

Geospatial Technologies Application for Water Resources Management in Taiwan

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Abstract

Water resources management is a significant issue in Taiwan because of the extensive mountain areas, vulnerable geological structures, short and rapid river flows, inconsistent precipitation, and difficulties in water storage and resource allocation. This article describes how to apply ESRI ArcIMS, ArcGIS series, and self-developed components to develop the relative management application systems for the central government agencies. WMS and WFS were combined with the application to share the water conservation information to other public agencies needed. The hybrid mode Web GIS systems were designed for providing spatial queries for flood area calculations, debris flow location, river bank locating piles, display DEM charts, concatenate construction data between different organizations by service oriented architecture that also provided users fast browsing and useful GIS functionalities, which can be an essential tool of decision supporting for water resource conversation policy makers.

Keywords: Water resources management, Hybrid mode Web GIS

Presentation Will Feature the Following ESRI Software
ArcInfo, ArcIMS

1. Introduction

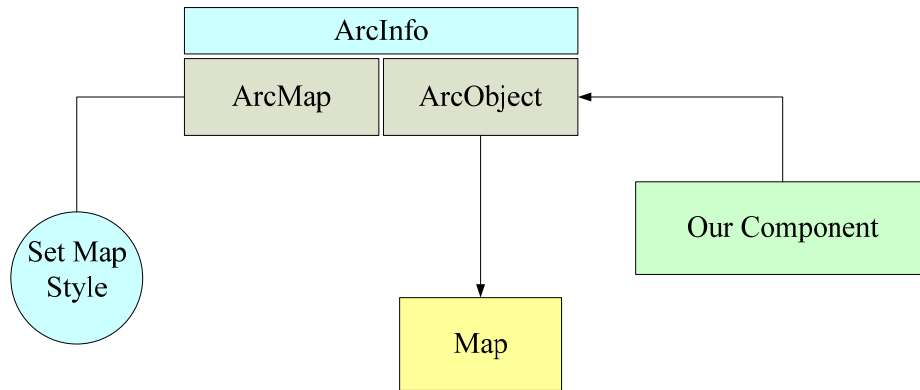
In the recent years, the requirements to GIS applications have been constantly increased in the whole world; GIS technologies and applications are relatively upgraded. We considered that users can't feel satisfied with only a simple map browser; opened internet applications have replaced desktop versions, complicate GIS query methods are not suitable for most people, humble user-interface can't attract end users anymore; web browsers (especially the Internet Explorer, Fire Fox, Chrome... etc) are embedded in most desktops. Based on the above considerations, we implement our study as Web-Based GIS Systems. End users can freely enter our GIS applications using a general web browser without any extra plug-ins.

We apply ESRI ArcIMS to be the GIS service provider, ESRI ArcInfo to be the GIS tool. Moreover, we develop several components to operate GIS services, to visualize user interfaces, to enhance web GIS performance, and so on.

In our study, we bring up a hybrid mode web GIS application. We provide a static cached map which is similar with WMTS to make users fast browsing maps. Moreover, basic or complicate GIS queries are combined in our applications. Not only the query result data sheets, but also visualized GIS graphs are displayed in our applications.

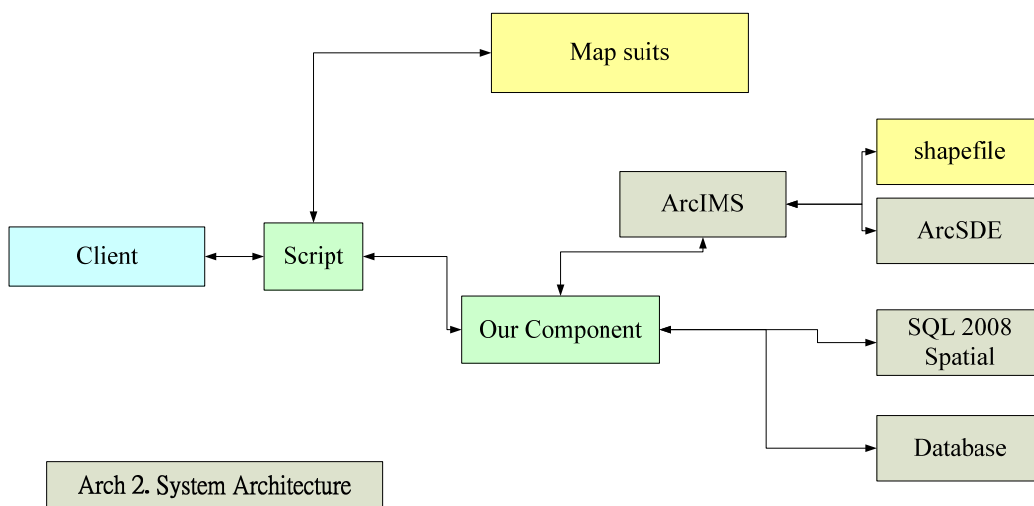
2. Architecture of our implementation

We apply ESRI ArcMap to set map styles and then generate mxd files to be the configuration files. Next, we develop our component to operate ArcObject to generate maps, which are formed as common image format such like jpg, png, gif...etc. Moreover, we generate those maps as many different scales. By the customized issue, we maybe generate the maps as 10 scales, which includes 1/5K, 1/10K, 1/25K, 1/50K, 1/100K, 1/250K, 1/500K, 1/1000K, 1/2500K and 1/5000K. For different requirement, we can generate different amount of scales.



Arch 1. generate maps

We apply ESRI ArcIMS to be the Dynamic image generator. The dynamic image includes dynamic layers, customized images (we use acetate layers to request ArcIMS map services). However, as the flexibility aspect, our feature operating methods are hybrid mode. We use ArcIMS's GET_FEATURE related functions to meet that the data sources are shapefiles or ArcSDE; we use our self-developed components to operate SQL server 2008 spatial when shapefiles or ArcSDE is not available. At the negotiation phase between client scripts and our component, our component plays the role to listen and response for client; on the other hand, the client scripts send requests to our component and maps.



3. Main features of our study

We apply our study to many water resource applications, several cases of our study are listed as the following sections.

3.1 Our customized spatial queries

Spatial query --- Authority of basin land management

According to current frame of national (Taiwan) land plan, different attributes or classes of basin land are involved with several laws and regulations. The land may not only belong to "hill area" but also belong to "Indigenous peoples preserved land" and "National landscape area". To generate the relationship between spatial data and monitoring messages, we apply our study to link laws and regulations database, spatial database and reservoir monitoring database. After integrating these databases, users can get laws and regulations information for specific queries.

Reservoir and basin area land management authority info sheet

Main Management Unit		Related Layers
Ministry of Economic Affairs	Water Resources Bureaus	Reservoir area
	Water Resources Agency	River land
Ministry Of Interior	National Park Administration Office	National park area
Ministry Of Transportation And Communications	Directorate General of Highways	Basin road system
	Tourism Bureau	National landscape area
Council of Agriculture, Executive Yuan	Soil and Water Conservation Bureau	Mountain hill area
	Forestry Bureau	National forest area
	Taiwan Forestry Research Institute	Experiment forest area
Council of Indigenous Peoples, Executive Yuan		Indigenous peoples reserved land area

Base on the management aspect, we provide related information for users. Users can overlay several topic layers to set

their queries. Therefore, our application can find out attributes of those layers and then response related laws and regulations. For example, we provide “Using coordinate to query land management authority”, “Using important landmarks to query land management authority”, “Using cadastres to query land management authority”... etc.

The screenshot shows a web application interface. On the left, there is a '以地籍查詢' (Cadastral Query) panel with dropdown menus for '縣市' (County/City) set to '桃園縣' (Taoyuan County), '鄉鎮' (Township) set to '復興鄉' (Fuxing Township), and '地段' (Parcel) set to '巴陵段' (Baling Parcel). Below these are buttons for '地段定位' (Parcel Location), '地號' (Parcel No.) set to '0002-0011', '地籍定位' (Cadastral Location), '權責機關查詢' (Authority Query), and '回到上層 BACK' (Return to Previous Level).

On the right, under the heading '坐落於' (Located at), there is a table with the following data:

主題圖層	相關法規	相關法規條文	主管機關
國有林遊地	森林法	第 22 條 全文	農委會林務局
原住民保留地	原住民保留地開發管理辦法	第 38 條 全文	原住民族委員會

Below the table, there is a preview of 'The Forestry Act Article 22' with the text: 'Whereas forests held by the state requirements shall be classified as follows: 1. Essential for preventing damage to property; 2. Essential for the conservation of natural resources; 3. Essential for preventing damage to public health; 4. Essential to national defense; 5. Essential to public health.' Below this is a link to the 'Laws and Regulations Database of The Republic of China'.

Fig.1. Cadastral query relate with Laws and regulations

3.2 Multiple suit map-set for different water resource application

We set our map styles using ESRI ArcMap, and generate different style maps. Moreover, we make those maps alignment. The users can swap the maps as they wish.



Fig.2. Map – named electronic map



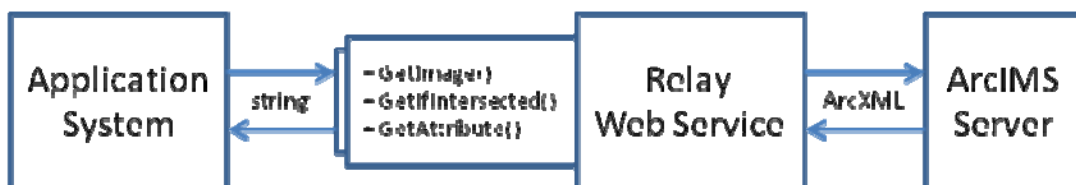
Fig.3. Map – Satellite map



Fig.4. Map – electronic map combined with satellite

4.3 Using web service to include complicate spatial queries to support water resource management

For the purpose to let the applications which are not composed as GIS systems to simply include GIS functionalities, we provide web services to be the GIS service broker. As the following image, the relay web service is based on ESRI ArcIMS map service, providing "GetImage", "GetIfIntersected" and "GetAttribute"... etc methods. Message format is using ArcXML between our web service and ArcIMS server; on the side, message is formed as streams between web service and client applications. The main methods of the web service are listed in the followings:



1. GetImage Method : input envelop and response image

Parameters:

Host: ArcIMS Server host name or IP

ServiceName: ArcIMS Service name

MinX: minimal X of the envelop

MinY: minimal Y of the envelop

MaxX: Maximum X of the envelop

MaxY: Maximum Y of the envelop

ImageWidth: returned image width in pixel

ImageHeight: returned image height in pixel

Return value: encoded with Base64Encode binary data

2. GetIfIntersected Method: input coordinate and return whether
inside the specific layer

Parameters:

Host: ArcIMS Server host name or IP

ServiceName: ArcIMS Service name

LayerIdList: query target layer list, formed as "LayerId1,
LayerId2, ..."

Xcoord: X coordinate

Ycoord: Y coordinate

Return value: query result list, formed as "N,Y,E,...", Y as
inside the layer, N as not and E as exceptions.

3. GetAttribute Method: input coordinate and return layer
attributes

Parameters:

Host: ArcIMS Server host name or IP

ServiceName: ArcIMS Service name

LayerId: query target layer ID

FieldName: target layer's attributes field name

Xcoord: X coordinate

Ycoord: Y coordinate

Return value: returns "Y,{field value}" if the input coordinate
is inside the layer, on the other hand, "N,{field value}" for
not"; if exception occurs, "E,{error message}" is returned

One of our implementation is to generate estimating sheets for constructions. Using this web service to combine with GPS position, our application can generate the construction's map and determine whether the construction is inside the govern business area (i.e. mountain hill protection area, flooding area, basin area... etc). Moreover, our application can also gather the related geological information of the constructions (i.e. debris flow id, cadastre number, river name, detail basin info... etc).

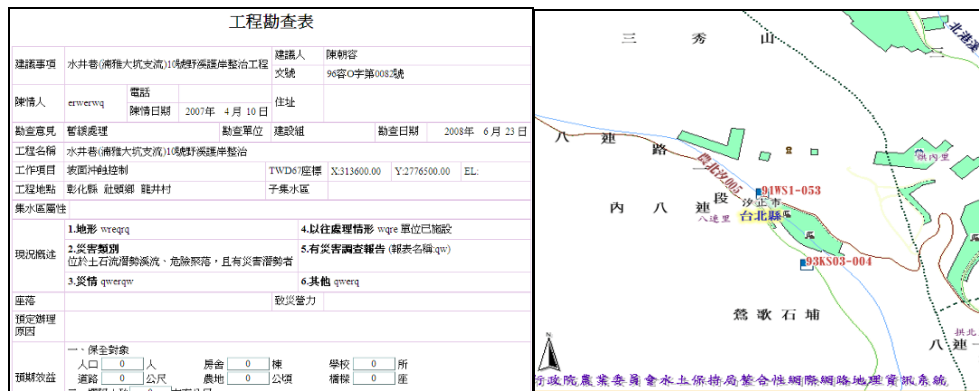


Fig.5. Result sheet with image by integrated web service

4.4 Generate DEM chart to support debris flow management

Landforms are critical information for debris flow management. Fig. 1 is a function users are easy to view a DEM chart by choosing any two points. A decision maker can easily understand the profile of debris, rivers, tumble or etc. In this function, we separate 50 points between the two points chosen by users and send "<GET_RASTER_INFO>" requests to ArcIMS asking the altitude at each point (Fig. 6). But a "<GET_RASTER_INFO>" request can get only one pixel value, there are 50 requests would be sent for drawing one chart.

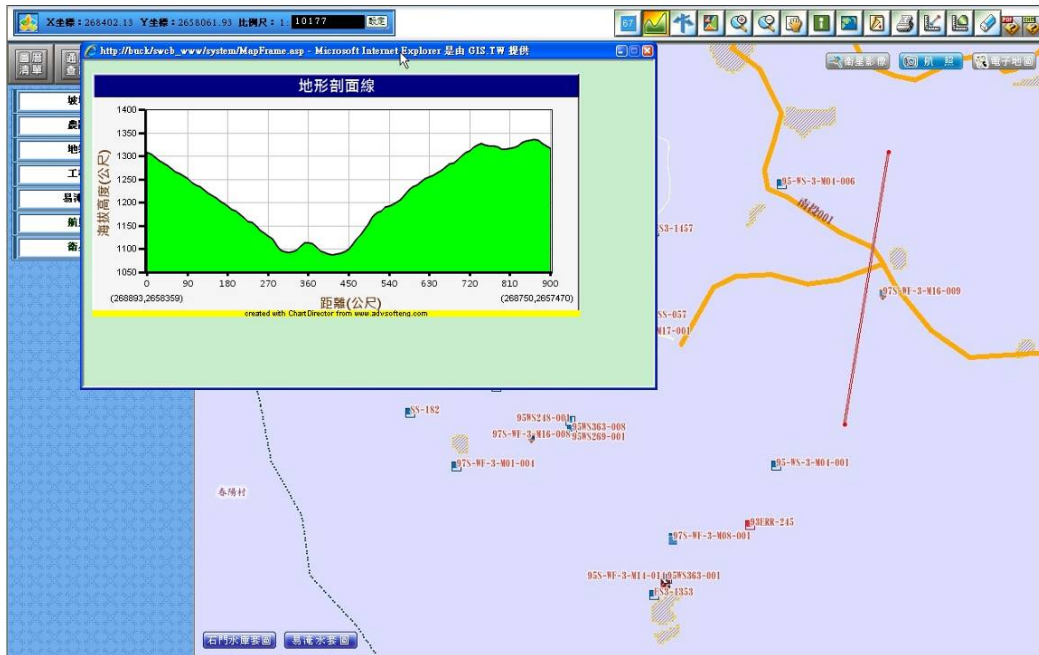


Fig.6. A profile between two points

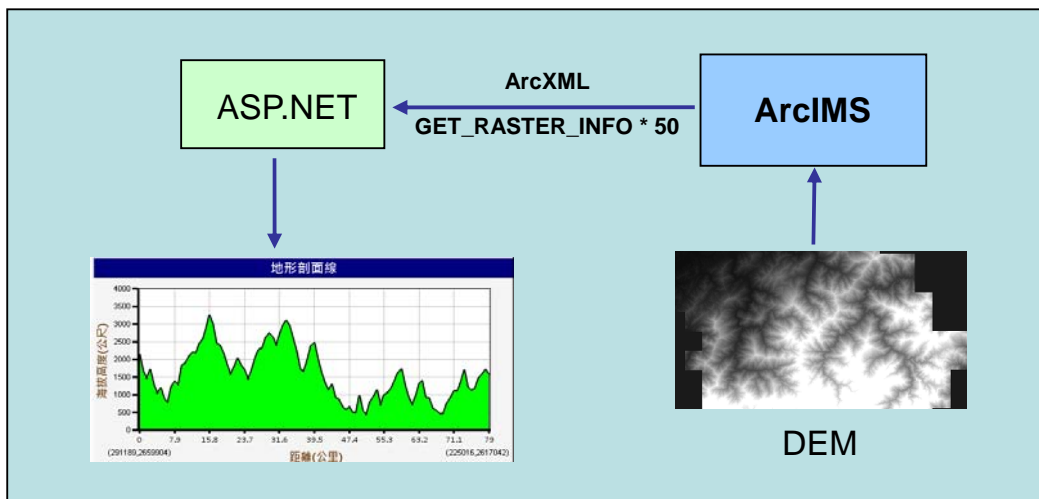


Fig.7. Generate a profile by getting altitudes from ArcIMS

4.5 Flexible and fine map layout

The users usually hope the map layout containing information as many as possible and fitting their own layout. We design a flexible map layout enabling users to attach, resize and position images, such like Fig. 8. Moreover, we add popular geography information usually drawn on maps, coordinate grid line, which is

not provided by ArcIMS directly. But the acetate layer is very powerful in ArcIMS to customize the layout. In Fig. 9, an acetate layer draw hollow square to shape the map and to create the empty space for customized information, like the title, creating date, institute mark and coordinate numbers. There are two key points, the customized information position and the gap of coordinate lines, in this format. To calculate customized information positions should consider font size and map layout size (A0~A4). A suitable distance between two coordinate lines should be found. If the distance is too small, the map will be crossed by many lines and will become complex to read. If the distance is too large user will be not easy to estimate the XY of a specific location on the map.



Fig.8. Map layout setting page

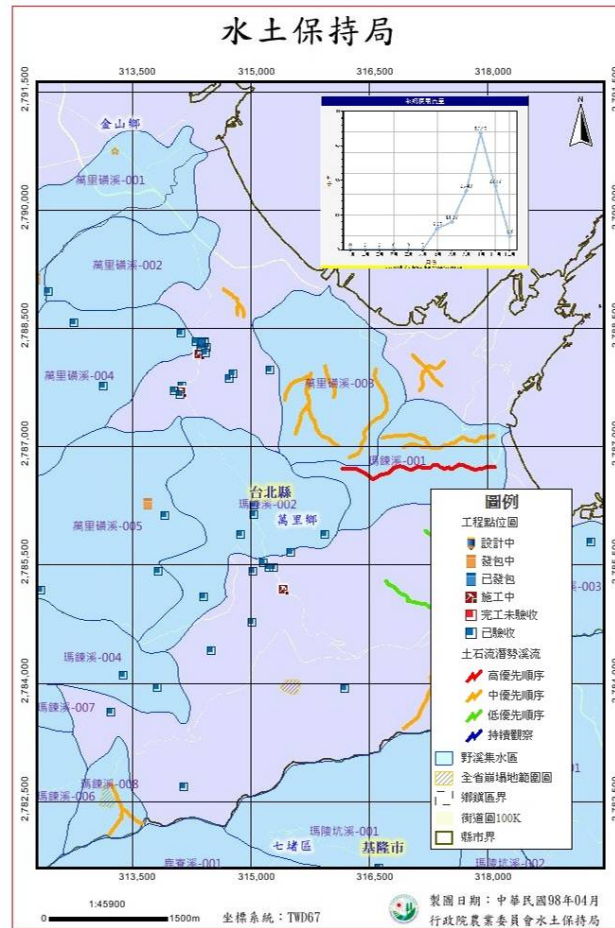


Fig.9. Customized map layout

4.6 Migration analysis

Inconsistent precipitation in Taiwan often makes lots of tumble area. We apply our study to develop some systems to display migration analysis for users to see different years' tumble area. Moreover, users can use this application to consider that the tumble area recuperating job is whether good.

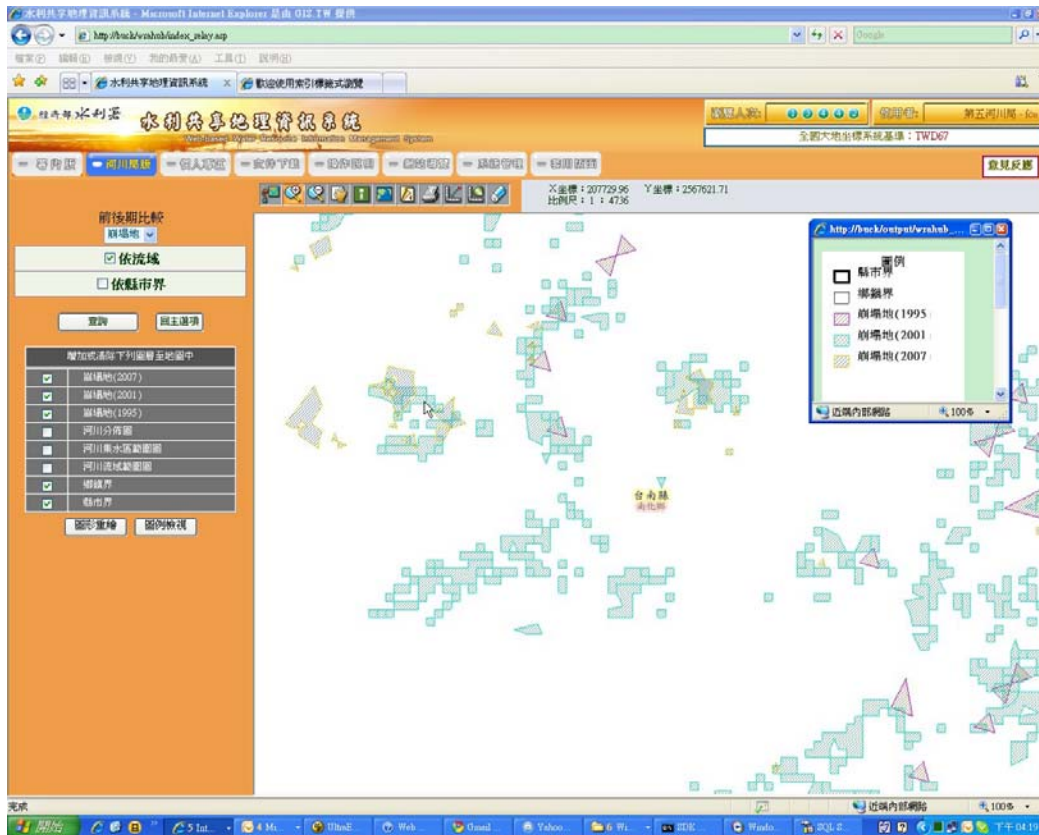


Fig.10. Migration analysis for tumble area

4.7 Collecting information and sharing in real time

In Taiwan, most of rainfall is in summer. A lot of rain disasters will be happened, especially in typhoon. To decrease these disasters, monitoring rainfall in real time becomes an important job for river bureau. In Fig. 11, we design a functionality allowing users showing pluviometers or flow meters on ArcIMS and opening real-time rainfall information by clicking them.

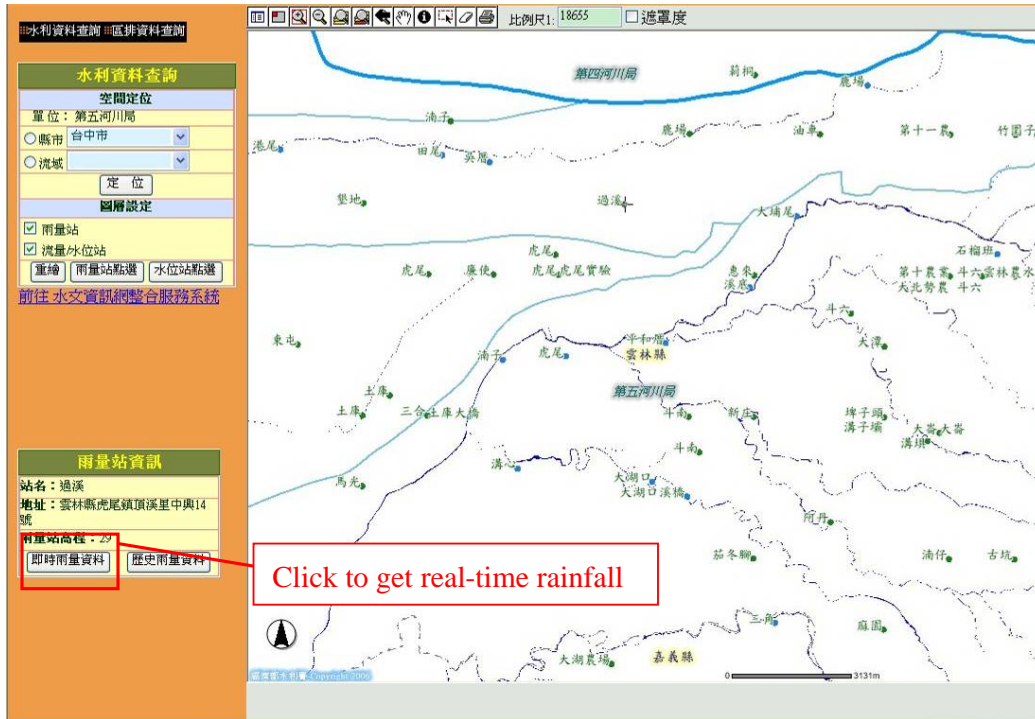


Fig.11. Pluviometer

4.8 Customized spatial tools for river bureau, i.e. riverbank constructions

In our study, we provide editing tools to create, to delete and to modify features. Here is an example to assist users to manage their riverbank constructions which need to set piles. Users can add new piles, delete piles, automatic calculate length and elevation, locate, save information and generate reporting sheets.

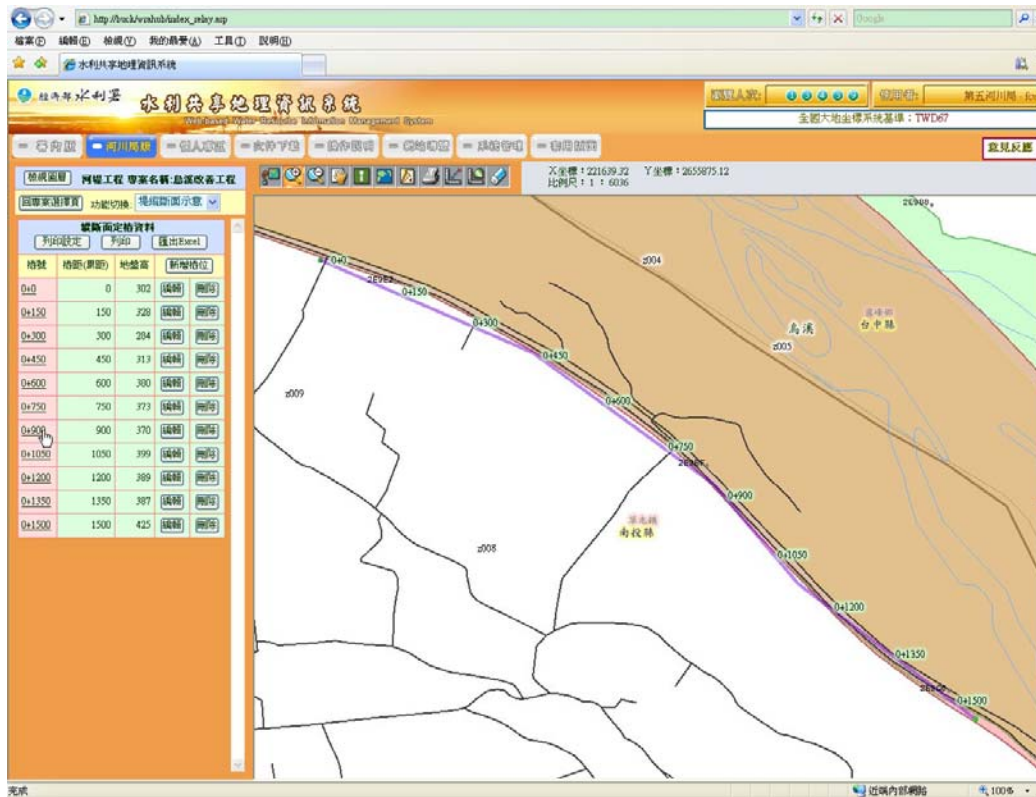


Fig.12. Feature operating tool for riverbank constructions

5. Conclusion

We integrate several ESRI software and technologies to build applications for water resource management via web.

We deeply trust that web GIS application is the best way to share, to display and to easily support end users. Combining web GIS applications with Rich Internet Application (RIA) is a good method to rise up user's interest. Showing 3D maps is a big requirement of common users.

In conclusion, users need not only the functionalities but also the surface. This is always under our consideration.

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