

Original Research

Virtualization System as a Decision-Making Report: A Case Study of the National Research Council of Thailand

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Abstract

According to the administration of research data and funding for governmental organizations and funding agencies, the National Research Council of Thailand (NRCT) employs a National Research Management System (NRMS). NRCT needs different categories of data to provide information to various government departments to make policy decisions related to research funding. NRMS has so far collected a significant amount of such data. However, the tools needed for prompt analysis of such large amounts of data are inadequate. The purpose of this article is to discuss a multi-dimensional report system to provide enhanced information to support the decisions of policymakers. This involves creating reports with diverse views based on the numerous fields in the system, such as sorting by year, funding entity, ministry, department, policy and research strategy, and research issues, etc. and exhibiting a dashboard report to the officers and executives responsible for decision-making in the form of an overview of national research data by using Business Intelligence (BI). For the development of the report system, the research uses Tableau software. The officers who assessed the proposed report system expressed satisfaction, as shown by the outcomes of the user evaluations. A key feature mentioned was the ability to submit more reports to high-level administrators quicker.

Keywords: National Research Management System, Business Intelligence, National Research Council of Thailand, Virtualization System, Decision-Making.

Introduction

The National Research Council of Thailand (NRCT) has used the National Research Management System (NRMS) for administer to research information and budget of governmental organizations and funding agencies. However, current problems of the NRCT are

1) a lot of data has been collected in the NRMS 2) lack of report featuring diverse perspectives and capacities of data analytics for presentation to the policy makers in different governmental agencies. For policy-based decision making, analytics on research data from NRMS are required in various forms of reports. Current problems of NRCT, nevertheless, are lack of many tools for data analysis and reporting systems that serve the executives' needs, such as analysis of the status of research works in the country from the year 2008 to the present to formulate a guideline on research fund allocation; and 3) delayed work on providing reports. Previously, NRMS staff had to retrieve data from the system and use Microsoft Excel to produce reports for the executives. This is time-consuming because much time is required to create a new report so that the information will be as current as needed by the executives. In Korea, a Research network and Knowledge map system analysis was implemented to visualize the information in the form of a knowledge structure network and show the presentation of research data for strategic decisions (Shon, Han, Kim, Cha & Ryu, 2017). Apart from this, it is possible to determine Business Intelligence (BI) to manage data because data quality and master data management have been concerned as the most important (Baier, L. et al., 2020) as shown below.

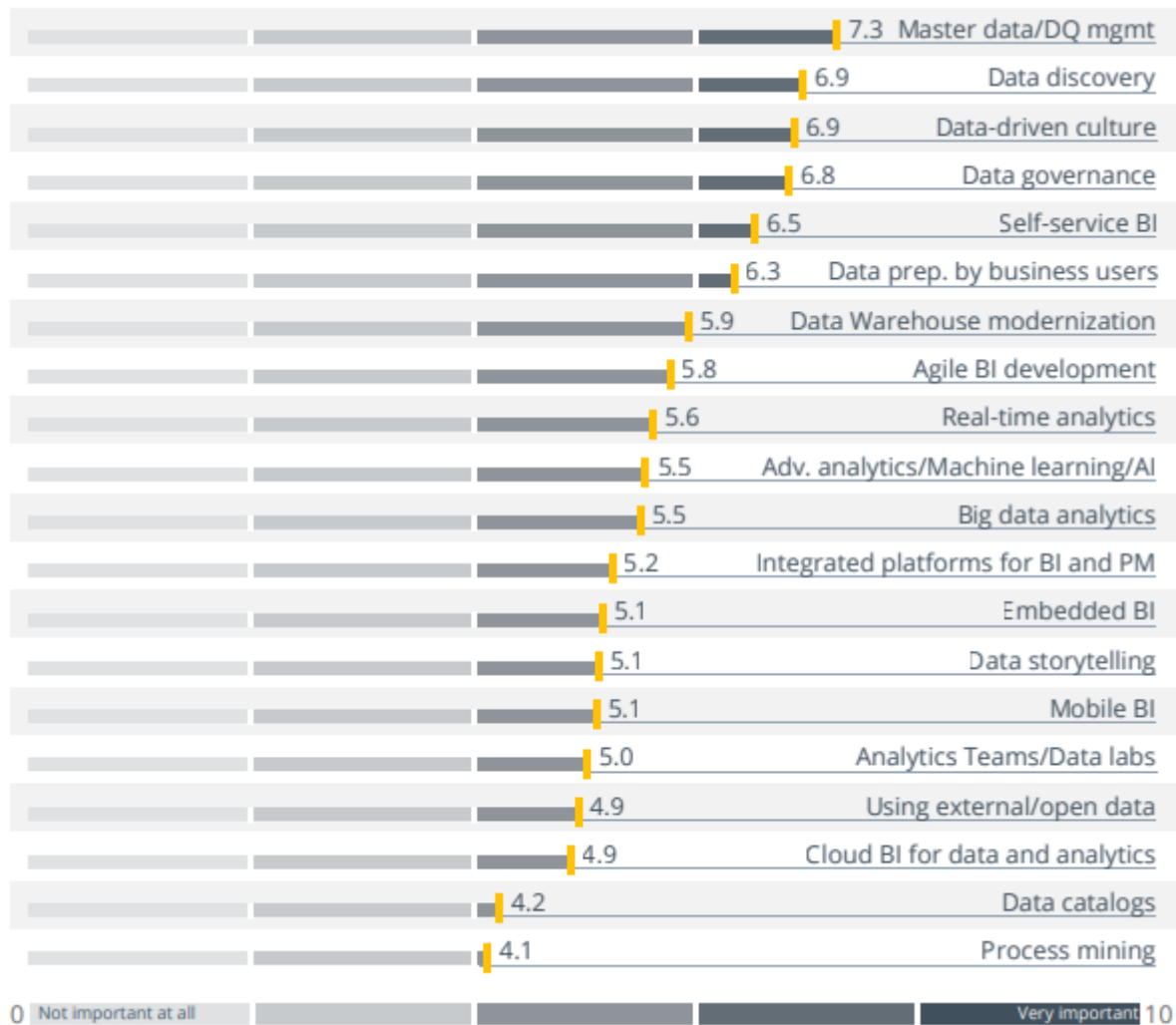


Figure 1: Importance of BI trends (Baier, L. et al., 2020)

As a result, this research aims to improve report systems in diverse perspectives to support policy-based decision making of NRCT through the use of Business Intelligence (BI). The system is designed to create reports that satisfy different purposes as well as presenting the reports in the form of a dashboard. This will facilitate the NRMS staff with an innovative tool to perform data analytics and present results to executives in a much easier way. At the same time, the NRCT's executives can apply the tool in planning and policy-based decision making by them.

Research Objectives

1. To analyze the needs to use research data of NRCT; and
2. To improve the report system in different perspectives to support policy-based decision making.

Literature Review

Business Intelligence (BI)

Hung and Chen (2020) mentioned that BI is an information technology tool used by users to process and analyze a lot of data of various sources and structures to effectively satisfy users need. It is also the tool to support decision making management for every task. BI system has three main features (Srisomrak Inthuchanyong, 2013) as follows:

1. Tools to extract transform and load in storage. Well known in terms of ETL, it helps sorting specific data required by a user out of every combined source. It works by data cleansing so that the data are consistent before being stored in a data warehouse.

2. Data warehouse is required to store some data extracted from a source inside an organization or the information technology system at functional levels. Information resources from outside the organization which the executives consider necessary for working, decision-making and personal data will be prepared in a form available as the analytical data. The data warehouse will serve as a database for an analysis with various commands, such as On-Line Analytical Processing (OLAP), Data Mining and other types of information technology systems.

3. Commands for analyses will consist of a set of commands to analyze various topics. Users will select some commands they need (Xiang, Fuchs, Gretzel & Höpken, 2020) as follows:

- (1) Commands for making a report include presentation of a report from an ad hoc query. The report to be presented is often results of performance according to an indicator, various performances of an organization or a follow-up and goal values of some important performances. The presentation of a report often comes in the form of a graph to facilitate understanding through the dashboard that users can access from an already made website.

- (2) On-Line Analytical Processing (OLAP) is a command which enables users to analyze data from a warehouse. Usually, the analysis of data is multidimensionality to help analysts to see in-depth information in different perspectives, thus promoting better understanding about a situation.

- (3) Data Mining is a command used to analyze data to find relations with data never discovered or expected before. Finding a new thing before others may be beneficial in a competition. Results from the analysis from the data mining, such as an analysis for

categorizing customers, sorting out a group of customers, finding types or behaviors of customers in a group, predicting customers' behaviors which may lead to any wrongdoing like organizational corruption.

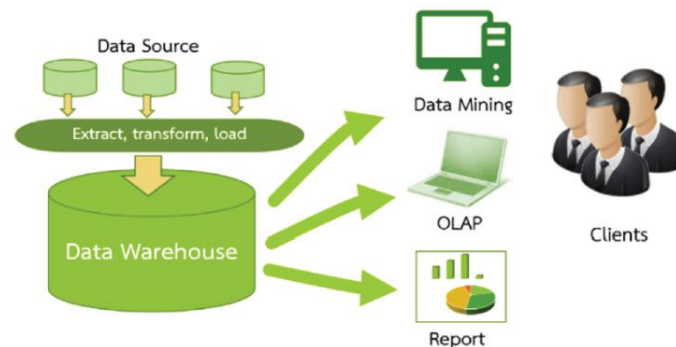


Figure 2: Components of Business Intelligence System

Dashboard

Key, Howe, Perry and Aragon (2012) and Witthaya Jitphakdi (2010) claimed that the dashboard was a presentation of data by selecting an interesting report or graph and showing them on the same screen. The executives or users can realize an overall picture of important data clearly and quickly, such as presentation of Balanced Scorecard data in terms of income compared with marketing capital costs or KPI in various perspectives as required.

Visualization

Arthit Sitthibanjerd (2009) and Kodaka, Kawasaki, Shirai, Acierto, , Zin & Kohtake (2020) said that visualization was crucial for perception which is a part of data or result presentation between a computer and users in the form of images because images enable users to learn and memorize data through looking at them better than using other kinds of senses. Later, images are used to present or serve as a conceptual framework and support decision-making.

National Research Management System (NRMS)

National Research Council of Thailand (2016) developed the NRMS in order to manage researches conducted by researchers, governmental agencies and the NRCT itself. Development of NRMS was initiated by the request of the Bureau of the Budget (BB) who wishes to know the effectiveness of the research budget granted to all governmental organizations. The NRMS composed of a researcher database, a proposal assessment subsystem, an ongoing research monitoring subsystem and a research evaluation subsystem.

Literature Review

Horakova and Skalska (2013) studied the business intelligence system and performance for a small size organization. They found that the system provided users with information technology and data analyses that supported better business strategies and processes. Their study shows a summary of present data, trends, and characteristics of tools for the business intelligence system that helps to solve problems of small and medium businesses. The example of using the business intelligence system in a small organization showed that the

multidimensional data analysis as well as application programs could be designed in proper operation and function in a small company.

Paphada Phokhamaphichai and Monthien Rattanasiriwongwut (2014) already developed a business intelligence system for a production plan inside an organization to support decision-making of the executives in analyzing marketing trends and having exact performance guidelines. This includes adjustment of business strategies in competition by using the system which includes creating a data mart, using existing information technology to make a dashboard, being able to adjust analytical perspectives to suit the executives' and users' needs. Results of the quality assessment of the system by an expert concluded that development of the business intelligence system, when applied to production plan in an organization, was practical at the good level.

Thipcharoen (2014) referred to characteristics of a big data, components for analyses of the data and use of tools or the business intelligence system to analyze the big data to provide opportunities or competitive advantages of entrepreneurs. A case study of different perspectives indicated that the big data was beneficial to an organization's business decision making, using the business intelligence system as a tool to analyze business data.

Mahatthanasin and Jirawichitchai (2015) developed a system of data warehouse for sale analyses of the Provincial Waterworks Authority (PWA), using techniques of processing in terms of on-line analyses and data presentation in the form of a report from the business intelligence system. The input data came from a daily sale database from which the data were extracted and transformed in terms of a data warehouse. This system was designed to support decision making about sale planning for the executives. According to an assessment of users who experimented the database, the satisfaction rate was at the good level.

Kubina, Koman, Kubinova and Finance (2015) presented possibilities of enhancing effectiveness of the business intelligence system used in a company. They explained that the system was effective in processing results and analyzing data of an organization from different data resources. This enables an organization to obtain important data and find advantages in competition. In this regard, processing data results is related to big data technology which helps manage unstructured or semi-structured data, therefore integration of the big data and the business intelligence system are required for consideration to support better management and decision making.

Research Tools

The relevant research tools in developing performance systems include the followings:

1. NRMS System

The NRMS system is software for management and a data resource to develop report systems.

2. Microsoft SQL Server 2012

This research uses the Microsoft SQL Server 2012, a database management system, because the NRMS uses it as the database management system and connects the Tableau program to create multidimensional data.

3. Tableau

Tableau is software on the business intelligence system which able to connect databases through many platforms, such as Excel, SQL Server, Oracle and Microsoft Analysis. This study

uses the Tableau Desktop program to develop multidimensional forms of report systems and the dashboard report page as well as allowing users to use report systems through Tableau Server and Tableau Public.

Functions of the Tableau software can link databases of the NRMS system which uses Microsoft SQL Server 2012. It also has functions for data analysis to calculate field and forecast. Besides, it can create a tool to assist users, such as drill down data presentation and filter. Users are allowed to import data in the form of a table, which corresponds to the needs of NRCT's staff.

Tableau is one of the first programs on business intelligence ranked by Gartner (Parenteau, Sallam, Howson, Tapadinhas, Schlegel & Oestreich, 2016) but there are some other programs with similar capacities to Tableau, such as Microsoft Power BI and QlikView. Nevertheless, the Tableau is used because NRCT has copyrights to use it and it has functions appropriate for the research's scopes.

Materials and Methods

This study highlights the following processes: 1) studies about functional processes of NRMS systems 2) collect and analyze NRCT's staff and executives on needs of using research data 3) develop data from NRMS in the form of multidimensional report systems and present the report via the dashboard, using the business intelligence system and 4) assess satisfaction of NRCT's staff.

Development of multidimensional report systems is described according to the following research methodologies:

1. Studies on Functional Processes of NRMS

The NRMS is an operational database using Microsoft SQL Server 2012 for data management. It stores data, such as data about researchers, research proposals, budgeted research projects, application of research works and concerned operations like a project's budget allocation, progress reports, qualified people's assessment results and research's information technology.

2. Data Collection

This research surveyed and collected data on the needs to use research data of NRCT's staff and executives by reviewing many documents, namely official documents, memorandums and 337 topics in complaint on-line filing systems of NRCT. Then, data forms were summarized according to the needs of users in different topics and perspectives, such as overall image data summarizing the number of projects and budget or project details. In terms of data categorized according to various perspectives such as years, funding agencies, ministries, policy making organizations, research strategies and topics, they aim to design and create data view from NRMS as well as report dimensions. Data from NRMS to be used for a report are of 120 GB size.

3. Development of Multidimensional Forms of Report in Systems

According to users' needs, a report system providing real-time data is required. Also, the system should capacitate multidimensional presentation; that is, a report should present various perspectives and presentation of different topics, such as the fiscal year, the organization and research topics. This research studies design and creation of data via NRMS, which is an

operational database, using Microsoft SQL Server 2012. In creating data perspectives, a study on data dictionary was conducted on NRMS to allow understanding of which tables provide data needed and which fields serve as primary or foreign keys. By doing so, it will result in correct data connection and data types as shown in Figure 3 below.

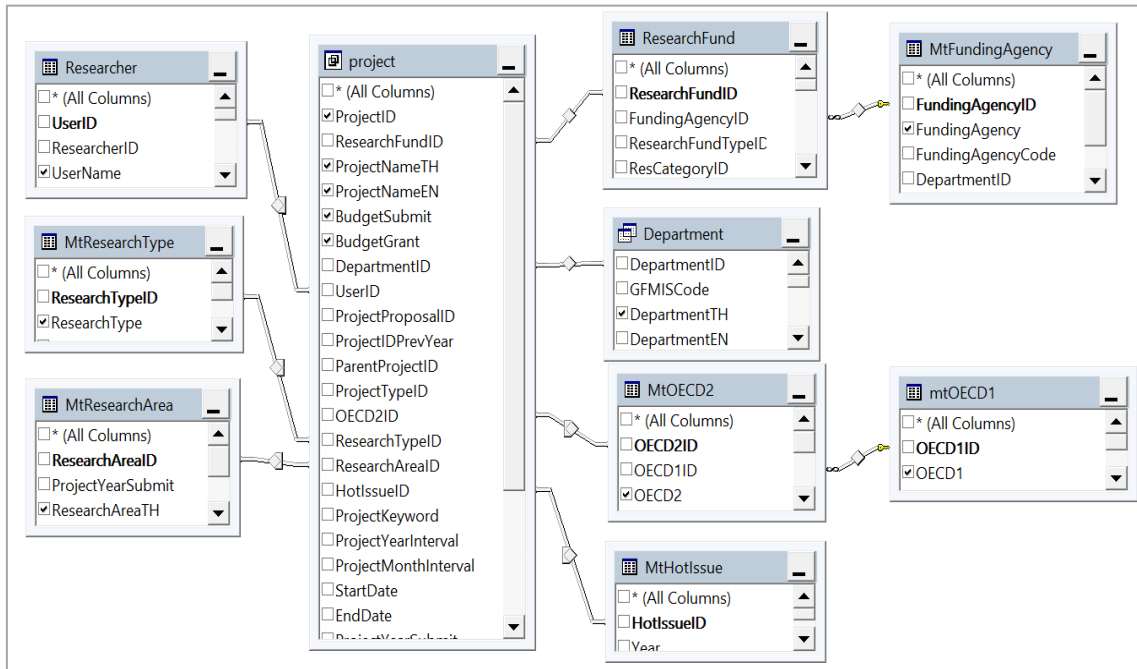


Figure 3: Sample of Data Design and Creation

Afterwards, the Tableau Desktop, which is a program on business intelligence, was connected as it could link data on several platforms, such as Excel, SQL Server, Oracle and Microsoft Analysis. By doing so, it requires specifying data dimensions and calculating measures. In this study, the data dimensions belong to the ones existing in the system, such as the fiscal year, funding agencies, ministries, organizations, research policy and strategies, research topics and areas. The values of data to be calculated are the amount of budget proposed and approved for a research project as shown in Figure 4 below.

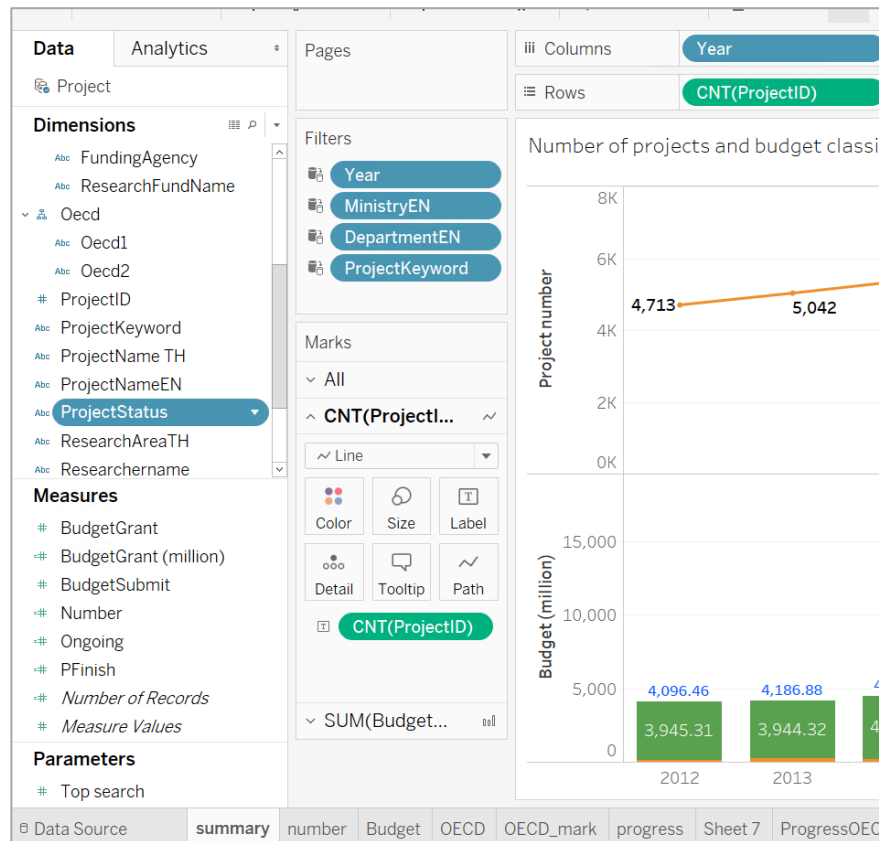


Figure 4: Development of Reports by Tableau Desktop

After developing report systems, they will be available via the Tableau server for NRCT's staff and executives. Connecting with the NRMS's database, the report shown in the server is typically real-time while public can view it by using the Tableau Public from the website of NRMS. The report via Tableau Public is separated from the extract database system, so it provides information not real-time.

Report presentation will be complete according to the visualization theory to create interesting graphs understandable for users. A technique of chromatic selection is used to separate information. For instance, green indicates a research project already completed while orange shows an on-going project. Selection of graphs to show data depends on needs for specific data presentation. For example, comparative data presentation will be shown as a bar chart while proportion of research budget will be presented by a pie chart. Besides, developing report pages in the form of the dashboard features presentation of relevant graphs on the same page so that users can view overall research perspectives better and compare one set of data to others as shown in the Figure 5 below.

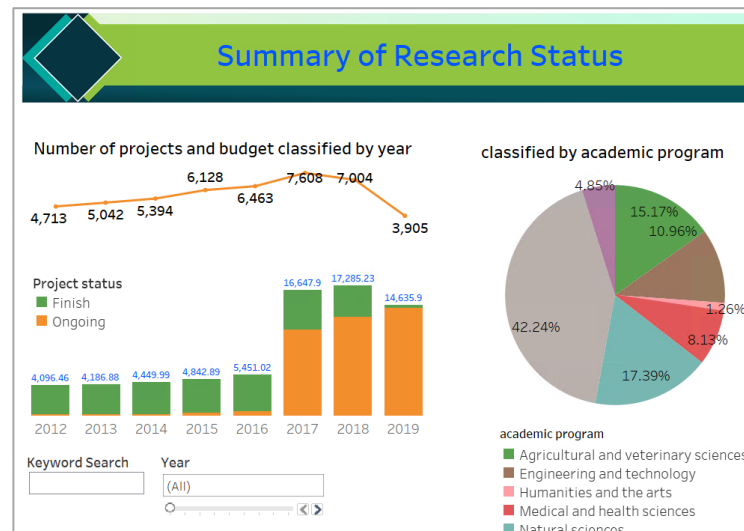


Figure 5: Developing Report Pages via the Dashboard

4. Assessment of NRCT's Staff's Satisfaction concerning Multidimensional Report Systems

The assessment was completed by a questionnaire to evaluate satisfaction and opinions of the executives and staff of NRCT, namely data supervisors, NRMS supervisors and NRCT's executives. It consists of the following topics: report's completion and accuracy, rapid data presentation and report system, attractive physical form of the report, convenient use and clear meaning expression of the report.

Results

According to the study on the needs to use research data of NRCT, it was found that the needs of current data were required in terms of the overall research picture which can be categorized by years, funding agencies, ministries, research bodies, research policy and strategies, research groups and topics. The data can be retrieved in the form of project details. Also, there are needs to know about researchers' status in relation to each research topics. This study used researchers' information and data on budgeted research projects to make a report and presentation in the form of the dashboard under 4 characteristics as follows:

1. Image Data of Status Combination

As shown in Figure 6, the data present research completed by an organization according to years, funding agencies, research bodies and research strategies as well as research topics.

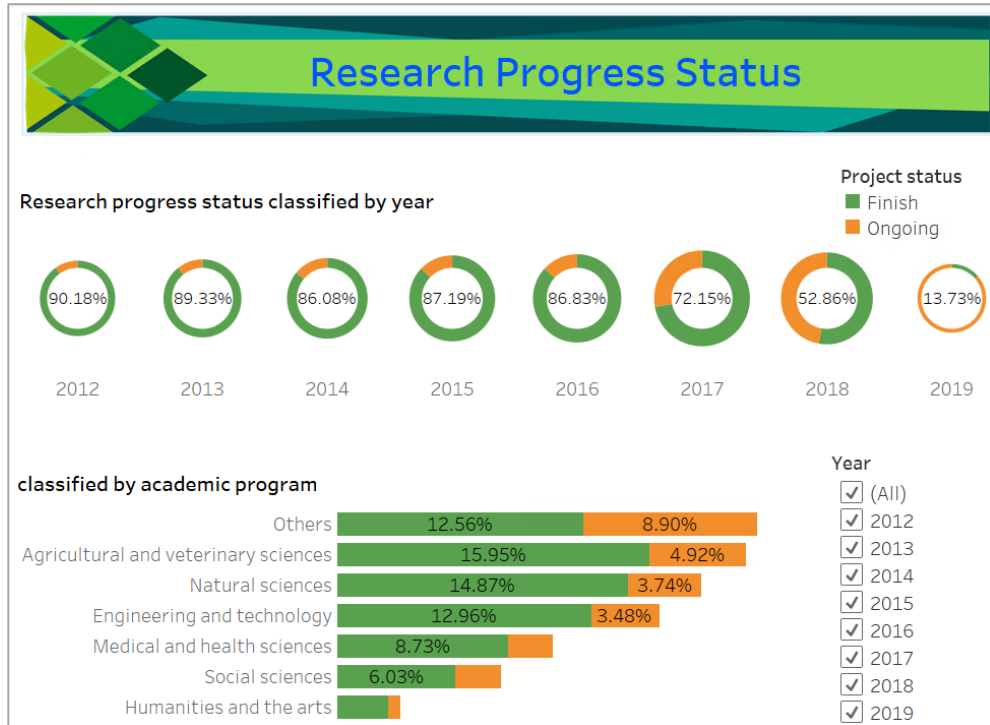


Figure 6: Report on Research Progress Status

2. Summary Data on Project Number and Research Budget

The data were presented in terms of areas where a research is conducted as shown in Figure 7.

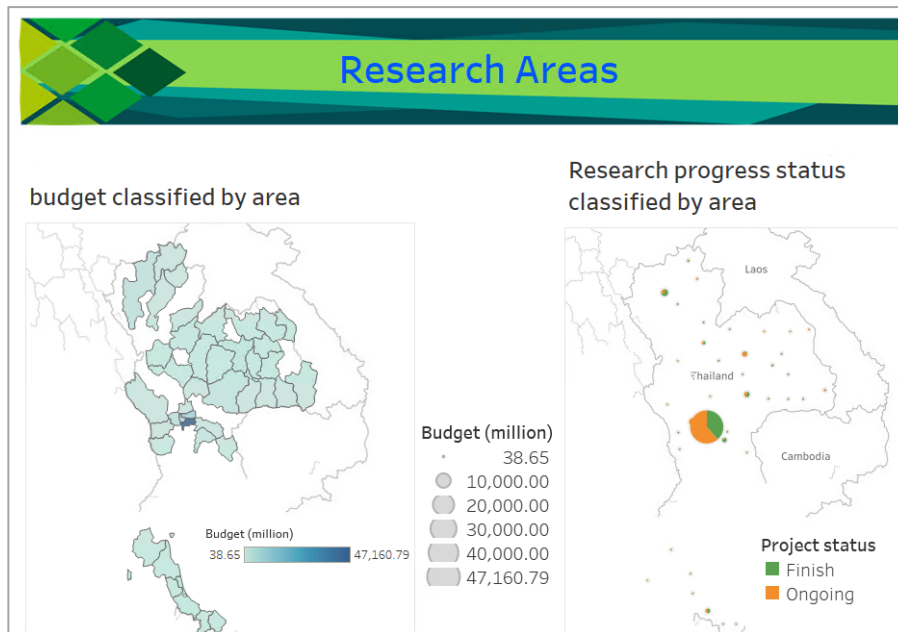


Figure 7: Report showing Research Areas

3. Data on Research Topics

The data can be categorized according to years and sub-groups of research works.

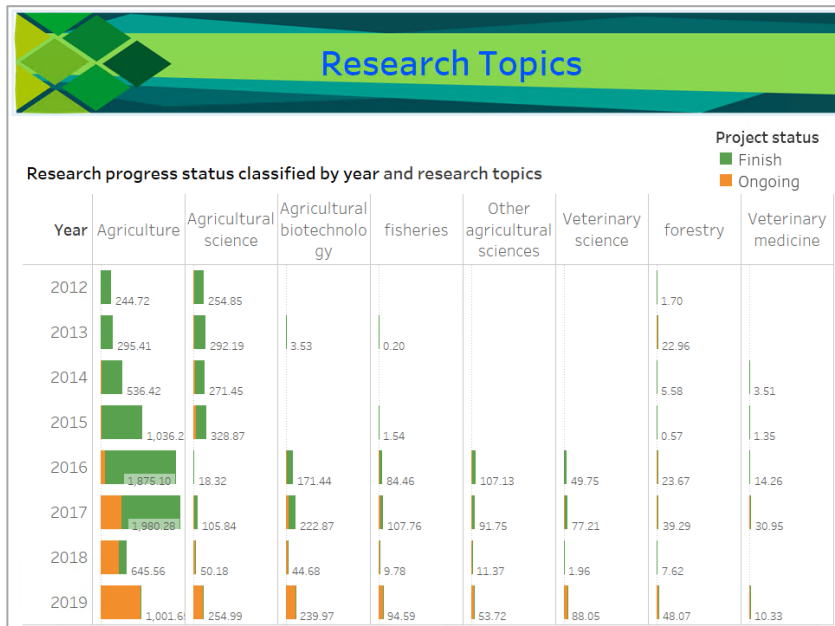


Figure 8: Report according to Research Topics

4. Data on Research Personnel’s Status in terms of Major Topics

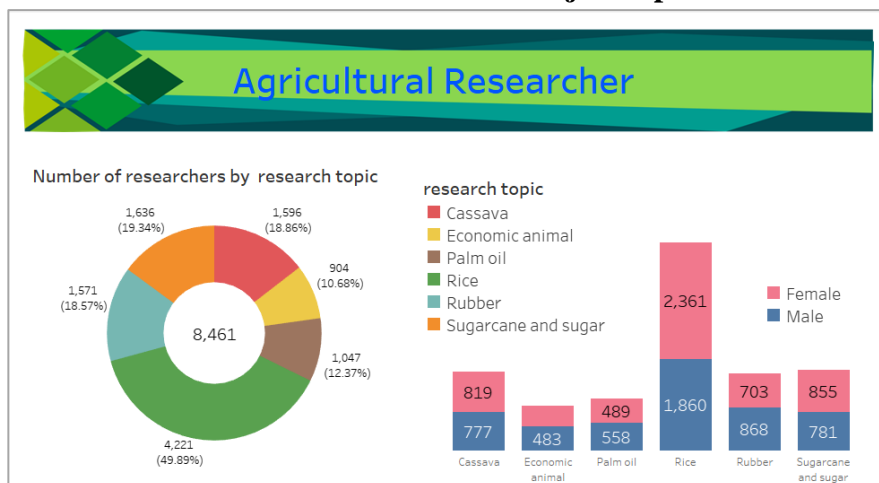


Figure 9: Report of Research Personnel’s Status

Development of report systems has found a tool to assist data analyses of a user. Presenting drill down data, filter data and parameter for a graph are required, namely a graph in which an order of budget amount is arranged from the highest to the lowest. Users have to indicate numbers in the parameter themselves. Besides data presented by the graph, users can select any data they are interested in and retrieve them in the form of a table, either the one that summarizes overall data or the one that shows details of individual project. Figures 10 and 11 show an example of tools for user assistance.

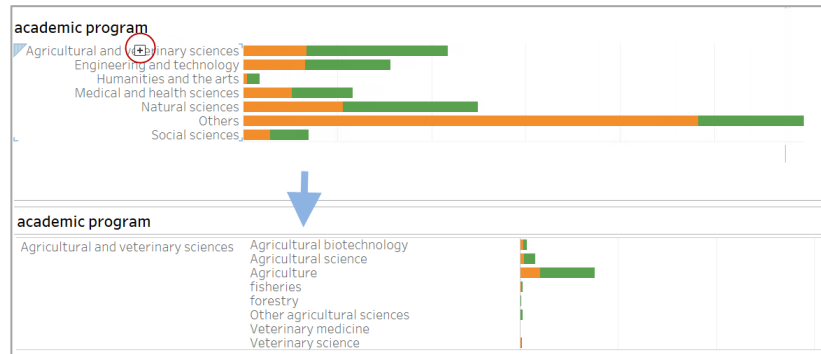


Figure 10: Presentation of Drill Down Data

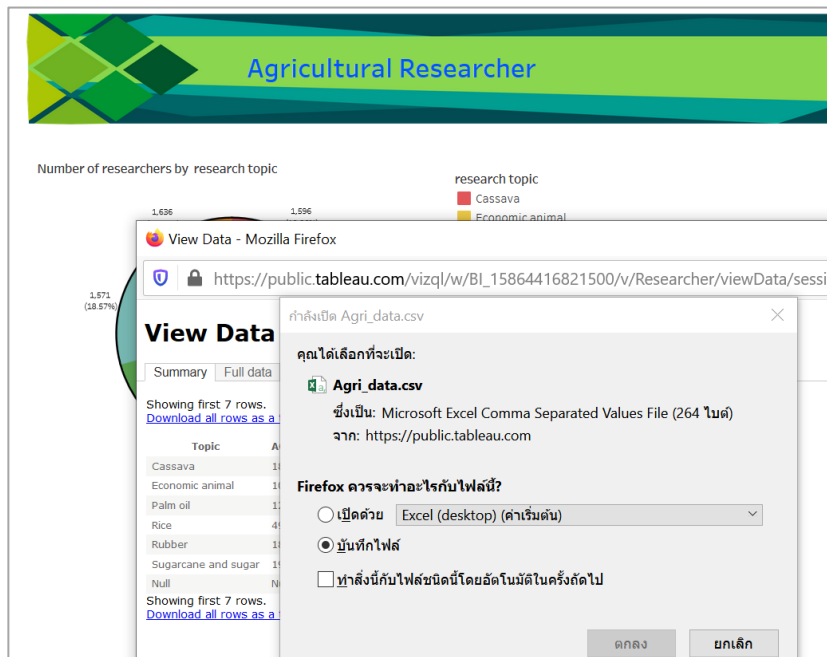


Figure 11: Transferring Data to Table

Assessment of satisfaction and opinions of NRCT’s staffs and executives concerning multidimensional report systems is divided into 4 levels: 4=very satisfied, 3=satisfied, 2=unsatisfied and 1=very unsatisfied. Overall users were satisfied with the report system (3.31 by average) in terms of fast data visualization as well as Easy to use (3.43 by average).

Table 1

Assessment of user satisfaction

| Topic | Average | Level of satisfaction |
|---|-------------|-----------------------|
| 1. Completeness of electronic reports | 3.29 | satisfied |
| 2. Accurate information in reporting data and figures | 3.29 | satisfied |
| 3. Fast data visualization | 3.43 | satisfied |
| 4. User interface design | 3.14 | satisfied |
| 5. Easy to use | 3.43 | satisfied |
| 6. Clearly interpreted report | 3.29 | satisfied |
| Overall items of the report system | ๓,๓๑ | satisfied |

A dashboard is defined as a data-driven support tool for decision making by querying multiple databases and providing a visual representation as (1) providing benchmark (2) providing notification (3) providing prediction and (4) providing summarized data. The benchmark with performance can assist with quality assurance and quality improvement. The notification can minimize adverse events by sending alerts if key metrics deviating from acceptable ranges. The prediction can show the outcomes based on current information. The summarized data can display an intuitive visual format in order to guide decision making for management. The future implementation of this system could be more flexibility and scalability for users in all operation levels. Also, Natural Language Generation (NLG) for automatic textual summary need to be developed in order to make the system more intelligence.

Discussion

Tableau Desktop is a business intelligence application for visual analytics. User can connect to data from several sources and formats; therefore, it can bring information from other sources to participate in the analysis and compilation of relevant information such as information about the agency's indicators, following-up data and NRCT's staff's research progress, etc. The purpose of this study was to improve the report system of NRCT's research data in order to support policy-based decision making. The result is in line with previous studies such as Horakova and Skalska (2013), Paphada et al. (2014), Thipcharoen (2014), Mahatthanasin and Jirawichitchai (2015) and Kubina et al. (2015) that the business intelligence system can be used for planning and decision making. The finding of this study also attempts to defend the view of Zeng, Xu, Shi, Wang, and Wu (2006) that many business intelligence applications are still difficult to deploy. The assessment of user satisfaction shows user's intention to accept a new proposed system because it can manage the current problem of NRCT with a data overload problem, no data visualization and more time-consuming to interpret data. This study has also shown that visualization system has a significant relationship with decision-making report as high level of user's satisfaction. This shown that users are willing to try new things and have a more positive attitude towards modern technology. However, user interface design needs to be more concerned in order to increase information quality. This study makes a significant contribution to existing literature by developing a visualized report with high level of satisfaction. Fast data visualization and easy to use are key success factor to develop a virtualization system as a decision-making report.

Conclusion

According to the study of the needs to use data of NRCT, interactive data should be updated frequently. The data should consist of overall research details, particularly years, funding agencies, ministries, research bodies, research policy and strategies, research groups and research topics as well as researchers' status. This research has developed systems of multidimensional report and various forms of dashboard to support policy-based decision making so that NRCT's staff make a report for their executives rapidly under diverse perspectives. Also, the staff can find interesting information they have never found before, namely average ages of a researcher, educational levels, academic positions and research topics. Such presentation can be completed by the Tableau for quick analyses. According to the assessment of satisfaction, users were satisfied with the report system and were able to use them for presentation to the executives and policy-based planning rapidly. The major tool to develop

the report system under this research is the Tableau as it can facilitate selection of any interesting data and extract them in a table. This is suitable for users who do not need any commands to retrieve data via NRMS and they can view a report and extract the data easily by the Tableau's tools. Also, data imported are real-time, reducing workload of system supervisors in terms of creating commands for data import.

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