Treatment Plant (WTP) profile, network utility, WTP water quality, treated water supply and demand, customer billing and complaints), and
- sewerage (Sewage Treatment Plant (STP) profile, network system, service area, manhole points and other sewerage facilities).

DIPAN-SMI is a positive development for data sharing in the water sector, especially in water supply and sewerage services sub-sectors. **Figure 1.8** shows the specification and scope of DIPAN-SMI that will strengthen information sharing amongst agencies under KASA and enable them to have access to crucial data related to water resources, water supply and sewerage.

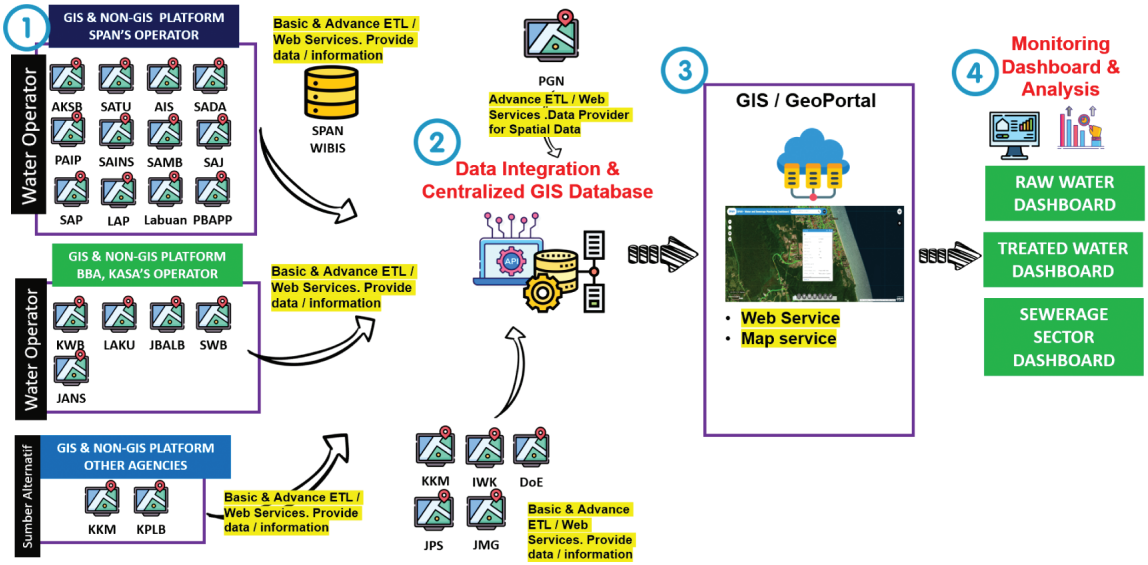


Figure 1.8: Specification and Scope of DIPAN-SMI
(Kementerian Alam Sekitar dan Air, 2021)

iii. HydroDat and GroW

HydroDat is a groundwater database system developed by JMG. It consists of physical attributes related to groundwater such as location of tube wells, groundwater level and groundwater maps. It also contains 24 hydro chemical parameters that are useful for applications in sectors such as irrigation and domestic water supply (Jabatan Mineral dan Geosains (JMG), 2021). Meanwhile, GroW is a decision-making support system (DMSS) developed by JMG to assist decision makers in matters related to groundwater. It utilises big data analytics to determine the most optimum groundwater utilisation. This includes aspects such as location of water stress, availability of groundwater resources, and cost-benefit analysis as shown in **Figure 1.9**.

HydroDat and GroW are two important groundwater data systems that complement the water resources management system in the country. Establishing linkages between IWSDC and these two systems will further strengthen the water data integration in the country in line with WST2040 focus areas of integrating water data management system.

iv. MyGDI

On the geospatial aspect, MyGDI is a government's initiative to develop a geospatial data infrastructure to increase the knowledge about data availability and enhance access to geospatial

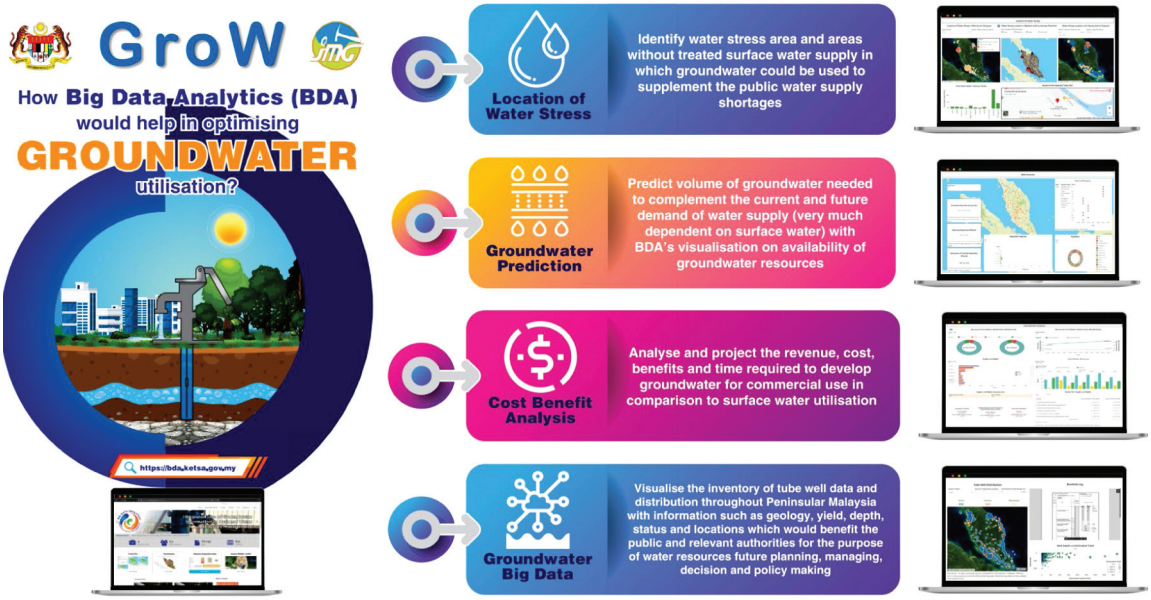


Figure 1.9: Utilisation of Big Data Analytics for GroW by JMG (Jabatan Mineral dan Geosains (JMG), 2021)

information. This is accomplished by enabling data sharing amongst partaking agencies. MyGDI, as the National Spatial Data Infrastructure (NSDI) for Malaysia, is a geospatial data infrastructure set up to achieve this objective (MyGeoportal, 2021). However, direct services of MyGDI are restricted to only registered users from government agencies. Any non-government users will still have to refer to the original data providing agency.

b. RDIC

i. Malaysia's International Competitiveness Assessment

Malaysia's apparent competitiveness at international level can be misleading. While certain indicators show that the country is performing well internationally in innovation, export market, competitiveness as well as knowledge and talent, a deeper inspection shows that Malaysia's actual competitiveness has been driven by talent and infrastructure rather than innovation. It also shows that Malaysia's innovation capacity and skill need to be strengthened to move STI-based innovation. **Figure 1.10** illustrates 'tip of the iceberg' nature of Malaysia's international competitiveness. For example, Malaysia is ranked 22nd out of 63 countries in the World Competitiveness Yearbook (WCY) 2019, with a score of 82.54 out of 100 points, according to the IMD World Competitiveness Centre in Lausanne, Switzerland (Malaysian Productivity Corporation (MPC), 2019). However, Malaysia is only ranked 44/63 in labour productivity and 46/63 in patent applications per capita. Malaysia is also ranked only 54/63 in 'start-up procedures' (Academy of Sciences Malaysia, 2021). Other categories such as innovation, market, knowledge, and talent also show worrying fundamental weaknesses of Malaysia's international competitiveness.

Almost 80% of researchers in Malaysia are based in higher learning institutions, while only 15.8% come from business enterprises (Academy of Sciences Malaysia, 2017), as shown in **Figure 1.11**. This is in stark contrast to countries such as South Korea and Japan, where most of their researchers (82% and 74% respectively) come from business enterprises.

Moreover, according to the report, over 75% of research activities in Malaysia in 2018 are in basic research and applied research categories, while only about 25% are in experimental research

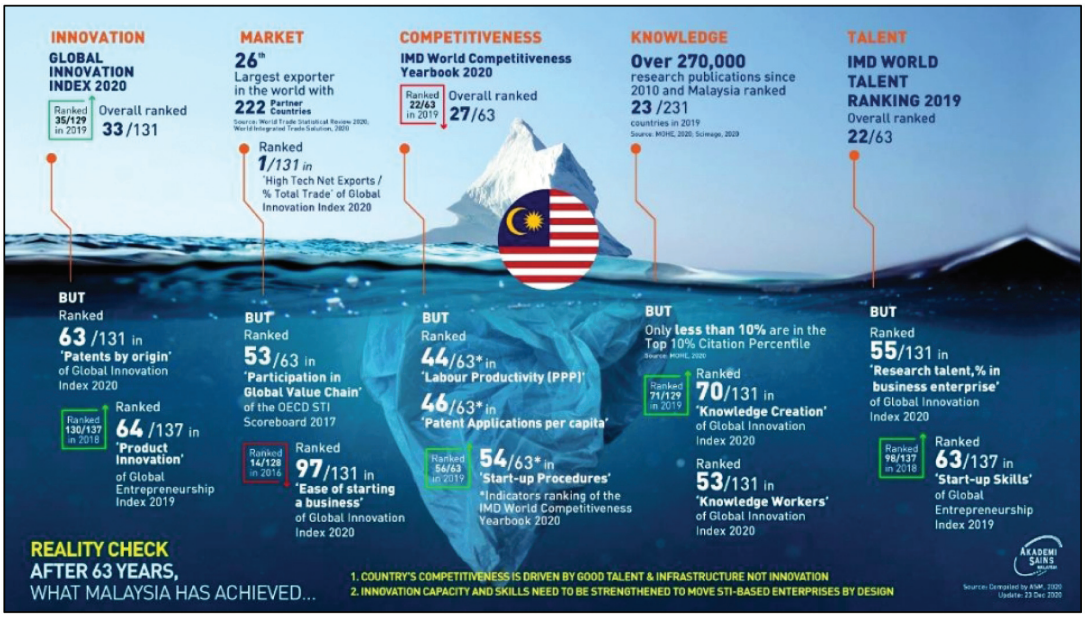


Figure 1.10: Reality check - RDIC achievements in Malaysia after 63 Years (Academy of Sciences Malaysia, 2021)

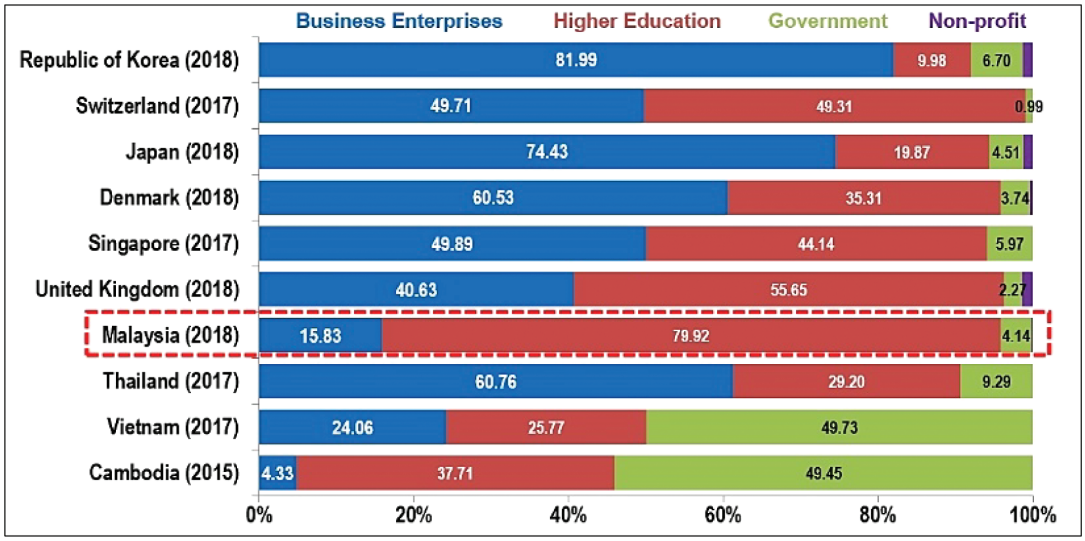


Figure 1.11: Percentage of Researchers (in full-time equivalent) (Academy of Sciences Malaysia, 2021)

category, as shown in **Figure 1.12**. Moreover, Malaysia's Gross Domestic Expenditure on R&D amounted to just 1% of its GDP in 2018.

ii. Status of Water Related RDIC

The RDIC scenario in water sector is also not very exciting. Research Universities are the dominant entities related to publications and grants on water research. The research grant award trend showed that 83% are for fundamental research and 66% for Science and Engineering. According to a study on "Setting a National Agenda for Integrated Water Research", there were 3,216 publications made from 1963 to 2012 in which 5,277 has been identified as unique authors from 814 institutions with limited focus on pollution and river related research (Academy of Sciences Malaysia, 2014).

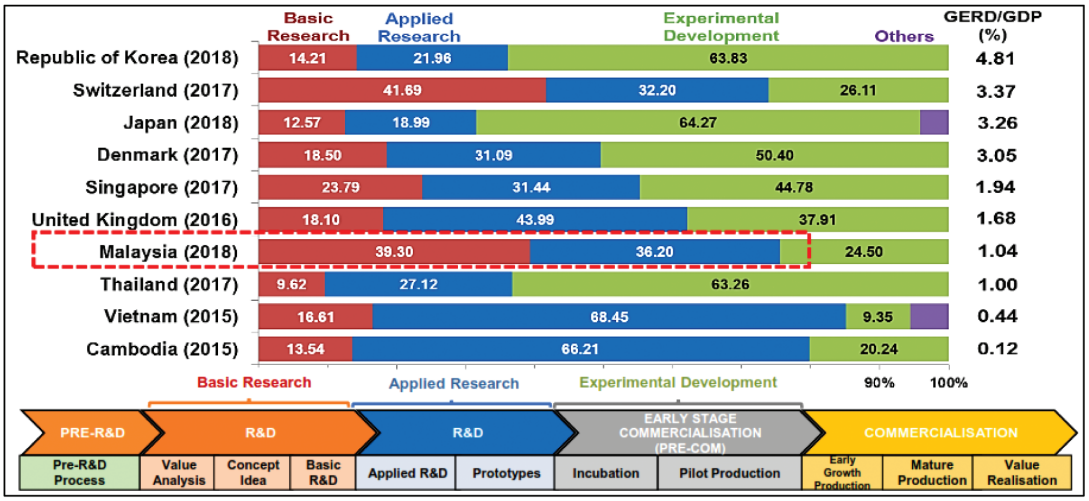


Figure 1.12: Categories of Research in Malaysia (2018)
(Academy of Sciences Malaysia, 2021)

The Study concluded that past and current research on water in Malaysia has been largely ad hoc, fragmented, and only for academic purposes. Although there are 20 research centres in local universities in the country which also conduct water related research, the research is mainly performed independently and to meet academic pursuits and needs. Various issues and challenges on water management have been identified from the research made, but there is no clear direction in place to solve these problems by harnessing science, technology, and innovation through integrated and coordinated multidisciplinary research underpinned by an overall R&D framework based on national needs and priorities.

In terms of grants for RDIC, Ministry of Science, Technology and Innovation (MOSTI) and Ministry of Education (MOE) have mostly managed the research and development funds in Malaysia, but the R&D for water is not significantly important (Academy of Sciences Malaysia, 2014). MOSTI reported that water security, even though considered as one of the national priority areas for R&D, received only 1.8% of the funding for R&D in 2018, as shown in **Table 1.2**, (Malaysia Science and Technology Information Centre (MASTIC), 2020).

Table 1.2: R&D Projects Funded by MOSTI for National Priority Areas in 2018

No	R&D by National Priority Area	Percentage (%)
1	Medical and Healthcare	13.9
2	Transportation and Urbanisation	11.3
3	Cyber security	10.1
4	Energy security	8.4
5	Environment and Climate Change	7.9
6	Biodiversity	5.9
7	Food Security	3.9
8	Plantation Crops and Commodities	3.8
9	Water Security	1.8
10	Other	33
	Total	100

Throughout 10th MP, water related RDIC projects accounted for only 21 out of 1737 (1.2%) projects approved by MOSTI, while the figure for 11th MP was 8 out of 217 or 3.69% (Ministry of Science, Technology and Innovation (MOSTI), 2021). This result shows that water security, even though listed as one of the key priority areas of RDIC, is not very well-funded.

Meanwhile, water quality and water treatment remain the biggest area of focus for RDIC projects approved in both 10th MP (29%) and 11th MP (50%) as shown in **Table 1.3** (Ministry of Science, Technology and Innovation (MOSTI), 2021). The focus areas for RDIC in water sector remain very narrow and other important areas such as virtual water and water footprints as well as water governing measurement tools such as water accounting remain underfunded.

Table 1.3: Areas of Focus within Water-Related Projects under 10th MP and 11th MP

No.	Area of Focus	10th MP	11th MP
1.	Infrastructure	1 (4.76%)	2 (25%)
2.	Weather Forecasting	1 (4.76%)	1(12.5%)
3.	Climate Change	4 (19.05%)	-
4.	Water Management System for Agriculture	2 (9.52%)	-
5.	Water Resource Management Tools	4 (19.05%)	-
6.	Stormwater Management	3 (14.29%)	1 (12.5%)
7.	Water Quality and Treatment	6 (28.57%)	4 (50%)0

iii. Success Stories in RDIC in the Water Sector

Despite the limited funding in water sector RDIC, several water sector products and services innovations by the private sectors and universities have been able to be commercialised through annual commercialisation programme, namely under Malaysian Commercialisation Year (MCY), a programme funded by MOSTI.

Amongst the innovations is the water filtration system to purify water, especially from raw, untreated water sources. This product is Efinity Water Filter System, a chemical specially formulated with high concentration of aluminium polymerisation, a system designed to treat polluted wastewater by the industry with the use of natural ingredients and invented Hydroxyapatite beads of fish scales as a medium for calcium ions in water filter applications. In terms of irrigation system for agriculture, a Scalable Skid for Smart Farming System has been invented to achieve higher yield (Ministry of Science, Technology and Innovation (MOSTI), 2019).

The above shows that while there have been a few success stories, the range of inventions in the water sector remains very narrow, mostly focussing on water filtration systems.

3. People (Intellectual Capital and Interactions)

a. Stakeholders Participation (Interactions)

Stakeholders' participation is one of the key aspects of empowering people in IWRM. The NCER water management system, for example, illustrates the need for data and information-based stakeholder engagement, as well as a formal platform for stakeholder engagement. This is a region that would not be able to achieve sustainable economic growth and social well-being without such an intensive network of water resources development and distribution. The complexity of such system is not only in the operations

and maintenance aspects, but from a political, sectorial, and social aspects too. The level of complexity will continue to increase in the future not just within this region but spread over the whole country.

This region hosts many investments of national interests – the Granaries for food security, the industrial areas, energy generation and tourism. The States are also concerned about protecting their development interests too, of which, water and land are both under the purview of the respective States. Thus, there will always be the Federal-State issues to resolve. With the system servicing multi-State (Kedah, Perlis, Pulau Pinang and Perak) water supply, there are also continuous State-State transboundary issues.

There are also operational issues involving inter-Sector coordination and cross-boundary management. Issues such as water resource facility and storage sharing and determining priorities for water in the short and long-term are not easily agreed upon.

Resolving all such issues requires constant negotiations. One of the key success factors under the circumstance is therefore to agree on the data and information as the basis for a scientific approach to decision-making.

The lack of trusted and meaningful data is also causing friction between water stakeholders in Malaysia, specifically inter-state transboundary water management. The friction between Pulau Pinang and Kedah, which shares a small part of Sungai Muda, is one such example. Without any mutually trusted data and information, which is either not shared or not available, on top of the absence of any mutually trusted platform for engagements, the two states continue to engage in political arguments which are not contributing to nation building.

Similar situation is also hampering the proposed water transfer between Perak and Pulau Pinang. The main issue of provision of raw water vs treated water to Pulau Pinang continues to be the main stumbling block. However, if the two sides are willing to negotiate based on reliable and trusted water prices data and information, then both parties will be able to make facts-based decisions on the matter.

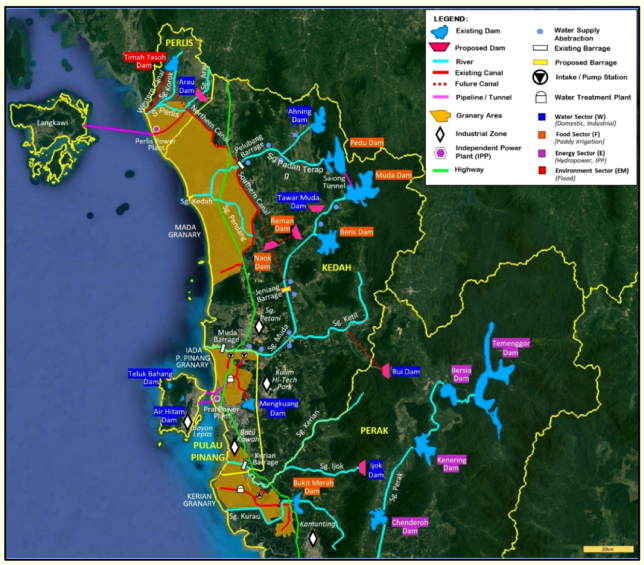
Furthermore, because of the current sectorial approach in water management, data for meaningful stakeholders' engagement and public participation in the water sector is currently fragmented. There is no centralised repository for up-to-date stakeholders' data which could be retrieved by all departments for use in any engagement activities. Much of the village, district and state level stakeholders' information remain scattered at state level and even when it is shared to Federal level, it is only on an ad-hoc basis.

One such example is the Water User Group (WUG) for irrigation management. Even though there are hundreds of WUGs in the country, the database of these WUGs (such as membership and organisation chart) is not readily available for the federal agency in charge, namely *Bahagian Pengairan dan Saliran Pertanian* (BPSP), Ministry of Agriculture and Food Industries (MAFI). Instead, the data is kept and managed by the individual Granaries across the country. For example, MADA manages the database of 49 WUGs under its administration (Mukhlis, 2019) while Integrated Agricultural Development Area (IADA Pulau Pinang manages the 66 WUGs database under its administration (IADA Pulau Pinang, 2019). This data and information disconnect between the central implementation agency and the state agencies may hamper the development of WUG as an institution, but more importantly it also hinders the development of a systematic capacity building programme for WUG members.

The stakeholders for water sector also comprise a core of people of similar background. However, with the current sectorial approach to water stakeholders' engagement, many of these same stakeholders are

called to present their views and feedback multiple times by various departments and agencies involved in water sector management. This is not only inefficient but may also demotivate many stakeholders who are not at liberty to devote so much of their time attending multiple engagements.

Box 1.13: NCER as a Potential Water Hub



Northern Corridor Economic Region (NCER) has many of the attributes that qualifies it to be the location for a National Water Hub.

This a region with very distinct dry season and its development is sustained by intensive water resources development (dams) and extensive water distribution network (canals, drains, rivers). These systems not only serve all types of water (agriculture, domestic and industrial water supply, sewerage, energy, environment (including floods)) and socio-economic (tourism, transport, manufacturing, and services) sectors, but also inter-State (transboundary) water management (Perlis, Kedah, Pulau Pinang, Perak). The rural-urban backdrop is also very distinct and there are still vast areas of coastal and inland biodiversity wealth to conserve. There is also a distinct mainland-island (Pulau Pinang, Langkawi) development management scenario.

Such a background should provide the inspiration for the full spectrum of water research, development, innovation and technological development and commercialisation activities in the water sector.

It is a region that has already well-established institutions of higher learnings (Universiti Utara Malaysia (UUM), Universiti Malaysia Perlis (UniMAP), Universiti Sains Malaysia (USM) and Universiti Teknologi PETRONAS (UTP)), and Universiti Teknologi MARA (UiTM)). There are also well established and matured industrial areas such as those in Pulau Pinang, Kedah and Perak that covers a broad range of products and services for export. Such establishments would be able to provide the necessary support for a Water Hub in terms of the eco-system necessary to attract expertise and talents.

This region is also serviced by good transportation network and facilities of international standard (airports, roads and highways, railway, ports, hotels).

For this region, the Northern Corridor Implementing Authority (NCIA) is already well established as a catalyst and implementor of high value-added development projects and programmes and to promote private sector investment in the region.

b. Specialist Career Development

An assessment of the career development structure in many government organisations also shows that the current arrangement in many agencies is not conducive to specialist capacity building and career development. One of the main issues hampering growth in field-specific technical skills in Government departments is that staff usually do not stay in a specific division for a considerable amount of time. Most government servants remain at a particular division for only a limited time and once they are promoted, they will move on to another division or even different department altogether. While this movement enriches the experience of the officer, it also has the effect of disrupting the continuity of specific skills development at a particular division, especially for technical positions.

The functional nature of water sector governance has also led to certain departments being dominated by specific professions. JPS for example, is dominated by civil engineers due to the need to fulfil its functions as the country's water resources manager. This organisational set-up has been highly successful in fulfilling the department's objectives, which tilts heavily towards development, operations, and maintenance, as well as providing services for the public.

However, this function-specific dominance also makes these government departments, through no fault of their own, to be more narrowly focussed and less nimble in developing non-traditional approaches to problem solving. One such aspect is in realising and unlocking the true value of data, where the lack of new professions such as data scientist and data analyst have not enabled these institutions to fully realise and unlock the maximum potential of massive data in their possession.

4. Infrastructure and Technology

Presently, each department oversees its own data and information infrastructure. JPS for example, collects hydrological data such as rainfall, river discharge, water level, evaporation and water quality and has its own infrastructure to accomplish these tasks. Meanwhile, DOE collects surface and groundwater quality data and has its own set of infrastructure. METMalaysia also collects data on rainfall, air temperature and relative humidity and its own infrastructure setup to collect these data.

The infrastructure development for data collection by each department is designed to serve their respective functions. Thus, there is little interoperability between the infrastructure setup of these departments. Each department also appoints its own vendors to install the equipment and other related infrastructure for data collection. Most of these vendors use proprietary software and hardware, usually from overseas, and they are not interoperable with other software and hardware, and they are not future proof. Thus, any attempts to integrate the data will inevitably face difficulties due to these issues.

Moreover, the data collected also follows standards and nomenclature set by the respective departments and there are variances in data collection quality assurance standards. This sometimes results in interoperability and usability issues when the data is shared with other agencies, and in the case where data is shared, it is not given in a standardised format. Some examples of this include data format, technical terms, and units of measurements.

There is also no universal standard for water data collection quality assurance and quality control. For the data collected, there is usually no declaration on the data standards and quality assurance by the source department or agency. For external users, it is often expressed that the data quality checking and validation is the responsibility of the end-users themselves. They also have problems of receiving incomplete data, where there is a period of 'no data' in the information given by the data provider.

There is also evidence that water data collection infrastructure is slowly deteriorating. One such instance is the Kerian Irrigation Scheme Telemetry System. The Kerian Telemetry system for hydrological data was installed in the 1980s to support the computerised decision support for irrigation, drainage, and flood management for the 22,000 ha. Kerian Granary. Over the years and particularly since early 2000s, the system performance deteriorated significantly to a point that it is now not functional anymore and water management is now dependent mainly upon the experience and knowledge of the Bukit Merah system operators. One of the main reasons cited for this situation was the result of the restructuring of JPS Malaysia when it was moved from MOA (now MAFI) to National Resources and Environment (NRE) Ministry (now KeTSA) in 2004. With this move, the focus of JPS Malaysia was more on water resources and flood management. Although MAFI has an Irrigation and Agricultural Drainage Division (BPSP) with Federal Staff seconded from JPS Malaysia, the focus of this Division is on development works under the IADA programmes. The Kerian system operations and management remains under JPS Perak State. With this arrangement, the budget allocation for the upkeep of the telemetry system declined significantly. Frequent changes of key staffs due to transfers is another factor that affected the continuity and enrichment of knowledge and skills in the system operations. The present system managers acknowledged that there is an urgent need to revitalise the system for higher levels of service and system water management efficiency.

5. Finance (Incentives)

Another barrier to data sharing in Malaysia is the financial cost to data acquisition. The Fees Act 1951 imposes fees on certain data obtained from the government. Some of the fees charged by various departments are shown in **Table 1.4.**

Table 1.4: Fees for Data Charged by Various Departments

No.	Government Agency	Type of Data	Amount (RM)
1.	JPS for hydrology Data	Rainfall	50 (for less than 3 months) 100 (for 3 months to 1 year or between) 50 (for 1 to 10 years or in between) 25 (for more than 10 years or in between)
		Water level	155 (for less than 3 months) 310 (for 3 months to 1 year or between) 155.00 (for 1 to 10 years or in between) 72.50(for more than 10 years or in between)
		Data Discharge (Stage-Discharge Curve of Derived Maps)	35 (for less than 3 months) 70 (for 3 months to 1 year or between) 35 (for 1 to 10 years or in between) 17.50 (for more than 10 years or in between)
		Data Discharge (Discharge Readings)	165 (for less than 3 months) 330 (for 3 months to 1 year or between) 165 (for 1 to 10 years or in between) 82.50 (for more than 10 years or in between)
		Evaporation	35 (for less than 3 months) 70 (for 3 months to 1 year or between) 35 (for 1 to 10 years or in between) 17.50 (for more than 10 years or in between)
2.	JMG for geospatial data (in .shp format)	Geology Mineral source	200/megabyte
		Geochemical	
		Hydrogeology	
		Engineering geology	
		Geophysics	300/megabyte
		Marine geology	650/megabyte

Table 1.4: Continued

No.	Government Agency	Type of Data	Amount (RM)
3.	DOA for geospatial data	Printed mapping	50/page (for A0/A1/A2/A3 size)
		Digital mapping (in .jpeg format)	50/page
		Digital mapping (in .shp format)	900/megabyte for land use mapping 600/megabyte for land use review 500/megabyte for published mapping
4.	JUPEM for mapping	Cadastre Survey and Mapping	12/copy for A0 size 10/copy for A1 size 8/copy for A2 size 6/copy for A3 size 4/copy for A4 size
		Digital cadastre data	8/image 30/megabyte in .shp format
		Aerial photography mapping	10/copy for black and white 20/copy for colour 0.25/megabyte for expansion mapping 65/model for mosaic preparation (digital) 100/model for mosaic preparation (paper copy) 0.25/megabyte for scanned image in .thf format 0.35/megabyte for digital printed 45/copy for mosaic printed
		Mapping reproduction	100/copy for mount print on reverse film 80/copy for mount print on ordinary film
		Topographic map on 1: 25,000 scale (in .dxf format)	24/megabyte for less than 1 megabyte 22/megabyte for 1 to 50 megabytes 20/megabyte for more than 50 megabytes
		Topographic map on 1: 50,000 scale (in .dxf format)	28/megabyte for less than 1 megabyte 26/megabyte for 1 to 50 megabytes 24/megabyte for more than 50 megabytes
		Topographic map on 1: 25,000 scale (in .shp format)	65/megabyte for less than 1 megabyte 60/megabyte for 1 to 20 megabytes 55/megabyte for more than 20 megabytes
		Topographic map on 1: 50,000 scale (in .shp format)	115/megabyte for less than 1 megabyte 110/megabyte for 1 to 20 megabytes 105/megabyte for more than 20 megabytes
		Geoid information	3/point for geoid height 250/page for 30KM X 30KM 20,000/set for Peninsular Malaysia 10,000/set for Sabah 10,000/set for Sarawak 250/set for Labuan F.T.
5.	PLANMalaysia	Digital geospatial data	100/megabyte for the first megabyte 30/megabyte for the next megabyte
		Printed geospatial data	250/copy for A0 size (colour) 125/copy for A0 size (black and white) 120/copy for A1 size (colour) 60/copy for A1 size (black and white) 60/copy for A2 size (colour) 30/copy for A2 size (black and white) 30/copy for A3 size (colour) 15/copy for A3 size (black and white) 20/copy for A4 size (colour) 10/copy for A4 size (black and white)

The Fees Act is not just a financial disincentive for data sharing, but it also adds another layer of bureaucracy to data sharing by creating extra administrative procedures. This will create further hindrances to parties looking to procure data and information for various purposes.

For the country to move towards a more open data society, there is a need to review the Fees Act 1951 to reduce the financial as well as administrative disincentives in data sharing. The Act provides authority for Heads of Departments to waive fees for documents and this provision could be utilised to remove most data sharing fees. While the government's revenue might be slightly reduced by waiving data fees, the potential economic value that could be created from this incentive is enormous and almost unlimited.

1.3 The Challenges and the Need for IWSDC

There is a need to integrate the water data management system, not only for the functional use of the respective departments collecting them, but also for the use of other water managers as well as the public and private sectors. Integrated water data management is a fundamental approach to accelerating IWRM. The need to establish an integrated water sector data centre is driven by the challenges below.

1.3.1 The Challenges

a. Meeting the Demand of National Aspirations

First, there is the challenge of meeting national and global aspirations, namely the WKB2030 and SDG2030. The WKB2030 focusses mainly on restructuring the economy towards a more knowledge-based and high-value economy while ensuring more equitable sharing of wealth (Ministry of Science, Technology and Innovation (MOSTI), 2019).

Box 1.14: Wawasan Kemakmuran Bersama 2030 (WKB2030)

WKB2030 is a commitment to make Malaysia a nation that achieves sustainable growth along with fair and equitable distribution, across income groups, ethnicities, regions, and supply chains. The commitment is aimed at strengthening political stability, enhancing the nation's prosperity, and ensuring that the *rakyat* are united whilst celebrating ethnic and cultural diversity as the foundation of the nation state.

The primary aim of WKB2030 is to provide a decent standard of living to all Malaysians by 2030.

Source: Ministry of Economic Affairs, Malaysia, 2019

Meanwhile, the SDG2030 has 17 sustainable development goals with the objective of ending all forms of poverty, fight inequalities and tackle climate change, while ensuring that no one is left behind (United Nations Development Programme, 2015). Accessibility to integrated data is one of the key tools which could help government plan and develop programmes to achieve these goals, while at the same time, data accessibility will empower the public to be more aware and involved in the decision-making process.

The recently released NSP 2021-2025 listed water as a national security item. The challenge for water sector institutions is now to provide a more consistent, detailed and granular assessment of water security status report in the country for the MKN. Achieving this objective will require precise water quantifying governance tools such as water accounting and water auditing reports. Furthermore, there are currently gaps in the water management spectrum that will have to be filled, such as water for the

Box 1.15: Sustainable Development Goals 2030 (SDG2030)

The SDGs, also known as the Global Goals, were adopted by the United Nations in 2015 as a universal call to action to end poverty, protect the planet, and ensure that by 2030 all people enjoy peace and prosperity

The 17 SDGs are integrated—they recognise that action in one area will affect outcomes in others, and that development must balance social, economic, and environmental sustainability. Ending poverty and other deprivations must go hand-in-hand with strategies that improve health and education, reduce inequality, and spur economic growth – all while tackling climate change and working to preserve our oceans and forests.

environment and biodiversity and water footprints and virtual water, which will have to be produced to present a more comprehensive national water security status report. These quantifying tools and reports require an integrated data platform that would be able to not just collect and compile data into one place, but also produce meaningful analysis of the status of the various water and water related sub-sectors.

Next, data integration also provide opportunity to support the MyDIGITAL initiatives. Many of the initiatives under MyDIGITAL, such as the digital transformation of the public sector, increasing public inclusivity in digital activities and improving cross border data transfer requires seamless data integration and data sharing (Economic Planning Unit, Prime Minister's Department, 2021). More importantly, many digital economy initiatives listed in the Blueprint, specifically under 'Thrust 2: Boost Economic Competitiveness through Digitalisation' also require a business-friendly data ecosystem using the FAIR principles.

Box 1.16: MyDIGITAL

MyDIGITAL is a national initiative to transform Malaysia into a digitally enabled and technology-driven high-income nation, and a regional lead in digital economy. MyDIGITAL is designed to complement national development policies such as RMKe-12 and WKB2030. It is formulated as the action plan to outline the efforts and initiatives which will be implemented up to 2030. The Blueprint charts the trajectory of the digital economy's contribution to the Malaysian economy and builds the foundation to drive digitalisation across Malaysia including bridging the digital divide.

Source: EPU, 2021

b. Meeting the Challenge of Water Demand Management

As the country progresses the demand for water gradually exceeds supply. Policy decisions on Water management is based on water and land data as applied in the NWRS 2012. Although seemingly outdated, this is still the current reference document for water policy and macro-management decisions. The results of the NWRS 2012 indicated that there are already severe deficits in available unregulated flows in several states **(Table 1.5)**.

The Study also indicated the deteriorating state of water quality and the environment (National Water Resources Vulnerability Index) in the country (**Figure 1.13**). All States in the Peninsular are already in the Moderately Vulnerable Category with four (4) States, Perlis, Pulau Pinang, Selangor and Melaka in the Vulnerable category. Only Sabah and Sarawak are in the Low Vulnerability Category but only just. As the country progresses further, the demand for water is projected to further increase and this will put further stress on the nation's water quality and the environment.

Table 1.5: Unregulated Flows in Malaysia by States
(RPM Engineers Sdn. Bhd.)

State	Land Area (sq.km)	Total Consumptive Water Demand (MCM)					Effective Rain (mm)	Effective Rain (MCM)	Excess/Deficit (MCM)-Unregulated Flows				
		2010	2020	2030	2040	2050			2010	2020	2030	2040	2050
Perlis	821	306	299	286	284	281	71	58	(248)	(241)	(228)	(226)	(224)
Kedah	9,500	2,922	2,976	2,842	2,873	2,876	113	1,074	(1,853)	(1,907)	(1,773)	(1,804)	(1,808)
P. Pinang	1,048	765	829	835	874	894	120	126	(639)	(703)	(710)	(748)	(768)
Perak	21,035	1,949	1,923	1,798	1,801	1,811	140	2,945	989	1,010	1,136	1,136	1,115
Selangor	8,396	2,238	2,491	2,570	2,760	2,922	114	957	(1,281)	(1,533)	(1,613)	(1,803)	(1,965)
N. Sembilan	6,686	340	361	358	366	374	74	495	154	134	134	127	120
Melaka	1,664	323	366	376	409	439	86	143	(181)	(224)	(234)	(267)	(297)
Johor	19,210	715	881	1,033	1,164	1,301	171	3,285	2,574	2,401	2,248	2,113	1,979
Pahang	36,137	726	946	897	911	959	165	5,963	5,240	5,023	5,059	5,059	5,023
Terengganu	13,035	884	975	970	999	1,026	254	3,311	2,425	2,333	2,333	2,307	2,281
Kelantan	15,099	1,632	1,619	1,586	1,600	1,604	176	2,657	1,012	1,027	1,072	1,057	1,042
Pen. Malaysia	**132,631**	**12,800**	**13,666**	**13,551**	**14,041**	**14,487**	**159**	**21,088**	**8,289**	**7,427**	**7,533**	**7,043**	**6,605**
Sabah	73,631	912	1,356	1,392	1,442	1,469	177	13,033	12,149	11,707	11,634	11,560	11,560
WP Labuan	91	18	24	26	28	29	323	29	11	5	3	2	0
Sarawak	124,450	1,054	2,162	2,125	2,175	2,247	221	27,503	26,383	25,263	25,263	25,263	25,139
East Malaysia	**198,172**	**1,985**	**3,541**	**3,542**	**3,645**	**3,745**	**269**	**53,308**	**51,327**	**49,741**	**49,741**	**49,543**	**49,543**
Total Malaysia	**330,803**	**14,785**	**17,207**	**17,093**	**17,686**	**18,232**	**255**	**84,355**	**59,545**	**57,229**	**57,229**	**56,898**	**56,237**

LEGEND

Unregulated Flow in Deficit

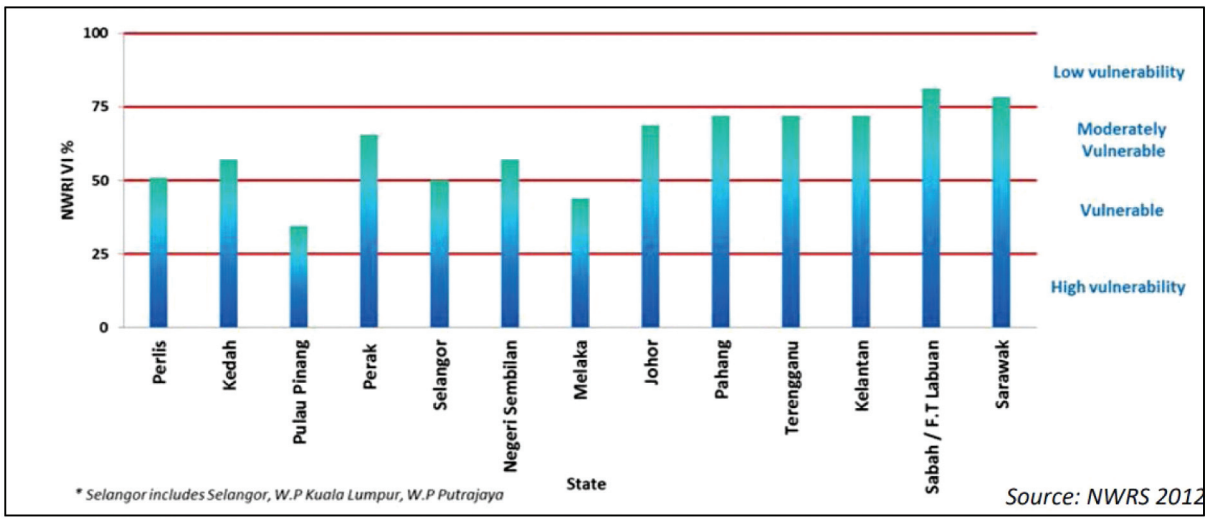


Figure 1.13: National Water Resources Vulnerability Index
(Academy of Sciences Malaysia, 2016)

Furthermore, as demand steadily increases, the inter-sector pressure to share resources also increases. Dams that used to be built for agriculture sector, such as Bukit Merah and dams in the MADA area, are now also serving domestic and industrial water supply needs. There are also now efforts to develop inter-state water transfer systems. The Pahang-Selangor water transfer system is already in place while the Perak-Pulau Pinang water transfer agreement is still being negotiated (Perbadanan Bekalan Air Pulau Pinang, 2019).

As water demand increases, finding the balance in WFE Nexus (**Figure 1.14**) will become more delicate and intense as storages may become inadequate and available water may not be enough to meet

demands of all sectors at any one time. Thus, negotiations will have to be made to reallocate water resources according to water security priorities and urgency.

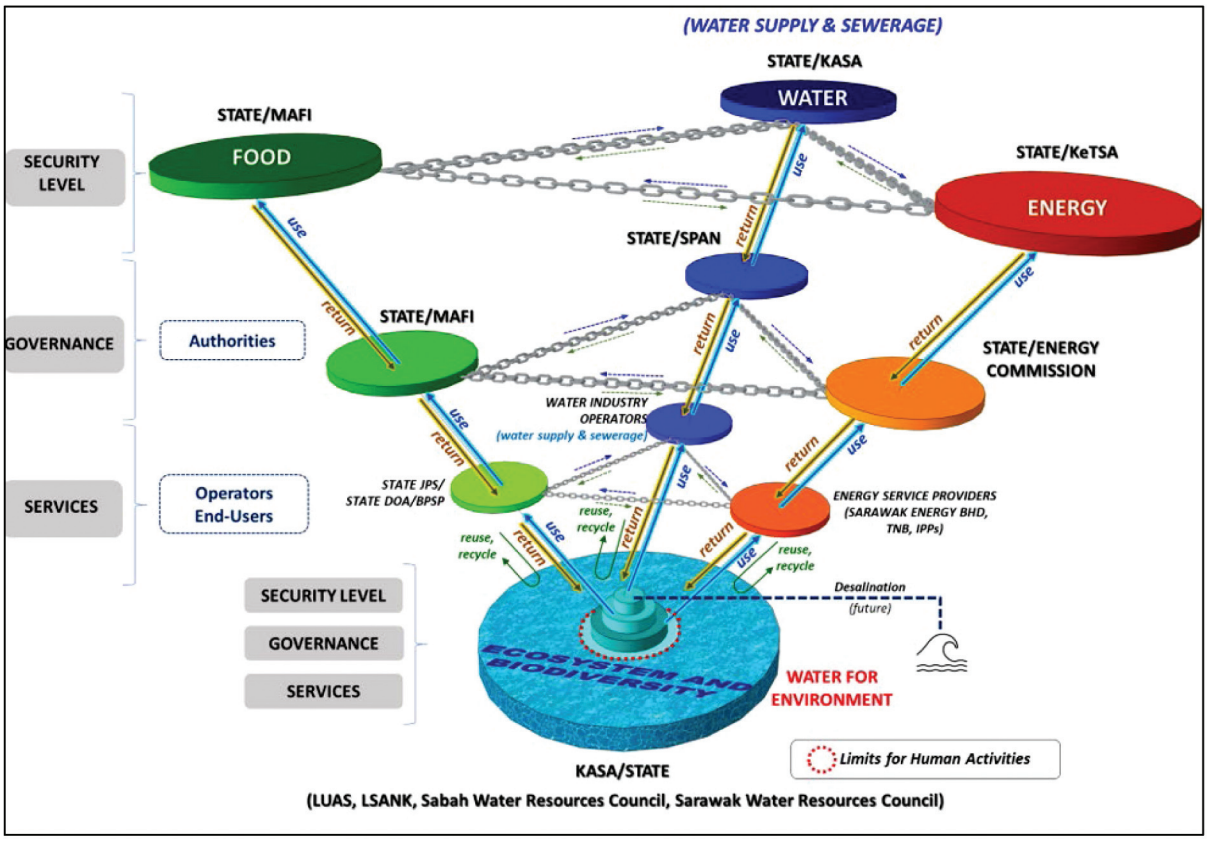


Figure 1.14: Water-Food-Energy Nexus with Respect to Water Resources
(RPM Engineers Sdn. Bhd.)

As the country transitions towards water demand management, the level of data complexity required will also increase (**Figure 1.15**).

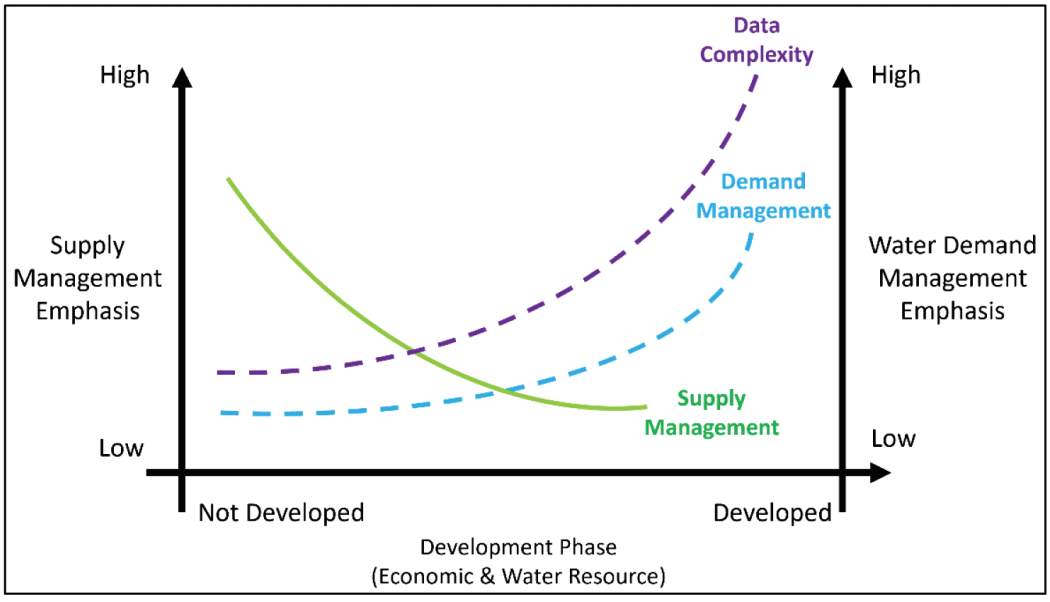


Figure 1.15: Water Demand Management and Data Complexity
(Academy of Sciences Malaysia, 2016)

All the water demand management scenarios described previously require a complex analysis, study, negotiations, and finally decision-making. These decisions could involve financial investments in infrastructure development and in non-infrastructure programmes. Each of these processes requires good, trusted data that is agreed upon as a basis by all negotiating parties. Furthermore, more precise and granular data is also required for complex WFE Nexus analysis in term of water resources prioritisation and allocation.

c. Climate Change, Extreme Events and Disaster Risk Management

The impact of climate change will challenge the current management of extreme weather patterns such as floods, droughts, and sea level rise. Malaysia's Third National Communication (TNC) projected that the average annual air temperature for the country may increase by 0.5^0C-1.0^0C during the period of 2030, and it may further rise to 0.9^0C-1.6^0C during the period of 2050. Central Sabah and the Northern Region of Peninsular Malaysia are projected to show the highest percentage of increments amongst the regions for 2030 and 2050, respectively (Ministry of Science, Technology, Environment and Climate Change, 2018).

As global temperature increases, more extreme weather events are expected to occur. The TNC reported that detailed studies to measure the climate change impacts on flood areal extent have been performed for 15 flood prone basins in Peninsular Malaysia. The results of this study show that 14 out of the 15 river basins are projected to experience increasing flood areal extents for 2030 and 2050 (**Figure 1.16**). The report also stated that the severity of flooding events is also projected to increase in the future.

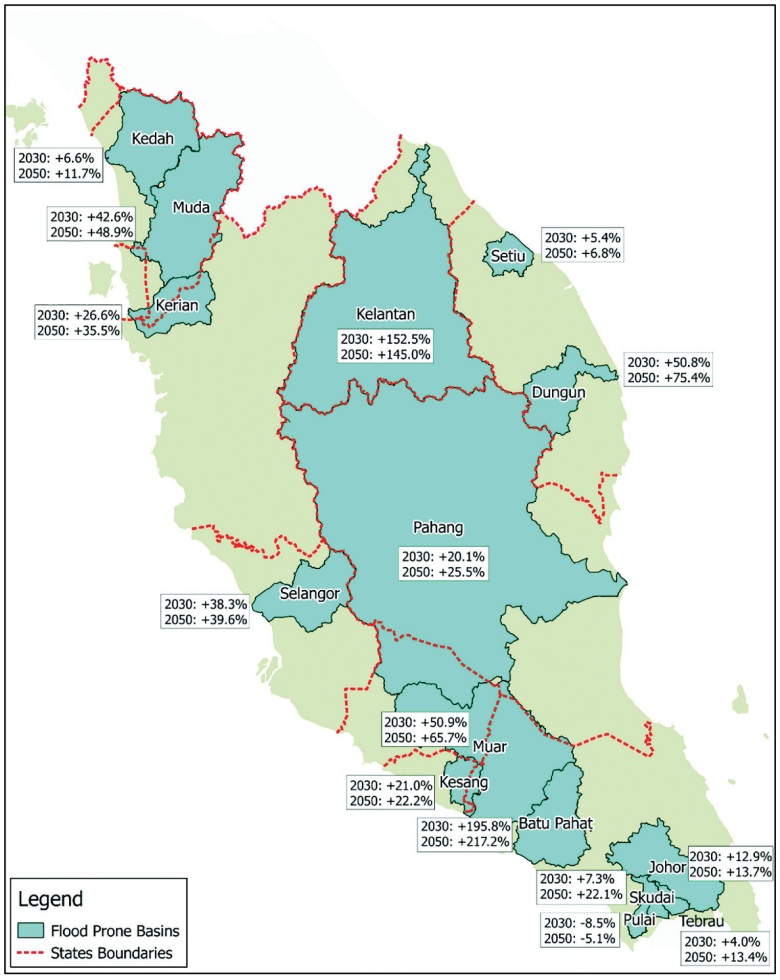


Figure 1.16: Projected Flood Areal Extent for 15 River Basins in Peninsular Malaysia (2030 and 2050) (Ministry of Science, Technology, Environment and Climate Change, 2018)

Malaysia is also projected to experience periods of dry spells in the future. The TNC reported that the most severe ones are projected to occur during the period of 2025-2035 in Peninsular Malaysia, while in Sabah and Sarawak, they are expected to occur within 2045-2055.

As for sea level rise, the West Coast of Peninsular Malaysia (inclusive of South Johor) is expected to experience a maximum sea level rise of 0.11m-0.21m for the period of 2050. The maximum sea level rise for Sabah is projected to be between 0.21m-0.62m for 2050 and Sarawak is projected to experience 0.15m-0.22m rise for the period of 2050.

The projected extreme events such as flooding and dry spells projected under climate change scenarios, as well as 'creeping impacts' from sea level rise are complex problems that require good data, advanced scientific analysis and technological applications to manage. The present sectorial approach to data management is no more acceptable to manage such complex problems such as climate change induced disaster risk management and a more integrated approach, including data management is required.

d. Water for Wealth Management

Malaysia is a water-rich country. Malaysia's total renewable water resource is 580 billion m^3 per year and the available renewable water resources per capita is 18,700 m^3 for a population of 31 million. When compared to Asia and the Pacific's average of 4,817 m^3/capita, this is abundant (Academy of Sciences Malaysia, 2018).

However, water sector is seen mostly as a supporting service for other sectors and there have been only limited efforts to utilise this water abundance into economic wealth. The transformation of water sector into a dynamic economic contributor requires an acceleration of IWRM approach. One of the key drivers behind this is the integration of data ecosystem, improvement of data quality and standards, and most importantly, high accessibility to reliable data for all users.

This transformation also requires an integrated platform for RDIC involving all stakeholders, including government and private sectors, as well as the public. This platform will be an inclusive and open ecosystem where RDIC spectrum related activities can be planned, developed, coordinated, collaborated, and executed to the full extent (i.e., until commercial success). This RDIC collaboration platform shall also be complemented by adoption of advanced technology, including space technology, as well as utilisation of IR4.0 technologies such as big data analytics, AI and blockchain.

e. Demand for Public Empowerment and Participation

Public participation and empowerment are an important component of national level water-related policy and Act, such as the NWRP 2012 (under Policy Directions for Core Area 3: Partnerships) (Ministry of Natural Resources and Environment Malaysia, 2012), and the WSIA 2006 (under Part V Chapter 1 Clause 69 and 70: Water Forum) (Suruhanjaya Perkhidmatan Air Negara (SPAN), 2006). The irrigation sector also has a public participation platform via the WUG. While public participation has long been advocated, it has yet to achieve widespread support and has not been systematically adopted.

An integrated data centre could be an important platform for empowering the public in IWRM. This could be accomplished by establishing a comprehensive database of water sector stakeholders which has been systematically documented and categorised. This database could be a basis for the establishment of a formal, national level stakeholders' participation platform that could elevate public involvement and contribution in the sector to a more meaningful level. This would also be helpful for the government in

delivering high-quality services for a more demanding, well informed, and affluent general public, in line with national and global aspirations.

1.3.2 The Need for an Integrated Water Sector Data Centre

An integrated water sector data centre is needed to meet the unique challenges presented above since these challenges require more precise and reliable data and information for decision making. Moreover, having a dedicated organisation will also provide few strategic advantages in terms of sustainability in achieving short-term and long-term objectives as well as in continuous career development.

a. Dedicated Pool of Talents

Water data management requires a very specialised sets of skills and knowledge. It also requires a long-term development and immersion, as well as high level of institutional maturity which provides high level of support services to water managers. Thus, a dedicated pool of talents must be developed and retained to develop specialised skills, sustain high service level, and develop industry-relevant solutions and innovations.

One example where long-term, specialised talent development has resulted in highly skilled and capable personnel is MADA. Being a Statutory Body has afforded MADA the ability to retain most of its officers throughout their career, and not worry about them being transferred to other agencies or departments. This ecosystem has also enabled MADA to train and develop these officers throughout their careers continually and systematically. As a result, MADA officers have specialised skills in various aspects of paddy production, including water data management. The telemetry system in MADA for example, has been consistently well operated, maintained, and improved upon throughout the years as MADA has retained the pool of dedicated and skilful staff who are familiar with the system.

b. Multi-disciplinary Talents and Cross-Functional Collaborations

Furthermore, an independent and statutorily recognised integrated water sector data centre will allow it to retain and develop multi-disciplinary talents. As opposed to traditional qualification and category-centric organisations, these diverse multi-disciplinary talents will give the centre more flexibility and alternatives in developing creative novel solutions, adding values, developing innovations, and fostering entrepreneurship collaborations. This is especially true in the age of globalisation, where most innovative solutions require cross-disciplinary and multi-agency partnerships and collaborations. The current Covid-19 pandemic for example, has shown an integrated, multi-agency public health approach, combined with an integrated data management platform as well as strong public participation, is the most effective way to contain the disease.

c. Developing Long-term Relationship and Confidence Building with Stakeholders

Having a dedicated organisation will also allow for the development of a long-term relationship between the organisation and its stakeholders. MADA is once again an excellent example of this relationship, where it has dedicated officers on the ground and interacting with the farmers to identify issues, solve problems and introduce new ideas and solutions. Over time, this long-term relationship builds mutual confidence, trust, and support between MADA and the farmers, which is crucial for sustainable development and investment. Similarly, having a dedicated integrated water sector data centre will also enable it to develop mutual trust and mutual benefits with its diverse stakeholders.

Chapter 2
IWSDC – The Concept

2.1 Establishing the Integrated Water Sector Data Centre (IWSDC)

The IWSDC is proposed as the first step in activating Strategy C1: Towards the establishment of an independent water data and information statutory body under Focus Area C – Enhancing the Data-driven Decision-making for Sustainability of Phase 1 of WST2040 (Ministry of Economic Affairs, 2019). The IWSDC will also accommodate the Water Research Collaboration platform as the initial facility towards the establishment of the Water Research Consortium as stated in Strategy C2 – Integrating research on water through the establishment of the Water Research Consortium. These strategies are affirmed under 12th MP, which lists the establishment of an integrated centre for water data and R&D&C&I by 2025 as one of the targets under Priority Area B: Transforming the Water Sector.

In developing the concept of IWSDC in terms of its roles and functions, the considerations include global visions and national visions and policies for sustainable growth and development. These include the SDG2030, WKB2030, MyDIGITAL, and the NSP 2021-2025. In addition to these are WST2040 aspirations for Malaysia to be recognised as an ASEAN Water Hub and producing internationally recognised local innovations and technologies.

2.2 The Concept

2.2.1 IWSDC as a Water and Land Data Integrator

IWSDC is to be established as a single-point, independent and dedicated reference centre for water and water-related data and information. It shall not duplicate the functions and services of existing Government Departments particularly with respect to water data and land data collection.

IWSDC plans to establish linkages with data providers including those with established and planned databases. These will bring massive advantage to IWSDC by enabling it to provide cohesive data related to water resources, water supply services, sewerage, agriculture (including rain-fed crops) as well as GIS related data. Thus, the IWSDC will be able to provide an integrated database which will cover the full spectrum of water sector, as well as data related to water such as land use, demographics and socioeconomics. This is proposed to be initially based on data sharing agreements or arrangements with the primary and secondary data providers whilst the data sharing policy and law are being developed.

The IWSDC will also collaborate with DOSM on the possibility of including water and water related data collection as an item in its proposed amendments of Statistics Act 1965. The IWSDC will also propose for it to be part of the MSDN and PADRN organisation set-up.

Consequently, an affirmative 'Data Sharing Policy' and the subsequent 'Data Sharing Law' such as the Freedom of Information Policy and Law, are to be established as the final step towards raising the standards of data sharing in this country on par with international standards and practices. At the same time data sharing disincentives and barriers should be reduced such as reviewing the Fees Act 1951 and the OSA 1972.

IWSDC will propose for the country to become a signatory to international open data alliances or partnerships such as the Open Data Charter or Open Government Partnership. Participation in an internationally recognised data sharing partnership is an effective way of improving the culture of data sharing in the country with a vision for higher levels of science and technology innovation capacity. In the long term, this partnership is also in line with the enactment of data sharing policy and law as proposed by this study.

Box 2.1: International Open Data Alliances and Partnerships

Open Data Charter

The International Open Data Charter was launched at the margins of the 2015 United Nations General Assembly following a global consultation led by key representatives from governments including the UK, Canada, and Mexico, and CSOs.

Over 150 governments and organisations are in collaboration to open up data based on a shared set of principles – to promote policies and practices that allow governments and CSOs to collect, share, and use well-governed data, to respond effectively and accountably to the following focus areas: anti-corruption, climate action and pay equity.

Source: Open Data Charter, n.d.

Open Government Partnership

The Open Government Partnership (OGP) was founded in 2011 based on the idea that an open government is more accessible, more responsive, and more accountable to citizens, and that improving the relationship between people and their government has long-term, exponential benefits for all.

OGP is a broad partnership involving members at the national and local level and thousands of CSOs who work together to co-create two-year action plans with concrete steps and commitments across an extensive range of issues.

78 countries and a growing number of local governments—representing more than two billion people— are members of OGP. All OGP governments sign on to the Open Government Declaration and are required to work with CSOs to co-create reforms as part of an action plan that can deliver real benefits to citizens. This unique model grants CSOs or direct citizen engagement a role in shaping and overseeing governments. Collectively, more than 4,000 commitments have been made globally.

Source: Open Government Partnership (OGP), 2021

IWSDC is essentially a water data integrator, digitally compiling and collating data, with all the security controls and data quality assurances, from all other data collectors; processing and storing them for access to all end-users.

With the vast amount of data collated it shall provide services that are cross-sectorial and independent in nature. It shall also undertake support services for additional elements to the present water management spectrum such as Water Security, Water Accounting and Water Auditing tools and system, Water-Food-Energy Nexus Management, Water Footprint, Virtual Water, Stakeholder Management, and Water and Climate Change Monitoring. These would subsequently lead to the timely preparation of selected strategic information and reports for decision-making.

IWSDC shall also provide a platform for Water Research Collaboration – encouraging and facilitating inter-Government, Public-Private Sector, including the Academia and their students, research collaboration as well as provide opportunities for Open Science for the public with a view to translate outcomes as of significant value for business development and commercialisation. This Water Research Collaboration platform is a precursor for the eventual establishment of a Water Research Consortium.

Box 2.2: Game Changers under the Five Focus Areas

Strategy Paper No. 16 presented a set of strategies and game changers under five Focus Areas, which are:

1. Focus Area A (People) - Empowering People to Drive Water Sector Transformation
   a) Strategy A1 – Institutionalising Public Participation and Communication (GAME CHANGER)
   b) Strategy A2 - Robust awareness, advocacy, and capacity-building (AACB) programmes targeting government agencies, industries, and general public on IWRM towards valuing water (GAME CHANGER)
2. Focus Area B (Governance) - Strengthening Governance of Water Sector at Federal and State Levels
   a) Strategy B2 - Establish the Water-Food-Energy Nexus Management Approach (GAME CHANGER)
3. Focus Area C (Information and RDIC) - Enhancing Data-Driven Decision-Making for Sustainability
   a) Strategy C1 - Towards establishment of an independent water data and information statutory body (GAME CHANGER)
   b) Strategy C2 - Integrating research on water through the establishment of the Water Research Consortium (GAME CHANGER)
4. Focus Area D (Finance) - Strengthening Financial Capability to Support Water Sector Transformation
   a) Strategy D1 - Strengthening financial sustainability of water services providers (GAME CHANGER)
5. Focus Area E (Infrastructure and Technology) - Developing Sustainable Water Infrastructure with Cost-Effective Technologies
   a) Strategy E8 - Incorporate smart technology to improve management of water infrastructure and its sustainability (GAME CHANGER)

Source: Ministry of Economic Affairs, 2019

Malaysia has recognised the importance of Open Science and has launched the Malaysia Open Science Platform (MOSP) Pilot Initiative on 7 November 2019 (MOSP, 2020). This initiative was implemented by ASM with five Research Universities in Malaysia to explore development of Open Science, especially in the areas of policy and guideline, capacity building and awareness, as well as infrastructure.

Box 2.3: ESA Monitoring Via Indigenous Knowledge and Crowdsourcing (Open Science)

Public participation can aid in the development of locally appropriate research questions and methods, for researchers that are intended to affect natural resource management or environmental policy-making decisions, particularly if the management or policy-making question requires understanding of how human behaviour interacts with ecological processes. Indigenous knowledge, such as harvesting or hunting practices in a given area, can help scientists understand human behaviours, local ecology, and threats to species, enabling them to formulate research questions and methods that can best help managers and other decision-makers.

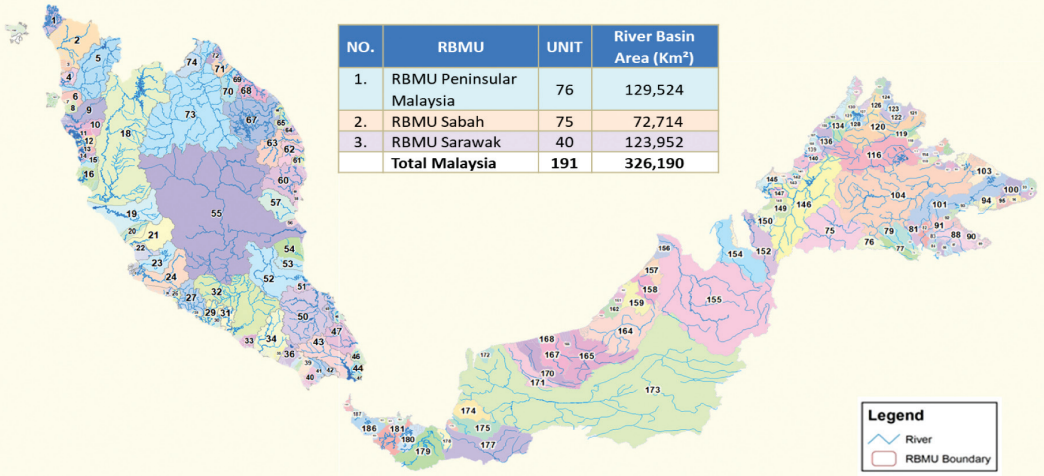
Source: McKinley et al., 2015

IWSDC by itself and as necessary, should undertake research and development projects such as water for the environment and water related software development. The vast amount of data could also be used for special projects using the latest applications of Big Data Analytics, Blockchain, Artificial Intelligence and Machine Learning.

Whilst many of the present water management services use "ground-based" technology applications, IWSDC shall also be developed to promote "Space as the New Frontier for Water Management" through applications of space sciences.

The establishment of IWSDC is planned to be in tandem with MYSA's high resolution (0.5m x 0.5m) satellite launching planned for 2025 along with the establishment of National Space Policy 2030 (**Figure 2.1)** and the *Lembaga Angkasa Malaysia* 2020 Bill. Preparations for capacity building for applications of remote sensing technology for water management shall be timed such that it will be ready to be fully activated when the Malaysian satellite is launched. Simultaneously, pilot projects in selected RBMUs should be activated. These should be seriously considered as Immediately Implementable Projects (IIPs) under 12th MP.

Box 2.4: River Basin Management Units (RBMUs) in Malaysia



NO.	RBMU	UNIT	River Basin Area (Km²)
1.	RBMU Peninsular Malaysia	76	129,524
2.	RBMU Sabah	75	72,714
3.	RBMU Sarawak	40	123,952
	Total Malaysia	**191**	**326,190**

Source: JPS Malaysia, 2021

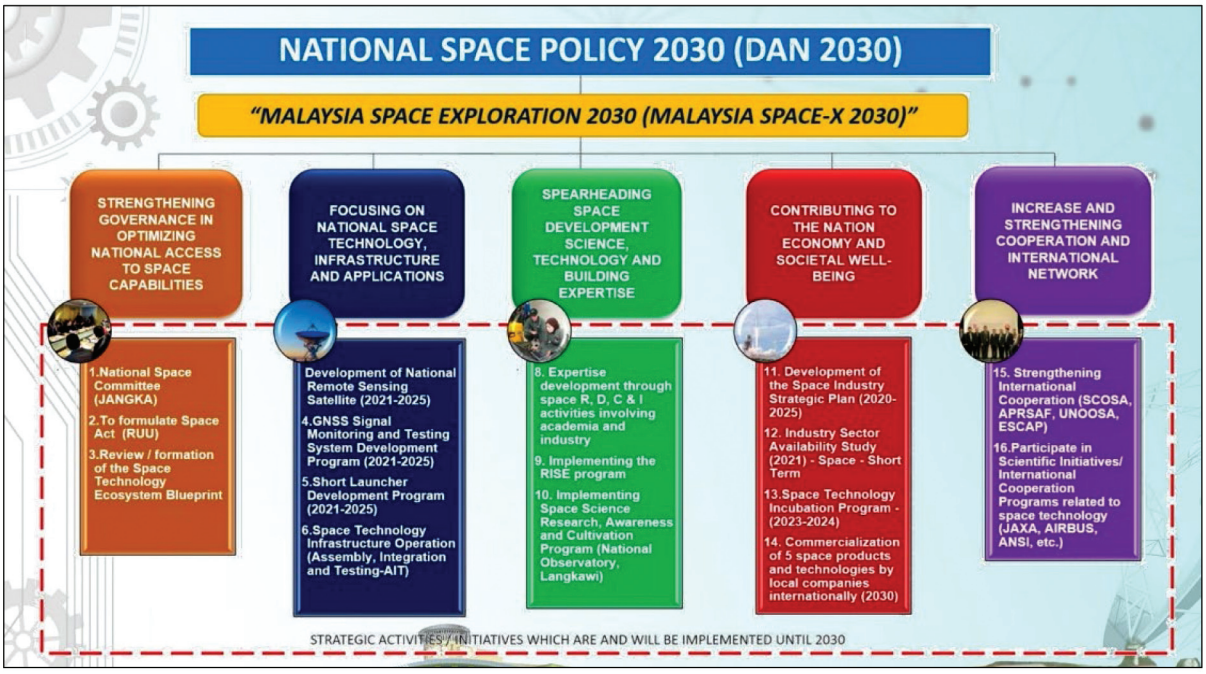


Figure 2.1: National Space Policy 2030
(Malaysian Space Agency, 2020)

In general, the concept of IWSDC is that it is a virtual platform functioning as a search engine for water data and information for all 191 RBMUs in the country, for water stress and for water for wealth management, facilitating Water Research Collaboration, encouraging applications of space sciences in water management and providing opportunities for significant public participation in water management and prospects for business development and attracting talents in high value jobs in a digital economy.

Equally important it shall also function as a source for improved designs and operations and maintenance for higher efficiency. An integrated data and information data source would also enable for the development of cross-sector integrated projects. It shall also be one of the central components in the development of a national and international water hub.

One excellent example is the Silicon Valley, which is world renowned as a hub for the IT industry. **Box 2.5** illustrates how socio-economic elements such as 'convergence of academia, businesspeople, private sector and government is vital to the success of Silicon Valley. Furthermore, cultural elements such as 'inspiration from past success stories' and 'level-headed approach to failure' are also very important resilience factors in Silicon Valley. Finally, from a business development and marketing point of view, Silicon Valley's preference for developing platforms over product innovation also plays a key role in the sustainable success of this renowned hub.

Box 2.5: Silicon Valley Industry Hub

Silicon Valley is a fertile ground for startups. There is so much opportunity and cash flowing through the area that entrepreneurs with the right skills, talents, and connections are confident that they will eventually strike it rich with the right business idea.

Six factors that make Silicon Valley an incredibly stable place to launch a tech startup or any type of business are summarised as:

1. **Convergence of Academia, the Private Sector, and Government**
   "…a steady stream of well-trained engineers, businesspeople, marketers, researchers; a vibrant venture capital community…"
2. **High Density of Wealthy Investors and Funding Institutions**
   "…access to investors…increased chance that startups will find financial support. Even when turned down…there are hundreds more waiting to listen."
3. **Access to Amenities**
   "…world-class hotels, large conference centres, sports teams and entertainment options…perfect test market for new products and services…"
4. **Inspiration from Past Success Stories**
   "Entrepreneurs are exposed to incredible war stories, case studies, and unique experiences of past successes…encourages the next generation to achieve something new…"
5. **Level-headed Approach to Failure**
   "The magic…is not (the) initial lightbulb moment but the commitment to assessing, refining, and reintroducing the systems that will make the thing work."
6. **Emphasis on Platform Over Product**
   "…a cultural mindset that prioritises platform development over product innovation…A product is very limited in what it can do, a platform's value is determined by the users that populate it…can easily be morphed into something else (in the future) …"

Source: Alton, 2018

It is in essence, a platform to "unlock the value of water data" that has long been virtually inaccessible to interested users.

The government has in its collection a treasure trove of data and information, which, if shared with the public, could unleash massive torrents of innovations and new enterprises. Furthermore, the experience of the IT industry has shown that building a platform creates a much more sustainable business model than just building a product or service. This has been proven in the success of 'platform giants' such as Google, Facebook and Amazon, amongst others. Similarly, IWSDC envisions itself to ultimately becoming such a platform for water management for all RBMUs in the country. This approach should be the catalyst for innovations and entrepreneurship which in line with the Phase 2 Theme of WST2040 (13th MP 2026-2030), namely, to develop world class indigenous technology.

2.2.2 Responding to Lessons learned from the Covid-19 Pandemic

The design of the IWSDC shall be based on the lessons learned from the Covid-19 experience that emphasised the need for timely exchange of good, reliable, trusted data and information for sound decision-making. The "Whole-of-Nation" approach that involves the collaborative efforts of the Government and society in water management. This is necessary not just for water crisis situations but for continuous management under all circumstances including for disaster risk reduction efforts, climate change mitigation and adaptation as well as for water for wealth.

2.2.3 The Game Changer

Transformation in the context of WST2040 is taken as increasing the rate of change or accelerating change to achieve the desired state of water management earlier than it would be at the current rate of change. To achieve this, the IWSDC has been designated as one of the Game Changers in WST2040.

Box 2.6: WSIA 2006

The most significant transformation in the Water Sector in recent years was through the promulgation of the Water Services Industry Act 2006 (Act 655) (WSIA) that became effective on 1 January 2008.

The WSIA was the game-changer – transforming the water services from the diverse approaches adopted by each State resulting in disparities in levels of investments and services between the States into one that recognises that water service is an industry, unified through a harmonised legislation, with a more sustainable investment structure, uniform organisational practices and standards, a firm commitment to levels of service and governance as well as providing platforms for public participation.

Achieving this required the full cooperation of the States with the Federal Government and involved changing the Constitution.

Source: SPAN, 2010 and Leow, 2014

As a Game Changer, IWSDC will need to be the catalyst to intensify and converge the focus, direction, and dynamics of data management by the many water players that would excite all other stakeholders and attract them to actively participate in water management as well as benefit from the opportunities provided by the Sector.

Thus, the structure of IWSDC is also designed such that the data and information sharing is systematically organised to be made available beyond sectorial boundaries. This by itself is a strategy to accelerate IWRM through data and information integration. With this, all Federal-State, State-State, Inter-Sector, public participation and decision-making shall be based on a common set of mutually agreed data and information.

2.2.4 Water Research Collaboration Platform

The water sector RDIC is guided by the 10-10 MySTIE Framework, which is part of the NSTIP 2030. The framework lays out a detailed plan to turn Malaysia into a knowledge-intensive economy. Its goal is to increase Malaysia's position in the global innovation value chain by generating shared economic success throughout the country's different ecosystems.

This Framework will make it possible for important economic sectors to become more knowledge-intensive and innovative. This will improve Malaysian industries' competitiveness and long-term viability. (Academy of Sciences Malaysia, 2021). 'Water and food' are listed as one of the key socio-economic drivers under the Framework and the science and technology drivers include areas such as advanced intelligence systems, augmented analytics, and data discovery, as well as blockchain.

The main function of this Water Research Collaboration Platform is to strengthen the linkages between Government and the Private Sector in RDIC. In many aspects, the Government will need to initiate and take the lead in research and development requiring huge capital and human resources investments. The Government will also have to take responsibility in activities that are routine but continuous and with national coverage that is necessary and important as building blocks for research and applications. Water data collection is one of these.

The RDIC linkages could only be strengthened with open data and information sharing all through the links and supported by a system or programmes that facilitates collaboration, especially for high-technological innovations and commercialisation. **Figure 2.2** illustrates some of the collaboration linkages.

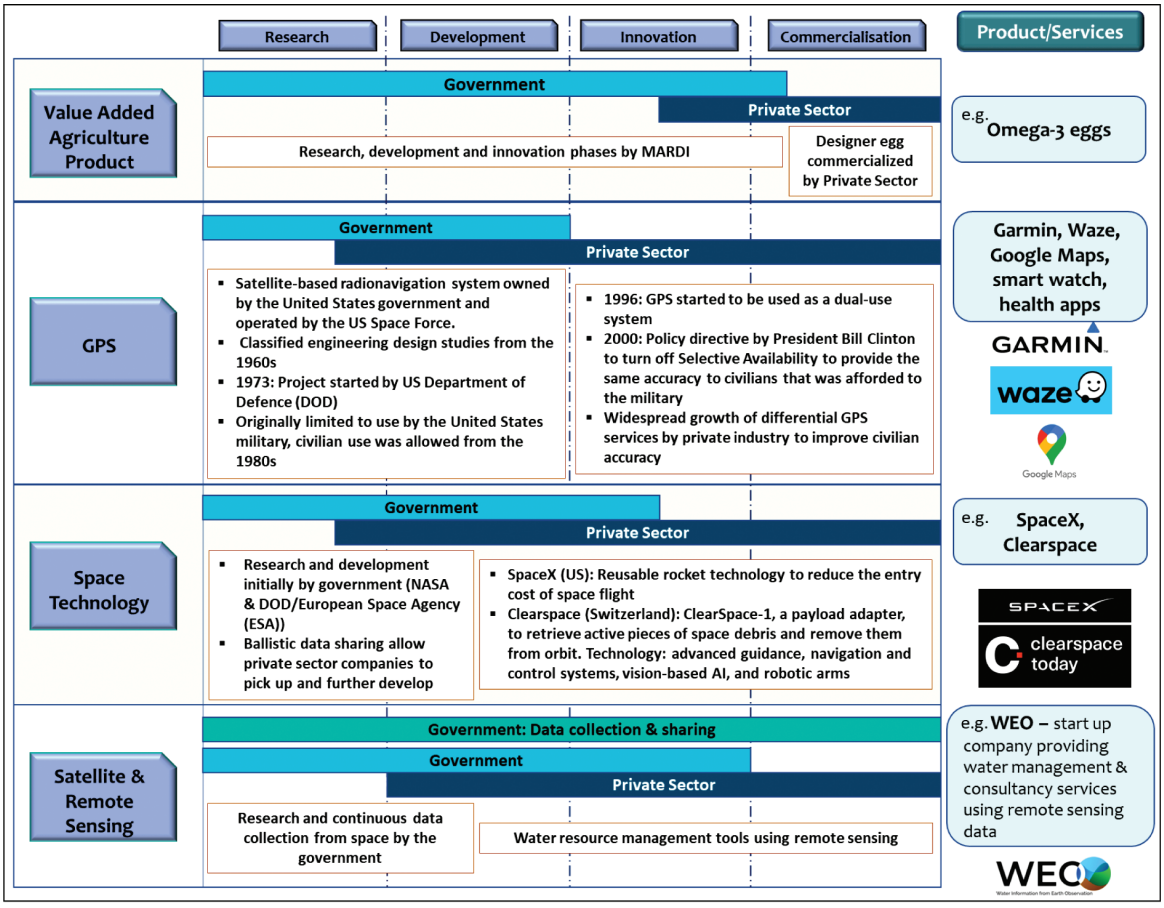


Figure 2.2: Examples of Full-scale Implementation of RDIC

One good example of a complete chain of RDIC is the development of premium chicken eggs (Omega Egg) by MARDI. Here MARDI conducted the Research and Development efforts until the technology was ready to be commercialised. Then, MARDI Corporation, which is a 100% MARDI owned company, licensed the technology to private sector for further innovation and commercialisation.

On higher levels of technology RDIC, the opening of the GPS facility by the US Government from a strictly military application to the public, spurred a series of world class private sector innovations such as Waze, Garmin, Google Maps, and many more. The sharing of space research and development data by Governments to the private sector has now allowed for private sector participation in space business such as space tourism (SpaceX), space entertainment, space debris cleaning and satellite launching.

The RDIC initiatives are not just for the large corporations or requiring large investors. The WEO for example, is a relatively small start-up company that is allowed free access to remote sensing data from the European Space Agency. This company then develops analytical techniques to provide water resources consultancy services.

Another model for encouraging private sector or even individuals to participate in the RDIC linkages is via hackathon competitions where participants submit proposals by using data made available through IWSDC. The winning proposals would then be eligible for funding through Government programmes such as that by MOSTI or private investors.

Box 2.7: Water Data and Information Hackathon

In 2017, Durham University, Durham County Council, the Environment Agency and Northumbrian Water initiated a collaborative project called "The Water Hub" to facilitate partnerships for innovative developments with practical solutions between small and medium-sized enterprises, research institutions, government agencies and universities.

The Water Hub hosted "The Hackathon", a competition by the Environment Agency to improve how environmental information can be better shared and communicated to enable local action and people participation.

Source: Durham University, 2017

The competition produced two joint winners: Jumping Rivers and Tracerco Flare.

1. Jumping Rivers pitched a modular development of the Environment Agency's Catchment Data Explorer tool to increase usability and improve engagement.
2. Tracerco Flare developed a wire frame for a mobile app that showcases environmental projects and incentivises action: Water Heroes - driving improvements in your local environment.

Source: The Water Hub, 2018

Box 2.8 describes the potential of a water hub. The potentials include development of applications (Apps), advanced hydraulic and hydrological models, environmental management models, space science applications and Open Science participation.

The proposed areas of focus under the Proposed National Water Innovation Roadmap (NWIR) could be encouraged by applying similar approach as shown in **Figure 2.3**.

This NWIR 2040 by KASA and its implementation by NAHRIM was approved by the High-Tech Nation Council and National Science Council. This Roadmap is one of the main references for water RDIC activities in the country for the next 20 years. The roadmap encompasses five main programme areas namely:

Box 2.8: What is a Water Hub?

A Water Hub is a centre for the coming together of new opportunities for businesses, communities, and end users to join with government organisations and research institutes.

A Water Hub should be designed to encourage the amalgamation of expertise to shape new opportunities, grow ideas, test products and deliver solutions to grow business opportunities and deliver sustainable solutions to societal challenges.

A Water Hub must eventually ensure that the activities being partaken benefit the people, the environment and the community. The values of a Water Hub should incorporate:

a) Sustainable living – social, economic, and environmental
b) Placed based innovation – facilities for businesses and researchers
c) Open and inclusive collaboration – businesses, researchers, and government bodies to benefit the people and communities
d) Integrated networks for practice – broad network of collaborators and partners to deliver impact
e) Social learning and capacity building – community engagements for user-centred design

Source: The Water Hub, 2017

a. Clean River
b. Reserve Margin
c. Smart Water
d. Disaster Risk Reduction
e. Water Financing

It is estimated that RM11.2 billion in Government funds can be saved through water efficiency and disaster reduction and RM6.4 billion in economy can be generated, involving eco-health tourism, sewerage treatment operations, water supply operators and efficient water treatment technology. It is also expected that 630,000 job opportunities can be created covering the scope of business, development, and operations in the fields of applications, software, water technology, finance, and other careers (National Water Research Institute of Malaysia (NAHRIM)). An initial cost of RM100 million is required over the period 2021 to 2040 from the Government and the private sector or industry for this proposed roadmap to be materialised.

2.2.5 The Outcomes of IWSDC and Water Research Collaboration under 12th MP

The general outcomes of the IWSDC in Phase 1 of the transformation plan are summarised in **Figure 2.4**.

For the objectives, the IWSDC would be able to support rapid exchange of data and information and produce strategic reports and support decision-making towards increasing the confidence level of the public on water security. The data and information would also be tuned not just for normal operations and for stress situations but for managing the wealth of water for the wealth of the nation.

Supporting the driver, high levels of data and information accessibility will empower people and encourage meaningful participation in water management. This can be accomplished by providing a formal stakeholder engagement platform. A more affirmative strategy for public participation would be to institutionalise stakeholder linkages to the National Water Council (MAN) and the respective State Water authorities as shown in **Figure 2.5**.

As enablers, the IWSDC shall develop quantitative tools for governance in the form of water accounting and water auditing system. In addition, IWSDC shall drive for the introduction of related data and information sharing policies and laws.

PROGRAM	ACTIVITY	METHOD/OUTCOME/OUTPUT	2021	2022	2023	2024	2025	2026	2030	2040
Clean River (CR)	▪ Odour Threshold & Sensor for Pollution Control	TON								
		Monitoring Sensor								
	▪ Apps & Portal for National River Trail (DSK)	River Tourism								
	▪ River Eyes	Enforcement & Monitoring								
	▪ Water Quality Enhancement	Odour & Quality Treatment								
		Eco-friendly (Flocculants & Filtration)								
		In-situ/Greywater Treatment								
	▪ Established Method/Threshold for Water Borne Disease (WBD) including pandemic - Emerging Pollutants	Detection Methods/Devices (AMR, EDC, Microplastic, etc)								
		Threshold								
Reserve Margin (RM)	▪ TAPS (raw water)	Multipurpose								
	▪ Coastal Reservoir (raw water)	Multipurpose								
	▪ UGD (treated water)	Artificial Recharge								
	▪ Penuaian Air Hujan (PAH)	Self-potable Water								
		Non-potable (General use)								
	▪ Reclaimed Water	Constructed Wetlands (General Use)								
		Advanced Filtration (Industrial Use)								
	▪ National Water Grid	Decentralisation								
Smart Water (SW)	▪ Local SME Entrepreneurship	Water Saving Devices								
	▪ Renewable Energy	Turbine Technology (Pipe, River & Coastal Tide)								
Disaster Risk Reduction (DRR)	▪ IR4.0	Integrated Early Warning System								
	▪ River & Coastal Integrated System	Water/Sediment Equilibrium								
	▪ Flood Control	Underground Bypass/Storage								
		MSMA/SABO								
Water Financing (WF)	▪ PAAB Diversification	Water Bank								
		Wakaf Sukuk								

Figure 2.3: Proposed National Innovation Roadmap 2040
(National Water Research Institute of Malaysia (NAHRIM))

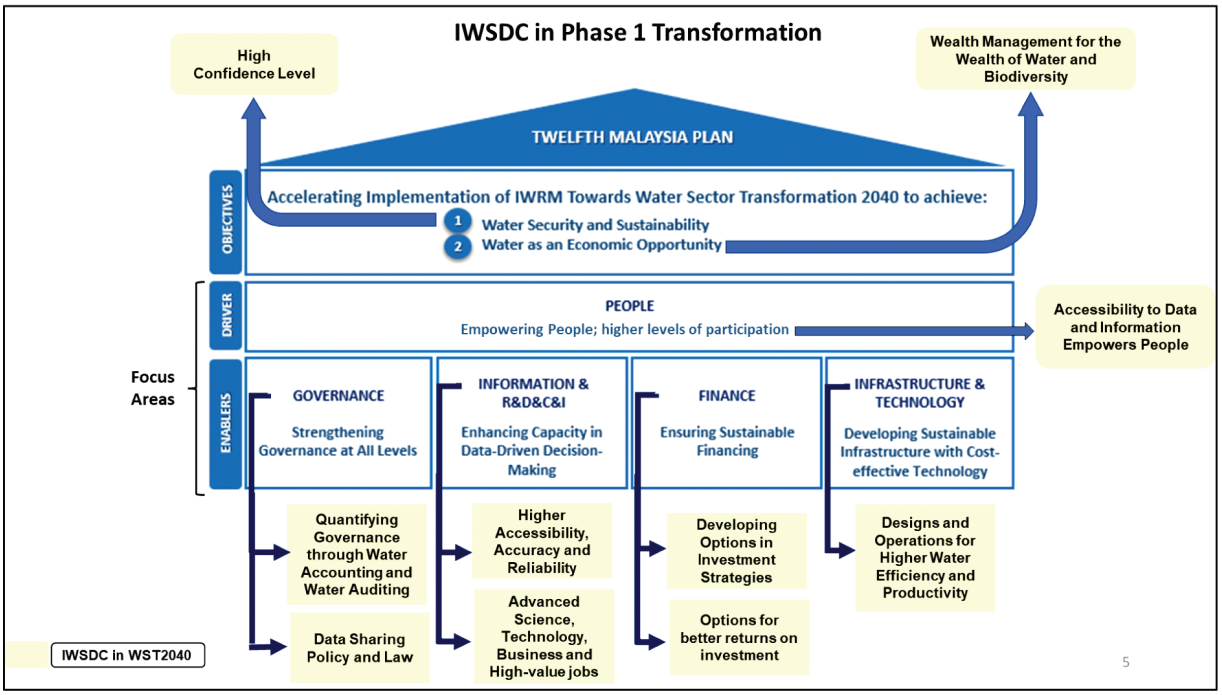


Figure 2.4: WST2040 12th MP Framework

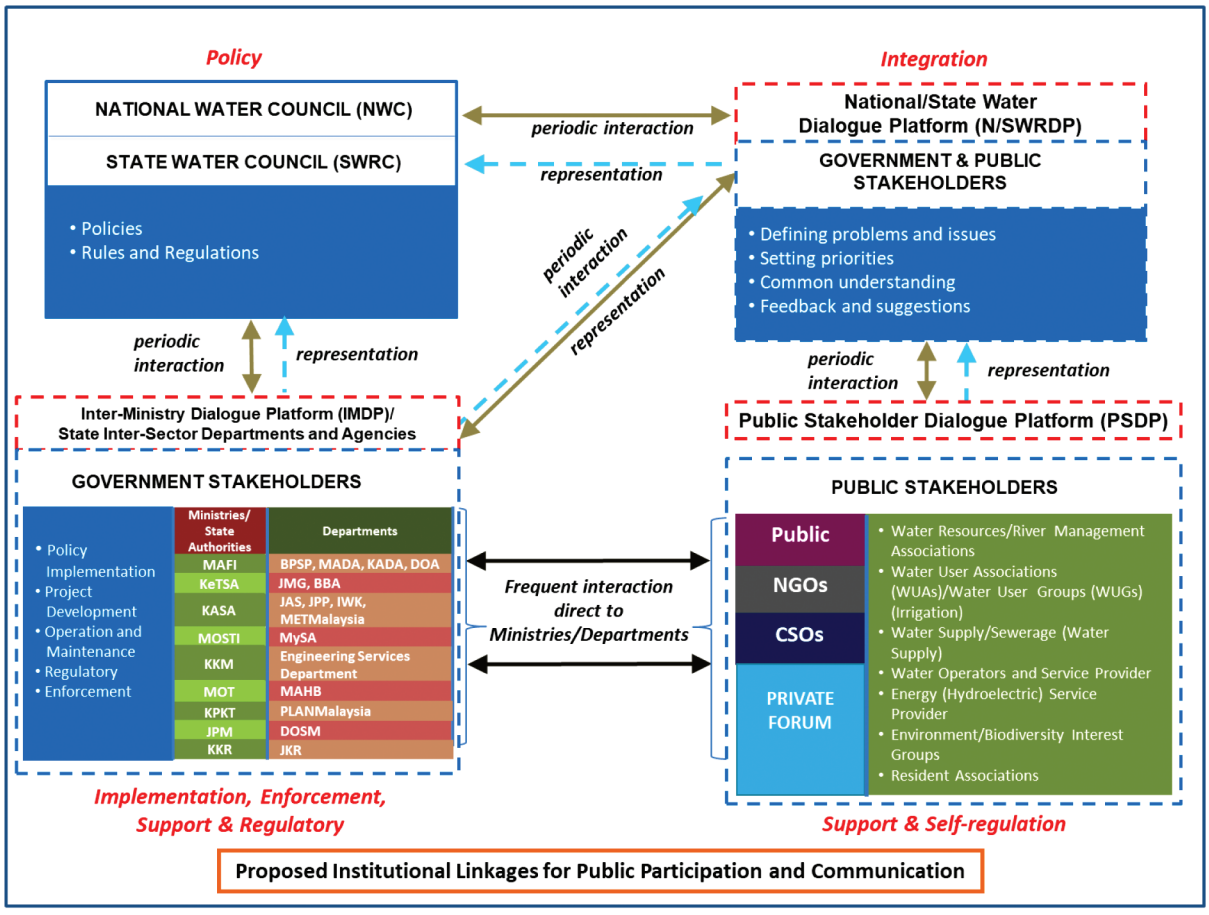


Figure 2.5: Linkages for Public Participation and Communication (Academy of Sciences Malaysia, 2018)

Apart from enhancing capacity in data-driven decision-making, the IWSDC will provide the Water Research Collaboration platform to strengthen the RDIC linkages and facilitate public-private collaboration with opportunities for innovations and new businesses.

IWSDC will provide continuous good, reliable, trusted data for sustainable financing with the ability to develop better project evaluation analysis, towards higher returns on investments and varied options for integrated water projects not only within the sector, but also beyond the sector, such as water and tourism, water and environment, and water and energy.

Similarly, IWSDC will play an active role to support more water efficient designs and operations and maintenance for existing and future infrastructure particularly with applications of space technologies.

Chapter 3
IWSDC – The Structure

3.1 IWSDC Overall Framework

IWSDC overall framework structure comprises the following as shown in **Figure 3.1.**

a. Input
b. Systems Architecture
c. Output and Services
d. Support
e. Enablers

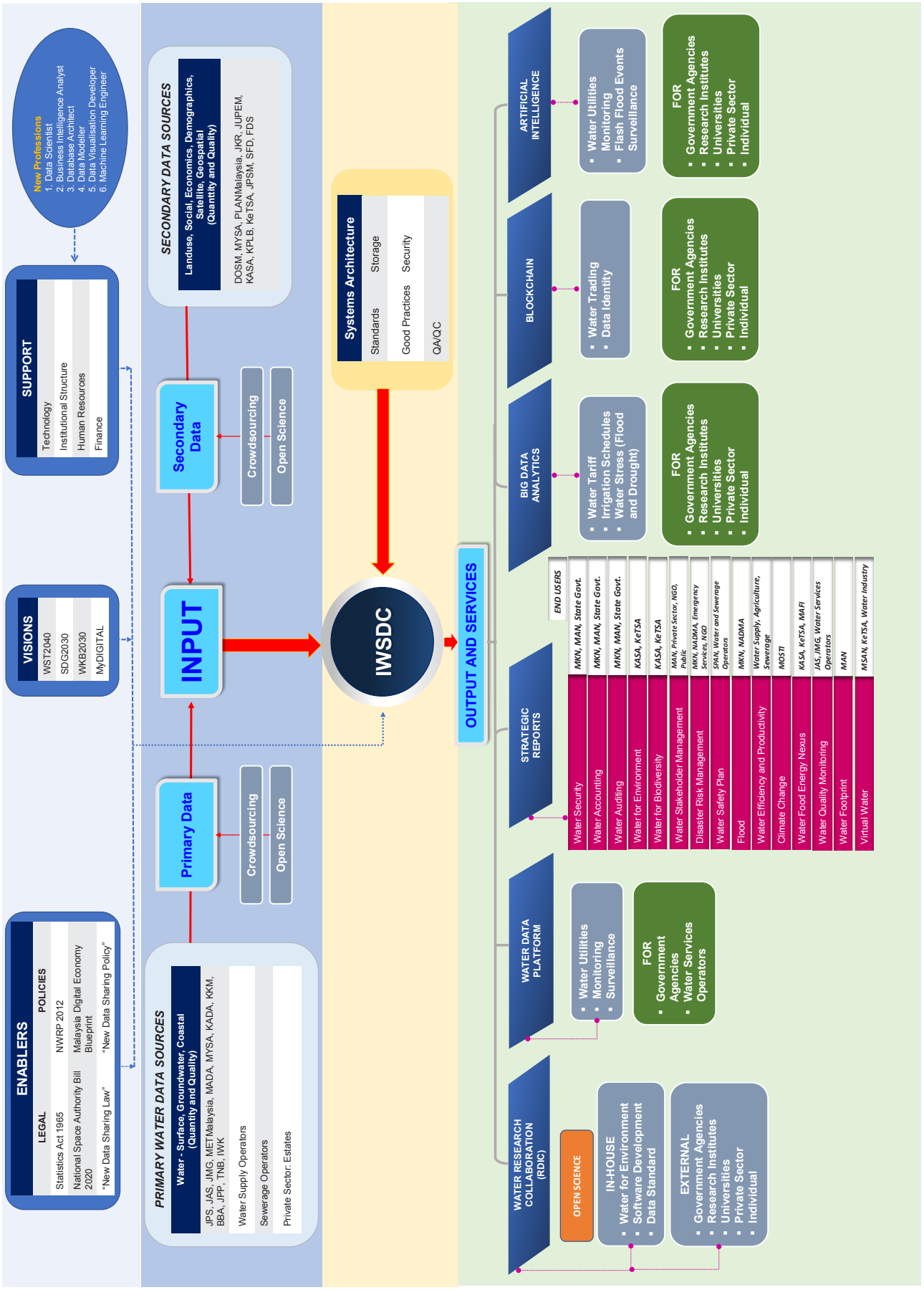


Figure 3.1: IWSDC Overall Framework

3.2 Input – Primary and Secondary

The input comprises primary and secondary data necessary to support water management as shown in **Figure 3.2**. Primary data inputs are common water data for use by water managers, the industry, and the public. Secondary data inputs are those needed to complement the primary water data in decision-making such as policy development and disaster risk management. The IWSDC input will also be complemented by crowdsourcing, indigenous knowledge, and other aspects of Open Science concept.

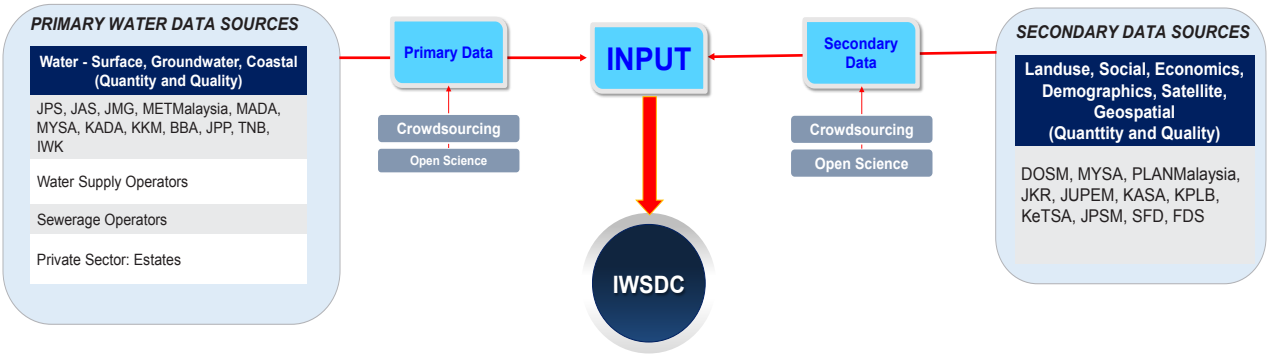


Figure 3.2: IWSDC Input

3.2.1 Current Organisational Structure and Water Sector Inventory

Systematic collection of water data is conducted by various government agencies, the main agency being JPS. Other main collectors and custodians of water and water related data would be METMalaysia, DOE, JMG, MOH, and BBA.

JPS's main function is to investigate drainage, floods, irrigation, water resources, rivers, river estuaries and the coastlines, and as such, JPS has, through the years, developed a network of hydrological stations (as shown in **Figure 1.3**) distributed all over the country to collect time series of water levels in rivers, point rainfall and evaporation and coastal data. Besides these, at the water level stations, JPS conducts regular river discharge gauging and at some of the water level stations, suspended sediment and water quality samplings. As for coastal data, the Coastal Engineering Division of JPS started a shore-based data collection programme, Littoral Environment Observation (LEO) of incident wave height, period and direction, current speed and direction and to record beach profiles changes over time (Department of Irrigation and Drainage, n.d.).

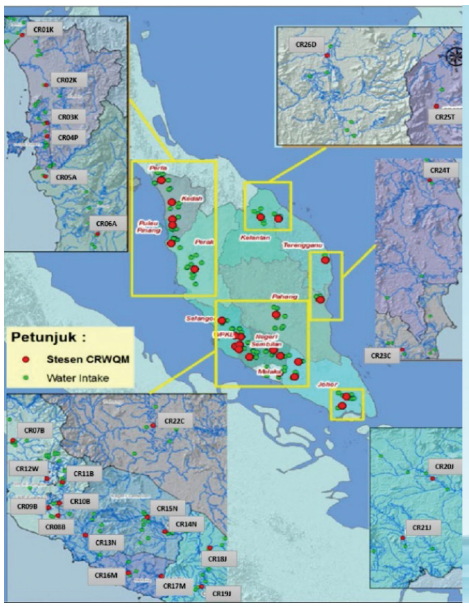
METMalaysia's primary function covers monitoring of weather, climate and the atmosphere and as such it collects rainfall, evaporation, wind speed and direction and other weather data. However, most of its stations are at the airports since besides weather forecasting, METMalaysia is focussed on weather and atmospheric conditions affecting flights. Due to the importance of maintaining flight safety, METMalaysia is also equipped with radar stations for detecting rainfall. Hence, the use of radar to complement point rainfall data collected by rainfall stations to get a more accurate assessment of rainfall over an area (Jabatan Meteorologi Malaysia, n.d.). **Figure 3.3** shows the main meteorological stations owned by METMalaysia. Currently, the department has 42 main meteorological stations throughout the country.

DOE conducts water quality samplings at many designated locations in rivers all over the country and at water intakes to monitor the state of the river water quality expressed in the form of water quality classes. DOE also monitors groundwater quality in many wells in the country (Department of Environment, n.d.). *Alam*



Figure 3.3: Main Meteorological Stations by METMalaysia
(Jabatan Meteorologi Malaysia, 2021)

Sekitar Malaysia Sdn. Bhd. (ASMA), a company that used to collect water quality data on behalf of DOE is still actively collecting data. **Figure 3.4** shows the monitoring stations across the country by DOE which consist of air monitoring stations, river monitoring stations, and marine monitoring stations.



TABURAN STESEN PENGAWASAN DI SELURUH MALAYSIA

	UDARA			SUNGAI		MARIN	
	Auto	Manual	Mobile	Auto	Manual	Auto	Manual
Jumlah	**65**	**14**	**3**	**30**	**1353**	**10**	**388**
Johor	8	3		4	227	2	63
Kedah	4	1		3	73	1	26
Kelantan	2	1		1	83		14
Kuala Lumpur	2	3		1	25		
Melaka	3	1		2	55	1	23
Negeri Sembilan	3	1		3	65	1	17
Pahang	5	2		2	192		36
Perak	5	1		2	149	1	19
Perlis	1				15		3
Pulau Pinang	4	1		1	67		33
Sabah	5		1	2	118	1	43
Sarawak	12		1	2	117	1	40
Selangor	5		1	5	98		19
Terengganu	4			2	69	1	40
Putrajaya	1						
Labuan	1					1	12

Figure 3.4: Monitoring Stations by DOE
(Department of Environment, 2021)

Pakar Scieno TW Sdn. Bhd. is another company specialising in water quality monitoring and was awarded in 2016 a 15-year contract to develop, establish and implement the National Environmental Quality Monitoring Programme (NEQMP) in Malaysia.

JMG is the department that conducts groundwater mapping and valuation, in addition to monitoring of quality, quantity, environmental impact and development related to agriculture, industry, mining and climate change (Department of Mineral and Geoscience Malaysia, n.d.). Currently, JMG has mapped a total of 4,758 tube wells across the country which is shown in **Figure 3.5**.

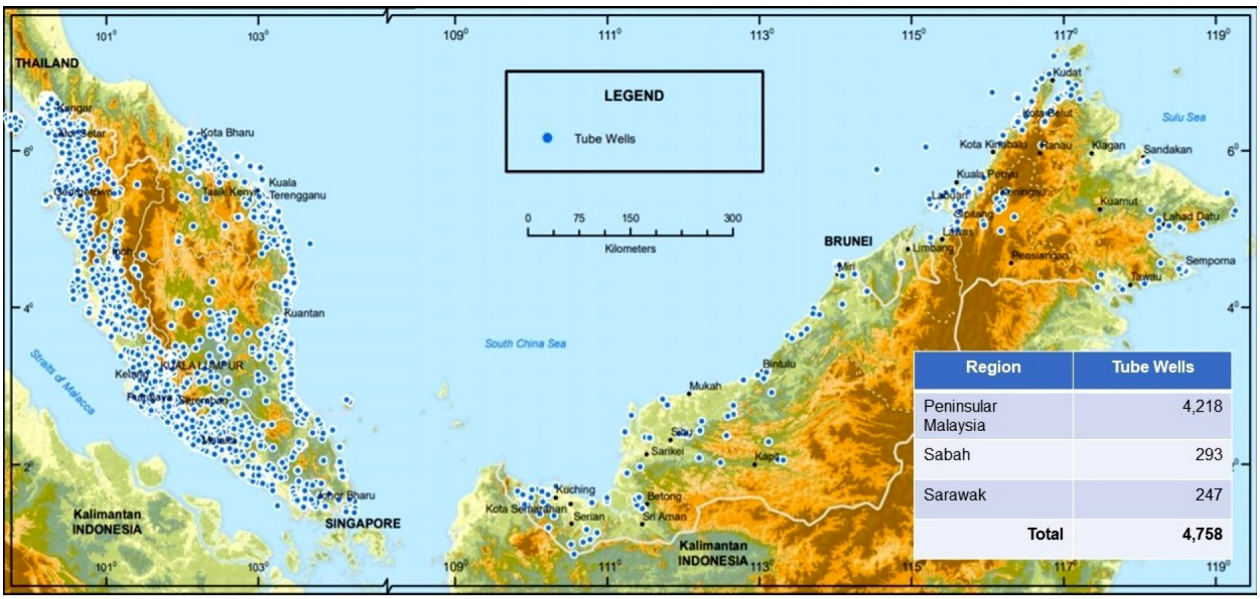


Figure 3.5: Tube Wells Mapping Location
(Jabatan Mineral dan Geosains (JMG), 2021)

Agencies dealing with agriculture such as BPSP, Agricultural Authorities such as MADA, KADA and the IADA offices also collect water data, especially rainfall, evaporation and water levels. The network of rainfall and water level stations maintained by MADA (as shown in **Box 1.4**) for their irrigation scheme areas is very comprehensive covering the levels of their water supply dams (Muda and Pedu Dams), water levels in their barrages (MADA Barrage and Pelubang Barrage), irrigation canals, pumping records, settings of their water control gates and so on (Ministry of Agriculture and Food Industries, n.d.). DOA collects data including geospatial data on land use, soil, agroclimatic, and rainfall area mapping. Under land resources, DOA conducts ground investigations on soil types and soil porosities beneficial for identifying water use for planting. DOA produces secondary data such as land use data through remote sensing from MYSA satellite imagery and water map using data from METMalaysia. **Figure 3.6** shows the Agricultural Water Resource Systems maintained by DOA.

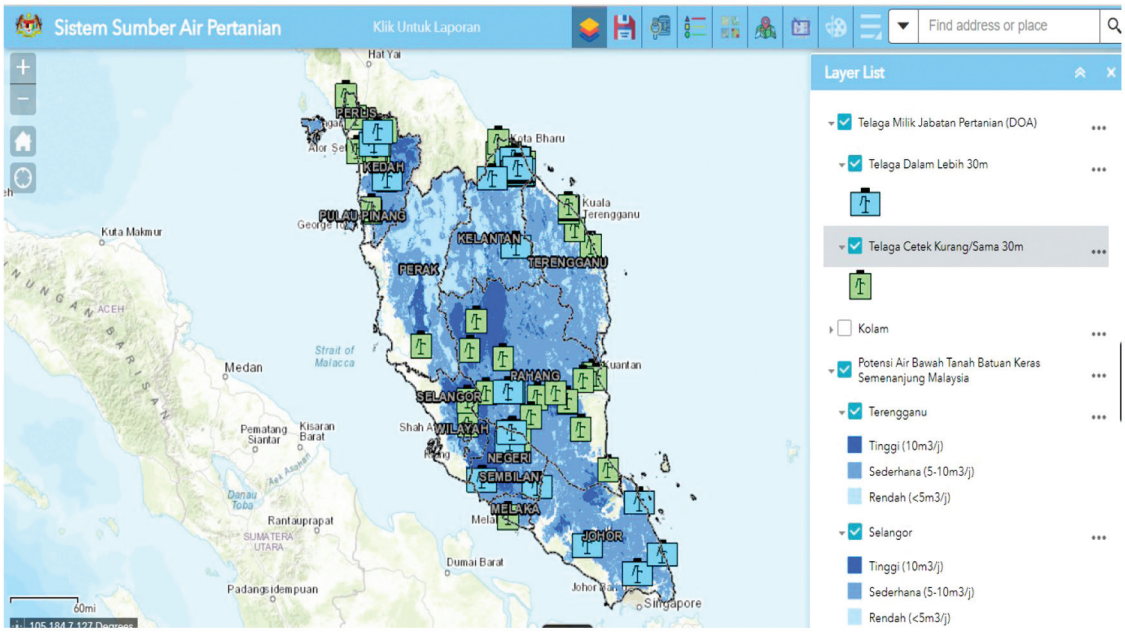


Figure 3.6: Agricultural Water Resource Systems by DOA
(Department of Agriculture, 2021)

Water regulating bodies such as Lembaga Urus Air Selangor (LUAS), *Lembaga Sumber Air Negeri Kedah* (LSANK) and water operators such as *Syarikat Air Negeri Sembilan* (SAINS), and *Pengurusan Air Selangor Sdn. Bhd.* (AiS) are also interested parties in water availability and water quality and as such they also collect water data, primarily water quality data. For example, the assets managed by AiS is sizeable, comprising 7 dams, 1 off-river storage (ORS), 29 water treatment plants (WTP), more than 600 pump houses and more than 1500 service and balancing reservoirs, including 30,000 km of pipelines. They monitor their status in terms of dam and ORS levels, releases, bursts and leakages in their pipelines, water quality at their WTP intakes and also operate 3 water quality laboratories.

Other agencies or bodies that collect water data would include TNB and its research arm, TNB Research Sdn. Bhd. (TNBR) which collects data such as the turbine releases of their hydropower system, dam releases for environmental flow, rainfall, flood flows, and dam levels for their dam inflow monitoring and forecasting system (Tenaga Nasional Berhad, 2021). **Figure 3.7** shows the hydrology stations maintained by TNB in peninsular Malaysia located in Perak, Pahang, Terengganu and Kelantan. Currently, TNB has a total of 121 hydrology stations.

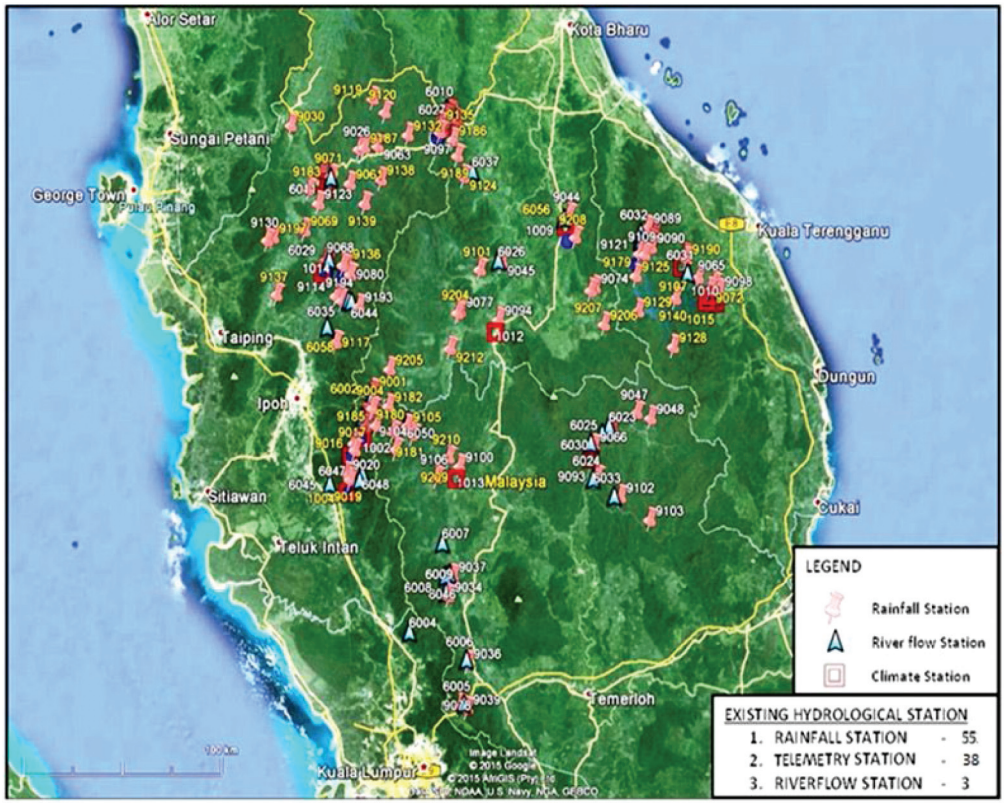


Figure 3.7: TNB Hydrological Stations in Perak, Pahang, Terengganu and Kelantan (Tenaga Nasional Berhad, 2021)

IWK and JPP sample and test effluent water quality of their sewage treatment plants for compliance. NAHRIM is actively involved in water research studies and is the main agency in the country involved in climate change studies and as such NAHRIM maintains a database of projected rainfalls, temperature and evaporation for various climate change scenarios and associated data such as climate change factors and water stress indices (NAHRIM, 2020).

The collection of tidal information is led by JUPEM, *Jabatan Laut Malaysia* (JLM) and *Pusat Hidrografi Nasional* (PHN). All three agencies publish annual tide data and tide projections. JLM's and PHN's interest is

more on navigation while JUPEM's interest is to monitor sea level. JUPEM also sets the tidal level and mean sea level with respect to Land Survey Datum (LSD). Levels of the tides form the lower boundary levels for any flood analyses (Jabatan Ukur dan Pemetaan Malaysia, n.d.).

Topography, land use, river alignments, locations of rainfall stations and areal distribution of rainfall which influenced flow in a catchment are spatial data collected, maintained, and used by various agencies with the main agency being JUPEM. The other government agency active in collecting and maintaining spatial data is PLANMalaysia (PLANMalaysia, n.d.). However, with advances in remote sensing, the involvement of Malaysian Space Agency (MYSA) in collection of data based on satellite imageries is gradually gaining importance and as such MYSA will be another agency contributing data for water management.

Other organisations collecting water data would include the large plantations such as Sime Darby which monitors rainfall for their crop water management.

MYSA has opened their remote sensing data to the public. Imagery from MYSA's remote sensing satellite is available for download and this service is used mostly by academics. MYSA will be launching satellites with sensors able to capture imageries with resolution of (0.5m x 0.5m), comparable with PLEIADES satellite made by France. The use of remote sensing will significantly reduce the problem with monitoring transient events. The problem of cloud cover which is the general problem of remote sensing in the tropical areas can be resolved with the use of cloud penetrating radar sensors. Remote sensing is one of the 3 areas of interest pursued by MYSA besides navigation and communications. MYSA has developed a series of application for clients since its inception. A total of forty (40) application systems have been developed since. The application systems encompass many fields including disaster management, land monitoring, agriculture and fisheries, natural resources and environment management, and environmental health (Malaysian Space Agency, n.d.).

Besides raw data, all the agencies involved also produce processed information in the form of charts, graphs, reports, isohyetal maps, hydrological procedures, water resources publications, and manuals. They are referred to by consultants, researchers and government agencies in water related studies and design of water related systems or works. Efforts by the government agencies and departments at integrating the infostructure related to water and water-related data and information include the SMSA by JPS, DIPAN-SMI by KASA, HydroDat and GroW by JMG, as well as MyGDI by National Geospatial Centre.

In short, these departments, agencies and private sector organisations contribute to overall primary data - water data which includes hydrological data (rainfall, seepage, river level), water quality, water reserve, water resource, water asset, river basin, and water use. Secondary data includes non-water related data such as land use, demography, topography, and socio-economic indicators. A summary of water data collection and the functions of the various departments collecting water data is summarised in **Figure 3.8** and **Figure 3.9.**

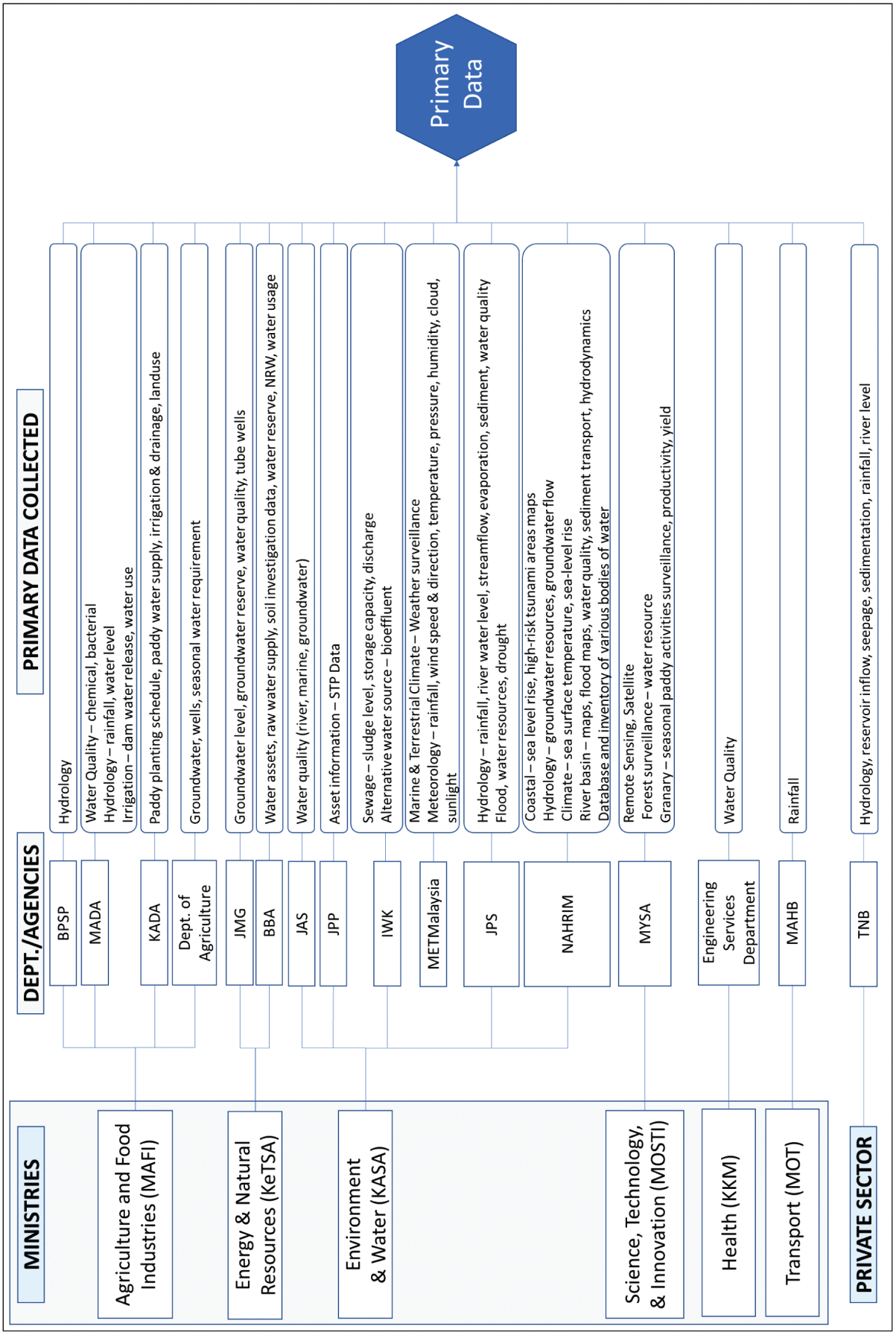


Figure 3.8: Primary data collected by different department and agencies

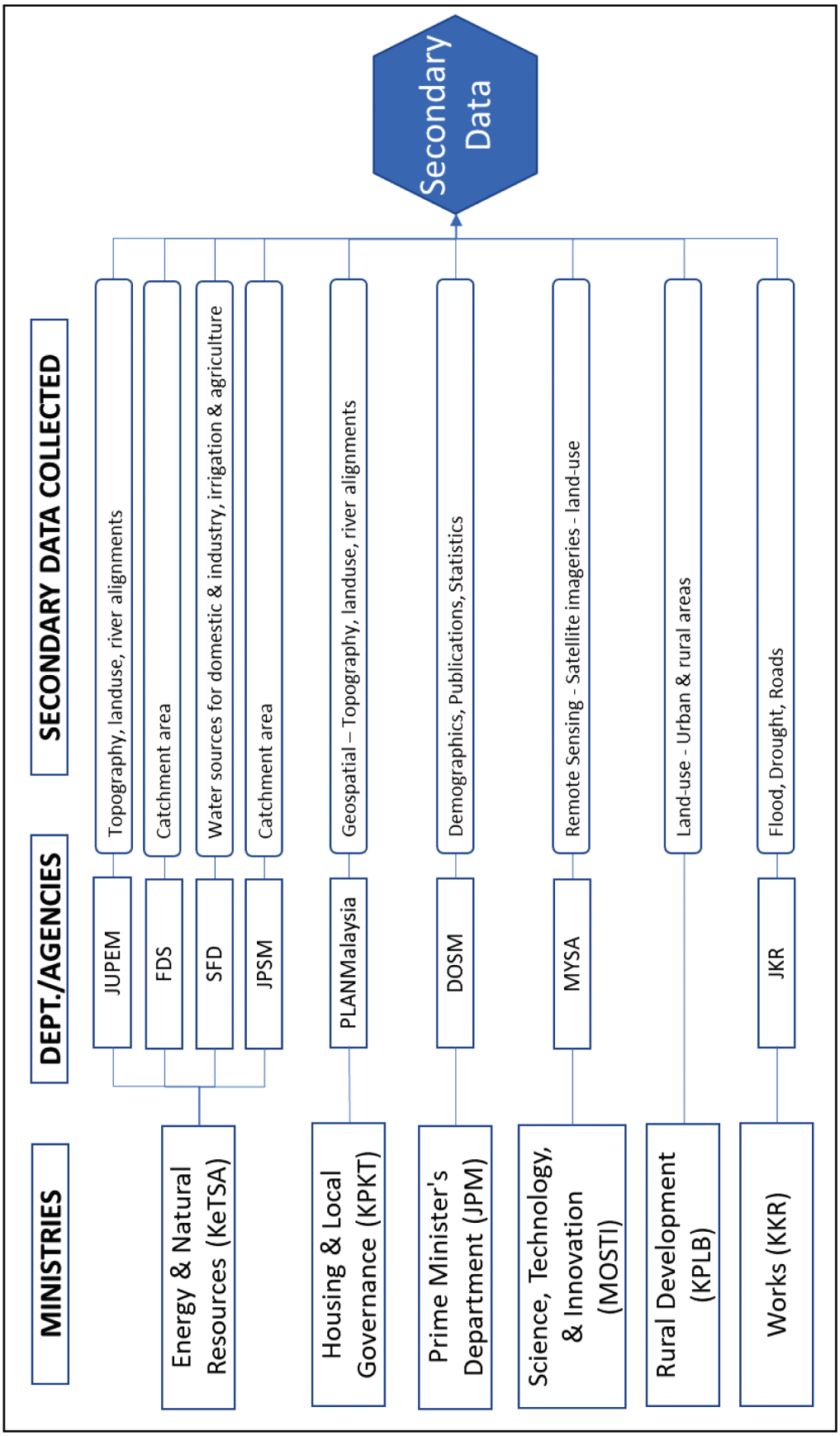


Figure 3.9: Secondary Data Collected by Different Department and Agencies

3.3 Systems Architecture

The systems architecture for IWSDC will contain elements such as standards, good practices, QA/QC, storage and security (**Figure 3.10)**.

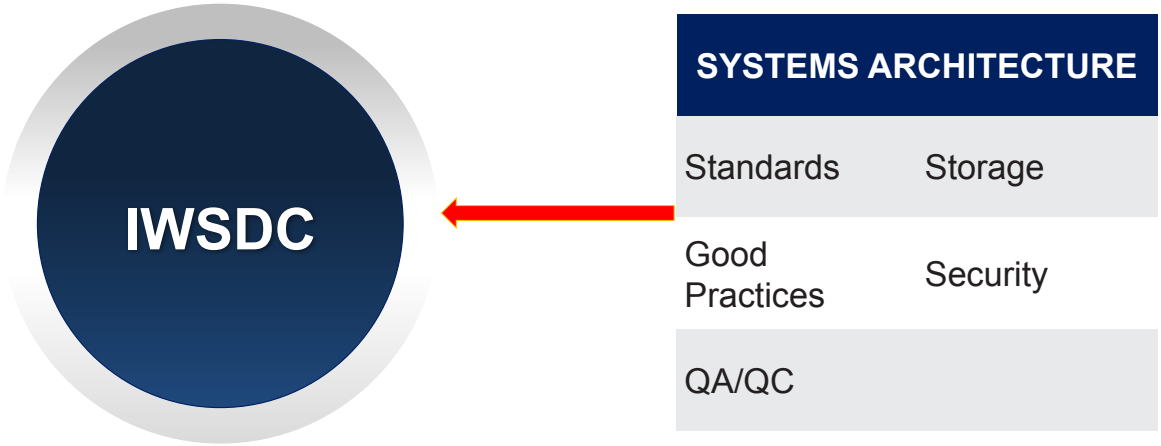


Figure 3.10: IWSDC Systems Architecture

3.3.1 Standards, Goods Practices and QA/QC

a. Standards

Both conventional and non-conventional water networks offer various water management guidelines and standards. Nowadays, most nations are shifting towards holistic restructuring of water systems in order to provide an integrated view on the state of water resources. This means exchange of water data with other organisations should be beneficial to those that have interest in the collected data. With this, water data standards must be established in support of all stakeholders upon the establishment of IWSDC. Currently, various government departments and the private sector collecting data and information related to water follow different standards.

Malaysia currently use MS1759, a Geographic Information/Geomatics – Features and Attributes Code MS 1759:2004 for geospatial data. For instance, JPS, as the biggest custodian for water is using MS1759 as their standard, as well as by other departments that are involved in water data collection (Pusat Geospatial Negara, 2020). The standard is set as a national GIS standard for geospatial data that enables data sharing process amongst government agencies. The standard is to be applied by all businesses that produce, distribute, or utilise geospatial data or/and non-geospatial data. It specifies the method for encoding of geospatial data as well as offers the discretion of the feature and its associated attributes for the exchange of digital geographic information.

National Water Quality Standards (NWQS) is currently being practiced by DOE Malaysia to evaluate the quality status of the river, lakes and reservoir, coastal, estuarine and island marine water, groundwater as well as drinking water. The standards describe the water class based on the standard values of 72 parameters, the classification of level of pollution by individual pollutant, as well as the water classes and their uses respectively (Department of Environment Malaysia, 2021).

Internationally, Open Geospatial Consortium (OGC) has developed WaterML 2.0 as a standard information model to represent water observations data to allow the exchange of such data sets across

information systems The Standards are funded through a water information research and development alliance between The Australian Commonwealth Scientific and Industrial Research Organisation and the Australian Bureau of Meteorology. It aims at being an interoperable exchange format that may be re-used to address a range of exchange requirements (Open Geospatial Consortium (OGC), 2012).

b. Good Practices

A good practice is a method or approach that has been widely acknowledged as superior to all alternatives as either it generates better results, or it becomes the normal way of doing things. It also includes a feature of accredited management standards by standard bodies such as International Organisation for Standardisation (ISO) and International Telecommunications Union (ITU) which IWSDC will apply wherever possible.

c. QA/QC

In collecting and standardising data, it is important to ensure that the data collected in a database is kept in a state of high quality, reliable, accurate and precise data with high standards. The data collected must also be able to be reliably compared to other similar datasets from other databases and original sources.

A plan must be formed by the database managers on how to review the data before it is collected or compiled, and they must think of how to systematically address the errors, conflicts, and other data problems they are likely to encounter in each dataset.

A quality control procedure should comprehensively provide a complete detail of the contents in the data and metadata dataset. QA/QC is an approach to list the actions taken to evaluate the data, how decisions were made regarding problem resolution, and what actions are taken to resolve the problems at each step in the data life cycle. Quality control and assurance should include:

i. Determining how to identify potentially erroneous data
ii. How to deal with erroneous data
iii. How problematic data will be marked

A data manager may observe a particular dataset for outliers and refer the original data source to confirm any suspicions about certain values and make a change to the dataset received. In live or real time data transfer, the data manager could compare data streams from remote sensors, finding discrepant data and choosing or dropping data sources accordingly. Recording how these steps were done can be invaluable for later understanding of the dataset, even by the original data collector.

Mechanisms must be in place to compare datasets against each other that provide a measurable means to alert any differences if they do indeed arise. These differences can indicate a possible error condition since one or more datasets are not exhibiting the expected outcome exemplified by similar datasets.

Automation via software can be an efficient way to document data QA/QC as it is being performed. These can be done via scripts, macro or standalone programs that can be distributed and used by data collectors and providers at the data source. To ensure as little discrepancies in data variation as possible, these programs should also include a built-in documentation. Automation creates error-checking and review that is highly repeatable. These types of data formatting and quality checking has been accomplished in Australia in the form of Australian Water Resources Information System (AWRIS). The AWRIS processes data and the associated metadata (such as location and method), and checks are

made to ensure that the data is consistent with existing information received before this data is loaded for public access (Nicholls, 2009).

The Australian Bureau of Meteorology has established consistent data collection, management and transfer standards to develop the Water Data Transfer Format. This format has been promoted as the preferred method for transferring water time series data and metadata to the AWRIS system. (Nicholls, 2009).

A plan for QA/QC is needed so that users of the final data can understand how to best use the data and avoid potential mistakes that might occur in the final product due to use of poor-quality data. Data documentation must be done explicitly to ensure the data collected is free from errors, missing information, and conflicts.

3.3.2 Storage and Security

The storage and security include eight main components which are big data architecture, Cloudera Data Platform (CDP) infrastructure design, network requirements as well as database setup (data lake, data warehouse and data mart). The Overall IWSDC Infrastructure Setup is as per **Figure 3.11.**

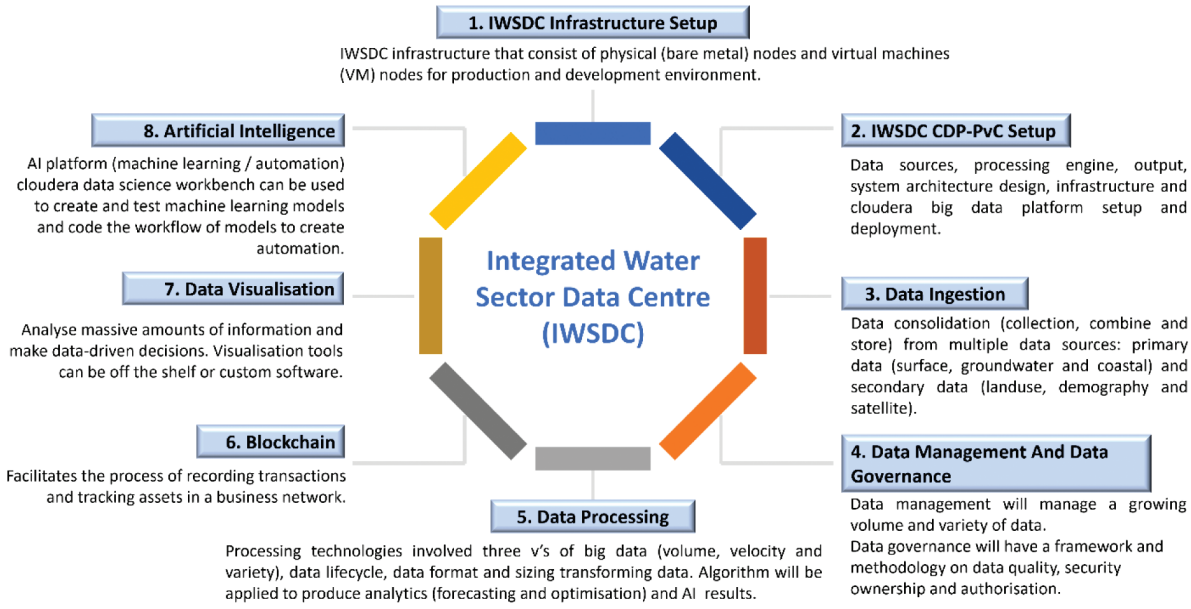


Figure 3.11: IWSDC Overall Infrastructure Setup

a. Big Data Architecture

Big Data Architecture is designed to manage the ingestion, processing, visualisation and analysis of data that are too large or too complex to handle with traditional tools. Depending on organisations, Big Data may be hundreds of gigabytes or hundreds of terabytes in size. The minimum amount considered as Big Data is 1 Terabyte (TB).

A Big Data Architecture determines how the collection, storing, analysis and visualisation of data is done. Big Data is also referred to when defining how to transform structured, unstructured, and semi-structured data for analysis and reporting.

The proposal is to use Cloudera Data Platform Private Cloud (CDP-PvC) Base License Environment for IWSDC's Big Data Platform Setup as shown in **Figure 3.12**.

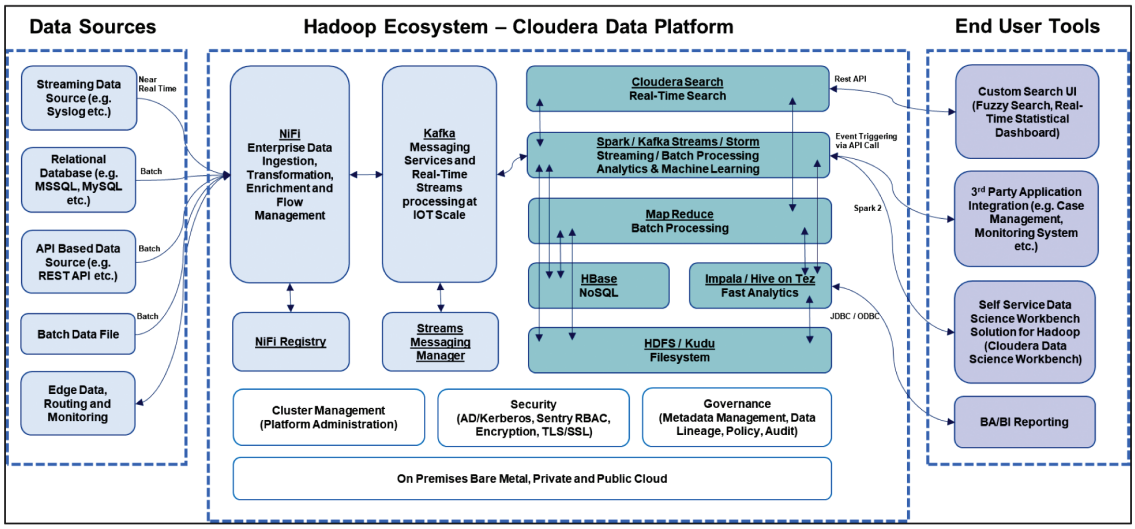


Figure 3.12: Generic Representation of CDP-PvC

The architecture shows how the Generic flows from Data Sources into the Hadoop Ecosystem using the Cloudera Data Platform and to End User Tools. This includes:

i. Data Sources: Raw information and logs originating from Primary and Secondary Data.
ii. Data Ingestion: Data is injected into the collector tool, which has been customised to ingest raw data. In the Ingestion Tool, data will be distributed to the Hadoop Ecosystem for Processing, Data and Statistics, QA/QC, Storage and Dissemination.

Data Processing shall be performed in the following stages:

i. Data Management
ii. Data Access
iii. Data Processing
iv. Data Storage

The processed and standardised data shall then be exported in a structured form and interactively for the final Data Representation Stage to serve IWSDC's functions such as:

i. Annual Strategic Reports
ii. Water Research Collaborations (RDIC)
iii. Data and Statistics Distribution for Operations
iv. Big Data Analytics applications
v. Blockchain applications
vi. Artificial Intelligence applications

b. CDP Infrastructure Design

The preliminary CDP infrastructure design for IWSDC is shown in **Figure 3.13** and **Figure 3.14**. The design is currently a concept and will be scalable in the future as the IWSDC expands and requires more servers to this Data Lake.

The low-level design will also be able to scale up to Exabytes in size without degradation of data or analytic performance. It will be able to cater up to 500,000 streams and perform batch processing of data sources, which can be up to 100 terabytes of incoming data.

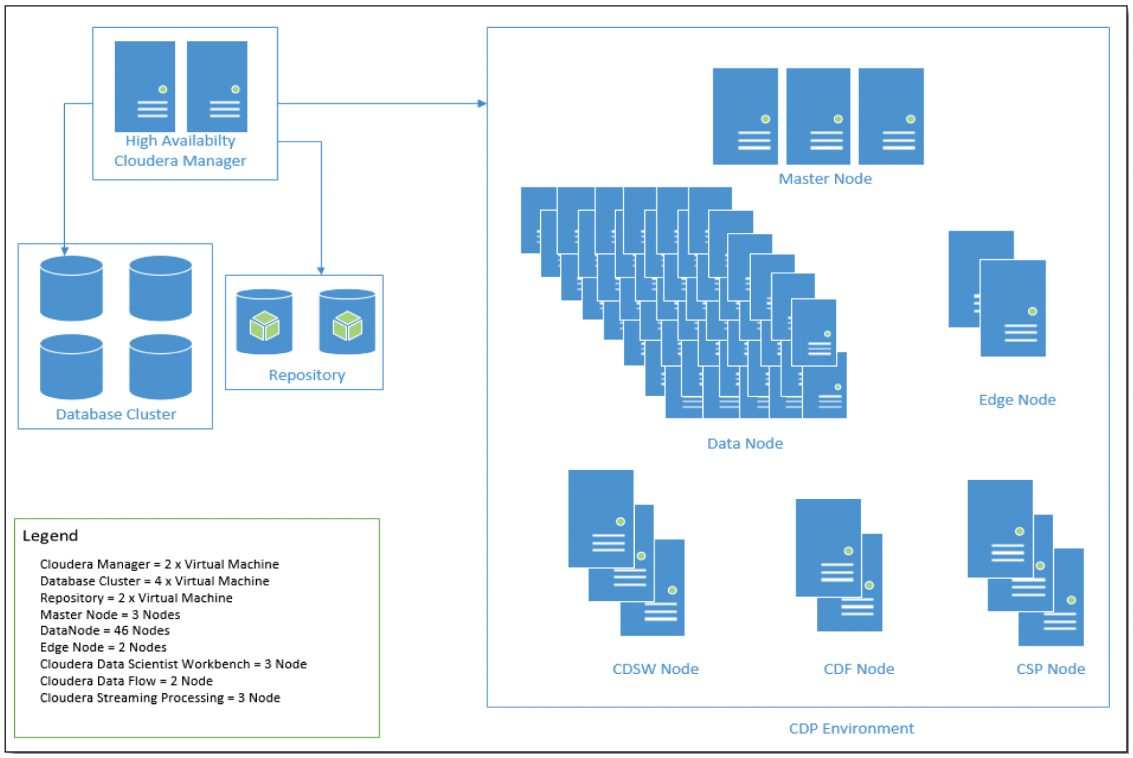


Figure 3.13: IWSDC Data Lake Ecosystem Design Diagram (1/2)

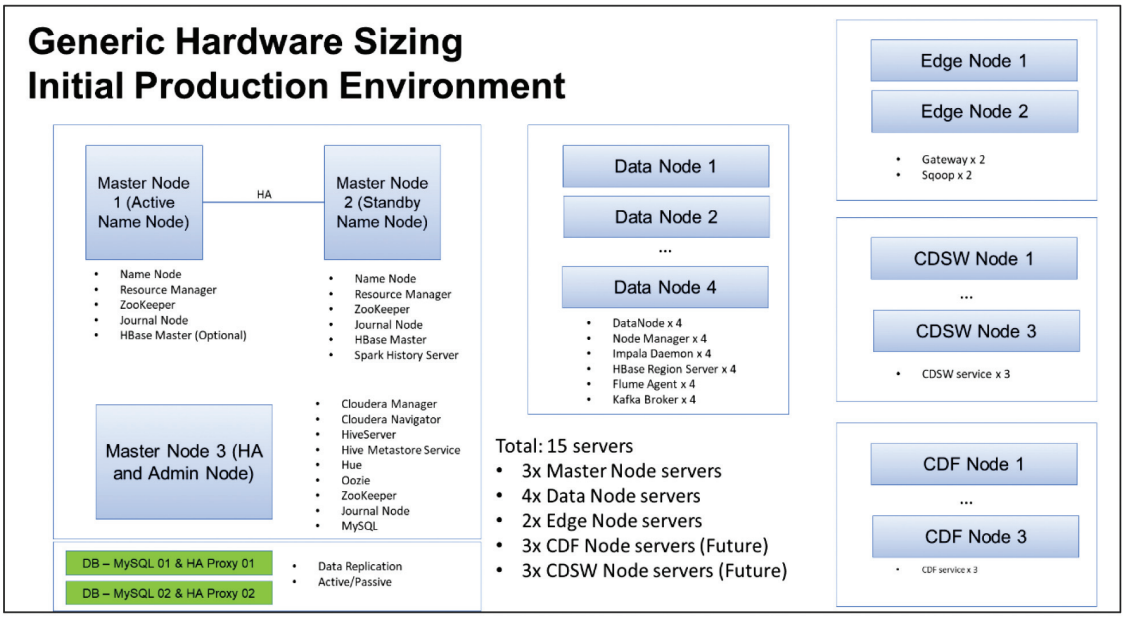


Figure 3.14: IWSDC Data Lake Ecosystem Design Diagram (2/2)

Figure 3.15 describes the IWSDC CDP Private Cloud Base Infra Physical Architecture Diagram in more detail together with the proposed generic Intranet network linkages.

c. Network Requirements

i. Network Specification

With a Dedicated Hardware Network, Hadoop can consume all available network bandwidth. For this reason, Cloudera recommends that Hadoop be placed in a separate physical network with

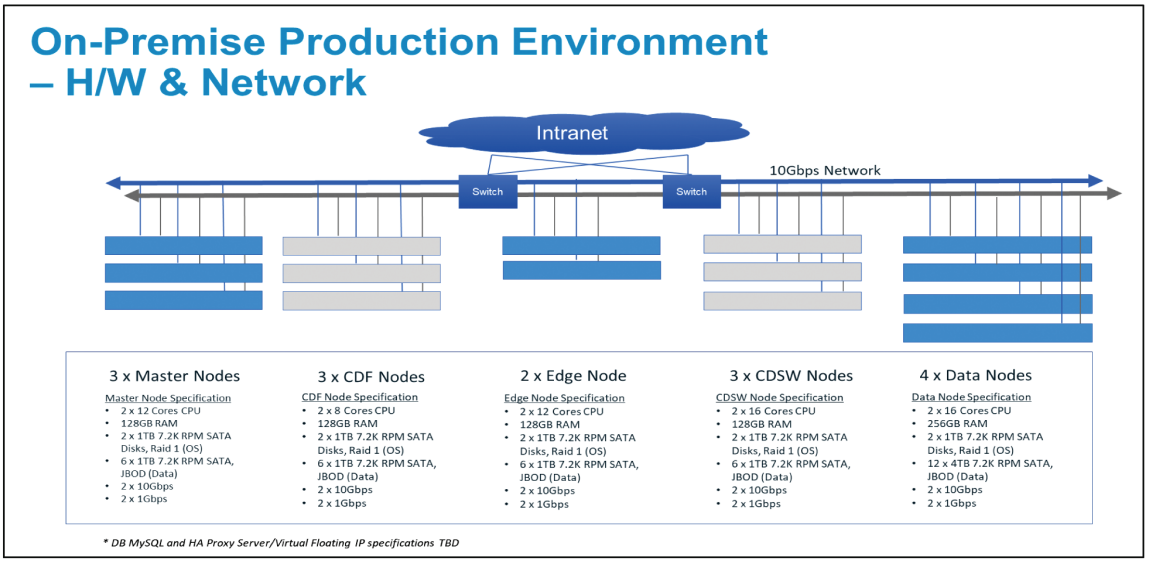


Figure 3.15: IWSDC CDP Private Cloud Base Infra Physical Architecture Diagram

its own core switch. Switch Per Rack Hadoop supports the concept of rack locality and takes advantage of the network topology to minimise network congestion.

Ideally, nodes in one rack should connect to a single physical switch. Two top-of-rack switches can be used for high availability. Each rack switch (i.e., top-of-rack switch) uplinks to a core switch with a significantly bigger backplane. Cloudera recommends 10 GigaBit Ethernet (or faster) connections between the servers and top-of-rack switches. Top-of-rack uplink bandwidth to the core switch (two switches in a high availability configuration) will often be oversubscribed to some extent.

ii. Uplink Oversubscription

Oversubscription is dependent on workload. Cloudera's recommendation is that the ratio between the total access port bandwidth and uplink bandwidth be as close to 1:1 as possible.

This is important for heavy workloads of extraction, transforming, loads, and MapReduce jobs that have high data traffic. Oversubscription ratios up to 4:1 is generally fine for balanced workloads, but network monitoring is needed to ensure uplink bandwidth is not the bottleneck for Hadoop. **Table 3.1** provides some examples as a point of reference:

Table 3.1: Guidelines for Oversubscription Ratio

Access Port Bandwidth (In Use)	Uplink Port Bandwidth (Bonded)	Ratio
48 x 1 GbE = 48 Gbit/s	4 x 10 GbE = 40 Gbit/s	1.2:1
24 x 10 GbE = 240 Gbit/s	2 x 40 Gig CFP = 80 Gbit/s	3:1
48 x 10 GbE = 480 Gbit/s	4 x 40 Gig CFP = 160 Gbit/s	3:1

It is important to not exceed 4:1 oversubscription ratio. For example, if a top-of-rack has 20 x 10 Gigabit Ethernet ports used, the uplink should be at least 50 Gigabit Per Second (Gbps). Different switches have dedicated uplink ports of specific bandwidth (often 40 Gbps or 100 Gbps) and therefore careful planning should be made to choose the right switch types.

iii. Redundant Network Switches

Having redundant core switches in a full mesh configuration allows the cluster to continue operating in the event of a core switch failure. Redundant top-of-rack switches will prevent the loss of an entire rack of processing and storage capacity in the event of a top-of-rack switch failure. General cluster availability can still be maintained in the event of the loss of a rack if master nodes are distributed across multiple racks.

iv. Accessibility

The accessibility of the Cloudera Enterprise cluster is defined by the network configuration and depends on the security requirements and the workload. Typically, there are edge/client nodes that have direct access to the cluster. Users go through these edge nodes via client applications to interact with the cluster and the data residing there. These edge nodes could be running a web application for real-time serving workloads, Business Intelligence tools, or simply the Hadoop command-line client used to submit or interact with Hadoop Distributed File System (HDFS). Cloudera recommends allowing access to the Cloudera Enterprise cluster via edge nodes only. The user can configure this in the security groups for the hosts that the user assigns.

v. Internet Connectivity

Clusters that do not require heavy data transfer between the Internet or services outside of the immediate network and HDFS still might need access to services like software repositories for updates or other low volume outside data sources. Completely disconnecting from the Internet will block access for software updates, making maintenance difficult.

vi. Operating System

For nodes of the Operating System, it is recommended to install Red Hat Enterprise Linux (RHEL) Centos 7.6 and above, because it has required software dependencies that Cloudera Software needs.

d. Data Lake / Data Warehouse / Data Mart

Raw data from the data lake will be used to populate the data warehouse. An administrator can create a virtual warehouse, created in Cloudera data warehouse module. Administrators can create multiple virtual data warehouses based on a single database catalogue. The virtual data warehouse can be dynamically scaled based on user requirements. Data from the data warehouse can be extracted to a smaller data mart – using Talend Data Extraction tool, tailored to user requirements. The transferred data can be scheduled to run at every hour or once a day, depending on the requirements. The data mart will be created on an Online Analytical Processing (OLAP) database, outside of Cloudera. The relationship between data lake, data warehouse and data mart are shown in **Figure 3.16.**

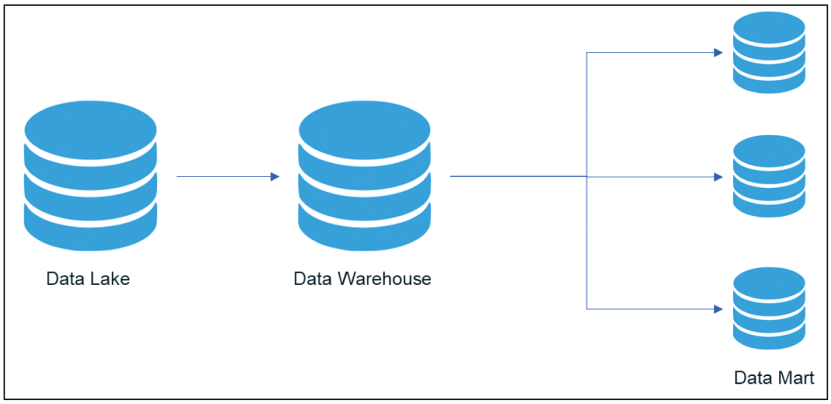


Figure 3.16: IWSDC Data Lake, Data Warehouse and Data Mart

3.4 Output and Services

Figure 3.17 illustrates the output and services of IWSDC. This new independent water data centre body will serve end users with the following:

a. Water Research Collaboration (RDIC)
b. Data and statistics distribution for operations
c. Strategic reports
d. Big data analytics applications
e. Blockchain applications
f. Artificial intelligence applications

3.4.1 Water Research Collaboration (RDIC)

The IWSDC will be promoting the role of Water Research Collaboration. The collaboration platform and programmes established by IWSDC will be a precursor to the establishment of a Water Research Consortium as envisaged in the Strategy Paper No. 16. One example of how a collaborative platform for RDIC works is through events such as hackathons. The Water Hub Hackathon in Durham, UK for example, was a competition for the public to develop solutions in the fields of water and environment. The Hackathon gave access to water and environmental data to the public and asked how this data and information could be better shared and communicated in a beneficial manner.

3.4.2 Water Data Platform (IWSDC Water Platform)

Water Data Platform function is one of the main components of IWSDC which fulfils its role as a one-stop centre for water and water related data for all stakeholders in the water sector. The IWSDC Water Platform will integrate the data and it will be made available to any user either in unstructured, semi-structured or structured forms. Users of these data include government institutions, students, consultants, industries, researchers, NGOs, and many others.

The Water Data Platform is shown in **Figure 3.18**. The data and information provided by the IWSDC will serve many functions including fulfilment of government department's duties and functions, planning and designing of projects, undertaking of studies, thesis, university related projects, RDIC activities as well as decision-making in investment, strategic planning, development and risk assessment.

3.4.3 Strategic Reports

The Strategic Reports are designed to fill in the gaps in the water management spectrum. IWSDC will produce these reports to service end users that include Federal and State Governments, water operators, research institutions, universities, private sectors, and the public.

a. Water Security

   Water security is defined as "the capacity of a population to safeguard sustainable access to adequate quantities of acceptable quality water for sustaining livelihoods, human well-being, and socioeconomic development, for ensuring protection against water-born pollution and water related disasters, and for preserving ecosystems in a climate of peace and political stability" (UN Water, 2013). Water security is also now an item under the NSP 2021-2025. It is now imperative that the state of the nation's water security and confidence level is reported in a detailed and consistent manner to the nation's decision makers. IWSDC can assist this undertaking by producing annual water security reports to MKN, which

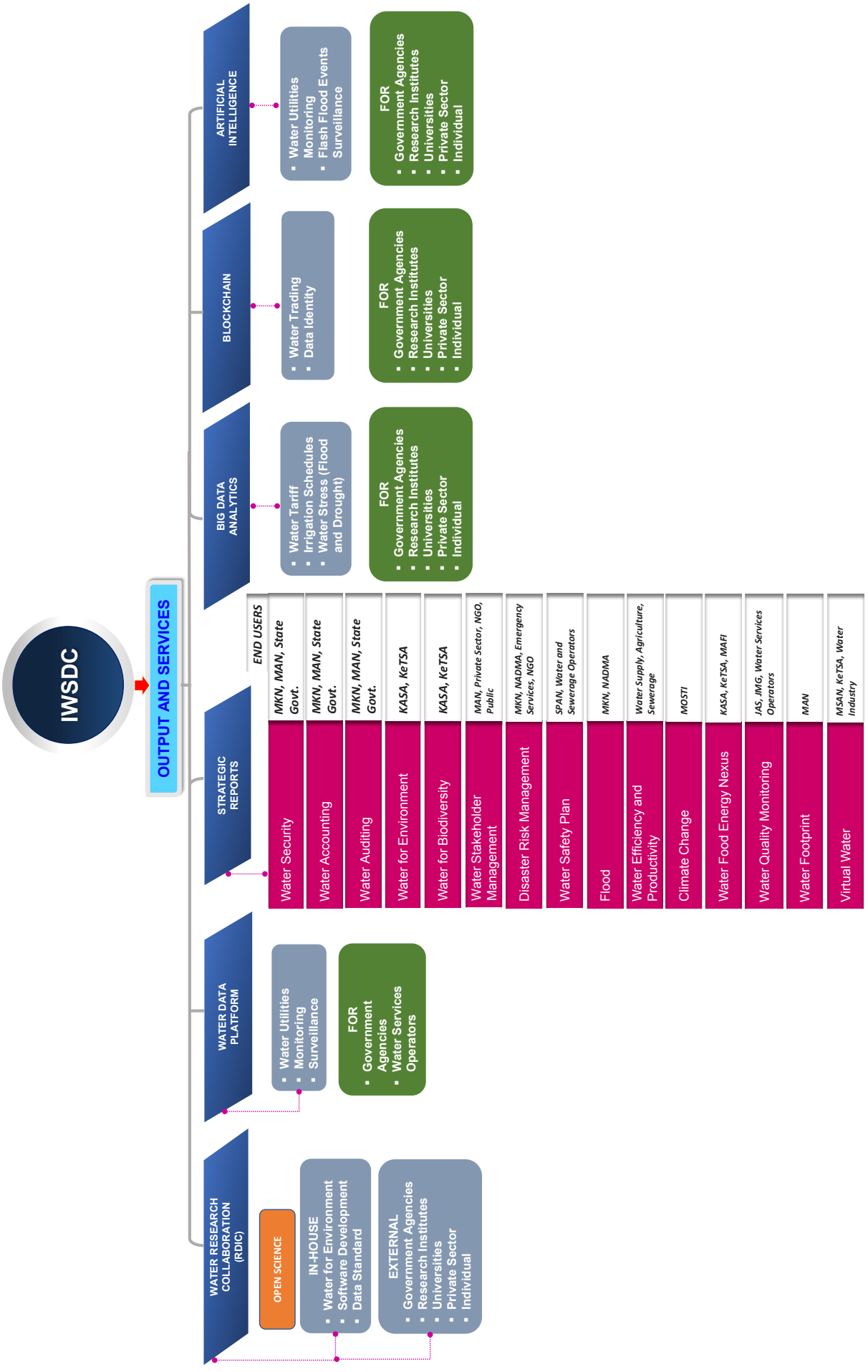


Figure 3.17: IWSDC Output and Services

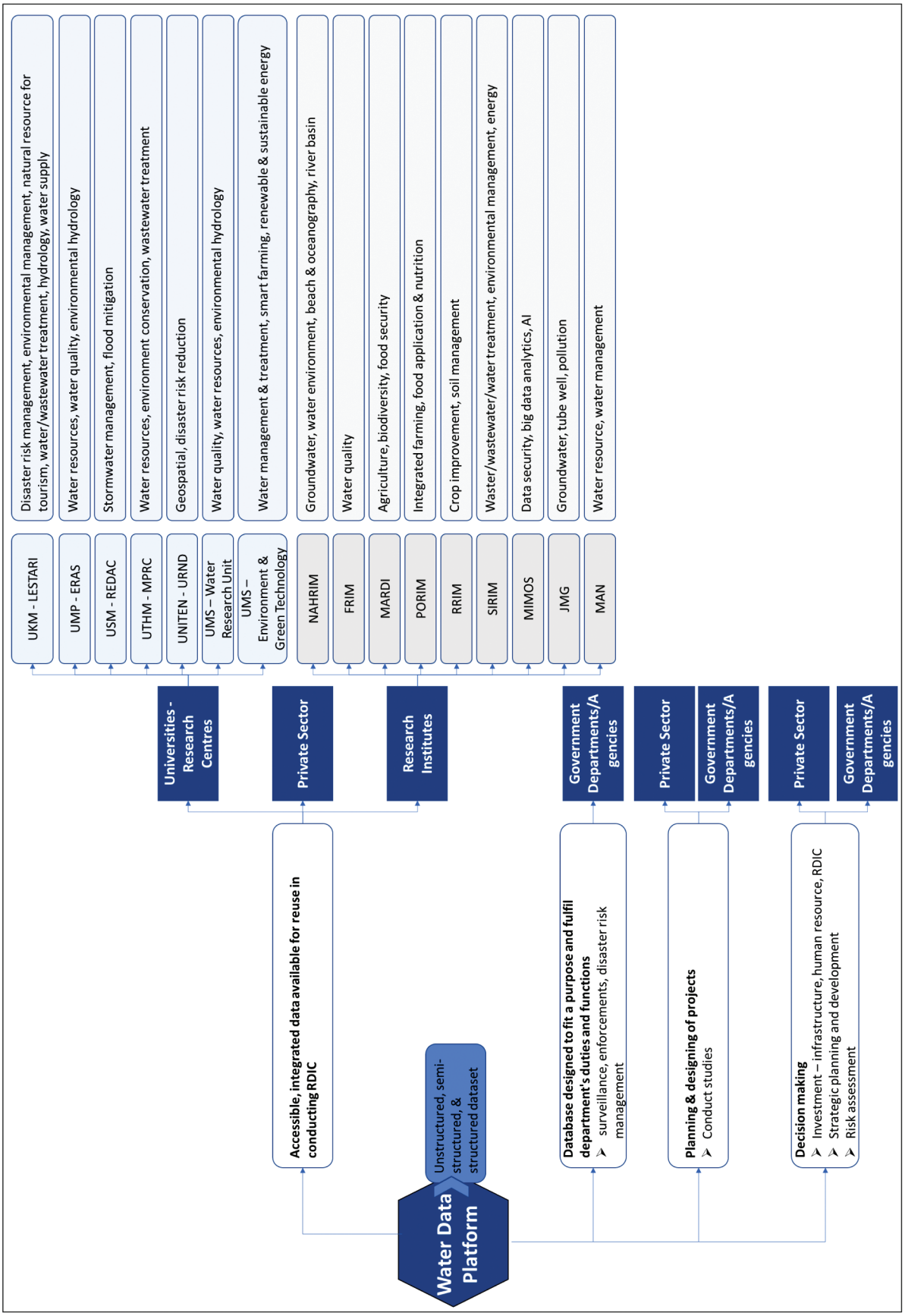


Figure 3.18: Proposed IWSDC Water Data Platform

Box 3.1: Water Accounting Concept

The Australian Water Accounting Standard (AWAS) developed a Water Accounting framework based on the concept of Financial Statements of Accounts as follows:

Water Accounting Statements	Equivalent Financial Accounting Statements
Statement of Water Assets and Water Liabilities	Balance Sheet
Statement of Changes in Water Assets and Water Liabilities	Income Statement
Statement of Water Flows	Cashflow Statement

Water Accounting Statements based on the Financial Accounting Statement (examples)

Statement of Water Assets and Water Liabilities as at 31 December 2X11
(equivalent to Financial Balance Sheet)

	Notes	2X11 ML	2X10 ML
Water Assets			
Surface Water			
Storages	2b 2c	**2,192,330**	1,447,852
Rivers	2b 2c	**3,155**	1,811
Groundwater			
Aquifers	2b 2c	-	-
Urban Water System			
Claims: Surface Water	2b 2c	-	-
Claims: Groundwater	2b 2c	-	-
Total Water Assets		**2,195,485**	1,449,663
Water Liabilities			
Surface Water Liability			
Allocation Remaining: Individual Users	2a	-	-
Allocation Remaining: Urban System	2a	-	-
Total Water Liabilities		-	-
Net Water Assets			
Net Surface Water Asset		**2,195,485**	1,449,663
Net Groundwater Asset		-	-
Net Urban Water Asset		-	-
Total Closing Net Water Assets		**2,195,485**	1,449,663
Total Change in Net Water Assets		**745,822**	(595,205)

Statement of Changes in Water Assets and Water Liabilities
for the year ended 31 December 2X11
(equivalent to Financial Income Statement)

	Notes	2X11 ML	2X10 ML
Water Asset Increases			
Precipitation	2c	**66,980**	86,206
Inflows	2c	**453,827**	501,554
Increase from surface water licence			
Burns Reservoir	2b 2c	**18,250**	18,250
Increase from groundwater licence			
Harner Basin	2b 2c	**10,000**	10,000
Increase from groundwater licence			
Pura Mound	2b 2c	**6,000**	6,000
Inter-segment transfer	2c	**20,094**	-
Total Water Asset Increases		**575,151**	622,010
Water Asset Decreases			
Evaporation	2d	**151,632**	151,632
Outflow	2d	**128,019**	138,703
Terra Firma water supplied to customers	2d	**255,312**	243,845
Losses	2d	**19,360**	16,940
Inter-segment transfers	2d	**20,094**	-
Forfeiture - Burns Reservoir	2b 2d	-	825
Forfeiture - Pura Mound	2b 2d	**154**	-
Forfeiture - Hamer Basin	2b 2d	**2,000**	80
Total Water Asset Decreases		**576,571**	552,025
Unaccounted-for difference	2e	**(4,108)**	(25,602)
Change in Net Water Assets	4a	**(5,528)**	44,383

Statement of Water Flows for the year ended 31 December 2X11
(equivalent to Financial Cashflow Statement)

	Notes	2X11 ML	2X10 ML
Water Inflows			
Surface water inflows			
Precipitation	2f	**9,938**	5,020
Precipitation			
Inflow from upstream water report entity			
Inflow from upstream water report entity including minimum flow claim	2c	**181,380**	180,120
Unregulated inflow of runoff			
Inflow of runoff to major regulated on-stream storage	2f	**725,519**	530,288
Inflow of runoff to regulated river channel	2f	**45,347**	32,840
Inflow of runoff to unregulated river channel	2f	**17,737**	13,312
Discharge from groundwater	2f	**71,978**	59,160
Discharge from groundwater to surface water storage - regulated			
Return flow from irrigation			
Return flow from irrigation	2f	**3,451**	3,451
Return flow of urban wastewater/effluent			
Urban wastewater/effluent	2f	**9,860**	9,720
Total surface inflows		**1,065,210**	833,911
Groundwater inflows			
Groundwater recharge			
Recharge from regulated river channel	2h	**3,945**	3,945
Recharge from landscape water storage to groundwater	2h	**36,975**	36,975
Inflow from groundwater system external to report entity			
Inflow from groundwater system external to report entity	2h	**3,944**	3,944
Total groundwater inflows		**44,864**	44,864

will not only provide it with information on the nation's water security status but also on the nation's food security situation (from water resources point of view).

b. Water Accounting

Water accounting involves the calculation of water resources and utilisation of water, analogous to financial accounts concept of presenting information on income and expenditure. The need of water accounting is based on the premise that 'One can only plan and manage resources which have been measured'.

IWSDC will produce water accounting report to enhance and quantify water governance in the country. It could be the basis for numerous strategic activities related to water, such as water allocation and inter-basin water transfer, water trading, water pricing, water infrastructure investment and conflict resolutions.

c. Water Auditing

A full water auditing system is yet to be established in Malaysia. IWSDC will support it by carrying out annual water accounting reports. Then there is also a need to establish the Water Auditor General, for instance, to audit the water accounting report. Similar to Public Accounts Committee (PAC), a Public Water Account Committee needs to be established to examine the water accounting report. The Committee will review and address the issues raised in the audit report and table it in the Parliament.

Box 3.2: The National Accounting Process

Every Government Department and Agency, both at Federal and State level, needs to prepare financial statements and submit them to the Accountants General Department for verification. The financial statements are then submitted to the Auditor General (AG) for auditing purposes.

At the Federal level, the audit findings in the AG's report are received by the Public Accounts Committee (PAC) to be tabled in the Parliament, whereas at the State level, the audit findings in the AG's report are tabled in the State Legislative Assembly.

Reference: PAC, 2021

d. Water for Environment and Biodiversity

Accounting for environmental needs in the total water resources management would indicate that the environment is the biggest user of water. At present, there is no single authority responsible for water for environment and biodiversity. The DOE Malaysia is only responsible for regulating the quality of water. IWSDC may be the lead institution responsible for reporting water for environment and biodiversity. This will be accomplished through the cooperation with relevant departments in government agencies such as DOE, Forestry Department as well as Department of Wildlife and National Parks.

Box 3.3: Water for Environment and Biodiversity

Water for environment and biodiversity is the water used by ecological processes or the water that is not used for human consumption. It is defined as any water that achieves ecological benefits such as wetlands.

Source: Hamstead, 2007

e. Disaster Risk Management (DRM)

Data and information are needed at different stages of disaster management that includes risk assessment, developing risk reduction strategies and action plans, developing disaster response plans during the disaster event and also planning for actions immediately after as well as short and long-term recovery plans. Overall, this can be considered as developing strategies for increasing the resilience of the community and the country to face disasters.

IWSDC is a centralised and integrated centre that stores primary and secondary data such as rainfall data, water level data, stream flow, evaporation, GIS, survey data, topography, satellite and aerial imageries, statistic and demography data (e.g., evacuation centres, hospitals) at national level. This will be an important data source for DRM. The size of data can be huge in capacity as these are integrated data from various agencies. Therefore, data must be structured and customised for better coordination and easy assessment by any organisation or ministry at any point of time.

f. Water and Climate Change

"Climate change" is defined as a change of climate which is ascribed directly or indirectly to human activity that changes the composition of the global atmosphere and which is in addition to natural climate variability observed over similar time periods (United Nations, 1992).

Malaysia's Third National Communication (TNC) projected that the average annual air temperature for the country may increase by 0.5^0C-1.0^0C during the period of 2030, and it may further rise to 0.9^0C-1.6^0C during the period of 2050. As a result, certain areas in Malaysia are expected to experience more severe floods, droughts as well as sea level rise in the future.

Climate change data requirements can be determined from the development of several model scenarios, whether generic or specific such as the sea level rise, agricultural production loss, land loss, migration and relocation patterns, and water supply decrease.

g. WFE Nexus

Box 3.4: The WFE Nexus

The WFE nexus is the study of the connections between these three resource sectors, together with the synergies, conflicts and trade-offs that arise from how they are managed, i.e., water for food and food for water, energy for water and water for energy, and food for energy and energy for food.

Source: FAO, 2014

WFE Nexus based on a holistic economic and environmental perspective should use consistent, reliable, and comprehensive data as well as sound scientific references. It is also imperative that data across the nexus sectors are comparable in terms of accuracy and resolution. Accurate economic databases could further support the setting of efficient water prices. Moreover, precise data needs to be collected and maintained for agricultural and energy production and technology at various levels, including throughout the supply chains of goods and services concerned.

Data analysis and scenarios are part of a Nexus assessment, which inform stakeholders about Nexus interactions, highlighting trade-offs and synergies between different resource uses. As water becomes scarce, and competition is growing between the energy and agricultural sectors, there is still a lack of reliable and policy-relevant data and information to guide water allocation choices. Effective cross-sectorial consultation mechanisms are needed to ensure the development of concerted efforts to address this problem, and to make sure that decisions on water release and allocation are taken as part of an integrated, long-term and multi-sectorial strategy.

By enhancing data collection and management, IWSDC plans to spur the strengthening of WFE Nexus through interventions to strengthen the institutional capacities, enhance the finance mechanisms, and implement economic instruments and integrated economic approaches to measure the impact of Nexus to the economy.

h. Water Safety Plan

Unsafe drinking-water, inadequate sanitation and deficient hygienic practices remain the main reasons of disease in both developing and developed nations, causing millions of deaths each year, mostly amongst children under five years old (Prüss-Üstün A, 2008). Water Safety Plan (WSP) is an essential strategy to ensure the safety of water provided to the consumers. Within the WSP are the various necessary Standard Operating Procedures (SOP) which will ensure a constant state high service level as well as a state of preparedness for any untoward incidences that threaten or disrupt supplies supporting the comfort of lives and living for domestic and industrial end-users.

Water safety plans will require data that is considered to be part of water security. These datasets must consist of catchment area, asset locations and distribution network. The information required to assess water safety plans may include GIS, water quality data, water level data, rainfall data and weather forecasts.

IWSDC could assist in the implementation of WSP in several ways. For instance, collaborating with MOH to provide data on water quality monitoring based on WHO standards. This will allow for production of report on water safety. It could also provide related secondary data such as flood damage, land use planning, drought projection, amongst others. Furthermore, IWSDC could also provide surveillance capabilities to monitor potential sources of pollutions coming into sources of water supply and ensure safe water being supplied to consumers.

i. Water Stakeholder Management

The WST2040 Roadmap preparation involved a comprehensive participation of various stakeholders, including Ministries, Government Agencies, Non-Governmental Organisations (NGOs), academics, industry players and members of the public, to ensure the transformation is fully implemented.

IWSDC aims for the development and sharing of knowledge, adoption of interrelations, and establishment of cross-functionality between stakeholders through water stakeholder management report as well as the public stakeholder platform approach.

Box 3.5: Integrated Water Stakeholder Linkages

"The complete success of initiatives by water managers for higher levels of water management relies on the responses and support of the end-users and the public. End-users and the public should be recognised as a part of the entire water management system. This is critical to secure participation, buy-in and stewardship of the public and providing them a platform to voice their concerns and opportunities to take actions to address them jointly with the government agencies. Such platforms can be established at the local and state levels, leading to the representation of both government and NGOs, private sector and local community. Matters discussed at the local and state levels could be channeled and discussed at the National Water Council (NWC) with the NGOs and CSOs as representatives."

Source: Ministry of Economic Affairs, 2019

j. Water Quality Monitoring

Various types of data are needed for water quality monitoring including the quality and quantity information of water in water bodies. In line with many developed countries in monitoring water quality, Malaysia has also started using application of GIS including space based remote sensing for monitoring

purposes. This is done to limit the field cost, enhance data collected, produce digital map, and observe the large-scale monitoring of water quality.

The production of water quality monitoring report by IWSDC in a timely manner will assist in greater decision-making. This is especially important since Malaysia is experiencing rapid urbanisation and population growth that may affect water quality.

k. Virtual Water

IWSDC will publish virtual water report to assist in determining the amount of water required to produce various products and services as well as towards determining how best to use the scarce water available especially in semi-arid and arid areas.

Box 3.6: Virtual Water

Virtual water is the amount of water 'embedded' in a product. As agricultural products are sold and traded, the water that is used to produce them (natural rainfall or irrigation) is also essentially traded. In identifying the amount of virtual water embedded in a product, its implications for water management, practice, and policy should be taken account of.

Source: Allan, 2011

l. Water Footprint

The water footprint analysis of many industries in Malaysia can be improved with data and information from IWSDC. IWSDC will also be able to produce reports on the consumption of each industry, and even focus on specific companies to highlight its water use feasibility compared to others. With better data annually, trends can be analysed to a better plan on the aspect of sustainability, water tariffs, and even pollution taxes.

Box 3.7: Water Footprint

Water footprint was developed as a tool to measure virtual water use over entire supply chains from production to delivery to the consumer, and this includes the costs to pollution produced in the process.

Source: Hoekstra & Chapagain, 2008

m. Water Efficiency

To achieve better water efficiency, the water regulatory policies and the promotion for the mandatory use of efficient products or water saving device are the important aspects. Legislation is required for uniform application of standards, building codes and water efficiency labelling schemes.

Data must be measured pre and post water efficiency measures that have been put in place. Expansion of water efficiency activities can then be done with the information generated. Data requirements are not limited to water consumption, water use reduction, water landscaping and wastewater as it can be very broad depending on the industry, locality or purpose of water use at any given area.

Box 3.8: Water Efficiency

Water efficiency refers to a collection of practices and policies that works to maximise the benefit gained from every unit of water used. The idea behind water efficiency is to reduce water wastage. Reducing wastage can be done through finding the appropriate allocation of water volume for any given usage purpose. Water efficiency focusses on reducing waste in water use through better water management and allocation, rather than forcing behavioural change on individuals. It is the minimisation of the amount of water used to complete a given task, function, or result.

Source: Australian Water Association, 2012

The data and information collected by IWSDC can help communities gauge the water efficiency of each household. The water efficiency report can also be distributed to each household with comparisons to the housing area and national average, thus, better awareness can be achieved. The same is applied to larger scale industries with recommendations to improve their water efficiency.

n. Rainfed Agriculture Monitoring

At present, accessibility of wide range of spectral measurement, excellent spatial and temporal resolution, remote sensing is seen as a valuable tool for agricultural applications. It has high-performance tool from the availability of methods that allow the measurement of surface biophysical variables and modelling approaches in the water sector. IWSDC will adopt the use of remote sensing for improved rainfed agriculture water resource management and support it through production of rainfed agriculture reports. One sector that could immensely benefit from this service by IWSDC is the oil-palm plantation industry.

Box 3.9: Rainfed Agriculture

The rainfed agriculture systems are grouped into high-latitude rainfed systems with frigid winters, mid-latitude rainfed systems with mild winters, subtropical and tropical rainfed highland farm systems, and semi-arid tropical and subtropical agricultural systems.

Source: FAO, 2011

o. Environmentally Sensitive Areas (ESA) Monitoring using Indigenous Knowledge

ESAs are areas that are vital for the commodities, services, and life-support systems that they provide, such as water purification, pest management, and erosion control. Furthermore, they relate to locations that hold the nation's biodiversity's treasure (Ministry of Housing and Local Government, 2010).

Depending on the type, characteristic, and level of sensitivity/importance involved, it is critical that these regions remain unaffected by development, are protected, or sustainably maintained (Ministry of Housing and Local Government, 2010). The ESA are ranked as ESA 1, 2, or 3 based on these management criteria:

- ESA Rank 1: No development, agriculture or logging shall be permitted except for low-impact nature tourism, research and education.
- ESA Rank 2: No development or agriculture. Sustainable logging and low impact nature tourism may be permitted subject to local constraints.
- ESA Rank 3: Controlled development whereby the type and intensity of the development shall be strictly controlled depending on the nature of the constraints.

Figure 3.19 illustrates the map of ESAs in Peninsular Malaysia according to ESA 1, ESA 2 and ESA 3 rankings.

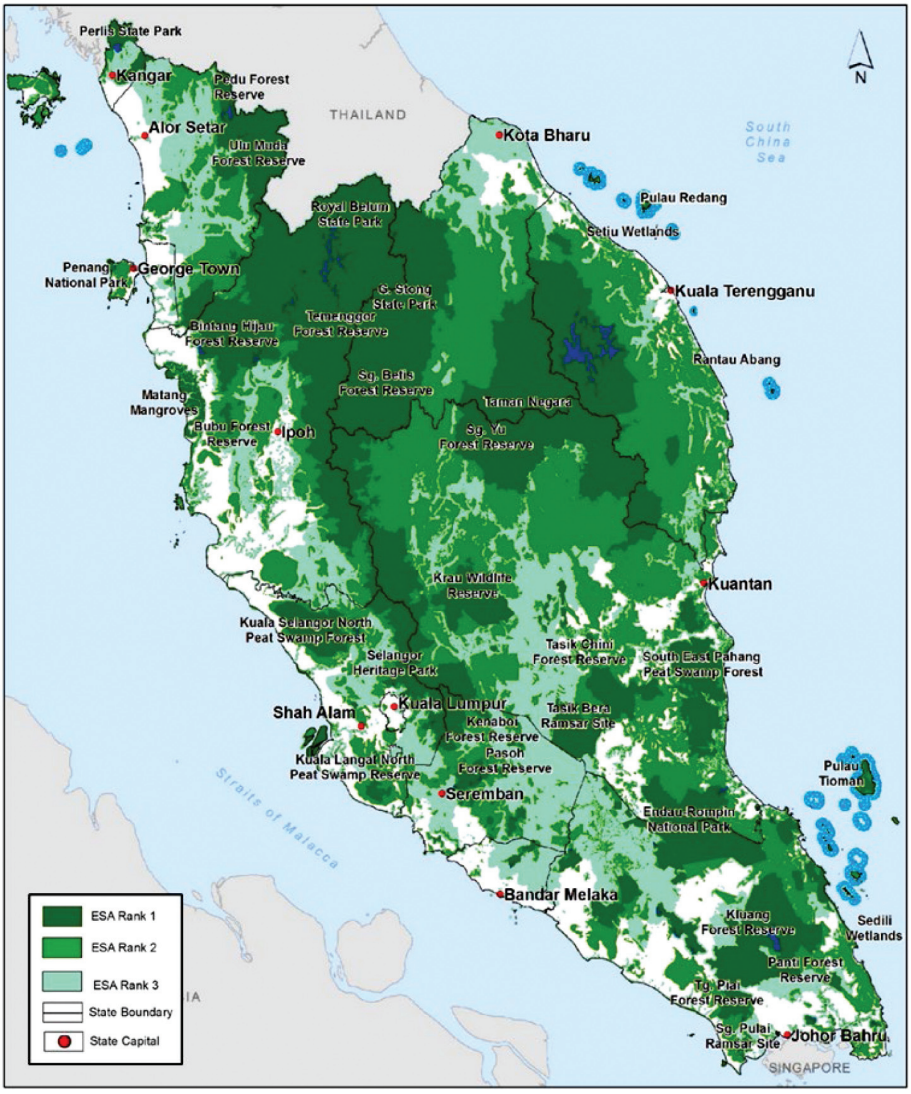


Figure 3.19: Map of ESAs in Peninsular Malaysia
(Ministry of Housing and Local Government, 2010)

Examples of ESAs monitoring using indigenous knowledge in Malaysia include habitat for wildlife, fireflies and river terrapins.

IWSDC will integrate the applications of indigenous knowledge through Open Science which will be the basis of sharing information on water and water related data. These data will be useful for the planning and development of water for environment and biodiversity by identifying the vulnerable areas as well as the potential alternative areas for the habitat requirements of flora and fauna across the country.

Box 3.10: Indigenous Knowledge of the Environment

Local and indigenous knowledge refers to the understandings, skills, and philosophies produced by communities with extensive histories of engagement with their natural surroundings. Local knowledge supports decision-making on key aspects of daily living for rural and indigenous peoples. This knowledge is part of a larger cultural complex that includes language, classification systems, resource management methods, social interactions, ritual, and spirituality. These distinct methods of knowing are significant aspects of the world's cultural variety, and they serve as a basis for locally suitable, long-term development.

Source: UNESCO, 2021

Box 3.11: Conservation of Natural Ecosystems

Habitat Requirement for Wildlife

Kerian border, Larut Matang and Manjung areas in The Matang Mangrove Forest Reserve, are almost fully covered by soft mud, the most suitable medium for various mangrove plant species. The vegetation acts as the natural habitat for a wide variety of wildlife such as insects, small fishes, reptiles, amphibians and, particularly, migratory birds that forage food before continuing their flight.

Source: AR & M, 2018

River Terrapin

River terrapins help maintain the quality of the river water by feeding on carrion. Conservation of the terrapins is important because of their ecological services as scavengers, herbivores, and carnivores, and often contribute significant biomass to the ecosystems.

The rivers of Kedah, Perak and Terengganu are major nesting grounds of the river terrapins. Pasir Temir and Pasir Lubuk Kawah by the Terengganu River are the largest nesting sites in the world for the river terrapin species, *Batagur baska*. In addition, there are 200 river Batagus affinis terrapins at Sungai Kemaman, Terengganu.

Source: The IUCN SSC Asian Species Action Partnership (ASAP), 2021

Fireflies

Kampung Kuantan Fireflies Park is home to one of the world's largest firefly colonies. They hinge on the Berembang mangrove trees, which serve as a source of food and shelter. Berembang trees usually grow in the wild along the banks of Selangor River as the conditions of the swampy and damp environment provide an ideal breeding ground for the fireflies.

The water quality of this river and its environment greatly influences the area's ecosystem which, if not preserved properly, can have disastrous effects on the mangrove swamp that serves as the fireflies' habitat.

Source: Tenaga Nasional, 2019; BERNAMA, 2021

p. WST2040 Monitoring Report

WST2040 is a 20-year long transformation plan which encompasses eight Sub-Sectors. Each of the Sub-Sectors has proposed strategies which outlines programmes and activities under the long-term plan. Upon EPU's approval, a comprehensive monitoring system based on criteria approved by a dedicated committee is necessary as an instrument to monitor the progress of the outcomes from the strategies undertaken by each Sub-Sector.

WST2040 Monitoring Report is proposed to be the instrument for measuring outcome-based impacts of the implementation strategies and initiatives by each Sub-Sector. The development and implementation of a monitoring system is important in ensuring all development projects and initiatives planned by the government under the WST2040 succeed according to plan.

i. WST2040 Monitoring System

A monitoring system needs to provide basic data and statistics regularly and interpret the data critically. The monitoring system will need to develop a set of indicators, establish baseline data, and guidelines for assessment on achievement (Mokhtar, Chan, & Goh, 2009).

The output-outcome-impact framework is shown in Figure 3.20. Outputs are the direct products or services delivered by the projects or initiatives. The outputs, combined in a complex way, will lead to the desired outcomes of the project or initiative as described in its objective. The outputs and outcomes provide a visualisation of the impact which is the changes after the project has been implemented (Mokhtar, Chan, & Goh, 2009).

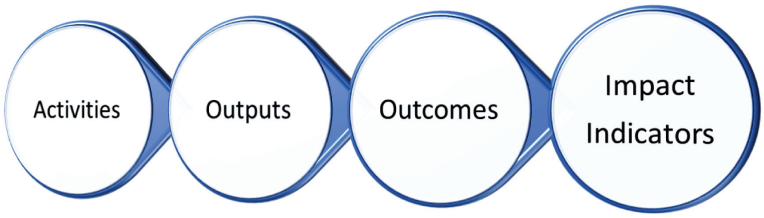


Figure 3.20: Output-outcome-impact framework

A sustainable monitoring system involves a continuous data collection and data analysis processes over the long term. It is important that the proposed collecting and analysing agencies commit themselves to provide information on a timely basis to continue sustaining the monitoring system (Mokhtar, Chan, & Goh, 2009).

Guidelines for assessing the progress of WST2040 shall be developed to cover technical information and technical worksheet for analysing and reporting. The performance progress could then be reported, and subsequently provide feedbacks.

ii. WST2040 Monitoring Committee

The design and management of the WST2040 monitoring system could be placed under IWSDC. The overall WST2040 proposals will need go through an approval process by EPU. This will include the formation of the WST2040 Monitoring Committee. The system will have to be designed based on the requirements of the Monitoring Committee relevant to the outcomes for each Sub-Sector.

WST2040 Monitoring Report will monitor and measure the achievement of the outcomes as proposed by each Sub-Sector which are approved by EPU. Appropriate indicators will be set for each outcome, as the monitoring tool to measure their achievement. Amongst the strategies proposed by each Sub-Sector, whose outcomes will require monitoring are shown in **Table 3.2**.

WST2040 Monitoring Report will be one of the strategic reports produced under IWSDC. This report will be the instrument to monitor the progress and achievements of the outcomes proposed under each Sub-Sector at all levels of planning, implementation, and evaluation. Specific indicators will be developed and will be used as the monitoring tool of the outcomes. This shall be developed upon the approval by EPU and consequent formation of the Monitoring Committee. The system will then be designed based on the requirements of the Monitoring Committee. The ASM Water Committee is proposed to spearhead the committee.

Table 3.2: Sub-Sectors Strategies

Sub-Sector	Strategy
AACB	Quadruple Helix stakeholders training Institutionalisation of Public Participatory Platform (PPP) Enforcement of policies and laws for better water governance via AACB Training Strategic partnership and establishment of resource person directory within Government's local/regional/international network Integrated and comprehensive data sharing and management for AACB programmes Publication and dissemination of best water management practices from Resource Person through public communication Funding for non-structural capacity building towards IWRM Tax incentives, awards, and recognitions to water managers IWRM training centres and *Pusat Informasi Sungai* Nucleus and complimenting Training Centres at national and state level
IWSDC	Establishment of an Integrated, Single-point Reference Centre Strategic Reports on Water Management Water Data Platform (water data and information interactive platform) RDIC Collaboration Platform Seamless Data Sharing Tools to Quantify and Assess Water Governance Public Participation Platform Establish Water Hub Capacity Building and Talent Development for Water Stakeholders
IR4.0WS	Innovation & Research and Development Centre (Centre of Excellence) Smart Water & Smart Citizen Water Wise & Smart Cities Digitalisation of manual water ecosystem Technology Advancement with Big Data Analytic & Data Warehouse, Blockchain & Artificial Intelligence Framework
WFE	National Water Department and River Basin Organisation (RBO) under KASA Needs Assessment at river basin level for WFEN policymaking WFEN Technical Guide and Manual WFEN Centre of Excellence WFE Nexus Modelling in key river basins Economic valuation of water at key river basins WFEN database and DSS in all river basins Indigenous WFEN infrastructure and technology mainstreaming and marketing
IR4.0	Innovation & Research and Development Centre (Centre of Excellence) Smart Water & Smart Citizen Water Wise & Smart Cities Digitalisation of manual water ecosystem Technology Advancement with Big Data Analytic & Data Warehouse, Blockchain & Artificial Intelligence Framework
WFE	National Water Department and River Basin Organisation (RBO) under KASA Needs Assessment at river basin level for WFEN policymaking WFEN Technical Guide and Manual WFEN Centre of Excellence WFE Nexus Modelling in key river basins Economic valuation of water at key river basins WFEN database and DSS in all river basins Indigenous WFEN infrastructure and technology mainstreaming and marketing

Table 3.2: Continued

Sub-Sector	Strategy
CCIA	Disaster preparedness and recovery Adaptive capacity to climate change Integrated climate change adaptation and disaster risk reduction approach Evidence-based and risk-informed actions, data driven decision-making, and knowledge assimilation in planning and implementation Financial capacity for climate resilience Technical capacity of operational agencies at the river basin level Investment in disaster risk management Adaptive capacity to climate change Regional linkages on disaster risks, climate change and IWRM Community engagement and capacity in disaster management
VWWF	VW & WF awareness amongst the public and industry Financial rewards and incentives Policy and law to support WF initiative Strengthening WF governance and WF in businesses VW & WF global trade Institutional set up Model river basin
AWF	Financial Sustainability of Water and Sewerage Operators New policy and regulatory instruments to support AWF Sewerage assets 'Facility License' Private investment and public participation in water supply, sewerage, and other non-tariff activities Disaster Risk Financing & Alternative Financing Utilisation of Green Climate Fund (GCF) Wakaf Air, Land Swap, PFI, PPP and PBC, Minimum Exposure Policy, and Cash Waqf Sukuk Implementations Development Bank (DB) for Water or Water Bank
WES	Institutional reforms at all levels Water tariff review Improved demand side water management Coordinated Collaborative Platforms Interconnected Water Supply System Multi- and Inter-Disciplinary talents in water sector Value Creation of Local Water Sector Integrated Smart Water Grid System

3.4.4 Big Data Analytics, Blockchain, and Artificial Intelligence

Big Data Analytics, Blockchain and Artificial Intelligence are three technological tools which will be utilised by IWSDC to enhance its data analysis, strengthen its products and services, and assist in decision-making. These technologies could also be applied in tandem with crowdsourcing activities. Some application examples include reporting of floods and water pollution and the management of paddy irrigation scheme.

Box 3.12: IR4.0 Technologies

Internet of Things

Internet of Things (IoT) is the concept of connecting any device to the Internet and to other connected devices. The IoT is a massive network of connected things and people – all of which collect and share data about the way they are utilised and about their surrounding environment.

Source: IBM, 2016

Big Data Analytics

Big data analytics is the complex process of examining big data to uncover information such as hidden patterns, correlations, market trends and customer preferences that can help organisations make informed business decisions. It is a form of advanced analytics, which encompasses complex applications with elements such as predictive models, statistical algorithms and what-if analysis driven by analytics systems.

Source: TechTarget, 2021

Blockchain

A blockchain is a database that stores encrypted blocks of data then chains them together, forming a chronological single-source-of-truth for the data. Instead of being copied or transferred, digital assets are distributed creating an immutable record of an asset. The asset is decentralised, allowing full real-time access and transparency to the public. A transparent ledger of changes preserves integrity of the document, which creates trust in the asset. Blockchain's inherent security measures and public ledger make it a key technology for almost every single sector.

Source: IBM, 2018

Artificial Intelligence (AI)

Artificial intelligence refers to systems or machines that mimic human intelligence to execute tasks and can iteratively improve themselves based on the information they collect. AI manifests in several forms such as: AI manifests in a number of forms such as:

a) Chatbots use AI to understand customer problems faster and provide more efficient answers
b) Intelligent assistants use AI to parse critical information from large free-text datasets to improve scheduling
c) Recommendation engines can provide automated recommendations for TV shows based on users' viewing habits

Source: ORACLE, 2021

3.5 Support

For the IWSDC to be successfully implemented, it will require a support structure as shown in **Figure 3.21**, which comprises:

a. Technology
b. Institutional Structure
c. Finance, and
d. Human Resources

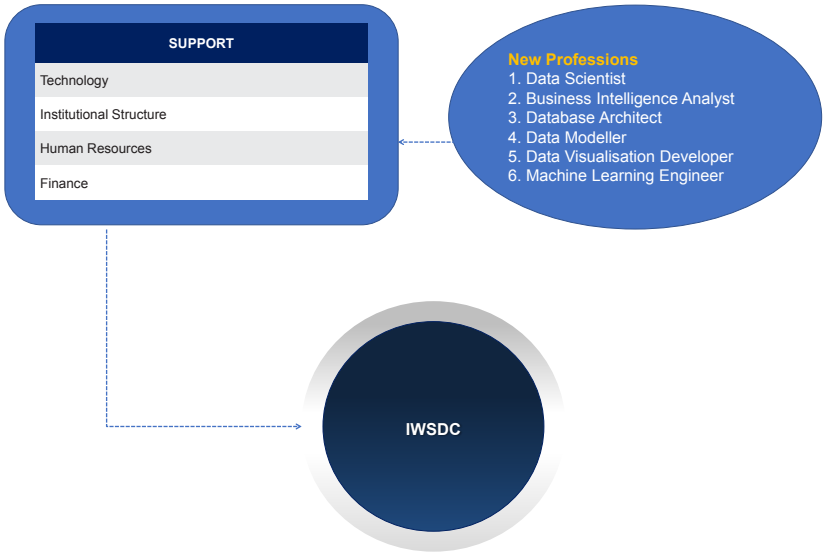


Figure 3.21: IWSDC Support

3.5.1 Technology

IWSDC will utilise space technology in coordination with MYSA, which is planning to launch a high-resolution satellite of (0.5m x 0.5m) in 2025 and renting three other satellites with similar capabilities. The combination of remote sensing and data technologies will enable IWSDC to develop applications such as irrigation monitoring management for paddy field area, artificial intelligence approaches to water catchment monitoring using remote sensing data and water quality modelling based on space based remote sensing applications. IWSDC will also be developed with built-in capabilities in latest data technologies such as big data analytics, artificial intelligence and blockchain. These applications are just a few samples of activities that illustrate the vision of IWSDC as a one-stop centre that will apply the latest technologies and utilise an integrated water data for the development of applications that will become catalysts for RDIC activities in the country.

Box 3.13: High-Resolution (0.5m x 0.5m) Satellite

A 0.5m high-resolution satellite image allows users to clearly see buildings, small boats, and narrow streets.

The satellite-based sensors orbiting Earth can now measure precipitation, evaporation, surface water levels, soil moisture, snow depth and groundwater, amongst others.

Whereas, the Remote Sensing Satellite imagery can now change the way people manage water resources, farmlands, rainforests, environmentally sensitive areas, and perform research.

Source: EOS, 2019

a. Space Technology as the New Frontier in Water Management

Figure 3.22 shows the 0.5m high-resolution satellite captured the changes in forest coverage from deforestation in and around Chiribiquete National Park (most of the area right of the Yarí River, Colombia). This shows how deforestation activities can be monitored remotely to ensure a more integrated approach to water resource and man-made disaster management.

Figure 3.23 shows a pair of images for part of the Upper Klamath National Wildlife Refuge, USA. In 2020, drainage channels appeared flooded by dark water from Agency Lake, whereas in 2021, water levels appeared lower, as a result of sustained drought in the area.

Currently, MYSA is a subscriber to satellite services from foreign countries including SPOT (France), PLEADES (France) RADARSAT (Canada) as well as from free satellite data providers namely NOAA (US) and MODIS (US). The satellite data from these providers is transmitted to MYSA's Satellite Operation

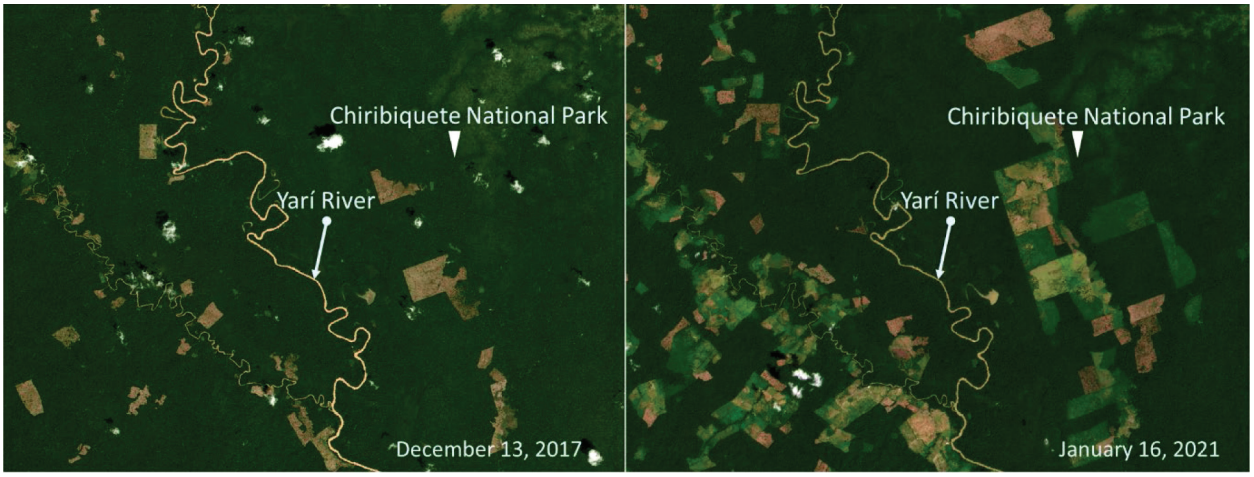


Figure 3.22: Water Resource Monitoring – Deforestation
(Planet Labs Inc., 2020)

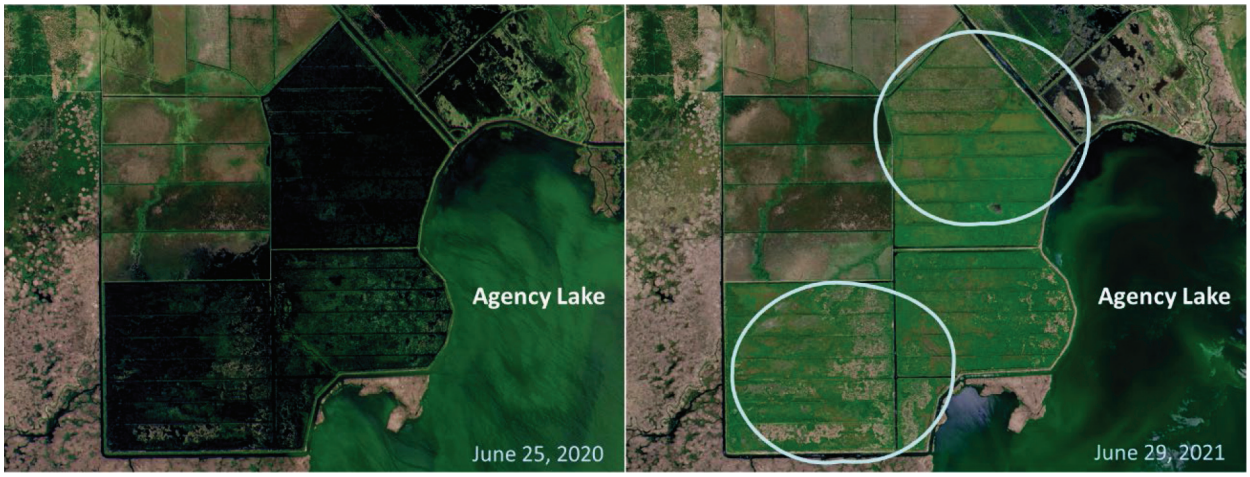


Figure 3.23 Environmentally Sensitive Areas (ESA) – Wetlands
(Planet Labs Inc., 2020)

Box 3.14: Applications of Remote Sensing Satellites in Water Management

Ground-based monitoring of water management can be supplemented with the use of Earth Observation (EO) technologies using satellite-based monitoring which can be very useful as it can provide a cost-effective means of replacing or complementing field data collection. EO technology provides coverage over large and remote areas with systematic, repetitive data captures. Integration of EO data with the in-situ collected data (i.e., real-time) produces effective up-to-date predictive and analytical products. Water management using in-situ data and remote sensing techniques can be applied in:

a) mapping of water bodies to determine the amount of surface water available in each area
b) water resource management and prospecting to provide solution to problems in ground water availability, reservoir management, soil erosion and flood risk mapping
c) space-based Remote Sensing in Disaster Management through rainfall forecasting, determining Digital Elevation Models (DEM), and flood water cover and after-disaster assessment.

Complex (SOC) in Temerloh, Pahang. An Antenna system purchased from Zodiac Data Systems; France is installed at SOC and can receive high resolution satellite data (0.5m). The system functions automatically and can trace the satellite in space at approximately (± 0.5 °). The radius of coverage area is 2000km from the SOC. The SOC can receive satellite data twice a day from these providers.

The SOC uses Direct Receiving Station Multi Mission (DRS MM) from Airbus DS GEO, France which processes satellite data from SPOT and Pleiades. This DRS MM system consists of specific hardware and software to produce standard satellite data from SPOT (1.5m resolution) and Pleiades (0.5m resolution).

Figure 3.24 and **Figure 3.25** show the Satellite Image Resolution Comparison of Masjid Putra, Putrajaya from a low resolution satellite to high resolution satellite (Pleiades 0.5m subscribed by MYSA). The high-resolution satellite capability enables MYSA to conduct remote sensing activities in many areas including water management. Once MYSA launches its own satellite in 2025, it will have higher degree

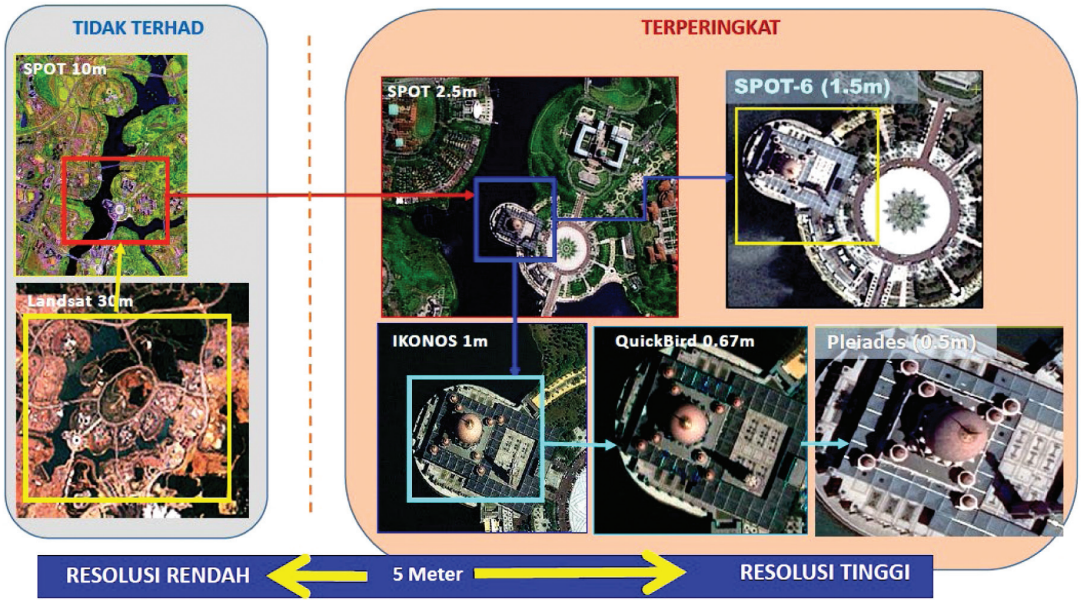


Figure 3.24: Satellite Image Resolution Comparison of Masjid Putra, Putrajaya (1/2)
(Malaysian Space Agency, 2021)



Figure 3.25: Satellite Image Resolution Comparison of Masjid Putra, Putrajaya (2/2)
(Malaysian Space Agency, 2021)

of independence and flexibility over the whole satellite data spectrum, from procurement to processing and distribution. Furthermore, with ownership, its capacity in the overall technological expertise related to satellite management will also be enhanced.

b. IR 4.0 Technologies

IR4.0 technologies will complement projects conducted by IWSDC, such as producing strategic reports or RDIC activities to enhance the technical and analytical capabilities, as well as to produce smart data-driven solutions for the stakeholders in the water sector.

3.5.2 Institutional Linkages

To successfully establish the IWSDC as a one-stop centre for water data, there must be a linkage between IWSDC and institutions that collect these data throughout the country. The IWSDC itself would not be collecting any primary or secondary water related data, but it will collect and integrate data from various institutions. This arrangement will ensure that IWSDC will not interrupt the current operations of various data collecting institutions in the government, and they will be able to continue with their traditional operational functions.

Next, the IWSDC will integrate, process, and analyse the data to produce outputs such as data and statistics for operations, strategic reports, applications and reports using big data analytics and artificial intelligence, and be a precursor to RDIC related activities. These outputs will be beneficial to various government agencies, universities, research institutions, NGOs, and businesses. Subsequently, the IWSDC will also become a platform of collaboration for businesses and start-ups to germinate and develop any ideas that could be translated into successful projects. IWSDC could provide facilities such as accessibility to data, linkages to research and development institutions, as well as possible access to financing by third party. The proposed overall IWSDC institutional linkages are shown in **Figure 3.26**.

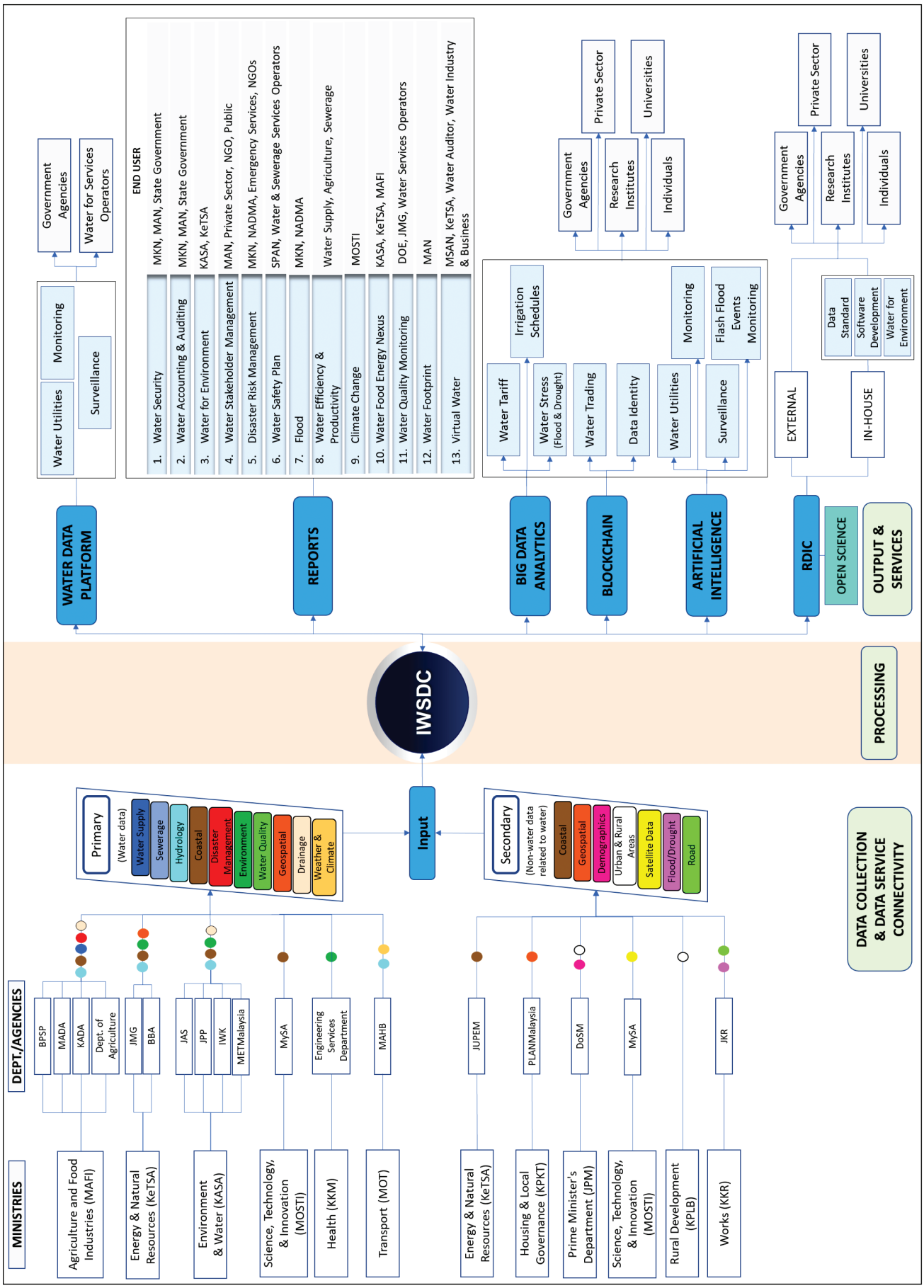


Figure 3.26: IWSDC Institutional Linkages

3.5.3 Finance

The IWSDC also requires financial and budgetary support to institutionalise its establishment as well as to sustainably operate and maintain the organisation. The detailed breakdown of IWSDC's budgetary requirements for both capitalisation as well as operations and maintenance are included in **Chapter 5**: of this report.

3.5.4 Human Resources

The IWSDC also requires multi-disciplinary and cross-sectorial expertise to ensure its viability as a one-stop data centre. Thus, it requires experts in data and database related fields such as data scientist, data analysts and data visualist. It also requires experts and researchers in various fields of science, social science, and engineering to properly utilise the data collected in IWSDC and produce strategic reports of value such as water accounting, water for the environment and water footprints and virtual water, to conduct in-house RDIC activities and coordinate external research efforts, as well as assist in space-based data analysis for water sector. The IWSDC will also be supported by experts in information technology, finance, human resources, and corporate matters.

a. Organisation Chart

The overall organisation chart for IWSDC is proposed as per **Figure 3.27** to **Figure 3.31**, outlining the various departments required for the IWSDC to fulfil its functions and duties properly.

Detailed Human Resources requirements for all divisions in IWSDC is as per **Appendix F** while the cost estimates are detailed in **Chapter 5:** of this report.

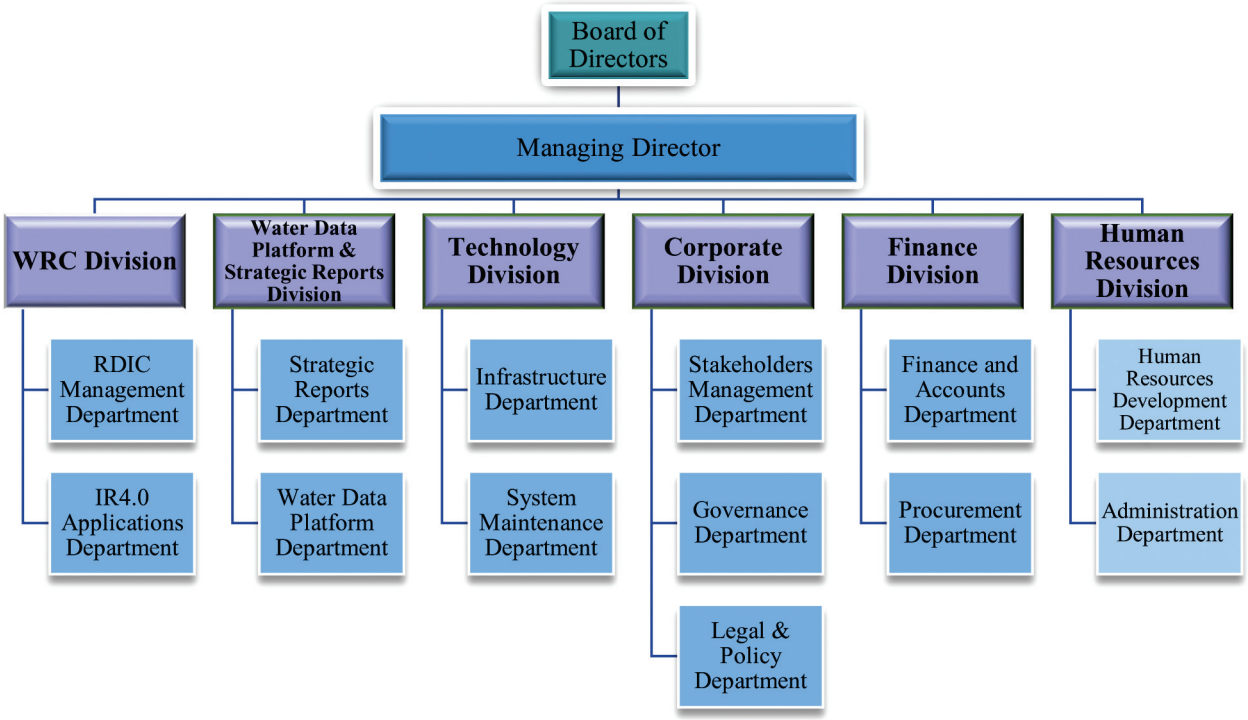


Figure 3.27: IWSDC Overall Organisation Chart

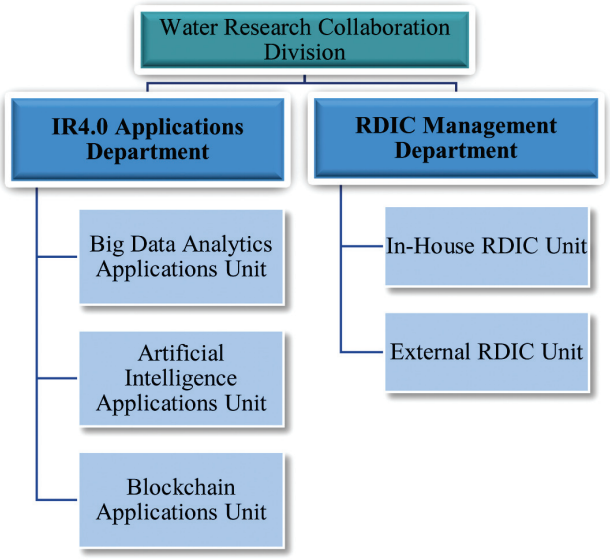


Figure 3.28: Water Research Collaboration Division

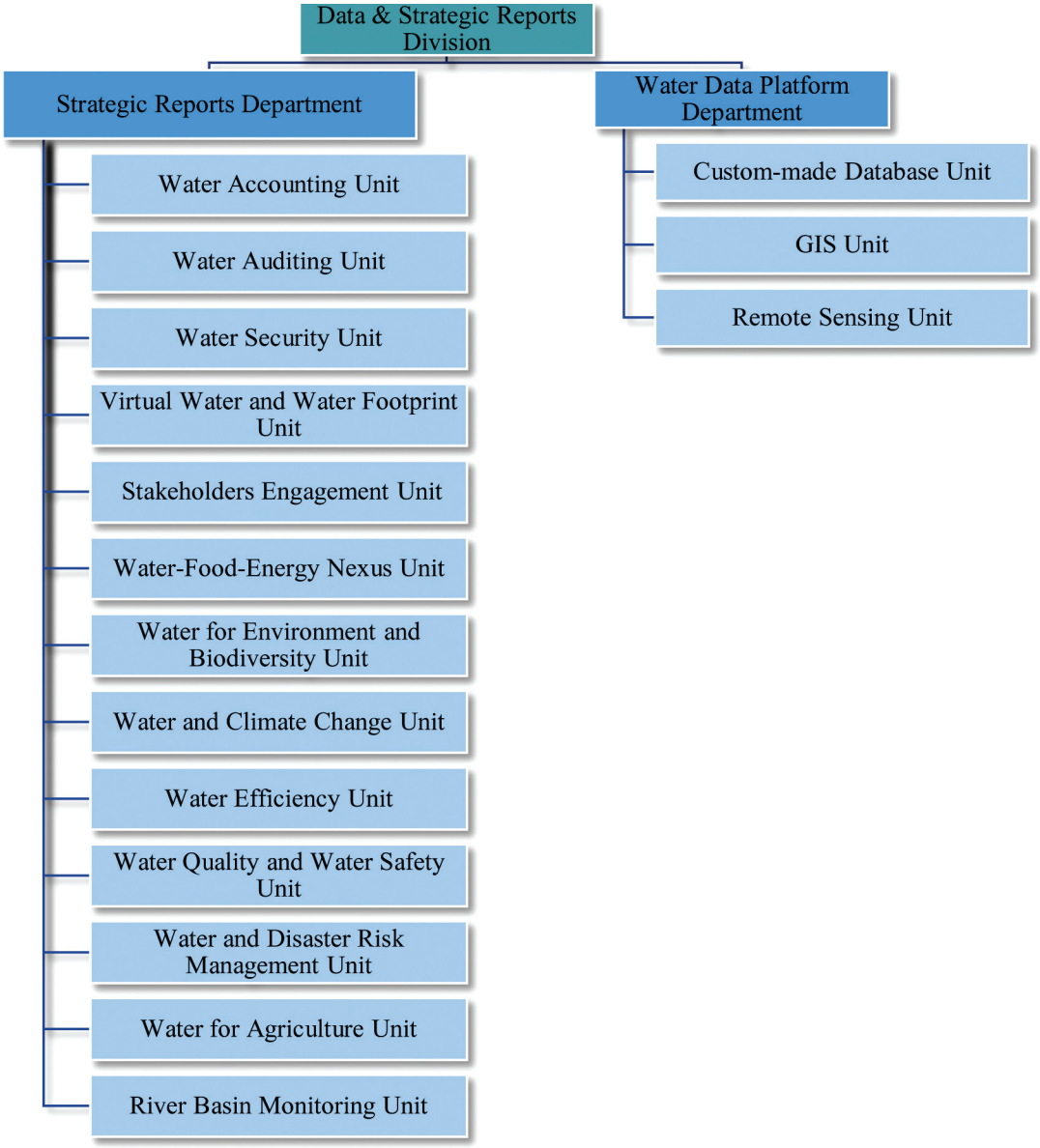


Figure 3.29: Water Data Platform and Strategic Reports Division

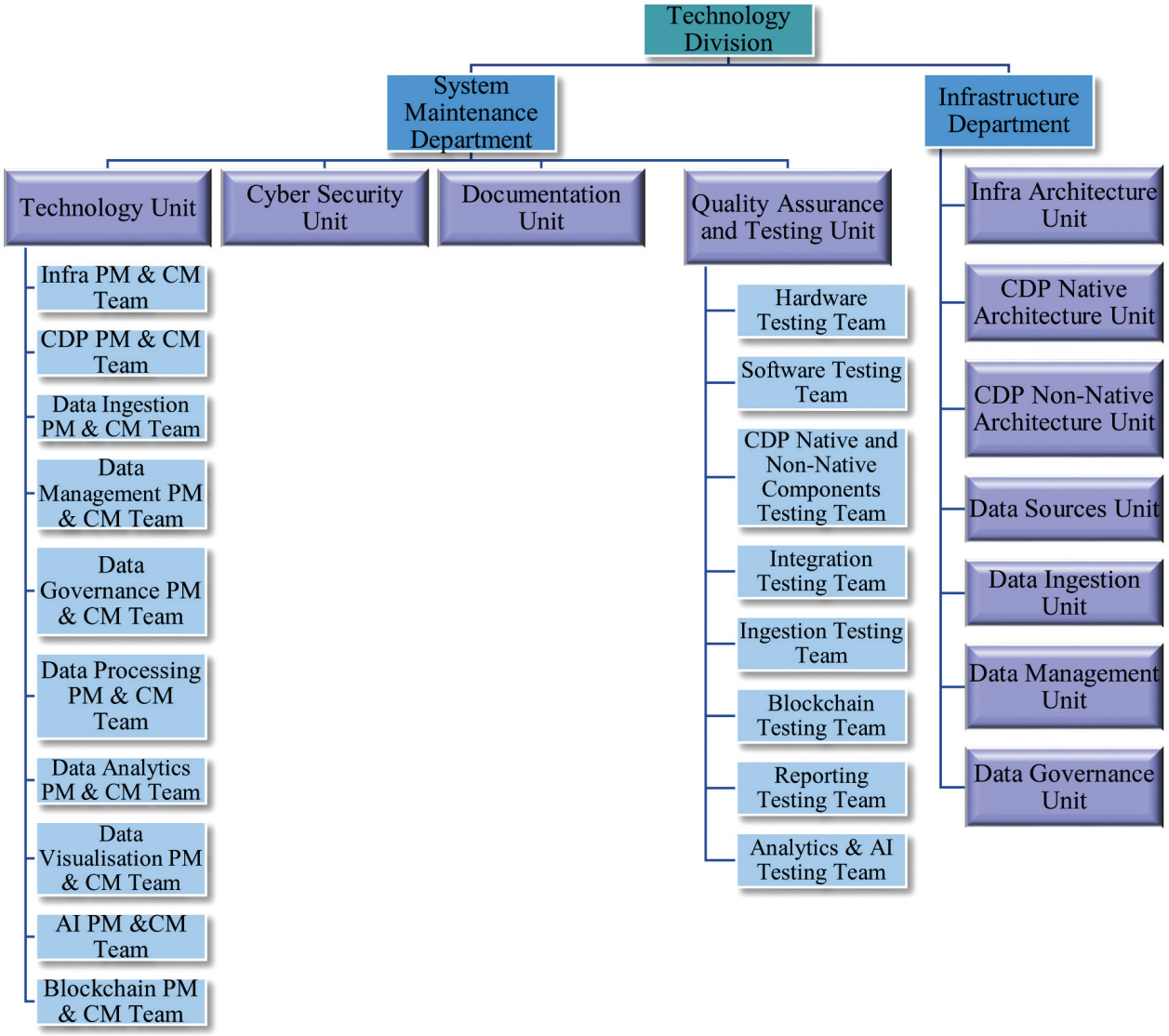


Figure 3.30: Technology Division

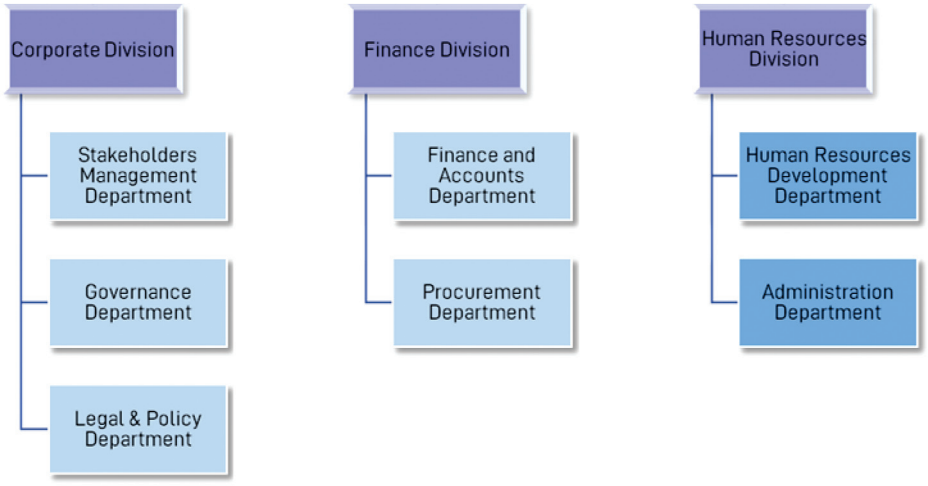


Figure 3.31: Corporate, Finance and Human Resources Divisions

3.6 Enablers

The enablers for IWSDC are policy and legal foundations which will become a source of authority for IWSDC to operate (**Figure 3.32**). The proposed policy and legal arrangements for IWSDC include the following:

a. Data sharing agreements with data collectors and providers
b. National Data Sharing Policy
c. National Data Sharing Law

The IWSDC will also take into consideration the following aspirations as the enables, namely:

a. SDG2030
b. WKB2030
c. WST2040
d. 12th MP
e. NSP 2021-2025
f. MyDIGITAL
g. 10-10 MySTIE

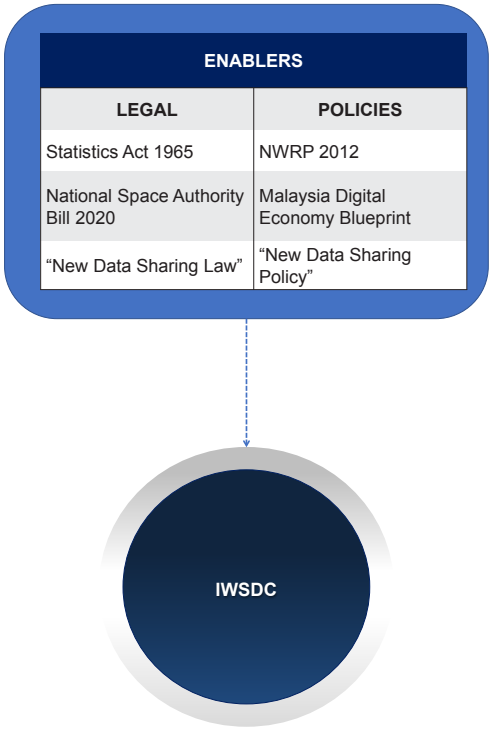


Figure 3.32: IWSDC Enabler

In the interim, data sharing agreements with data collectors will be made on a bi-lateral or multi-lateral basis, where IWSDC will sign agreements with various data providers, including Sabah and Sarawak state agencies. The next steps are the drafting and eventual adoption of a National Data Sharing Policy and subsequently, a National Data Sharing Law.

Currently, a National Data Sharing Policy has already been prepared for the Cabinet. This policy is, however, not affirmative in nature but more of a guideline for public and private sectors to share data in a more open manner. Nevertheless, this is an important first milestone towards the implementation of an affirmative data sharing policy and subsequently a National Data Sharing Law. The IWSDC's functionalities in terms of data sharing can be enhanced based on the approval of this Draft National Data Sharing Policy.

Chapter 4
IWSDC Roadmap

4.1 Roadmap

The IWSDC's roadmap towards achieving the targets under WST2040 is summarised in **Figure 4.1,** while the detailed roadmap is in **Table 4.1.** The roadmap is structured in four Phases along the timeframe of the five-year Malaysia Plans and with a specific theme for each Phase, namely:

a. 12th MP (2021-2025) – WST2040 Phase 1: Accelerating Adoption of IWRM
b. 13th MP (2026-2030) – WST2040 Phase 2: Developing Indigenous Technology to be on par with International Standards
c. 14th MP (2031-2035) – WST2040 Phase 3: Achieving Economies of Scale
d. 15th MP (2036-2040) – WST2040 Phase 4: Becoming the Regional Water Industry Hub

4.1.1 12th MP: WST2040 Phase 1: Accelerating Adoption of IWRM

Water data and information integration is a strategic move in accelerating the IWRM implementation. The establishment of the IWSDC by 2025 shall be the main target (**Table 4.1**). The planned launching of a satellite by MYSA in 2025 is identified as an important milestone which IWSDC will leverage on. Establishment of IWSDC will begin after a detailed design study is completed by 2023. This will be followed by physical establishment activities such as physical works, installation of equipment and software and other capacity building programmes such as establishing the organisation, training and setting-up programmes including undertaking Water Platform Pilot Projects involving ground-based as well as space-based data and information. The initial set up will enable IWSDC to execute the initiatives under 12th MP as the following:

a. The integration of water data and non-water data through institutional linkages between IWSDC and government departments, research institutions, and the private sector. These linkages will be established via data sharing arrangements or agreements with various data providers.
b. The production of thirteen named Strategic Reports to complete the full spectrum of water management that are not currently being produced by any Government Agencies.
c. The establishment of IWSDC Water Data Platform as an interactive platform for sharing of water data and information. This will be initiated with Water Data Platform Pilot Projects on four river basins as a proof of concept for the IWSDC. The river basins for the Pilot Projects have been selected based on the completed IRBM studies conducted by JPS, namely Sg Perak, Sg Linggi, Sg Padas (Sabah) and Sg Miri (Sarawak). IWSDC will also establish an Integrated River Basin Management System Solution which will incorporate space-based technology for these river basins. This system will be expanded for implementation in all RBMUs in the next phases.
d. The establishment of Water Research Collaboration Platform that facilitates the sharing of data and information for the development of water RDIC projects in 12th MP using space technology (3 RDIC projects) and ground-based applications (3 RDIC projects) that will eventually stimulate the creation of new entrepreneurs, businesses, services, and products in advanced science.
e. The establishment of initiatives and review of Policies and Laws to enhance data sharing. This involves a data sharing arrangement between all primary and secondary data collectors, and the review of Data Sharing Policy, Data Sharing Law, Fees Act 1951, and Statistics Act 1965. The drafting of a national data sharing policy and law will be initiated.
f. Acceleration of Open Science and Open Data through crowdsourcing and utilisation of indigenous knowledge as components to data input.
g. Malaysia to be part of at least one international Open Data Alliance for higher level of data and information sharing, advanced sciences, and businesses collaborations, and attracting foreign investment.

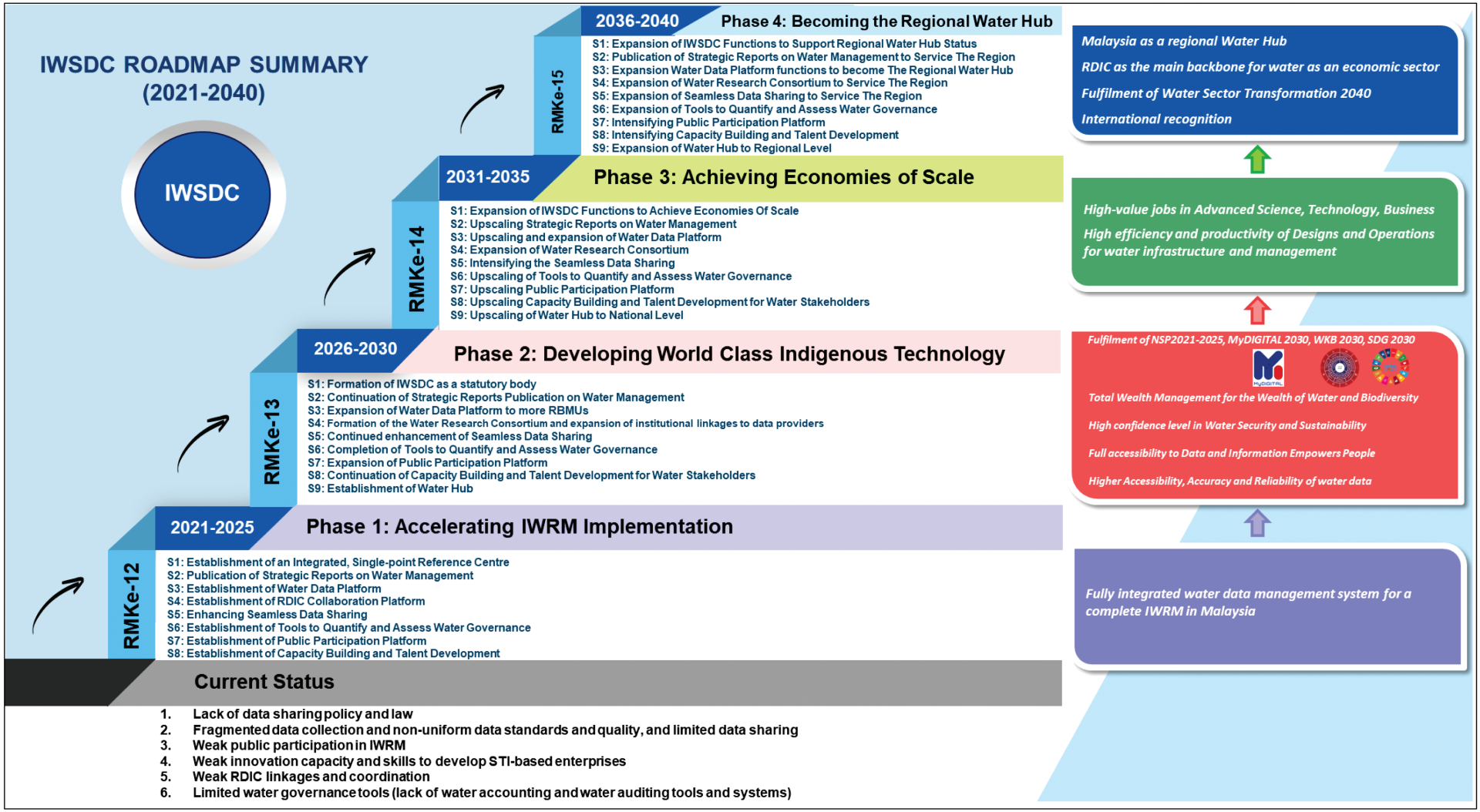


Figure 4.1: IWSDC Roadmap Summary

h. The adoption of sound governance tools and systems via Water Accounting and Water Auditing. The governance tools and systems will be promoted for adoption in the 16 major RBMUs.

i. The establishment of a formal Public Participation Platform. This will be complemented by the production of annual reports on Stakeholder Management, facilitation of stakeholder linkages, a register of stakeholders in 16 RBMUs and the adoption of AACB training modules.

j. Annual capacity building and talent development programmes for water stakeholders in Space Technology, Data Technology, and Water Sector Management. The programmes will continue in the next phases.

4.1.2 13th MP: WST2040 Phase 2: Developing Indigenous Technology to be on par with International Standards

By 13th MP, the formalisation of IWSDC as a statutory body will be completed. IWSDC will accelerate all programmes initiated under Phase 1, by focussing on facilitating the creation of new STI-based enterprises and RDIC projects. In relation this, IWSDC will continue the initiatives under 13th MP as the following:

a. The formation of Water Research Consortium with RDIC players. The continuation of the Water Research Collaboration Platform with 10 RDIC projects involving space technology and 10 ground-based applications in 13th MP.

b. The continuation of annual publications of Strategic Reports.

c. The expansion of Integrated River Basin Management System Solution implementation into an additional 30 river basins.

d. The expansion of institutional linkages between IWSDC and government departments, research institutions, and the private sector, along with stakeholder management support.

e. The passing of a national data sharing policy and law to facilitate seamless data and information sharing in the country.

f. The expansion of Open Science initiatives and indigenous knowledge utilisation in water resources management.

g. The expansion of the water governance tools and systems (Water Accounting and Water Auditing) to 30 major RBMUs.

h. The establishment of a Water Hub. The physical development of the Water Hub will include the development of a Water Hub Master Plan. The northern region, which is being developed by the NCER, is one area that could be considered as a water hub.

i. The continuation of capacity building and talent development programmes for water stakeholders.

4.1.3 14th MP: WST2040 Phase 3: Achieving Economies of Scale

By 14th MP, the IWSDC shall be the main platform for the expansion of the water industry leading to achieving the economies of scale. The initiatives under 14th MP includes:

a. The continued production and expansion of the annual strategic reports.

b. The upscaling and expansion of the Integrated River Basin Management System Solution into an additional 50 river basins.

c. The Water Research Consortium at IWSDC shall support the growth of water hub by upscaling space technology and ground-based data applications and water RDIC activities to support new and maturing businesses, enterprises, and entrepreneurs in STI to achieve economies of scale. The continuation of the Water Research Collaboration Platform with 30 RDIC projects involving space technology and 30 ground-based applications in 14th MP.

d. The upscaling and expansion of Open Science and Open Data initiatives to international level.

e. The upscaling and expansion of the water governance tools and systems to 50 major RBMUs.

f. The upscaling and expansion of institutional linkages between IWSDC and government departments, research institutions, and the private sector, along with stakeholder management support.

g. Upscaling of Water Hub to national level.

h. The upscaling and expansion of capacity building and talent development programmes for water stakeholders.

4.1.4 15th MP: WST2040 Phase 4: Becoming the Regional Water Industry Hub

By 15th MP, the applications of space technology and IR4.0 technology for water management will be the major strength of the IWSDC at ASEAN level. Initiatives under 15th MP includes:

a. Continued production and expansion of the strategic reports.

b. The full implementation of Integrated River Basin Management System Solution in all 191 river basins.

c. Water Research Consortium to have the capacity to support national and international level RDIC. The continuation of the Water Research Collaboration Platform with 50 RDIC projects involving space technology and 50 ground-based applications in 15th MP.

d. The policy, law, and institutional linkages to support seamless data and information sharing.

e. The full adoption of Open Science and Open Data initiatives for data input and RDIC.

f. The full adoption of the water governance tools and systems at national level.

g. Upscaling of Water Hub to regional (ASEAN) level.

h. The upscaling and expansion of capacity building and talent development programmes for water stakeholders.

Table 4.1: IWSDC Roadmap for 12th MP to 15th MP

IWSDC ROADMAP FOR RMKe-12 to RMKe-15																		
Water Security and Water Sustainability & Water as an Economic Opportunity																		
No.	**Focus Areas**	**Strategy**	**Initiatives/Programmes**	**Activities**	**Lead / Implementing Agency**	**Collaborating Agencies**	**KPI**	**RMKe-12**					**RMKe-13**	**RMKe-14**	**RMKe-15**	**Output**	**Outcome**	**Notes**
							Units	**2021**	**2022**	**2023**	**2024**	**2025**	**2026-2030**	**2031-2035**	**2036-2040**			
Milestone			Satellite launch (by MYSA) *1 Malaysian *3 Rentals	High resolution remote sensing satellite launch	MYSA	MYSA	No. (1)					1				New tools and applications for IWRM and RDIC through space technology	**1.Fully integrated water data management system for a complete IWRM in Malaysia** **2.High confidence level in Water Security and Sustainability** **3. Total Wealth Management for the Wealth of Water and Biodiversity** **4. Full accessibility to Data and Information which Empowers People** **5. Complete Water Accounting and Water Auditing system for Water Governance** **6. Higher Accessibility, Accuracy and Reliability of water data** **7. Widespread applications and opportunities for high-value jobs in Advanced Science, Technology, Business** **8. Availability of reliable data for optimum data driven decision-making options in Investment Strategies** **9. High efficiency and productivity of Designs and Operations for water infrastructure and management** **10. Fulfilment of Digital Economy Blueprint 2030** **11. Fulfilment of Wawasan Kemakmuran Bersama 2030** **12. Fulfilment of Water Sector Tansformation 2040** **13. Fulfilment of Sustainable Development Goals 2030** **14. Malaysia as a Regional Water Hub**	
1	**Information and RDIC**	**(S1) Establishment of an Integrated, Single-point Reference Centre**	**(S1-I1) Establish IWSDC**	Establish IWSDC *Design study in 2022 A) Physical Infrastructure: 1. Physical space (rental, maintenance) 2. Existing data collection station modification B) Technology: 3. Software, Hardware, Network, Security 4. Big Data Analytics 5. Blockchain 6. Artificial Intelligence 7. Data standards C) Organisation: 8. Institutional Set Up 9. Human Resources 10. Capacity Building and Training Program 11. Linkages and Platform for RDIC to water and water-related data managers, and researchers	KASA	KASA, Federal and State Agencies, Private Sector	Phases (4)					Phase 1	Phase 2	Phase 3	Phase 4	**Physical Infrastructure:** 1. Establishment of IWSDC (RMKe-12) 2. Formalisation of IWSDC as a statutory body (RMKe-13) 3. Establishment of software, hardware, network and security systems 4. Seamless data Integration, distribution 5. Identification of the physical location of a Water Hub (RMKe-13) 6. Establishment of a Water Research Consortium (RMKe-13) **Technology:** 7. Standardised data 8. Extensive capabilities in space technology big data analytics, blockchain and artificial intelligence 9.Locally owned businesses, industries, products, technologies, software that is of international renown **Organisation:** 10. Human resources and institutional set up 11. Capacity building and training programs established		1. Phase 1 - 2023 - RMK-12 objectives - accelerating IWRM - Interim Launch - to have enough capacity to complete Water Platform Pilot Projects - Preparation for Satellite launch and ground-based space applications begin in 2023 2. Phase 2 - 2026 - IWSDC Core Team is established - Ready to support development of indigeneous technologies, businesses, applications - Establish IWSDC as a statutory body - Identify and establish a Water Hub 3. Phase 3 - 2031 - Expansion/scaling up of RMK12-13 objectives 4. Phase 4 - 2036 - Malaysia as a regional Water Hub - Water Research Consortium to support international RDIC
				D) IWSDC Operation 1. Maintenance 2. Upgrading 3. Emoluments		KASA	Phases (4)					Phase 1	Phase 2	Phase 3	Phase 4	Operational IWSDC		IWSDC Operational and recurring costs will be detailed in Costing
2	**Information and RDIC** **Finance Infrastructure and Technology**	**(S2) Strategic Reports on Water Management**	**(S2-I1) Strategic Reports Publication (annual)**	Stakeholder Management		Federal agencies, State agencies, Private Sector, NGO	No. (1/y)					1	5	5	5	Annual reports		Starts in RMKe-12 Continuous annual reports
				Virtual Water		Federal agencies, State agencies, Private Sector, NGO	No. (1/y)					1	5	5	5	Annual reports		Starts in RMKe-12 Continuous annual reports
				Water Footprint		Federal agencies, State agencies, Private Sector, NGO	No. (1/y)					1	5	5	5	Annual reports		Starts in RMKe-12 Continuous annual reports
				Water-Food-Energy Nexus		Federal agencies, State agencies, Private Sector, NGO	No. (1/y)					1	5	5	5	Annual reports		Starts in RMKe-12 Continuous annual reports
				Water for Environment and Biodiversity		Federal agencies, State agencies, Private Sector, NGO	No. (1/y)					1	5	5	5	Annual reports		Starts in RMKe-12 Continuous annual reports
				Water and Climate Change		Federal agencies, State agencies, Private Sector, NGO	No. (1/y)					1	5	5	5	Annual reports		Starts in RMKe-12 Continuous annual reports
				Water Efficiency		Federal agencies, State agencies, Private Sector, NGO	No. (1/y)					1	5	5	5	Annual reports		Starts in RMKe-12 Continuous annual reports
				Water Quality Monitoring		Federal agencies, State agencies, Private Sector, NGO	No. (1/y)					1	5	5	5	Annual reports		Starts in RMKe-12 Continuous annual reports
				Disaster Risk Management		Federal agencies, State agencies, Private Sector, NGO	No. (1/y)					1	5	5	5	Annual reports		Starts in RMKe-12 Continuous annual reports
				Water Safety Plan		Federal agencies, State agencies, Private Sector, NGO	No. (1/y)					1	5	5	5	Annual reports		Starts in RMKe-12 Continuous annual reports
				Rainfed Agriculture Monitoring		Federal agencies, State agencies, Private Sector, NGO	No. (1/y)					1	5	5	5	Annual reports		Starts in RMKe-12 Continuous annual reports
				Water Security Report		Federal agencies, State agencies, Private Sector, NGO	No. (1)					1	5	5	5	Annual Strategic Report on Water Security for the National Security Policy		Starts in RMKe-12 Continuous annual reports
				WST2040 Monitoring		Federal agencies, State agencies, Private Sector, NGO	No. (1/y)					1	5	5	5	Annual reports		Starts in RMKe-12 Continuous annual reports

IWSDC ROADMAP FOR RMKe-12 to RMKe-15

Water Security and Water Sustainability & Water as an Economic Opportunity

No.	Focus Areas	Strategy	Initiatives/Programmes	Activities	Lead / Implementing Agency	Collaborating Agencies	KPI	RMKe-12					RMKe-13	RMKe-14	RMKe-15	Output	Outcome	Notes
							Units	2021	2022	2023	2024	2025	2026-2030	2031-2035	2036-2040			
3	**Information and RDIC** **Infrastructure and Technology** **People** **Governance** **Finance**	**(S3) Water Data Platform (Water Data and Information Interactive Platform)**	**(S3-I1) Establish Water Data Platform** **(S3-I2) IWSDC Water Data Platform Pilot Projects**	**IWSDC Water Data Platform Pilot Projects:** A) Sg Perak River Basin Pilot Project a) Space Technology Applications in Water Management: 1. AI approach to water catchment monitoring 2. Water quality modelling via Remote Sensing and Artificial Intelligence 3. Irrigation monitoring management for Paddy Fields b) Ground-based Data Applications Framework: 1. Disaster Risk Reduction 2. Stakeholders Management 3. WFE Nexus 4. IR4.0 5. Water Footprint & Virtual Water 6. AACB 7. Climate Change 8. Water Accounting 9. Water Auditing 10. Environmentally Sensitive Areas (ESA) Monitoring and Indigenous Knowledge	KASA	MYSA, MAFI, KeTSA, Other Federal Agencies, Perak State Government	A) No. (Projects) a) No. (Projects) b) No. (1 Project each)			A) 1 →	a) 1 b) 1 →	a) 1	a) 1	3 (Continued)			1. New tools and applications for IWRM and RDIC through space technology: - Surveillance - Monitoring 2. Complete database for Sg Perak river basin		3 Space Technology projects beginning 2023 to continue until 2026 RMKe-13 to RMKe-15 will have new projects Open Science and Open Data to include indigenous knowledge and crowdsourcing programs and initiatives
				B) Sg Linggi River Basin (N. Sembilan/ Melaka)		MYSA, MAFI, KeTSA, Other Federal Agencies, N.Sembilan and Melaka State Governments	No. (1)				1 →					Complete database for Sg Linggi river basin		Water Platform Pilot Projects to include: 1. AI approach to water catchment monitoring 2. Water quality modelling via Remote Sensing and Artificial Intelligence 3. Irrigation monitoring management for Paddy Fields
				C) Sg Padas River Basin (Sabah)		MYSA, MAFI, KeTSA, Other Federal Agencies, Sabah State Government	No. (1)				1 →					Complete database for Sg Padas River Basin		
				D) Sg Miri River Basin (Sarawak)		MYSA, MAFI, KeTSA, Other Federal Agencies, Sarawak State Government	No. (1)				1 →					Complete database for Sg Miri River Basin		
			(S3-I3) Integrated River Basin Management System Solution for all other River Basins	A) Space Technology Applications in Water Management B) Ground-based Data Applications Framework		MYSA, MAFI, KeTSA, Other Federal Agencies, State Governments	All 191 RBMU					12 →	30	50	95	Complete database for all 191 RBMU		Continuous beyond RMKe-15
4	**Information and RDIC** **Infrastructure and Technology**	**(S4) RDIC Collaboration Platform**	**(S4-I1) Water Research Collaboration Platform (RDIC) on Space Technology Applications**	Space Technology applications on River Basin Management for entrepreneurs (including Citizen Developers)	KASA	NAHRIM, MOSTI, MYSA, MAFI, KeTSA, DOE, MPIC, MPOB, State agencies, Private Sector	No. (Projects)			1	1	1	10 →	30 →	50	New services, products and businesses based on Space Technology		IWSDC will be a collaboration platform to support RDIC activities with capabilities in: - Big Data Analytics - Blockchain - Artificial Intelligence
			(S4-I2) Water Research Collaboration Platform (RDIC) on Ground-based Applications	Ground based data Applications for Advanced Science Businesses			No. (Projects)			1	1	1	10 →	30 →	50	New services, products and businesses, including reports on River basin management status such as: ESA status, monitoring and surveillance		*Establishment of a Water Research Consortium (RMKe-13) from the Water Research Collaboration Platform Continuous beyond RMKe-15

IWSDC ROADMAP FOR RMKe-12 to RMKe-15

Water Security and Water Sustainability & Water as an Economic Opportunity

No.	Focus Areas	Strategy	Initiatives/Programmes	Activities	Lead / Implementing Agency	Collaborating Agencies	KPI	RMKe-12					RMKe-13	RMKe-14	RMKe-15	Output	Outcome	Notes
							Units	2021	2022	2023	2024	2025	2026-2030	2031-2035	2036-2040			
5	Governance	(S5) Enhancing Seamless Data Sharing	(S5-I1) Initiatives, Policies and Laws to Enhance Data Sharing	Data Sharing Agreement/Arrangement	KASA	KASA, All primary and secondary data collectors	No. (1)			→	→	→				Data Sharing Agreement/Arrangement		In the interim period, an agreement to be established between IWSDC and water providers to share data - to begin in 2023 **Federal Institutions & States**
				Malaysia to be part of international Open Data Alliance / Partnership	MCMM	MCMM, MOSTI	No. (1) Alliance / Partnership			1						Malaysia to be part of international open data alliance/partnership		
				Adoption of Open Science including indigenous knowledge and crowdsourcing programs and initiatives	KASA	KASA, MOSTI, All primary and secondary data collectors	Adoption by higher learning institutions, government agencies,			→	→	→	→	→	→	Open Science to include indigenous knowledge and crowdsourcing programs and initiatives		
				Data Sharing Policy	JPM	JPM (BHEUU)	No. (1)				→	→				Data sharing policy or 'Freedom of Information Policy'		Process to begin in 2024
				Data Sharing Law		JPM (BHEUU)	No. (1)				→	→				Data sharing law or 'Freedom of Information Law'		Process to begin in 2024
				Review of Fees Act 1951		JPM (BHEUU)	No. (1)				→	→				Zero rate fees under Fees Act 1951		Process to begin in 2024
				Review of Statistics Act 1965 by DOSM		JPM (DOSM)	No. (1)				→	→				Water as an item in Statistics Act 1965 review and amendments		Process to begin in 2024
6	Governance	(S6) Tools to Quantify and Assess Water Governance	(S6-I1) Governance Tools and System Development	A) Water Accounting 1. Water Accounting Tools	KASA	Federal agencies, State agencies, Private Sector, NGO	No. (1)				→	→				Production of strategic reports: Water accounting		Continuous beyond RMKe-15
				2. Water Accounting System		Federal agencies, State agencies, Private Sector, NGO	No. (20 Major River basins)					16	30	50	95	Pilot projects: 1. Sg Perak 2. Sg Linggi 3. Sg Padas 4. Sg Miri		
				B) Water Auditing 1. Water Auditing Tools		Federal agencies, State agencies, Private Sector, NGO	No. (1)				→	→				Production of strategic reports: Water auditing		
				2. Water Auditing System		Federal agencies, State agencies, Private Sector, NGO	No. (20 Major River basins)					16	30	50	95	Pilot projects: 1. Sg Perak 2. Sg Linggi 3. Sg Padas 4. Sg Miri		
7	People Governance	(S7) Public Participation Platform	(S7-I1) Stakeholder Management Initiatives	Stakeholder Management A) Establish Stakeholder Platform Linkages B) Register of Stakeholders C) Capacity Building Programme	KASA	Federal agencies, State agencies, Private Sector, NGO	A) No. (1) B) No. (191 RBMU) C) No. of modules by AACB				→	16	30	50	95	Water Stakeholder's Platform A) Annual Stakeholder Management Report B) Stakeholder Linkages in Water Sector C) Adoption and sharing of AACB training modules including Space Technology and Ground-based applications capacity building		IWSDC will host the platform, provide access, and facilitate the training modules Space Technology and Ground-based applications capacity building Continuous beyond RMKe-15
8	People Information and RDIC	(S8) Capacity Building and Talent Development	(S8-I1) Continual Capacity Building and Talent Development Programmes for Water Stakeholders	Talent Development in: 1. Space Technology 2. Data Technology 3. Water Sector Management	KASA	KASA	No. (1)			1	→	→	→	→	→	Dedicated Specialist Talent in: 1. Space Technology 2. Data Technology 3. Water Sector Management		
9	Infrastructure and Technology Information and RDIC People Governance Finance	(S9) Establish Water Hub	(S9-I1) Physical Development of a Water Hub	Development of a Water Hub Master Plan: A) Identification of a Physical Location of Water Hub B) Development of Concept, Study, Incentives C) Identification of a Hub Management Agency D) Promotion of Water Hub	KASA, NCIA	Federal agencies, State agencies, Private Sector, NGO	No. (1) Master Plan						1			A) Facilitate the collaboration between researchers, businesses, and government bodies B) Place-based innovation for businesses and researchers C) Data and information sharing environment to attract investment D) Facilitate advanced tech start-ups E) Financing Facilities via the establishment of a Water Bank		

4.2 Implementation Plan

The criteria for establishing IWSDC's implementation structure is based on the Strategy Paper 16, which states that IWSDC should be an independent statutory body. The IWSDC should also be set up with a dedicated and multi-disciplinary staff to enhance organisational and personnel development and sustainability. The most appropriate custodian for IWSDC is the Ministry of Environment and Water (KASA) since it is the leading ministry in water management in the country. The options for IWSDC's institutional set-up are as the following:

a. To establish IWSDC as an agency under KASA in 12th MP

b. To form IWSDC as a government-owned company under the Minister of Finance (Incorporated) [MOF (Inc.)] but administrated by KASA (13th MP onwards).

Some examples MOF (Inc.) companies include Malaysian Digital Economy Corporation (MDEC) (which is currently administrated by MCMM), Cradle Fund Sdn. Bhd. and MIMOS Berhad.

Box 4.1: MOF (Inc.)

MOF (Inc.) is a corporate body established under the Minister of Finance (Incorporation) Act 1957.

The objectives of MOF (Inc.) company investments are to:

- Close the market gap in which the private sector prioritises less investment, owing to high initial investment costs and market obstacles.
- Provide public social services including public transportation and utility services.
- Invest in strategic industries such as technology research and development to boost economic growth.
- Entice domestic and international investors to invest in certain fields such as biotechnology and information technology.

It is recommended that the IWSDC is eventually established as a Government Owned Company under MOF (Inc.) and administrated by KASA. Setting up IWSDC as a company under MOF (Inc.) will give it the independence and flexibility to pursue projects and programmes that require public-private partnerships, investment from private sector, as well as those requiring multi-disciplinary and multi-sectorial collaborations.

NAHRIM was rebranded as the National Water Research Institute of Malaysia on 20 January 2021 to expand its role for a wider scope of water research topics and collaboration with public and private institutions. NAHRIM will also take the lead in implementing the National Water Innovation Roadmap 2040. With this extended scope, it would be possible for NAHRIM to develop the idea of establishing a Water Research Consortium as envisaged under WST2040 Strategy C2 – *Integrating research on water through the establishment of the Water Research Consortium* that is proposed here to be implemented under 13th MP.

4.3 Immediately Implementable Projects

From the strategies proposed in the Roadmap, the immediately implementable projects in 12th MP are listed in **Table 4.2**.

It is pivotal that the programmes in this phase are achieved as they are essentially the foundation of IWSDC in 12th MP.

Table 4.2: The Immediately Implementable Projects under 12th MP

No.	Strategy	Potential Projects under 12th MP	Target	KPI	Timeframe
1.	Establish IWSDC	Establishment of IWSDC 12th MP 2022 – Detailed Design Study 2023 – Interim Establishment 2025 – Full-scale Establishment	One stop centre for water and water-related data in the Country.	1. Complete IWSDC Physical Infrastructure, Technology, and Organisation 2. IWSDC ready for Operations 3. Production of Annual Strategic Reports 4. Linkages for RDIC to water and water-related data managers, researchers (100%) 5. Establishment of data standards	12th MP (2023 – Interim) (2025 – Full-scale)
2.	IWSDC Water Platform Pilot Project	IWSDC Water Platform Pilot Project in four river basins: 1. Sg. Perak River Basin (Perak) 2. Sg. Linggi River Basin (N. Sembilan/Melaka) 3. Sg. Padas River Basin (Sabah) 4. Sg. Miri River Basin (Sarawak)	1. New tools and applications for IWRM and RDIC through space technology: - Surveillance - Monitoring 2. Complete database for River Basins: - Sg. Perak - Sg. Linggi - Sg. Padas - Sg. Miri	1. Space Technology Applications in Water Management: - AI approach to water catchment monitoring - Water quality modelling via Remote Sensing and Artificial Intelligence - Irrigation monitoring management for Paddy Fields 2. Ground-based Data Applications Framework: - Disaster Risk Reduction - Stakeholders Management - WFE Nexus - IR4.0 - Water Footprint & Virtual Water - AACB - Climate Change - Water Accounting - Water Auditing - ESAs Monitoring and Indigenous Knowledge	12th MP
3.	Data Sharing Initiatives and Incentives	1. Data Sharing Agreement/ Arrangement 2. Data Sharing Policy Review 3. Data Sharing Law Review 4. Review of Fees Act 1951 5. Review of Statistics Act 1965 by DOSM	Establishment of Data Sharing Initiatives and Incentives to facilitate seamless data sharing	1. Data Sharing Agreement/Arrangement 2. Data sharing policy or 'Freedom of Information Policy' 3. Data sharing law or 'Freedom of Information Law' 4. Zero rate fees under Fees Act 1951 5. Water as an item in Statistics Act 1965 review and amendments	12th MP and 13th MP

Table 4.2: Continued

No.	Strategy	Potential Projects under 12th MP	Target	KPI	Timeframe
4.	Governance Tools and Systems Development	1. Water Accounting Tools and System 2. Water Auditing Tools and System	Establishment of Water Governance Tools and System to be adopted by Federal and State Agencies, Water Operators, Private Sector and NGO	1. Production of Annual Strategic Reports in Water Accounting, Water Auditing and Water Security 2. Adoption of Water Accounting and Water Auditing System	12th MP and beyond
5.	Water Research Collaboration Platform	1. Space Technology application projects on River Basin Management for entrepreneurs (including Citizen Developers) 2. Ground based data applications for Advanced Science Businesses	A platform that enables water RDIC opportunities by using Space Technology applications and IR4.0 applications in water management	1. New services, products and businesses in water sector based on Space Technology and IR4.0 technology	12th MP and beyond

4.4 Key Performance Indicators (KPIs) for IWSDC

One of the strategic targets of the Water Sector Transformation Plan 2040 under the 12th Malaysia Plan is the establishment of IWSDC by 2025.

Subsequently the IWSDC is expected to operate and provide integrated data management as an integral activity in accelerating IWRM. IWSDC shall also deliver strategic water management services related to 191 RBMUs that include publication of cross-water sector strategic reports. It shall also establish a water data platform to facilitate a more affirmative public stakeholders' participation in local, regional and national water management. To encourage public-private sector Research-Development-Innovation-Commercialisation (RDIC) initiatives, it shall also establish a research collaboration platform. Overall, the role of IWSDC is to facilitate higher levels of water data accessibility, unlock the value of data and provide a common set of data and information as a common basis for decision-making between Federal and States, between States and between Water Sectors and end-users. At the same time, the activities of IWSDC are also planned to facilitate the adoption of space technologies for advanced water management and STI.

The strategic KPIs in establishing the IWSDC and its subsequent delivery of services is summarised in **Table 4.3**.

Referring to **Table 4.3**, the main points to note are:

a. The IWSDC is planned to be operational in Phases.

b. The initial Phase is aimed to be in tandem with the planned launched of a Malaysian satellite by MYSA in 2025.

c. Thus, Phase 1 is planned to start in 2022, to be ready and operational by 2023. The IWSDC will be expanded gradually to be fully operational as planned by 2026.

d. The operations are planned to begin with deliveries of selected strategic reports and services facilities that include:
    i. Establishment of Water Data Platform (A water data and information search engine and applications).
    ii. Establishment of an RDIC Collaboration Platform.
    iii. Establishing instruments to facilitate and encourage data sharing (Arrangements with KASA, Policy, Law).
    iv. Developing Water Governance Tools and systems (Water Accounting and Water Auditing).
    v. Establish a formal public stakeholder platform.
    vi. Capacity building programmes.
    vii. Undertake a Masterplan Study towards the establishment of a physical water hub.

These KPIs in terms of focus areas as defined by the WST2040 Study is summarised in **Table 4.4.**

These KPIs are expected to be monitored by the proposed WST2040 National Monitoring Committee (**Figure 4.2**).

Table 4.3: IWSDC Establishment and Operational KPIs

No.	Transformation Item	Measurement	Performance Target	Baseline	12th MP	13th MP	14th MP	15th MP
1.	(S1) Establishment of an Integrated, Single-point Reference Centre (S1-I1) Establish IWSDC A) Detailed design study B) Physical Establishment	 No. of Study No.	 1 1	 - -	 1 (2022) 1 (2023)			
2.	Malaysian Satellite Launch (MYSA)	No.	1	-	1 (2025)			
3.	(S2) Strategic Reports on Water Management (S2-I1) Strategic Reports Publication (annual)	No. / year	13	-	12 (2025)	65	65	65
4.	(S3) Water Data Platform (Water Data and Information Interactive Platform) (S3-I1) Establish Water Data Platform (S3-I2) IWSDC Water Data Platform Pilot Projects (S3-I3) Integrated River Basin Management System Solution for all other River Basins	 No. of projects No. of projects No. of RBMUs	 1 4 191	 - - -	 1 (2023) 1 (2023), 3 (2024) 12 (2025)	 46	 111	 191
5.	(S4) RDIC Collaboration Platform (S4-I1) Water Research Collaboration Platform (RDIC) on Space Technology Applications (S4-I2) Water Research Collaboration Platform (RDIC) on Ground-based Applications	 No. of RDIC Projects No. of RDIC Projects	 3 3	 - -	 9 (2023) 9 (2023)	 15 15	 15 15	 15 15
6.	(S5) Enhancing Seamless Data Sharing (S5-I1) Initiatives, Policies and Laws to Enhance Data Sharing A) Data Sharing Agreement/Arrangement B) Review of Policy C) Review of Law D) Malaysia to be part of international Open Data Alliance / Partnership	 No. of Agreement/Arrangement No. of Policy No. of Law No. of Alliance/Partnership	 1 1 1 1	 - Draft National Data Sharing Policy - -	 1 (2023) 1 (2023)	 1 1		
7.	(S6) Tools to Quantify and Assess Water Governance (S6-I1) Governance Tools and System Development A) Water Accounting Tool and System adoption in Major River Basin (i) Tool (ii) System Implementation B) Water Auditing Tool and System adoption in Major River Basin (i) Tool (ii) System Implementation	 No. of Tool No. of RBMUs (Major) No. of Tool No. of RBMUs (Major)	 1 20 1 20	 - - - -	 1 (2024) 5 (2025) 1 (2024) 5 (2025)	 10 10	 15 15	 20 20
8.	(S7) Public Participation Platform (S7-I1) Stakeholder Management Initiatives A) Establish Stakeholder Platform Linkages B) Register of Stakeholders	 No. of Platform No. of RBMUs	 1 191	 - -	 1 (2024) 16 (2025)	 46	 96	 191
9.	(S8) Capacity Building and Talent Development (S8-I1) Capacity Building and Talent Development Programmes for Water Stakeholders	 No. of programmes	 3	 -	 9 (2023)	 15	 15	 15
10.	(S9) Establish Physical Water Hub A) Master Plan Study	No. of Master Plan	1	-		1		
Estimated Cost		RM (mil)			219.82	435.75	688.40	807.00

Notes:
(S) – Refers to a Strategy item in the main IWSDC Roadmap (Table 4.1, pg 113)
(S - I) – Refers to the Initiatives under the respective Strategy

Table 4.4: IWSDC KPIs by WST2040 Focus Areas

No.	Focus Areas	KPI	Measurement	Performance Target	Baseline	Targets			
						12th MP	13th MP	14th MP	15th MP
1	People	(S7) Public Participation Platform (S7-I1 A) Establish Stakeholder Platform Linkages (S7-I1 B) Register of Stakeholders	 No. of Platform No. of RBMUs	 1 191	 - -	 1 (2024) 16 (2025)	 30	 50	 95
2		(S8) Capacity Building and Talent Development*	No. of programmes	54	-	9 (2023)	15	15	15
3	Governance	(S5) Enhancing Seamless Data Sharing (S5-I1 A) Data Sharing Agreement/Arrangement (S5-I1 B) Data Sharing Policy (S5-I1 C) Data Sharing Law (S5-I1 D) Malaysia to be part of international Open Data Alliance / Partnership	 No. of Agreement/Arrangement No. of Policy No. of Law No. of Alliance/Partnership	 1 1 1 1	 - Draft National Data Sharing Policy ** -	 1 (2023) 1 (2023)	 1 1	 	
4		(S6) Tools to Quantify and Assess Water Governance (S6-I1 A) Water Accounting Tool and System adoption in Major River Basin (i) Tool (ii) System Implementation (S6-I1 B) Water Auditing Tool and System adoption in Major River Basin (i) Tool (ii) System Implementation	 No. of Tool No. of RBMUs No. of Tool No. of RBMUs	 1 191 1 191	 - - - -	 1 (2024) 16 (2025) 1 (2024) 16 (2025)	 30 30	 50 50	 95 95
5	Infrastructure and Technology	(S9) Establish Physical Water Hub	No. of Master Plan	1	-		1		
6		Malaysian Satellite Launch (by MYSA)	No.	1	-	1 (2025)			
7	Information and RDIC	(S1) Establishment of an Integrated, Single-point Water Data Reference Centre (IWSDC) (S1-I1 A) Detailed design study (S1-I1 B) Physical Establishment	 No. of Study No.	 1 1	 - -	 1 (2022) 1 (2023)	 	 	
8		(S2) Strategic Reports on Water Management***	No.	208	-	13 (2025)	65	65	65
9		(S3) Water Data Platform (Water Data and Information Interactive Platform) (S3-I1) Establish Water Data Platform (S3-I2) IWSDC Water Data Platform Pilot Projects (Sungai Perak, Sungai Linggi, Sungai Padas, Sungai Miri) (S3-I3) Integrated River Basin Management System Solution for River Basins (Water Data Platform)	 No. of projects No. of projects No. of RBMUs	 1 4 187	 - - -	 1 (2023) 1 (2023) 3 (2024) 12 (2025)	 30	 50	 95
10		(S4) RDIC Collaboration Platform (S4-I1) Water Research Collaboration Platform (RDIC) on Space Technology Applications (S4-I2) Water Research Collaboration Platform (RDIC) on Ground-based Applications	 No. of RDIC Projects No. of RDIC Projects	 93 93	 - -	 3 (2023) 3 (2023)	 10 10	 30 30	 50 50

Notes:
1. (Start year)
2. * 3 programmes annually, one each for Space Technology, Data Technology dan Water Sector Management.
3. ** Subject to introduction of Data Sharing Policy.
4. *** 13 annual reports.

The progress of all KPIs under IWSDC will be monitored by the National Management Committee (NMC), which will be chaired by the Chief Secretary to the Government of Malaysia (KSN). The IWSDC is placed under the sub-committee of Information and RDIC, that will be chaired by MOSTI and/or DOSM (**Figure 4.2).**

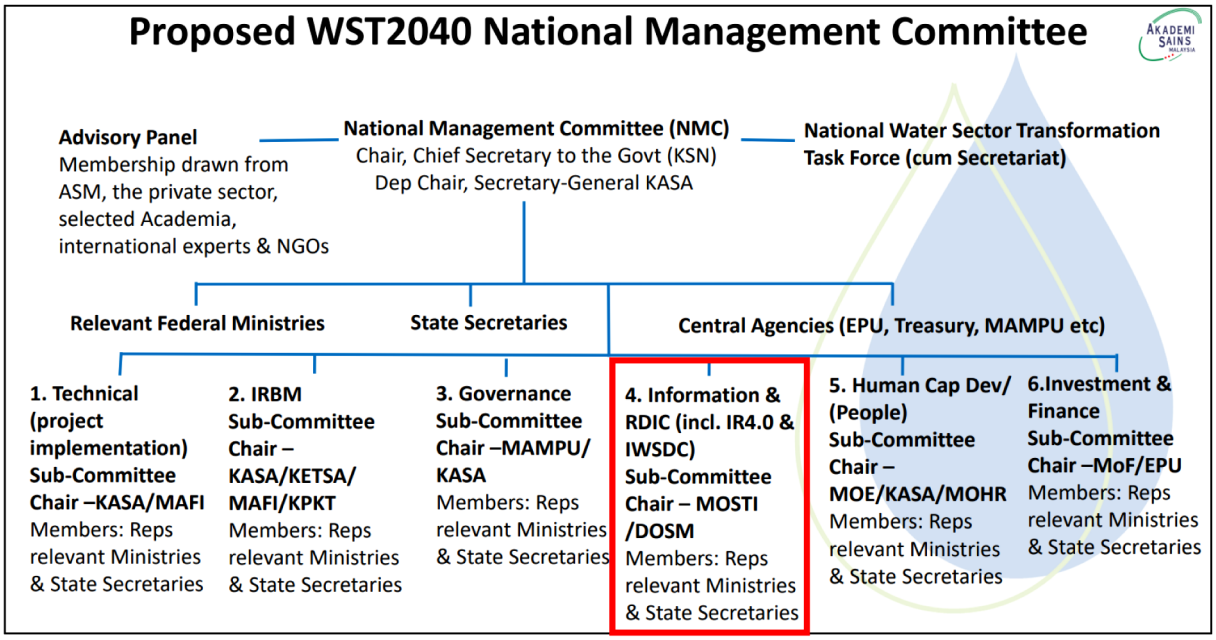


Figure 4.2: The proposed WST2040 National Management Committee

The summary of overall KPIs is shown in **Table 4.5**.

Table 4.5: Summary of number of KPIs by WST2040 Focus Areas

Focus Areas	12th MP		13th MP		14th MP		15th MP	
	Targets	KPIs	Targets	KPIs	Targets	KPIs	Targets	KPIs
People	3	3	2	2	2	2	2	2
Governance	6	6	4	4	2	2	2	2
Infrastructure and Technology	1	1	1	1	0	0	0	0
Information and RDIC	9	9	4	4	4	4	4	4
Finance	0	0	0	0	0	0	0	0
Total	19	19	11	11	8	8	8	8

4.5 Pilot Project for IWSDC Water Platform

4.5.1 The Need

The IWSDC is based on the premise that data has value, and this value can only be realised by sharing and realising the opportunities available. Thus, the IWSDC development theme of "Unlocking the Value of Data".

To facilitate this "unlocking and gaining value" process, IWSDC will develop an IWSDC Water Platform for data and information sharing that is open to the stakeholders. This platform is not just as a search engine but also for the public, entrepreneurs, businesses, and organisations to use the available data to develop ideas and

business opportunities, propose suggestions, innovations, and many more. This platform will also serve as a public participation platform for water management. It will provide water manager-public interaction and communication to gain support and advocacy in managing responsible water use, care for the environment and water quality, continuous capacity building and opportunities in Water Research Collaborations, Open Science and crowdsourcing for information and even funding.

Ultimately the IWSDC and the Water Research Consortium will be the platform for water management for all 191 RBMUs in the country. Beyond that, it shall also be developed to provide services for the international arena with the support for realising the ambition for Malaysia to be a Regional Hub by 2040.

As proof of concept, the Water Platform Pilot Projects are proposed for four river basins under 12th MP. The main objective of these pilot projects is as a proof-of-concept on the role and function of IWSDC and the Water Research Collaboration platform, as well as a start-up for the IWSDC Water Platform.

The four river basins proposed for the pilot projects are Sg. Perak, Sg. Linggi, Sg. Padas (Sabah), and Sg. Miri (Sarawak). These four river basins are selected based on the IRBM Masterplan prepared by JPS.

Sungai Perak is proposed based on its distinct characteristic of having all the WFE elements in one river basin. It is also one of the more developed river basins in terms of population, settlement and industry, tourism and rainfed agriculture. Apart from providing an intensive drainage network, it is also of national interest as its water resource is used for hydroelectric power generation and fed into the national electricity grid and, also for irrigating a national Granary Area, the Seberang Perak Irrigation Scheme, that contributes to the national food security levels. The Royal Belum State Park is also recognised by the Government of Malaysia as a National Heritage Site. Sungai Perak serves as the backbone of Perak State, servicing 70% of the total State land area with its water resource and drainage network. It is one of the most developed river basins in the country and has always been the root of traditions, culture, history, and the development of the State.

The Sungai Linggi River basin is proposed because it is the river basin that is already showing signs of rapid urban development following the sequence of development overflow after Sungai Klang and Sungai Langat River basins. Sungai Padas and Sungai Miri are proposed as being representatives of regional river basin management characteristics.

The pilot project shall cover the following scope:

a. Primary and secondary data sharing arrangements
b. Data collection, processing, storage, and distribution
c. System architecture designs
d. Data and information sharing system
e. Water Research Collaboration initiation
f. Public participation and Open Science
g. Preparation of selected strategic reports
h. Remote Sensing applications for water management

The remote sensing application shall be in collaboration with MYSA and covers the following scope:

a. Artificial Intelligence approaches to water catchment monitoring using remote sensing data;
b. Water quality modelling based on satellite remote sensing applications and artificial intelligence; and
c. Improvement of paddy field irrigation management using remote sensing technology.

The pilot area for component 1) and 2) above is Sungai Perak while for component 3) is Integrated Agriculture Development Area (IADA) Seberang Perak which has an area of 17,403 hectare. The duration of the pilot project is two (2) years. As the pilot project progresses, the IWSDC platform will be expanded and extended to be replicated over the whole country.

The project will focus on advanced applications of space technology and ICT which includes AI and Big Data Analytics.

The expected outputs of the remote sensing pilot project are as the following:

a. Current status of catchment area;
b. AI-based algorithm/model for catchment monitoring;
c. Map of Total Suspended Solid (TSS), Total Dissolve Solid (TDS), Turbidity and Chlorophyll;
d. Water quality map;
e. Current status of water classification; and
f. Irrigation status information.

The detailed timeline, methodology of projects, and breakdown of the planned financial allocations can be read in further detail in the **Appendix C** and **Appendix E.**

Apart from the remote sensing applications, the pilot project shall also start a preliminary concept design and models for:

a. Water Governance Tools (Water Accounting, Water Auditing systems)
b. Strategic Reports (Water Security, WFE, Monitoring of ESAs)
c. Customised database for water managers, water users and other stakeholders (such as river basin management, WFE Nexus management, disaster risk management, stakeholders' management)
d. Public Participation modules including Open Science and crowdsourcing opportunities
e. Water Research Collaboration Modules

This process will include desktop study, literature review, as well as engagement sessions with all water players including policy makers, water managers and water users via workshops, formal and informal interviews, and surveys.

4.6 IWSDC Water Platform Pilot Project Pre-Test

4.6.1 The Pre-Test Concept

Under this Study, a Pilot Project Pre-Test was initiated. The idea of this pre-test is a pre-proof of concept to obtain some preliminary results of the expected output of the IWSDC Water Platform pilot projects proposed.

The Sungai Perak River basin was selected for this pre-test as extensive data and information were made available contributed pro bono by Reka1 Tech PLT, a data and information service provider company. The data and information were in the form of a GIS for Sungai Perak River Basin as well as some project proposals. This Study Team then went through group brainstorming exercises to develop some ideas on the use of this concept water platform as a preliminary demonstration of the applications of the IWSDC Water Platform.

4.6.2 The Preliminary Output

a. Data Structure for River Basin Management

A tool for developing comprehensive data and information structure for Primary Data (Water Data) and Secondary Data (Land use and others) for the river basin Management (**Figure 4.3**).

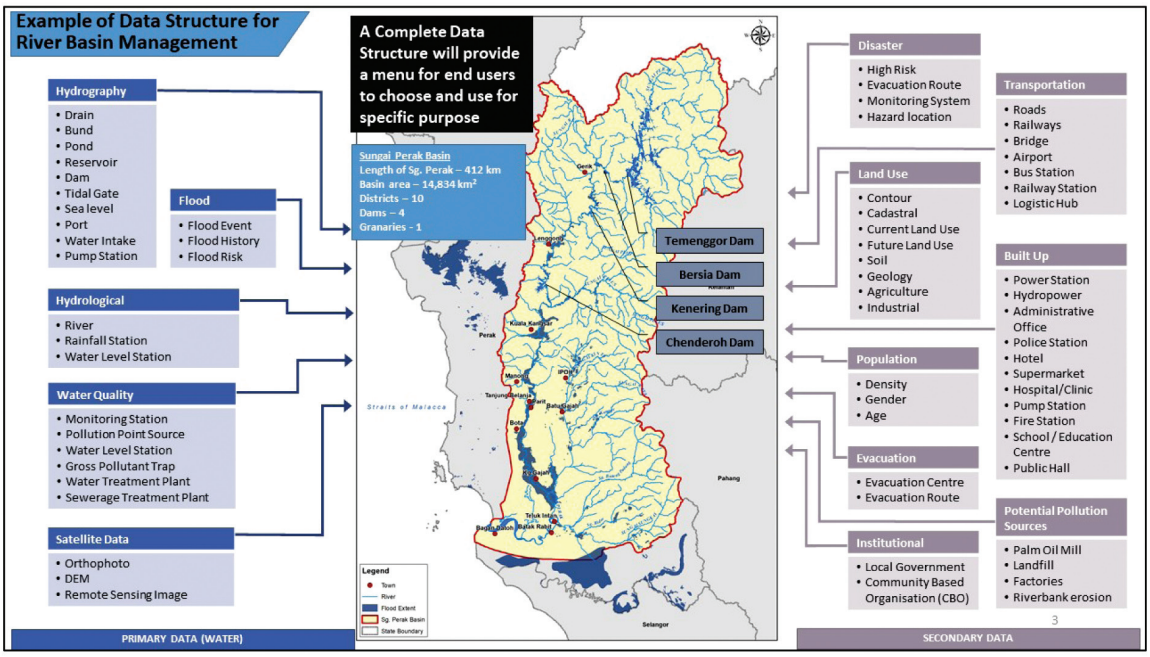


Figure 4.3: Data Structure for River Basin Management Data Structure

b. Stakeholder Participation Management

The identification of stakeholders and developing the data and information structure specific and even unique to the river basin. In this case, the existing 4 dams, the Granary Irrigation Scheme and the configuration of the districts in a sequential arrangement from upstream to downstream following the flow of the rivers (**Figure 4.4**).

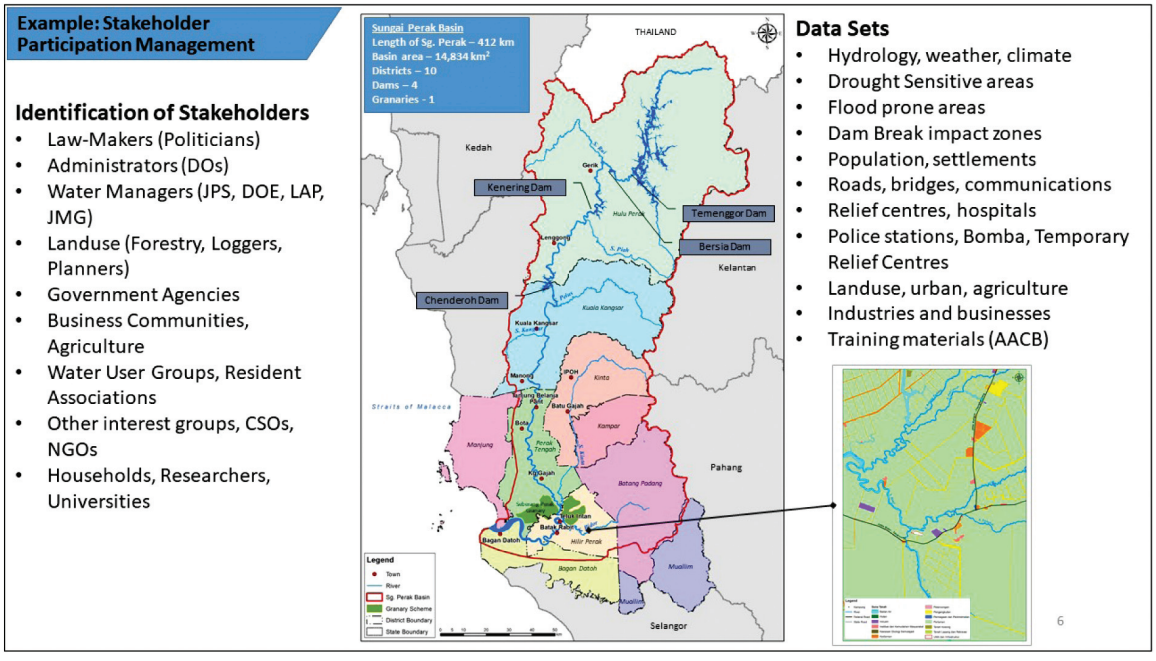


Figure 4.4: Stakeholder Participation Management Data Structure

c. Disaster Risk Reduction Management

The platform could also be used to encourage public participation in the development of a Disaster Risk Management plan and responses to disaster that is specific to the river basin. In this basin the sequential arrangement of the four dams along the river is unique in terms of disaster risk and consequential risk of dam breaks. So too the impact on the settlement areas, towns along the rivers, and the road and railway network (**Figure 4.5**).

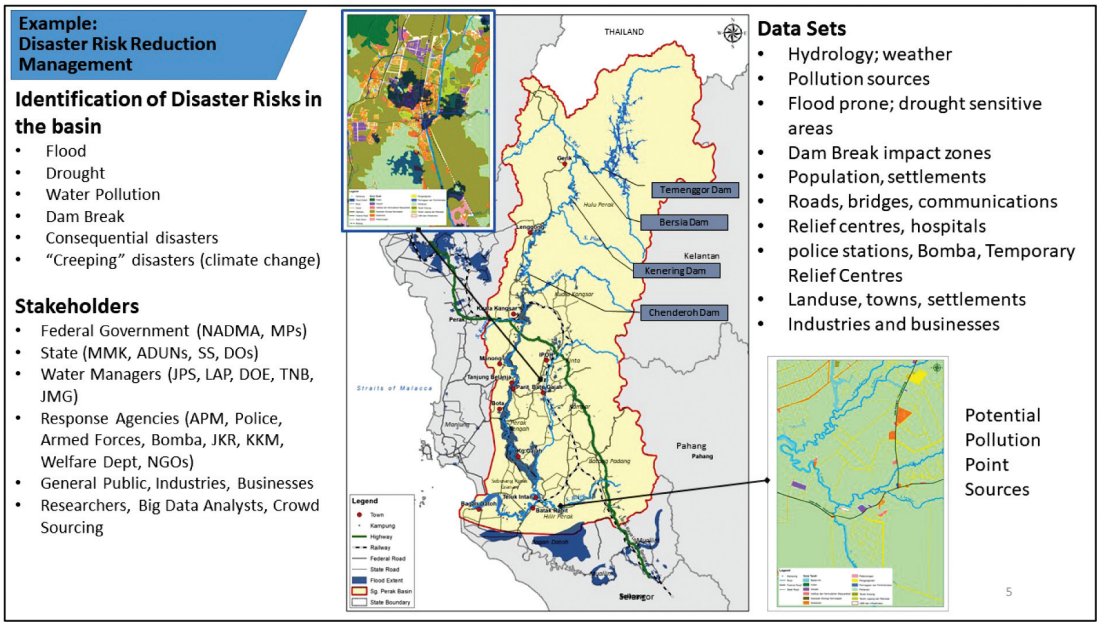


Figure 4.5: Disaster Risk Reduction Management Data Structure

d. WFE Nexus Management

The WFE Management in this river basin could also be unique compared to other river basins in the sense that the impact will not be just on the river basin but may also have direct implications on the national economy as well. This is mainly because of the hydroelectric power that serves the national grid, the Granary for national food security and in future, the Sungai Perak Water transfer scheme that has both regional and national impacts (**Figure 4.6**).

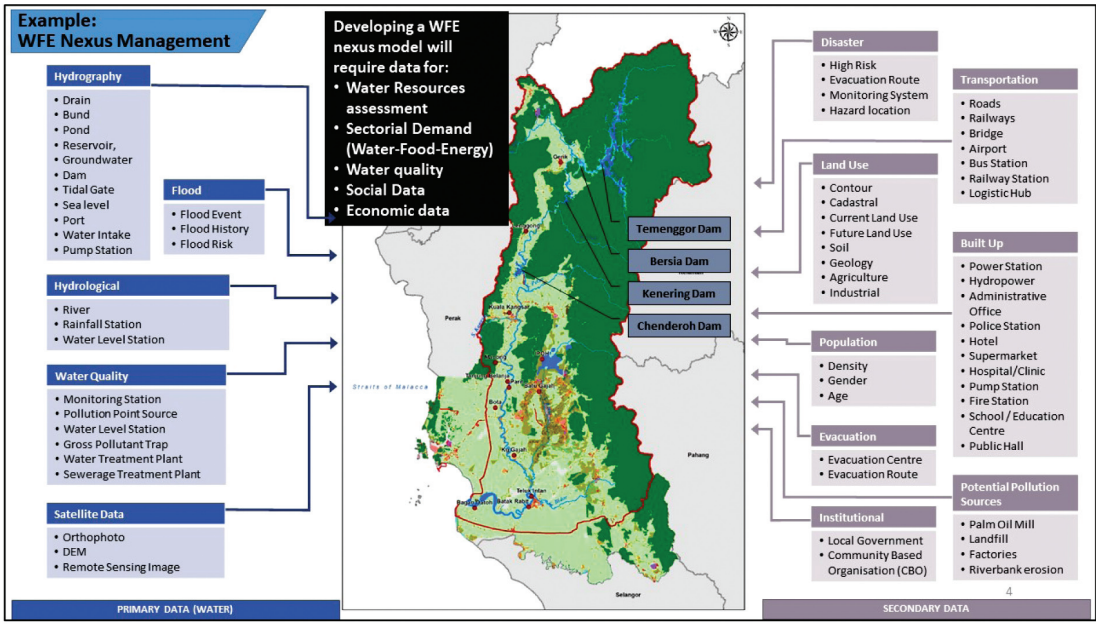


Figure 4.6: WFE Nexus Management Data Structure

e. Other Outputs

This rapid demonstration of the use of the IWSDC Water Platform has also provided some other interesting outputs. Referring to **Figure 4.7**, the platform would also encourage participation of lawmakers in their respective constituencies. Another is the possibility of developing a "River Address" as promoted by the Global Environmental Centre (GEC) to inculcate a higher sense of ownership and care of the river nearest to their residences. There is also the possibility of installing water quality monitoring stations at district boundaries. These in turn would provide a governance tool for quantitative assessment of river water quality received from upstream districts and that is discharged to adjacent district.

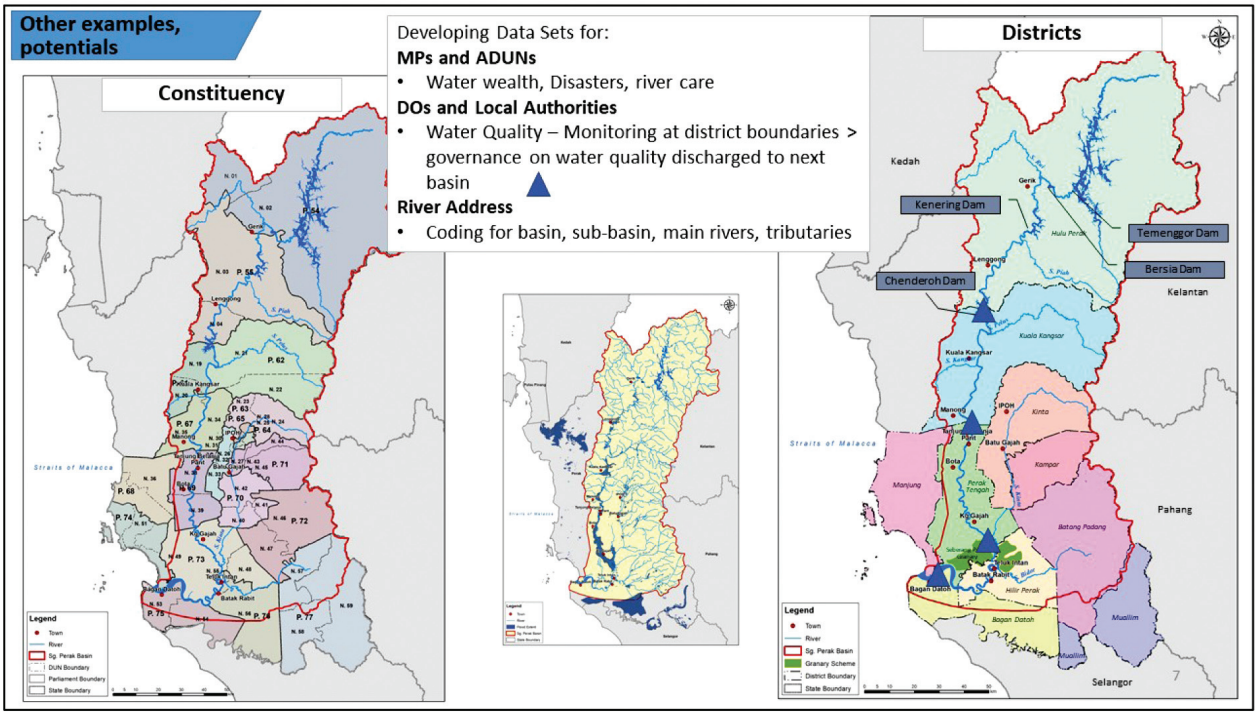


Figure 4.7: Examples of Data Applications in Constituencies and Districts

Figure 4.8 shows the population distribution that could be further analysed in terms of their demographic details for refined and tailor-made public participation programmes. The sample remote sensing image for Sungai Perak for a 0.5m resolution could lead to the development for detailed river basin monitoring and surveillance system and other advanced water management models. This pre-test has also demonstrated that the IWSDC Water Platform would facilitate the production of various strategic reports necessary for more comprehensive approach to water management as envisaged by WST2040. **Table 4.6** summarises the data sets for selected reports.

This demonstration has also shown other potentials. For climate change monitoring, sea-level rise monitoring stations could be established at the coastal areas and along the tidal stretch of the river. There are also potentials for public participation in the form of crowd sourcing of data and information of flood events and also Open Science participation for points of interest such as the terrapin conservation centre in Sungai Perak and the water for the environment, and the biodiversity of the Belum Forest reserve.

This concept of IWSDC Water Platform was demonstrated at a Stakeholder Engagement session on 16 August and 9 September 2021 organised by MIGHT under its Perak Sustainable Greenprint 2030 Plan. Two potential projects namely the Sungai Perak Bike Trail and the Sungai Perak River Cruise were selected for further consideration by the Perak State Government as potential Quickwin projects. These two projects

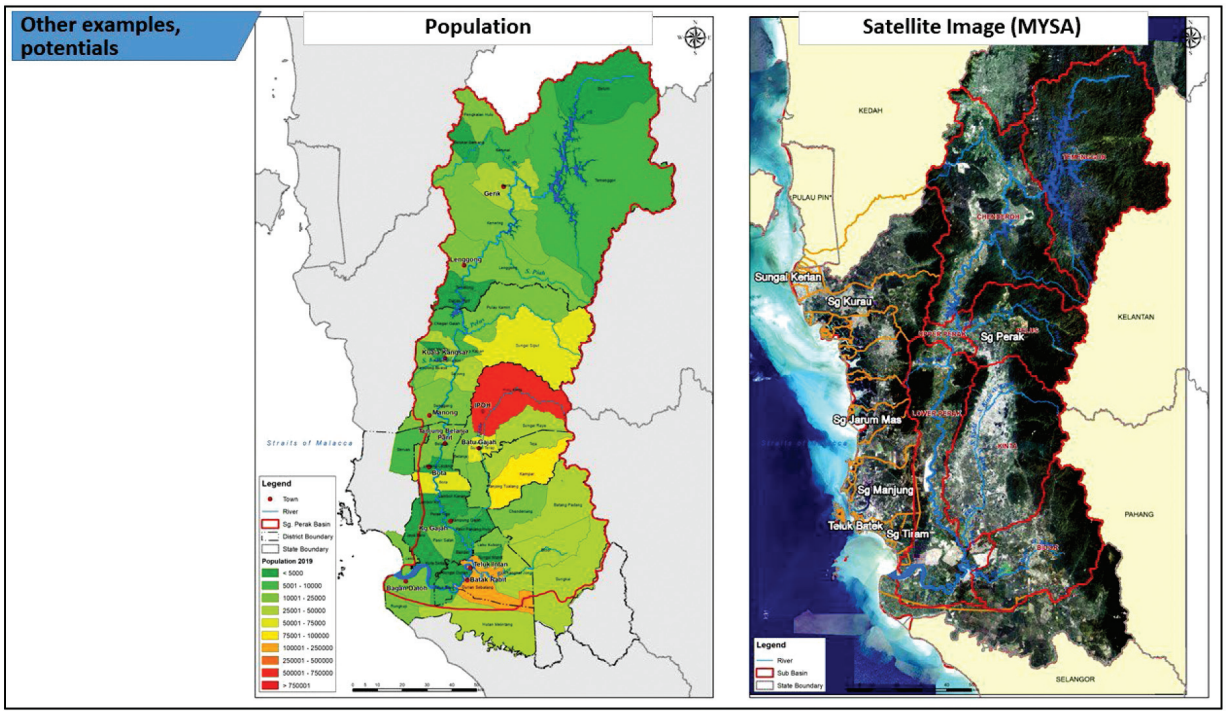


Figure 4.8: Examples of Data Applications for Population and Space Imaging Application

were presented as strategies to instil the value of the river to the socio-economic well-being of the riverside population.

Overall, this rapid demonstration based on the pre-test on the concept pilot project has shown the endless possibilities of unlocking the value of data and information in river management.

Table 4.6: Summary of Data Requirements for Various Strategic Requirements

No	STRATEGIC AREAS	PRIMARY DATA (WATER)				SECONDARY DATA												
		Hydrology	Flood	Water Quality	Satellite data	Disaster	Land Use	Transportation	Population	Built Up	Evacuation	Pollution Sources	Institutional	Settlement	Agriculture	Tourism	Parliamentarians
1	Disaster Risk Management	√	√	√	√	√	√	√	√	√	√	√	√	√		√	√
2	Water Food Energy			√			√	√	√					√			
3	Water Accounting	√	√	√	√		√		√					√			
4	Water Auditing	√	√	√													
5	Stakeholder Management					√	√		√		√	√	√	√		√	√
6	Water Security		√		√		√		√			√	√				
7	Water Footprint	√	√	√	√		√		√					√	√	√	√
8	Water for Environment & Biodiversity		√	√	√	√	√		√			√	√	√			
9	Water and Climate Change		√		√	√	√		√			√					
10	Water Efficiency	√		√			√		√					√	√		
11	Water Quality Monitoring		√	√			√		√	√		√		√	√		
12	Flood	√	√		√	√	√		√	√	√		√	√	√	√	
13	Water Safety Plan						√										√
14	Rainfed Agriculture Monitoring	√		√	√							√			√		
15	Water Resources Monitoring Using Indigenous Knowledge	√	√	√	√	√	√		√			√		√	√	√	√

Chapter 5
IWSDC Costing

5.1 IWSDC Cost Estimate

The cost estimate for the IWSDC in each MP is stated as below (**Table 5.1**):

a. 12th MP: RM 219.82 mil
b. 13th MP: RM 435.75 mil
c. 14th MP: RM 688.40 mil
d. 15th MP: RM 807.00 mil

The summary of cost estimate for each MP is shown in **Table 5.2.**

5.1.1 Capital Expenditure

The Capital Expenditure for 12th MP consists of:

a. IWSDC set-up
    i. Physical, Technology, and Organisation set up
    ii. Integrated River Basin Management System Solution
    iii. Strategic Reports
    iv. RDIC Projects
    v. Data Sharing Initiatives and Incentives
    vi. Governance Tools and System Development
    vii. Open Data
    viii. Stakeholder Platform

The costing also includes:

a. The initial detailed design study to set up the IWSDC.
b. Technology update every five years.
c. Pilot Projects on four river basins, with two components: Space Technology Applications in Water Management and Ground-based Data Applications Framework.

In total, the capital expenditure for 12th MP is approximately RM 219.82 million, while the total cost throughout WST2040 is estimated to be approximately RM 405.52 million.

5.1.2 Operational Expenditure

The Operations and Maintenance costs are the costs that is expected to incur in the running of the IWSDC. This costing includes:

a. Operational systems support and maintenance of the hardware and software, training and capacity building of talents, office rental, staff, and administrative costs.
b. The continuation of Integrated River Basin Management System Solution after the Pilot Projects which will cover the rest of the RBMUs across Malaysia. The costing per river basin is expected to be lower as its basis will have already been established.
c. The production of annual Strategic Reports, support for RDIC projects in Ground-based applications and Space Technology, data sharing initiatives and incentives and Governance Tools which include Water Accounting and Water Auditing.

In total, the operational expenditure throughout WST2040 is estimated to be approximately RM1.745 billion.

Table 5.1: IWSDC Costing from 12th MP to 15th MP

A.	Capital Expenditure (*Perbelanjaan Pembangunan*)	12th MP						13th MP	14th MP	15th MP	Notes
No.		2021 RM (mil)	2022 RM (mil)	2023 RM (mil)	2024 RM (mil)	2025 RM (mil)	Total RM (mil)	2026-2030 RM (mil)	2031-2035 RM (mil)	2036-2040 RM (mil)	
1	IWSDC Set Up		5.00	42.30	6.40	0.00	53.70	35.70	42.10	47.90	Technology refresh for 13-, 14-, 15th MP
2	Water Data Platform Pilot Projects:							-	-	-	
a)	Sg Perak River Basin (Perak)			2.00	2.98	2.10	7.08	-	-	-	
b)	Sg Linggi River Basin (N. Sembilan/Melaka)				2.98	4.10	7.08	-	-	-	
c)	Sg Padas River Basin (Sabah)				2.98	4.10	7.08	-	-	-	
d)	Sg Miri River Basin (Sarawak)				2.98	4.10	7.08	-	-	-	
3	IWSDC Physical, Technology and Organisation	-	-	7.70	31.00	34.00	72.70				
4	Integrated River Basin Management System	-	-	-	-	42.00	42.00				
5	Strategic Reports Publication	-	-	-	-	2.40	2.40				
6	RDIC Collaboration Platform	-	-	2.00	2.00	2.00	6.00				
7	Enhancing Seamless Data Sharing	-	-	0.25	1.00	1.25	2.50				
8	Tools to Quantify and Assess Water Governance	-	-	-	3.00	3.20	6.20				
9	Public Participation Platform	-	-	-	-	-	-				
10	Capacity Building and Talent Development	-	-	2.00	2.00	2.00	6.00	15.00	20.00	25.00	
11	Establish Water Hub	-	-	-	-	-	-				
	Total	0.00	5.00	56.25	57.33	101.25	219.82	50.70	62.10	72.90	

B.	Operational Expenditure (Perbelanjaan Mengurus)	12th MP						13th MP	14th MP	15th MP	
No.		2021 RM (mil)	2022 RM (mil)	2023 RM (mil)	2024 RM (mil)	2025 RM (mil)	Total RM (mil)	2026-2030 RM (mil)	2031-2035 RM (mil)	2036-2040 RM (mil)	
1	IWSDC Operations and Maintenance	-	-	-	-	-	-	198.30	254.30	322.10	
2	Water Data Platform (Integrated River Basin Management System)	-	-	-	-	-	-	105.00	175.00	95.00	Continuation of pilot projects for all 191 river basins
3	Strategic Reports Publication	-	-	-	-	-	-	12.00	12.00	12.00	
4	RDIC Collaboration Platform	-	-	-	-	-	-	60.00	180.00	300.00	RDIC projects include Space and Ground RDIC projects: e.g. space imaging software, public participation applications (See Water Hub UK)
5	Enhancing Seamless Data Sharing	-	-	-	-	-	-	0.75	-	-	
6	Tools to Quantify and Assess Water Governance	-	-	-	-	-	-	5.00	5.00	5.00	
7	Public Participation Platform	-	-	-	-	-	-	-	-	-	Costs are covered under the IWSDC Set Up Costs
8	Capacity Building and Talent Development	-	-	-	-	-	-	-	-	-	
9	Establish Water Hub	-	-	-	-	-	-	4.00			
	Total							385.05	626.30	734.10	

Table 5.2: Costing Per MP Summary

Costing Per MP		12th MP RM (mil)	13th MP RM (mil)	14th MP RM (mil)	15th MP RM (mil)
Capital Expenditure (Perbelanjaan Pembangunan)		219.82	50.70	62.10	72.90
Operational Expenditure (Perbelanjaan Mengurus)		-	385.05	626.30	734.10
	Total	219.82	435.75	688.40	807.00

Chapter 6
Conclusion, Recommendations and Closing Statement

6.1 Conclusion

The main reason why data ecosystem in Malaysia is in such a fragmented state is due to the sectorial governance and management approach, coupled with a lack of affirmative data sharing policy and law. The water sector RDIC scenario in the country is also limited by lack of coordinated strategic approach, limited of access to data, and limited funding, which ultimately results in Malaysia's inability to turn water wealth into economic wealth.

Thus, the IWSDC will require a shift from the present paradigm in water sector data management towards a new and transformative way of water data integration, management, and applications. The structure, operations, and outputs of IWSDC are designed to catalyse the achievement of WST2040 objectives (water security and water as an economic opportunity), as well as support the enabling driver (empowering people) and four enablers (governance, information and RDIC, infrastructure and finance). The IWSDC will also support the implementation of 12th MP vision of a prosperous, inclusive, and sustainable Malaysia as well as the WKB2030 vision of a more equitable sharing of prosperity in society.

The IWSDC will also apply advanced space technology by taking advantage of the launch of a high-resolution satellite by MYSA in 2025 to spur development in space remote sensing in water management. This will be supported by applications of big data analytics and artificial intelligence. This focus is in line with the objectives of the 10-10 MySTIE Framework and the MyDIGITAL.

Furthermore, more than just being a platform for integrating data, IWSDC will also be a centre for creating wealth in water. This will be accomplished by being an integrated platform for collaborations in RDIC. This RDIC collaboration platform is expected to excite a broad section of the society and industries for new and exciting opportunities towards higher levels of science and technology application and promote the development of nationally owned innovative products of international standards. This collaborative platform is the precursor for the formation of a Water Research Consortium which could elevate RDIC in the water sector to the next level.

In summary, in-line with the WST2040 Plan, and as mandated by 12th MP Development Plan, the IWSDC shall be designed as a Game Changer in water management. It shall integrate water data and water-related data collection and process it in-line with common standards and good practices. The IWSDC shall aim to feed "trusted" data to all end-users and be used as a basis for science-based decision-making, especially in Federal-State, State-State and Inter-Sector negotiations. It shall facilitate the empowerment of the public in water management and be a catalyst to spur a prolific RDIC and invigorate the water business and industry.

6.2 Recommendations

The following are the recommended actions as the way forward for the WST2040 plan based on the five focus areas:

a. People
    i. The IWSDC will propose a formal, national-level stakeholders engagement platform which will provide a stage for the public to participate in water sector decision-making process.
    ii. The IWSDC will also help expand the public participation in water sector through participation of people through establishment of Open Science concept and Crowdsourcing.

b. Governance
   i. The IWSDC will develop and propose a data sharing agreement with all primary and secondary water data providers at Federal, Regional (Sabah and Sarawak), and states levels as well as with private sector and NGOs.
   ii. The IWSDC will subsequently propose the establishment of a 'Data Sharing Policy' and the subsequent 'Data Sharing Law' as the final step towards raising data sharing in this country on par with international standards and practices.
   iii. The IWSDC will propose to DOSM on the possibility of including water and water related data collection in its proposed amendments of Statistics Act 1965. The IWSDC will also propose for it to be part of the MSDN and PADRN organisation set-up.
   iv. The IWSDC will also produce Annual Water Security report to support decision making on water security for MKN.
   v. The IWSDC will also produce an independent, annual water accounting report which will become the most essential water governance quantifying tool in this country.
   vi. The IWSDC will publish strategic reports, such as virtual water and water footprint report and Water-Food-Energy Nexus report, to enhance data-driven decision-making process and complete the water management spectrum.
   vii. The IWSDC will propose for Malaysia to join an international open data alliance such as Open Government Partnership or Open Data Charter.

c. Information and RDIC
   i. The IWSDC will eventually be established as a single-point, independent statutory body in-line with the goals under WST2040.
   ii. The IWSDC will establish a research collaboration platform which will link RDIC institutions from government, institutions of higher learning and private sector to collaborate on novel and advanced solutions in water sector. This is a precursor to the eventual establishment of a Water Research Consortium.
   iii. The IWSDC will establish a water data platform which will host a complete database of the RBMUs in Malaysia, and enhanced by space technology, as a reference and collaborative platform for users from various sectors.

d. Infrastructure and Technology
   i. The IWSDC will provide access to high quality data as well as provide new tools which will facilitate the development of options in planning, design, operations, maintenance, and performance evaluations of water systems.
   ii. The IWSDC will also venture and upscale into space technology applications in water sector and this will be complemented with big data analytics, artificial intelligence, and blockchain. This technology will support IWSDC's output such as strategic reports as well as RDIC activities.

e. Finance
   i. The IWSDC will propose measures to incentivise the free sharing of data and information that is already being continuously collected and subsequently unlock their values. This could be accomplished by reviewing the Fees Act 1951.
   ii. IWSDC will provide data and information for managing the wealth of water in the nation through the development of better options for investment decisions and strategies through supporting data and information published in the annual strategic reports.

6.3 Closing Statement

The IWSDC is envisioned as a 'game-changer' in the National Water Sector Transformation 2040. A game changer can be demonstrated in transformative projects such as the mission to the moon. In highlighting the enormous task faced by the Americans, President Kennedy mentioned that

"*We choose to go to the Moon in this decade and do the other things, not because they are easy, but because they are hard; because that goal will serve to organise and measure the best of our energies and skills, because that challenge is one that we are willing to accept, one we are unwilling to postpone, and one we intend to win, and the others, too." (Boyd, 2012)*

As the country progresses, the challenge is to manage water scarcity events in such a way that would ensure a sustained comfort of life and living whilst managing the wealth of water and biodiversity for the wealth of the nation; both in situations of uncertainties induced by the climate change.

This requires a good, reliable, and trusted common data, the prerequisites not only for precise water management, but for qualitative Federal-State, State-State and inter-sector negotiations on water use priorities in various scenarios and needs. IWSDC is the data provider, facilitator and a platform for these negotiations.

Beyond data management, IWSDC is designed to be a catalyst to accelerate IWRM, to unlock the value of data, empowering people for meaningful participation, providing high-value jobs and business opportunities in a digital economy, connecting RDIC seamlessly and, propelling national capacity in STI through applications of space technology.

Ultimately, IWSDC is to support IWRM in realising the vision of "Clean, Living, Vibrant and Spiritually-enriching rivers and river basins".

References

Jabatan Meteorologi Malaysia. (n.d.). Laman Web Rasmi Jabatan Meteorologi Malaysia. *Radar Malaysia.* Retrieved September 20, 2020, from https://www.met.gov.my/pencerapan/radar/radarmalaysia

Academy of Sciences Malaysia. (2014). *Setting a National Agenda for Integrated Water Research Volume 1: ASM Advisory Report 2/2014.*

Academy of Sciences Malaysia. (2016, May). Agriculture Water Services for Agribusiness. Retrieved 2021, from https://www.akademisains.gov.my/asm-publication/agriculture-water-services-for-agribusiness/

Academy of Sciences Malaysia. (2017). *Academy of Sciences Malaysia.* Retrieved August 31, 2021, from Science Outlook: https://www.akademisains.gov.my/studies/flagship/science-outlook/

Academy of Sciences Malaysia. (2018, January 17). *Strategies to Enhance Water Demand Management in Malaysia.* Retrieved June 30, 2021, from Academy of Sciences Malaysia: https://www.akademisains.gov.my/asm-publication/water-demand-management/

Academy of Sciences Malaysia. (2021). *10-10 Malaysian Science, Technology, Innovation and Economy (MYSTIE) Framework.* Retrieved September 10, 2021, from Academy of Sciences Malaysia: https://www.akademisains.gov.my/10-10-mystie/

Academy of Sciences Malaysia. (2021, August 30). UTM Merdeka Webinar. Becoming a Developed Nation: Are We on Track?

Ahluwalia, H. P. (n.d.). Application Of Space-Based Remote Sensing to Water Management. Retrieved September 26 2021

Akademi Sains Malaysia. (2014). *Setting A National Agenda For Integrated Water Research.* Akademi Sains Malaysia.

Allan, T. (2011). *Virtual water: tackling the threat to our planet's most precious resource.* London: L.B. Tauris & Co Ltd. Retrieved September 27, 2021, from https://www.researchgate.net/publication/254377365_Virtual_water_tackling_the_threat_to_our_planet's_most_precious_resource_by_Tony_Allen

Allen, T., & Cohen, S. (1969). *Information Flow in R&D Laboratories.*

AR, A., & M, T. (2018). HABITAT REQUIREMENTS OF MIGRATORY BIRDS IN THE MATANG MANGROVE FOREST RESERVE, PERAK. *Journal of Tropical Forest Science, 30*(3), 304-311.

Asian Species Action Partnership. (n.d.). *Southern River Terrapin Batagur affinis.* Retrieved August 30, 2020, from Asian Species Action Partnership: https://www.speciesonthebrink.org/species/southern-river-terrapin/

Australian Government Bureau of Meteorology. (2014). *Water Accounting Conceptual Framework for the Preparation and Presentation of General Purpose Water Accounting Reports.* Retrieved September 19, 2021, from http://www.bom.gov.au/water/standards/wasb/documents/Water-Accounting-Conceptual-Framework-Accessible.pdf

Australian Water Association. (2012, October). *The Case for Water Efficiency Position Paper.* Retrieved from Northern Territory Government - Department of Environment, Parks and Water Security: https://denr.nt.gov.au/__data/assets/pdf_file/0011/529454/The_Case_for_Water_Efficiency_Position_Paper.pdf

Babulal, V. (2020, April 18). *New Straits Times.* Retrieved August 30, 2021, from Air and Water Quality Improve During MCO: https://www.nst.com.my/news/nation/2020/04/585488/air-and-water-quality-improve-during-mco

Bandini. (2019). Unmanned Airborne Vehicles (UAVs) for Monitoring Small Streams and Optimising River Maintenance.

BERNAMA. (2020, January 2). Local Hero Out to Save Firefly Habitat. Kuala Selangor.

Binance Academy. (2020, July 8). *History of Blockchain.* Retrieved July 8, 2020, from Binance Academy: https://academy.binance.com/blockchain/history-of-blockchain

Boyd, J. (2012). *JFK's 1962 Moon Speech Still Appeals 50 Years Later.* Retrieved from Rice University: http://news.rice.edu/2012/08/30/jfks-1962-moon-speech-still-appeals-50-years-later/

Builtin. (2020, July 8). *Builtin.* Retrieved July 8, 2020, from Blockchain 101: https://builtin.com/blockchain

Chew, V. (2019, July). *Singapore-Malaysia water agreements.* Retrieved May 20, 2021, from Singapore Infopedia: https://eresources.nlb.gov.sg/infopedia/articles/SIP_1533_2009-06-23.html

Choi, K. (2020). *New Solutions for Water Resources Management in South Korea.*

Cohen, W., & Levinthal, D. (1990). *Absorptive Capacity: A New Perspective on Learning and Innovation.*

Department of Agriculture. (2021, April 9). Slide Presentation. *Pengumpulan Data Air Pertanian.* Retrieved April 9, 2021

Department of Environment. (n.d.). *Groundwater Monitoring.* Retrieved September 20, 2020, from Official Portal of Department of Environment. https://www.doe.gov.my/en/2021/10/26/groundwater-monitoring/

Department of Environment. (2021, February 17). Slide Presentation. *Water Quality Monitoring.* Retrieved February 17, 2021.

Department of Environment Malaysia. (2021). *National Water Quality Standards*. Retrieved from https://www.doe.gov.my/portalv1/wp-content/uploads/2019/05/Standard-Kualiti-Air-Kebangsaan.pdf

Department of Irrigation and Drainage. (n.d.). Department of Irrigation and Drainage. *Coastal Management – Activities*. Retrieved September 20, 2020, from https://www.water.gov.my/index.php/pages/view/515?mid=290

Department of Mineral and Geoscience Malaysia. (n.d.). *Functions and Roles*. Retrieved September 20, 2020, from Department of Mineral and Geoscience Malaysia: https://www.jmg.gov.my/en/mengenai-kami/profil-korporat/fungsi

DOSM. (2020). *State Socioeconomic Report 2019*. Retrieved May 31, 2021, from Department of Statistics Malaysia Official Portal: https://www.dosm.gov.my/v1/index.php?r=column/cthemeByCat&cat=102&bul_id=TExzYmVmRC83S1hBMEUrUDVzczdLUT09&menu_id=TE5CRUZCblh4ZTZMODZIbmk2aWRRQT09

Economic Planning Unit. (2021, September). *Rancangan Malaysia Kedua Belas 2021-2025*. Retrieved September 30, 2021, from RMK12: https://rmke12.epu.gov.my/en

Economic Planning Unit, Prime Minister's Department. (2021). *Malaysia Digital Economic Blueprint*. Retrieved September 21, 2021, from Economic Planning Unit (EPU): https://www.epu.gov.my/sites/default/files/2021-02/malaysia-digital-economy-blueprint.pdf

EOS. (2019, April 8). *Improving Water Resources Management with Satellite Data*. Retrieved September 14, 2021, from EOS by American Geophysical Union: https://eos.org/research-spotlights/improving-water-resources-management-with-satellite-data,

EPU. (2021). Retrieved April 13, 2021, from Economic Planning Unit, Prime Minister's Department: https://www.epu.gov.my/sites/default/files/2021-02/malaysia-digital-economy-blueprint.pdf

FAO. (2016). *Water Accounting and Auditing - A sourcebook. Rome: Food and Agriculture Organisation of the United Nations (FAO)*. Retrieved November 20, 2020, from Food and Agriculture Organisation of the United Nations (FAO): http://www.fao.org/policy-support/tools-and-publications/resources-details/en/c/1395514/

FAO. (2018). *Policy Brief: Water Accounting for Water Governance and Sustainable Development*. Retrieved April 15, 2021, from Food and Agricuture Organisation of the United Nations: http://www.fao.org/3/I8890EN/I8890EN.pdf

Food and Agriculture Organisation (FAO) of the United Nations. (2016). *FAO Water Reports: Water Accounting and Auditing - A sourcebook*. Rome: Food and Agriculture Organisation of the United Nations (FAO). Retrieved November 20, 2020.

Food and Agriculture Organisation of the United Nations. (2011). *Types of Rainfed Farming Systems Around the World*. Retrieved September 22, 2021, from https://agris.fao.org/agris-search/search.do?recordID=AU2019106423

Food and Agriculture Organisation of the United Nations. (2014). *The Water-Energy-Food Nexus: A new approach in support of food security and sustainable agriculture*.

Frishammar, J., & Horte, S. (2005). *Managing External Information in Manufacturing Firms: The Impact on Innovation Performance*.

GardaWorld. (2020, January). *Malaysia: First cases of 2019-nCoV confirmed January 25*. Retrieved from GardaWorld: https://www.garda.com/crisis24/news-alerts/308496/malaysia-first-cases-of-2019-ncov-confirmed-january-25

Gnaneswaran, D. (2018, February 6). *Digital transformation to contribute US$10 billion to Malaysia GDP by 2021*. Retrieved March 3, 2021, from Microsoft Malaysia News Centre: https://news.microsoft.com/en-my/2018/02/06/digital-transformation-contribute-us10-billion-malaysia-gdp-2021/

Government of Malaysia. (2006, January 1). *Attorney General's Chambers of Malaysia*. Retrieved February 20, 2021, from Official Secrets Act 1972: http://www.agc.gov.my/agcportal/uploads/files/Publications/LOM/EN/Act%2088.pdf

Government of Malaysia. (2006, January 1). *Fees Act 1951*. Retrieved February 24, 2021, from Laws of Malaysia: http://www.dvs.gov.my/dvs/resources/auto%20download%20images/560df8e6537cf.pdf

Government of Malaysia. (2019, October 7). *Shared Prosperity Vision 2030*. Retrieved August 15, 2020, from Prime Minister's Office: https://www.pmo.gov.my/2019/10/shared-prosperity-vision-2030-2/

Government of Malaysia. (2021, July 16). *RMK12*. Retrieved September 30, 2021, from RMK12: https://rmke12.epu.gov.my/en

Hamstead, M. (2007). *What is "Environmental Water?"*. Blaxland: Hamstead Consulting Pty Ltd. Retrieved April 20, 2021

Hoekstra, A. Y., & Chapagain, A. K. (2008). *Globalisation of water: sharing the planet's freshwater resources*. Oxford, UK: Blackwell Publishing.

IADA Pulau Pinang. (2019, May 18). *Amanat Pengerusi Kumpulan Pengguna Air IADA Pulau Pinang*. Retrieved March 12, 2021, from Malaysia Dokumen: https://fdokumen.site/document/amanat-pengerusi-pengguna-air-kpa-bilangan-petani-kumpulan-pengguna-air.html

IBM. (2016, November 17). *What is the Internet of Things (IoT)?* (J. Clark, Editor) Retrieved September 28, 2021, from IBM Business Operation Blog: https://www.ibm.com/blogs/internet-of-things/what-is-the-iot/

IBM. (2018, August). *What is Blockchain Technology?* (S. Explained, Editor) Retrieved September 26, 2021, from IBM: https://builtin.com/blockchain

IMD World Competitiveness. (2016). *IMD World Competitiveness*.

Jabatan Meteorologi Malaysia. (2021, March 24). Slide Presentation. *Focus Group Discussion: IWSDC*. Retrieved March 24, 2021

Jabatan Mineral dan Geosains (JMG). (2021, March 5). Sesi Focus Group Discussion (FGD) Integrated Water Sector Data Centre (IWSDC) Bersama Jabatan Mineral dan Geosains Malaysia (JMG).

Jabatan Pengairan dan Saliran Malaysia. (2020, July 28). Slide Presentation. *Enterprise Portal Maklumat Sumber Air*. Retrieved July 28, 2020

Jabatan Perkhidmatan Awam. (2018). *Arahan Pentabiran Pengurusan Rekod Jabatan Perkhidmatan Awam.* Retrieved September 11, 2021, from Jabatan Perkhidmatan Awam: https://docs.jpa.gov.my/docs/pelbagai/2018/APPR012018.pdf

Jabatan Ukur dan Pemetaan Malaysia. (n.d.). *Malaysia Tide Prediction Table*. Retrieved September 20, 2020, from Jabatan Ukur dan Pemetaan Malaysia: https://www.jupem.gov.my/page/malaysia-tide-prediction-table-1

JPS. (2017, November). SMSA Blueprint. Retrieved April 12, 2021

JPS. (2017, November). SMSA Blueprint. Retrieved April 12, 2021

KASA. (2021, February). DIPAN-SMI Summary. Retrieved April 12, 2021

Kementerian Alam Sekitar dan Air. (2021, March 21). Spec and Scope DIPAN SMI.

Korn Ferry. (2018). *The Future of Work: The Global Talent Crunch- Country Perspective: Malaysia.* Retrieved April 2, 2021, from Korn Ferry: https://focus.kornferry.com/wp-content/uploads/2015/02/KF-Talent-Crunch-Country-Report-Malaysia-Digital.pdf

Korn Ferry. (2018). *The Talent Shift: Leaders' Perspective: Malaysia.* Retrieved April 2, 2021, from Korn Ferry: https://www.kornferry.com/content/dam/kornferry/docs/pdfs/KF-Talent-Shift-Country-Report-Malaysia-Digital.pdf

Lim, J. (2020, November 02). *Tech Talk: Much room for improvement in open data policy.* Retrieved November 29, 2020, from The Edge Markets: https://www.theedgemarkets.com/article/tech-talk-much-room-improvement-open-data-policy

Lim, J. (2021, March 15). *Experts call for data initiatives to be prioritised.* Retrieved April 2, 2021, from The Edge Markets: https://www.theedgemarkets.com/article/experts-call-data-initiatives-be-prioritised%C2%A0

Lim, J. (2021, March 1). *Malaysia Digital Economy Blueprint: Still many gaps in open data policy.* Retrieved April 11, 2021, from The Edge Markets: https://www.theedgemarkets.com/article/malaysia-digital-economy-blueprint-still-many-gaps-open-data-policy

Lypchenko, S. (2019, Feb 26). *Dzone*. Retrieved July 8, 2020, from How Can We Benefit From Using Blockchain Technology?: https://dzone.com/articles/how-can-we-benefit-from-using-blockchain-technolog

MADA. (n.d.). Location of Telemetry Stations In Muda Area. Retrieved 2021

Majlis Keselamatan Negara. (2021, 7 7). Dasar Keselamatan Negara 2021-2025. *Dasar Keselamatan Negara 2021-2025*. Putrajaya, Putrajaya, Malaysia: Majlis Keselamatan Negara. Retrieved 9 19, 2021, from https://asset.mkn.gov.my/web/wp-content/uploads/sites/3/2019/08/DASAR-KESELAMATAN-NEGARA-2021-2025.pdf

Malaysia Science and Technology Information Centre (MASTIC). (2020, July). *National Research and Development (R&D) Survey*. Retrieved from Malaysia Science and Technology Information Centre (MASTIC): https://mastic.mosti.gov.my/index.php/sti-survey-category/national-research-and-development-rd-survey

Malaysian Productivity Corporation (MPC). (2019). *Malaysia in the IMD World Competitiveness Yearbook*. Retrieved from http://www.mpc.gov.my/wp-content/uploads/2019/09/wcy-page-by-page-12062019.pdf

Malaysian Space Agency. (n.d.). *Laporan Tahunan 2020.* Retrieved September 20, 2020, from Official Portal Malaysian Space Agency: https://www.mysa.gov.my/publication/#42-46-annual-report-mysa

Malaysian Space Agency. (2020, November 17). Presentation MYSA. Retrieved November 17, 2020

Malaysian Space Agency. (2021). Presentation MYSA-Image Satellite Comparison of Masjid Putra. Retrieved October 18, 2021

MAMPU. (2021). *Dasar Perkongsian Data Nasional (NDSP)*. Retrieved September 26, 2021, from MAMPU: https://www.malaysia.gov.my/portal/content/31182

Marr, B. (2018, Feb 16). *A Very Brief History Of Blockchain Technology Everyone Should Read*. Retrieved July 8, 2020, from Forbes: https://www.forbes.com/sites/bernardmarr/2018/02/16/a-very-brief-history-of-blockchain-technology-everyone-should-read/#2e9950717bc4

Ministry of Agriculture and Food Industries. (n.d.). *Telemetry System*. Official Website Muda Agricultural Development Authority (MADA). Retrieved September 20, 2020, from https://www.mada.gov.my/?page_id=4877&lang=en

Ministry of Economic Affairs. (2019). *Strategic Paper 16: Water Sector Transformation, 12th Malaysia Plan 2021-2025 (Draft).*

Ministry of Economic Affairs. (2019). Strategy Paper 16: Water Sector Transformation 2040; 12th Malaysia Plan 2021-2025.

Ministry of Finance Malaysia. (n.d.). *What is Ministry of Finance Incorporated [MoF (Inc)]?* Retrieved September 11, 2021, from Ministry of Finance Malaysia: https://www.mof.gov.my/pdf/bahagian/gic/faq-en.pdf

Ministry of Housing and Local Government. (2010, August 13). *National Physical Plan 2- Ministry of Housing and Local Government*. Retrieved June 13, 2021, from Ministry of Housing and Local Government: https://www.yumpu.com/en/document/view/42390861/national-physical-plan-ministry-of-housing-and-local-government

Ministry of Natural Resources and Environment Malaysia. (2012). National Water Resources Policy.

Ministry of Science, Technology and Innovation (MOSTI). (2014). *Indicators Report 2013.* Putrajaya: MOSTI.

Ministry of Science, Technology and Innovation (MOSTI). (2019). *Katalog Produk/Teknologi/Perkhidmatan Tahun Pengkomersialan Malaysia (MCY) 2019.*

Ministry of Science, Technology and Innovation (MOSTI). (2021, April 22). *Approved Projects*. Retrieved April 26, 2021, from Ministry of Science, Technology And Innovation (MOSTI): https://www.mosti.gov.my/web/en/funds-grants/approved-projects/

Ministry of Science, Technology, Environment and Climate Change. (2018, September). *Malaysia Third National Communication and Second Biennial Update Report to the UNFCCC*. Retrieved June 12, 2021, from United Nations Framework Convention on Climate Change (UNFCCC): https://unfccc.int/sites/default/files/resource/Malaysia%20NC3%20BUR2_final%20high%20res.pdf

MKN. (2019, July 22). *National Security Policy.* Retrieved May 20, 2021, from Majlis Keselamatan Negara: https://www.mkn.gov.my/web/wp-content/uploads/sites/3/2019/08/English-National_Security_Policy.pdf

Mohamad Nor, D. D. (2012). Kepentingan Maklumat Geospatial dalam Program Transformasi Negara. *NGIS 5.* Retrieved September 10, 2020

Mokhtar, M., Chan, H. Y., & Goh, C. T. (2009). Programme Monitoring System (PMS): An Experience in Measuring Performance Towards Sustainability. *European Journal of Social Sciences, 7*(3), 7-16.

MOSP. (2020). *What is Malaysia Open Science Platform?* Retrieved April 13, 2021, from Malaysia Open Science Platform: https://www.akademisains.gov.my/mosp/about/what-is-malaysia-open-science-platform/

Muhamad, H. (2021, March 11). *KASA dalam peringkat akhir penubuhan Jabatan Air Negara - Tuan Ibrahim*. Retrieved April 11, 2021, from Astro Awani: https://www.astroawani.com/berita-malaysia/kasa-dalam-peringkat-akhir-penubuhan-jabatan-air-negara-tuan-ibrahim-287412

Mukhlis, Z. A. (2019, August 26). Air untuk Semua. Kota Bharu, Kelantan, Malaysia.

MyGeoportal. (2021). *Policies and Standards.* Retrieved April 2, 2021, from National Geospatial Centre: http://www.mygeoportal.gov.my/node/80

MyGovernment. (2019). *Open Government Data.* Retrieved March 12, 2021, from MyGovernment: https://www.malaysia.gov.my/portal/content/30024

NAHRIM. (2020). Slaid Pembentangan NAHRIM.

NASA. (2004, May 24). *Exerpt from the Special Message to the Congress on Urgent National Needs.* Retrieved from https://www.nasa.gov/vision/space/features/jfk_speech_text.html#.VWIGJ0_tmkp

National Water Research Institute of Malaysia (NAHRIM). (n.d.). *The Water Innovation Roadmap (NWIR, 2021-2040).* Ministry of Environment and Water (KASA).

Nicholls, D. (2009, October 13). *Australian Government Bureau of Meteorology*. Retrieved June 12, 2021, from Bureau of Meteorology: http://www.bom.gov.au/water/newEvents/document/4_Water_Regulations_and_Water_Data_Transfer_David_Nicholls.pdf

Nuarrual Hilal, M. D. (2011, March 15). *Law*. Retrieved February 21, 2021, from Malaysian Official Secrets Act 1972 (OSA): https://nuarrualhilal.wordpress.com/2011/03/15/malaysian-official-secret-act-1972-osa/

Open Data Barometer. (2014). *Global Rankings.* Retrieved March 13, 2021, from opendatabarometer.org: https://opendatabarometer.org/2ndEdition/analysis/rankings.html

Open Geospatial Consortium (OGC). (2012). *OGC WaterML2.0.* Retrieved from https://www.ogc.org/docs/is

Open Knowledge Foundation. (2016). *Global Open Data Index.* Retrieved March 11, 2021, from https://index.okfn.org/place/

ORACLE. (2021). *What is AI? Learn about Artificial Intelligence*. Retrieved September 27, 2021, from ORACLE: https://www.oracle.com/artificial-intelligence/what-is-ai/

Oxford. (2020, August 29). *Meaning of "game changer".* Retrieved from Lexico powered by Oxford: https://www.lexico.com/definition/game_changer

Pakar Scieno TW Sdn Bhd. (n.d.). *Pakar Scieno TW* . Retrieved September 20, 2020, from http://pstw.com.my

Parliament Public Accounts Committee. (2021). *Parliament Public Accounts Committee*. Retrieved August 27, 2021, from https://www.parlimen.gov.my/pac/latarbelakang-pac.html?&lang=en

Perbadanan Bekalan Air Pulau Pinang. (2019). *Sungai Perak Raw Water Transfer Scheme*. Retrieved September 20, 2021, from Perbadanan Bekalan Air Pulau Pinang: https://sprwts.pba.com.my/

Planet Labs Inc. (2020, April). *Planet Gallery*. Retrieved September 14, 2021, from https://www.planet.com/gallery/?

PLANMalaysia. (n.d.). *Fungsi Jabatan.* Retrieved September 20, 2020, from Official Portal PLANMalaysia: https://www.planmalaysia.gov.my/index.php/mengenai-kami/plan-malaysia/fungsi-jabatan

Prime Minister's Office of Malaysia . (2020, March). *Restriction of Movement Order*. Retrieved from Prime Minister's Office of Malaysia Official Website` : https://www.pmo.gov.my/2020/03/movement-control-order/

Prüss-Üstün A, B. R. (2008). *Safer Water, Better Health, Costs, Benefits and Sustainability of Interventions to Protect and Promote Health.* Geneva: World Health Organisation.

Pusat Geospatial Negara. (2020). *MS1759 Malaysian Standard Geographic Information/Geomatics Feature and Attribute Codes*. Retrieved May 31, 2021, from http://ms1759.mygeoportal.gov.my/ms1759v3/page.php?pageid=content

Ragupathy, D. K., Baharin, S., & Turan, F. M. (2020). *University Industry Collaboration: Journal of Modern Manufacturing Systems and Technology.*

Right2Info. (2019, May). *Countries with ATI Laws.* Retrieved April 11, 2021, from Good Law and Practice: https://www.right2info.org/resources/publications/countries-with-ati-laws-1/view

RPM Engineers Sdn. Bhd. (n.d.). JPS Hydrological Stations. Retrieved 2020

RPM Engineers Sdn. Bhd. (n.d.). Total Consumptive Water Demand against Total Surface Water Availability for All Sectors (Derived from: Review of the National Water Resources (2000-2050). Retrieved 2021

RPM Engineers Sdn. Bhd. (n.d.). Water Data Collection Management in Malaysia. Retrieved 2021

RPM Engineers Sdn. Bhd. (n.d.). Water-Food-Energy Nexus with Respect to Water Resources. Retrieved 2021

Shaharudin, A. (2020). *Open Government Data for Academic Research.* Khazanah Research Institute. Retrieved from http://www.krinstitute.org/assets/contentMS/img/template/editor/210422%20WP%20-%20Open%20government%20data%20for%20academic%20research%20v3.pdf

Spiliakos, A. (2019). *TRAGEDY OF THE COMMONS: WHAT IT IS AND 5 EXAMPLES*. Retrieved September 5, 2021, from Harvard Online Business School: https://online.hbs.edu/blog/post/tragedy-of-the-commons-impact-on-sustainability-issues

Suruhanjaya Perkhidmatan Air Negara (SPAN). (2006). *Water Services Industry Act 2006*. Retrieved August 12, 2021, from Suruhanjaya Perkhidmatan Air Negara (SPAN): https://www.span.gov.my/document/upload/66ILUPtM99inqSJ4o7YLUgOrK4IrZtOq.pdf

TechTarget. (2021, February 2). *BIg Data Analytics*. Retrieved September 26, 2021, from SearchBusineesAnalytics: https://searchbusinessanalytics.techtarget.com/definition/big-data-analytics

Tenaga Nasional Berhad. (2021). Hydrology Services.

Tenaga Nasional Berhad. (2021, March 15). Slide Presentation. *Hydrological Services: Dam Surveillance and Hydrology*. Retrieved March 15, 2021

Tenaga Nasional. (n.d.). *Nature's Glow Sees a Brighter Future*. Retrieved August 29, 2021, from Tenaga Nasional Better Brighter: https://betterbrighter.my/articles/our-work/firefly-conservation-project

The Water Hub. (2018). *Our Project and Case Studies*. Retrieved September 9, 2021, from The Water Hub: https://thewaterhub.org.uk/

The World Bank. (2010). *Improving Water Management in Rainfed Agriculture: Issues and Options in Water-Constrained Production Systems.* Retrieved September 28, 2021

Trading Economics. (2020). *Malaysia GDP*. Retrieved 2020, from https://tradingeconomics.com/malaysia/gdp

Trading Economics. (2020). *Malaysia GDP Per Capita in Purchasing Power Parity*. Retrieved 2020, from https://tradingeconomics.com/malaysia/gdp-per-capita-ppp

UN Water. (2013). *Water Security and the Global Water Agenda*. United Nations University.

UNESCO. (2020). *First draft of the UNESCO Recommendation on Open Science*.

UNESCO. (n.d.). *Local and Indigenous Knowledge Systems (LINKS)*. Retrieved August 30, 2021, from UNESCO: https://en.unesco.org/links

United Nations. (1992). *United Nations Framework Convention on Climate Change*. Retrieved November 29, 2020, from UNFCCC: https://unfccc.int/files/essential_background/background_publications_htmlpdf/application/pdf/conveng.pdf

United Nations Development Programme. (2015). *Sustainable Development Goals*. Retrieved March 11, 2021, from United Nations Development Programme: https://www.undp.org/content/dam/undp/library/corporate/brochure/SDGs_Booklet_Web_En.pdf

United Nation's Division for Sustainable Development Goals. (2015, September). *Transforming our world: the 2030 Agenda for Sustainable Development*. Retrieved August 27, 2020, from United Nations: https://sustainabledevelopment.un.org/post2015/transformingourworld

United States Environmental Protection Agency. (n.d.). *U.S. Electricity Grid & Markets*. Retrieved December 20, 2020, from United States Environmental Protection Agency: https://www.epa.gov/greenpower/us-electricity-grid-markets#main-content

Water Network Research. (2020, May 11). *The Water Network*. Retrieved July 8, 2020, from Busan Turns to Blockchain Technology for Water Supply System: https://thewaternetwork.com/article-FfV/busan-turns-to-blockchain-technology-for-water-supply-system-IqecQMSBBMXilh_NulnC6A

Water Research Network. (2020, May 13). *Australian government in Water Ledger blockchain for trading water rights*. Retrieved July 8, 2020, from The Water Network: https://thewaternetwork.com/_/rising-water-technologies/article-FfV/australian-government-in-water-ledger-blockchain-for-trading-water-rights-Zuf%E2%80%A6

World Health Organisation (WHO). (2020, January). *Pneumonia of unknown cause – China*. Retrieved from World Health Organisation: https://www.who.int/csr/don/05-january-2020-pneumonia-of-unkown-cause-china/en/

Worldometer. (2020). *Malaysia Population*. Retrieved 2020, from https://www.worldometers.info/world-population/malaysia-population/

Appendices

Appendix A

List of Engagements

No.	Event	Ministry	Department/Agency	Dates and Time	Venue	List of attendees
1.	Focus Group Discussion (FGD) No. 1 with Department of Irrigation and Drainage (DID)	Ministry of Environment and Water (KASA)	Department of Irrigation and Drainage (DID)	21 July 2020 2:30 pm to 5:00 pm	Bilik Gerakan, DID Headquarters, Jalan Sultan Salahuddin, Kuala Lumpur (physical meeting)	
2.	Addendum FGD No. 1 with Department of Irrigation and Drainage (DID)	Ministry of Environment and Water (KASA)	Department of Irrigation and Drainage (DID)	28 July 2020 2:30 pm to 5:00 pm	*Bilik Mesyuarat Bahagian Pengurusan Maklumat*, DID Headquarters, Jalan Sultan Salahuddin, Kuala Lumpur (Physical meeting)	
3.	FGD No. 2 with National Water Research Institute Malaysia (NAHRIM)	KASA	National Water Research Institute Malaysia (NAHRIM)	8 September 2020, from 10:00 am to 01:00 pm	Meeting Room – Administration Building, NAHRIM, Jalan Putra Permai, Seri Kembangan, Selangor (physical meeting)	

List of attendees – FGD No. 1

No.	Name	Division
1.	Dato' Ir. Mohd Azmi Ismail	Pejabat Ketua Pengarah
2.	Azril Hafiz Ab Rahim	Pejabat Ketua Pengarah
3.	Norazizah Abdul Kadir	Bahagian Korporat
4.	Daniel Liew Yu Chuan	Bahagian Pengurusan Lembangan Sungai
5.	Mohd Hazri Moh Khambali	Bahagian Rekabentuk & Empangan
6.	Ir. Sofiah Binti Mat	Bahagian Rekabentuk & Empangan
7.	Ir. Rosita Binti Salam	Bahagian Saliran Mesra Alam
8.	Azli Ayub	Bahagian Pengurusan Banjir
9.	Fairus Binti Ahmad	Bahagian Pengurusan Zon Pantai
10.	Ir. Azmi Amat	Bahagian Pengurusan Fasiliti & GIS
11.	Gs. Yusri Abd Jalil	Bahagian Pengurusan Fasiliti & GIS
12.	Zainalfikry Daud	Pusat Kawalan SMART
13.	Mohamad Nazif Daud	Pejabat Lembangan Sungai Klang
14.	Ir. Sazali Osman	Pusat Ramalan& Amaran Banjir Negara
15.	Ir. Dr. Asnor Muizan Ishak	Bahagian Pengurusan Sumber Air & Hidrologi
16.	Nor Hamizah Binti Muhamad	Bahagian Pengurusan Sumber Air & Hidrologi
17.	Artiesa Binti Arris	Bahagian Pengurusan Maklumat
18.	Khairudin Bin Mohamad Mor	Bahagian Pengurusan Maklumat
19.	Mohamedd Hafiz Kamaluddin	Pengurusan Sumber Air & Hidrologi
20.	Datuk Ir. Mohd Adnan Mohd Nor	IWSDC Chair
21.	Ir. Liam We Lin	IWSDC Lead SME
22.	Ahmad Ashrin Abdul Jalil	IWSDC Analyst
23.	Aida Syarafina Ismail	IWSDC RA

List of attendees – Addendum FGD No. 1

No.	Name	Division
1.	Artiesa Arris	Bahagian Pengurusan Maklumat
2.	Nur Murniwati Abd Majid	Bahagian Pengurusan Maklumat
3.	Siti Noorain Zulkifly	Bahagian Pengurusan Maklumat
4.	Ahmad Ashrin Abdul Jalil	IWSDC Analyst
5.	Aida Syarafina Ismail	IWSDC RA

List of attendees – FGD No. 2

No.	Name	Division
1.	Ir. Mohd Zaki Mat Amin	Pejabat Timbalan Ketua Pengarah
2.	Ir. Dr. Safari Hj Mat Desa	Pusat Kajian Lembangan Sungai
3.	Ismail Tawnie	Pusat Kajian Hidrogeologi
4.	Ir. Azman Mat Jusoh	Pusat Kajian Sumber Air & Perubahan Iklim
5.	Saiful Bahri Hamzah	Makmal Hidraulik & Instrumentasi/Bahagian Perancangan Korporat
6.	Mohd Kamarul Huda	Makmal Hidraulik & Instrumentasi
7.	M. Syazwan Faisal	Pusat Kajian Lembangan Sungai
8.	Ir. Dr. Lee Hin Lee	Pusat Kajian Pantai & Oseanografi
9.	Liew Yuk San	Pusat Kajian Lembangan Sungai
10.	Dr. Zati Sharip	Pusat Kajian Kualiti Air & Alam Sekitar
11.	Azian Fatilah Mia	Bahagian Pengurusan Maklumat

No.	Event	Ministry	Department/Agency	Dates and Time	Venue	List of attendees

No.	Name	Division
20.	Datuk Ir. Mohd Adnan Mohd Nor	IWSDC Chair
21.	Ir. Liam We Lin	IWSDC Lead SME
22.	Ahmad Ashrin Abdul Jalil	IWSDC Analyst
23.	Aida Syarafina Ismail	IWSDC RA
24.	Najmuddin Abdul Rahim	IWSDC RA

4.	IWSDC Task Force Meeting No. 1	Various	Various	23 September 2020; from 9:00am to 12:00pm	Council Room, ASM MATRADE (hybrid meeting)

No.	Name	Department
1.	Datuk Ir. Mohd Adnan Mohd Nor	IWSDC Chairperson (ASM)
2.	Zuraimi Suleiman	MySA
3.	Ardi Bakhtiar	ASMA
4.	Voon Kok How	KKM
5.	Mohd Zunaidi Mat	METMalaysia
6.	Alvyn Clancey Mickey	JMG
7.	Gs. Yusri Abd Jalil	JPS
8.	Fariza Binti Kambut	DoSM
9.	Yaashinni A/P Peraniandy	DoA
10.	Nik Kun Nik Man	MADA
11.	Ir. Dr. Nordin Ramli	MIMOS
12.	Ts. Ahmad Fuad Zainudin	Air Selangor
13.	Noryusuhasriq Mohd Yusof	TNB
14.	Ir. Dr. Safari Hj. Mat Desa	NAHRIM
15.	Rosni Ismail	JASM
16.	Van Kong Tze Yien	JPS Sabah
17.	Normahyusni Mohd Anuar	JPS Sarawak
18.	Hj. Alias Mohammed	JPP
19.	Nur Suhaida Azemi	PLANMalaysia
20.	Ir. Dr. Salmah Zakaria	PMC WST2040 Chairperson (ASM)
21.	Ahmad Ashrin Abdul Jalil	IWSDC Analyst (ASM)
22.	Aida Syarafina Ismail	Research Assistant (ASM)
23.	Najmuddin Abdul Rahim	Research Assistant (ASM)
24.	Loh Chia Hur	PMC Analyst (ASM)
25.	Hareehaaran A/L Mathialagan	PMC Analyst (ASM)

5.	FGD No. 3 with Department of Statistics Malaysia (DOSM)	Prime Minister's Department (PMD)	Department of Statistics Malaysia (DOSM)	26 October 2020, from 10:00am to 12:30pm	Online meeting

No.	Name	Division
1.	Siti Zakiah Mohamad Isa	*Bahagian Perangkaan Pertanian dan Alam Sekitar* (DOSM)
2.	Fariza Kambut	*Bahagian Perangkaan Pertanian dan Alam Sekitar* (DOSM)
3.	Siti Salwaty Ab Kadir	*Bahagian Perangkaan Pertanian dan Alam Sekitar* (DOSM)
4.	Sahida Aris @ Idris	*Bahagian Perangkaan Pertanian dan Alam Sekitar* (DOSM)
5.	Romiati Chinkeruan	*Bahagian Perangkaan Komunikasi Strategik dan Antarabangsa* (DOSM)
6.	Ismail Abdul Rahman	*Bahagian Perangkaan Pertanian dan Alam Sekitar* (DOSM)

No.	Event	Ministry	Department/Agency	Dates and Time	Venue	List of attendees
						No. Name Division 7. Datuk Ir. Mohd Adnan Mohd Nor IWSDC Chair 8. Ahmad Ashrin Abdul Jalil IWSDC Analyst 9. Aida Syarafina Ismail IWSDC RA 10. Najmuddin Abdul Rahim IWSDC RA
6.	SME Meeting No. 1 – Systems Architecture	-	Millenium Radius Sdn Bhd (MRSB)	2 November 2020, from 10:00am to 12:30pm	Meeting room RPM Engineers Sdn Bhd (Physical meeting)	No. Title Division IWSDC Project Team 1. Mohd Adnan Mohd Nor Datuk Ir. IWSDC Chair 2. Ahmad Ashrin Abdul Jalil Tuan IWSDC Analyst 3. Aida Syarafina Ismail Puan IWSDC RA 4. Najmuddin Abdul Rahim Tuan IWSDC RA 5. Shah Izzni Talif Mohd Adnan Ir. Team - SME on IR4.0 Applications 6. Mohd Hazri Mohd Zuhuri Tuan Representative from MRSB 7. Engku Ghaz Adli Engku Abdullim Tuan Representative from MRSB 8. Kamarul Hairi Kamarudin Tuan Representative from MRSB 9. Hanis Ab. Hamid Puan Representative from MRSB
7.	FGD No. 4 with Malaysian Space Agency (MYSA)	Ministry of Science, Technology and Innovation (MOSTI)	Malaysian Space Agency (MYSA)	17 November 2020, from 10:00am to 12:30pm	Online meeting	No. Name Division 1. Haji Azlikamil bin Napiah Ketua Pengarah, MYSA 2. Zuraimi Sulaiman Pengarah, Bahagian Pengurusan Sumber (MYSA) 3. Adnan bin Haji Ismail Timbalan Ketua Pengarah, Bahagian Penyelidikan dan Pembangunan (MYSA) 4. Faitz Aqira Bin Nordin Bahagian Perancangan dan Komunikasi Strategik (MYSA) 5. Datuk Ir. Mohd Adnan Mohd Nor IWSDC Chair 6. Ahmad Ashrin Abdul Jalil IWSDC Analyst 7. Najmuddin Abdul Rahim IWSDC RA
8.	SME Meeting No. 2 - RDIC in the Water Sector	KASA	NAHRIM	9 December 2020; From 2:00pm to 4:00pm	RPM Engineers Sdn Bhd (Hybrid meeting)	No. Name Division 1. Datuk Ir. Mohd Adnan Mohd Nor IWSDC Chairperson 2. Ahmad Ashrin Abdul Jalil IWSDC Analyst 3. Aida Syarafina Ismail IWSDC Research Assistant 4. Najmuddin Abdul Rahim IWSDC Research Assistant 5. Ir. Mohd Zaki Mat Amin SME on RDIC in the Water Sector
9.	SME Meeting No. 3 - SME on Space Technology	MOSTI	MYSA	14 December 2020; From 3:00pm to 4:30pm	RPM Engineers Sdn Bhd (Hybrid meeting)	No. Name Division 1. Datuk Ir. Mohd Adnan Mohd Nor IWSDC Chairperson 2. Ahmad Ashrin Abdul Jalil IWSDC Analyst 3. Aida Syarafina Ismail IWSDC Research Assistant 4. Najmuddin Abdul Rahim IWSDC Research Assistant 5. Adnan Ismail SME on Space Technology

No.	Event	Ministry	Department/Agency	Dates and Time	Venue	List of attendees
10.	FGD No. 5 with Department of Environment (DOE)	KASA	Department of Environment (DOE)	17 February 2021, from 10:00am to 12:30pm	Online meeting	
11.	*Mesyuarat Mengenai Projek Pembangunan Data Industri Perkhidmatan Air Negara Beserta Spatial Mapping Yang Interaktif* (DIPAN SMI)	Prime Minister's Department (PMD) and KASA	Economic Planning Unit (EPU)-KASA	19 February 2021, from 3:00pm to 5:00pm	Online meeting	

List of attendees — FGD No. 5 with Department of Environment (DOE)

No.		Title	Division
IWSDC Project Team			
1.	Mohd Adnan Mohd Nor	Datuk Ir.	IWSDC Chair
2.	Ahmad Ashrin Abdul Jalil	Tuan	IWSDC Analyst
3.	Aida Syarafina Ismail	Puan	IWSDC RA
4.	Najmuddin Abdul Rahim	Tuan	IWSDC RA
5.	Nurul Syahidatul Balqis Haidzir	Cik	IWSDC RA
6.	Liam We Lin	Ir.	Lead SME
7.	Shah Izzni Talif Mohd Adnan	Ir.	Team - SME on IR4.0 Applications
8.	Mohd Za'im Mohd Zuhuri	Tuan	SME on Systems Architecture
9.	Engku Ghaz Adli Engku Abdullim	Tuan	Representative from MRSB
10.	Hanis Ab. Hamid	Puan	Representative from MRSB
11.	Kamarul Hairi Kamarudin	Tuan	Representative from MRSB
12.	Norizan Abdul Fattah	Puan	Representative from MYSA
Representative from DOE			
13.	Mohd Hidzir Bakar	Tuan	*Bahagian Air dan Marin*
14.	Rosni Ismail	Puan	*Seksyen Pembangunan Sumber Air*
15.	Norina Frederick Sambang	Cik	*Seksyen Perlindungan Air Marin*
16.	Zuhainim Abd Ghaffar	Puan	*Seksyen Pengawasan Air Tanah*
17.	Jamal Affendy Shahar	Tuan	*Seksyen Beban Pencemaran*
18.	Mazlina Sulong	Puan	*Seksyen Kawalselia*
19.	Dayang Nurbaini Awang Bujang	Cik	*Pegawai Kawalan Alam Sekitar Kanan*
20.	Mastawa Zainuddin	Puan	*Pegawai Kawalan Alam Sekitar*
21.	Rosnani Ahmad	Puan	*Pegawai Kawalan Alam Sekitar*
22.	Khairul Nizam Samsuri	Puan	*Pegawai Kawalan Alam Sekitar Kanan*

List of attendees — *Mesyuarat Mengenai Projek Pembangunan Data Industri Perkhidmatan Air Negara Beserta Spatial Mapping Yang Interaktif* (DIPAN SMI)

No.		Title	Division
1.	Azhar Noraini	Tuan	Timbalan Ketua Pengarah (Sektoral) Unit Perancang Ekonomi, Jabatan Perdana Menteri
2.	Nor Aziman Azman	Puan	Penolong Pengarah Unit Air dan Pembentungan Bahagian Infrastuktur dan Kemudahan Awam Unit Perancang Ekonomi, Jabatan Perdana Menteri
3.	Ching Thoo A/L Kim	Dr.	Timbalan Ketua Setiausaha (Air dan Pembentungan) KASA
4.	Ahmad Ashrin Abdul Jalil	Tuan	IWSDC Analyst
5.	Aida Syarafina Ismail	Puan	IWSDC RA
6.	Najmuddin Abdul Rahim	Tuan	IWSDC RA
7.	Nurul Syahidatul Balqis Haidzir	Cik	IWSDC RA
8.	Nurul Rahimah Abu Bakar	Cik	PMC Analyst
9.	Hareehaaran Mathialagan	Tuan	PMC Analyst

No.	Event	Ministry	Department/Agency	Dates and Time	Venue	List of attendees
12.	FGD No. 6 with Muda Agricultural Development Authority (MADA)	Kedah State Government	Muda Agricultural Development Authority (MADA)	1 March 2021, from 10:00am to 12:30pm	Online meeting	

No.		Title	Division
IWSDC Project Team			
1.	Mohd Adnan Mohd Nor	Datuk Ir.	IWSDC Chair
2.	Ahmad Ashrin Abdul Jalil	Tuan	IWSDC Analyst
3.	Aida Syarafina Ismail	Puan	IWSDC RA
4.	Najmuddin Abdul Rahim	Tuan	IWSDC RA
5.	Nurul Syahidatul Balqis Haidzir	Cik	IWSDC RA
6.	Liam We Lin	Ir.	Lead SME
7.	Shah Izzni Talif Mohd Adnan	Ir.	Team - SME on IR4.0 Applications
8.	Norizan Abdul Fattah	Puan	Representative from MYSA
9.	Shiamala A/P Velaichamy	Gs.	SME on GIS and Data Structure
Representative from DOE			
10.	Nik Kun Nik Man	Tn.	Bahagian Pembangunan & Pengurusan Projek
11.	Khuzairi bin Abd Aziz		Bahagian Empangan & Sumber Air
12.	Mohd Khalil bin Othman		Bahagian Perkhidmatan Pengairan & Saliran
13.	Siti Hajar binti Hussain		Bahagian Pembangunan & Pengurusan Projek

No.	Event	Ministry	Department/Agency	Dates and Time	Venue
13.	FGD No. 7 with Department of Mineral and Geoscience Malaysia (JMG)	Ministry of Energy and Natural Resources (KeTSA)	Department of Mineral and Geoscience Malaysia (JMG)	5 March 2021, from 9:30am to 11:30am	Garnet Meeting Room, JMG HQ (Hybrid meeting)

No.		Title	Note
IWSDC Project Team			
1.	Mohd Adnan Mohd Nor	Datuk Ir.	IWSDC Chair
2.	Ahmad Ashrin Abdul Jalil	Tuan	IWSDC Analyst
3.	Aida Syarafina Ismail	Puan	IWSDC RA
4.	Najmuddin Abdul Rahim	Tuan	IWSDC RA
5.	Nurul Syahidatul Balqis Haidzir	Cik	IWSDC RA
6.	Liam We Lin	Ir.	IWSDC Lead SME
Representative from JMG			
7.	Siti Aminah Abdul Sarif	Puan	Pengarah Caw. Pengurusan Maklumat
8.	Rusli Mohamed	Tuan	Pengarah Caw. Pengurusan Maklumat
9.	Abd Rahim Harun	Tuan	Timb. Pengarah, Unit Perancangan Geosains, Caw. Pengurusan Maklumat
10.	Alvyn Clancey Mickey	Tuan	Penolong Pengarah Kanan, Unit Perancangan Geosains, Caw. Pengurusan Maklumat
11.	Che Aslinaliza Che Ahmed	Puan	Pegawai Teknologi Maklumat, Unit Infrastruktur dan Keselamatan, Caw. Pengurusan Maklumat

No.	Event	Ministry	Department/Agency	Dates and Time	Venue	List of attendees		
						No.	**Title**	**Note**
						IWSDC Project Team		
						12. Suhaimizi Yusoff	Tuan	Ketua Penolong Pengarah, Unit Pengurusan Data Berkomputer, Caw. Pengurusan Maklumat
						13. Syamillah Samsudin@Murad	Puan	Pegawai Teknologi Maklumat Kanan, Caw. Pengurusan Maklumat, Bahagian Perkhidmatan Teknikal
						14. Suzannah Akmal	Puan	Penolong Pengarah Kanan, Caw. Pengurusan Maklumat, Bahagian Perkhidmatan Teknikal
						15. Wan Neqhaikal Wan Abdul Karim	Tuan	Penolong Pengarah Geosains, Unit Geosains Negeri Sembilan/ Melaka
						16. Muhammad Nursafwan Mustafa	Tuan	Penolong Pengarah Geosains, Unit Geosains Negeri Selangor/ Wilayah Persekutuan
						17. Mazatul Akmar Aros	Puan	Penolong Pengarah Kanan, Unit Geosains Negeri Selangor/ Wilayah Persekutuan
						18. Hasnida Zabidi	Puan	Ketua Penolong Pengarah, Unit Geosains, Negeri Selangor/ Wilayah Persekutuan
14.	FGD No. 8 with Sewerage Services Department (JPP)	KASA	Sewerage Services Department (JPP)	12 March 2021, from 3:00 pm to 5:00 pm	Director General Discussion Room, JPP HQ (Hybrid meeting)	**No.**	**Title**	**Note**
						IWSDC Project Team		
						1. Mohd Adnan Mohd Nor	Datuk Ir.	IWSDC Chair
						2. Ahmad Ashrin Abdul Jalil	Tuan	Analyst
						3. Aida Syarafina Ismail	Puan	Research Assistant
						4. Najmuddin Abdul Rahim	Tuan	Research Assistant
						5. Nurul Syahidatul Balqis Haidzir	Cik	Research Assistant
						Representative from JPP		
						6. Alias Mohamed	Tuan Haji	*Pengarah Bahagian Perancangan Strategik*
						7. Noor Zarina Mohd Nazir	Puan	*Ketua Penolong Pengarah Bahagian Perancangan Strategik*
						8. Ahmad Azrul Naimuddin	Tuan	*Penolong Jurutera Bahagian Perancangan Strategik*
						9. Norasrin Abu Bakar	Puan	*Penolong Jurutera Bahagian Perancangan Strategik*

No.	Event	Ministry	Department/Agency	Dates and Time	Venue	List of attendees
15.	FGD No. 9 with Tenaga Nasional Berhad (TNB Generation Power Sdn Bhd) – TNB Hydropower	-	Tenaga Nasional Berhad (TNB Generation Power Sdn Bhd)	15 March 2021, from 9:30 am to 12:00 pm	Meeting room Engineering Services GENCO, Armcorp Tower, Petaling Jaya (Hybrid meeting)	
16.	FGD No. 10 with Malaysian Meteorological Department (METMalaysia)	KASA	Malaysian Meteorological Department (METMalaysia)	24 March 2021, from 2:30 pm to 5:00 pm	Cumulus Meeting Room, METMalaysia HQ (Hybrid meeting)	
17.	SME Meeting with No. 4 - Space Technology	MOSTI	MYSA	25 March 2021; from 2:30pm to 5:00pm	MYSA HQ (Hybrid meeting)	

15.

No.	Name	Division
1.	Datuk Ir. Mohd Adnan Mohd Nor	IWSDC Project Team
2.	Hj. Sarbani Anjang Ahmad	Head, Engineering Services - Hydro
3.	Ismail Faruq bin Serip Mohamad	Senior Engineer – Hydrology
4.	Noryusuhasriq bin Mohd Yusof	Principal Engineer – Feasibility Study
5.	Nurmalisa Fazrina binti Ismail	Senior Engineer – Feasibility Study
6.	Ahmad Ashrin Abdul Jalil	Analis IWSDC
7.	Aida Syarafina Ismail	Pembantu Penyelidik IWSDC
8.	Najmuddin Abdul Rahim	Pembantu Penyelidik IWSDC
9.	Nurul Syahidatul Balqis Haidzir	Pembantu Penyelidik IWSDC

16.

No.	Name	Title	Note
IWSDC Project Team			
1.	Mohd Adnan Mohd Nor	Datuk Ir.	IWSDC Chair
2.	Ahmad Ashrin Abdul Jalil	Tuan	Analyst
3.	Aida Syarafina Ismail	Puan	Research Assistant
4.	Najmuddin Abdul Rahim	Tuan	Research Assistant
5.	Nurul Syahidatul Balqis Haidzir	Cik	Research Assistant
Representative from METMALAYSIA			
6.	Dr. Mohd Hisham Mohd Anip	Dr.	Strategic and Technical
7.	Mohd Zunaidi Mat	Tuan	Meteorology Communication Division
8.	Wan Mohd Nazri Wan Daud	Tuan	Meteorology Instrumentation Division
9.	Sharmijasdi Abdul Razak	Tuan	Meteorology Instrumentation Division
10.	Suzalina Kamaruddin	Puan	Corporate Communication Unit
11.	Nor Sherizan Bt Darus	Puan	National Climate Centre
12.	Norjana Bt Jamal	Puan	National Climate Centre
13.	Noor Azura Bt Ismail	Puan	National Climate Centre
14.	Rosmadinor B Mohamad	Puan	Meteorology Communication Division
15.	Mohamad Izzudin bin Mansor	Tuan	Meteorology Communication Division

17.

No.	Name	Division
1.	Datuk Ir. Mohd Adnan Mohd Nor	IWSDC Chairperson
2.	Ahmad Ashrin Abdul Jalil	IWSDC Analyst
3.	Nurul Syahidatul Balqis Haidzir	IWSDC Research Assistant
4.	Adnan Ismail	SME on Space Technology
5.	Zuraimi Suleiman	SME on Space Technology (team)
6.	Norizan Abdul Pattah	SME on Space Technology (team)

No.	Event	Ministry	Department/Agency	Dates and Time	Venue	List of attendees
18.	Perbincangan Penyelarasan WST2040 dan Projek DIPAN SMI	KASA	-	29 March 2021; from 9:30am to 11:30am	Online meeting	No. Name Division 1. Datuk Ir. Mohd Adnan Mohd Nor IWSDC Chairperson 2. Ahmad Ashrin Abdul Jalil IWSDC Analyst 3. Aida Syarafina Ismail IWSDC Research Assistant 4. Najmuddin Abdul Rahim IWSDC Research Assistant 5. Nurul Syahidatul Balqis IWSDC Research Assistant 6. Dr. Ching Thoo Kim Representative from KASA 7. Nurul Shidah Mohd Yasan Representative from SPAN 8. Datuk Ir. Abdul Kadir Mohd Din IR4.0W Chairperson
19.	SME Meeting No.5 – All SMEs	Various	Various	30 March 2021; from 9:30am to 12:00pm	RPM Engineers Sdn Bhd (Hybrid meeting)	No. Name Division 1. Datuk Ir. Mohd Adnan Mohd Nor IWSDC Chairperson (ASM) 2. Aida Syarafina Ismail IWSDC Research Assistant (ASM) 3. Najmuddin Abdul Rahim IWSDC Research Assistant (ASM) 4. Nurul Syahidatul Balqis IWSDC Research Assistant (ASM) 5. Ir. Shah Izzni Talif SME on IR4.0 Applications (Reka1 Tech) 6. Mohd Zaim Mohd Zuhuri SME on Systems Architecture (Millenium Radius Sdn Bhd, MRSB) 7. Hanis Ab Hamid SME on Systems Architecture (team) 8. Adnan Ismail SME on Space Technology (MYSA) 9. Ir. Mohd Zaki Mat Amin SME on RDIC in the Water Sector (NAHRIM)
20.	SME Meeting No. 6 – All SMEs	Various	Various	30 March 2021; from 9:30am to 12:00pm	Council Room, ASM MATRADE (Physical meeting)	No. Name Division 1. Datuk Ir. Mohd Adnan Mohd Nor IWSDC Chairperson 2. Ir. Liam We Lin Lead SME 3. Adnan Ismai SME on Space Technology (MYSA) 4. Samsudin Omar SME on Space Technology – team (MYSA) 5. Norizan Abdul Patah SME on Space Technology – team (MYSA) 6. Nur Hazwani Izehar SME on Space Technology – team (MYSA) 7. Ir. Shah Izzni Talif SME on IR4.0 Applications – team (Reka1 Tech) 8. Mohd Zaim Mohd Zuhuri SME on Systems Architecture (MRSB) 9. Hanis Ab Hamid SME on Systems Architecture – team (MRSB) 10. Engku Ghaz Engku Abdullim SME on Systems Architecture – team (MRSB) 11. Kamarul Hairi SME on Systems Architecture – team (MRSB) 12. Mohd Hazri Mohd Zuhuri SME on Systems Architecture – team (MRSB) 13. Aida Syarafina Ismail IWSDC Research Assistant 14. Najmuddin Abdul Rahim IWSDC Research Assistant 15. Nurul Syahidatul Balqis Haidzir IWSDC Research Assistant
21.	FGD No. 11 with Department of Agriculture (DOA)	MAFI	Department of Agriculture	9 April 2021, from 9:30am to 11:00am	Cempaka Meeting Room, DOA HQ (Hybrid meeting)	No. Name Title Note IWSDC Project Team 1. Mohd Adnan Mohd Nor Datuk Ir. IWSDC Chair 2. Ahmad Ashrin Abdul Jalil Tuan Analyst 3. Aida Syarafina Ismail Puan Research Assistant 4. Najmuddin Abdul Rahim Tuan Research Assistant

No.	Event	Ministry	Department/Agency	Dates and Time	Venue	List of attendees

No.	Name	Title	Note
IWSDC Project Team			
5.	Nurul Syahidatul Balqis Haidzir	Cik	Research Assistant Representative from DOA
Representative from DOA			
6.	Zahimi Hassan	Dato'	Timbalan Ketua Pengarah Pertanian (Pengurusan dan Regulatori)
7.	Yaashinni A/P Peraniandy	Puan	*Ketua Penolong Pengarah Seksyen Kejuruteraan*

22. FGD No. 12 with DID Sarawak — KASA — DID Sarawak — 14 April 2021, from 9:30 - 12:00 pm — Online meeting

No.	Name	Division
1.	Datuk Ir. Mohd Adnan Mohd Nor	IWSDC Project Team
2.	Ir. Normahyusni Hj Mohd Annuar	Penolong Pengarah (DID Sarawak)
3.	Cik Tay Siew Voon	Jurutera Awam (DID Sarawak)
4.	Pn. Dewiza Khalimatul Jamisa Bt. Jamain	Jurutera Awam (DID Sarawak)
5.	En. Mohammad Azirin Bin Dawi Saifuddin	Penolong Jurutera (DID Sarawak)
6.	En. Lo Hong Ming	Penolong Jurutera (DID Sarawak)
7.	Pn. Maniza binti Mahfuz (Salbiah)	*Ketua Penolong Pengarah* *Unit Air dan Pembentungan* *Bahagian Infrastuktur dan Kemudahan Awam* *Unit Perancang Ekonomi, Jabatan Perdana Menteri*
8.	Ahmad Ashrin Abdul Jalil	*Analis* IWSDC
9.	Aida Syarafina Ismail	*Pembantu Penyelidik* IWSDC
10.	Najmuddin Abdul Rahim	*Pembantu Penyelidik* IWSDC
11.	Nurul Syahidatul Balqis Haidzir	*Pembantu Penyelidik* IWSDC

23. FGD No. 13 with DID Sabah — KASA — DID Sabah — 16 April 2021, from 9:30 - 12:00 pm — Online meeting

No.	Name	Title	Note
IWSDC Project Team			
1.	Mohd Adnan Mohd Nor	Datuk Ir.	IWSDC Chair
2.	Ahmad Ashrin Abdul Jalil	Tuan	Analyst
3.	Aida Syarafina Ismail	Puan	Research Assistant
4.	Najmuddin Abdul Rahim	Tuan	Research Assistant
5.	Nurul Syahidatul Balqis Haidzir	Cik	Research Assistant
6.	Liam We Lin	Ir.	Lead SME
Representative from DID Sabah			
7.	Van Kong Tze Yien	Tuan	*Timbalan Pengarah 2*
8.	Miklin Ationg	Tuan	*Ketua Bahagian Pengurusan Sumber Air*
9.	Dayang Siti Zubaidah Mohd Hanan	Puan	*Ketua Unit Hidrologi*

No.	Event	Ministry	Department/Agency	Dates and Time	Venue	List of attendees
						IWSDC Project Team
						10. Ir. Prisca Thomas — Puan — *Jurutera Kanan* Integrated Catchment Planning
						11. Rodney Tinggas — Tuan — *Jurutera Kanan* RWQA Data Collection
						Representative from EPU
						12. Dg Shalbia Abdul Ghani — Cik — *Timbalan Pengarah II Bahagian Infrastruktur dan Kemudahan Awam Unit Perancang Ekonomi, Jabatan Perdana Menteri*
						13. Maniza binti Mahfuz — Puan — *Ketua Penolong Pengarah Unit Air dan Pembentungan Bahagian Infrastuktur dan Kemudahan Awam Unit Perancang Ekonomi, Jabatan Perdana Menteri*
24.	SME Meeting No. 7 - on Space Technology	MOSTI	MYSA	23 April 2021; from 9:30am to 12:00pm	MYSA HQ (Physical Meeting)	1. Ahmad Ashrin Abdul Jalil — IWSDC Analyst 2. Najmuddin Abdul Rahim — IWSDC Research Assistant 3. Adnan Ismail — SME on Space Technology 4. Zuraimi Suleiman — SME on Space Technology – team (MYSA) 5. Samsudin Omar — SME on Space Technology – team (MYSA) 6. Nur Hazwani Izehar — SME on Space Technology – team (MYSA) 7. Norizan Abdul Patah — SME on Space Technology – team (MYSA)
25.	SME Meeting No. 8 SME (Financial)	-	-	8 August 2021; from 12:30pm to 1:30pm	Online meeting	1. Datuk Ir. Mohd Adnan Mohd Nor — IWSDC Chairperson 2. Ahmad Ashrin Abdul Jalil — IWSDC Analyst 3. Najmuddin Abdul Rahim — IWSDC Research Assistant 4. Nurul Syahidatul Balqis Haidzir — IWSDC Research Assistant 5. Mdm. Khong Lai Quan — SME (Financial) 6. Ir. Narimah Mohd Sies — IWSDC Report Reviewer
26.	Site Visit to Kerian Granary Area	KASA	DID Perak	9 August 2021; from 8:00am to 5:00pm	Site Visit	1. Datuk Ir. Mohd Adnan Mohd Nor — IWSDC Chairperson 2. Ahmad Ashrin Abdul Jalil — IWSDC Analyst 3. Najmuddin Abdul Rahim — IWSDC Research Assistant 4. Nurul Syahidatul Balqis Haidzir — IWSDC Research Assistant 5. Ir. Narimah Mohd Sies — IWSDC Report Reviewer 6. Mohd Hazri Mohd Zuhuri — SME on Systems Architecture – team (MRSB) 7. Engku Ghaz Adli Engku Abdullim — SME on Systems Architecture – team (MRSB)

No.	Event	Ministry	Department/Agency	Dates and Time	Venue	List of attendees
						No. Name Division 8. Hanis Ab Hamid SME on Systems Architecture – team (MRSB) 9. Ir. Vasukey Palany Kumar DID Perak 10. Mohamad Syamsul Hizham Sablee DID Perak 11. Habibah binti Jamil DID Perak 12. Aznan bin Ismail DID Perak 13. Mohd Zamri Hisham DID Perak
27.	SME Meeting No. 9 - Financial and Systems Architecture	-	-	12 August 2021; from 2:30pm to 4:00pm	Online meeting	No. Name Division 1. Ir. Liam We Lin IWSDC Lead SME 2. Najmuddin Abdul Rahim IWSDC Research Assistant 3. Nurul Syahidatul Balqis Haidzir IWSDC Research Assistant 4. Mdm. Khong Lai Quan SME (Financial) 5. Ir. Narimah Mohd Sies IWSDC Report Reviewer 6. Mohd Zaim Mohd Zuhuri SME on Systems Architecture (MRSB) 7. Engku Ghaz Adli Engku Abdullim SME on Systems Architecture – team (MRSB) 8. Hanis Ab Hamid SME on Systems Architecture – team (MRSB) 9. Mohd Hazri Mohd Zuhuri SME on Systems Architecture – team (MRSB)
28.	FGD No. 14 with Malaysian Digital Economy Corporation (MDEC)	Ministry of Communications and Multimedia	Malaysian Digital Economy Corporation (MDEC)	20 August 2021; from 4:00pm to 5:30pm	Online meeting	No. Name Division 1. Datuk Ir. Mohd Adnan Mohd Nor IWSDC Chairperson 2. Ahmad Ashrin Abdul Jalil IWSDC Analyst 3. Najmuddin Abdul Rahim IWSDC Research Assistant 4. Nurul Syahidatul Balqis Haidzir IWSDC Research Assistant 5. Ir. Narimah Mohd Sies IWSDC Report Reviewer 6. Dr. Sumitra Nair Vice President and Head of Digital Skills and Jobs (MDEC) 7. Ir. Dr. Karl Ng Kah Hou Director - Innovation Capital (MDEC)
29.	SME Meeting No. 10 - Financial and Systems Architecture	-	-	12 August 2021; from 2:30pm to 4:00pm	Online meeting	No. Name Division 1. Ir. Liam We Lin IWSDC Lead SME 2. Najmuddin Abdul Rahim IWSDC Research Assistant 3. Nurul Syahidatul Balqis Haidzir IWSDC Research Assistant 4. Mdm. Khong Lai Quan SME (Financial) 5. Ir. Narimah Mohd Sies IWSDC Report Reviewer 6. Mohd Zaim Mohd Zuhuri SME on Systems Architecture (MRSB) 7. Engku Ghaz Adli Engku Abdullim SME on Systems Architecture – team (MRSB) 8. Hanis Ab Hamid SME on Systems Architecture – team (MRSB) 9. Mohd Hazri Mohd Zuhuri SME on Systems Architecture – team (MRSB)
30.	FGD No. 15 with Malaysian Industry-Government Group for High Technology (MIGHT)	MOSTI	Malaysian Industry-Government Group for High Technology (MIGHT)	9 September 2021; from 9:30am to 12:00pm	Online meeting	No. Name Division 1. Datuk Ir. Mohd Adnan Mohd Nor IWSDC Chairperson (ASM) 2. Ahmad Ashrin Abdul Jalil IWSDC Analyst (ASM) 3. Dr. Raslan Ahmad Vice President (MIGHT) 4. Mohd Azreen Firdaus Abd Aziz Analyst (MIGHT)

No.	Event	Ministry	Department/Agency	Dates and Time	Venue	List of attendees
						No. Name Division 5. Anusha Magendram Principle Analyst (MIGHT) 6. Mohd Arif Misrol Analyst (MIGHT) 7. Saiful Hayaz Abu Bakar Representative from Fusionex 8. Akmal Adlin Representative from Fusionex
31.	SME Meeting No. 11 - Financial	-	-	15 September 2021, from 9:30am to 10:30am	Online meeting	No. Name Division 1. Datuk Ir. Mohd Adnan Mohd Nor IWSDC Chairperson 2. Ahmad Ashrin Abdul Jalil IWSDC Analyst 3. Najmuddin Abdul Rahim IWSDC Research Assistant 4. Nurul Syahidatul Balqis Haidzir IWSDC Research Assistant 5. Mdm. Khong Lai Quan SME (Financial) 6. Ir. Narimah Mohd Sies IWSDC Report Reviewer
32.	SME Meeting No. 12 - Financial	-	-	18 September 2021, from 4:00pm to 5:00pm	Online meeting	No. Name Division 1. Datuk Ir. Mohd Adnan Mohd Nor IWSDC Chairperson 2. Ahmad Ashrin Abdul Jalil IWSDC Analyst 3. Najmuddin Abdul Rahim IWSDC Research Assistant 4. Nurul Syahidatul Balqis Haidzir IWSDC Research Assistant 5. Mdm. Khong Lai Quan SME (Financial) 6. Ir. Narimah Mohd Sies IWSDC Report Reviewer
33.	Site Visit to MADA	MAFI	MADA	10-11 October 2021	Physical	No. Name Division 1. Datuk Ir. Mohd Adnan Mohd Nor IWSDC Chairperson 2. Ahmad Ashrin Abdul Jalil IWSDC Analyst 3. Najmuddin Abdul Rahim IWSDC Research Assistant 4. Nurul Syahidatul Balqis Haidzir IWSDC Research Assistant 5. Ir. Narimah Mohd Sies IWSDC Report Reviewer 6. Tuan Nik Kun Nik Man *Timbalan Pengurus Besar, Teknikal* (MADA) 7. Tuan Noor Effarizan Ismail *Pengarah Bahagian Perkhidmatan Pengairan dan Saliran* (MADA) 8. Faridzul Mohammad Fadzil *Jurutera Hidrologi* (MADA) 9. Siti Hajar Husain *Jurutera Pengairan Saliran* (MADA) 10. Mohd Fadzil Mat Desa *Jurutera Mekanikal* (MADA) 11. Hasni Jaafar *Penolong Jurutera* (MADA) 12. Siti Fatimah *Penolong Jurutera* (MADA) 13. Mohd Rodzi Ibrahim *Penolong Jurutera* (MADA) 14. Anas Izzuan Awang Ahmad *Penolong Jurutera* (MADA) 15. Muhamad Nazrol Idris *Penolong Jurutera* (MADA)
34.	Site Visit to Satellite Operation Complex MYSA, Temerloh	MOSTI	MYSA	14 October 2021 10:00am to 1:00pm	Physical	No. Name Division 1. Datuk Ir. Mohd Adnan Mohd Nor IWSDC Chairperson 2. Ahmad Ashrin Abdul Jalil IWSDC Analyst 3. Najmuddin Abdul Rahim IWSDC Research Assistant 4. Nurul Syahidatul Balqis Haidzir IWSDC Research Assistant

No.	Event	Ministry	Department/Agency	Dates and Time	Venue	List of attendees		
						No.	Name	Division
						5.	Puan Norizan Abdul Pattah	Pengarah (MYSA)
						6.	Puan Siti Aishah	Pegawai Penyelidik (MYSA)
						7.	Puan Noraini	Pegawai Penyelidik (MYSA)
						8.	En. Arjuna	Pegawai Penyelidik (MYSA)
						9.	En. Jefri	Pegawai Penyelidik (MYSA)
						10.	En. Zaki	Pegawai Penyelidik (MYSA)
						11.	En. Fakrul	Jurutera (MYSA)
35.	Site Visit to JPS Pahang (in Kuantan)	KASA	JPS	22 October 2021, 9:30am to 4:30pm	JPS Pahang HQ and Sungai Lepar (telemetry station)	No.	Name	Division
						1.	Datuk Ir. Mohd Adnan Mohd Nor	IWSDC Chairperson
						2.	Ir. Narimah Mohd Sies	IWSDC Report Reviewer
						3.	Ahmad Ashrin Abdul Jalil	IWSDC Analyst
						4.	Najmuddin Abdul Rahim	IWSDC Research Assistant
						5.	Nurul Syahidatul Balqis Haidzir	IWSDC Research Assistant
						6.	Ir. Mohd Noor Bidin	Pengarah JPS Pahang
						7.	Hj. Shiham Ab Ghapar	Timbalan Pengarah JPS Pahang
						8.	Hasmira Ab. Hamid	Pegawai Hidrologi Negeri
						9.	Mohd Hisyam Mohmed Nor	Penolong Jurutera Awam

Appendix B

IWSDC Costing

IWSDC COSTING FOR WST2040 (2021-2040)

No.	Focus Areas	Strategy	Initiatives/Programmes/Activities	Lead Ministry/State Govt.	Collaborating Agencies	COSTING (RM '000,000) 2021	2022	2023	2024	2025	Total RMKe-12	RMKe-13	RMKe-14	RMKe-15	Funding Source	Target Completion	Remarks
Milestone		Satellite launch (MYSA) *1 Malaysian *3 Rentals	High resolution remote sensing satellite launch	MYSA	MYSA											RMKe-13	
1	Information and RDIC	**(S1) Establishment of an Integrated, Single-point Reference Centre**	**(S1-I1) Establish IWSDC** *Design study in 2022 A) Physical Infrastructure: 1. Physical space (rental, maintenance) 2. Existing data collection station modification B) Technology: 3. Software, Hardware, Network, Security 4. Big Data Analytics 5. Blockchain 6. Artificial Intelligence 7. Data standards C) Organisation: 8. Institutional Set Up 9. Human Resources 10. Capacity Building and Training Program 11. Linkages and Platform for RDIC to water and water-related data managers, and researchers	KASA	MYSA, MOSTI, MCMM, MDEC, MIGHT, MAMPU		**5.00 Design Study** →			Phase 1 →		Phase 2	Phase 3	Phase 4	KASA	Phase 1 - 2023-2025 Phase 2 - 2026-2030 Phase 3 - 2031-2035 Phase 4 - 2036-2040	
								42.30	**6.40**		**53.70**	**35.70**	**42.10**	**47.90**			
			D) IWSDC Operation 1. Maintenance 2. Upgrading 3. Emoluments		KASA			**7.70**	**31.00**	**34.00**	**72.70**	**198.30**	**254.30**	**322.10**		RMKe-12 (Continuous)	
2	Information and RDIC Finance Infrastructure and Technology	**(S2) Strategic Reports on Water Management**	**(S2-I1) Strategic Reports Publication (annual):** Stakeholder management report	KASA	Federal agencies, State agencies, Private Sector, NGO	-	-	-	-	0.20	0.20	1.00	1.00	1.00	KASA	RMKe-12 (Continuous)	
			Virtual Water reports		Federal agencies, State agencies, Private Sector, NGO	-	-	-	-	0.20	0.20	1.00	1.00	1.00		RMKe-12 (Continuous)	
			Water Footprint reports		Federal agencies, State agencies, Private Sector, NGO	-	-	-	-	0.20	0.20	1.00	1.00	1.00		RMKe-12 (Continuous)	
			Water-Food-Energy reports		Federal agencies, State agencies, Private Sector, NGO	-	-	-	-	0.20	0.20	1.00	1.00	1.00		RMKe-12 (Continuous)	
			Water for Environment and Biodiversity reports		Federal agencies, State agencies, Private Sector, NGO	-	-	-	-	0.20	0.20	1.00	1.00	1.00		RMKe-12 (Continuous)	
			Water and Climate Change reports		Federal agencies, State agencies, Private Sector, NGO	-	-	-	-	0.20	0.20	1.00	1.00	1.00		RMKe-12 (Continuous)	
			Water Efficiency reports		Federal agencies, State agencies, Private Sector, NGO	-	-	-	-	0.20	0.20	1.00	1.00	1.00		RMKe-12 (Continuous)	
			Water Quality Monitoring		Federal agencies, State agencies, Private Sector, NGO	-	-	-	-	0.20	0.20	1.00	1.00	1.00		RMKe-12 (Continuous)	
			Disaster Risk Management reports		Federal agencies, State agencies, Private Sector, NGO	-	-	-	-	0.20	0.20	1.00	1.00	1.00		RMKe-12 (Continuous)	
			Water safety plan reports		Federal agencies, State agencies, Private Sector, NGO	-	-	-	-	0.20	0.20	1.00	1.00	1.00		RMKe-12 (Continuous)	
			Rainfed agriculture monitoring reports		Federal agencies, State agencies, Private Sector, NGO	-	-	-	-	0.20	0.20	1.00	1.00	1.00		RMKe-12 (Continuous)	
			WST2040 Monitoring		Federal agencies, State agencies, Private Sector, NGO	-	-	-	-	0.20	0.20	1.00	1.00	1.00		RMKe-12 (Continuous)	

IWSDC COSTING FOR WST2040 (2021-2040)

No.	Focus Areas	Strategy	Initiatives/Programmes/Activities	Lead Ministry/State Govt.	Collaborating Agencies	COSTING (RM '000,000)									Funding Source	Target Completion	Remarks
						2021	2022	2023	2024	2025	Total RMKe-12	RMKe-13	RMKe-14	RMKe-15			
3	Information and RDIC Infrastructure and Technology People Governance Finance	**(S3) Water Data Platform (Water Data and Information Interactive Platform)**	**(S3-I1) Establish Water Data Platform** **(S3-I2) IWSDC Water Data Platform Pilot Projects** <u>A) Sg Perak River Basin Pilot Project</u> a) Space Technology Applications in Water Management: 1. AI approach to water catchment monitoring 2. Water quality modelling via Remote Sensing and Artificial Intelligence 3. Irrigation monitoring management for Paddy Fields	KASA	MYSA, MAFI, KeTSA, Other Federal Agencies, Perak State Government	-	-	1.00	1.98	1.10	4.08				KASA	RMKe-12	
			<u>A) Sg Perak River Basin Pilot Project</u> b) Ground-based Data Applications: 1. Disaster Risk Reduction 2. Stakeholders Management 3. WFE Nexus 4. IR4.0 5. Water Footprint & Virtual Water 6. AACB 7. Climate Change 8. Water Accounting 9. Water Auditing 10. Environmentally Sensitive Areas (ESA) Monitoring and Indigenous Knowledge		MYSA, MAFI, KeTSA, Other Federal Agencies, Perak State Government	-	-	1.00	1.00	1.00	3.00					RMKe-12	
			B) Sg Linggi River Basin (N. Sembilan/ Melaka) a) Space Technology Applications in Water Management b) Ground-based Data Applications		MYSA, MAFI, KeTSA, Other Federal Agencies, N.Sembilan and Melaka State Governments	-	-	-	2.98	4.10	7.08					RMKe-12	
			C) Sg Padas River Basin (Sabah) a) Space Technology Applications in Water Management b) Ground-based Data Applications		MYSA, MAFI, KeTSA, Other Federal Agencies, Sabah State Government	-	-	-	2.98	4.10	7.08					RMKe-12	
			D) Sg Miri River Basin (Sarawak) a) Space Technology Applications in Water Management b) Ground-based Data Applications		MYSA, MAFI, KeTSA, Other Federal Agencies, Sarawak State Government	-	-	-	2.98	4.10	7.08					RMKe-12	
			(S3-I3) Integrated River Basin Management System Solution for all other River Basins A) Space Technology Applications in Water Management B) Ground-based Data Applications		MYSA, MAFI, KeTSA, Other Federal Agencies, State Governments	-	-	-	-	42.00	42.00	105	175	95		RMKe-12 (Continuous)	Costing will reduce with time as the tools and systems are already estbalished with the templates from the IWSDC Water Platform Pilot Projects. River basin sizes are not the same, therefore an average of 3.5 mil per river basin is expected
4	Information and RDIC	**(S4) RDIC Collaboration Platform**	**(S4-I1) Water Research Collaboration Platform (RDIC) on Space Technology Applications**	KASA	MOSTI, MYSA, MAFI, KeTSA, DOE, MPIC, MPOB, State agencies, Private Sector	-	-	1.00	1.00	1.00	3.00	30.00	90.00	150.00	KASA	RMKe-12 (Continuous)	
			(S4-I2) Water Research Collaboration Platform (RDIC) on Ground-based Applications			-	-	1.00	1.00	1.00	3.00	30.00	90.00	150.00		RMKe-12 (Continuous)	
5	Governance	**(S5) Enhancing Seamless Data Sharing**	**(S5-I1) Initiatives, Policies and Laws to Enhance Data Sharing:** Data Sharing Agreement/Arrangement	KASA	KASA, All primary and secondary data collectors	-	-	0.25	0.25	0.5	1				KASA	RMKe-12	
			Malaysia to be part of international Open Data Alliance / Partnership		MCMM	-	-	-	-	-	-	-	-	-			
			Data Sharing Policy Review	JPM	JPM	-	-	-	0.25	0.25	0.5	0.25			JPM		
			Data Sharing Law Review		JPM	-	-	-	0.25	0.25	0.5	0.25					
			Review of Fees Act 1951		JPM	-	-	-	0.25	0.25	0.5	0.25					
			Review of Statistics Act 1965 by DOSM		JPM (DOSM)	-	-	-	-	-	-						

IWSDC COSTING FOR WST2040 (2021-2040)

No.	Focus Areas	Strategy	Initiatives/Programmes/Activities	Lead Ministry/State Govt.	Collaborating Agencies	COSTING (RM '000,000) 2021	2022	2023	2024	2025	Total RMKe-12	RMKe-13	RMKe-14	RMKe-15	Funding Source	Target Completion	Remarks
6	Governance	**(S6) Tools to Quantify and Assess Water Governance**	**(S6-I1) Governance Tools and System Development:** A) Water Accounting 1. Water Accounting Tools	KASA	Federal agencies, State agencies, Private Sector, NGO	-	-	-	1	1	2	1	1	1	KASA	RMKe-12	RMKe-12 - tool establishment and strategic report production RMKe-13 onward is strategic report production - RM200k/yr
			2. Water Accounting System		Federal agencies, State agencies, Private Sector, NGO	-	-	-	0.5	0.5	1	1	1	1		RMKe-12 (Continuous)	
			B) Water Auditing 1. Water Auditing Tools		Federal agencies, State agencies, Private Sector, NGO	-	-	-	1	1	2	1	1	1		RMKe-12	RMKe-12 - tool establishment and strategic report production RMKe-13 onward - strategic report production - RM200k/yr
			2. Water Auditing System		Federal agencies, State agencies, Private Sector, NGO	-	-	-	0.5	0.5	1	1	1	1		RMKe-12 (Continuous)	
			C) Water Security Report (annual)		MKN	-	-	-		0.2	0.2	1.00	1.00	1.00		RMKe-12 (Continuous)	
7	Governance People	**(S7) Public Participation Platform**	**(S7-I1) Stakeholder Management Initiatives** Stakeholder Management A) Establish Stakeholder Platform	KASA	Federal agencies, State agencies, Private Sector, NGO	-	-	-	-	-	-	-	-	-	KASA	RMKe-12 (Continuous)	Cost is part of operational costs, as IWSDC will host the platform and facilitate access for end users
			B) Register of Stakeholders			-	-	-	-	-	-	-	-	-			
			C) Capacity Building Programme			-	-	-	-	-	-	-	-	-			
8	People Information and RDIC	**(S8) Capacity Building and Talent Development**	**(S8-I1) Continual Capacity Building and Talent Development Programmes for Water Stakeholders**	KASA	Federal agencies, State agencies, Private Sector, NGO	-	-	2	2	2	6	15	20	25	KASA	RMKe-12 (Continuous)	
9	Information and RDIC Infrastructure and Technology People Governance Finance	**(S9) Establish Water Hub**	**(S9-I1) Physical Development of a Water Hub**	KASA	Federal agencies, State agencies, Private Sector, NGO	-	-	-	-	-	0	4			KASA	RMKe-13	

	RMKe-12	RMKe-13	RMKe-14	RMKe-15
Total =	219.82	435.75	688.40	807.00
Total RMKe-12 - RMKe-15			=	2,150.97

IWSDC Set Up Costing

Integrated Water Sector Data Center (IWSDC)
Summary - Budgeted Capex and Opex for Years 2023 to 2040

	RMK 12 2023-2025 RM'000	RMK 13 2026-2030 RM'000	RMK 14 2031-2035 RM'000	RMK 15 2036-2040 RM'000	Total 2023-2040 RM'000
Capex	48,680	35,717	42,096	47,942	174,435
Opex	72,386	198,283	254,341	322,056	847,066
Total Capex and Opex	**121,066**	**234,000**	**296,437**	**369,998**	**1,021,501**

	Year 2022 RM	
Detailed design study	**RM5,000,000**	10.27% of RMK 12 Capex

Integrated Water Sector Data Center (IWSDC)
Summary - Budgeted Yearly Capex and Opex Expenditure

	2023 RM'000	2024 RM'000	2025 RM'000	2026 RM'000	Tech Refresh 2027 RM'000	2028 RM'000	2029 RM'000	2030 RM'000	Tech Refresh 2031 RM'000	2032 RM'000	2033 RM'000	2034 RM'000	Tech Refresh 2035 RM'000	2036 RM'000	2037 RM'000	2038 RM'000	Tech Refresh 2039 RM'000	2040 RM'000	Total 2023-2040 RM'000
Capex																			
Hardware	11,461	240	-	-	13,567	-	-	-	16,070	-	-	-	-	19,074	-	-	-	-	60,412
Application Software Development	7,296	1,824	-	-	-	-	-	-	-	-	-	-	-	-					9,120
Software Licenses, Apps and Apps Tools	8,155	4,324	-	-	14,404	-	-	-	16,392	-	-	-	-	18,679	-	-	-	-	61,954
Disaster Recovery, Cloud, Others	5,930	-	-	-	6,738	-	-	-	7,668	-	-	-	-	8,738	-	-	-	-	29,074
Office Equipment	1,470	-	-	-	1,008	-	-	-	1,966	-	-	-	-	1,451	-	-	-	-	5,895
Renovation, Furniture & Fittings	7,980	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7,980
Total Capex	**42,292**	**6,388**	**-**	**-**	**35,717**	**-**	**-**	**-**	**42,096**	**-**	**-**	**-**	**-**	**47,942**	**-**	**-**	**-**	**-**	**174,435**
Opex																			
Operational System Support and Maintenance	300	3,470	5,360	6,000	6,400	7,142	7,818	8,218	9,011	9,729	10,129	10,981	11,746	12,146	13,066	13,886	14,286	15,284	164,972
Training & Capacity Building	300	1,050	900	900	900	900	900	900	900	900	900	900	900	900	900	900	900	900	15,750
Office Rental	3,360	3,480	3,000	3,300	3,300	3,300	3,630	3,630	3,630	3,993	3,993	3,993	4,392	4,392	4,392	4,832	4,832	4,831	70,280
Staff Costs	3,241	19,297	20,262	21,275	22,339	23,456	24,629	25,860	27,153	28,511	29,936	31,433	33,005	34,655	36,388	38,207	40,117	42,123	501,887
Admin costs	476	3,667	4,223	4,356	4,556	4,702	4,855	5,017	5,268	5,445	5,632	5,828	6,033	6,348	6,574	6,812	7,061	7,324	94,177
Total Opex	**7,677**	**30,964**	**33,745**	**35,831**	**37,495**	**39,500**	**41,832**	**43,625**	**45,962**	**48,578**	**50,590**	**53,135**	**56,076**	**58,441**	**61,320**	**64,637**	**67,196**	**70,462**	**847,066**
Total Capex and Opex	**49,969**	**37,352**	**33,745**	**35,831**	**73,212**	**39,500**	**41,832**	**43,625**	**88,058**	**48,578**	**50,590**	**53,135**	**56,076**	**106,383**	**61,320**	**64,637**	**67,196**	**70,462**	**1,021,501**

Assumptions

1. *Design study in 2022. Submission of design study 1Q 2023.*
2. *Commencement of app development 2Q 2023.*
3. *The application software ready by end 2023, deployment of software end Q1 2023.*
4. *Procurement and installation of hardware in 3Q 2023.*
5. *Office space to conclude by Q3 2023 and ready by end 2023.*
6. *Staff force at 40% in 4Q 2023 and full force in 1Q 2024. Positions at Directors' level start in 3Q 2023.*
7. *Tech refresh every 5 years.*

Appendix D

Space Technology Applications

Introduction

The Malaysian Government in its Vision for Water 2025 states that rivers should achieve Class II as measured by Malaysia's Water Quality Index (WQI) (Class I is cleanest). However, water quality of Sg Perak became worst due to rapid urbanisation recently. Based on the study done by Wakif et al. (2019), the quality of water for four sampling stations along Sungai Perak were classified into CLASS III with only one station classified as CLASS IV according to the National Water Quality Standards (NWQS). Water Quality Index Class III indicates that water supply requires extensive treatment while Class IV is suitable for irrigation.

During the last few years, water quality has been threatened by various pollutants. Therefore, modelling and predicting water quality have become very important in controlling water pollution. In this project, modelling using a remote sensing technology and advanced artificial intelligence (AI) algorithms are developed to predict concentrations value for each physical water quality parameters.

Catchment monitoring is important because it aids sustainable management of the area. It also highlights any issues or challenges that the area can face. In order to obtain more information about a catchment, monitoring and sampling should be done as often as possible. The use of one method or instrument to gather all the relevant data needed in order to successfully monitor a catchment would be impossible due to its complexity. Catchment monitoring requires real-time, high-resolution data to maintain the quality of water and provide alerts to threats that the catchment might be exposed to. Different monitoring technologies can be combined with information and communications technology (ICT) and advanced data analysis techniques to provide extensive long-term datasets. These can be effectively transmitted and managed with at low cost to help support the decision-making processes involved in catchment monitoring.

The used of remote sensing is the best tool to monitor a large area and dynamic changes such as paddy cultivation area through its capability to capture the earth surface in synoptic view and various dates as compared to the conventional method. Furthermore, monitoring through satellite images saves time by 50% compared to the field survey and monitors 100% of the total granary.

Objective

The overall objective of this paper is to develop a space-based application by exploiting of Artificial Intelligence approach for improvement of integrated water resource management. Specific objectives include:

a. To delineate catchment area boundary from (Digital Elevation Model) DEM;
b. To classify and quantify the LULC changes in the study area;
c. To develop an AI-based algorithm/model for catchment monitoring;
d. To monitor water pollution where it can reliably retrieve water quality parameters using multispectral sensors with accuracy further enhanced by Artificial Intelligence algorithms; and
e. To determine irrigation status for a more efficient monitoring and management.

Project Component

This project consists of three (3) components which are as follows:

a. Artificial Intelligence approaches to water catchment monitoring using remote sensing data;

b. Water quality modelling based on satellite remote sensing applications and artificial intelligence; and
c. Improvement of paddy field irrigation management using remote sensing technology.

Pilot Study

Sungai Perak is approximately 400 km long with a basin size of 14,900 km^2. The river extends from the mountainous Perak-Kelantan-Thailand border of the Belum Forest Reserve and ends at the Straits of Malacca (Wakif et al., 2019). Sungai Perak is the second longest river in Peninsular Malaysia. It serves as the primary source of raw water and contributes to (approximately) 70 percent of raw water in the Perak state. The river also serves as one of the main sources of livelihood for fishermen and is also a tourist attraction by providing tourist activities such as kayaking and canoeing.

The pilot area for component i) and ii) is Sungai Perak which is the second-longest river in peninsular Malaysia. The river sources from the highlands in Upper Perak region, near the Thai border. It then flows through the regions of two largest towns of Gerik and Lenggong, before meeting with the Kangsar River at the royal seat of Kuala Kangsar. It then enters the Perak Tengah region, flowing through the towns of Parit, Pasir Salak and Kampung Gajah, before emptying into the Straits of Malacca just outside Teluk Intan in the Hilir Perak (Lower Perak) region. Meanwhile the study area for component iii) is Integrated Agriculture Development Area (IADA) Seberang Perak which has an area of 17,403 hectare. The duration of the pilot area is approximately two (2) years, then the implementation of the project will be extended for the whole Malaysia.

The project will be focussed on the advancement of space technology and ICT which includes Artificial Intelligence (AI) and Big Data analytic.

Materials

1. Data Requirements
    a. Remotely sensing data such as DEM from Shuttle Radar Topography Mission (SRTM) and SPOT 6 / SPOT 7 image were utilised to delineate catchment boundary, deriving its profile and mapping the land use and land cover.
    b. (LULC).
    c. Multi spectral and spatial resolution remote sensing satellite imageries.
    d. Ancillary data such as Data Cadastral (JUPEM), Data Catchment (DID), and Irrigation based data (MAFI).
    e. In-situ data measurement;
        i. Total Suspended Solids (TSS)
        ii. Total Dissolved Solids (TDS)
        iii. Chlorophyll (Chl-a)
        iv. Turbidity
        v. pH
        vi. Dissolved Oxygen (DO)
        vii. Biochemical Oxygen Demand (BOD)
        viii. Chemical Oxygen Demand (COD)
        ix. Ammoniacal Nitrogen (NH_3-N)

2. Scientific Equipment, Software and Hardware Requirements

a. Scientific Equipment

Scientific equipment and specific image processing software with full license are required in this project are shown in **Table E 1** and **Table E 2**.

Table E 1: Scientific Equipment

No.	Item	Description
1	Water Quality Monitoring System	Regularly send all water quality sensor information to the clouds in real-time (automatically) (GSM cell networks/Ethernet/CDMA/WiF)
	i. Hub Sensor	
	ii. Adapter Sensor	To connect standard water quality sensors
	iii. Telemetry Sensor	For remote monitoring
	iv. Water quality sensor probes	To measure pH, temperature, turbidity, dissolved oxygen (DO), Total Suspended Solids (TSS), Total Dissolved Solids (TDS), Chlorophyll (Chl-a), Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Ammoniacal Nitrogen
	v. Battery/solar panel	Electrical power source

b. Software and Hardware

Table E 2: Software and Hardware Requirements

No.	Item	Unit
	A. Hardware	
1.	Server	2
2.	Processing Workstation	6
3.	Storage	1
4.	Web-Server	2
5.	Switch	2
6.	Notebook/mobile WS	3
	B. Software	
1.	Image processing	4
2.	GIS Modelling	3
3.	GIS Publishing	2
4.	Image Server	2

Human Resource and Collaborator

1. MYSA Personnel

Table E 3 shows some of the proposed personnel to run the ground-based application by MYSA.

Table E 3: Human Resource Requirements

No.	Field of Expert(s)	Numbers of Personnel
1	Satellite data processing and analysis	3
2	i. Ground sampling/measurement for field verification ii. Vector/spatial data editing and cleaning	2
3	Remote Sensing (Environment, HydroGIS, Precision Forestry and Precision Farming)	15
4	AI/DL algorithms developing, integrating and implementing	5
5	Big Data experts	2
6	Spatial statistic	1

b. Proposed Collaborators

Table E 4 shows the proposed collaborators to execute the proposed projects for ground-based applications by MYSA.

Table E 4: Proposed Collaborators

No.	Type of Collaborators	List of Agencies	Expertise	Scope of Work
A. Water Catchment Monitoring				
1.	Research Agencies	National Hydraulic Research Institute of Malaysia (NAHRIM)		i. Conducting basic and applied research within water sector ii. Providing advisory role in the water related fields
2.	Operational/ Stakeholder Agencies	Department of Irrigation and Drainage (DID)	Hydrologist	i. Coordinate on-site hydrological activities ii. Provide supporting services during field verification
		Forestry Department of Peninsular Malaysia (FDPM)	Forest Management	i. Study area is in Permanent Reserved Forest (PRF) which is under FDPM jurisdiction ii. Provide technical advice and assistance with regard to forest policies, management & operation
B. Water Quality Modelling				
1.	Research Agencies	National Hydraulic Research Institute of Malaysia (NAHRIM)	Hydrologist	Providing advisory role in the water related fields
2.	Stakeholder	Department of Environment	Water Pollution	i. Provides water quality data – physical and chemical parameters for verification purposes ii. Providing advisory role in the water related to pollution and Water Quality Index (WQI)
3.	Centre of Excellent (CoE)	National University of Malaysia (UKM)	AI expert-Optical	Subject Matter Expert AI

No.	Type of Collaborators	List of Agencies	Expertise	Scope of Work
C. Paddy Field Irrigation Management				
1.	Operational / Stakeholder Agencies	i. Department of Agriculture (DOA) ii. IADA Seberang Perak	Rice Farming Expert	Provide relevant data and coordinating agencies
2.	Centre of Excellence (CoE)	National University of Malaysia (UKM)	AI expert-SAR	Subject Matter Expert AI

Methodology

1. Water Catchment Monitoring

   This proposed study employed AI-based remote sensing and geographic information system (GIS) techniques to automatically delineate catchment area, processing and analysing LULC change. Generally, there are three main stages of methodology proposed in this study, namely; i) data acquisition, ii) AI model training and development, and iii) data processing and analysing. The general flow of the methods employed in this study is illustrated in **Figure E 1.**

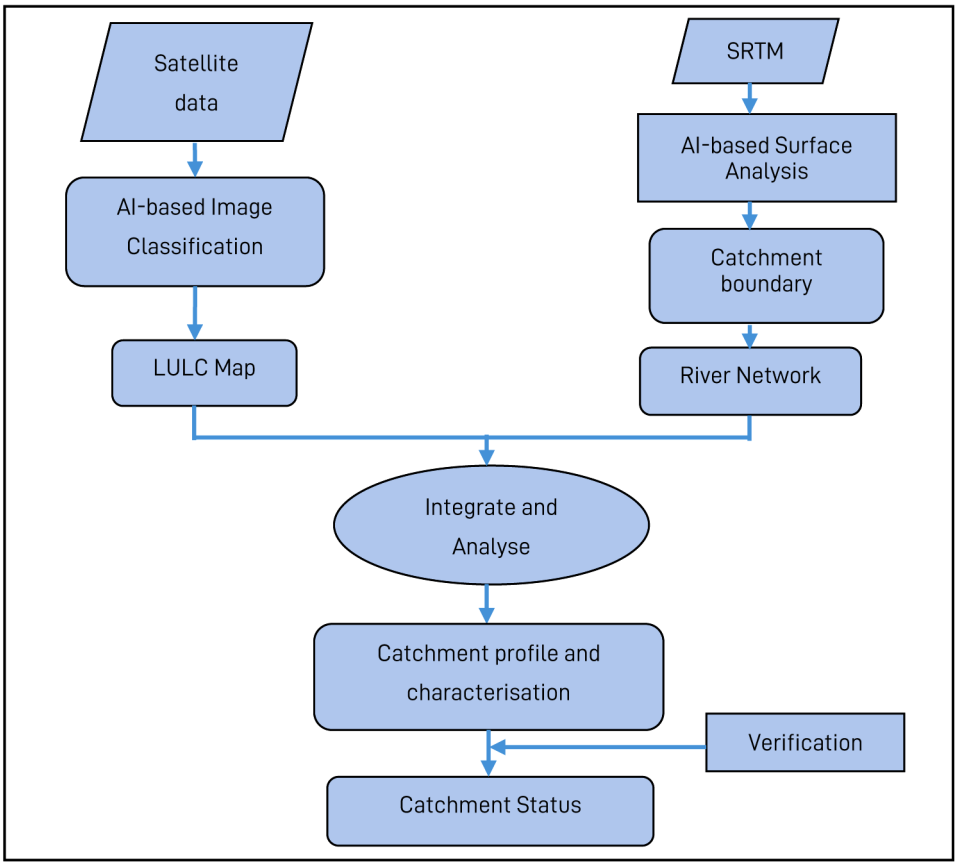


Figure E 1: Proposed Conceptual Framework

2. Water Quality Modelling

   Several image processing techniques including radiometric correction, atmospheric correction, regression analysis, modelling and advanced artificial intelligence will be used in this study. Significant

concentration for each physical parameter related to in-situ data measurements will be classified by a specific image processing software.

3. Paddy Field Irrigation Management
   The methodology of the study is as stated in **Figure E 2.**

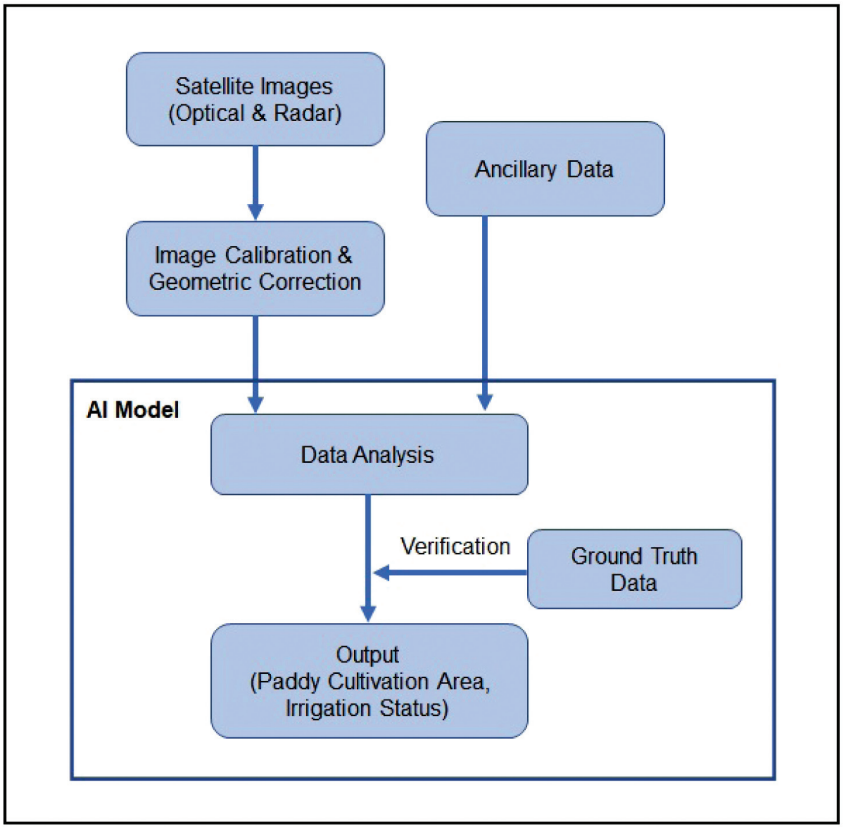


Figure E 2: Flow procedure of Image Extraction for Irrigation Status

Milestones

1. Water Catchment Monitoring
   Table E 5 shows the proposed water catchment monitoring milestones for the ground-based applications.

Table E 5: Water Catchment Monitoring Milestones

No.	Target	Year 1				Year 2			
		Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
1	Satellite data acquisition								
2	Satellite data processing and analysing								
3	Ground truthing								
4	Catchment profiling and characterisation								
5	AI modelling, training, testing & validation								
6	Effective & integrated catchment monitoring								

2. Water Quality Modelling

Table E 6 shows the proposed water quality monitoring milestones for the ground-based applications.

Table E 6: Water Quality Modelling Milestones

No.	Activities	Year 1				Year 2			
		Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
1	Acquisition of Water Quality Monitoring System								
2	Remote sensing and ancillary data acquisition								
3	Processing remote sensing data								
4	Water quality data collection (in situ measurement)								
5	GIS Analysis								
6	AI model development								
7	Model Validation and Accuracy Estimation								
8	Documentation								

3. Paddy Field Irrigation Management

Table E 7 shows the proposed paddy field irrigation milestones for the ground-based applications.

Table E 7: Paddy Field Irrigation Milestones

Activities	Year 1				Year 2			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
AI/DL approach								
1. Methodology development								
2. Data preparation								
3. Data processing								
4. Output generation								
5. Verification & Validation								
6. Accuracy assessment								
7. Documentation								

Expected Output

The main expected output from this study as the following:

a. Current status of catchment area;
b. AI-based algorithm/model for catchment monitoring;
c. Map of Total Suspended Solid (TSS), Total Dissolve Solid (TDS), Turbidity and Chlorophyll;
d. Water quality map;
e. Current status of water classification; and
f. Irrigation status information.

Financial Implication

The financial implication proposed for two(2) years study for identified pilot area and can be extended for the whole country. The software and hardware can be optimising for five (5) years period with some upgraded version. Meanwhile, the cost for satellite images is not included in this financial report due its already incurred under MYSA contributions.

1. Scientific Equipment, Ancillary Data and Travelling Expenses
   Table E 8 shows the budgeting requirements for Scientific Equipment, Ancillary Data and Travelling Expenses to execute the ground-based applications.

Table E 8: The Budgeting Requirements for Scientific Equipment, Ancillary Data and Travelling Expenses

No.	Item	Cost (RM)		Total Cost
		Year 1	Year 2	(RM)
1	Acquisition of Water Quality Monitoring System - including installation and training (8 units)	400,000	-	400,000
2	AI capacity building	15,000	15,000	30,000
3	Travelling expenses	45,000	45,000	70,000
4	Documentation	-	30,000	30,000
	Sub Total	460,000	90,000	530,000
	Contingency (10%)	46,000	9,000	53,500
	TOTAL	506,000	99,000	583,000

2. Software and Hardware
   Table E 9 shows the budgeting requirements for software and hardware to execute the ground-based applications.

Table E 9: The Budgeting Requirements for Software and Hardware

No.	Item	Unit	Cost (RM)
A. Hardware			
1.	Server	2	300,000
2.	Processing Workstation	6	720,000
3.	Storage	1	500,000
4.	Web-Server	2	60,000
5.	Switch	2	50,000
6.	Notebook/mobile WS	3	60,000
B. Software			
1.	Image processing	4	400,000
2.	GIS Modelling	3	450,000
3.	GIS Publishing	2	480,000
4.	Image Server	2	140,000
	Sub Total		3,160,000
	Contingency (10%)		316,000
	TOTAL		3,476,000

Overall financial implication of the project for two (2) years' implementation period is **RM 4,059,000.00.**

Conclusion

The use of space technology in water sector has been implemented since the establishment of the Malaysian Space Agency, however, due to the complexity of data covering various fields, improvement through the latest technology is a major challenge that requires commitment and support from all relevant agencies.

To date, space technology provides vast opportunities with the advancement of Artificial Intelligence (AI) / Deep Learning (DL), Internet of Things (IoT), Big Data and the Fourth Industrial Revolution (IR4.0) in the water sector to ensure that these technologies deliver the significant contribution to the country, especially in improving the management of national water resources which is an important asset of the country. The advantages offered by space technology, especially the wide and repetitive coverage area are very useful in the collection of dynamic data such as water. Furthermore, a single image captured through remote sensing can be analysed and interpreted for use in various applications and purposes, opening up vast opportunities towards improving water resource, quality and irrigation management.

The development of local experts and provision state of the art infrastructure such as advanced satellite data processing system and latest satellite data reception station at Temerloh, Pahang is a government initiative through MOSTI to spearhead the development and revolutionises management in various sectors including water resource management in the country.

References

A. I. J. M. , v., & L. J. , R. (2011). Water resource monitoring systems and the role of satellite observations. Hydrology and Earth System Sciences, 39-55.

Allan, D. J., Erickson, D., & Fay, J. (1997). The influence of catchment land use on stream integrity across multiple spatial scales. Freshwater Biology, 149-161.

Ana C. , T. (2016). Optical Satellite Remote Sensing of the Coastal Zone Environment — An Overview. Environmental Applications of Remote Sensing, 165-196.

Babulal, V. (2020, April 18). New Straits Times. Retrieved August 30, 2021, from Air and Water Quality Improve During MCO: https://www.nst.com.my/news/nation/2020/04/585488/air-and-water-quality-improve-during-mco

Carole, D., Yoshihide , W., Thomas , K., & Michael J. , P. (2017). Groundwater depletion embedded in international food trade. Nature, 700-704.

David J, L., Amir H, A., Amir H, G., & Annette L. , W. (2016). Machine learning in geosciences and remote sensing. Geoscience Frontiers, 3-10.

David M , L., Keith W , O., Mark G , F., Peter E , T., Sean C , S., Peter J , L., . . . Andrew G , S. (2011). Parameterisation improvements and functional and structural advances in Version 4 of the Community Land Model. Journal of Advances in Modelling Earth Systems.

Deepak R. , M., Igor , O., & Anatoly A. , G. (2017). Bio-optical modelling and remote sensing of inland waters. Candice Janco.

Demaria, E., & Serrat-Capdevilla, A. (2016). PART III: Validation of remote sensing estimated meteorological variables. Washington DC: World Bank Group.

Department of Environment (DOE). (2003). Water quality management in Malaysia. Kuala Lumpur: DOE Documents.

Economic Planning Unit. (2021, September). Rancangan Malaysia Kedua Belas 2021-2025. Retrieved September 30, 2021, from RMK12: https://rmke12.epu.gov.my/en

Fairuz. (2016). Matang Forest . Forestry Journal, 66-68.

Goh, K. C. (1984). Water resources management in Malaysia. Malaysian Journal of Tropical Geography, 28-38.

Hakimi, A. (2016). Sistem Banjir. Kuala Lumpur: ARSM.

J. Anthony , A., Trahel G. , V., & Christina , H. (2009). Threats to Global Water Security. Springer, Dordrecht.

Jabatan Pengairan dan Saliran Malaysia. (2021, May 19). *Lembangan Sungai Muda*. Retrieved from JPS GIS MUDA: http://gis.water.gov.my/gismuda/index.aspx

Jorge G, A.-R., Robert L, P., Natalie C, B., & Jon , B. (2015). Advancing Land-Sea Conservation Planning: Integrating Modelling of Catchments, Land-Use Change, and River Plumes to Prioritise Catchment Management and Protection. PLOS ONE.

Jürgen , H., Daniel , K., Ralf , I., Michael , S., Saulyegul , A., Sonja , H., & Andrew , K. (2015). Initial Characterisation and Water Quality Assessment of Stream Landscapes in Northern Mongolia. Water, 3166-3205.

Justin, S., Eric, W., Ming, P., Hylke, B., Gabriele, C., A., S.-C., & Koen , V. (2018). Satellite Remote Sensing for Water Resources Management: Potential for Supporting Sustainable Development in Data-Poor Regions. Water Resources Research, 9724-9758.

Landscape South Australia - Northern and York. (2021, May 19). Retrieved from Natural Resources/Northernandyork: https://www.landscape.sa.gov.au/ny/water/managing-water-resources

Matthew F. , M., Matthew , R., Douglas E. , A., Diego G. , M., Remko , U., Wolfgang , W., . . . Eric F. , W. (2017). The future of Earth observation in hydrology. Hydrology and Earth System Sciences, 3879–3914.

Mertes L, D. (2004). *Thermal Infrared Remote Sensing of Water Temperature in Riverine Landscapes*. Hoboken, NJ USA: John Wiley and Sons

Michelle V. , J., Alexander T. , D., Marlowe Edgar C. , B., & Evelyn B. , T. (2019). Catchment characterisation to support water monitoring and management decisions using remote sensing. Sustainable Environment Research.

Ministry of Economic Affairs. (2019). Strategy Paper 16: Water Sector Transformation 2040; 12th Malaysia Plan 2021-2025.

Muhammad Nazir , S., Noryusdiana Mohamad , Y., Zuraimi , S., & Nurul Aina , A. (2019). Application Of Multi-Temporal Radarsat-2 Backscattering for Monitoring of Paddy-Planting Stages in Malaysia. The 40th Asian Conference on Remote Sensing (ACRS 2019) Proceedings. Daejeon, Korea: Asian Association on Remote Sensing (AARS).

PM , K., FI , M., & TR , N. (2015). The Use of GIS and Remote Sensing Techniques to Evaluate the Impact of Land use and Land Cover Change on the Hydrology of Luvuvhu River Catchment in Limpopo Province. Gezina, South Africa: Water Research Commission.

S A M , W., N , S., & I , A. (2020). Water quality assessment at selected sites in Perak and Kinta River. IOP Conference Series: Materials Science and Engineering.

Silvia F., P., & Daniel A. , W. (2000). Use of water quality indices to verify the impact of Córdoba City (Argentina) on Suquıa River. Water Research, 2915-2926.

Siti Rahyla, R., RB Radin, F., Samsurijan, M., & Lim, Y. (2019). Leading key players and support system in Malaysian paddy production chain. Cogent Food & Agriculture.

Yu , Z., Ming , P., & Eric F. , W. (2016). On Creating Global Gridded Terrestrial Water Budget Estimates from Satellite Remote Sensing. Surveys in Geophysics, 249-268.

Appendix E

IWSDC Human Resource Requirement and Job Description

Human Resources Requirements (Directors)

No.	Position	Division / Department	Quantity	Notes
1	Managing Director	Managing Director	1	
2	PA to Managing Director	Managing Director	1	
3	Deputy Managing Director	Managing Director	1	
4	PA to Deputy Managing Director	Managing Director	1	
5	RDIC Director	RDIC	1	
6	Data & Strategic Reports Director	Data & Strategic Reports	1	
7	Technology Director	Technology	1	
8	Corporate Director	Corporate	1	
9	Finance Director	Finance	1	
10	Human Resources Director	Human Resources	1	
	Total		10	

Human Resources Requirements for RDIC Division

No.	Position	Department	Quantity	Notes
1	Data Analysts	IR4.0 Applications	2	
2	Earth Observation Data	IR4.0 Applications	1	
3	Earth Observation Data Analyst	IR4.0 Applications	1	
4	Data Scientist	IR4.0 Applications	1	
5	Machine Learning Engineer	IR4.0 Applications	1	
6	AI Engineer	IR4.0 Applications	1	
7	Blockchain Developer	IR4.0 Applications	1	
8	Data Visualist	IR4.0 Applications	1	
9	Technical Assistants	IR4.0 Applications	2	
10	Business Intelligence Analyst	IR4.0 Applications	1	
11	Research & Development Manager	RDIC Management	1	
12	Innovation & Commercialisation Manager	RDIC Management	1	
13	Modellers	RDIC Management	3	Hydrology, water supply, climate change
14	Business Development Manager	RDIC Management	1	
15	Software Developers	RDIC Management	2	
16	Researchers	RDIC Management	4	
17	Research Assistants	RDIC Management	4	
	Total		28	

Human Resources Requirements for Data & Strategic Reports Division

No.	Position	Department	Quantity	Notes
1	Water Resources Engineer	Strategic Reports	2	
2	Hydrologist	Strategic Reports	2	
3	Water Supply Engineers	Strategic Reports	2	
4	Irrigation Engineer	Strategic Reports	1	
5	Environmental Scientist	Strategic Reports	1	
6	Environmental Engineer	Strategic Reports	1	
7	Statistician	Strategic Reports	1	
8	Water Accounting Expert	Strategic Reports	1	
9	Water Auditing Expert	Strategic Reports	1	
10	Agriculturist	Strategic Reports	1	
11	Socio-Economist	Strategic Reports	1	
12	Climate Change Analyst	Strategic Reports	1	
13	Hydrogeologist	Strategic Reports	1	
14	Stakeholder Engagement Expert	Strategic Reports	1	
15	Data and Information Administrator	Data and information Distribution	1	
16	Statistician	Data and information Distribution	1	
17	GIS Experts	Data and information Distribution	2	
18	Remote Sensing Expert	Data and information Distribution	1	
19	Technical Assistants	Data and information Distribution	2	
	Total		24	

Human Resources Requirements for Technology Division

No.	Position	Department	Quantity	Notes
1	Solution Architect	Infrastructure	1	
2	System Engineers	Infrastructure	2	
3	Data Scientist	Infrastructure	1	
4	Data Analyst	Infrastructure	1	
5	Data Visualist	Infrastructure	1	
6	Database Engineers	Infrastructure	2	
7	Database Administrator	Infrastructure	1	
8	System Engineer	System Maintenance	2	For Hadoop & OS
9	Technical Assistants	System Maintenance	2	
10	Technical Writer	System Maintenance	1	
11	Quality Assurance Tester	System Maintenance	2	1 Hardware tester 1 Software tester
12	Network & Cyber Security Expert	System Maintenance	1	
13	Network & Cyber Security Technical Assistant	System Maintenance	1	
	Total		18	

Human Resources Requirements for Finance, Human Resources and Corporate Divisions

No.	Position	Department/ Division		Quantity	Notes
Finance Division					
1	Accountant	Finance Division	1		
2	Finance and Accounts Executives	Finance & Accounts Dept	3		
3	Procurement Executives	Procurement Dept	2		
			Sub-Total (1)	6	
Human Resources Division					
4	Human Resources Manager	Human Resources Division	1		
5	Human Resources Executives	HRD Dept	2		
6	Administration Executives	Admin Dept	2		
7	Administration Clerks	Admin Dept	4		
			Sub-Total (2)	9	
Corporate Division					
8	Corporate Manager	Corporate Division	1		
9	Corporate Executive	Stakeholders Management Dept	1		
10	Corporate Executive	Governance Dept	1		
11	Legal Officer	Legal & Policy Dept	1		
			Sub-Total (3)	4	
			Grand Total	**19**	

Job Descriptions

Many of these positions proposed for IWSDC are new and emerging jobs, especially those related to data analytics, artificial intelligence and remote sensing. These jobs are becoming more and more important in the era of IR4.0 and big data. The descriptions of these positions are as the following:

IWSDC's Human Resources Job Descriptions

No.	Roles	Responsibilities
1	Solution Architect – Cloudera Big Data Infrastructure Architect – Lead Engineer	• Responsible for designing the overall Cloudera Big Data Infrastructure Architectural layout • Responsible to lead the team to manage the Hadoop ecosystem, such as: – Cloudera Manager features that make managing the clusters easier, such as aggregated logging, configuration management, resource management, reports, alerts, and service management. – The internals of Cloudera Manager, HDFS, Apache HBase, Apache Kafka, Apache NiFi, Apache Hive, Apache Spark, Spark Sql, Apache Solr and other required Components – Determining the correct hardware and infrastructure for the cluster – Proper cluster configuration and deployment to integrate with the Data Centre – How to load data into the cluster from dynamically generated files using Flume, Sqoop and Kafka. – Best practices for preparing and maintaining Apache Hadoop in production – Troubleshooting, diagnosing, tuning, and solving Hadoop issues • Responsible to lead the requirements and analysis studies based on infrastructure needs.

No.	Roles	Responsibilities
		• Responsible to guide System Engineer / Cloudera Engineer on the infrastructure needs. • Responsible to produce overall project Implementation plan activities • Responsible to guide and provide information to Technical Writer on information related to Infrastructure Technical Documentation: • Report to Project Manager for progress updates.
2	System Engineer / Cloudera Engineer	• Responsible for requirements gatherings based on infrastructure needs. • Responsible for performing installation and configuration of Operating Systems, Cloudera Hadoop components for the Client's On-Premises. • Responsible for performing Fine Tuning activities on the related hardware Infrastructure components and Hadoop components. • Responsible for identifying integration or migration activities required. • Responsible for providing technical information for documentation purposes if required. • Responsible for performing System Acceptance Test, Application Penetration Test and Load/Performance Test if required. • Report to Solution Architect for task reference. • Report to Project Manager for progress updates. • Responsible to assist in managing the Hadoop ecosystem
3	Data Scientist	• Responsible for Python or R programming. • Responsible for exploring and analysing data and developing statistical or machine learning models. • Responsible for the data science and machine learning at scale • Responsible for the knowledge of Hadoop ecosystem architecture • Responsible for working with HDFS data, HBase and Hive tables • Responsible for the knowledge of Cloudera Data Science Workbench • Responsible for the knowledge of Apache Spark, Kafka and NiFi • Responsible for implementing/using Kafka, NiFi, Spark, Spark SQL, and Spark MLlib, PySpark, sparklyr and Cloudera Data Science Workbench (CDSW) and Hue
4	Data Analyst	• Responsible for designing and building big data applications. • Responsible for analysing problems using Apache Hadoop and associated tools in the enterprise data hub. • Responsible for utilising the entire process of designing and building solutions, including ingesting data, determining the appropriate file format for storage, processing the stored data, and presenting the results to the Client in an easy-to-digest form. • Responsible on the open-source ecosystem knowledge of how big data tools addresses challenges not met by traditional RDBMSs • Responsible to implement Apache Hive and Apache Impala to provide SQL access to data • Responsible to process and analyse semi-structured and unstructured data • Responsible to optimise Hive and Impala queries • Responsible to determine whether Hive, Impala, an RDBMS, or a mix of these is best for a given task

No.	Roles	Responsibilities
5	Database Engineers / Database Administrator	• Responsible to establish the needs of users and monitoring user access and security • Responsible to monitor performance and manage parameters in order to provide fast responses to front-end users • Responsible to map out the conceptual design for a planned database • Responsible to consider both back-end organisation of data and front-end accessibility for end-users • Responsible to refine the logical design so that it can be translated into a specific data model • Responsible to further refine the physical design to meet system storage requirements • Responsible to install and test new versions of the database management system (DBMS) • Responsible to maintain data standards, including adherence to the Data Protection Act • Responsible to write database documentation, including data standards, procedures and definitions for the data dictionary (metadata) • Responsible to control access permissions and privileges • Responsible to develop, manage and test back-up and recovery plans • Responsible to ensure that storage and archiving procedures are functioning correctly • Responsible to carry out capacity planning • Responsible to work closely with project manager and developers • Responsible to communicate regularly with technical, applications and operational staff to ensure database integrity and security • Report to Lead Engineer for progress updates
6	Data Visualist	• Data visualist presents large amount of information in ways that are universally understandable or easy to interpret and spot patterns, trends and correlations. • These representations include charts, graphs, infographics and other pictorial diagrams. • Data visualisation analysts use visualisation tools and software to communicate information
7	Earth Observation (EO) Data Science Expert	• Explores the fields of big data analytics and AI applied to EO; • Builds full-stack analysis solutions using earth observation data (optical satellite imagery, weather data, radar measurements, etc.) • Research and prototype data processing & analysis algorithms. • Develop and deploy data pipelines. • Support rapid prototyping and benchmarking of innovative EO-based solutions using AI and other innovative IT
8	Remote Sensing Engineers	• Imagery analysts use statistical analysis software and image analysis software to analyse the images and apply them in various areas, such as water resources management, for example to identify watercourses and potential areas of flooding. • Establish databases to make it easy to quickly access the images and analyses for research, evidentiary or historical purposes • Monitors remote sensing projects to determine their quality and recommends changes in equipment or procedures

Appendix F

River Basin Management Units in Malaysia

No.	Name of River Basin	Area (sq.km)	State/country
1	Sg Perlis	724.398	Perlis/Kedah (transboundary)
2	Sg Juru	80.756	Pulau Pinang
3	Sg Perai	447.824	Pulau Pinang/Kedah (transboundary)
4	Sg Jawi	231.031	Pulau Pinang/Kedah (transboundary)
5	Sg Kerian	1,420.23	Pulau Pinang/Kedah/Perak (transboundary)
6	Sg Kedah	2,971.82	Kedah
7	Sg Merbok	439.407	Kedah
8	Sg Yan Kechil	83.699	Kedah
9	Sg Muda	4,150.40	Kedah/Pulau Pinang (transboundary)
10	Sg Perak	14,907.64	Perak
11	Sg Kurau	740.125	Perak
12	Sg Manjung	595.107	Perak
13	Sg Larut/Sg Jaha	340.683	Perak
14	Sg Beruas	310.915	Perak
15	Sg Sangga Besar/Sg Sepetang	248.321	Perak
16	Sg Temerloh	244.949	Perak
17	Sg Jarum Mas	213.961	Perak
18	Sg Tiram	91.325	Perak
19	Sg Bernam	2,836.33	Perak/Selangor (transboundary)
20	Sg Selangor	1,936.87	Selangor
21	Sg Tengi	527.721	Selangor
22	Sg Klang	1,297.38	Selangor/Federal Territory (transboundary)
23	Sg Buloh	451.926	Selangor/Federal Territory (transboundary)
24	Sg Langat	2,347.88	Selangor/Federal Territory/NSembilan (transboundary)
25	Sg Sepang	101.933	Selangor/Negeri Sembilan (transboundary)
26	Sg Lukut Besar	173.384	Negeri Sembilan
27	Sg Linggi	1,297.67	Negeri Sembilan /Melaka
28	Sg Melaka	614.575	Negeri Sembilan /Melaka
29	Sg Duyong	131.032	Melaka
30	Sg Baru	86.549	Melaka
31	Sg Kesang	658.263	Melaka/Johor/Negeri Sembilan (transboundary)
32	Sg Johor	2,285.64	Johor
33	Sg Batu Pahat	2,048.79	Johor
34	Sg Sedeli Besar	1,424.61	Johor
35	Sg Benut	614.557	Johor
36	Sg Lebam	365.457	Johor
37	Sg Pontian Besar	362.047	Johor
38	Sg Pulai	345.512	Johor
39	Sg Skudai	293.329	Johor
40	Sg Sarang Buaya	291.829	Johor
41	Sg Sedeli Kechil	1,424.61	Johor
42	Sg Mersing	273.458	Johor
43	Sg Tebrau	256.972	Johor
44	Pt Botak	150.206	Johor
45	Sg Jemaluang	140.558	Johor
46	Sg Sanglang	119.69	Johor
47	Sg Santi	117.36	Johor
48	Sg Ayer Baloi	81.655	Johor
49	Sg Muar	6,137.80	Johor/Pahang/Melaka/Negeri Sembilan (transboundary)
50	Sg Endau	4,739.06	Johor/Pahang (transboundary)
51	Sg Pahang	28,682.25	Pahang/Negeri Sembilan (transboundary)
52	Sg Rompin	3,939.23	Pahang
53	Sg Kuantan	1,684.35	Pahang
54	Sg Bebar	1,117.40	Pahang

No.	Name of River Basin	Area (sq.km)	State/country
55	Sg Mercung	628.259	Pahang
56	Sg Pontian	319.723	Pahang
57	Sg Penur	146.43	Pahang
58	Sg Baluk(Sg Air Putih)	97.819	Pahang
59	Sg Cerating	88.541	Pahang
60	Sg Terengganu	4,596.00	Terengganu
61	Sg Kemaman	2,190.89	Terengganu
62	Sg Dungun	1,828.11	Terengganu
63	Sg Besut	953.222	Terengganu
64	Sg Setiu	876.189	Terengganu
65	Sg Paka	832.229	Terengganu
66	Sg Marang	411.889	Terengganu
67	Sg Keluang Besar	287.72	Terengganu
68	Sg Mercang	259.449	Terengganu
69	Sg Kertih	248.903	Terengganu
70	Sg Ibai	124.273	Terengganu
71	Sg Kelantan	12,981.19	Kelantan
72	Sg Kemasin	347.659	Kelantan
73	Sg Semerak	500.498	Kelantan/Terengganu (transboundary)
74	Sg Golok	1,011.13	Kelantan/Thailand (transboundary)
75	Terusan Kinabatangan	16,072.95	Sabah
76	Sg Padas	8,822.16	Sabah
77	Sg Labuk	5,667.59	Sabah
78	Sg Segama	4,402.69	Sabah
79	Sg Sugut	3,066.72	Sabah
80	Sg Kalabakan	1,337.44	Sabah
81	Sg Kalumpang	1,112.01	Sabah
82	Sg Tuaran	988.417	Sabah
83	Sg Abai	861.88	Sabah
84	Sg Kretam Besar	844.742	Sabah
85	Sg Maruap	839.306	Sabah
86	Sg Tuingkayu	789.777	Sabah
87	Sg Papar	788.033	Sabah
88	Sg Tandek	703.916	Sabah
89	Sg Serudong	698.933	Sabah
90	Sg Paitan	670.483	Sabah
91	Sg Brantian	599.063	Sabah
92	Sg Mengalong	587.846	Sabah
93	Sg Silabukan	525.721	Sabah
94	Sg Bongon	499.502	Sabah
95	Sg Klias	479.79	Sabah
96	Sg Bongaya	444.794	Sabah
97	Sg Umas Umas	415.371	Sabah
98	Sg Kaindangan	375.11	Sabah
99	Sg Tiram	352.455	Sabah
100	Sg Bukau	349.72	Sabah
101	Sg Sinsilog	305.164	Sabah
102	Sg Membakut	292.244	Sabah
103	Sg Sengarong	278.13	Sabah
104	Sg Burong	275.985	Sabah
105	Sg Monyog	274.26	Sabah
106	Sg Samawang	260.474	Sabah
107	Sg Bandau	253.21	Sabah
108	Sg Ulu Tungku	250.393	Sabah
109	Sg Segaliud	248.943	Sabah
110	Sg Kanibongan	227.776	Sabah
111	Sg Keguraan	226.119	Sabah
112	Sg Sahabat	225.119	Sabah

No.	Name of River Basin	Area (sq.km)	State/country
113	Sg K.Klagan	208.456	Sabah
114	Sg Bongawan	206.807	Sabah
115	Sg Lakutan	204.385	Sabah
116	Sg Langkon	202.936	Sabah
117	Sg Mumiang	198.307	Sabah
118	Sg Kimanis	190.425	Sabah
119	Sg Gum-Gum Besar	163.739	Sabah
120	Sg Binsuluk	160.881	Sabah
121	Sg Telaga	155.776	Sabah
122	Sg Mamahat	152.157	Sabah
123	Sg Sapagaya	127.985	Sabah
124	Sg Merotai	149.599	Sabah
125	Sg Jeragan Bistari	148.085	Sabah
126	Sg Tawau	142.194	Sabah
127	Sg Pegagau	141.542	Sabah
128	Sg Sepagaya	127.985	Sabah
129	Sg Sulaman	127.595	Sabah
130	Sg Kolapis	121.255	Sabah
131	Sg Sabahan	120.946	Sabah
132	Sg Tanjung Labian	116.801	Sabah
133	Sg Apas	116.042	Sabah
134	Sg Mengkabong	114.66	Sabah
135	Sg Milau	114.384	Sabah
136	Sg Tempasuk	110.154	Sabah
137	Sg Sekong Besar	108.147	Sabah
138	Sg Betotan	107.994	Sabah
139	Sg Suanlamba Besar	100.858	Sabah
140	Sg Inanam	95.899	Sabah
141	Sg Simandalan	93.495	Sabah
142	Sg Tatulit	90.644	Sabah
143	Sg Bode Besar	89.861	Sabah
144	Sg Pimpin	85.729	Sabah
145	Sg Sibunga Besar	81.887	Sabah
146	Sg Manalunan	81.374	Sabah
147	Sg Tegupi	81.347	Sabah
148	Sg Sibuku	799.452	Sabah/Indonesia (transboundary)
149	Sg Sembakung	5,467.77	Sabah/Indonesia (transboundary)
150	Batang Balingian	2,227.47	Sarawak
151	Batang Baram	22,109.00	Sarawak
152	Batang Kayan	1,063.38	Sarawak
153	Batang Kemena	5,765.56	Sarawak
154	Batang Kerian	1,479.11	Sarawak
155	Batang Lawas	996.752	Sarawak
156	Batang Lupar	5,942.87	Sarawak
157	Batang Matu	355.564	Sarawak
158	Batang Mukah	2,030.60	Sarawak
159	Batang Oya	2,078.89	Sarawak
160	Batang Rajang	50,531.60	Sarawak
161	Batang Rambungan	132.407	Sarawak
162	Batang Sadong	3,526.61	Sarawak
163	Batang Salak	97.795	Sarawak
164	Batang Samarahan	903.093	Sarawak
165	Batang Saribas	1,905.66	Sarawak
166	Batang Suai	1,443.19	Sarawak
167	Batang Tatau	4,848.21	Sarawak
168	Batang Terusan	2,443.09	Sarawak
169	Sg Bayan	91.165	Sarawak
170	Sg Bedengan	111.598	Sarawak

No.	Name of River Basin	Area (sq.km)	State/country
171	Sg Maludam	164.009	Sarawak
172	Sg Samunsam	176.087	Sarawak
173	Sg Santubong	114.505	Sarawak
174	Sg Sematan	216.64	Sarawak
175	Sg Siang-Siang	95.035	Sarawak
176	Sg Sibu Laut	128.702	Sarawak
177	Sg Sparan	93.261	Sarawak
178	Sungai Likau	106.455	Sarawak
179	Sg Limbang	3,682.40	Sarawak
180	Sungai Miri	680.914	Sarawak
181	Sg Niah	1,316.20	Sarawak
182	Sg Nyalau	267.272	Sarawak
183	Sg Sarawak	1,726.84	Sarawak
184	Sg Sarupai Sadupai	217.41	Sarawak
185	Sg Sebuyau	520.526	Sarawak
186	Sg Sibuti	892.662	Sarawak
187	Sg Similajau	532.021	Sarawak
188	Sg Telong	97.754	Sarawak
189	Sg Pandaruan	222.378	Sarawak/Brunei (transboundary)
190	Pulau Langkawi	299.794	Kedah
191	Pulau Pinang	295.634	Pulau Pinang

Source from the Malaysian River Basin Boundary Study Phase I by the River Division (2009)

Category 1: River Basin within the state

Category 2: River Basin shared with more than 1 state

Category 3: River Basin shared with other country

Appendix G

IWSDC Fulfilment of TOC WST2040 Study

Introduction to the IWSDC Sub-Sectorial Study

The 12th Malaysia Plan 2021-2025 (12th MP) affirms the Government's commitment to transform the Water Sector from one that is merely providing a supporting role to all economic and social activities to one that is vibrant as an economic sector whilst ensuring high levels of water security for sustainable development and growth. This transformation is set to continue through the 13th, 14th, and the 15th Malaysia Plans as envisaged in the Water Sector Transformation (WST2040). The themes of this WST2040 over the respective Malaysia Plans are as shown in **Figure H 1**.

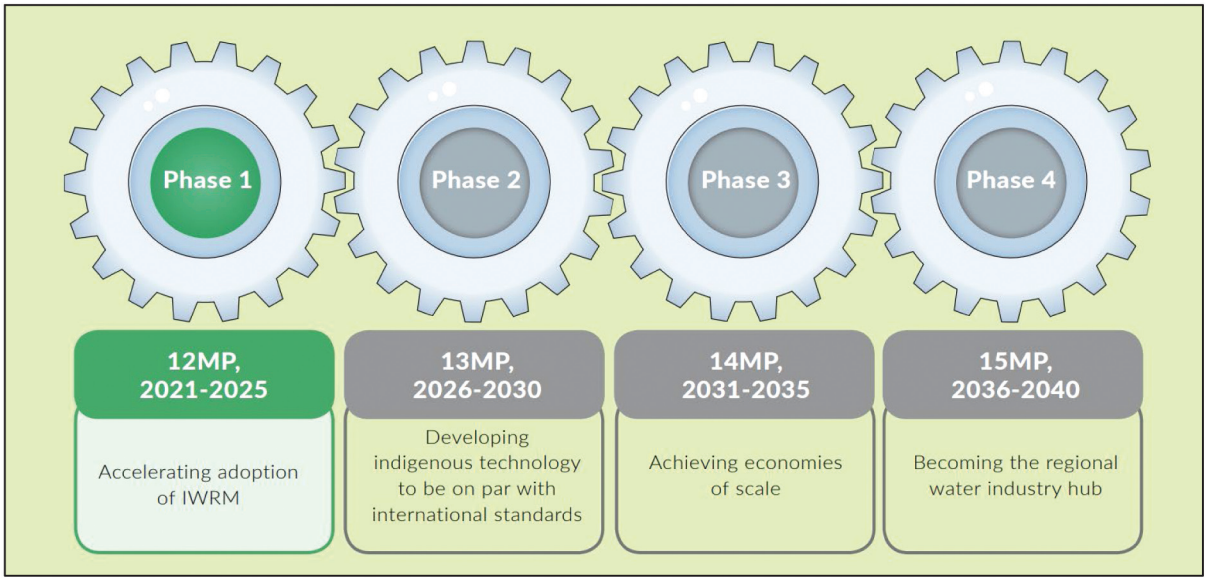


Figure H 1: WST2040 Themes
(Economic Planning Unit, 2021)

Under this Twelfth Malaysia Plan, one of the targets under the WST2040, and in line with SDG Goal No. 6: Clean Water and Sanitation, is the establishment of the Integrated Centre for Water Data and R&D&C&I by 2025, as shown in **Figure H 2**.

The long-term plan is related to Strategy C1: *Towards the establishment of an independent water data and information statutory body* and Strategy under Focus Area C – *Enhancing the Data-driven Decision-making for Sustainability* of Phase 1 of the WST2040 (Ministry of Economic Affairs, 2019). Another strategy is Strategy C2 – *Integrating research on water through the establishment of a Water Research Consortium*.

The idea of establishing IWSDC is for it to be a precursor towards the formation of those two institutions stated under strategies C1 and C2. At the onset, IWSDC will be structured to provide the environment to initiate and encourage Water Research Consortiums.

In establishing this IWSDC it is necessary to appreciate the present key characteristics of water data management practices that requires special attention for the role of IWSDC as a Game Changer in the WST2040.

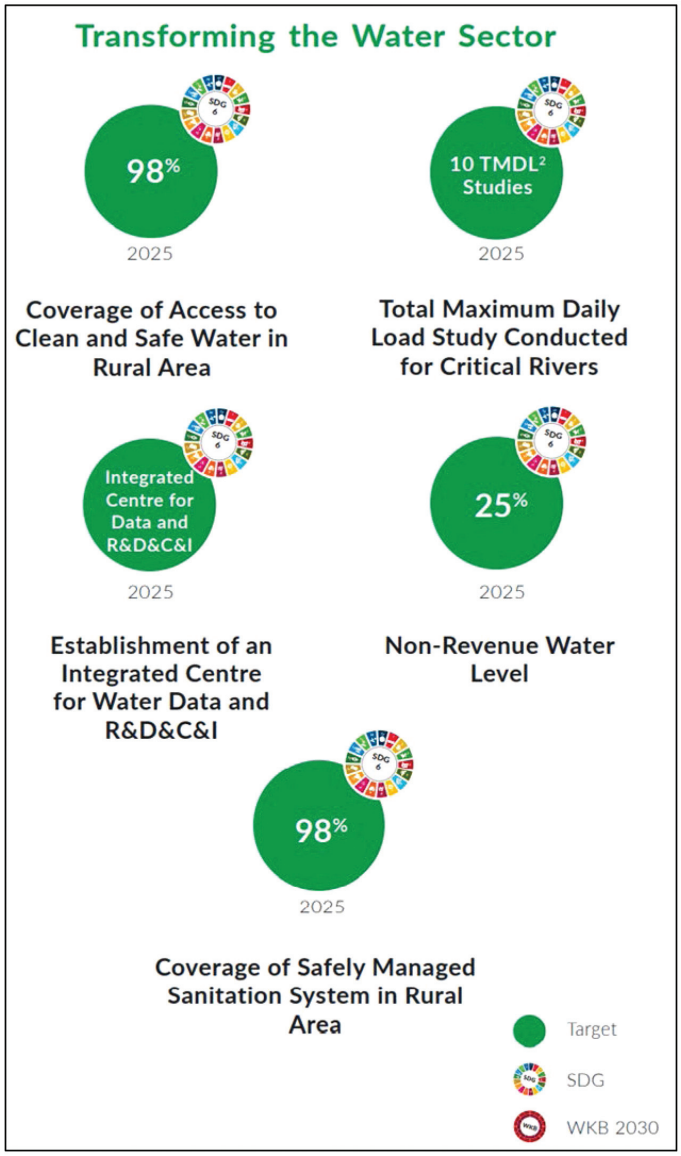


Figure H 2: Integrated Centre for Water Data and R&D&C&I under 12th MP (Economic Planning Unit, 2021)

Objectives of the IWSDC Sub-Sectorial Study

The objective of this Sub-Sectorial Study is:
To establish the IWSDC which will become a **single-point reference centre** and provide **reliable** and **consistently high-quality** water data and information that includes **primary data** (water-related data) and **secondary data** (non-water data related to water).

IWSDC is seen as a "**Game Changer"** under WST2040, which will have the characteristics as follows:

a. Becoming a single-point reference centre and provide reliable and consistently high-quality water data and information that includes primary data and secondary data to inspire trust and confidence and scientifically support the decision making of relevant water stakeholders,
b. Having the capacity to unlock the value of data to exploit intelligence and innovation in the water sector,
c. Having the capacity to manage standardised data based on local and international standards,
d. Empower people by having a formal and structured public participatory platform that will improve the accessibility to water data and information through open science and crowdsourcing initiatives,

e. Managing the wealth of water for the wealth of the nation and having tools to quantify and assess water governance by producing strategic reports, processes, and procedures (water accounting report, water auditing report and water for environment among others) to service gaps within the water management spectrum, and to complete water sector spectrum of services, and

f. Making use of space technology and becoming a linkage for Research, Development, Innovation and Commercialisation (RDIC) activities, which through these, high-value jobs and business opportunities can be created and lead to new indigenous applications and technologies that can be internationally recognised.

Scope of the IWSDC Sub-Sectorial Study According to the Terms of Reference (TOR)

The scope of IWSDC's study will be based on the WST2040 main framework established in the TOR, consisting of two objectives, one driver as well as four enablers, as shown in **Figure H 3**.

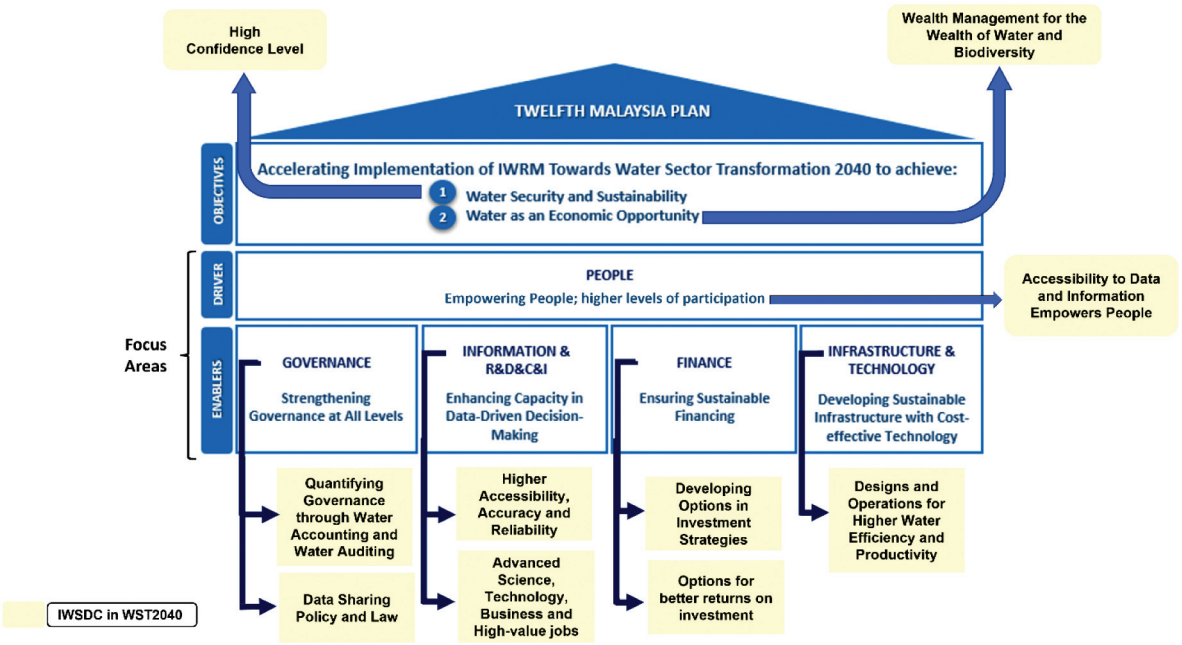


Figure H 3: Transformation for WST2040 Study and IWSDC Sub-Sectorial Study

To satisfy the acceleration of IWRM and the objectives of the WST2040, The IWSDC Sub-Sectorial's scope of study will focus on data and information that will provide high confidence level for all stakeholders. This will be guided by the twin objectives of the WST2040 study, namely **Water Security and Sustainability** as well as **Water as an Economic Opportunity**.

The Five Focus Areas

The IWSDC will also provide data and assist in wealth management of water and biodiversity which will be supported by five (5) focus areas describe as follows:

1. People

   The IWSDC Sub-Sectorial Study will empower people through accessibility to data information. This will be supported by legal means as well as promotion of Open Science, citizen science and crowdsourcing concepts. In addition, the Study will also explore ways to strengthen capacity in data science and applications by recommending new and specialised positions in data related fields.

2. Governance
   The Study will take into consideration on establishing the water governance tools through water accounting and water auditing. The Study will also review current laws and policies to enhance the data sharing in the country, especially on water data.

3. Information and RDIC
   The Study will enhance the decision-making which will be higher accessibility, accuracy, and reliability through the publications of strategic reports. This will be equipped with the advanced science and technology, and essentially will spur RDIC in the water sector.

4. Finance
   The Study will have high-quality data and information as to ensure the sustainable financing by developing options in investment strategies as well as options for better returns on investments.

5. Infrastructure and Technology
   At present, there is little reliable data on performance infrastructure, hence the Study will develop a sustainable infrastructure with cost-effective technology for designs and operations for a higher water efficiency and productivity.

The Covid-19 Pandemic

The Covid-19 pandemic have stirred substantial challenges for the progress of the study of IWSDC. The key areas of investigation for this sub-sectorial study must involve investigations into the many on-the-ground situations of government agencies, organisations and private sectors that are currently collecting primary water data and secondary data related to water. This is important as understanding the current situation in these departments through site inspections - available tools, equipment and technical capability - can provide a sense for their infrastructure readiness and how equipped or underequipped they are to support the IWSDC.

Seven lessons COVID-19 has taught about data strategy

Data drives better decisions. Governments are not new to data-driven decision-making—their efforts to use data to replace intuition with objectivity span decades. In the current COVID-19 crisis, governments have quickly reacted to available data and developed strategies to combat the effects of the virus on people, governments, and the economy. Using data, analytics, and emerging technologies, governments made informed policy decisions to enforce restrictive protocols to reduce the spread of the virus. In addition, data has informed policy decisions around the release of economic aid, reopening of cities, improving public health capacity, and much more.
The following seven lessons have emerged post-coronavirus:

1. *Real-time data is key to resilience*
2. *Data presentation is most effective when it's centred on users*
3. *Cloud converts data from a luxury to a utility*
4. *Data governance is crucial*
5. *A data strategy is incomplete without privacy and security*
6. *Data-sharing enables innovation*
7. *Identifying and addressing data issues can strengthen decision-making*

Source: Deloitte, 2021

The IWSDC study requires multiple site visits and face-to-face discussions, but this methodology has been greatly handicapped due to the movement restrictions imposed by the government to curb the Covid-19 pandemic. Although online meetings are doable, communication barriers are still prevalent in this mode of communication. Connection instability, daily household distractions, lack of body language cues can all stir discontent from both parties in communicating new ideas, especially transformative ones like the IWSDC.

But more importantly, the Covid-19 pandemic has inadvertently highlighted the importance of having strategy when it comes to data management.

Data Has Enabled Rapid Pandemic Responses

Unconscious decision making or intuition are rapidly being replaced by data-driven decision making. The most successful mitigation plans in the Covid-19 pandemic have all stemmed from governments quickly reacting to available data to develop strategies to curb the spread of the virus on people, governments, and the economy.

The current situation sees that the practice of having well-managed data, partaking in analytics and emerging technologies, are pivotal for the government to make informed policy decisions and protocols to restrict the virus spreading. These include the movement control orders, school closures, quarantine measures, and social distancing guidelines that have all proved to be effective in minimising virus propagations. Additionally, it is with data and information that policies centred around economic aid and city reopening are made possible.

In the context of water sector, there were effects in the river water quality as well as water usage in domestic and commercial sectors for both in quality and quantity due to Covid-19 lockdown. Many rivers have improved in a short span of time because of the lockdown. Malaysia recorded an overall improvement in air and water quality within the first four weeks of the Movement Control Order (MCO), from 18 March to 14 April 2020 (Babulal, 2020). Amongst the river stations monitored were those at Sungai Linggi, Sungai Muar, Sungai Johor, Sungai Pahang, Sungai Kuantan, Sungai Besut, Sungai Kelantan and Sungai Batang Sadong. It was also noted during the lockdown period, there was a decrease of around 50% in rubbish collected from booms in Sungai Klang compared to in 2017 and 2018.

The lockdown has also increased the domestic water demand and decreased the non-domestic demand. As personal hygiene is one of the most important measures to prevent virus infection, the demand for water has increased the water usage. This has further worsened during the prolonged lockdown and have affected the demand and supply patterns of water. However, the lack of sharing of data by the water operators on the water usage makes it difficult for the Government to conduct a quantifiable analysis.

The Covid-19 pandemic has shown that data is one of the government's greatest assets, and while it is abundant across the many government departments, it needs to be integrated and used strategically to maximise the value that the data brings. The Covid-19 response provides opportunities for the government to refresh and re-strategise the use of data that they already possess, to bring value and even generate new business opportunities from existing data.

Report on Findings based on Scope of the Sub-Sectorial Study as required by the Terms of Reference

As mentioned in the Terms of Reference for the WST2040 Roadmap Study under 12th MP, the Study shall consider the 6 scopes which are described as below:

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

Laws and Directives Review

A total of nineteen (19) Laws and one (1) Directive were reviewed in identifying the gaps as well as opportunities in the current legal sphere in relation to the establishment of the IWSDC. The analysis is conducted with the view of discovering a 'source of authority' for IWSDC to become an independent statutory body in collecting, integrating, and sharing water data in the country. From the review, the most relevant laws to impact the IWSDC are the **Official Secrets Act (OSA) 1972**, the **Ministerial Functions Act 1969** and the **Statistics Act 1965**.

Policy Review

A total of nineteen (19) policies, masterplan, guidelines, framework, plan, and blueprint have been reviewed in identifying the gaps as well as opportunities in the current policies in relation to the establishment of the IWSDC. Subsequently, the most relevant policies to the IWSDC are the **Digital Economy Blueprint 2021**, the **National Security Policy (NSP) 2021-2025**, the **National Water Resources Policy 2012** and the **Government Open Data Initiative 2014.**

Scope 2: Undertake Comparative Strategy Analysis and Business Models

The Study Team has undertaken the desktop benchmarking analysis for water management in Australia, South Korea, India, and Singapore including the policies, legal, technologies as well as data sharing aspects.

Similar to Malaysia, Australia's water management is under purview of state government. However, under the Meteorology Act 1955 and the Commonwealth Water Act 2007, The Australian Bureau of Meteorology is given the responsibility in compiling and delivering comprehensive water data and information via Australian Water Resources Information System (AWRIS). The AWRIS is a secure repository for all water-related data and a means to deliver high quality water information to all Australians.

India's water management is managed through India Water Resources Information System (India-WRIS). The India-WRIS is a portal/website that is accessible to the public and capable to provide comprehensive water data and information in real-time.

The water management in South Korea is managed by a government-owned company, Korea Water Resources Corporation (K-Water) since the 1960s. The country is known to Smart Water City concept where the data is integrated throughout the entire water supply processes (from treatment to tap). At the same time, this data can be accessed by the public in real-time such as status of water process and water quality, amongst others. South Korea is also renowned for its numerous water technologies in implementing IWRM.

Singapore also has become a world leader in managing water. In early 2000, the country had initiated the "Four National Taps" programme for a sustainable water supply from four water sources – Water from Local Catchment, Imported Water, NEWater (high-grade reclaimed water) and Desalinated Water. The adoption of water membrane technology for water production, treatment and recycling process has made Singapore renowned to the world as the nation aims to become self-sufficient, with 40% of water from recycling, 30% from desalination, and 20% from rainwater collection.

The Study Team has also undertaken desktop benchmarking for freedom of information (FOI). In the UK, the FOI Act 2000 was established, that gives the individual people in the UK the general right of access to information that is held by most public authorities. It is aimed at promoting a culture of transparency and

accountability across the public sector in the UK. It enables a better-informed public, understanding how public authorities carry out their duties.

Besides, Canada has also formulated a law called 'Access to Information Act 1985, that was formed to provide access to information under the control of the government of Canada and provide proactive publication of certain information. Similar to the FOI 2000 Act in the UK, this Canadian Act was formed to enhance the accountability and transparency of federal institutions to promote an open and democratic society, and to enable public debate on the conduct of these institutions. The authority is required to publish the dataset in a re-usable form, where reasonably practicable.

In Malaysia, the FOI has been enacted in two states: Selangor and Penang. The law was formulated in Selangor in 2011 and enforced in 2013, with the objective of enhancing the externalisation of information for public interest and to provide opportunities for individuals to access information held by State Government Departments through applications submitted to the relevant department. For Selangor, two subsidiary legislations were also made to support this Act, namely the Freedom of Information (State of Selangor) (Access to Information) Regulations 2012 and State Information Board (State of Selangor) Rules 2012.

The Penang Freedom of Information Enactment 2010 came into enforcement in 2015 and was similarly formed to provide the disclosure of information made by every State Department for public interest. Under this law, any person may be given access to the State Department information, unless the information sought is contained in a document which is subject to any written law

Scope 3: Study Potential of the Nation's Water Sector Industry
The Water as an Economic Sub-sectorial Study has been detailed out in Scope 3. However, the IWSDC Sub-Sectorial Study's will also enhance the water management by capitalising advanced technology such as space technology whereby the Study promotes "Space as the New Frontier in Water Management". This will create new businesses, new professions, and new set of skills to contribute to the nation's GDP.

Scope 4: Transformation Strategy and Initiative Implementation Framework
The framework shown in **Table H 1** and **Table H 2** has been adopted by the Technical Committee and Steering Committee of the Study.

Table H 1: Proposed WST2040 Roadmap Framework

WST2040 RoadMap																				
Focus Area	Water as a Resource /Water Security And Sustainability									Water for Livelihood/Water As An Economic Opportunity										Focus Area
	11MP/12MP/13MP/14MP/15MP									11MP/12MP/13MP/14MP/15MP										
	Strategy	Initiatives/ Pro-grammes	Activities	Hierarchi-cal Level	Lead Author-ity/Col-laborating Partners	Imple-menting Authority	Current Status	Target Comple-tion	Remarks	Strategy	Water User Category	Initiatives/ Pro-grammes	Activities	Hierarchi-cal Level	Lead Author-ity/Col-laborating Partner	Imple-menting Authority	Current Status	Target Comple-tion	Remarks	
People																				
Governance																				
Finance																				
Infrastructure and Technology																				
Information and RDIC																				

Table H 2: Budget Requirements

WST2040 Budget Requirements

Focus Area	Water as a Resource/Water Security and Sustainability																			Water for Livelihood/Water as an Economic Opportunity															
	Strategy	Initiatives/ Programmes	Activities	Lead Ministry/ State Govt.	Budget (RM '000,000)									Funding Source	Target Completion	Remarks	Strategy	Initiatives/ Programmes	Activities	Lead Ministry/ Organisation	Budget (RM '000,000)									Funding Source	Target Completion	Remarks
					2021	2022	2023	2024	2025	Total 12MP	13MP	14MP	15MP								2021	2022	2023	2024	2025	Total 12MP	13MP	14MP	15MP			
Infrastructure & Technology																																		
Finance																																		
Information & RDIC																																		
Governance																																		
People																																		

Scope 5: Undertake Consultations with Stakeholders and Experts

The Study promotes the idea of transformation in the water management during the engagements with the key stakeholders. This includes to change the mindset on data sharing and data openness to the public. The consultations include one (1) Task Force Members meeting, eighteen (18) Focus Group Discussions (FGDs) and follow-up discussions, four (4) site visits and twelve (12) Subject Matter Experts (SME) meetings.

Scope 6: The Roadmap of WST2040

The IWSDC Sub-Sectorial Study's Roadmap is presented in **Chapter 4** of this report.