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INNOVATIVE WATER ENGINEERING FOR SUSTAINABLE DEVELOPMENT

DEVELOPMENT OF DIGITAL TESTBEDS TO SUPPORT THE POLICY OF RIVER BASIN DISASTER RESILIENCE AND SUSTAINABILITY BY ALL

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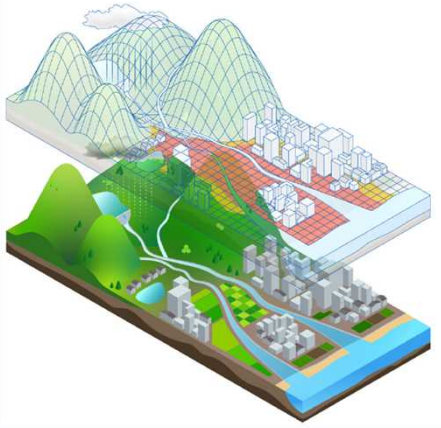


National Institute
for Land and Infrastructure Management
Ministry of Land, Infrastructure, Transport and Tourism

Overview

1. Introduction
2. Examination of the development policy of DTB
3. Development and trial of DTB
4. Consideration
5. Summary and future plans

DTB: Digital Testbeds for River Basin Disaster Resilience and Sustainability by All

Activities of NILIM

National Institute
for Land and Infrastructure Management
Ministry of Land, Infrastructure, Transport and Tourism

NILIM is one of the research institutes of the Ministry of Land, Infrastructure, Transport and Tourism（MLIT）.

→NILIM has a variety of experimental facilities.
We are also promoting digital transformation.

1. Introduction

Background

Impacts of Climate Change

Water disasters will continue to intensify. It is necessary to enhance the methods of measures to improve safety quickly.

Typhoon Hagibis (2019)

Floods in Japan (2018)

Social Trends

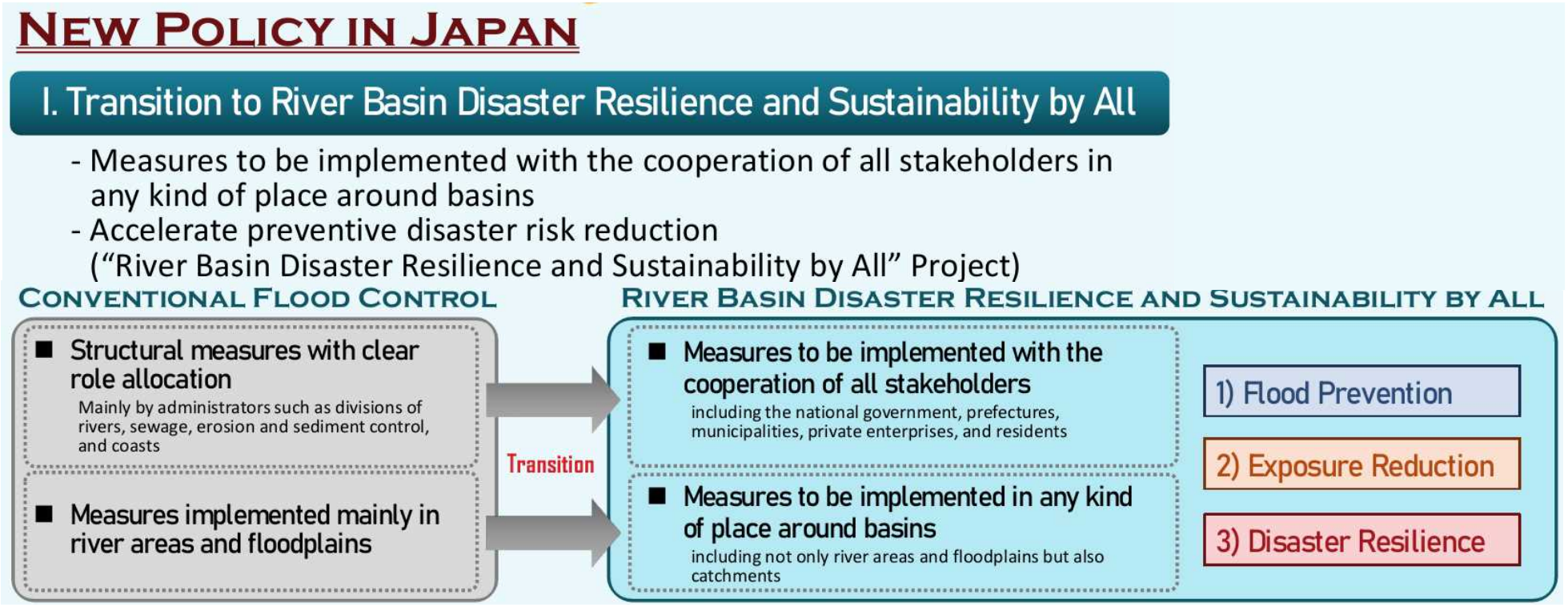
With Japan facing a declining and aging population, it is necessary to achieve safe and secure Compact Plus Network urban planning to maintain regional vitality.

Technological Innovation

Remarkable progress is being made in technologies such as 5G, AI, Big Data, and IT . It is necessary to utilize these technologies in disaster risk reduction, including evacuation.

1. Introduction

Japan is shifting to a new policy, "River Basin Disaster Resilience and Sustainability by All".
The policy aims to reduce water disasters across entire river basins in cooperation with all stakeholders.



1. Introduction

In order to promote the policy, it is necessary to have smooth risk communication among stakeholders.

For this purpose, it is necessary for stakeholders
to have bird's-eye views of entire river basins,
to intuitively understand the risks and effects, and
to have a common understanding.

The use of digital twins is expected to be one of the most effective tools to implement these measures.

It is necessary to compare and evaluate advanced elemental technologies of private companies and universities, integrate them as a system, and conduct field tests.
→ We need Digital Testbeds

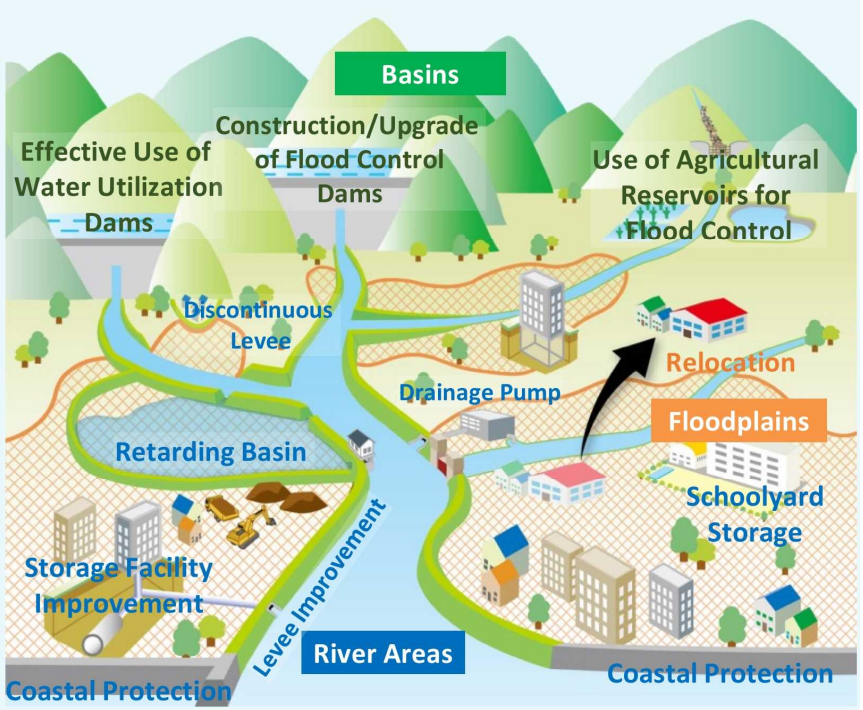


IMAGE OF RIVER BASIN DISASTER RESILIENCE AND SUSTAINABILITY BY ALL

1. Introduction

In real space, we have few opportunities to experience flood disasters and they are dangerous.

But in cyberspace, we can experience past, present and future water disasters without risk.

This experience can be utilized for planning and risk communication of flood control measures before water disasters occur in reality.

This study aims to examine the development method of DTB and to develop some functions of DTB.
It focuses on three components;

i) Basic data of river basins,
ii) Analysis environment,
iii) Utilization of data

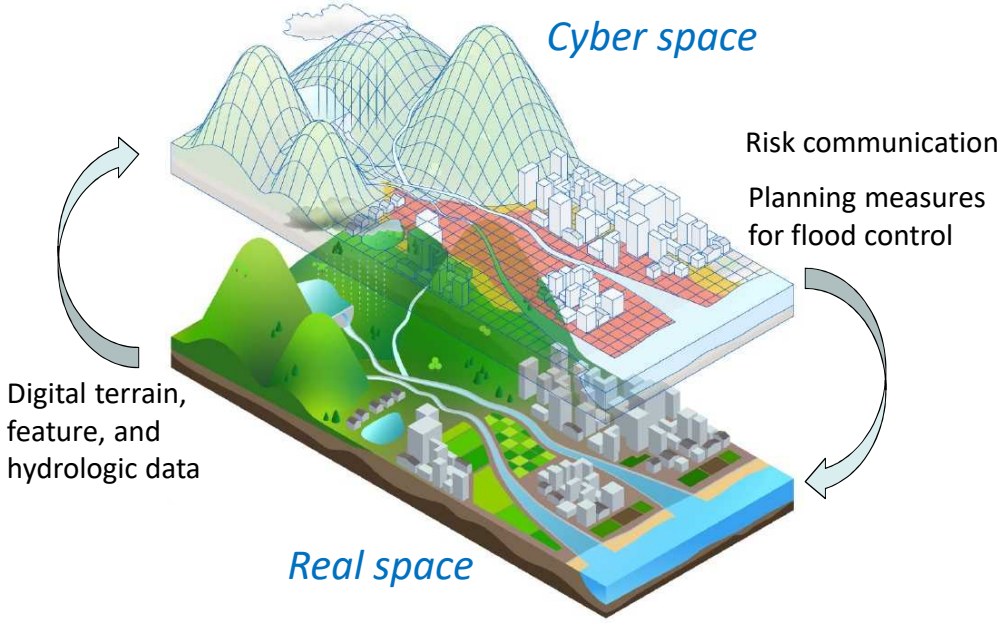


Fig 1. Image of Digital Testbeds for River Basin Disaster Resilience and Sustainability by All

2. Examination of the development policy of DTB

Preliminary research from domestic and overseas cases indicates these three points are necessary to realize DTB.

1) Basic data of river basins
2) Analysis environment
3) Utilization of data

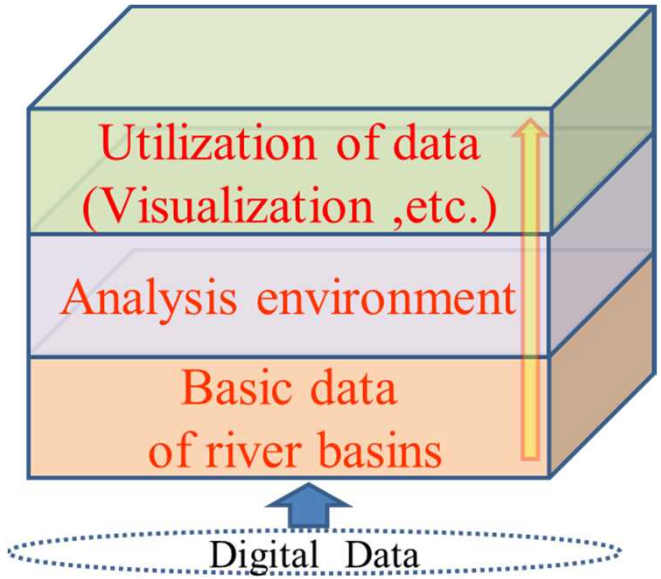


Fig. 2. Schematic diagram of the DTB components

2. Examination of the development policy of DTB

1) Basic data of river basins

MLIT is developing the River Basin Data Platform (DPF) that digitizes watershed data and manages and uses it in a cloud environment.

By adding the functions of DTB to a part of the DPF, it is expected to achieve both efficient development of DTB itself and effective use of the digital data in DPF.

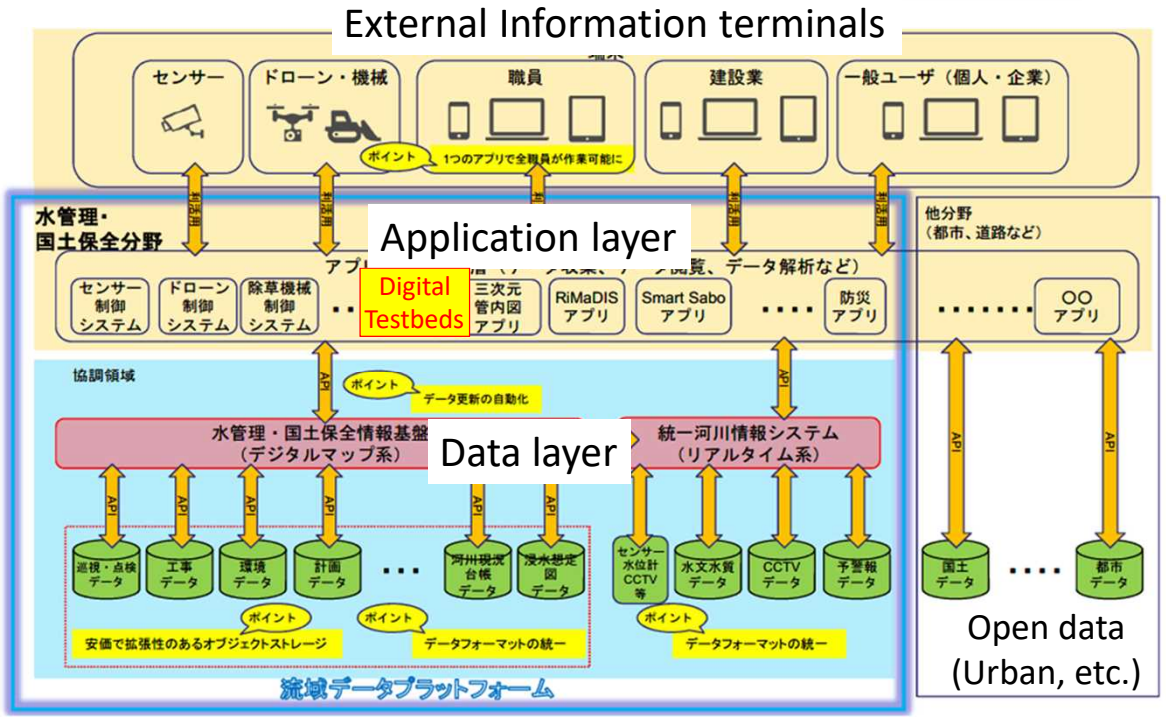


Image of the River Basin Data Platform (DPF)

2. Examination of the development policy of DTB

2) Analysis environment

According to the results of recent paper submissions in Japan, original software developed by universities or consultants was used the most, followed by iRIC software and RRI models.
Thus, we need to use various kinds of software. We also need to link software with input and output data.

Among the papers of the Japan Society of Civil Engineers (JSCE) from 2017 to November 2023, 215 papers related to watershed flood control.

Original software :	184 papers
iRIC (International River Interface Cooperative):	69 papers
RRI (Rainfall-Runoff-Inundation Model) :	58 papers

2. Examination of the development policy of DTB

3) Utilization of data

In promoting the policy, it is necessary for each stakeholders in river basin management
to know and accept responsibility for the risks and effects of flood control measures, and
to take appropriate actions such as cooperation for flood control measures, risk communication among stakeholders, and evacuation in an emergency.

In particular, for non-experts to understand the risks and effects, programs to visualize the data in three dimensions are required.

However, the information required for visualization is different for each river basin.
So, only basic functions are developed, and other optional functions are developed as needed in each watershed after the operation of DTB starts.

3. Development and trial of DTB

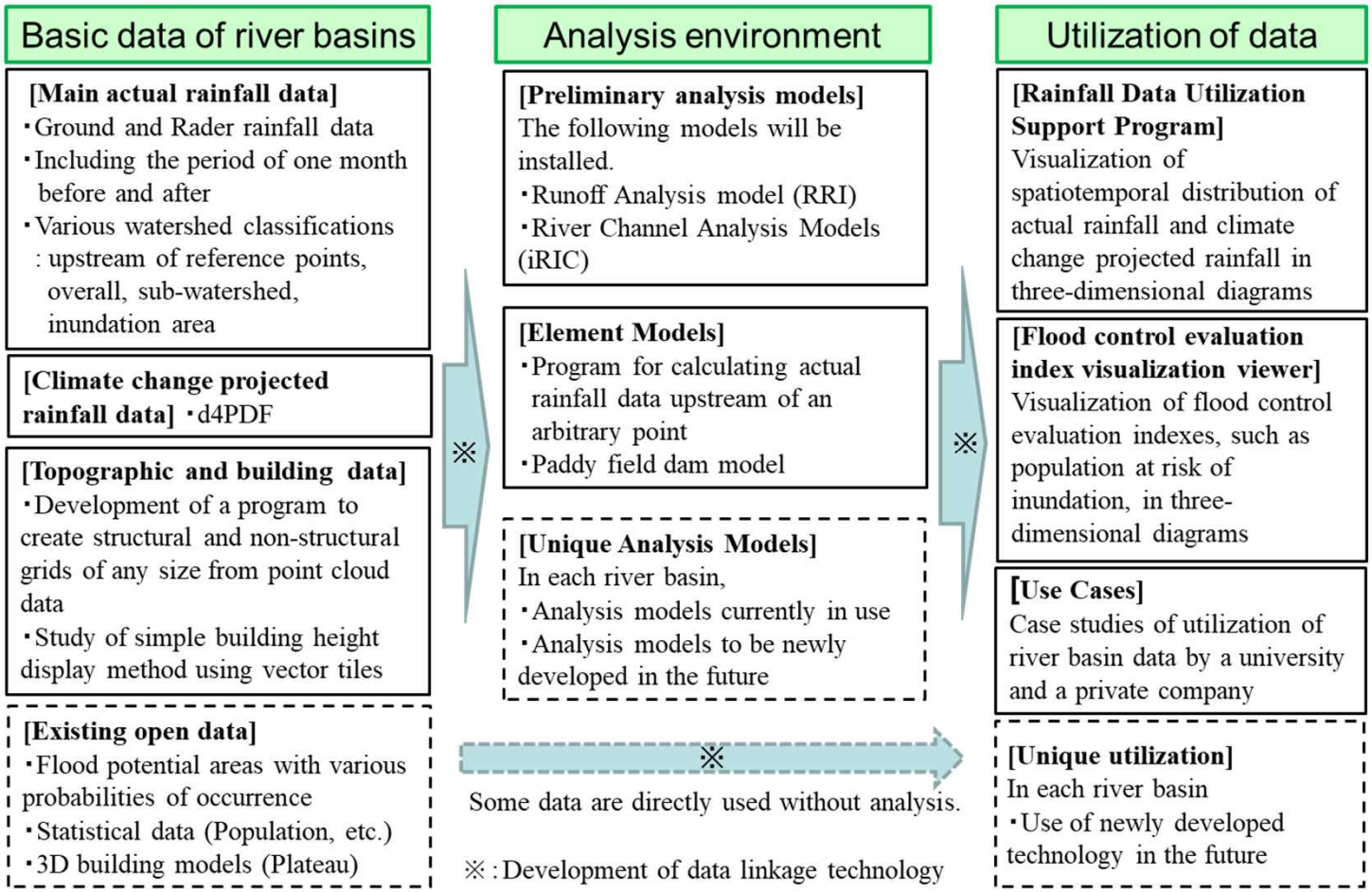
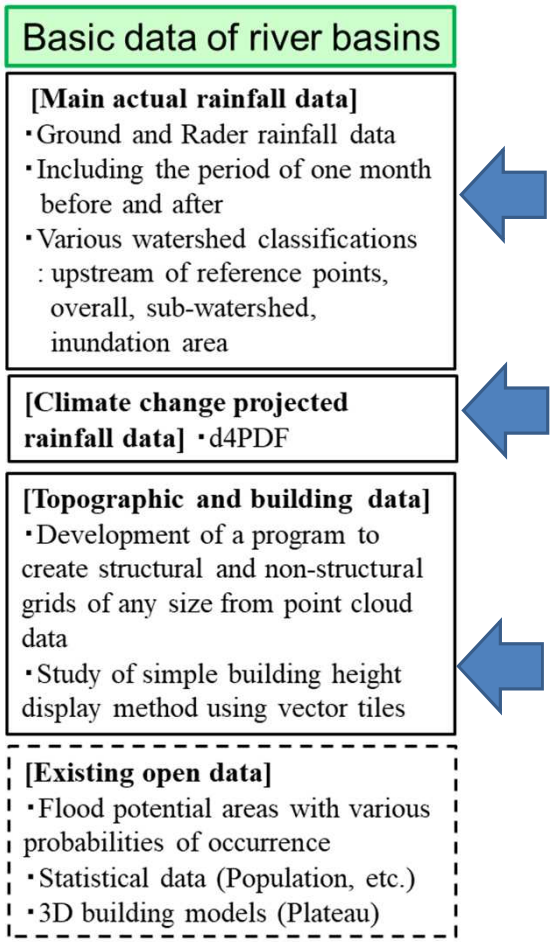


Fig. 3. Overall structure of DTB feature development

3. Development and trial of DTB



As for basic data,
NILIM collected and arranged rainfall data used for the examination of flood control plans of 109 Class A river systems.

The data of spatiotemporal distribution of rainfall in d4PDF (large-ensemble climate model predictions) was collected for all class A river systems.

We developed a program that can output topographic data at any spatial resolution from point cloud data created by aerial laser surveys of all class A river systems.

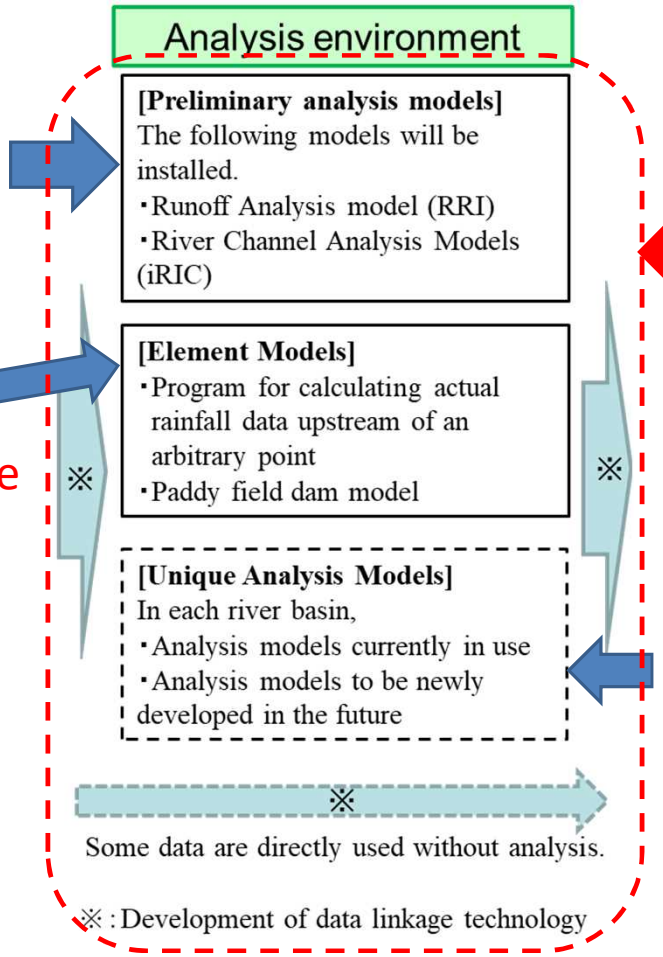
Fig. 3. Overall structure of DTB feature development

3. Development and trial of DTB

In the analysis environment, RRI models and iRIC software will be installed as preliminary analysis models in DTB.

As element models,
- a program to calculate the average rainfall data at any point upstream of the river , and
- a model to show the effect of paddy field dams

will be installed.



The technology necessary to efficiently link the basic data, analysis environment, and utilization components, has been developed.

The unique analysis models currently in use or to be developed in the future will be used in DTB.

Fig. 3. Overall structure of DTB feature development

3. Development and trial of DTB

As basic functions of DTB, NILIM developed

a rainfall data utilization support program

a flood control evaluation index visualization program

In order to reveal potential issues in R & D using DTB for public-private partnerships, commissioned researches using watershed data was carried out by a university and a private company

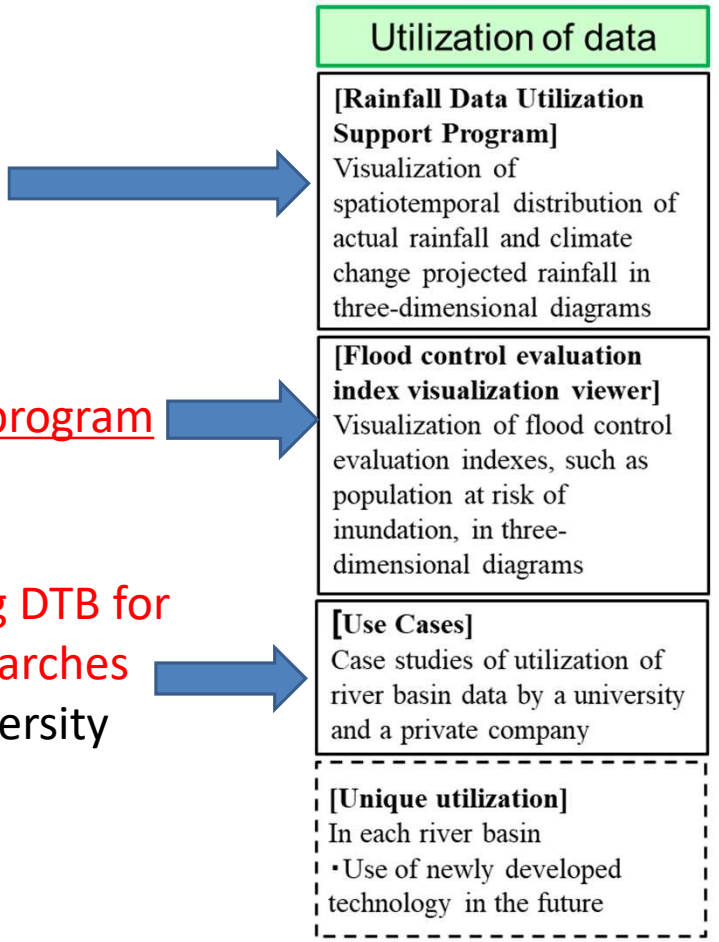


Fig. 3. Overall structure of DTB feature development

3. Development and trial of DTB

Development of rainfall data utilization support program

Because of climate change, unusual rainfall events are expected to increase in the future.
For this reason, we developed a program that displays the spatiotemporal distribution in three dimensions.

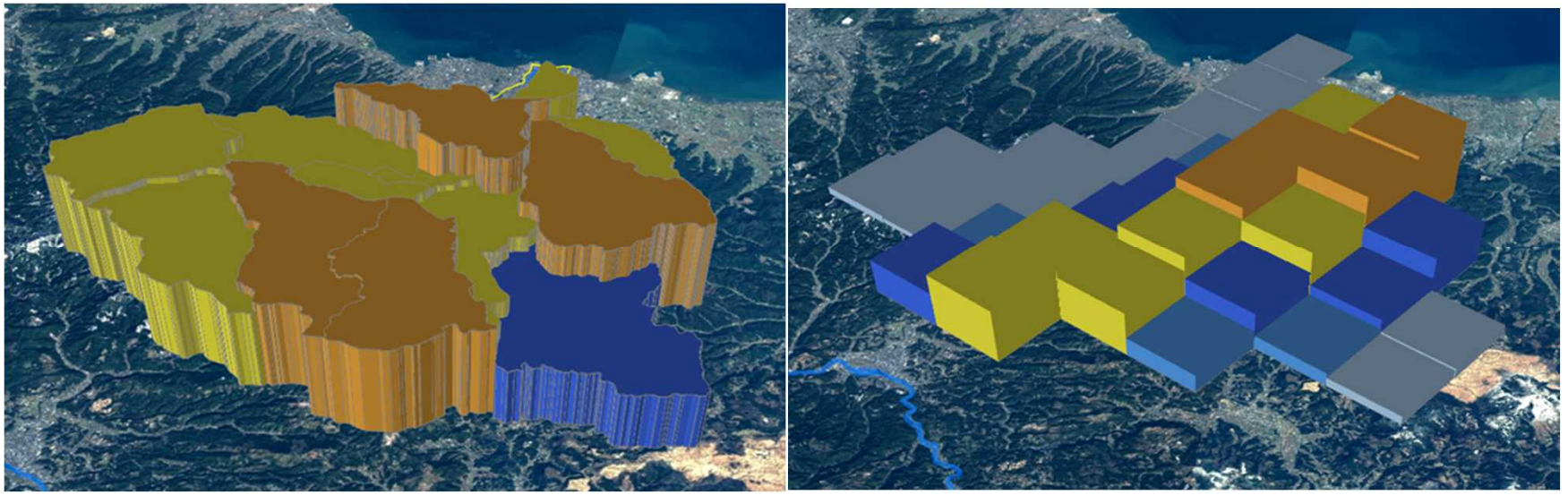


Fig. 4. Example of rainfall visualization program (Left: Actual rainfall; Right: Climate change projections)

3. Development and trial of DTB

Development of visualization program for flood control evaluation index

We developed a 3D visualization program that can display an inundation estimation area map and compare flood control evaluation indicators such as population and number of businesses on two screens.

In Japan, the spatial resolution of flooded areas and population data is different. So, we devised a method to automatically allocate the population to buildings.

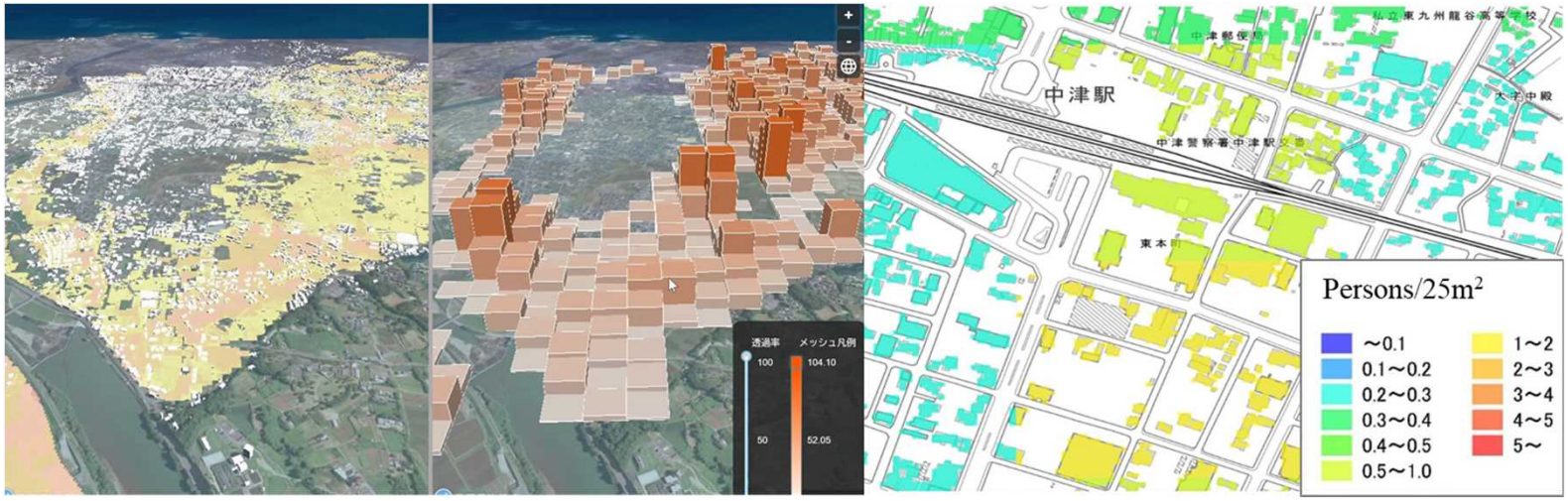


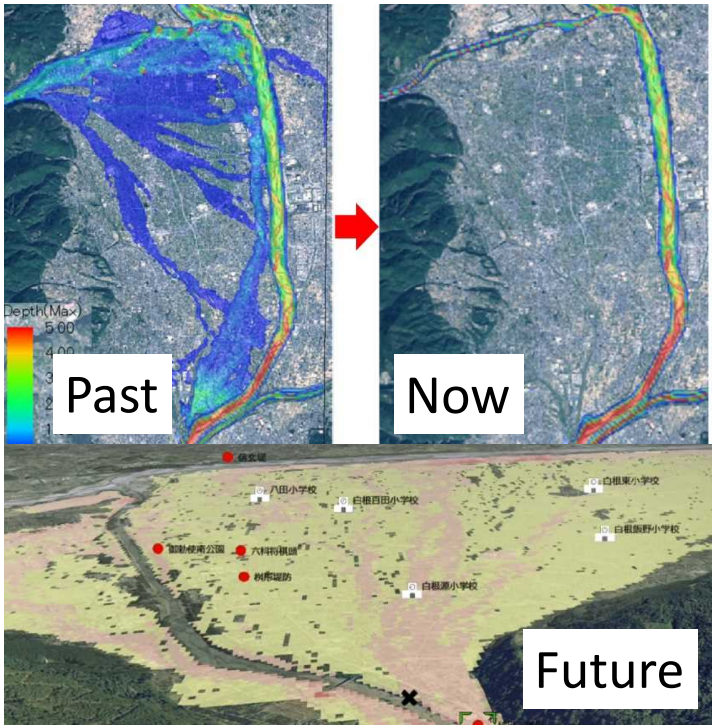
Fig. 5. Display example of 3D visualization program
(Left: flood inundation estimated area and population,
Right: Results of automatic allocation of population data to building areas)

3. Development and trial of DTB

Use cases

In order to examine the functions of DTB necessary for public-private collaboration, research was conducted with a university and a private company using watershed data and XR.

XR of Nara Institute of science and technology



XR of Pacific consultants

3. Development and trial of DTB

Trial of the development programs

We explained the functions of these development programs and exchanged opinions with the staff of MLIT and a council officials, etc.

We also introduced these programs and exchanged opinions with the participants of universities and private companies at the Geospatial EXPO held in Tokyo in January 2025.

4. Consideration

Consideration of basic data

The staff of MLIT requested that the effect of flood control measures such as river improvement in the past be visualized and explained to the people in the basins.

→ It is necessary to make the topographic data before and after flood control measures in DTB.

In 2024, in Noto Peninsula, Japan, there was a heavy rain disaster in September after an earthquake in January.

→ DTB could be used for hydraulic analysis to grasp the change of flood damage risk after the earthquake using new topographic data.

4. Consideration

Consideration of analysis environment

University officials said that the data and programs in DTB are easy to use and that the system is extensible for future research and development.

→ We need to conduct data linkage, standardization and usability improvement.

To address concerns about information security and handling of intellectual property rights,

→ we need to create information security measures utilizing cloud managed services.

4. Consideration

Consideration of utilization

Stakeholders commented that the 3D display was easier to understand than numbers and graphs.
But the quality and contents of the display required by each watershed and individual were different.

→Not only NILIM but also universities, private companies, and regional development bureaus can conduct technology development, improvement, and feasibility confirmation on DTB.

5. Summery and future plans

1) We summarized the DTB's development policy for three components;
   i) basic data
   ii) analysis environment
   iii) utilization was summarized.

2) We conducted development and trial of DTB functions and have three main requests;
   i) introduction of past data and new observation data,
   ii) ensuring convenience and safety of DTB,
   iii) development of systems in which DTB can be used by organizations other than NILIM.

3) MLIT aims to start limited operation of DTB by the end of FY 2025.

5. Summery and future plans

In order to promote public-private partnership, nationwide deployment and customization,
DTB will be expanded to three usage fields: research, development, and trial.
In FY 2025, only development fields will be operated.
Research and trial fields will be operated sequentially according to the usage of DTB.

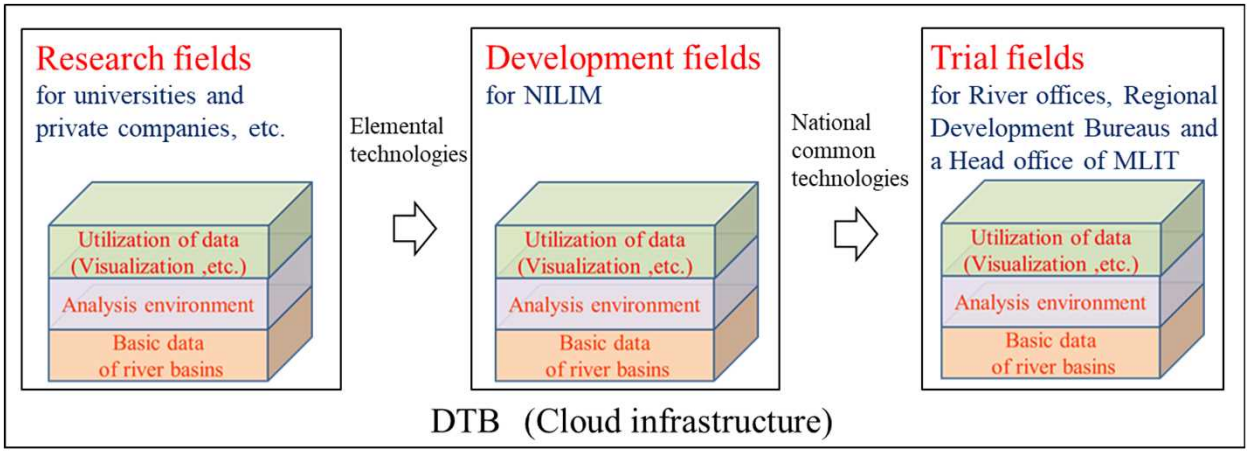


Fig. 6. Three usage fields of DTB

Research fields: Universities and private companies will conduct research using basin data.
Development fields: NILIM will use the results of research fields to develop common technologies nationwide.
Trial fields: River offices, regional development bureaus and a head office of MLIT will confirm the practicality of the technology in development fields or customize it in trial fields.