A DECISION SUPPORT SYSTEM FOR GEOINFORMATICS MAPPING OF RENEWABLE ENERGY RESOURCES AND SYSTEMS IN THE PHILIPPINES

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Abstract

A geoinformatics-based decision support system was developed to build wealth of georeferenced data and information on renewable energy (RE) resources (solar, wind, water, and biomass) for policy research and development on energy resources. Geo-referenced database and thematic maps as major outputs showed various indicators on assessment, monitoring and evaluation, and efficiency thrusts that are useful for energy research, planning and policy options for rationalization and resource management of energy mix required under the medium- and long-term energy development and investment plan of the country. The use of satellite remote sensing (SRS), geographic information system (GIS) and global positioning system (GPS) for survey of databases on RE resources and systems, as well as other geographic features are emerging, dynamic, geoinformatics mapping tools to share statistical data, information and knowledge among stakeholders on geographic areas and related policy issues which could be easily shared in the world wide web. A graphic user interface visual programming linked with ArcView GIS, mobile mapping systems architecture, interface with long-range alternatives planning system or LEAP software, other georeferenced energy resources will be presented. The combined use of SRS, GIS, and GPS with graphic user programming language has proven to be a very valuable and indispensable geoinformatics tools for gathering, organizing, easy retrieval and storing geo-referenced data for subsequent analyses and retrieval. Efforts to create a cadre of expertise on geoinformatics professionals and students, conduct of advance collaborative research projects, symposia, and partnerships with local and international and inter-agency collaboration in the Philippines with JAXA and others for productivity, sharing of resources, expertise and excellence in space technology will also be discussed.

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Keywords: Geoinformations, remote sensing, GIS, GPS and decision support system

1. INTRODUCTION

The Philippines being an archipelago coupled with diverse geography and varying regional socioeconomic conditions, renewable energy (RE) basic data and information availability, accessibility and affordability are some of the major issues that affect RE development in these areas in the country. It was reported that sources of RE are much more abundant in Japan than their fossil counterparts [1]. However, one technology that does not often come to mind when planning to realize the potential of renewables is that of space-based remote sensing satellites. It was argued that Japan has a need for increased domestic energy supply and a desire to promote global welfare through technology suggested that Japanese space technology efforts should prioritize the very practical endeavor of using satellite-based remote sensing to develop three renewable energy resources: solar, wind and geothermal which then provide examples of potential economic benefits, as well as propose opportunities for inter-agency and international cooperation. Aside from this, the diversity of the target groups requires different treatments and packaging of RE information to facilitate adoption and assimilation. Thus, there is a need to conduct of RE resource assessments in the country and update data and information that can be utilized by project developers/investors in conceptualizing, designing and evaluating RE projects [2]. To continue the implementation of the medium- and long-term plans, rationalization of programs and projects on RE in the country, the Department of Energy (DOE) emphasized the importance of systematic collection, storage, analysis and annual updating of voluminous data and information on RE sources and systems through its 21 ANECs. To manage such voluminous database, systematic tools should be used and assembled as a decision support system (DSS). A DSS is a computer-based of integrating database and analytical modeling methods such as artificial intelligence, decision analysis, optimization, modeling, etc. to support decision making [3] and using geoinformatics tools [4]. The structure of geoinformatics can be understood in many ways, what can be seen from the more or the less complex schemes published in various articles. Geoinformatics creates new possibilities for the precise analysis of spatial phenomena, such as for following their dynamics or defining the associations existing between their components. The use of remote sensing data (land satellites) in such research, takes to another level those areas of knowledge, in which are becoming reliable materials in concerned agencies or could be accessed through internet. It also enables the current monitoring of those phenomena which can not be investigated and estimated in any other way, as well as the modeling of spatial (geographical) phenomena to build an expert system or DSS. However, such DSS had been applied mostly on agricultural land use planning options, crop suitability, and natural resources management and being considered just lately in higher education and policy researches [4]. Likewise, there are some attempts for such energy resource assessments, but such are static, not user-friendly and could not be updated at will to have a continuing RDE activities on RE [5], [6]. In 1994, the DOE provided a NESCON software to all ANEC researchers throughout the country to be used in RE inventory and perform energy mix analysis. As one of the mandated activities of all the 21 ANECs in the country, voluminous data and information on RE sources and systems were gathered and stored in NESCON. However, with the fast changing of computer software and hardware configuration, the NESCON was corrupted, obsolete and some voluminous databases were lost and could not be retrieved easily for possible use. To solve this predicament, the MMSU–ANEC has started to conceptualize a geoinformatics based DSS on RE sources and systems in Ilocos Norte, Ilocos Sur and Abra provinces in 2005. Hence, this study was conducted to: 1) develop a geoinformatics based DSS methodology on geo-referenced data and information of RE sources and systems; and 2) operationalize such DSS and pilot engineering, policy RDE options on RE, as well as to implement regular updating program for the RE databases storage and exchange.

2. METHODOLOGY

2.1. Decision Support Systems on Renewable Energy

A set of geoinformatics tools such as SRS, GIS, GPS, and internet mapping was assembled to gather, store, easy retrieval and analyze spatial geo-referenced data/information and generate/disseminate information about RE sources and systems. RE sources refers to energy resources that do not have an upper limit on the total quantity to be used. Such resources are renewable on a regular basis, and whose renewal rate is relatively rapid to consider availability over an indefinite period of time. These include, among others, solar, wind, hydropower, geothermal and ocean energy. RE systems refers to energy systems which convert renewable energy resources into useful energy forms, like electrical, mechanical, etc. .

The methodological framework of the study is presented in Figure 1 showing the input database, process or analysis and the expected outcomes of the analysis. Special emphasis is given to the step from geo-referenced data to spatial analysis that is tailored to the type and quality of readily available attribute of data gathered.

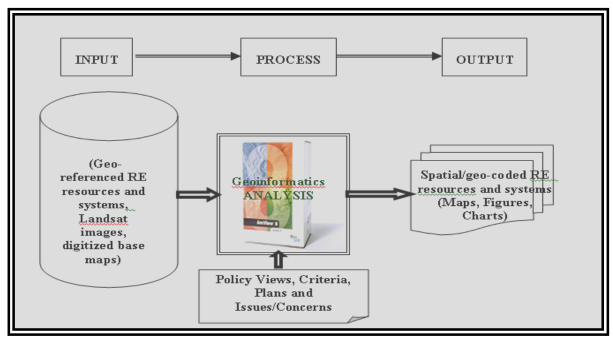


Fig. 1. Paradigm of the study showing input-process-output relationships of the DSS.

Modules in GIS, remote sensing and internet works software were used for image analysis, geospatial query (theme-on-theme selection), overlaying tools of map themes based on specific data elements or attributes were employed based on criteria and various indicators for each policy options, issues and concern as required. Once the various data entries, GIS query modules, report generation and other pertinent documents were assembled and fine-tuned, a graphic user interface of Visual Basic and GIS software was applied to automate such DSS tool.

2.2 Research Design

Structured questionnaire which contained major data elements profile of RE systems from the old version of NESCON was revised and used by ANEC staff during field surveys. A GPS receiver was used to locate the latitude and longitude coordinates taken at each RE system, which represent the geo-reference point data of a RE system as an input database in the ArcView GIS software. Such geo-referenced data conform to the standard map projection (universal traverse mercator or UTM at Zone 51) for spatial analysis. The old database files of NESCON were retrieved and reformatted in order to be compatible with the new software being developed.

2.3 Estimation of RE Sources

For solar energy, the Climatological Solar Radiation (CSR) Model of the National Energy Research Laboratory, USA was used [6]. This model converts information on satellite- and surface derived cloud cover data collected at a 40-km spatial resolution to estimate the monthly, average daily total global horizontal solar resource. In hydropower resource, the total resources available to this technology can be specified according to the potential power output (Ps) defined by the equation;

$$Ps = \varepsilon g \rho Q H \qquad (1)$$

where ε is the overall system efficiency, g is the acceleration of gravity, Q is the flow rate of the water being used by the system, ρ is the density of water, and H is the effective head of the water.

The level of the wind power resource is defined in terms of the wind-power-density value, expressed in watts per square meter. This value incorporates the combined effects of the wind speed frequency distribution, the dependence of the wind power on air density, and the cube of the wind speed as defined by NREL [5],[6]. To estimate biomass resources, some conservative assumptions were made to make a practical and reliable estimate of the biomass resources in the country. For example, crop straw and stalk outputs are calculated based on crop outputs and the ratio of grain production to stalk mass. These assumptions were related to the type of processing done for a particular commodity [6], [7]. Other geographic data from land satellites, digital landuse/boundary maps, hydrometeorological data were gathered and compiled as input databases and basemaps.

2.4 Source of Data and Methods of Analysis

Major source of input databases came from primary GPS-based surveys conducted by ANEC while secondary sources (landsat, digital basemaps, available RE statistics, etc.) were gathered from various agencies such as DOE, NAMRIA, BSWM, DA-BAR, IRRI, NREL-USA publications, internet, other ANECs and previous database files of NESCON. ArcView GIS software was used for the spatial query analysis [8] while Visual Basic 6 was used to develop graphic user interface programming to compile the georeferenced input data, as well as the graphic user interface of linking relational databases to GIS application query modules.

3. RESULTS AND DISCUSSION

3.1 Development of DSS Methodology

With the input-process-output relationship, the DSS was developed to build wealth of data and information of RE resources and called Renewable Energy-Map Analysis Program or *RE-MAP*. The *RE-MAP* is a dynamic, user-friendly window-based software for ease in data encoding/editing/updating, transaction, GIS query, output printing and linking other related documents such as its user guide, tutorial lessons in visual basic programming and other documents (Fig. 2).

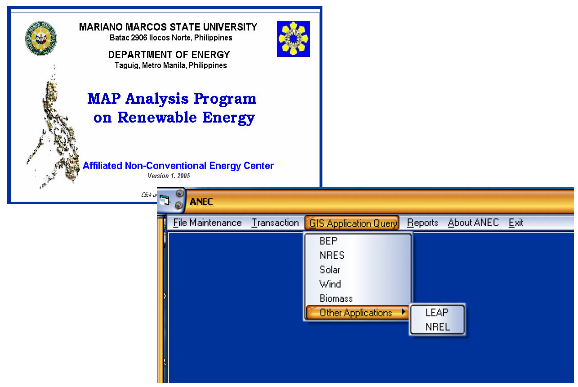


Fig. 2. Graphic user interface showing splash menu and window-based modules, and structure of RE-MAP.

Such DSS methodology in its on-going development was presented to major stakeholders, such as the heads and staff of DOE-EUMB-REMD, other ANECs staff and researchers, as well as colleagues in the academe and other research institutions. Their comments and suggestions were considered in the development. Such productive interactive process development of DSS to other stakeholders also brought interest for similar thinking and other applications on RDE. Some colleagues indicated their interest to learn such emerging tools in their offices.

3.2 Applications of RE-MAP

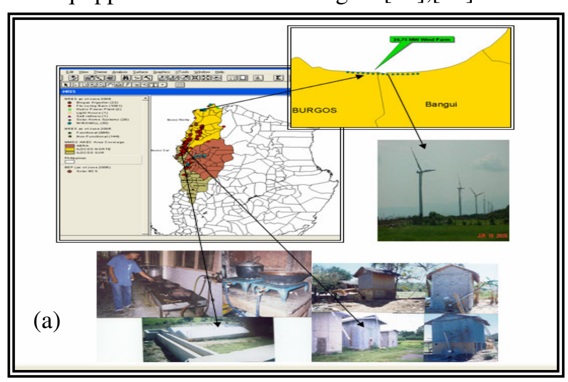
The MMSU ANEC is one among the 21 RE centers in the country and served 18 years as RDE partners of DOE to promote the use and commercialization of RE resources. Each ANEC is strategically located nationwide and being hosted mainly by state colleges and universities, and mostly managed by agricultural engineers. Hereunder are some of the applications of RE-MAP on some mandated tasks such as annual inventory of RE, and conduct/monitoring of barangay electrification program (BEP).

GPS-Survey/Monitoring of RE. Inventory of RE systems in Ilocos Norte, Ilocos Sur and Abra, Philippines was conducted to determine the contribution of these systems installed in the aforementioned three provinces and energy mix in general. In 2006 inventory, utilization of biomass particularly fuelwood for fluecuring of Virginia tobacco got the highest share (97.73%) and the least resource utilized was the manure for the biogas plants. Other resources such as wind, water and solar were utilized in a very minimal amount (2.17%, 0.08% and 0.012%, respectively) although they are increasing as compared to the passed years [9]. To date, there were 779 RE systems that were georeferenced using GPS and Figure 3 (upper map/photo) shows some typical outputs on RE sources and systems using *RE-MAP*. Such RE inventory databases were incorporated already in *RE-MAP* for data banking for easy retrieval, monitoring, evaluation and analysis by DOE, ANEC and other interested parties.

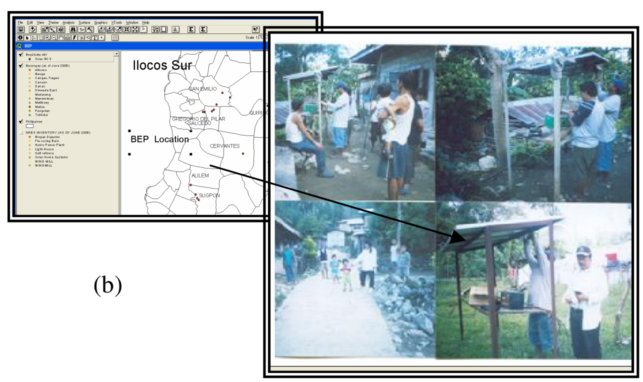
<u>BEP in Off-Grid Areas</u>. The MMSU ANEC is also mandated to energize at least two off-grid barangays in the Ilocos (Ilocos Norte, Ilocos Sur and Abra, Philippines). From 1999-2005 budget operations funded by DOE under the BEP, the MMSU ANEC was able to install battery charging stations (BCS) in 12 off-grid barangays. Thus, for the 4.53 million pesos budget from DOE, it generated a total 10,050 Wp BCS serving more than 300 households, 12 barangay halls, churches, cooperative and rural health unit in those far-flung communities that could only be reached through trail hiking for 4 to 10 hours and back. Figure 3 (lower map/photo) shows BSCs in far-flung barangays of eastern interior towns of Ilocos Sur during annual field monitoring.

<u>Implications</u>. Despite the DSS methodology development of *RE-MAP*, it is of utmost importance to involve stakeholders and end-users from the beginning in the system design and frequent interactions between funders, policy researchers from DOE, ANECs and other stakeholders during development. The *RE-MAP* developed served as a tool to share data, information and knowledge, as well as policy issues and concerns to rationalize RE in the country. Such dynamic and user-friendly DSS could also be linked to LEAP software and other NREL databases from DOE. Initial trainings of the concept were already disseminated to some ANECs, colleges and universities, and research institutions here and abroad. Likewise, agricultural engineers among agencies, LGUs and other government and NGOs were equipped on these tools for their land use planning, tax mapping, RDE activities through advanced training, here and abroad. Thus, such methodological framework should be introduced to other agricultural engineering professionals to equip such emerging tool for possible entrepreneurship works, locally and/or globally. Moreover, such tools should be incorporated in the computer application subjects of BSAE course and other related courses among academic institutions to learn geoinformatics tools in diverse and various fields of applications in engineering and other related courses/field of studies.

In order to develop the best remote sensing systems for the development of renewable energy resources, and in order to make the most use of them domestically and abroad, JAXA should consider cooperation with the space agencies of other nations. Japan has one of the world's leading space programs, but it is not very large relative to that of the United States or Europe, nor does it have the most extensive experience. It occupies a middle ground when compared to the other nations of the world and thus has both much to contribute and much to learn. JAXA has also identified opportunities to use the upcoming ALOS satellite to help mitigate and possibly prevent natural disasters in developing countries in Asia. The geological data obtained from ALOS can be very effective in identifying areas of potential landslide, and this application has been suggested as an area of potential cooperation for with Vietnam, Indonesia, the Philippines and Bangladesh, where ground-based facilities are not well equipped to detect these dangers [10],[11].



(a) Geo-referenced database such as the 24.75 MW Windfarm at Bangui Bay, Ilocos Norte by NortWind, Inc.; biogas plants for cooking of more than 100 nuns at St. Benedict, Vigan City, developed by MMSU ANEC Staff; and tobacco fluecuring barns during GPS-survey



(b) Geo-referenced database such as BEP in Ilocos Sur using photovoltaic battery charging stations.

Fig. 3. Thematic maps outputs of RE-MAP showing geo-referenced (a) renewable resources; and (b) barangay electrification program (BEP) during field monitoring and GPS-survey.

5. CONCLUSIONS AND RECOMMENDATIONS

The MMSU ANEC developed a user-friendly and dynamic operational DSS software called *RE-MAP* to replace the old version NESCON. More importantly, *RE-MAP* can use the old database files of NESCON through reformatting/conversion of input files. The DOE and ANECs should focus on ready-to-update database for a national compilation or atlas showing important RE data elements coupled with spatial context so that researchers, planners and investors can access such operational data and information with good quality, accuracy and security in sharing such wealth of RE data and information. This needs an investment support before collaboration in further methodology development of *REMAP* comes to the forefront**.** Thus, the institutionalization use of *REMAP* is important for ANECs, DOE and other interested entities that lend data and information support in pursuit of the government independence in energy. Most importantly, such RDE initiatives on *RE-MAP* managed and empowered mostly by agricultural engineers is an epitome of entrepreneurs as engine for sustained development for local and global arena, particularly in RE. Such innovation can be replicated, duplicated, or modified by agricultural engineers globally in other fields of specialization and endeavors for sustainable development of our vast natural resources.

ALOS has multiple objectives: to support improved cartography, especially within the Asia-Pacific region, to gather environmental observations in support of sustainable development efforts, to survey natural resources, to develop technologies for further Earth Observation missions and to monitor disasters on a worldwide basis – JAXA having signed the International Charter on Major Disasters in February 2005 [12]. Continued international cooperation of JAXA with others in earth observation and natural resources should be strived, with the noble objective of acquiring greater competence in using space technology for RE, among other fields of interests. The convergence of Japan's energy needs and its space technology capabilities makes it a logical choice not only to become familiar with these applications, but to share their resources and expertise for other developing countries, such as Philippines and others. By further developing its own remote sensing technologies, the Philippines and like Japan can not only realize the social welfare of RE resources for themselves, but also for the other countries for harnessing such renewables.

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