SOBA 2B: WISDM WATER INFORMATION SYSTEM FOR DATA MANAGEMENT (WISDM)

AYEYARWADY STATE OF THE BASIN ASSESSMENT (SOBA)

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Disclaimer
"The Ayeyarwady State of the Basin Assessment (SOBA) study is conducted within the political boundary of Myanmar, where more than 93% of the Basin is situated."

TABLE OF CONTENTS

ACKNOWLEDGEMENTS

About IWMI

The International Water Management Institute (IWMI) is a non-profit, scientific research organization focusing on the sustainable use of water and land resources in developing countries. IWMI works in partnership with governments, civil society and the private sector to develop scalable agricultural water management solutions that have a real impact on poverty reduction, food security and ecosystem health. Headquartered in Colombo, Sri Lanka, with regional offices across Asia and Africa, IWMI is a CGIAR Research Center and leads the CGIAR Research Program on Water, Land and Ecosystems (WLE).

4

LIST OF ABBREVIATIONS

AIRBM	Ayeyarwady Integrated River Basin Management
C1	Component 1
HIC	Hydro-Informatics Centre
ISO	International Standardization Organization
IWMI	International Water Management Institute
SOBA 1	State of the Basin Assessment 1: Hydrology
SOBA 2a	State of the Basin Assessment 2a: Groundwater Resources of the Ayeyarwady Basin
SOBA 6	State of the Basin Assessment 6: Participatory 3D Mapping and Local Consultations, and Communities Atlas
WMS	Web Mapping Service

EXECUTIVE SUMMARY

The Water Information System for Data Management, is a web-based data portal that provides secure access to a wide range of spatial and time series data, and other information relevant to managing and developing water resources in Myanmar's major river basins. The portal will facilitate sharing of key datasets among the State of the Basin package teams, between government departments, international and local organizations, universities and the global research community. The initial role of Water Information System for Data Management is to facilitate access to data for all Component Teams to support the State of the Basin Assessment.

WISDM has three main modules: Datasets, Document-hub and Mapping-portal. The Datasets module has been developed to provide access to the water-related spatial and non-spatial datasets, including time series data. An authorized user can access and search the database for which s/he is authorized to do so and view the metadata. The Document-hub is a knowledge-base repository for easy access to literature relevant to the water resources of the Ayeyarwady Basin. It facilitates information collection, organization and retrieval supported by a search facility. The mapping-portal is an online mapping tool that enables visualization of all spatial data available under WISDM. The available map layers are organized into interdisciplinary topics or categories. The mapping-portal is provided with basic functions such as zoom-in, zoom-out, pan, etc., to support the visualization and exploration of the spatial data.

WISDM has a tailor-made user and data management system, which provides the administrator with full control to define user access rights and data sharing for each individual data. WISDM is developed using the latest open source web-development and database technologies, making it flexible enough to be customized and meet the future needs.

1   INTRODUCTION

The International Water Management Institute (IWMI) has been contracted to provide data management support to the State of the Basin Assessment under the Ayeyarwady Integrated River Basin Management (AIRBM) project.

The core objective of the data management sub-component is to develop the Myanmar Water Information System for Data Management (WISDM), a web-based data portal to provide secure and easy access to a wide range of spatial and time series data, and other information relevant for managing and developing water resources in the country's major river basins. The initial role of WISDM is to facilitate access to data for the Component 1 (C1) Team from all packages working on the State of the Basin Assessment.

Simultaneously, the aim is that WISDM will form the basis for, and seamlessly merge with, the information systems being developed for the Hydro-Informatics Centre (HIC). In addition to the technical requirements for data access, an important role of the project will be to help develop modalities for government and non-government partners to share data; and to provide advice on conceptual design for an expanded system as the basis for an Ayeyarwady Decision Support System.

The WISDM data portal has been created as a web-based tool with the core objective of data-management and data sharing. It provides controlled access to a wide range of spatial and time series data, and other information relevant to managing and developing water resources in the Ayeyarwady Basin, which can be expanded to other major river basins of Myanmar. Following are the major features of the portal considered during its development:

- The data portal is designed as a community driven platform, where users can upload and download the data and documents.
- The platform includes a publishing workflow for all contents uploaded (data and documents), which go through a review process before being published for use.
- The platform applies a role based user management system where each user has specific roles such as editor, reviewer, publisher and/or administrator.
- The platform includes a spatial data viewer where users can visualize the spatial data available through the platform
- The platform includes a knowledgebase called Document-Hub, which provides access to reports, and publications divided into different categories; if required, users can add new categories as well.
- The data, spatial data, and Document-Hub are provided with a search facility to help users locate the data or publications of interest.

1.1   Purpose and Structure of the Report

This report is prepared for the State of the Basin Assessment (SOBA) for the AIRBM project and presents a detailed description of the WISDM. It explains the purpose and feature of the portal, the interfaces of the system, what the portal will do, the constraints under which it must operate, and the system response to user inputs. This document is intended for: (i) end users; (ii) system developers wishing to extend the WISDM system; and (iii) WISDM system maintenance staff.

2 WISDM REQUIREMENTS SPECIFICATIONS

The WISDM portal is conceived as a data portal, initially to facilitate data sharing among SOBA packages and at a later stage among relevant stakeholders. The following three points outline IWMI's approach and requirement of the WISDM:

1) Understanding that an effective information system is as much about partnerships and data-sharing as about technical design and implementation
2) The need to facilitate data coordination and access immediately to support timely preparation of SOBA
3) The importance of building flexible systems capable of handling a wide range of data and information types, to international best practice standards and formats, in order to provide a solid basis for transitioning to an expanded state of the art Decision Support System in HIC in the longer term.

The WISDM system is designed to include the following specific requirements:

• A database of water-related spatial datasets and metadata, including time-series data on hydrology and climate;
• An online mapping and visualization tool to view and query data;
• Facilities for partner organizations and SOBA packages to upload and download datasets (subject to permission from the owner of the data); and
• A knowledgebase – a document repository for easy access to relevant literature.

2.1 General Requirements

In addition to the specific requirements, the general requirements consist of objectives and goals that were stated in the project proposal and discussed during the meetings with the client. General requirements of the WISDM are:

• Is accessible via the Internet.
• Allows authorized users to log in to the system;
• Allows System Administrator and Project Management Unit (PMU) Staff to access and download data;
• Restricts access to functionality of the system based upon user roles;
• Allows package users to log in and upload data and view metadata;
• Needs to be installed and maintained in either a cloud server or a local computer/server;
• Includes help feature to guide user; and
• A product reference manual that describes how to install/setup and run the application.

2.2 Expected Requirements

These requirements are implicit to the system and may be so fundamental that the client does not explicitly state them. The necessary features have been developed in the WSDM system to meet the following fundamental requirements:

• The system shall maintain a database of all tabular and spatial data and metadata in the information system.
• The system shall enable the administrator to change a user's type to any user type.
• The administrator will be able to configure any changes and control access at individual dataset level.
• The system shall enable the authorized PMU user to change or update any data, where permitted.

8

- The system shall allow the user to log in based upon an assigned login ID and password.
- The system shall automatically send notifications to the reviewer and administrator when authorized users upload any content.
- The user interface of the system shall be easy to use and will make use of drop-down boxes, radio buttons, and other selectable fields wherever possible instead of fields that require the user to type in data.

2.3   Specific Data Access Requirements

The portal is designed with functionality that can provide open access to a reference set of public domain base data layers (such as elevation, basin extent, population and land cover) for the Ayeyarwady, whereas, for specialized datasets from partner organizations, access is provided based on IP rights/copyrights and agreements with the data providers.

The client required a high degree of data confidentiality. This requirement changed the nature of the WISDM portal from the initial concept design set out in the contract, as a data-sharing platform 'to facilitate access to data for all component teams to support the State of the Basin Assessment'. After discussions with the client, the following agreement was reached (Thein 2017).

1) The WISDM portal will remain internal to SOBA for the time being (at least until its handover to C1). Therefore, the WISDM developer (a sub-set of the SOBA 2: Groundwater Groundwater Resources of the Ayeyarwady Basin and WISDM – Water Information System for Data Management Team) will not allow access to the public from their end. However, the portal will go 'live' online (after review by the C1 Team, - which is normal procedure for any internet publication such as the AIRBM website) and allow public users to visualize the data contained within the portal. To provide immediate support to SOBA packages from WISDM, the following arrangements had been made.

> NO DATA WILL BE AVAILABLE FOR DOWNLOAD UNITL **WISDM** DEVELOPMENT IS COMPLETE AND IS HANDED-OVER

   a. Two log-in authorizations were given to each SOBA package (not to individuals, but as e.g. SOBA5 User 1 and 2).

   b. These log-ins provide access as follows:
   1. Full access to the knowledge base of documents (now called Document Hub).
   2. Read access to the database listing including metadata.
   3. Upload access for data and metadata to each SOBA's respective compartment (each SOBA can upload and download in their own compartment or access area). However, they cannot see each other's data through WISDM but can share it through PMU (Mya Mya Win, the GIS Specialist, PMU) by using a non-disclosure agreement and data sharing agreements (this is a normal routine workflow for data sharing).
   4. All data uploads by each SOBA team will be checked, verified, and arranged by the WISDM Team and stored in the data repository.
   5. Download will be available only for data uploaded by the same package team.
   6. Access to the mapping tool to view mapped data, but no download. All data will be available for viewing and screen capture only.
   7. No data will be available for download until the WISDM is handed-over to C1. Data transfer can be done through data sharing procedure until the WISDM development is completed and handed over to C1.

2.4   Roles and Permissions

To meet the client's specific requirements for controlled access, the WISDM data access uses defined roles and permissions. The access to data, documents, and metadata is controlled by the assigned set of roles and permissions for each registered user.

Definite groups and roles have been defined to control the access to the data based on the specified data access policy of the client. The WISDM portal supports the following user roles. Each user role is composed of a set of data access permissions, which are not available for external configuration. For simplicity and security, only WISDM administrator(s) can assign roles to users.

Table 1 - Description of user roles

ROLE	DESCRIPTION
Viewer	Users assigned the viewer role are permitted to view reports and metadata but cannot edit, upload, or download data, except where permitted
Editor	The editor role has all of the permissions of the viewer role, as well as permission to upload data and, literature and create metadata. This role is restricted to the package user only and each package user will have access to their relevant package data only.
Reviewer	The reviewer role has all of the permissions of the rditor role, as well as the permission to review the uploaded data, literature, and metadata created by the editor. This role is restricted to the package user only and each package user will have access to their relevant package data only.
Publisher	The publisher role has the all permissions of editor and reviewer; in addition, the publisher can approve any data/metadata, or documents to be published on the WISDM portal.
Administrator	The administrator role has all of the reviewer/editor/publisher permissions, as well as the ability to create new users and assign them roles.

To assign data access permissions, and to avoid confusion, all users are divided into different groups. Each group is assigned with a set of predefined permissions.

Table 2 - Description of user groups

ROLE	DESCRIPTION
Normal user	All users under this group can only access metadata and download public domain data.
Authenticated user	All users under this group have the privileges of normal user but have to register, provide personal information, and agree to license/terms of use to download the data with restricted access
Package User	This group is based on the users under the SOBA packages and has all of the privileges of a normal user, with limited access to data uploaded by their package only.
PMU user	The PMU user is a specialized group, and can access all available data on the WISDM portal.
Administrators	This group has access to all data on the portal and can create new user and assign users to different groups

2.5   Functional requirements and solutions

Table 3 - Functional requirements and provided solutions

S. NO.	REQUIREMENT	RATIONALE	SOLUTION CAPABILITY
1	Only authorized clients can log-in to the system.	This solution ensures that only authenticated clients can log-in to the system.	An authentication system based on roles and user groups has been implemented.
2	Initially, only package user can upload the data.	Before launch WISDM remains internal to SOBA.	Only authenticated packages users are permitted to upload the data.
3	Full access to the knowledge base of documents.	This ensures that all of the documents in the knowledge-base are available to the package clients	Access to documents under knowledgebase is kept open for the package clients.
4	The WISDM portal shall remain internal to SOBA until officially published/launched.	This ensures that access to the sensitive data is controlled.	Aside from the home page, access to all other modules is restricted. Only authorized package and PMU clients will be able to get access.
5	Limited authorizations for each package.	To limit the access of the package user to their relevant data.	Only two sets of credentials have been issued to each package.
6	Read access to the datasets listing and metadata.	Restricted access to the data.	Authorized package users can only access the metadata.
7	Package users can upload data.	To facilitate data submission, package users are allowed to upload data to the WISDM.	The authentication system allows the package users to upload the data through the WISDM system.
8	All data uploads to be checked and verified.	To ensure quality and relevance of the uploaded data before making it available through WSIDM .	A data submission workflow has been implemented to ensure quality content shared through WISDM.
9	This solution shall provide download access to the data uploaded by the package only.	This ensures the data sharing among packages through PMU only.	Download access to data is restricted to the relevant data uploaded by that package.
10	The solution shall provide viewing capability to the spatial data but no downloads.	This will ensure that the client knows about the available spatial data and access requests.	The download access to all spatial data is disabled.
11	Organize data in specific categories.	Data should be arranged in related categories for the ease of searching, and viewing.	Category and sub category hierarchical arrangement of data has been implemented for all content viewing and uploading.
12	Provide simple text search on metadata.	This allows the clients to search for specific data or documents.	A full text search mechanism has been implemented to carry out searches for specific document data.
13	Provide options to refine search results.	This will ensure that the client finds the required data/documents.	The advance search module has been implemented to support the clients search using metadata.

2.6   Non-Functional Requirements

Performance requirements:

The WISDM portal will be used as the main platform to manage the whole database of water related data and information in the AIRBM project and relevant government organizations. Therefore, the WISDM database must perform all the functional requirements specified.

Safety requirements:

The database may crash from time to time as a result of a computer virus or operating system failures. Therefore, the WISDM managers must ensure that regular backups of the database are made. Daily backups are recommended to ensure minimal loss of work, enabling rapid reinstatement of full functionality after a software system failure.

Security requirements:

The WISDM database has secure access. WISDM recognizes multiple categories of user groups, namely: administrators, publishers, reviewers, editors and users. These users can view all or some specific information from the database; depending on the user rights of the user group. For example, administrator level users are able to modify the data, including editing, appending, and/or deleting records. Similarly, the administrator has the privilege to add or remove users and to define their access rights. All other users only have rights to retrieve, view and download the information, where permitted, from WISDM.

2.7   User Interface

The heart of interface design is hiding complexity. Each additional step from the home page to the desired piece of information will progressively dissuade users from browsing. A good interface provides simple paths to go through in order to get where a user wants.

A simple and visible search box is a perennial interface element that is recognized by the majority of users; for many of them, the search box is the default way of browsing. Therefore, it is important to make it visible and accessible on the homepage as well as in all of the website's individual pages.

Considering this, the search box has been placed in the centre of the homepage and is a point where the user can start interacting with the portal. Similarly, other resources/modules i.e., Datasets, Document-Hub, and Mapping Portal, have been given prominent visibility on the homepage, just below the search box. If a user is interested in any one of the particular categories can start interacting with it.

2.8   Main Modules of the Portal

The WISDM data portal provides advanced features for searching, visualizing and reporting data about the Ayeyarwady Basin. The portal's functionality works entirely in a web browser such a Microsoft Internet Explorer or Google Chrome. A separate user guide describes the portal's features in detail and provides step-by-step instructions for using the various functions. The portal contains the following main sections:

Home Page - Welcome message and access to search, Datasets, Document-Hub and Map-Portal.

Datasets - A module providing access to list and search water related datasets.

Document-Hub - A knowledgebase of articles, reports, presentations and info-graphics with search facility.

Mapping-Portal - Visualization of spatial data

Login - Login facility for user access to upload and/or download data or knowledgebase entities (depending on the access rights).

2.8.1   Home page

The homepage is the most important part of any website or data portal, providing the user easy access to their desired content. However, it is impossible to predict where the user want to start for every user/visitor of the portal. New visitors or returning leads might want to know the story behind the portal, while others will head straight to search for specific data or documents, or map visualization. That is why navigation bar, search, and multiple in and outbound links are utilized on the home page, so that all visitors can have easy access to any content they might want.

The top section of the home page provides the information about why this portal was developed and who owns it. Further details can be accessed on the linked page. This is for the first time visitors or anyone who wants to get more detail on the story behind the portal.
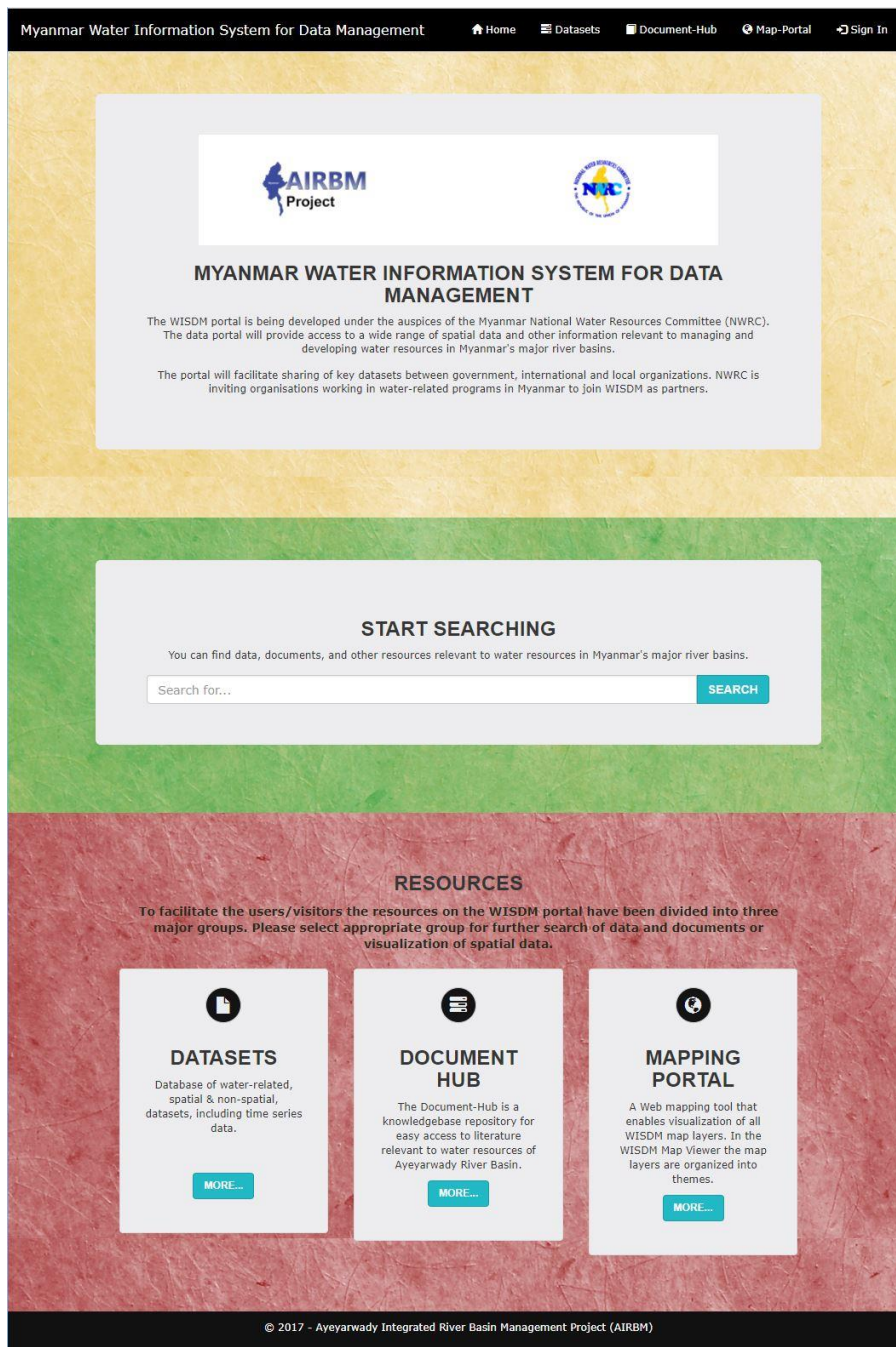
Figure 1: WISDM home page

Immediately after the introduction, the search box is placed prominently to facilitate returning visitors interested in searching for specific data, documents or maps.

The resources section provides links to the Datasets, Document-Hub, and Mapping Portal and gives a brief definition of what visitors can find in the linked pages.

The logos are linked with the relevant websites i.e., AIRBM logo is hyperlinked with the project website (http://www.airbm.org/) whereas the National Water Resources Committee (NWRC) logo is hyperlinked with its page under the AIRBM website (http://www.airbm.org/nwrc-2/). These links will provide ready access to the visitors if they want to know more about the AIRBM Project or NWRC.

2.8.2   Datasets

The Datasets module has been developed to provide access to the water-related spatial and non-spatial datasets, including time series data. An authorized user can access and search the database for which s/he is authorized, and view the metadata. However, at completion of the project no data is available to download. Future administrators can redefine the access levels and make the data downloadable.
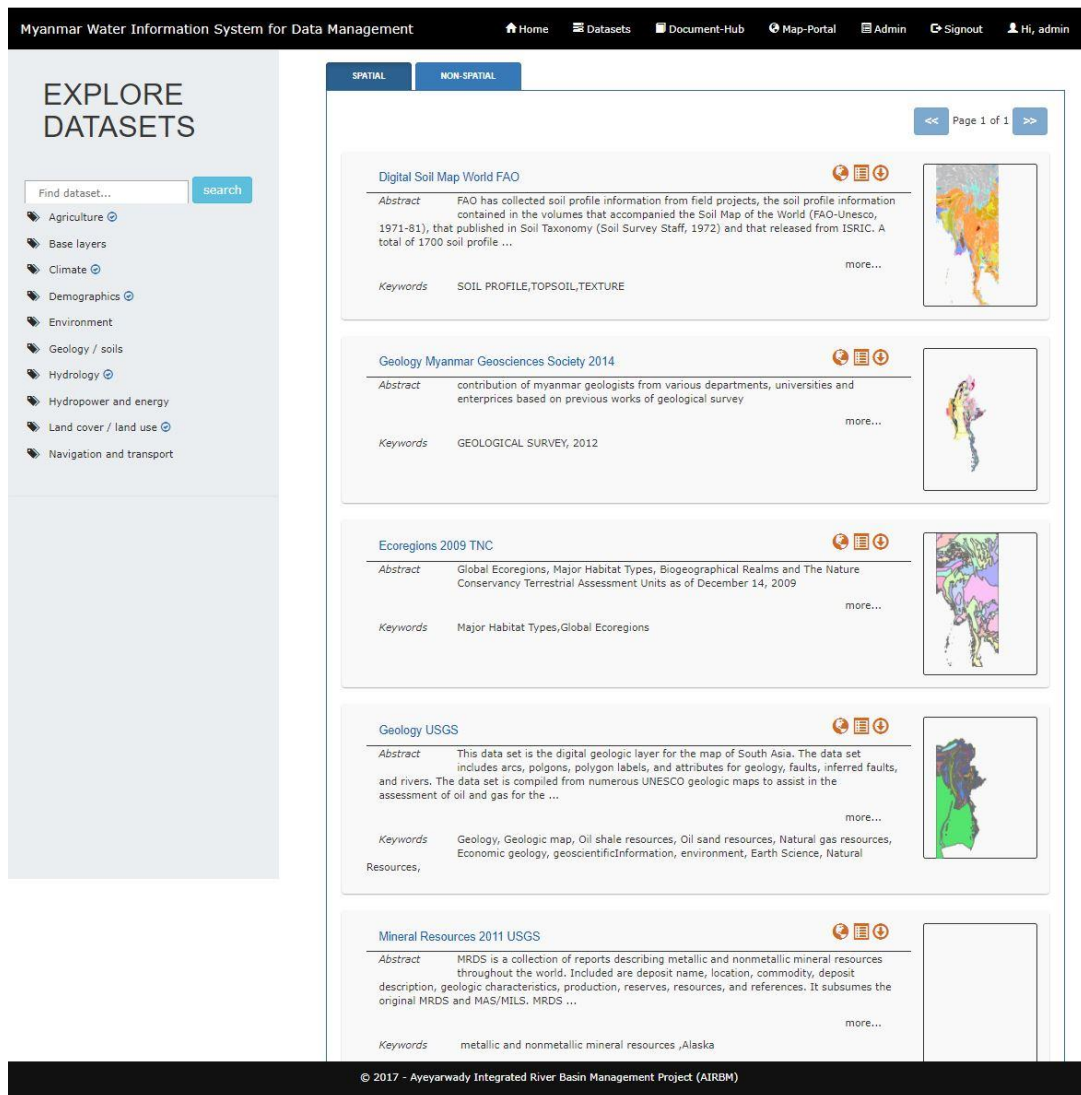
Figure 2: Data search results

2.8.3   Document-Hub

The Document-Hub is a knowledgebase repository for easy access to literature relevant to the water resources of Ayeyarwady Basin. It facilitates information collection, organization and retrieval supported by a search facility. It provides a one-stop access to this information and can save time and resources by decreasing the amount of time spent in searching for the required information. It is not a static collection of information, but a dynamic resource, which can develop as the project evolves.
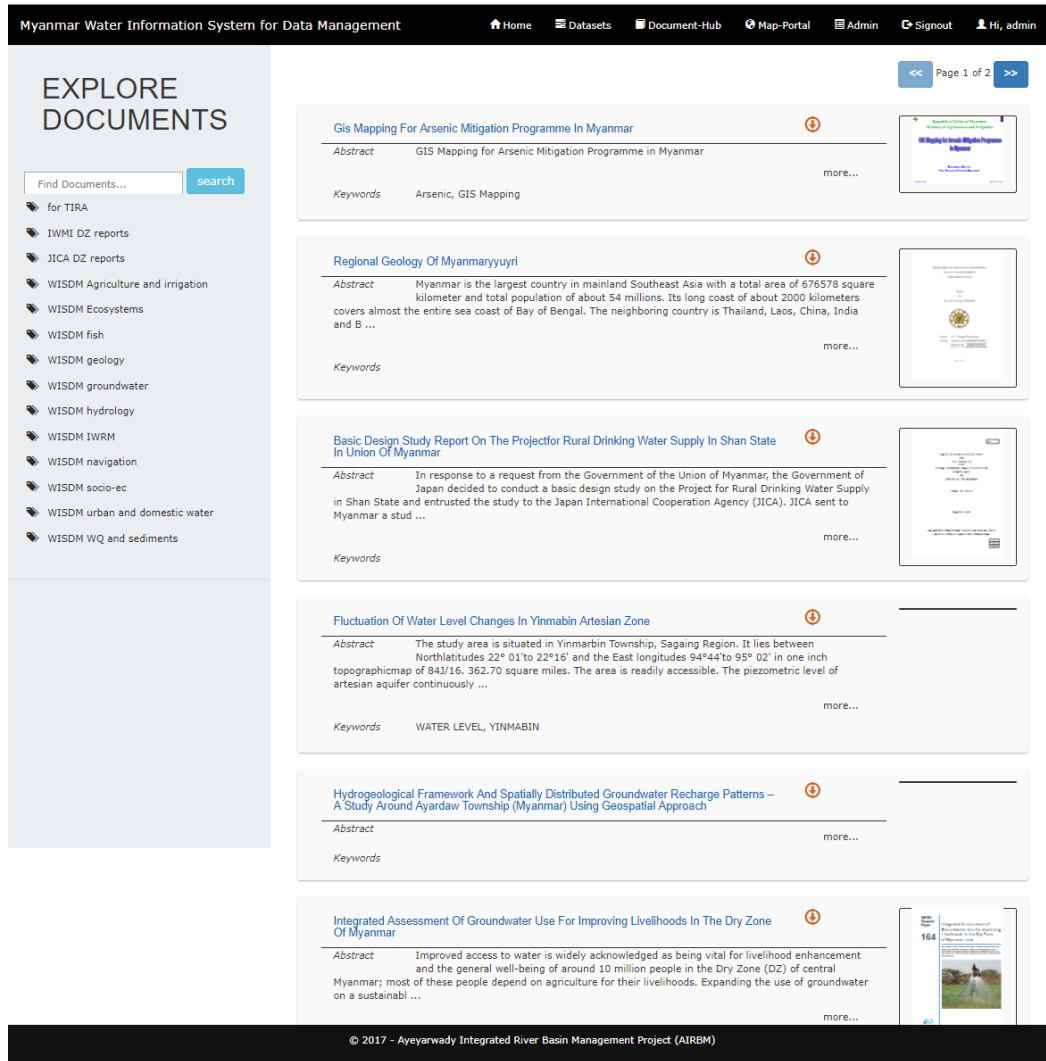
Figure 3: Document search results

2.8.4   Mapping-Portal

The Mapping Portal is a Web mapping tool that enables visualization of all WISDM spatial layers. In the WISDM Map Viewer, the map layers are initially organized into 14 interdisciplinary topics (categories), which users can select. Users can also zoom into a region of interest using a selection list, in addition to standard pan and zoom functions. The map viewer enables users to visualize data and map layers related to Socioeconomic, Infrastructure, Natural Disasters, and Environment. Users can overlay and visualize a subset of WISDM spatial layers in conjunction with satellite images.
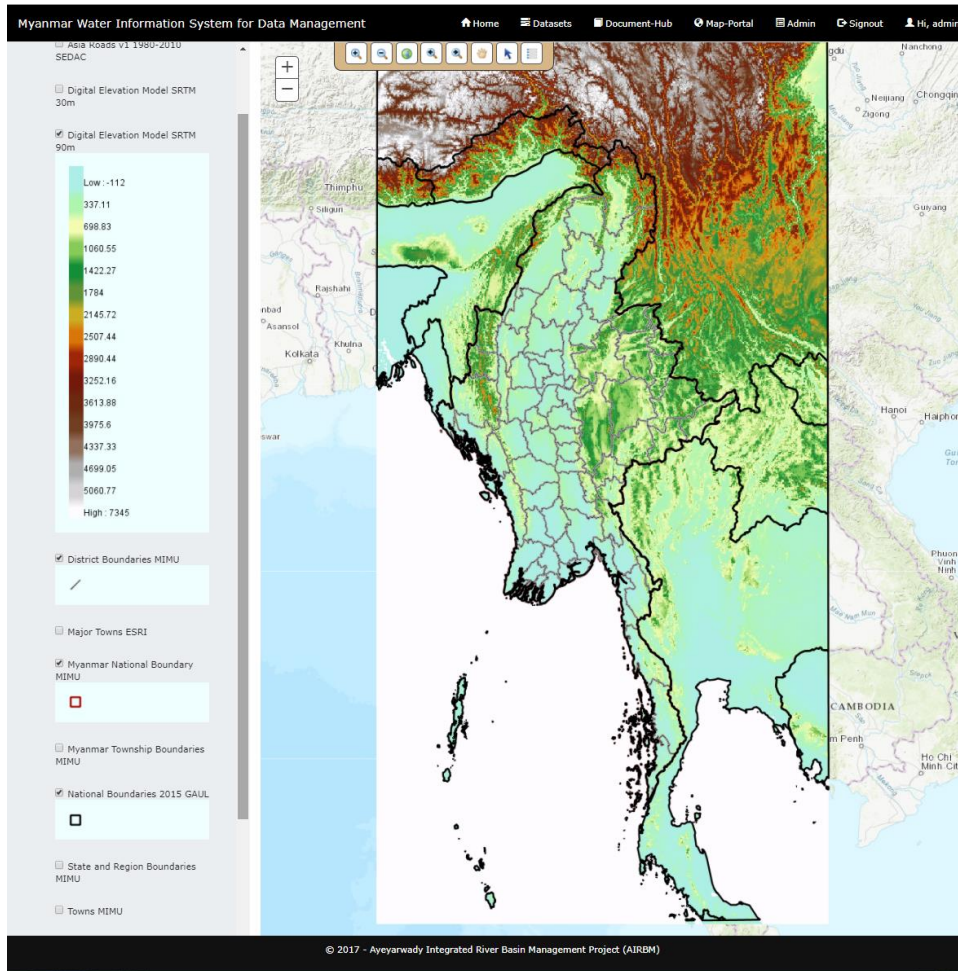
Figure 4: Mapping portal

The map visualization interface has been developed using Angular 2 and REST services from PostgreSQL database. Whereas the relevant and subsequent Web Map Services (WMS) are published through an open source GeoServer.

2.9   Data Submission Workflow

The WISDM portal has been designed with functionality to enable users to upload and download data, depending on the access rights granted by the administrator.

However, although users can upload time series, or spatial data, and knowledgebase articles all data elements must go through the WISDM Data Submission workflow (Figure 5) before being published through the WISDM portal. This workflow has been specifically designed to check the relevance of the uploaded contents and ensure quality control.

As content is uploaded, it goes through an editorial workflow managed by trusted roles. There are three roles in the workflow with specific permissions: editor, reviewer, and publisher/administrator. The reviewer and administrator are informed of submissions for review or approval through an email.
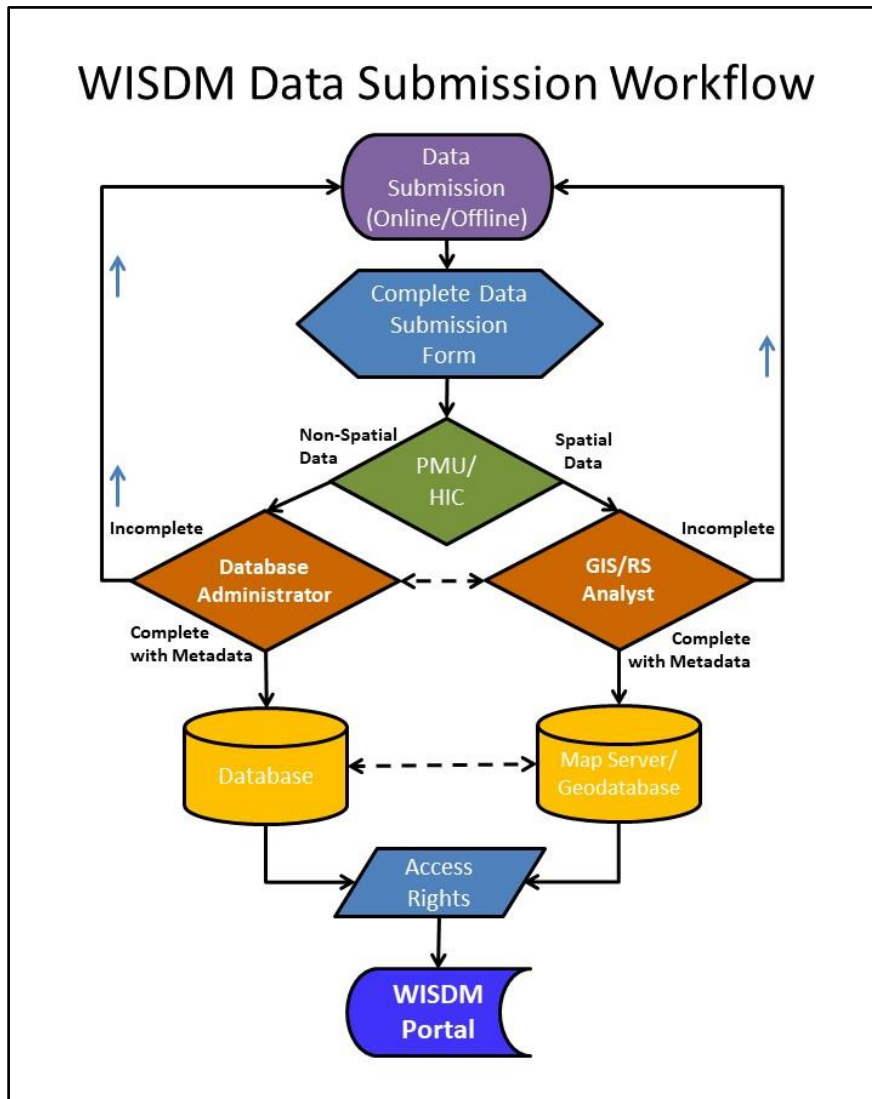
Figure 5: WISDM Data Submission Workflow

Reviewer users ensure that data uploaded to the site does not have any sensitive or private information included within it. They also check whether the file format is listed correctly, and that it is associated with the correct access level. Lastly, the reviewer surveys the metadata associated with the content to ensure accuracy and completeness. The reviewer will check the following before allowing the submitted content in to the database and/or publishing the data entity:

- Relevance of the item;
- Completeness of the metadata;
- Quality/completeness of the data

 Once the content is reviewed and approved for publishing, the Publisher (usually a member of the PMU user group) and the administrator will be notified to approve the content to be published.

2.10   Use Cases:

Create new category

USE CASE NAME	CREATE NEW CATEGORY
Use Case Description	Create category/ taxonomy for datasets and documents, These categories will be used in dataset displays, spatial data display in the mapping portal etc.
Actor	Administrator, Editor, Reviewer, Publisher
Pre-condition	User must be logged in to the system and should have one of following roles assigned: Administrator, Editor, Reviewer, Publisher
Basic Flow	1. User navigates to **admin** tab 2. User selects **content** and **category** tab 3. User selects **add new category** 4. User fills in , • Category name • Category description • Category type • Parent category 5. User **save** new category
Alternative Flows	1. User **cancel** adding new category 2. User **save** incomplete category form
Post Condition	Category has been created as a draft version

Create new dataset

USE CASE NAME	CREATE NEW DATASET
Use case description	Creates new dataset, metadata and submit archive for review; once reviewed, dataset can be published on the WISDM.
Actor	Administrator, Editor, Reviewer, Publisher
Pre-condition	User must be logged in to the system and should have one of following roles assigned: Administrator, Content Editor, Content Reviewer, Publisher
Basic flow	1. User navigates to **admin** tab 2. User selects **content** and **datasets** tab 3. Users selects **add new dataset** 4. User fills in , • Dataset title • Abstract • Keywords • Category 5. User navigate to next step. 6. User fills in metadata • Create date • Revision date • Publish date • Begin date • End date • Data source URL • Metadata author • Metadata author's organization 7. User navigates to next step 8. User fills in contact details for the dataset • Organization name • Voice • Country

18

	• Email • Contact type 9. User navigate to next step 10. User uploads the data archive
Alternative flows	1. User navigates to next steps without completing the data forms 2. User **cancels** new dataset creation
Post condition	New dataset has been created as a draft version

Create new document

USE CASE NAME	CREATE NEW DOCUMENT
Use case description	Creates new document, metadata and submit document for review; once reviewed, document can be published on the WISDM.
Actor	Administrator, Editor, Reviewer, Publisher
Pre-condition	User must be logged in to the system and should have one of following roles assigned. Administrator, Editor, Reviewer or Publisher.

Basic flow	1. User navigates to **admin** tab.
	2. User selects **content** and **document** tab.
	3. User selects **add new document.**
	4. User fills in:-,
	    • Title
	    • Abstract
	    • Keywords
	    • Category
	5. User navigate to next step
	6. User uploads the data archive

Alternative flows	1. User navigates to next steps without completing the data forms 2. User **cancels** new document creation
Post condition	Document has been created as a draft version

View Datasets - Spatial

USE CASE NAME	VIEW DATASET - SPATIAL
Use case description	View dataset - spatial based on user permission
Actor	Authenticated user, Public user , Administrator, Editor, Reviewer, Publisher
Pre-condition	Published dataset
Basic flow	1. User logs in to the WISDM. 2. User navigates to datasets in top menu bar. 3. User selects a category from the list of categories in the left-hand panel and spatial tab. 4. List of Datasets are displayed based on the category selected. Single dataset display will have a dataset title, abstract, keywords, and image preview. 5. User clicks on the **dataset title** or the display metadata icon to show the metadata of the dataset. 6. User clicks on the **view dataset** on map option to visualize spatial data on the map. 7. User clicks on **download dataset** option to download data in different formats.
Alternative flows	See data search – text search
Post Condition	None

View datasets – non spatial

USE CASE NAME	VIEW DATASET – NON SPATIAL
Use case description	View dataset – non spatial based on user permission
Actor	Authenticated user, Public user, Administrator, Editor, Reviewer, Publisher
Pre-condition	Published dataset
Basic flow	1. User logs in to the WISDM. 2. User navigates to datasets in top menu bar. 3. User selects a **category** from the list of categories in the left-hand panel and **non-spatial tab**. 4. List of non-spatial datasets are displayed based on the category selected. Single dataset display will have a dataset title, abstract, & keywords. 5. User clicks on the **dataset title** or the **display metadata** icon to show the metadata of the dataset. 6. User clicks on **download dataset** option to download data in different formats.
Alternative flows	See data search – text search
Post condition	None

View documents

USE CASE NAME	VIEW DOCUMENTS
Use case description	View documents based on user permission
Actor	Authenticated user, Public user , Administrator, Editor, Reviewer, Publisher
Pre-condition	Published document
Basic flow	1. User logs in to the WISDM. 2. User navigates to **document-Hub** in top menu bar. 3. User selects a **category** from the list of categories in the left-hand panel. 4. List of documents are displayed based on the category selected. Single dataset display will have a document title, abstract, keywords and preview image of the PDF document. 5. User clicks on the **document title** or the **display metadata** icon to show the metadata of the dataset. 6. User clicks on **download document** option to download related document.
Alternative flows	See data search – text search
Post condition	None

View mapping portal

USE CASE NAME	VIEW MAPPING PORTAL
Use case description	View spatial data based on user permission.
Actor	Authenticated user, Public user, Administrator, Editor, Reviewer, Publisher
Pre-condition	• Published spatial data. • Data needs to be published on the Geo-server and valid WMS URL should be linked to the spatial-data set.
Basic flow	1. User logs in to the WISDM. 2. User navigates to **map portal** in top menu bar. 3. User expands the **categories** in tree control to view spatial data sets. 4. User selects **check box** from spatial-data tree view control to add it to map view.

20

	5. Legend key displayed under selected node of the spatial data tree control
Alternative flows	None
Post condition	None

Data search – text search

USE CASE NAME	TEXT -SEARCH
Use case description	Text search to find different data types in WISDM Search term is searched in title, abstract, keywords columns in the database.
Actor	Authenticated user, Public user, Administrator, Editor, Reviewer, Publisher
Pre-condition	None
Basic flow	1. User navigates to home page. 2. User enters a search term in the **search box**. 3. User navigates to search result page. 4. List of spatial data, non-spatial data, documents, pictures and maps open to public and matching the search criteria is displayed in different tabs. 5. Single spatial, non-spatial, and document data are displayed in the same way as in the dataset, document-hub viewer pages. Pictures and maps are displayed as image gallery. User clicks on the **preview image** to open full view
Alternative flows	None
Post condition	Only public domain content is displayed

Data search – advanced search

USE CASE NAME	ADVANCED -SEARCH
Use case description	Advanced search to refine search results in WISDM Search term is searched in title, abstract, keywords columns in the database separately.
Actor	Authenticated user, Public user, Administrator, Editor, Reviewer, Publisher
Pre-condition	1.
Basic flow	1. User navigates to search result page. 2. User opens the **advanced search** panel from the left side bar. 3. User enters search term in the title and/or abstract and/or keywords text boxes to run the search. 4. List of spatial data, non-spatial data, and documents, pictures and maps matching search criteria is displayed in different tabs. 5. Single spatial, non-spatial, document data are displayed in the same way as in the dataset, document-hub viewer pages. Pictures and maps are displayed as image gallery. User clicks on the **preview image** to open full view.
Alternative flows	None
Post condition	None

3 WISDM TECHNICAL SPECIFICATIONS

3.1   System Architecture

The WISDM is a system in which major part is comprised of data, including spatial and non-spatial data and the associated metadata for each data entity or element. The user selects one of the available predefined options or search as the input to the system to find data. Based on to the input selected, the system performs the functions. The administrator can operate any part of the system and can access any data. Other user roles can only access the parts they have been authorized to access by the administrator.

WISDM enables metadata sharing, including visualizing metadata, over a web map. Users can login to the system from any part of the world with an active internet connection to their computers, (Figure 6).
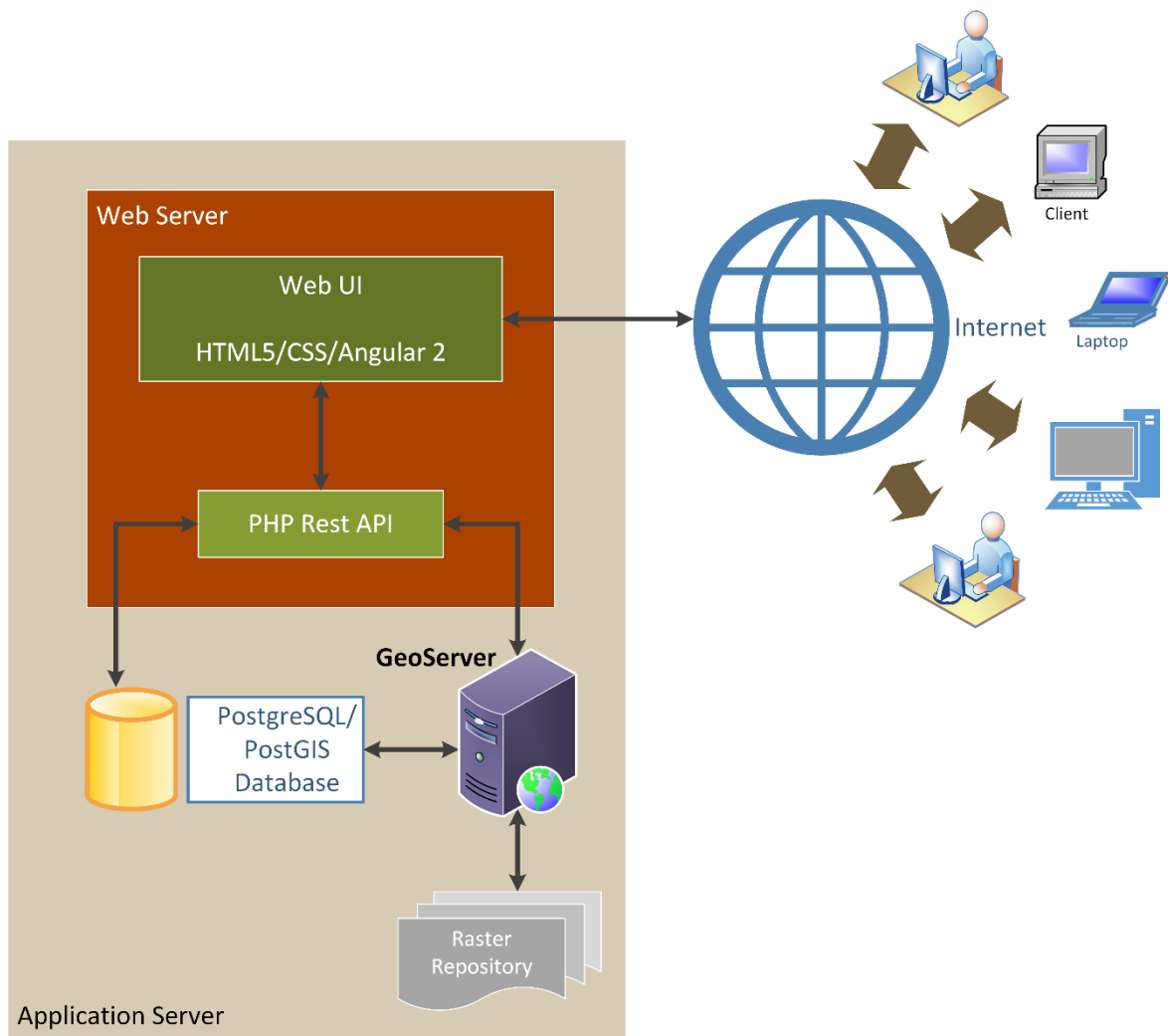
Figure 6: System architecture diagram

3.2   Relational Schemas of WISDM

An identified set of relational schemas are used to build the WISDM database. The identification of relational schemas are explained by the schemas below. The schema name is highlighted and its primary key is underlined, while other associated field names are separated by a comma and included within brackets. The foreign key references of each scheme are underlined by a dotted line. Each foreign key was defined in an above schema before it was referred.

category   (category_id, category_type_id, category, category_description, parent_id)

sub_category   (sub_category_id, category_id, sub_category, sub_category_description)

metadata_base   (metadata_id, dataset_title, data_type_id, creation_date, revision_date, publication_date, data_duration_bigin, data_duration_end, abstract, data_source_url, keywords, language, specification, explanation, pass boolean, metadata_author_individual, metadata_author_organization, file_path, file_name, thumbnail_name, parent_metadata_id)

metadata_category   (metadata_category_id, metadata_id, category_id)

metadata_sub_category   (metadata_category_id, metadata_id, sub_category_id)

contact_type   (contact_type_id, contact_type, description)

metadata_contact   (contact_id, metadata_id, organization_name, voice, country, email, contact_type_id)

format   (format_id, format, description)

metadata_format   (metadata_format_id, format_id, metadata_id)

metadata_log   (id, system_name, url, date_created, metadata_id)

geographic_coverage_type (coverage_type_id, coverage_type, coverage_type_description)

geographic_coverage   (geographic_coverage_id, goegraphic_coverage, geom, geographic_coverage_type_id)

metadata_geograpchic_coverage (metadata_geograpchic_coverage_id, metadata_id, geographic_coverage_id)

system_functions   (function_id, function_name, function_description)

role   (role_id, role_name, role_description, content_tab, user_tab, permission_tab)

system_functions_role   (function_role_id, role_id, function_id)

user_groups   (usergroup_id, usergroup_name, usergroup_desrciption)

system_user   (user_id, user_name, user_group_id, userpassword)

system_user_role   (user_role_id, user_id, role_id)

matadata_user_role   (matadata_user_role_id, user_role_id, metadata_id)

3.3   Entity Relationship Diagram

The conceptual data model of the system is shown in Figure 7. The figure shows the relationships of various data tables in the system. The table name is highlighted on top and associated field names are displayed as they are configured in the PostgreSQL database. The primary keys of the entities are marked by a key sign and relations are shown by an arrow displaying the foreign key ID on the arrow nock.
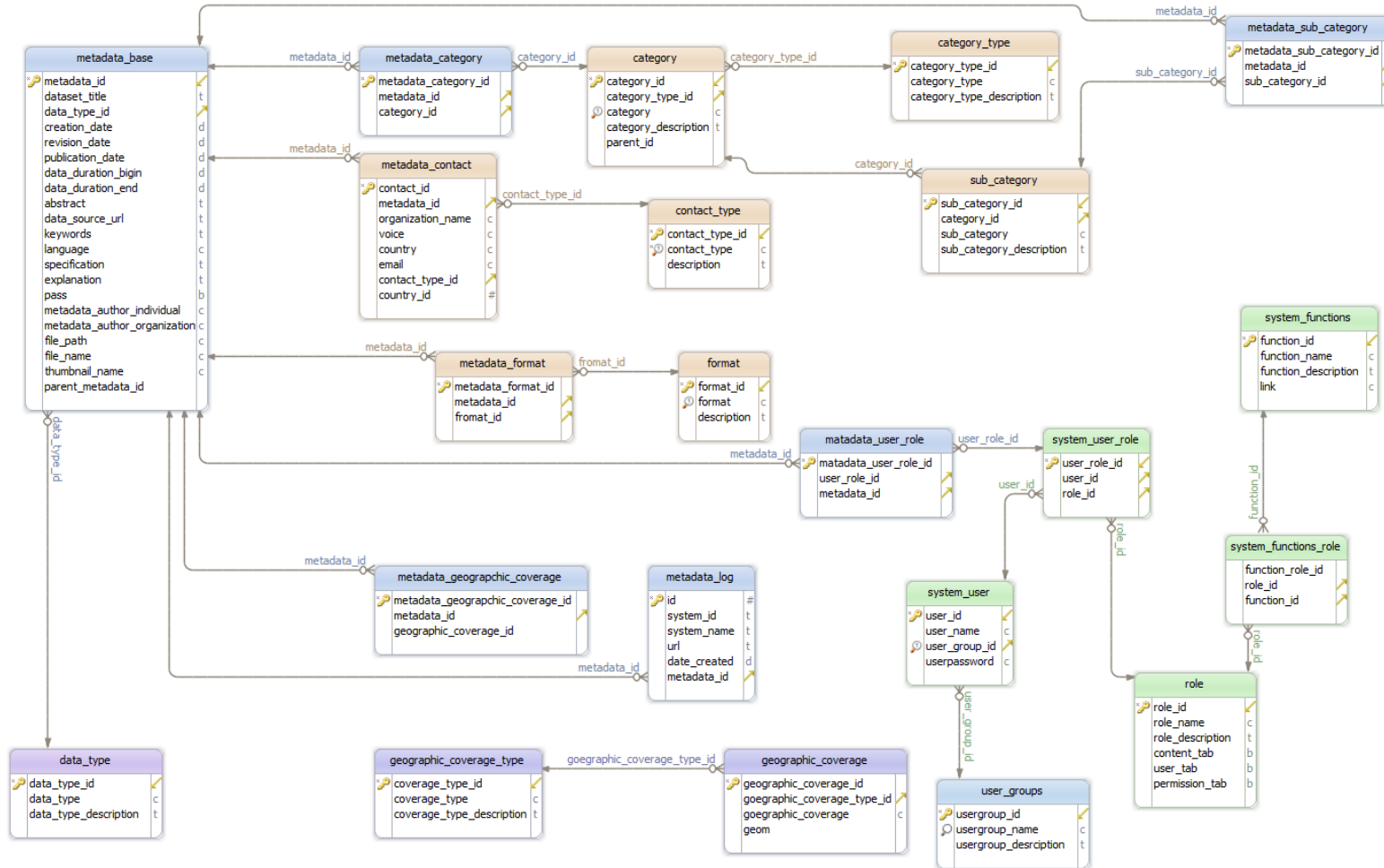
Figure 7 - Entity Relationship Diagram

3.4   User Authorization Process

Error! Reference source not found. shows the assignment of roles and permissions to the various user groups as described in Section 2.4.
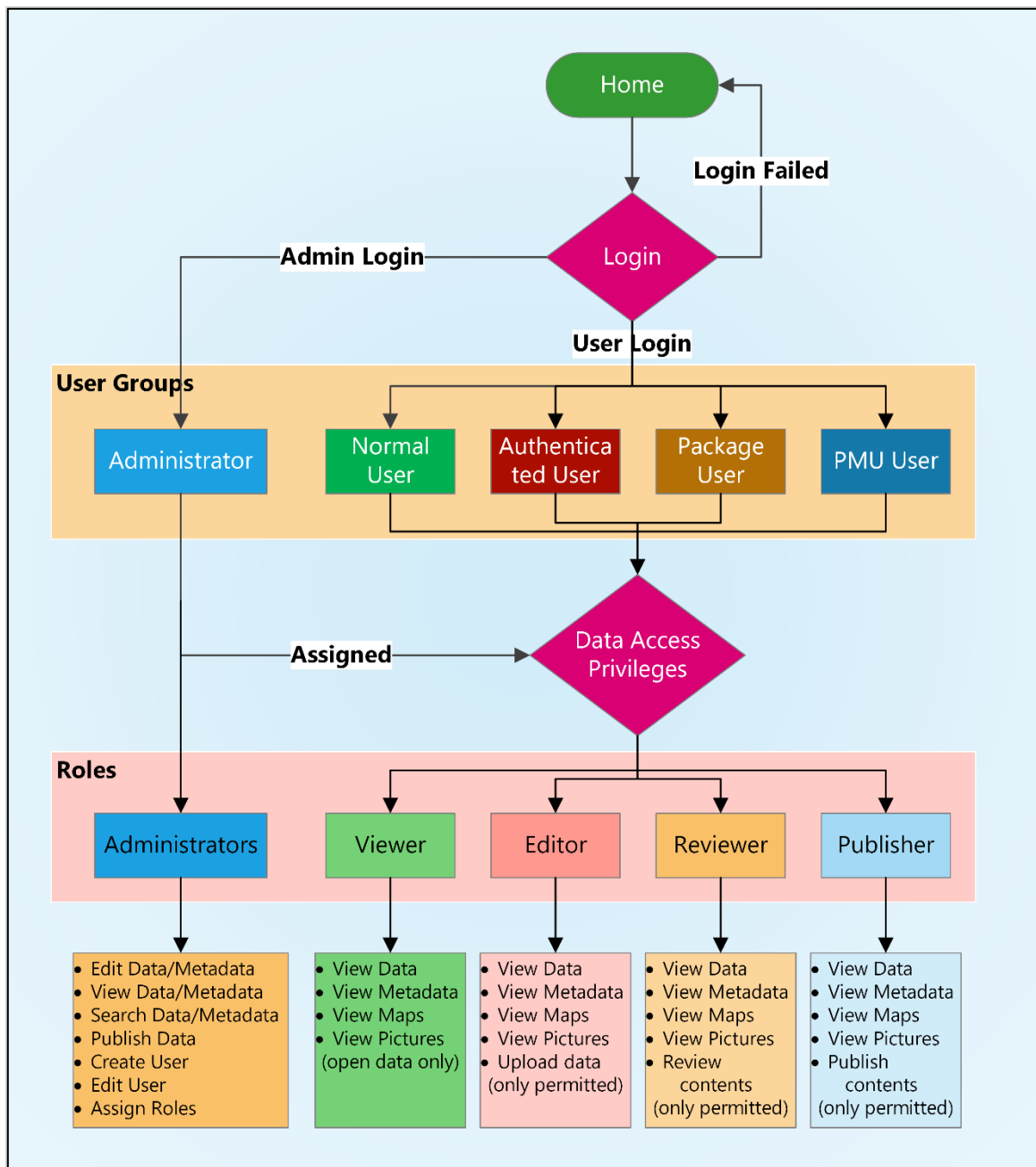
Figure 8 - User authorization flow

3.5   Technology Overview

 Open source application development tools have been used for all the following components of the WISDM:

Technologies used

- •   Front end: HTML 5, Java and Angular 2
- •   Web designing language: PHP
- •   Relational database management systems (RDBMS) (back end): PostgreSQL/PostGIS

25

Software requirements:

- PHP
- Apache Server
- GeoServer
- Microsoft Windows

Hardware requirements:

An application server has to be set up for hosting the system. The basic specifications for the application server are given in Table 1. There are two options for system hosting and the system can be setup in either of the servers provided.

- An existing or new web server or
- A VM set up in a cloud server.

Table 4 – Hardware Requirements

ITEM	COMBINED WEB & DATABASE SERVER (MINIMAL)	COMBINED WEB & DATABASE SERVER (RECOMMENDED)
Processor	2 x 1.6 GHz CPU	4 x 1.6 GHz CPU
RAM	3.5 GB RAM	7 GB RAM
HDD	1 x 40 GB of free space or more is recommended for the system excluding OS and data	1x 40 GB of free space or more is recommended for the system excluding OS and data

Server components:

- PHP is used as the programming language for server side data processing.
- Service oriented architecture (JSON Rest services) used for data communication.
- Apache server is used as the web server.

Data storing:

- PostgreSQL database is used as data repository.
- PostGIS extension is used for geographical data storing.
- WMSs are published on GeoServer.
- A separate file repository is maintained for raster data.

Client components:

- Angular 2 is used for web user interface along with HTML5 and CSS.
- JQuery and Java scripting libraries are used at relevant levels of data presenting.
- Access done through http requests using any web browser.

3.5.1 PHP

PHP is a general-purpose scripting language that is especially suited to server-side web development. PHP code is embedded into the HTML source document. Any PHP code in a requested file is executed by the PHP runtime, usually to create dynamic web page content. It can also be used for command-line scripting and client-side GUI applications. PHP can be deployed on many web servers and operating systems, and can be used with many RDBMS. It is available free of charge, and the PHP group provides the complete source code for users to build, customize and extend for their own use. The WISDM REST API is written in PHP 5.3.13 and uses a 'Slim' micro framework (https://www.slimframework.com/).

3.5.2   Service Oriented Architecture

WISDM follows Service Oriented Architecture, which is an evolution of distributed computing based on the request/reply design paradigm for synchronous and asynchronous applications. An application's business logic or individual functions are modularized and presented as services for consumer/client applications. What is key to these services is their loosely coupled nature; i.e., the service interface is independent of the implementation. Application developers or system integrators can build applications by composing one or more services without knowing the details of the services that underpin the implementations.

3.5.3   Apache Server

Apache is a freely available web server distributed under an 'open source' license that can be accessed at https://httpd.apache.org/download.cgi. Apache Web Server is designed to create web servers that have the ability to host one or more http-based websites. Notable features include the ability to support multiple programming languages, server-side scripting, an authentication mechanism and database support. The WISDM portal has been tested and is compatible with Apache version 2.2.22 and the latest version Apache version 2.4.27.

3.5.4   PostgreSQL

PostgreSQL is a powerful, open source, object-relational database system or simply a relational database management system (RDBMS), developed by a worldwide team of volunteers. Being open-source and robust, PostgreSQL was selected to manage the database behind the WISDM portal. The database has been developed using PostgreSQL 9.5 and is compatible with the latest version PostgreSQL 9.6.

3.5.5   PostGIS

PostGIS is a spatial database extender for PostgreSQL object-relational database. It adds support for geographic objects allowing location queries to be run in SQL. PostGIS extends capabilities of PostgreSQL to increase its data management capabilities by adding geospatial types and functions to enhance spatial data handling within a relational database structure. PostGIS is an Open Geospatial Consortium compliant software. PostGIS version 2.2 for PostgreSQL 9.5 has been used in the development of the WISDM portal.

3.5.6   GeoServer

GeoServer is a powerful map and feature server for sharing, analyzing, and editing geospatial data from spatial data sources using open standards. GeoServer is open source software, released under the GNU General Public License, that implements many Open Geospatial Consortium standards including WMS (1.1.1, 1.3.0), Web Feature Service (WFS & WFS-T 1.0.0, 1.1.0, 2.0), Web Coverage Service (WCS 1.0.0, 1.1.1), and Web Processing Service (1.0.0). GeoServer 2.11.1 has been used to provide WMS for the mapping portal of the WISDM.

3.5.7   Angular 2

Angular is an open-source development platform for creating applications using modern web standards developed by Google and a global community of individuals. Angular is a framework for building client applications in HTML and either JavaScript or a language like TypeScript that compiles to JavaScript. WISDM client applications are written as an Angular 2 CLI Application (https://cli.angular.io/).

4 DATA AND METADATA STANDARDS

It has been recognized that a major component of the cost of projects is the cost of acquiring, processing, and managing of data. To reduce the cost of data and its management for project operations, a strategy is to enable sharing data/information between different projects and across the components or packages within a specific project. Sharing spatial and time series databases requires mechanisms to enable understanding of the contents of each database that may be accessed. This critical need resulted in the development of metadata concepts.

Before the development of metadata standards, the descriptions of information at regional and/or national levels evolved in different ways and were often incompatible. The problem was that these various standards defined metadata elements in different and diverse ways. These incompatibilities were the motivation for the development of a global standard for data descriptions, such as the International Standardization Organization (ISO) Technical Committee 211 are often called the ISO 19100 family of standards. The ISO 19115 'Metadata' is probably the best-known standard of the ISO 19100 family.

The ISO 19115 International Standard defines an extensive set of metadata elements. Out of these elements, typically only a subset of the full number of elements is used. However, ISO 19115 recommends that a basic minimum number of metadata elements called core metadata elements be maintained for a dataset Taking this into consideration State of the Basin 2b:-WISDM Water Information System for Data Management has adopted metadata specifications from ISO 19115 based on project requirements and to be implemented using WISDM Platform (see Annex 1).

Metadata for the data hosted and shared through WISDM is mapped using the ISO Standard 19115 (http://www.iso.org/standard/26020.html). ISO Technical Committee 211 developed a suite of metadata standards that is rich enough for describing the relevant geospatial data and associated sensors and platforms. Use of ISO standards increases the interoperability and sharing of data.

Though this International Standard is applicable to digital data, its principles can be extended to many other forms of geographic data such as maps, charts, and textual documents as well as nongeographic data. (https://www.iso.org/standard/53798.html). Therefore, most of the elements of ISO minimum standard metadata for spatial data can be used to create metadata for non-spatial and survey data, as some fields related to spatial data, such as coordinate system and geographic extent, can be skipped.

4.1 Metadata Specifications for WISDM

ISO 19115 metadata is currently the best practice standard, which is being adopted by many international organizations including United Nations organizations and FAO GeoNetwork. This standard is being implemented by systems like the Digital Asia Network. There is a hope that most existing standards and development of future standards for geospatial metadata will converge through the ISO 19115.

The metadata profile used by the WISDM platform to describe the data and services is based on ISO 19115. This standard provides information related to the identification, spatial and temporal extent, quality, and distribution of a dataset. WISDM provides powerful metadata editing, searching and sharing functions as well as an embedded interactive web map viewer.

4.1.1 Metadata package and entity relationship

In this International Standard, metadata for data is presented in UML packages. Each package contains one or more entities (UML Classes), which can be specified (subclassed) or generalized (superclassed). Entities contain elements (UML class attributes) which identify the discrete units of metadata. Entities may be related to one or more other entities. Entities can be aggregated and repeated as necessary to meet:

1. the mandatory requirements stated in this International Standard; and
2. additional user requirements.

Figure 9 illustrates the layout of the packages.

28
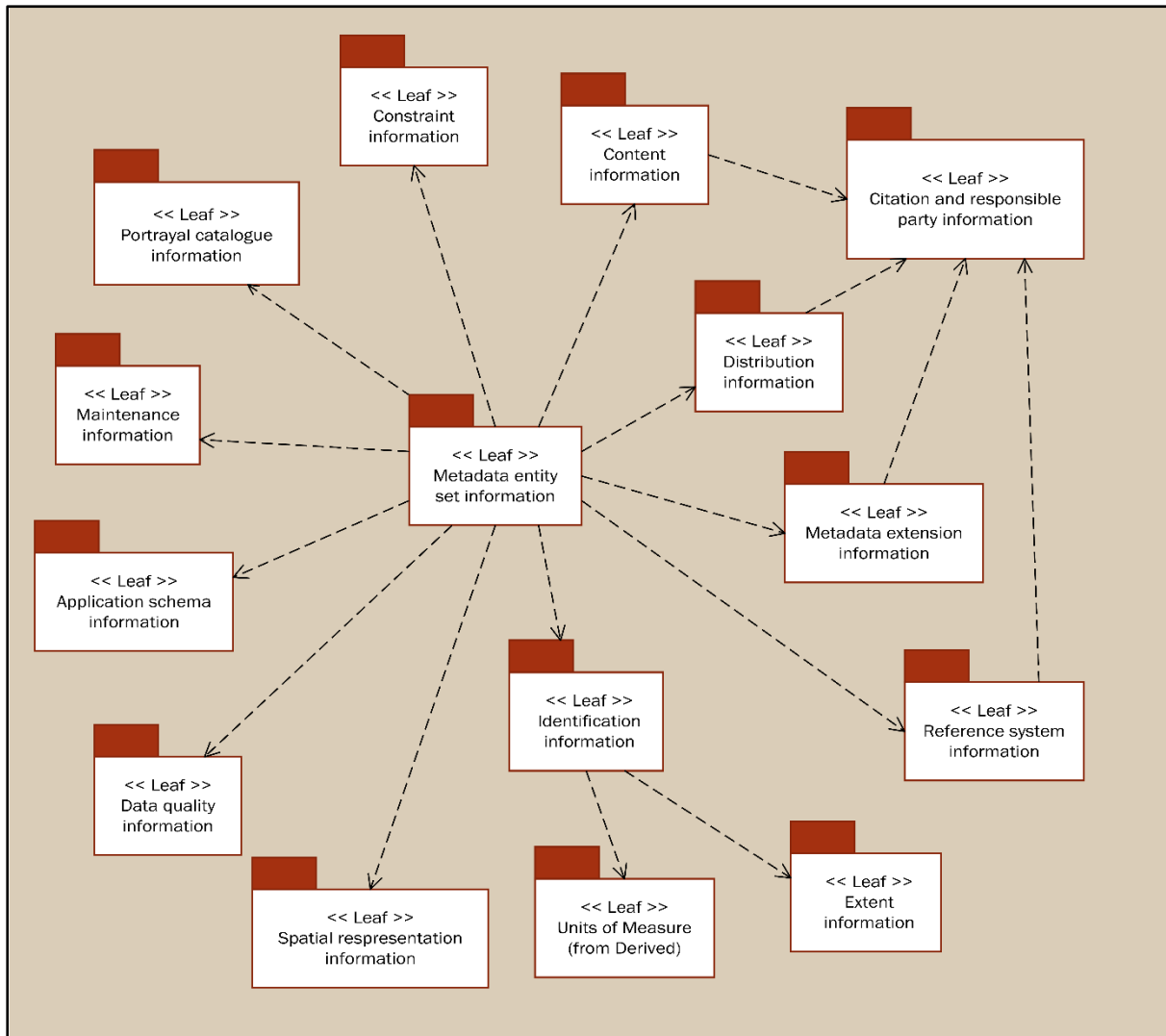
Figure 9 - UML package-diagram of ISO 19115 'metadata'

4.1.2   Package descriptions

4.1.2.1   Metadata entity set information (MD_Metadata)

Metadata entity set information consists of the entity (UML class) MD_Metadata, which is mandatory. The MD_Metadata entity contains both mandatory and optional metadata elements (UML attributes). The MD_Metadata entity is an aggregate of the following entities, which are further explained in the following subclauses:

- MD_Identification
- MD_Constraints
- DQ_DataQuality
- MD_MaintenanceInformation
- MD_SpatialRepresentation
- MD_ReferenceSystem
- MD_ContentInformation
- MD_PortrayalCatalogueReference
- MD_Distribution
- MD_MetadataExtensionInformation

- MD_ApplicationSchemaInformation

4.1.2.2 Identification information (MD_Identification)

Identification information contains information to uniquely identify the data. Identification information includes information about the citation for the resource, an abstract, the purpose, credit, the status and points of contact. The MD_Identification entity is mandatory. It contains mandatory, conditional, and optional elements. The MD_Identification entity may be specified (subclassed) as MD_DataIdentification when used to identify data and as MD_ServiceIdentification when used to identify a service. MD_ServiceIdentification provides a high-level description of a service, for further information see ISO 19119. MD_Identification is an aggregate of the following entities:

- MD_Format, format of the data
- MD_BrowseGraphic, graphic overview of the data
- MD_Usage, specific uses of the data
- MD_Constraints, constraints placed on the resource
- MD_Keywords, keywords describing the resource
- MD_MaintenanceInformation, how often the data is scheduled to be updated and the scope of the update
- MD_AggregateInformation, information about datasets that are aggregate parts of the dataset that the metadata describes

The extent element of MD_DataIdentification is conditional; either the EX_GeographicBoundingBox or the EX_GeographicDescription subclass of extent's geographicElement Role shall be included if the dataset is spatially referenced. If necessary, both may be used.

4.1.2.3 Constraint information (MD_Constraints)

This package contains information concerning the restrictions placed on data. The MD_Constraints entity is optional and may be specified as MD_LegalConstraints and/or MD_SecurityConstraints.

The otherConstraint element of MD_LegalConstraints shall be non-zero (used) only if access Constraints and/or useConstraints elements have a value of 'otherRestrictions', which is found in the MD_RestrictionCode codelist.

4.1.2.4 Data quality information (DQ_DataQuality)

This package contains a general assessment of the quality of the dataset. The DQ_DataQuality entity is optional and contains the scope of the quality assessment. DQ_DataQuality is an aggregate of LI_Lineage and DQ_Element. DQ_Element can be specified as DQ_Completeness, DQ_LogicalConsistency, DQ_PositionalAccuracy, DQ_ThematicAccuracy and DQ_TemporalAccuracy. Those five entities represent Elements of data quality and can be further subclassed to the sub-Elements of data quality.

This package also contains information about the sources and production processes used in producing a dataset. The LI_Lineage entity is optional and contains a statement about the lineage. LI_Lineage is an aggregate of LI_ProcessStep and LI_Source. Either the 'report' or 'lineage' roles of DQ_DataQuality must be present if DQ_DataQuality.scope.DQ_Scope.level has a value of 'dataset'.

- The 'levelDescription' element of DQ_Scope is mandatory if the 'level' element of DQ_Scope does not have a value of 'dataset' or ' series'.

- The 'statement' element of LI_Lineage is mandatory if DQ_DataQuality.scope.DQ_Scope.level has a value of 'dataset' or 'series' and the LI_Lineage roles of 'source' and 'processStep' are not documented.
- The 'source' role of LI_Lineage is mandatory if the 'statement' element and the 'processStep' role of LI_Lineage are not documented.

- The 'processStep' role of LI_Lineage is mandatory if the 'statement' element and the 'source' role of LI_Lineage are not documented.

- Either the 'description' or 'sourceExtent' element of LI_Source must be documented.

4.1.2.5   Maintenance information (MD_MaintenanceInformation)

This package contains information about the scope and frequency of updating data. The MD_MaintenanceInformation entity is optional and contains mandatory and optional metadata elements.

4.1.2.6   Spatial representation information (MD_SpatialRepresentation)

This package contains information concerning the mechanisms used to represent spatial information in a dataset. The MD_SpatialRepresentation entity is optional and can be specified as MD_GridSpatialRepresentation and MD_VectorSpatialRepresentation. Each of the specified entities contains mandatory and optional metadata elements. When further description is necessary, MD_GridSpatialRepresentation may be specified as MD_Georectified and/or MD_Georeferenceable.

4.1.2.7   Reference system information (MD_ReferenceSystem)

This package contains the identification of the spatial and temporal reference system(s) used in a dataset. MD_ReferenceSystem contains an element to identify the reference system used. MD_ReferenceSystem may be subclassed as MD_CRS, which is an aggregate of MD_ProjectionParameters and MD_EllipsoidParameters. MD_ProjectionParameters is an aggregate of MD_ObliqueLineAzimuth and MD_ObliqueLinePoint.

4.1.2.8   Content information (MD_ContentInformation)

This package contains information identifying the feature catalogue used (MD_FeatureCatalogueDescription) and/or information describing the content of a coverage dataset (MD_CoverageDescription). Both description entities are subclasses of the MD_ContentInformation entity. MD_CoverageDescription may be subclassed as MD_ImageDescription, and has an aggregate of MD_RangeDimension. MD_RangeDimension may additionally be subclassed as MD_Band.

1.1.1.1   Portrayal catalogue information (MD_PortrayalCatalogueReference)

This package contains information identifying the portrayal catalogue used. It consists of the optional entity MD_PortrayalCatalogueReference. This entity contains the mandatory element used to specify which portrayal catalogue is used by the dataset.

4.1.2.9   Distribution information (MD_Distribution)

This package contains information about the distributor of, and options for obtaining, a resource. It contains the optional MD_Distribution entity. MD_Distribution is an aggregate of the options for the digital distribution of a dataset (MD_DigitalTransferOptions), identification of the distributor (MD_Distributor) and the format of the distribution (MD_Format), which contains mandatory and optional elements. MD_DigitalTransferOptions contains the medium used for the distribution (MD_Medium) of a dataset, and is an aggregate ofMD_Distributor. MD_Distributor's other aggregate is the process for ordering a distribution (MD_StandardOrderProcess).

- The 'distributionFormat' role of MD_Distribution is mandatory if the 'distributorFormat' role of MD_Distributor is not documented.

- The 'distributorFormat' role of MD_Distributor is mandatory if the 'distributionFormat' role of MD_Distribution is not documented.

4.1.2.10   Metadata extension information (MD_MetadataExtensionInformation)

This package contains information about user specified extensions. It contains the optional MD_MetadataExtensionInformation entity. MD_MetadataExtensionInformation is an aggregate of information describing the extended metadata elements (MD_ExtendedElementInformation).

- If the 'dataType' element of MD_ExtendedElementInformation does not have a value of 'codelist', 'enumeration' or 'codelistElement'; then the 'obligation', 'maximumOccurence' and 'domainValue' elements are mandatory.

- If the 'dataType' element of MD_ExtendedElementInformation has a value of 'codelistElement', then the 'domainCode' element is mandatory.

- If the 'dataType' element of MD_ExtendedElementInformation does not have a value of 'codelistElement', then the 'shortName' element is mandatory.

- If the 'obligation' element of MD_ExtendedElementInformation has a value of 'conditional', then the 'condition' element is mandatory.

4.1.2.11   Application schema information (MD_ApplicationSchemaInformation)

This package contains information about the application schema used to build a dataset. It contains the optional entity MD_ApplicationSchemaInformation. The entity contains mandatory and optional elements.

4.1.3   Core metadata for datasets

ISO specifies an extensive set of metadata elements. However, a basic minimum number of metadata elements are required for describing a dataset. Listed below are the core metadata elements required to identify a dataset, typically for catalogue purposes. This list contains metadata elements that answer the following questions:

- 'Does a dataset on a specific topic exist ('what')?'
- 'Does a dataset for a specific place exist ('where')?'
- 'Does a dataset for a specific date or period exist ('when')?' and
- 'Who is the point of contact to learn more about or order the dataset ('who')?'

Using the recommended optional elements in addition to the mandatory elements will increase interoperability, allowing users to understand without ambiguity the data and the related metadata provided by either the producer or the distributor. Dataset metadata profiles of this International Standard shall include this core.

This table gives the list of the core metadata elements. An M indicates that the element is mandatory, an O indicates that the element is optional, and a C indicates that the element is mandatory under certain conditions.

Table 5: Core metadata elements

Dataset title (M) (MD_Metadata > MD_DataIdentification.citation > CI_Citation.title)	Spatial representation type (O) (MD_Metadata > MD_DataIdentification.spatialRepresentationType)
Dataset reference date (M) (MD_Metadata > MD_DataIdentification.citation > CI_Citation.date)	Reference system (O) (MD_Metadata > MD_ReferenceSystem)
Dataset responsible party (O) (MD_Metadata > MD_DataIdentification.pointOfContact > CI_ResponsibleParty)	Lineage (O) (MD_Metadata > DQ_DataQuality.lineage > LI_Lineage)
Geographic location of the dataset (by four coordinates or by geographic identifier) (C) (MD_Metadata > MD_DataIdentification.extent > EX_Extent> EX_GeographicExtent > EX_GeographicBoundingBox or EX_GeographicDescription)	On-line resource (O) (MD_Metadata > MD_Distribution > MD_DigitalTransferOption.onLine > CI_OnlineResource)
Dataset language (M) (MD_Metadata > D_DataIdentification.language)	Metadata file identifier (O) (MD_Metadata.fileIdentifier)
Dataset character set (C) (MD_Metadata > MD_DataIdentification.characterSet)	Metadata standard name (O) (MD_Metadata.metadataStandardName)
Dataset topic category (M) (MD_Metadata > MD_DataIdentification.topicCategory)	Metadata standard version (O) (MD_Metadata.metadataStandardVersion)
Spatial resolution of the dataset (O) (MD_Metadata > MD_DataIdentification.spatialResolution > MD_Resolution.equivalentScale or MD_Resolution.distance)	Metadata language (C) (MD_Metadata.language)
Abstract describing the dataset (M) (MD_Metadata > MD_DataIdentification.abstract)	Metadata character set (C) (MD_Metadata.characterSet)
Distribution format (O) (MD_Metadata > MD_Distribution > MD_Format.name and MD_Format.version)	Metadata point of contact (M) (MD_Metadata.contact > CI_ResponsibleParty)
Additional extent information for the dataset (vertical and temporal) (O) (MD_Metadata > MD_DataIdentification.extent > EX_Extent > EX_TemporalExtent or EX_VerticalExtent)	Metadata date stamp (M) (MD_Metadata.dateStamp)

4.1.4 Metadata Template

A simplified metadata template has been developed that hides the complexity of ISO 19115 standard. The metadata template (Table 6) shows the list of metadata elements selected for the dataset in the project.

Table 6: ISO Minimum standard metadata template

DATASET TYPE	METADATA FIELDS		
Non - Spatial Data			Dataset number
			Dataset title
			Data type (spatial / non-spatial / survey / satellite imagery)
			Creation date (dd/mm/yyyy)
			Revision date (dd/mm/yyyy)
			Publication date (dd/mm/yyyy)
	Date duration (dd/mm/yyyy)		Begin date
			End date
			Abstract (description of the dataset)
			Linkage (resource space, library)
	Originator		Organization name
			Voice
			Country
			Email
	Publisher		Organization name
			Voice
			Country
			Email
	Contributor		Organization name
			Voice
			Country
			Email
			Keywords
			Language
			Specification
			Explanation
			Pass
			Data file name (s)
			Supplementary file name(s)
			Format
			Constraint information
	Metadata author (point of contact)		Individual name
			Email
			Organization
			Comments

The detailed metadata template elements description and entity table are given in Appendix 1 and 1a respectively.

5 DATA HOLDINGS

5.1 Public Domain Data

A wide range of public domain spatial and time-series data, built on prior work by IWMI on water-issues in Myanmar, is incorporated into the WISDM database. The public domain data added to WISDM is divided into following categories:

- Administrative Boundaries
- Agriculture
- Hydrology
- Hydropower and Energy
- Geology and Soils
- Environment
- Demography
- Climate

The full list of the added datasets is given in Annex 2.

5.2 SOBA Package Data

The SOBA study has been initiated in six work packages. Each package has responsibility for specific data themes which are incorporated in WISDM as described in the following sections.

5.2.1 State of the Basin Assessment 1: Hydrology (SOBA 1)

Under SOBA 1, Hydronumerics, Alluvium Consulting and ALS Hydrographics have conducted an extensive audit of hydrological data, including an assessment of quality and reliability of hydrological data (see Report on Activity 360201.04 - Hydrological data audit and capacity building in data management) and packaged the time series hydrological and climatic data into a desktop application called HydroHub. Through HydroHub the data is available to PMU/HIC only. In order to make it accessible to others, when required, the data has been added to the WISDM. The details of the data added to WISDM are available under Annex 3.

5.2.2 State of the Basin 2a: Groundwater Resources of the Ayeyarwady Basin (SOBA 2)

The SOBA 2a has provided a large number of spatial and non-spatial data as well as bibliographic records. The provided data and bibliographic records have already been added to the WISDM portal. The detailed listing is available under Annex 4 for bibliographic records.

Data from other packages is not yet available and can be added to the WISDM as it becomes available.

5.3 Document Hub

A substantial amount of information relevant to development in the Ayeyarwady is available only as unpublished 'grey' literature – reports prepared by Government and non-Government agencies, which are publicly available. This also includes conference presentations and workshop reports. These can be very valuable sources of both qualitative information and quantitative data, but are often difficult to access. WISDM currently holds about 82 reports, articles and presentations on different aspects of the Ayeyarwady Basin and which are included in Knowledge Hub under the following categories:

- Dry Zone Reports
- Agriculture and Irrigation
- Ecosystems

- IWRM
- Urban and Domestic Water
- Water Quality and Sediments
- Fish
- Geology
- Groundwater
- Hydrology
- Navigation
- Socio-economic

A complete list of articles, reports, and presentations is available in Annex-5

6 CONCLUSIONS

The WISDM portal has been developed using the latest, open source technologies, including Angular 2 and PHP, PostgreSQL, and GeoServer. A beta version of the portal has been deployed online with access limited to project authorized users. The SOBA package teams and PMU and HIC staff have to use the provided login credentials to access the Data (metadata only), Document-Hub, and Mapping Portal. This arrangement has been implemented based on the instructions from the PMU.

As November 2017, data from SOBA 1 and SOBA 2 has been added and are accessible through the WISDM portal to authorized users. WISDM has yet to receive data from other packages but can be added as soon as it is provided.

Currently, the portal is deployed on IWMI owned and operated servers. Once the PMU has reviewed and confirmed compliance with the specifications, it will be moved to the cloud and to a server at the HIC. PMU and HIC staff will be trained in the deployment, management, and maintenance of the portal. A detailed user guide will be provided during the training for ready reference for operation and maintenance of the WISDM database and service interfaces.

6.1 New features

Following the discussions and suggestions from reviewers and participants of the SOBA Draft Package Report Review Workshop, the following new features have been added to the WISDM portal:

6.1.1 Gallery

A new module named 'Gallery' has been added, providing access to Maps, Pictures and Participatory 3D Model (P3DM) sub-menu items:

- **Maps** - All of the packages will submit data and spatial data layers, though the data will be submitted as individual layers and not as compiled maps where number of layers have been styled and developed together. However, many of the SOBA packages developed a number of maps presented during the workshop. In order to preserve those beautiful compiled and developed maps a section called maps under Gallery has been added.

- **Pictures -** Similarly, all packages captured a lot of photographs during their field trips, which were also presented during the workshop. A section called 'Pictures' has been added under Gallery to store the records of the fieldwork carried out by the package teams.

- **Participatory Three-Dimensional Model (P3DM) -** State of the Basin 6: Participatory 3D Mapping and Local Consultations, and Communities Atlas (SOBA 6) developed a P3DM of the Ayeyarwady River Basin to use it in field consultations with communities living along the river. A section called 'P3DM' has been added under Gallery to capture and share the use of P3DM in the consultation process.

6.1.2 Mapping Portal

Following the recommendations from participants of the workshop, and suggestions from seminars conducted for young water professionals and junior researchers, a basic Geographic Information System capability was added to the mapping portal:

- **Transparency Tool -** A layer transparency tool has been provided for each spatial layer in the mapping portal. The transparency tool allows the user to adjust the transparency of the layer in order to visualize the features of the layer beneath.

The option of adding additional features such as buffering, intersect and other functions could be explored.

6.1.3   Data Download

Based on the recommendation by the workshop participants, an option has been added for the user to choose the format for downloading the spatial data; i.e., as a Shapefile, KML or JSON.

WISDM has been developed using the latest open source web development technologies and database systems, which makes it quite flexible and provides a lot of room for expansion and to accommodate future requirements. Further, unlike common content management systems (CMSs), the user and data access and management system is tailor made and provides the administrator with the full control of users, user groups and data at the individual level.

The relevant HIC staff will be trained, and the knowledge on management and maintenance of the system will be provided during the training session to be held in January 2018. Since not much data has been provided by the SOBA packages, the HIC staff will also be trained in bulk data uploading to facilitate the data upload process.

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APPENDIX I - METADATA TEMPLATE ELEMENT DESCRIPTION

Listed below are the metadata elements (mandatory and recommended optional) selected for describing a dataset. In the 'Obligation' column 'M' indicates that the element is mandatory, an 'O' indicates that the element is optional and a 'C' indicates that the element is mandatory under certain conditions.

	PACKAGE	ENTITY	OBLIGATION
A.	**Metadata entity set information**		M
		File identifier	O
		Language	C
		Character set	C
		Contact (metadata author)	M
		Date stamp	M
		Metadata standard name	O
		Metadata standard version	O
1	**Identification information**		
		Citation	M
		Abstract	M
		Language	M
		Character set	C
		Keyword	M
		Spatial representation type	O
		Spatial resolution - equivalent scale	C
		Topic category	C
a	**Extent information**		
		Polygon	M
		West bound longitude	M
		East bound longitude	M
		South bound latitude	M
		North bound latitude	M
b	**Citation and responsible party information**		
		Title	M
		Date	M
		Edition	O
		Responsible party	
		Individual name	C
		organization name	C
		Role	M
		Phone	O
		Delivery point	O
		City	O
		Postal code	O
		Country	O
		Electronic mail address	O
2	**Constraint information**		
		Access constraints	O
		Use constraints	O
		Other constraints	O
		Classification	M
3	**Data quality information**		
		Scope	M

40

	PACKAGE	ENTITY	OBLIGATION
		Lineage - statement	C
4	**Maintenance information**		
		Maintenance and update frequency	M
5	**Spatial representation information**		
		Number of dimensions	M
		Dimension name	M
		Dimension size	M
		Resolution	M
6	**Reference system information**		
		Projection	O
		Ellipsoid	O
		Datum	O
		Name	M
		Code	M
7	**Content information**		
		Attribute description	M
		Content type	M
8	**Distribution information**		
		Online	O
		Format name	M
		Format version	M

APPENDIX IA - METADATA ENTITY SET definitions

S. No.	ENTITY	DEFINITIONS
A.	**Metadata entity set information**	
	File identifier	Unique identifier for this metadata file
	Language	language used for documenting metadata
	Character set	Full name of the character coding standard used for the metadata set
	Contact (metadata author)	Party responsible for the metadata information
	Date stamp	Date that the metadata was created
	Metadata standard name	Name of the metadata standard (including profile name) used
	Metadata standard version	Version (profile) of the metadata standard use
1	**Identification information**	
	Citation	Citation data for the resource(s)
	Abstract	Brief narrative summary of the content of the resource(s)
	Language	Language(s) used within the dataset
	Characterset	Full name of the character coding standard used for the dataset
	Keyword	Commonly used word(s) or formalized word(s) or phrase(s) used to describe the subject
	Spatial representation type	Method used to spatially represent geographic information
	Spatial resolution - equivalent scale	Factor which provides a general understanding of the density of spatial data in the dataset
	Topic category	Main theme(s) of the dataset
a	**Extent information**	
	Polygon	Sets of points defining the bounding polygon
	West bound longitude	Western-most coordinate of the limit of the dataset extent, expressed in longitude in decimal degrees (positive east)
	East bound longitude	Eastern-most coordinate of the limit of the dataset extent, expressed in longitude in decimal degrees (positive east)
	South bound latitude	Southern-most coordinate of the limit of the dataset extent, expressed in latitude in decimal degrees (positive north)
	North bound latitude	Northern-most, coordinate of the limit of the dataset extent expressed in latitude in decimal degrees (positive north)
b	**Citation and responsible party information**	
	Title	Name by which the cited resource is known
	Date	Reference date for the cited resource
	Edition	Version of the cited resource
	Edition date	Date of the edition
	Responsible party	
	Individual name	Name of the responsible person surname, given name, title separated by a delimiter
	Organization name	Name of the responsible organization

S. No.	ENTITY	DEFINITIONS
	Role	Function performed by the responsible party
	Phone	Telephone numbers at which the organization or individual may be contacted
	Delivery point	Address line for the location (as described in ISO 11180, Annex A)
	City	City of the location
	Postal code	ZIP or other postal code
	Country	Country of the physical address
	Electronic mail address	Address of the electronic mailbox of the responsible organization or individual
2	**Constraint information**	
	Access constraints	Access constraints applied to assure the protection of privacy or intellectual property, and any special restrictions or limitations on obtaining the resource or metadata
	Use constraints	Constraints applied to assure the protection of privacy or intellectual property, and any special restrictions or limitations or warnings on using the resource or metadata
	Other constraints	Other restrictions and legal prerequisites for accessing and using the resource or metadata
	Classification	Name of the handling restrictions on the resource or metadata
3	**Data quality information**	
	Scope	The specific data to which the data quality information applies
	Lineage - statement	General explanation of the data producer's knowledge about the lineage of a dataset
4	**Maintenance information**	
	maintenance and update frequency	Frequency with which changes and additions are made to the resource after the initial resource is completed
5	**Spatial representation information**	
	Number of dimensions	Number of independent spatial temporal axes
	Dimension name	Name of the axis
	Dimension size	Number of elements along the axis
	Resolution	Degree of detail in the grid dataset
6	**Reference system information**	
	Projection	Identity of the projection used
	Ellipsoid	Identity of the ellipsoid used
	Datum	Identity of the datum used
	Name	Name of reference system used
	Code	Alphanumeric value identifying an instance in the namespace
7	**Content information**	
	Attribute description	Description of the attribute described by the measurement value
	Content type	Type of information represented by the cell value
8	**Distribution information**	
	Online	Information about online sources from which the resource can be obtained
	Format name	Name of the data transfer format(s)
	Format version	Version of the format (date, number, etc.)

APPENDIX II - PUBLIC DOMAIN DATASETS INCORPORATED INTO WISDM

THEME	SUB-THEME	DATASET
Administrative Boundaries		
		Myanmar Land use map - UNEP 2000
		Myanmar National Boundary - MIMU
		National boundaries with Neighbouring
		Myanmar River network (major rivers only)
		Myanmar Roads
		Myanmar towns - points
		Myanmar township boundaries - MIMU
		Population Places - Major Towns (ESRI)
		SRTM DEM 30 m
		State & Region boundaries - MIMU
		Village Tract - MIMU
Agriculture		
		Cropland V1 2000 SEDAC
		Length of growing period
		Major Farming Systems - FAO
		Irrigated Areas Occurrence (FGGD)
		Global Agriculture cropland - 2000
		Harvested Area & yield
		Occurrence of Irrigated Areas
		IWMI Irrigated Area Map
Hydrology		
	Flooding	
		Flood Extent of annual recurrent flood
		Annual floods
	Dams and Lakes	
		Dams v1.1 2011 SEDAC
		Reservoirs v1.1 2011 SEDAC
		WLE dam dataset
	Basin	
		Hydrobasins/hydrosheds
		HydroBasins Level 4,6, 8
	Rivers	

THEME	SUB-THEME	DATASET
		Rivers Hydrosheds
		Rivers - Hydrobasins - 15 arc second
		WWF Rivers
		Rivers - MIMU
		Rivers OSM
		Ayeyarwady Bain Boundary
		MHRI Hydro-ecozones
		Salween Basin
	Wetlands	
		Global Lakes Water Authority - Level1
		Global Lakes Water Authority - Level2
		Global Lakes Water Authority - Level 3
		Global mangrove forest - 2000 (30m)
		Global Pastures
		Global LV 2009
		GMLUCA V2.10
		Irrigated Area map - 2000
		Irrigated Area map - 2010
		NDVI - MODIS
		Salween Land Cover - 2014 (IWMI)
		Myanmar Land use (MIMU)
		IWMI GIAM
Hydropower Energy		
	WLE Hydropower dataset	
	Utilities Lines 2001/2002 (United Nations Development Programme /FAO)	
	Navigation	
		Asia Roads
		Major Ports
		Port Index
		Railways
		Airport
Geology and Soil		

THEME	SUB-THEME	DATASET
		Geology (USGS)
		Digital Soil Map of the World
		Mineral Resources
		Geology of Myanmar - Geosciences Society 2014
		Soil types 2001-2002 (UNEP/FAO)
		Ecoregions (TNC)
Environment		
		Forest Cover change - Hansen GFC2015
		Protected Areas - IUCN Global
		Protected Areas - GMS
		Protected Areas - WDPA
Demographic		
		GRUMP - Pop count and density - 1990, 1995 2000
		GWP V3 - Projections for 2005, 2010, 2015
		Ethnic groups
		Poor population density
		Worldmap (persons per grid) 2010 & 2015
		Population 2014 - Census & village level data
		Poverty Data
		Poverty Data -WFP
		Rural Poverty Density
		Urban areas
Climate		
		Change in NPP 1981 to 2003
		CHIRPS Daily Precipitation 1981- 2016
		ET - Annual - 2000 to 2014
		ET Monthly – 2014
		Global Soil Water balance AET 1 - 12 and year SWC 10 12 and year
		IWMI World water and climate atlas Annual Atlas
		Mean Monthly Temp.
		Potential ET - Monthly
		Precipitation - Monthly

APPENDIX III - LIST OF HYDROLOGICAL AND CLIMATIC DATA ADDED TO WISDM FROM HYDROHUB (SOBA 1)

THEME	SUB-THEME	DATASET
Hydrology		Monthly Statement Of Water Supply Utilization- Falam Township
		Monthly Statement Of Water Supply Utilization - Pharkant Township, Mohnyin Township, Moegaung Township, Waimaw Township
		Monthly Statement Of Water Supply Utilization - Demoso Township, Bawlakhe Township,
		Monthly Statement Of Water Supply Utilization - Poung Township, Hlaing Bwe Township
		Monthly Statement Of Water Supply Utilization - Kyauk Taw, Taung Goke, Gwa Township, Kyauk Taw,
		Monthly Statement Of Water Supply Utilization - Hlegu Township, Taik Kyi Township, Kyaukton Township, Kyaukton Township,
		Monthly Statement Of Water Supply Utilization- Hlegu Township, Taik Kyi Township, Kyaukton Township,
		Monthly Statement Of Water Supply Utilization - Ma Mya Dam
		Monthly Statement Of Water Supply Utilization - Kyangin Township
		Monthly Statement Of Water Supply Utilization - Oktwin Towship, Leway, Pyinmana Township, Naypyitaw, Lewe Township, Ottrathiri Township
		Monthly Statement Of Water Supply Utilization - Daik U Township, Kyauktaga
		Monthly Statement Of Water Supply Utilization - Bago
		Monthly Statement Of Water Supply Utilization - Phyu Township
		Monthly Statement Of Water Supply Utilization - Bago Township
		Monthly Statement Of Water Supply Utilization-Magway Division, Gyobinkauk Township
		Monthly Statement Of Water Supply Utilization - Pyay, Pauk Khaung, Shwe Daung, Padaung, Paungda
		Monthly Statement Of Water Supply Utilization - Min Hla Dam
		Monthly Statement Of Water Supply Utilization - THE GAW DAM

THEME	SUB-THEME	DATASET
		Monthly Statement Of Water Supply Utilization - AUNG LAN TOWNSHIP, Pwint Phyu
		Monthly Statement Of Water Supply Utilization- Natmauk, Taungdwingyi, Myothitm, Myothit, Yenangyaung, Aunglan,
		Monthly Statement Of Water Supply Utilization - Setoktaya Township, Minbu, Pwinpyu, Salin, Ngaphe
		Monthly Statement Of Water Supply Utilization - Seik Phyu, Myiang, Yesagyo, Pakokku, Saw, Yesagyo, Seik Phyu, Seikphyu
		Monthly Statement Of Water Supply Utilization - Kinda Mutipurpose project
		Monthly Statement Of Water Supply Utilization - Zeyar Thir, Outayathir, Lewe, Tatkon, Outaya Thiri
		Monthly Statement Of Water Supply Utilization - Meiktila Township, Mahlaing Township, Thazi Township, Wundwin Township, Yamethin Township, Pyawbwe Township
		Monthly Statement Of Water Supply Utilization - Kyaukse
		Monthly Statement Of Water Supply Utilization MADAYA TOWNSHIP, Pyin Oo Lwin Township, Singu Township
		Monthly Statement Of Water Supply Utilization - Taung Tha, Na To Gyi, Ngan Azon, Kyauk Pa Taung, Kyauk Pa Taung, Nyung Oo, Nga Tha Yauk, Myingyan
		Monthly Statement Of Water Supply Utilization - Mudon , Thaton Towship
		Monthly Statement Of Water Supply Utilization - Kalay Township, Kantbalu
		Monthly Statement Of Water Supply Utilization - Salingyi Township, Pele Township, Chaungoo Township, Monywa Township, Pele Township, Myin My Township, Budalin Township, Ayadaw Township, Depayin Township, Myaing Township
		Monthly Statement Of Water Supply Utilization - Kanbalu Township
		Monthly Statement Of Water Supply Utilization - Kanbalu Township
		Monthly Statement Of Water Supply Utilization - Nam San Township, Lashio Township, Yet Sawk Township, Namtu Township
		Mean Daily Water Level Gauge Reading (In cm)
		Mean Daily Water Level Gauge Reading (In cm)

THEME	SUB-THEME	DATASET
		Daily and Monthly Rainfall (In Inches)
		Mean Daily Water Level Gauge Reading (In Centimeter)
		Daily and Monthly Evaporation (In mm)
		Daily and Monthly Rainfall (In Inches)
		Mean Daily Water Level Gauge Reading (In Centimeter)
		Available Data provided by Hydrology Branch
		Discharge Measurement Result of River Flow in Ayeyarwady Delta (2015)
		Observed Rainfall at Kanbet (with Auto Raingauge)
		Daily Tidal Gauge Reading (In cm) - Kunhtaw
		Daily Tidal Gauge Reading (In cm) - Kunhtaw
		Daily Tidal Gauge Reading (In cm) - Kunhtaw
		Daily Tidal Gauge Reading (In cm) - Kyaukphyu
		Daily Tidal Gauge Reading (In cm) - Kyaukphyu
		Daily Tidal Gauge Reading (In cm) - Kyaukphyu
		Water demand and supply for irrigation in 2015-16 (River Pumping for raining season)
		Daily Mean Sediment Discharge (kg /sec)
		Daily Mean Discharge (m3/Sec) - Monywa, Sagaing, Pya
		Daily Mean Sediment Discharge (kg /sec) - Katha, Thabeikkyin, Sagaing, Zalun, Mawlaik, Hkamti, Aunglan
		Daily Mean Water Level (cm) - Myitkyina - Sagaing - Monywa - Pyay
		Daily Mean Sediment Discharge (kg /sec),Pyay
		Daily Mean Discharge (m3/Sec), Myitkyina, Katha, Sagaing, Nyaung Oo, Magway, Pyay, Hkamti, Mawlaik, Monywa
		Daily Mean Water LeveL (cm), Myitkyina, Bhamo, Katha, Sagaing, Mandalay, Pakokku, Nyaung Oo, Minbu, Magway, Pyay, Hinthada, Hkamti, Mawlaik, Monywa, Gangaw
		Water Level Yeywa Hydropower Station
		Water Level Yeywa Hydropower Station 2016
		Reservoir and Tail Water Level, Yeywa
		Daily Temperature, Yeywa
		Yeywa Hydropower Project Reservoir Operation Rule Curve
		Water Level 2010 - Dapein (1) Hydropower Station
		Water Level 2011 - Dapein (1) Hydropower Station
		Water Level 2013 - Dapein (1) Hydropower Station
		Water Level 2014 - Dapein (1) Hydropower Station

THEME	SUB-THEME	DATASET
		Water Level 2015 - Dapein (1) Hydropower Station
		Water Level 2016 - Dapein (1) Hydropower Station
		Dapein 1 hydropower station Elevation level related with Storage
Climate		Climatic Data (Temp Min, Temp Max, Rainfall, Relative Humidity, WindSpeed) - Hkamti
		Climatic Data (Temp Min, Temp Max, Rainfall, Relative Humidity, WindSpeed) - Hinthada
		Climatic Data (Temp Min, Temp Max, Rainfall, Relative Humidity, WindSpeed) - Hkamti
		Locations of Meteorology Stations of Department of Meteorology and Hydrology
		Climatic Data (Temp Min, Temp Max, Rainfall, Relative Humidity, WindSpeed) - Magway
		Climatic Data (Temp Min, Temp Max, Rainfall, Relative Humidity, WindSpeed) - MUNBU
		Climatic Data (Temp Min, Temp Max, Rainfall, Relative Humidity, WindSpeed) - Monywa
		Climatic Data (Temp Min, Temp Max, Rainfall, Relative Humidity, WindSpeed) - PAKOKKU
		Climatic Data (Temp Min, Temp Max, Rainfall, Relative Humidity, WindSpeed) - SAGAING
		Climatic Data (Temp Min, Temp Max, Rainfall, Relative Humidity, WindSpeed) - BHAMO
		Climatic Data (Temp Min, Temp Max, Rainfall, Relative Humidity, WindSpeed) - MYITKYINA
		Climatic Data (Temp Min, Temp Max, Rainfall, Relative Humidity, WindSpeed) - KATHA
		Climatic Data (Temp Min, Temp Max, Rainfall, Relative Humidity, WindSpeed) - MANDALAY
		Climatic Data (Temp Min, Temp Max, Rainfall, Relative Humidity, WindSpeed) - MAWLAIK
		Climatic Data (Temp Min, Temp Max, Rainfall, Relative Humidity, WindSpeed) - NYAUNGOO
Socio-economic		Registered Private Industrial Enterprises by Commodity Group, Ayethatar, Pokokku, Pyay, Saging, Shwebo, Monywa, Pathein, Hinthada, Myaung mya, Yangon, Meiktila, Myingyan, Mdy
		Residential, Staff Housing, Commercial, Upgrade, Green, Research, highway station, Guest House, Warehouse, Industry, Phar pon
		Households with less than (18) years old or older / POPULATION, Pyarpon

THEME	SUB-THEME	DATASET
Hydropower & Energy		Dapein 1 hydropower station Elevation level related with Storage

APPENDIX IV - LIST OF BIBLIOGRAPHY PROVIDED BY SOBA 2A

S. NO.	CATEGORY	TITLE
1	WISDM Groundwater	A brief accounts on Mineral Exploration Activities and Investment Opportunities in Myanmar
2	WISDM Groundwater	Agricultural Water Resources Study in Myanmar
3	WISDM Groundwater	An Interview with Ramgopall Agarwala Wanted for Africa: Funds to Boost Reforms
4	WISDM Groundwater	Arsenic contamination, Hydrogeology and Design for Sanitary Protection of Tubewells in Ayeyarwady Region
5	WISDM Groundwater	Arsenic and WASH studies
6	WISDM Groundwater	Arsenic Contamination in Groundwater: A Global Perspective with Emphasis on the Asian Scenario
7	WISDM Groundwater	Arsenic contamination of water sources in rural Myanmar
8	WISDM Groundwater	Arsenic Distribution and Correlation between Arsenic and Other Selected Parameters of Groundwater in Kyonpyaw township, Ayeyarwady region
9	WISDM Groundwater	Arsenic occurrence in groundwater in South and East Asia
10	WISDM Groundwater	Artisanal and small-scale gold mining in Myanmar: Preliminary research for environmental mercury contamination
11	WISDM Groundwater	Assessment of Groundwater Quality in Hinthada Township, Ayeyarwady Region
12	WISDM Groundwater	Assessment of Groundwater Quality in Kyaunggon Township, Ayeyarwady Region
13	WISDM Groundwater	Assessment of Groundwater Quality of Pyay Area, Pyay District, Bago Region
14	WISDM Groundwater	Climate Change Impacts to the Water Environment and Adaptation Options
15	WISDM Groundwater	Confirmation of elevated arsenic levels in groundwater of Myanmar
16	WISDM Groundwater	Coping with water scarcity in the Ayeyarwady Delta
17	WISDM Groundwater	Database Design
18	WISDM Groundwater	Estimating the Groundwater Recharge of the Chindwin and Irrawaddy Basin in Myanmar Using Remote Sensing Based Water Accounting (WA+)
19	WISDM Groundwater	Facilities and Activities
20	WISDM Groundwater	Field Report Ayeyarwady Delta survey
21	WISDM Groundwater	Geological Map of Myanmar
22	WISDM Groundwater	Geological Maps of Dry Zone & Outside Dry Zone for groundwater availability

S. NO.	CATEGORY	TITLE
23	WISDM Groundwater	GIS Mapping for Arsenic Mitigation Programme in Myanmar
24	WISDM Groundwater	Groundwater - surface water interaction in the Ayeyarwady river delta, Myanmar
25	WISDM Groundwater	Groundwater Quality
26	WISDM Groundwater	History of RWSD and Groundwater Mapping Requirements in Myanmar
27	WISDM Groundwater	Hydrogeological Study of Bogale Ara, Ayeyarwaddy Division and Aquifer Test of Irrawaddian Aquifer at South Dagon Myothit, Yangon Division
28	WISDM Groundwater	Hydrogeology of Myaungmya Township, Ayeyarwaddy Region, Myanmar
29	WISDM Groundwater	Hydrogeology of Zalun Township, Ayeyarwaddy Region
30	WISDM Groundwater	IRRAWADDY Delta Hydrological Inverstigations and Delta Survey
31	WISDM Groundwater	Onshore petroleum geology of Myanmar: Central Burma Depression
32	WISDM Groundwater	Outline of Irrigation and Water Utilization Department
33	WISDM Groundwater	Predicting groundwater arsenic contamination in Southeast Asia from surface parameter
34	WISDM Groundwater	Relating the KBDI with sea water intrusion to farm land
35	WISDM Groundwater	Report On Regional Geology of Myanmar
36	WISDM Groundwater	Salinity at High Water Springs
37	WISDM Groundwater	Solar Pumping System in Myanmar
38	WISDM Groundwater	Southeast Asia At High Risk For Arsenic Contamination In Water
39	WISDM Groundwater	Stratigraphy
40	WISDM Groundwater	Stratigraphy and Lithology
41	WISDM Groundwater	The Geology of Burma (Myanmar): An Annotated Bibliography of Burma's Geology, Geography and Earth Science
42	WISDM Groundwater	The metallogenic provinces of Myanmar
43	WISDM Groundwater	Township Table
44	WISDM Groundwater	Township Table - P1
45	WISDM Groundwater	Township Table - P2
46	WISDM Groundwater	Water Management
47	WISDM Groundwater	Water Resource Assessment - Appendix 1
48	WISDM Groundwater	Water Supply Improvement Project Study for Yangon City and Pathein City

S. NO.	CATEGORY	TITLE
49	WISDM Groundwater	Water, Sanitation & Hygiene Disaster Risk Reduction Assessment
50	WISDM Groundwater	Groundwater development in Hard Rock Aquifer
51	WISDM Groundwater	Groundwater and Surface Water Resources Assessment Lemaungkwe Hills
52	WISDM Groundwater	Assessment of groundwater quality in Baw Hsaing area, Kalaw Township
53	WISDM Groundwater	Safe Drinking Water in Myanmar
54	WISDM Groundwater	Indawgyi Lake - The One and Only Tectonic Lake in Myanmar
55	WISDM Groundwater	Basic Design Study Report On The Project For Rural Drinking Water Supply In Shan State
56	WISDM Groundwater	Drilling Mytkyina IWUMD irrigation
57	WISDM Groundwater	Structural study along the Kyaukkyan fault, Shan state
58	WISDM Groundwater	The Irrawaddy 29 April 2016 - El Niño Also Scorches Areas of Shan State
59	WISDM Groundwater	Online KBZ's new - Water Supply project update
60	WISDM Groundwater	Brighter Future Myanmar Foundation's water project
61	WISDM Groundwater	Gold Mining in Kachin State-Burma-At What price?
62	WISDM Groundwater	Groundwater observation in Lashio - Northern Shan state
63	WISDM Groundwater	Drilling completion report KBZ
64	WISDM Groundwater	Status of Ruby and Sapphire mining in the Mogok tract belt
65	WISDM Groundwater	Stratigraphy of Shan plateau (Bender et al., 1983)
66	WISDM Groundwater	Field report Shan state south short survey
67	WISDM Groundwater	DruryField report_ Hydrogeology of Myittha Region
68	WISDM Groundwater	Water and Waste Water Management in Yangon, Myanmar
69	WISDM Groundwater	Urban Hydrogeology of Yangon
70	WISDM Groundwater	Water Supply Improvement Project Study for Yangon City and Pathein City
71	WISDM Groundwater	Assessment Of Groundwater Vulnerability In Yangon City, Myanmar
72	WISDM Groundwater	TW Inventory involved in Hydrogeol mapping & geophysical parameters (VES) of greater Yangon

S. NO.	CATEGORY	TITLE
73	WISDM Groundwater	A Strategic Urban Development Plan of Greater Yangon
74	WISDM Groundwater	One-third of Yangon homes off water grid
75	WISDM Groundwater	Environmental Impact Assessment For Industrial Area Of Zone B
76	WISDM Groundwater	Initial Environmental Examination - MYA: Yangon Urban Renewal and District Cooling Project
77	WISDM Groundwater	Hydrological Study of Htaukkyant and Pyinmabin Area, Yangon Division
78	WISDM Groundwater	Hydrological Assessment of the Collector Well at Kamayut Township, Yangon Region
79	WISDM Groundwater	Management of Groundwater Resources in Ywama Tyre Factory Compound, Insein Township, Yangon Region
80	WISDM Groundwater	Potential Salt Water Intrusion Study at Kyeemyindaing Township, Yangon Region
81	WISDM Groundwater	Study of Salt Water Intrusion at Hlaing Township, Yangon Region
82	WISDM Groundwater	Assessment of the Potential Groundwater Contamination in Botahtaung and Kyauktada Townships
83	WISDM Groundwater	Comparison of Hydraulic Characteristics and Chemical Composition of Groundwater lying between S-Okkalap and Hlaing across Shwedagon-Mingalardon Ridge
84	WISDM Groundwater	Groundwater Monitoring for connection with Tidal effect at Myayamon, Waterfront Villa Project, Dagon Myothit (South), Yangon Region
85	WISDM Groundwater	Hydrological Study of HMAWBI Area, Yangon Region

APPENDIX V - LIST OF ARTICLES, REPORTS, AND PRESENTATIONS IN DOCUMENT-HUB

S. NO.	CATEGORY	TITLE
1	DZ Reports	Community survey on water access, availability and management issues in the Dry Zone of Myanmar
2	DZ Reports	Defining the dry zone appendices
3	DZ Reports	Identifying priority investments in water in Myanmar's Dry Zone
4	DZ Reports	Improving water management in Myanmar's Dry Zone
5	DZ Reports	IWMI recommendations for priority action in the Dry Zone of Myanmar
6	DZ Reports	Sustainable management of water to improve food security and livelihoods in the Dry Zone of Myanmar
7	DZ Reports	Water resource assessment of the Dry Zone of Myanmar
8	WISDM Agriculture and Irrigation	Background paper No.1 Myanmar bio-physical characterization: Summary findings and issues to explore
9	WISDM Agriculture and Irrigation	Commercial Agriculture Expansion in Myanmar: Links to Deforestation, Conversion Timber, and Land Conflicts
10	WISDM Agriculture and Irrigation	data collection survey on agriculture sector in the Republic of the Union of Myanmar
11	WISDM Agriculture and Irrigation	Myanmar: Agriculture, natural resources, and environment initial sector assessment, strategy, and road map
12	WISDM Agriculture and Irrigation	Proceedings of the regional workshop on the future of large rice-based irrigation systems In Southeast Asia
13	WISDM Agriculture and Irrigation	Spate irrigation in Myanmar
14	WISDM Ecosystems	Current status of climate change mitigation and adaptation
15	WISDM Ecosystems	Ecosystems in the greater Mekong past trends, current status, possible futures
16	WISDM Ecosystems	Forest resource management forest resource management of Myanmar using GIS and remote sensing
17	WISDM Ecosystems	Myanmar: Key habitats and birds
18	WISDM Ecosystems	River reach classification for the greater Mekong region
19	WISDM Ecosystems	Timber trade flows and actors in Myanmar: the political economy of Myanmar's timber trade
20	WISDM Ecosystems	Using global datasets to create environmental profiles for data-poor regions: a case from the Irrawaddy and Salween river basins
21	WISDM Ecosystems	Wetland conservation in Myanmar
22	WISDM Fish	Characteristic, structure and resources of the sector
23	WISDM Fish	Myanmar aquaculture and inland fisheries
24	WISDM Fish	Myanmar- Opportunities in aquaculture
25	WISDM Geology	Data base building in Ministry of Mines, Myanmar
26	WISDM Geology	Earthquake hazards: A brief analysis of seismotectonic activities in Myanmar region
27	WISDM Geology	Eocene to Miocene composite Total petroleum system, Irrawaddy-Andaman and North Burma geologic provinces, Myanmar

S. NO.	CATEGORY	TITLE
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29	WISDM Geology	Gold Mining in Kachin state, Burma
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32	WISDM Geology	Report on regional geology of Myanmar
33	WISDM Geology	The geology of Burma (Myanmar): An annotated bibliography of Burma's geology, geography and earth science.
34	WISDM Groundwater	Greater water security with groundwater - Groundwater mapping and sustainable groundwater management
35	WISDM Groundwater	Groundwater issues in Myanmar
36	WISDM Groundwater	Groundwater serial maps of Asia - Hydrogeological map, groundwater resources map, geothermal map
37	WISDM Groundwater	Groundwater Sampling and Analysis – A Field Guide
38	WISDM Groundwater	Mapping groundwater resources in India – A pilot project covering six areas and more than 3000 km2 of land
39	WISDM Hydrology	A global hydrological model for deriving water availability indicators: model tuning and validation
40	WISDM Hydrology	Estimating daily time series of stream flow using hydrological model calibrated based on satellite observations of river water surface width: Toward real world applications
41	WISDM Hydrology	Generating river discharge estimates for the Bay Of Bengal using NASAs land information system
42	WISDM Hydrology	Geo-referenced information systems for disaster risk management activities in DMH
43	WISDM Hydrology	Hydrological modeling of large-scale ungauged basin case study: Ayeyarwady (Irrawaddy) basin, Myanmar
44	WISDM Hydrology	Hydrological studies of the Irrawaddy Delta
45	WISDM Hydrology	Instruments in department of meteorology and hydrology Myanmar
46	WISDM Hydrology	List of full time meteorology and hydrology station
47	WISDM Hydrology	Prediction of Ayeyarwady river discharge using distributed hydrologic model
48	WISDM Hydrology	Surface freshwater from Bay of Bengal runoff and Indonesian through-flow in the tropical Indian Ocean
49	WISDM Hydrology	The Irrawaddy river
50	WISDM Hydrology	Water management activities
51	WISDM IWRM	Challenges and practices in watershed management in Myanmar
52	WISDM IWRM	FAO Watershed management review
53	WISDM IWRM	Myanmar integrated water resources management strategic study – 'From vision to action'
54	WISDM IWRM	Myanmar integrated water resources management strategic study - Research and analysis, strategies and measures

S. NO.	CATEGORY	TITLE
55	WISDM IWRM	National action programme of Myanmar to combat desertification in the context of United Nations Convention To Combat Desertification (UNCCD)
56	WISDM IWRM	National report on the UNCCD implementation - United Nations Convention to Combat Desertification (UNCCD) Union of Myanmar
57	WISDM Navigation	Competitiveness between road and inland water transport: The case of Myanmar
58	WISDM Navigation	Water transport
59	WISDM Socio-economic	A regional perspective on poverty in Myanmar
60	WISDM Socio-economic	Assessing community capacity and vulnerability to strengthen resilience: Lessons from Myanmar's Dry Zone
61	WISDM Socio-economic	Food security assessment in the Dry Zone Myanmar
62	WISDM Socio-economic	Integrated household living conditions survey In Myanmar (2009-2010)
63	WISDM Socio-economic	Land acquisition law and practice in Myanmar: Overview, gap analysis with IFC PS1 & PS5 and scope of due diligence recommendations
64	WISDM Socio-economic	Myanmar multiple indicator cluster survey 2009 - 2010
65	WISDM Socio-economic	Qualitative social and economic monitoring
66	WISDM Socio-economic	Save the Children, WFP and the Ministry of Livestock, Fisheries and Rural Development
67	WISDM Socio-economic	The 2014 Myanmar population and housing census highlights of the main results census report Volume 2 - A
68	WISDM Socio-economic	The Dry Zone Of Myanmar A strategic resilience assessment of farming communities
69	WISDM Socio-economic	Visibility versus Vulnerability: Understanding instability and opportunity in Myanmar
70	WISDM Socio-economic	Vulnerability and resilience assessment Ayeyarwady Delta, Myanmar
71	WISDM Urban	Growing through manufacturing: Myanmar's industrial transformation
72	WISDM Urban	Myanmar urban development and water sector assessment, strategy, and road map
73	WISDM WQ and sediments	A preliminary estimate of organic carbon transport by the Ayeyarwady (Irrawaddy) and Thanlwin (Salween) rivers of Myanmar
74	WISDM WQ and sediments	Ayeyarwaddy, the river endangered
75	WISDM WQ and sediments	Decision support for generating sustainable hydropower in Mekong basin
76	WISDM WQ and sediments	Evaluation of arsenic mitigation in four countries of the Greater Mekong Region. Final report – December 2008
77	WISDM WQ and sediments	Reanalysis of the 19th century hydrology and sediment load dataset for the Irrawaddy River, Myanmar
78	WISDM WQ and sediments	Sediment dynamics in Irrawaddy river, Myanmar
79	WISDM WQ and sediments	The changing sediment loads of the Hindu Kush-Himalayan rivers: an overview
80	WISDM WQ and sediments	The Irrawaddy river sediment flux to the Indian Ocean: The original nineteenth-century data revisited
81	WISDM WQ and sediments	Water quality assessment of Ayeyarwady river in Myanmar

S. NO.	CATEGORY	TITLE
82	WISDM WQ and sediments	Water quality management at river basin in Myanmar