

WEBGIS TECHNOLOGY FOR MANAGEMENT AND SHARING SPATIAL DATA OF PROTECTED AREA, A CASE STUDY IN XUAN LIEN NATURE RESERVE, THANH HOA

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ABSTRACT

Protected area (PA) spatial data has significant scientific value for biodiversity conservation, as well as to support PA's managers design management tools. Most protected areas have basically completed spatial data of biological resources and data are printed maps, pictured maps and GIS maps.

However, there are some limitations regarding this method namely that information is stored in multiple formats, coordinates systems and scales are not unified, especially the access possibility is limited in many cases.

This article reports a research in developing a web-based geographical information system (WEBGIS) that facilitates the access and use of the protected area's spatial data. The system provides online access, exploration, visualization, and analysis of the archived spatial data, mostly in the form map, within a WEBGIS. The results indicate that WEBGIS, developed using MapServer, Remote sensing, GIS technologies, provides built up a spatial database of PA, and suggests that such a system can more advanced all protected areas's spatial data access and analysis tools.

Keywords: WEBGIS, protected area, map sharing, GIS conservation, spatial data.

1. BACKGROUND

In 1962 the International Union for Conservation of Nature (IUCN) published a list of 9214 conservation areas and in 2013 there were 102,102 which cover approximately 18.8 million square kilometers. In 2014 there were 209,000 conservation areas equivalent to 30 million

square kilometers, [1]. As of 2014, there are 34 National Parks and over 140 areas of Nature Conservation established in Vietnam [2].

One of the tools which has been used to manage protected areas is printed or digital maps. The development of Information Technology (IT) and Geographic Information System (GIS) improved efficiency of mapping protected areas. However, people find some disadvantages of this method since information is in multiple formats, coordinates systems and map scales are not unified, and especially since data access is limited.

WEBGIS is a new Internet-based technology that has capabilities to display and share information that will contribute to enhancing the ability to get information from map data which will make its application simpler to use and manage.

Many global institutions have developed and applied WEBGIS technology to collect information on ice [3], to study and manage underground water [4]. The website <http://www.freegis.org> mentions a series of open source WEBGIS software [5]. In Vietnam, this technology has been introduced to many institutions in different fields. The website of Vietnam Government <http://chinhpheu.vn> has built data at district level. Provinces of Lao Cai, Binh Duong, Dong Nai and Ben Tre etc. have their own WEBGIS maps for administration and industrial zones management [6].

In the management of forest resources and biodiversity IUCN has built a map database of all protected areas in the world and WEBGIS technology is sharing that map information. At the website <http://www.protectedplanet.net>, the map information of global protected areas in the world is shown including boundaries, name, type, countries area etc. Information about the Xuan Lien Nature reserve (NR) is located at: <http://www.protectedplanet.net/303022>, [7] In Vietnam, the Forest protection department applied WEBGIS for fire management [8].

Xuan Lien Nature Reserve (NR) was established in 2000 and is located in the five communes of Bat Mot, Yen Nha, Van Xuan, Xuan Cam, Luong Son in Thuong Xuan District. It is situated 60 km from Thanh Hoa city, with geographic coordinates 19°51'00" to 19°59'00" latitude and from 104°58'00" to 105°19'20" longitude. Its map data is almost completed but neither well organized nor accessible in the internet.

This paper presents the results of WEBGIS technology applications for managing and sharing spatial data and focuses on: 1) Using Remote Sensing and GIS technology to build database of NR; 2) Using WEBGIS technology to manage and share map information using an example of Xuan Lien NR, Thanh Hoa.

2. MATERIALS AND METHODS

2.1. Data and information

The used data includes: topographic maps, thematic maps and Landsat and VNRED-sat satellite images as below:

Topographic maps at a scale of 1: 50,000 using the VN2000 coordinate system for Thanh Hoa zone. The map sheets are: Ban Loc (E-48-6-B); Bai Chay (E-48-7-A); Thuong Xuan (E-48-7-b); The Ban Muong (F-48-90-D); Lang Chanh (F-48-91-C) and Ngoc Lac (F-48-91-D), those maps are produced by the Ministry of Natural Resources and Environment.

The thematic maps include: Boundaries of the nature reserve area; zonation map; infrastructure maps; sub regional maps collected from Xuan Lien NR, in MapInfo format, coordinate system is VN2000, Thanh Hoa.

Satellite images including Landsat 5, 7 and Landsat 8, with 30m resolution, the resolution of band 8 is 15 m [9]. VNRED-Sat image were taken in 2014 with a resolution of 10 m, and 2.5 m of panchromatic band. Landsat images can be freely download at the site of the department of United States Geological Survey, <http://glovis.usgs.gov>. VNRED-Sat satellite imagery were provided by the National Remote Sensing Department. V20131025_040241P-X; V20131025_040243P_1A-X; V20131219_034851P-X V20131219_034854P-X; V20150402_033526P-X; V20150402_033529P-X;

MapServer open source software is used to build web maps application through the Internet. MapServer supports display and query of vector and raster data, using OGC formats and Web Map Service maps and geographic information retrieval by Web Feature Service, the with library support to includes GoogleMaps.

2.2. Methodology

We applied the following methods:

(1) Remote sensing and GIS for mapping of protected areas and to build thematic maps, vegetation maps, land cover change maps, zoning maps...

Using ARCGIS software to build maps. The layers of topographic maps are divided into polygon, line, point layer [9]. Using Universal Translator function of MapInfo to convert maps into shape files, and project tool to convert coordinates of the map.

ERDAS 9.1 - remote sensing software was used to classify images and build the map of vegetation in 2000, 2014 [10].

(2) The WEBGIS to manage and display maps on the Internet.

The steps of the WEBGIS system are displayed in Figure 1:

B1: Preparation of papers maps, satellite images,

B2: Synchronize, edit, convert coordinates and analysis,

B3: Build map database of Xuan Lien NR,

B4: Build WEBGIS system to share map information.

3. RESULT

3.1. Map database of Nature reverse

The maps of NR include: topographic map, boundary map of NR, functional zoning map, infrastructure map and map of sub-regions.

Topographic maps include elevation, rivers and streams. The elevation information includes contour line, rivers and elevation points. Those information layers have a scale of 1: 50,000. The "Union" tool was used to combine six map sheets to build the elevation map and it was repeated to build the four other layers of elevation map, showed in Table 1.

The elevation layer included lines and points. Hydrology systems include rivers and lakes defined as polygons and lines with the name of rivers and lakes.

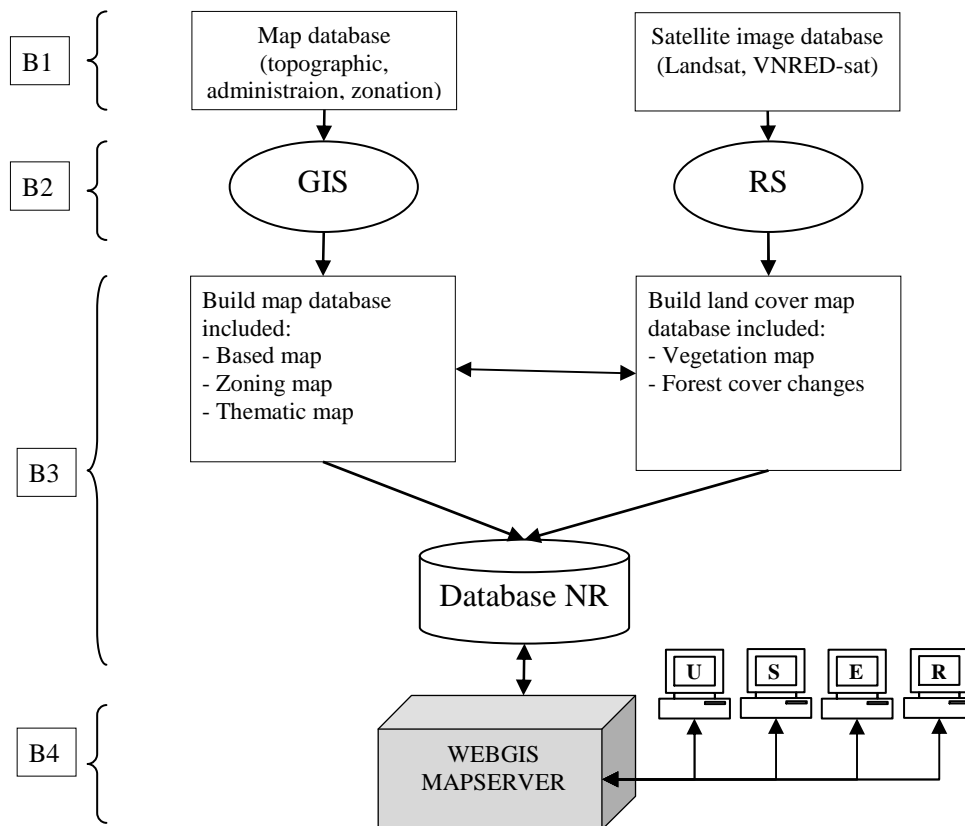


Figure 1. Process of building WEBGIS systems.

Table 1. The topographic map layer of Xuan Lien NR, Thanh Hoa.

#	Name of map	Data type	Property	Property type
1	dh_line_xl.shp	line	docao	Integer
2	dh_point_xl.shp	point	docao	Integer
3	th_line_xl.shp	line	tensuoi	Character (20)
4	songho_poly_xl.shp	polygon	ten	Character (20)

Table 2. The map of boundary and functional zone of Xuan Lien NR.

#	Name of map	Data type	Property	Property type
1	rg_poly_xl.shp	polygon	ten_kbt	Character (20)
2	pk_poly_xl.shp	polygon	ten_pk	Character (20)
3	tk_poly_xl.shp	polygon	tieukhu	Integer
4	trambv_point_xl.shp	point	ten_tram	Character (20)
5	duongtr_line_xl.shp	line	dodai	Integer
6	xa_poly_xl.shp	polygon	tx_xa	Character (20)

Thematic maps including a boundary map, a functional zoning map, an infrastructure and sub-regional map. The maps were built from data provided by NR (Table 2). The style of boundary map, functional zoning map and sub-regional map is polygon. The names of objects are stored as attributes with the data.

The style of the guard stations map is point, map of patrol is line and the name of stations and length of road are stored as attributes with the data.

The maps in this paper were designed in UTM grid, WGS84 coordinates system. This coordinates system is fits of right location of protected areas system for Google map.

3.2. Biodiversity map database

Vegetation plays an important role in creating suitable habitat for species in the NR. Satellite images were used to build the forest cover map. This example application used Landsat 7 from 2000 and 8 from 2014 [8], the resolution for both images is 30 m. The VNRED-Sat satellite image was acquired in 2014, with a resolution of 10m multispectral and 2.5 m for the panchromatic band. Research literature on forest structure includes: forest transect survey, ground truthing data, field survey data has been used [10].

Table 3. The area of forest cover types for Xuan Lien NR, (calculated from the map).

#	Type	2000 (ha)	2014 (ha)	Change
1.	Closed forest	1805.05	1539.72	-265.34
2.	Medium forest	3918.83	3947.27	28.44
3.	Open forest	4522.66	3741.64	-781.02
4.	Grassland and shrub	3494.27	4194.52	700.25
5.	Agriculture	16.06	20.53	4.46
6.	Resident mixed garden	4046.57	4294.96	248.39
7.	Bare land	321.07	386.00	64.93
8.	Water surface	0.11	0.00	-0.11
	Total	18124.62	18124.64	

The example application classifies satellite images of the protected into eight types: closed forests (rk); medium forest (rtb); open forest (rth); Grassland and shrub (cb_tc); resident mixed garden (dc_v); agriculture (nn); water surface (mn) and bare land (dt).

Closed forest includes evergreen trees, conifer or broadleaf trees. Medium forest includes secondary evergreen trees, evergreen limestone trees, or bamboo trees. Open forest includes bamboo mixed broadleaf trees.

Application of Landsat images in mapping has the advantage that the sources images are always available on the internet. It allows to study the change in vegetation of the protected areas (Table 3).

VNRED-Sat image was used to classify forest map and provide information for mapping at a scale of 10: 000.

Table 4. Area of forest cover change between 2000 and 2014, in Xuan Lien NR (calculated from the map).

Type	cb_tc	cd_v	dt	mn	nn	rk	rtb	rth	Total
cb_tc	6137.13	863.41	148.1 3	15	7.23	0.00	132.41	998.37	8301.48
dc_v	1637.51	2630.98	209.4 6	113.2 7	102.8 9	0.00	18.79	91.94	4804.84
dt	545.80	220.78	294.08	50.05	36.18	0.00	13.65	131.84	1292.37
mn	11.37	10.53	4.50	202.87	1.33	0.00	0.95	0.00	231.56
nn	4.42	87.38	74.91	16.83	449.48	0.00	0.00	0.18	633.21
rk	0.27	0.00	0.00	0.00	0.00	906.52	366.50	42.36	1315.65
rtb	538.12	263.69	11.36	7.68	0.15	708.70	3888.41	1449.50	6867.61
rth	2229.73	195.06	79.28	1.03	0.09	125.20	1156.34	6082.96	9869.69
Total	11104.35	4271.83	821.73	406.52	597.36	1740.41	5577.05	8797.15	33316.40

The rows in **Table 4** show the data of 2000, and columns show data of 2014.

The query tool is designed to select the object by area of object, type of vegetation, the length of the trails, name of station in the NR (**Table 5**).

Table 5. Forest cover map of Xuan Lien NR, Thanh Hoa.

#	Name of map	Data type	Property	Property type
1	tvt_poly_xl_2000.shp	polygon	Tentham; dientich	Character (20); Integer
2	tvt_poly_xl_2014.shp	polygon	Tentham; dientich	Character (20); Integer
3	...			
4	bd_tvt_poly_00_14.shp	polygon	Tentham00;Tentham14; dientich	Character (20); Character (20); Integer

A drawback of using remote sensing images for mapping forest cover is that some images were covered by clouds. The images of the area includes: 41 images acquired from 1990 to 1999; 314 images, acquired from 2000 to 2009 and 172 images acquired from 2009 to September 2015. Among those images, 48 images are <10 % of cloud cover per image, 12 images were clear (clouds = 0 %), 3 images has cloud cover of 1% and 4 images covered 2 % area [8].

The 30 m resolution of the image allows creating a map at a scale of 1: 50,000. This scale supports detailed information is sufficient for studying a nature reserve but not enough detail for investigations on the sub-regional level.

3.3. WEBGIS system for management and share map of protected area

With the aim to show how interactive maps of a nature reserve can be accessed on the Internet, using IE, Firefox, Google Chrome. The WEBGIS system displays boundaries and protected area names, functional zone, sub-regional, guard stations and patrol routes. Information such as: name of protected area, name of functional zone, station name, length patrol trails, are included. The user hardware of this system works without GIS software or prior knowledge of GIS and the data are always available on the Internet.

This study arranges data for terrain, administrative and thematic group. The topographic data includes: contour layer, rivers and streams. Administrative data includes: infrastructure, functional zones, sub-zones, guard stations, and patrol roads. The map of forest cover includes forest map, 2000 and 2014, thematic group includes the forest cover change.

The WEBGIS system interactive tools include zoom in, zoom out, turn on, turn off, pan, measure distances, selecting the objects by the query.

Mapserver software was used to build this WEBGIS system and it is free and available on the Internet.

Map Layer arranges the layers in the mapfile. When the user requires topographic maps MapServer requests the topographic layers from the mapfiles: dh_point_xl.shp; th_line_xl.shp; dh_line_xl.shp; songho_poly_xl.shp. The functional zoning map includes: tk_poly_xl.shp; pk_poly_xl.shp (Figure 2); infrastructure maps include: trambv_point_xl.shp; duongtr_line_xl.shp; rg_poly_xl.shp; vegetation map includes ttv_poly_xl_2000.shp; ttv_poly_xl_2014.shp; bd_ttv_poly_00_14.shp. (Figure 2).

Map Object defines the objects in the map (color, brush, style, frame the map, font, name and the export file)...

CONFIG [key] [value] this parameter defines placement using EPSG files from libraries PROJ.4. CONFIG PROJ_LIB / CSDL_BanDo /

EXTENT [minx] [miny] [maxx] [MAXY] limit the area of the map. In Xuan Lien NR these parameters are EXTENT [494 030] [2184220] [536 512] [2,215,160].

Fontset [filename] defines the font style and includes font name and path to the font. The font use with MapServer is the True Type fonts.

The WEBGIS architecture system for managing the nature reserve is shown in Figure 2. The architecture of mapfile is shown in Figure 3. Mapfile includes Map Layers, Map object, Map Projection, Map ... Query. The source code of webmap, which combines guard stations, traffic system and forest bock layers is shown in Figure 4.

IMAGECOLOR [r] [g] [b] the background color of the displayed image is composed of 3 basic colors namely red, green and blue.

ImageType [gif | png | jpeg | Wbmp | gtiff | swf | userdefined] image format of the map is PNG.

NAME [name] define the name of the map, ruler scale, while the note is created from this mapfile. NAME XL_ map created images will be prefixed as XL_ (XL_ 2015.png).

RESOLUTION [int] defines the image's resolution, which affect the map's scale. The default setting is 72 dpi.

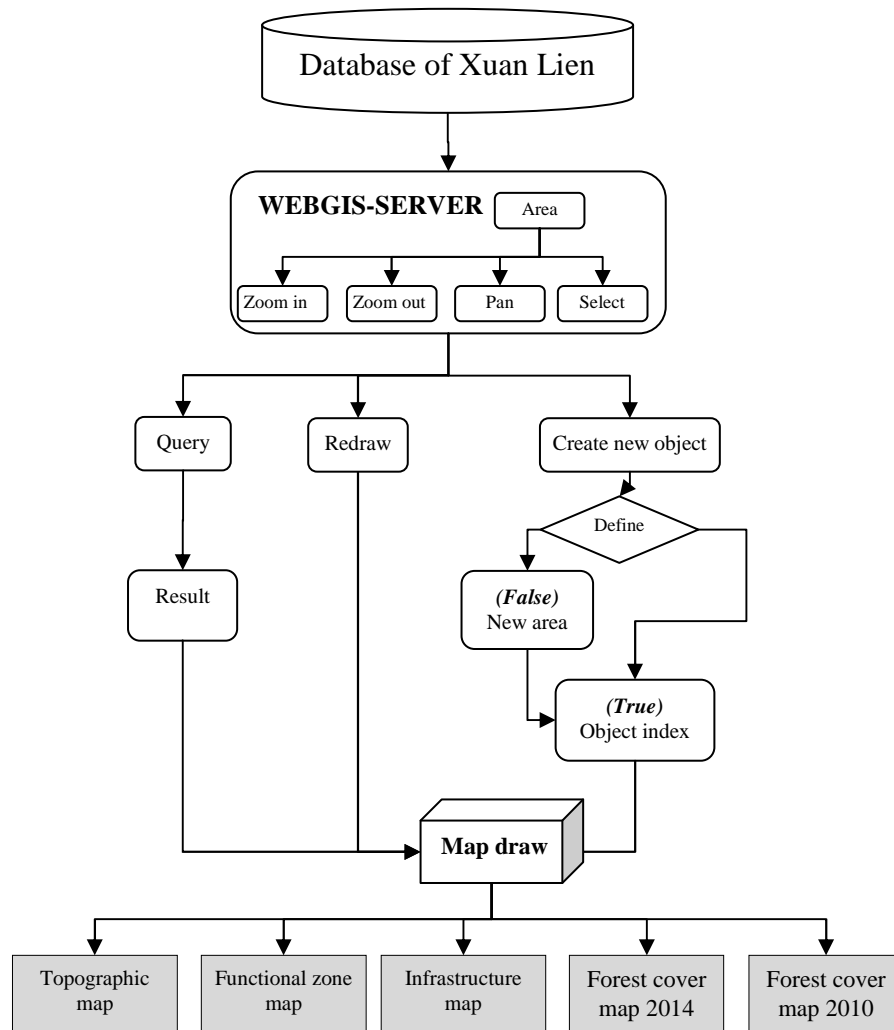


Figure 2. The architecture system diagram of WEBGIS of Nature Reserve.

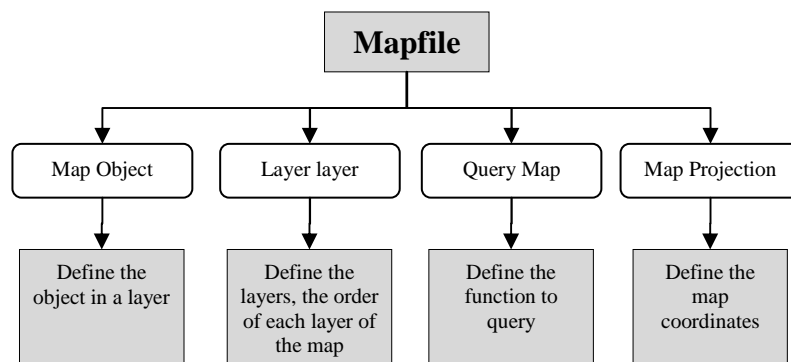


Figure 3. The architecture system diagram of Mapfile.

SIZE [x] [y]: The size of pixels of the map.

STATUS [on | off] defines image maps, ruler scale, reference maps. STATUS controls the status of the enabled maps. If STATUS is [off] MapServer will not create maps.

SYMBOLSET [filename]: File name contains a collection of symbols used on the map.

TRANSPARENT [on | off] set a transparent background for the map. The default setting is off.

UNITS [feet | inches | kilometers | meters | miles | dd] the unit of the map, UNITS is [meters].

```
});
//Declare layer 1_4_rg_khubaoton
var wms_TramKiemLam= new OpenLayers.Layer.WMS(
    "Tram Bảo Vệ",
    "../../../cgi-bin/mapserv.exe?map="+ dir +"mapfile/XuanLien.map",
    {
        layers : "layer_TramKiemLam",
        isBaseLayer : false,
        transparent: true},
    {
        singleTile: true, ratio: 1
    }
});
var wms_GiaoThong= new OpenLayers.Layer.WMS(
    "Đường giao thông",
    "../../../cgi-bin/mapserv.exe?map="+ dir +"mapfile/XuanLien.map",
    {
        layers : "layer_GiaoThong",
        isBaseLayer : false,
        transparent: true},
    {
        singleTile: true, ratio: 1
    }
});
var wms_TieuKhu= new OpenLayers.Layer.WMS(
    "Ranh giới Tiểu Khu",
    "../../../cgi-bin/mapserv.exe?map="+ dir +"mapfile/XuanLien.map",
    {
        layers : "layer_TieuKhuChuyenDe",
        isBaseLayer : false,
        transparent: true},
    {
        singleTile: true, ratio: 1
    }
});
```

Figure 4. The code for display the zoning map in Mapserver.

CLASS the habitat map of each species is drawn from a data table. The value in the each data table is "1" or "0". When the "value" = 1, the species is present, and "value" = 0, species is absent. MapServer only draws values of "1".

CLASSITEM [attribute] the name of the attribute of the data table, which is defined in the mapfile.

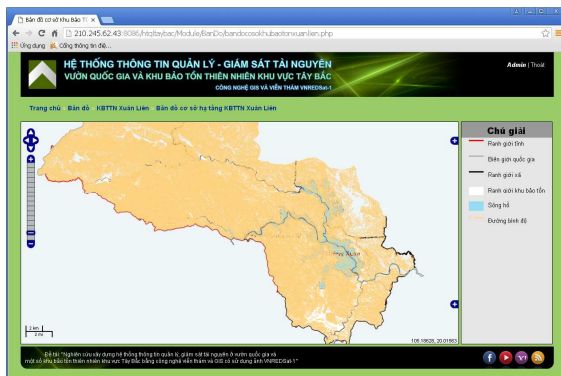
MaxScale [double] is the largest scale of the layer. MAXSCALE of Xuan Lien NR [double], corresponding to an area 50 m × 50 m is displayed on the screen resolution of 600×800 dpi.

MinScale [double] the smallest scale of the layer is drawn. MinScale of Xuan Lien NR is [double] corresponding to the entire NR is displayed with a screen resolution of 600x800px.

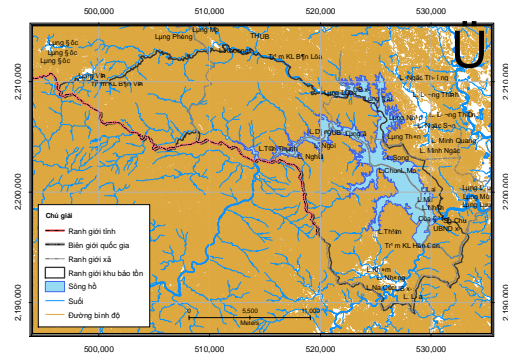
NAME [string] is limited to 30 characters. The name is used to link the layer and mapfile. From the web interface the user can choose the display layer. The name of the layer is selected from the source code.

STATUS [on | off | default] if the value is default, layers are always drawn. The default value for the sub-layer is off.

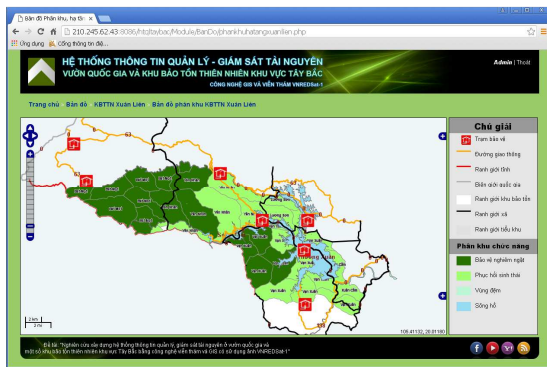
TRANSFORM [true | false] requires MapServer to convert the geographic coordinate system into the graphics coordinate system. Default is True. For the graphics coordinate system, the origin is in the upper left corner.



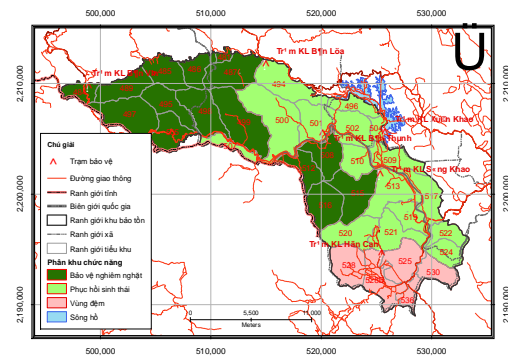
(a) Topographic map



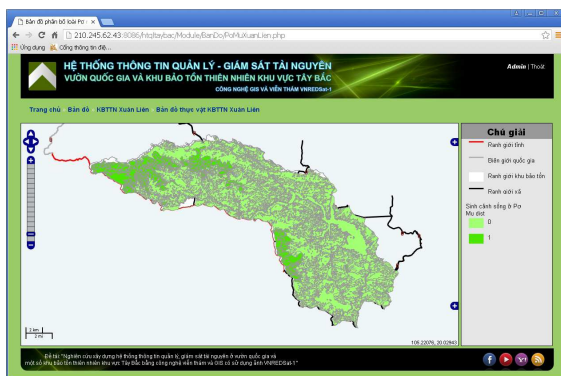
(b) Topographic map



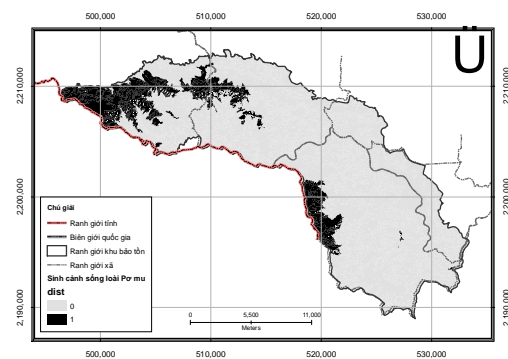
(c) Zonation



(d) Zonation



(e) Forest cover



(f) Forest cover

Figure 5. The map displayed by WEBGIS and ARCGIS
(a, c, e) Map displayed in WEBGIS; (b, d, f) Map displayed in ARCGIS.

TYPE [point | line | polygon | circle | annotation | raster | query] determine the type of data to draw. In many case there are multiple map data types (region, line and point), while the map only shows the defined objects.

Map Projection defines the map coordinates. The coordinate system of the map is UTM, the WGS 84 reference system, region 48.

Map Query defines the tool to query the objects and layer. There are two levels of queries, viz. one query with one condition and another query combining multiple conditions.

After programming, the maps are displayed in Figure 5, in which Figure 5a, 5c, 5e are maps created with WEBGIS, 5b, 5d, 5f are maps displayed by GIS software.

4. CONCLUSION

Applying Remote Sensing and GIS in designing and building a map database to manage protected areas represents advantages in time savings, a high accuracy of the map and a high diversity of formats. The free satellite imagery on the Internet makes it possible to build maps of Conservation Areas efficiently. These data are a basic data resource for evaluating the change of these Conservation Areas.

The classification of Landsat and VNRED-Sat images of Xuan Lien nature reserve has high applicability. They are used to assess changes in the protected area. Maps were built using ARCGIS software with a coordinate reference system using WGS 84, zone 48 UTM projection. The maps include: topographic maps with four layers, functional zoning maps, infrastructure, administrative maps including six layers and thematic maps including three layers. The map is divided into four groups for display on internet browsers (IE, Firefox, Google Chrome) using free software Mapserver.

The main content to display a map on the Internet is defined in the mapfile. Each mapfile defines 1 map. The main information in the mapfile includes: map layer, map object, map projection and map query ... the map layer defines the name, the order of displayed layer. The map object defines the style of objects of the map. The map projection defines the coordinate system and map Query defines the query to select an object.

WEBGIS technology is used to manage, display, and share spatial information of NR to promote the exploitation of map. The user do not need the depth knowledge of GIS. The data are always available on the Internet. This new technology can be applied to the entire system of protected areas and national parks of Vietnam.

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