

Web-based GIS Atlas of Rice in Asia

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Abstract

A significant number of requests for geo-referenced rice statistical data had spurred IRRI to create and host a web-enabled GIS atlas of rice. The aim of this project is to make available a geographically referenced dataset of rice statistics for public use. The atlas features spatial and temporal information at sub-national level of rice acreage, yield, production, and type of culture.

Presenting the statistics in an interactive map form allows the user to identify trends, patterns and/or relationships spatially. The atlas enables users to interact with the database and allows them to make maps and perform simple query analysis. The user, for instance, can assess trends in rice area or yield over a given number of years at the sub-national level or at the national level. This tool allows users to integrate information, visualize scenarios, and develop effective solutions in deciding how to prioritize and allocate limited research resources to address production challenges.

1 Introduction

In 1982, IRRI published the Rice Area by Type of Culture: South, Southeast, and East Asia. This was the first attempt to map the rice growing areas in Asia. The publication includes three large colored maps of the different rice cultures (Upland, Deepwater, Rainfed Shallow, Rainfed Intermediate, Irrigated Wet Season, and Irrigated Dry Season) for South Asia, Southeast Asia, and China and Korea. The extent of rice area for each culture type was mapped using repeated symbols. A revised and updated version, published in 1997, reported not only rice area but also yield and production by sub-national administrative units. The data sets and maps were presented both in printed and also in GIS-based digital formats. Both publications remain in high demand and the significant number of requests for rice statistical data had spurred IRRI to create and host a web-enabled GIS atlas for rice. The contents of the atlas have been expanded to other rice-related datasets.

GIS technology facilitates our ability to map and visualize spatial data. More recent advances in information and communications technology, increasing accessibility and widespread use of the Internet present opportunities for GIS data sets and services to be offered on-line. At IRRI we are taking advantage of Internet mapping and web-services technology to make available the Atlas of Rice for public use. Earlier attempts to make the “Rice Area by Culture Type” database accessible on-line, with simple map manipulation functions, were made based on ArcView 3.x[™] with a customized interface.

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The products - The Asian Rice Spatial Statistics (ARSE) and the World Atlas of Rice Production Statistics (WARPS) – are still functional, but accessibility is confined to limited users because of software licensing limitations. Intra- and Internet based GIS applications provide the means for availing online mapping to a wider user base.

2 Implementation of the web-based Atlas of Rice

2.1 System configuration

We make use of ArcIMS[™] and the Jakarta Tomcat Servlet to provide online mapping capability for the rice statistics database that IRRI had been compiling at sub-national level. The database and software are hosted on a dedicated server (a Dell PowerEdge 4400 Dual Processor) named 'GISMAPSERVER', running on MS Windows 2000 Server SP4 with IIS 5. This server is connected to the IRRI network and to the Internet. Installed in the server are the GIS data, Internet Information Service (IIS) for web publishing, ESRI ArcIMS for Internet mapping service and Jakarta Tomcat servlet to bridge IIS and ArcIMS.

Two components were constructed to build the Atlas of Rice, namely the GIS database component and the web component.

2.2 GIS Database

2.2.1 Spatial data

The spatial component of the Atlas database consists mainly of digital maps of sub-national administrative boundaries for most rice-growing Asian countries. The administrative boundary maps for a number of Asian countries were provided by the *Population Database for Asia* project [Deichman, 1996]. Correction and updating of the boundaries was done in-house by staff members of IRRI's GIS-IP Laboratory. Whenever possible the source maps were obtained from the most authoritative agency, preferably the national mapping agency in each country and preferably at lowest sub-national level available. Table 1 shows the scale in which the different countries were digitized. For the Atlas, all spatial layers are maintained in geographical coordinates.

Through mapping activities related to country-specific projects, we also have maps of delineated rice areas for selected countries including the Philippines, Malaysia and Vietnam. The rice area maps were derived mainly from land use maps for these countries.

2.2.2 Non-spatial data

The attribute data sets contain mainly rice statistics at sub-national level. These data sets are stored and maintained in an Access format. In the early

[™] ArcIMS is a trademark of the Environmental Systems and Research Institute (ESRI), Redlands, CA, U.S.A.

1980s a major effort was undertaken to gather rice statistics for the Asian rice producing countries, with the exception of Japan. An attempt was made by IRRI scientists to categorize rice growing environments by water regime, resulting in the “rice by culture type” classification with six categories (see Table 2) that have direct relevance for research prioritization. Knowledge of area extents under different rice culture types (i.e. irrigated, rainfed shallow, rainfed intermediate, deepwater and upland conditions) would indicate the relative importance of these rice culture types and guide rice research institutions in deciding how to prioritize and allocate limited research resources to address production problems in these environments.

However, many countries do not report rice area by these culture types or environments. A concerted effort was made for in the mid-1980s to collect official rice statistics from the various Asian countries. Then, in consultation with knowledgeable rice scientists from the National Agricultural Research Systems (NARS) and through examining maps and satellite imagery, estimates were made of rice areas under the different culture types [Huke, 1982]. A repeat exercise was made in 1997 to update the rice area estimation by culture type, and in the process other relevant data on yields and production were added where available [Huke, 1997]. The tabulated data at sub-national level from the 1997 updating comprise the attribute data sets of the Atlas of Rice linked to the administrative boundary maps.

Time series rice statistics on production, yield and area harvested are also being collected and collated on a regular basis from official publications of the various government agencies and through with NARS research partners. The data are continually checked and converted into international units of measure for inclusion into the country attribute data sets. Other data (e.g. on demography) that are readily available and of potential interest and use for rice researchers are also included in the country attribute data sets.

2.3 The Atlas of Rice homepage and Map Services

We developed the Atlas of Rice homepage (http://gismapservirri.cgiar.org/Atlas_of_Rice) as a web interface for online access to the GIS-based rice database (see Figure 1). The homepage also links to the GIS-IP Laboratory and IRRI homepages through the globe and IRRI logo respectively. Presently the IRRI GIS-IP Laboratory home page is accessible by registered users only. The Atlas of Rice homepage is a dynamic page that launches the online map service and enables users to search for available data sets and electronic mapping services. Clicking on the Search button brings up the database selection window, whereby the user may choose the map category and geographical area of interest.

We used ArcIMS’s built in wizards to design, create, and manage the online map service. There are a number of map services available based on the category-location combination selected by the user. Table 3 lists available map services, which are presently limited to simple display, navigation, data query, and mapping tools similar to those commonly found in desktop GIS software. The interface components are listed in Table 4 and shown in Figure 2.

Almost all the map services that we developed make use of scale dependent layers, labels and symbols. This feature allows presentation of additional information at larger viewing scale. This does not only reduce downloading time and increase processing speed but also allows data of varying detail to be put into place at particular magnification levels. Figure 3 illustrates the application of scale factoring and scale rendering. The first scene shows the location of rice growing area (single symbol) and regional boundaries of the Philippines. When viewed at a larger scale the cropping practices adapted in the particular rice growing area (multi symbol) and provincial boundaries are drawn in.

The Atlas is still in the developmental stage and it is likely that modifications will be made to the interface prior to application completion. The map services that have been developed and are presently available online for a number of GIS databases are described below.

- **Administrative Boundaries**

This service provides simple viewing and querying facilities. It provides information like name and land area from national to the smallest available sub-national level. Figure 4 shows an example of the Malaysian Administrative Map Service at different viewing scale. Scale dependency was employed for each administrative layer. Because the different map layers are sourced from different organizations, common boundaries often did not align properly. This poses a problem when these map layers are displayed together, and when scale dependent display is invoked. Map realignment was achieved by making minor corrections to the bounding coordinates in ArcView. This problem is not readily solved in the case of maps from other countries. For example in the case of the Philippines, the boundaries of the smallest administrative units (the municipality and the barangay) and those of the higher administrative units (the province) are too poorly aligned to be co-registered (see Figure 4b).

- **Rice Area by Culture Type, First edition**

This service also provides simple viewing and querying facilities for the first Rice Area by Culture data set for South, Southeast and East Asian countries (Huke, 1982). It represents the extent of rice area for each culture type by repeated points, whereby each point (color-coded by culture type) represents a fixed area of rice (approximately 3,000 ha.). Other map layers like rivers and cities were included and rendered visible at larger viewing scale. Figure 5 shows a snapshot of the map service.

- **Rice Area by Culture Type, Second edition**

This service provides mapping and query functions for the second Rice Area by Culture Type data sets for South, Southeast and East Asia (Huke, 1997). In these data sets, the six categories of rice culture type are expressed as percentages of total rice area for the lowest administrative units available for the country of interest (see Figure 6). Scale factoring was used to display administrative unit labels, cities and rivers.

- **Rice Production, Yield and Area Harvested**

This map service provides for mapping time series data on rice production, yield and harvested area at the smallest sub-national administrative unit available for the main rice-producing countries of Asia (see Figure 7). As with the other map services described above, scale factoring was implemented to display additional information.

- **Maps of physical rice areas**

This map service offers simple viewing and querying of maps showing areas where rice is grown. For some countries, e.g. the Philippines, the mapped rice areas are distinguished by number of rice crops grown in a year (single, double crops) and by irrigated and rainfed systems. As with the other map services, scale factoring and rendering are implemented (see Figure 3).

2.4 Implementation issues and lessons learnt

In designing the map service, we placed importance on simplicity of use and fast response time. Therefore the map services are configured as an image server and published using the basic HTML Viewer. The HTML viewer is considered to be a relatively thin client and easily customizable. Requested information is easily transmitted over the Internet. It works with a wide variety of browsers with less client side processing and does not require Java 2 plug-in or applet support. The disadvantage is that the client is limited to working in a web browser with reduced GIS functionality, and restricted to the data and symbolization functions that the ArcIMS Author has created. It does not support some functionalities used by Feature Services such as EditNotes, MapTips, and MapNotes. Data integration, such as allowing users to add local data layers, is also not supported [ESRI, 2000].

In creating the map services, the following steps were taken to prepare the spatial and attribute data for mapping. First, sub-national administrative boundary maps were digitized and merged where necessary (i.e. if digitized in parts) to produce a complete and coherent layer for each country, or for regional mapping and the spatial units coded with unique identifiers. Then the attribute data had to be incorporated as additional fields in the map attribute table. This requires that the tables in our Access database containing the rice data had to be converted in dbf format and manually joined to the map attribute table. This design presents a shortcoming in that whenever the rice statistics database is revised, the corresponding map attribute table would need to be rebuilt. Our ultimate strategy is to use a combination of the Thematic and Parcels HTML Viewer (a sample template package with ArcIMS) in rendering the maps. The Thematic viewer allows the user interactive selection of the rice culture type and customized designing of the map classification scheme, while the Parcel viewer provides dynamic linkage of the administrative map to an external data file that contains the rice statistics. For this to work an ODBC connection has to be defined and established. Customizing the HTML viewer requires working knowledge of ArcXML and Javascript. This strategy will be attempted in the enhancement phase of this map service.

Another limitation is in the creation of map classes during map composition. ArcIMS Author permits only the equal interval classification for graduated symbology, and does

not allow the user assignment of class thresholds. One way of circumventing this limitation is to edit the map configuration file using a text editor and manually change the symbol of a layer.

In composing the time series maps, the repetitive process of loading the same shape file and assigning the same symbol for each year can be shortened by editing the map configuration file. The lines of code used to render a year in the series can be copied and pasted n number of times to create themes for the different years by changing the value assigned to the year field. The result however, is a long layer list as shown in Figure 7.

The map configuration file is in ArcXML thus a working knowledge of the ArcXML elements is needed in order to incorporate additional features not present in Author. The edited map configuration file can be opened and reviewed using Author but should not be saved. Otherwise the map configuration will revert back to its original setting.

3 Conclusion

Initially, GIS was used as a tool for integrating, analyzing, and visualizing geographic information. GIS later emerged as a powerful technology for coordinating and integrating the work of an organization around a common and shared geographic database. GIS is now evolving into an architecture allowing communities of organizations to connect and share their geographic information and applications as network and Internet-based services to one another.

Over the course of this project, many problems with data, software and programmer limitations were encountered. Even though these problems were encountered, the initial delivery of the Atlas of Rice proved to be successful. In terms of product development, this project found that using the Intra- and Internet as a forum for GIS to be very effective and efficient by providing GIS functionality without the logistical costs. Only one license of ArcIMS software is required drastically reducing the price of traditional GIS tools. Custom GIS applications provide a cost-effective way to create custom database interfaces, analysis tools, and data dissemination tools for a broad audience of users. ArcIMS-based applications are scalable and can incorporate many different types of data from different sources.

4 Future plans

The Atlas is still at its developmental stages and enhancements are underway to make the service fast and user friendly without compromising its functionality. Priority is given to the following improvements:

- Improve the HTML Viewer with customized implementation of the basic GIS tools.
- Incorporate a metadatabase and search facility.
- Explore ways of dynamically linking the statistics and spatial data.
- Include the facility to update and maintain the database online.
- Develop functionalities that allow for more user interaction (e.g., custom rendering or symbol application, data incorporation).

5 Acknowledgements

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The Atlas of Rice is dedicated to the memory of Dr. Robert Huke, who recently passed away, for initiating the rice area mapping effort even before the adoption of GIS technology at IRRI.

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Table 1. Administrative Level of Asian Countries in the Database

Region	Country	Administrative Level	Typical Area (sqkm)
South Asia	Bangladesh	District	5 - 12,941
	Bhutan	District	453 - 5435
	India	State, District	13 - 89,738
	Nepal	District	106 - 7967
	Pakistan	District	929 - 54,768
	Sri Lanka	District	683 - 7250
Southeast Asia	Cambodia	Province	1,363 – 15,783
	Indonesia	Province	3,054 – 431,065
	Lao PDR	District	3,572 – 21,161
	Malaysia	State, District	120 – 8,182
	Myanmar	Township	111 – 12,299
	Philippines	Province	205 – 14,596
	Thailand	Changwat	504 – 23,845
	Vietnam	Province	881 – 19,298
East Asia	China	Province	34,300 – 721,000
	Korea	District	149 – 18,855

Table 2. Classification of Rice Culture.

Classification	Description
Upland	Areas with unpuddled soil and no provision for holding standing water
Deepwater	Areas where the water depth is >100 cm.
Irrigated Wet Season	Areas where water may be added using a source other than local rainfall or local runoff. Usually taken as the high sun period - but in portions of far southern India, the eastern Philippines and much of Indonesia, the term 'main season' might have been more appropriate
Irrigated Dry Season	Areas subject to the addition (and removal) of water during the local dry period
Shallow Rainfed	Areas where water depths are 0-30 cm.
Intermediate Rainfed	Areas where water depths are 30-100 cm.

Table 3. Matrix of available map service

Region	Country	Ecosystem	Production	Yield	Area Harvested	Political Boundary	Rice Area
Asia		√					
South Asia	Bangladesh	√	√	√	√		
	Bhutan		√	√	√		
	India	√	√	√	√		
	Nepal	√	√	√	√		
	Pakistan	√	√	√	√		
	Sri Lanka	√	√	√	√		
Southeast Asia	Cambodia	√	√	√	√		
	Indonesia	√	√	√	√		
	Lao PDR	√	√	√	√		
	Malaysia	√	√	√	√	√	√
	Myanmar	√	√	√	√		
	Philippines	√	√	√	√	√	√
	Thailand	√	√	√	√		
	Vietnam	√	√	√	√		
East Asia	China	√	√	√	√		
	Korea	√	√	√	√		

Table 4. Interface component of the default HTML Viewer

Component	Description
Map Display	Located in the central section of the interface, this is where the spatial feature is drawn based on a predefined scale, symbol and data. In some map services, scale factoring and scale dependent rendering was used
Map Layers	Located in the upper right section of the interface, this allows users to toggle the map layers on and off. Visibility of certain map layer is dependent on the displayed scale. Selected map layers contain feature attribute information such as feature names and identifiers. This information can be accessed only when the selected map layer is set 'Active' and by using identify, query or find function. The "Map Layer" also doubles as the "Map Legend" when toggled.
Navigation, Query and Project Tools	These tools allow users to navigate and explore the displayed map theme, zoom into geographic regions, perform searches, queries or spatial selection for features, and print the results.

Figure 1. The Atlas of Rice homepage interface.

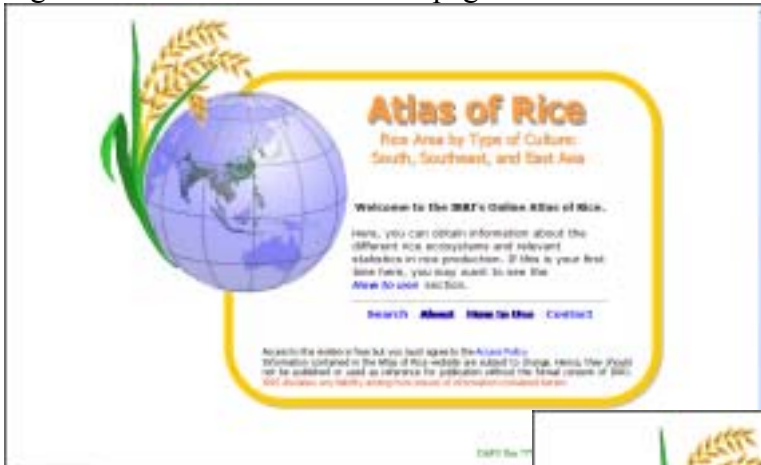


Figure 2. Components of a sample map service.

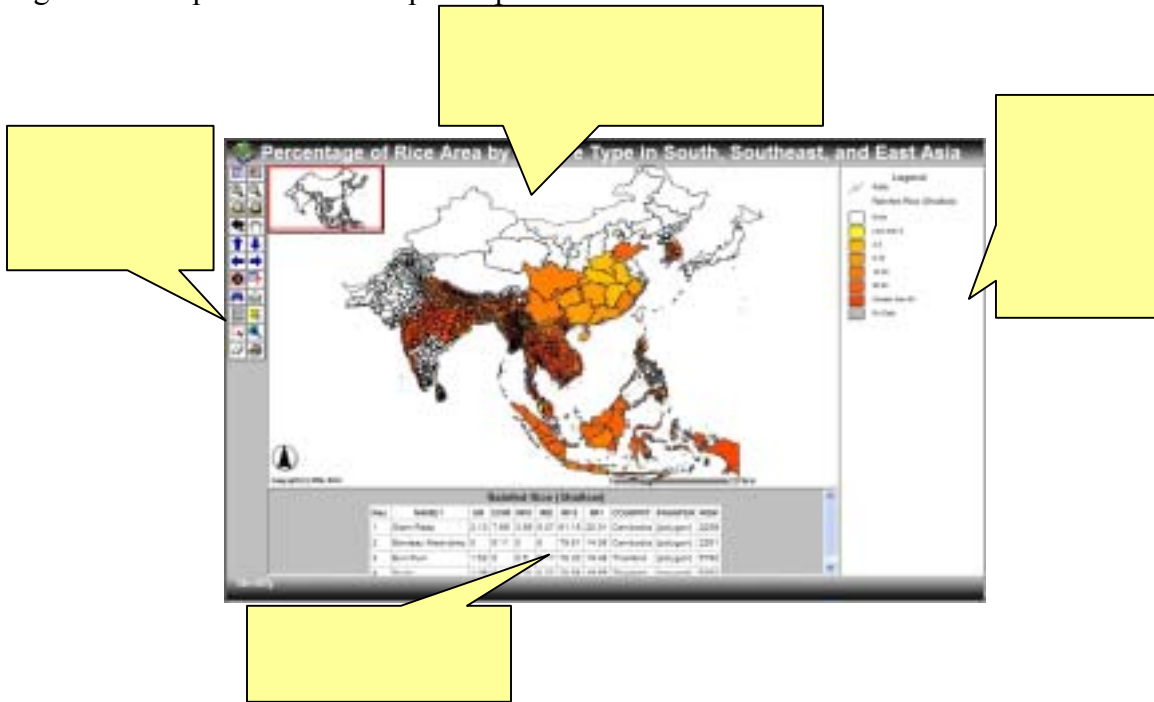


Figure 3. Scale factoring and scale dependent rendering

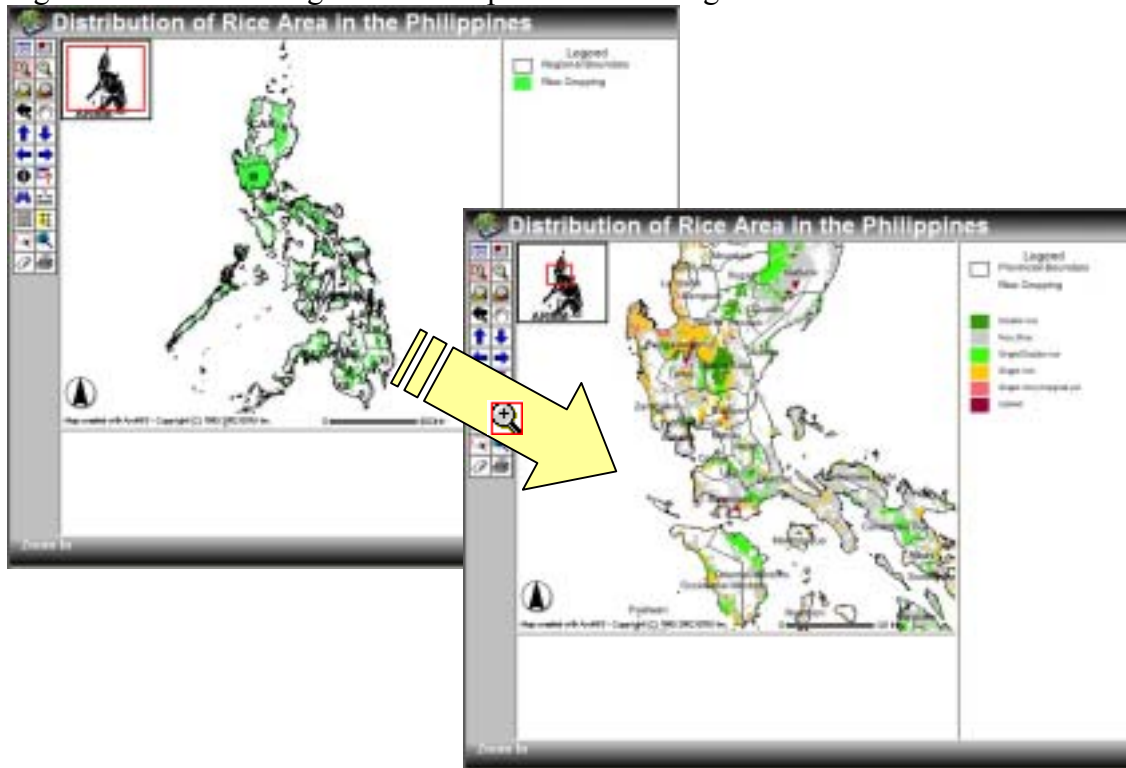


Figure 4. The Administrative Boundaries map service: example for Malaysia at different viewing scales.

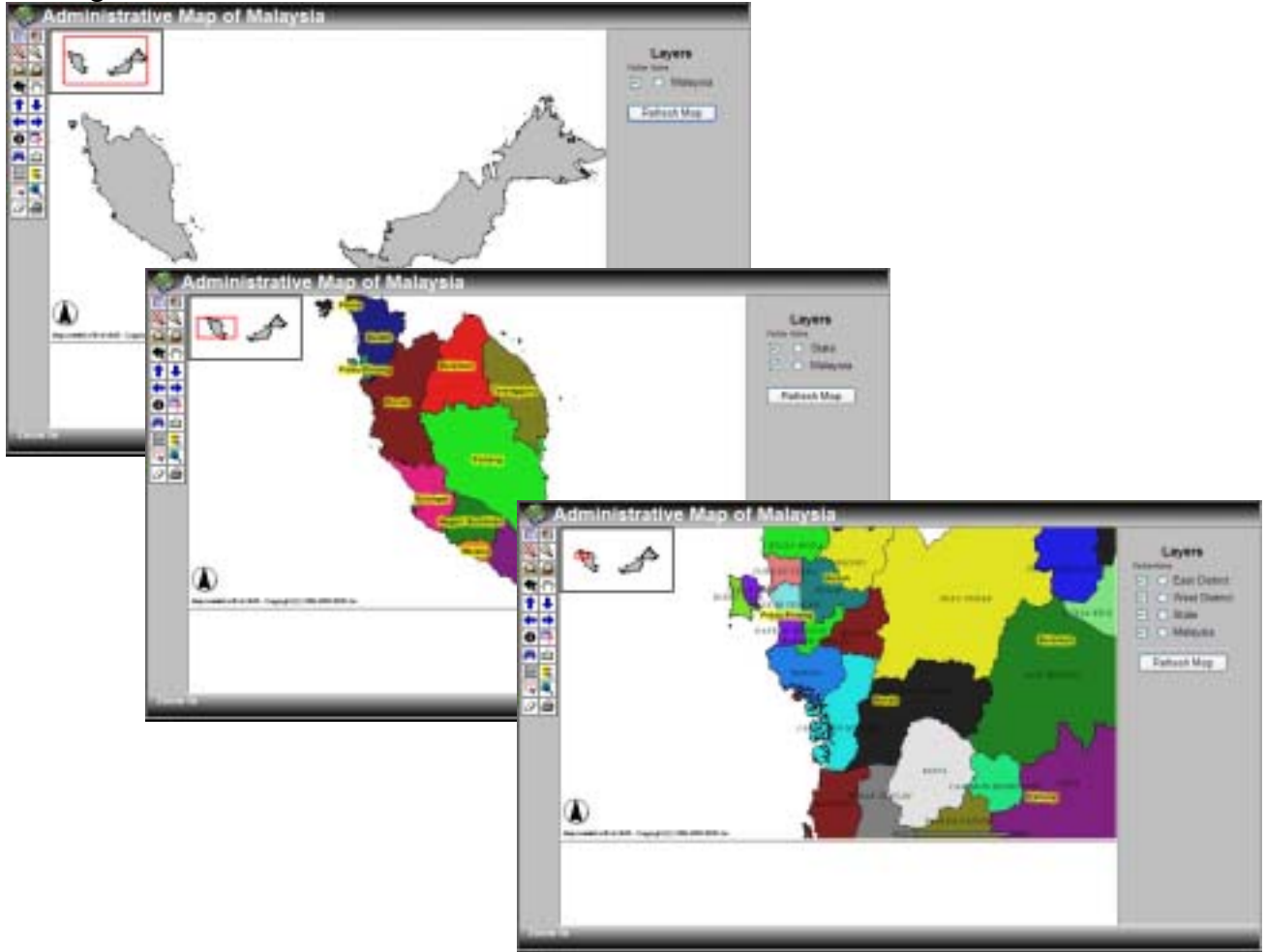


Figure 4b. Example of boundary misalignment.

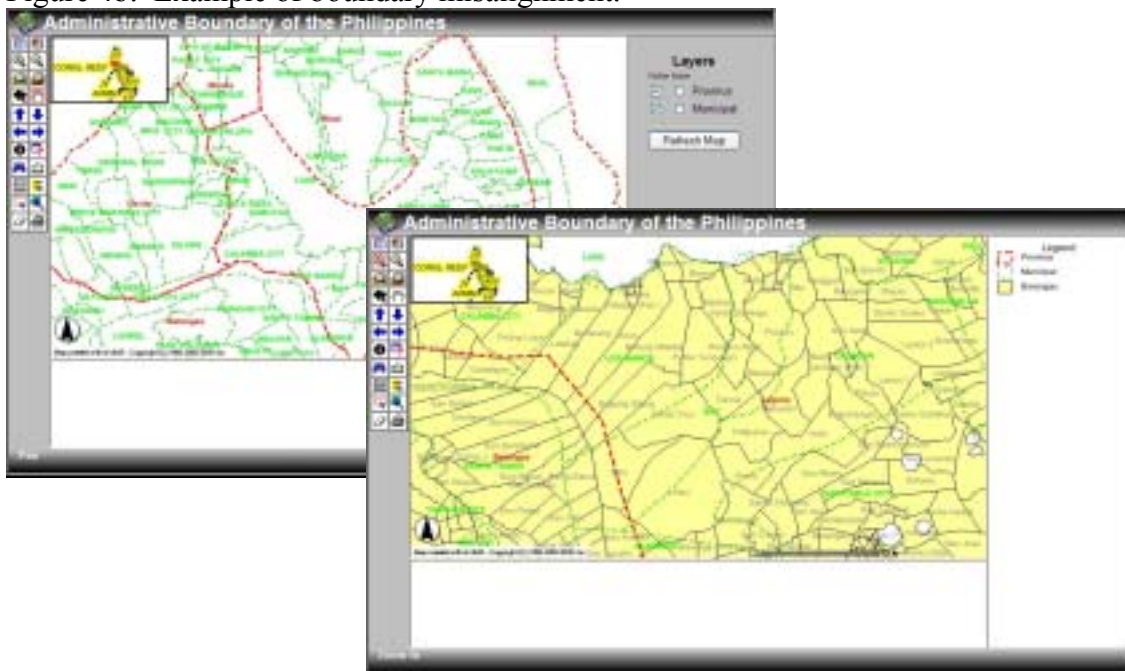


Figure 5. The Rice Area by Culture Type (First Edition) map service.

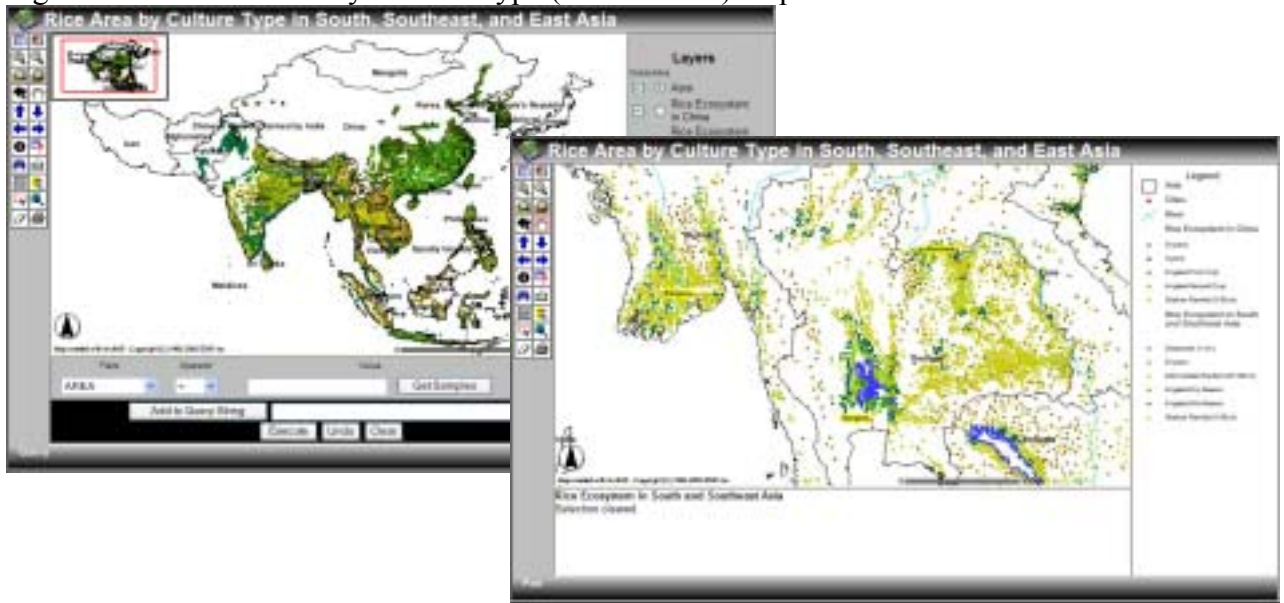


Figure 6. The Rice by Culture Type (Second Edition) map service.

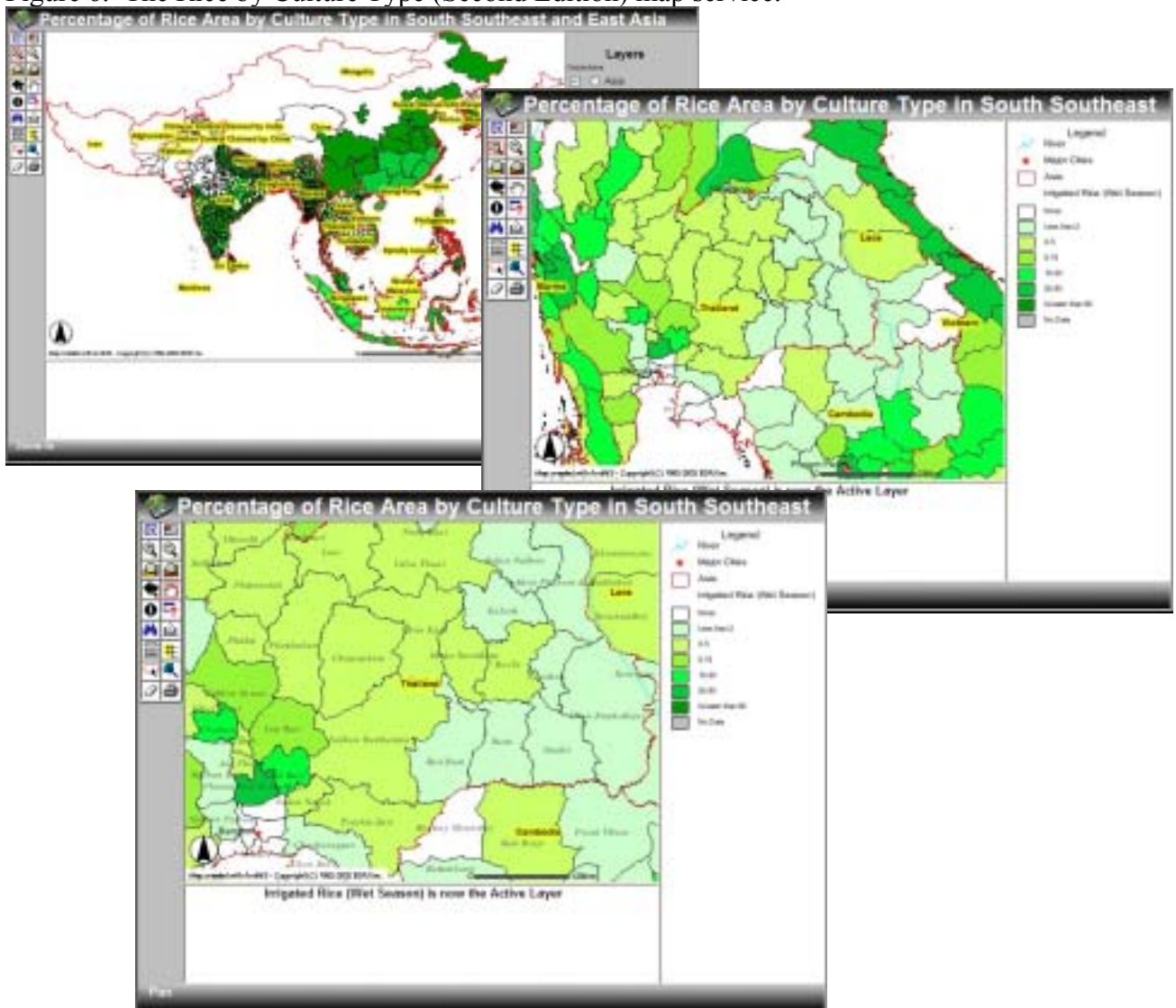
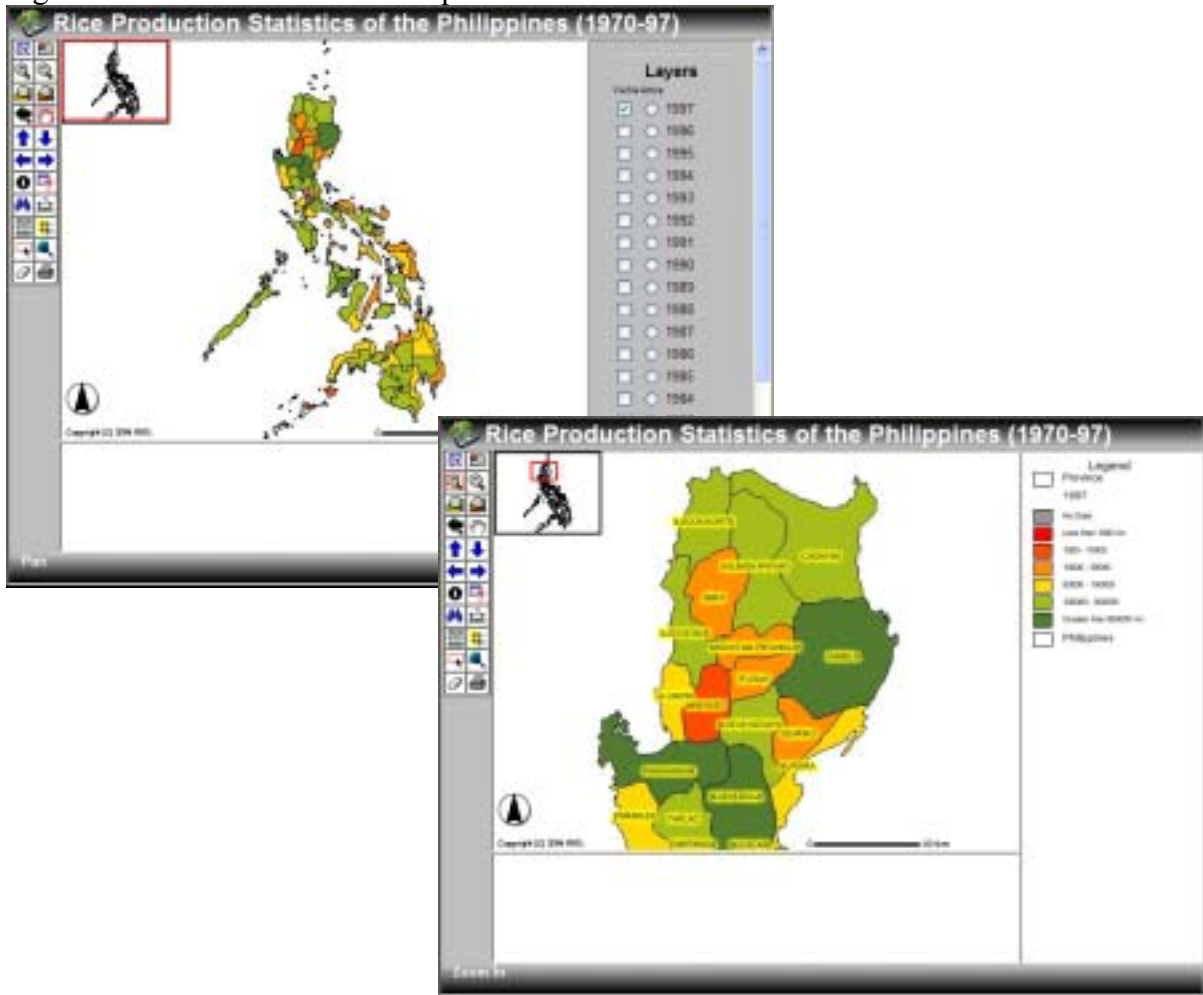


Figure 7. The Rice Production map service



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