# GIS MCE AND ICT BASED PRECISION AGRICULTURAL MODEL FOR RURAL AGRICULTURAL DEVELOPMENT

K.J.C. Kumara[1], K. Sanga-Ngoie[2] & Duminda Nishantha[3]

[1] Doctoral Candidate, Laboratory of Environmental Geoscience, Graduate School of Asia Pacific Studies, Ritsumeikan Asia Pacific University, Japan, Email: kumara.kjc@ieee.org

[2] Professor, Laboratory of Environmental Geoscience, Graduate School of Asia Pacific Studies, Ritsumeikan Asia Pacific University, Japan, Email: sangank1212@gmail.com

[32] Professor, Department of ICT, Ritsumeikan Asia Pacific University, Japan, Email:dumindalk@ieee.org

**ABSTRACT**

Precision agricultural techniques has been in practice for last three decades and it has been more functional and versatile with the integration of GIS, GPS and remote sensing techniques for the data collection, processing and analysis, and the ICT platforms for effective information sharing. The problem is how these techniques are integrates with climate change responses which are currently being a threat for every industry especially in the context of rural agriculture and economic development. This research paper investigate and proposed applications of GIS multi-criteria analysis for site suitability analysis, expansion and zoning, precision agricultural practices for monitoring and controlling, and ICT for platform development can be implemented in the development of rural agriculture sustainably in every means combating with the consequences of climate change.

***Key words*:** Climate change, GIS, Mathematical modeling, Multi-criteria analysis, Precision Agriculture, Remote Sensing, Rural farming

## 1. INTRODUCTION

Precision agricultural techniques has been in practice for last three decades in various scale but it has been more functional and versatile since the integration of GPS and remote sensing techniques for data collection, GIS software platforms for data processing, database building and analysis (tools for map development, data integration from widespread sources and development of suitability maps), and mathematical modeling for objective computer-based simulation and prediction needed for sound decision making [1]. Agro-ecological zoning aims at describing the homogeneous plots of land which are equally fit to given agricultural activities mainly based on climatic conditions, soil types and land forms [2]. GIS has proved to be a versatile set of computational tools used for zoning and site selection purposes. Climate change (CC) is influencing agriculture in different ways (productivity and quality of crop) [3], and at different scales. CC impacts on the food supply chain strongly link with the whole socio-economic development [4], and especially health, food security and existence of balance ecosystem. Agriculture is the main income of rural communities in most of the countries in the world. As for developing countries, extreme urbanization, loosing of lands and reduction of economical gain have transformed the rural agriculture to low quality and low level employment category, and this has been directly affecting to the declining of rural agriculture through the lack of labor capacity. The elimination of rural farming constraints were proposed through precision farming technology platforms [6] consisting of 3 key technologies: mapping techniques, variable rate technique and decision support system. Although similar kind of technical initiatives and solutions are practiced in Japan and many other parts of the world, the following problems were identified through the literature reported and past research experiences in the field.

## 2. RESEARCH PROBLEMS AND OBJECTIVES

The whole agricultural model which can address the issues stated above is not well defined and

applications are inadequate as full capacities (from site selection to harvesting yields) of the available technologies have not been in practice especially when considering current state and future expansions of the rural farming. Integration of climate change issues is an essential requirement of the system which is also partly investigated. The complete prototype model proposed here combine three main modules: (1). GIS multi-criteria evaluation (MCE) for analysis [7, 8], (2). Precision agricultu -ral techniques [9] addressing agro-meteorological needs including analysis and mathematical –computer modeling, and (3). Decision support platform which integrates responses of climate change responses [10] derived for local agro-industry.

Main objectives of this research are to investigate, analyze and describe: (a) different applications of GIS as a processing and analytical tool which utilizes the advantage of precise datasets available through remote sensing (RS), real time monitoring stations, resources developed by the various institutes and sophisticated climatic models (b) precision farming techniques including instrumentation which covers the indicators of biophysical parameters, data collection, logging, processing, and transmission [8,11]; (c) artificial intelligent techniques [12,13 & references there in] for modeling (d) key elements of the decision support systems with regards to rural context; and (e) issues of integration of above modules together taking climate change responses into account, and presentation of complete model for rural socio-economic development of Japan as one case from developed countries, and extending these experiences in developing countries (Sri Lanka) will be ultimate target.

## 3. MAIN STEPS OF THE METHODOLOGY

Field studies for the proposed work covered most of rural farming area of *Ajimu, Usa City, Oita Prefecture* [14] to learn existing system, and Jafna, Banadarawela and Hambanthota, Sri Lanka to explore the feasibility, with the help of the local farming community, government agricultural and other institutions, and local governments. GIS MCE with set of indicators is proposed as the zoning and potential site exploration technique for future expansions. Indicators are assessed through PA instrumentations and remote sensing information with the integration of climate change scenarios as one complete decision making support system. Figure 1 shows four layers: input (IPL) including real time data collection through PA stations, RS data, datasets & databases, processing, analysis & modeling (PAML) – GIS MCE, mathematical modeling, integration & decision support (IDPL) and result interpretation (RIL) of the model summarizing the overall picture while Figure 2 depicts main steps of the sub-steps of the methodology developed for GIS analysis for the remote sensing and ground based data.

## 4. PROPOSED MODEL

The proposed precision agricultural model (Fig.1) consists of four layers. The input layer receives all kind of information including real time data collection through PA stations, RS data, and management system outputs. The processing, analysis & modeling layer is the implementation of mathematical modeling and different tools and techniques including GIS, followed by the integration and decision support layer. The result interpretation layer links the model outputs to the management.

## 5. CONCLUSION

This research addresses the three main aspects of the rural agricultural development issues: lacking of labour power due to aging society and urbanization, loosing of landscape values (described as the *satoyanma* in Japanese) in developed countries vs. to barriers in developing countries, and coping with the climate change responses as a common threat. Guidelines for development of technical platform associating with the well established technologies: GIS & remote sensing, precision agriculture and decision support platform are provided. The proposed prototype model is emphasized as a need for the development of rural community in developing countries through their agriculture associated regional adding values and attraction young generation through integrating these to education system. In a large sense this is arising

mainly in the developing countries where the people don't have access to the updated technology and proper use in the field.

## 6. REFERENCES


[1]. Peterschmidt, B. *Application of GIS in Precision Agriculture*. 2009, http://people. oregonstate.edu/~peterscb/bib (accessed 04.15, 2010)

[2]. Fischer, G. et al, *Agro-ecological zone assessment*, International institute for applied systems Analysis. www.iiasa.ac.at/Admin/PUB/ Documents/RP-06-003.pdf(accessed 2010.03.01)

[3]. Reddy, K.R. & Hodges, H.F. "Climate change and global crop productivity," *CABI publishing*. 2000

[4]. Fischer, G. et al. "Socio-economic and climate change impacts on agriculture: an integrated assessment, 1990–2080," *Philosophical transaction of the Royal society*, B360, 2005: 2067 – 2083.

[5]. Team GW of MRI (meteorological research institute Japan). *Comprehensive projection of climate change around Japan due to the global warming, 2008,* http://www.mri-jma.go.jp/Project /1-21/1-21-en.htm (accessed 2010.05.10).

[6]. Shibusawa, S., "Precision farming – Japan model," *Journal of Agricultural information research*. 12, no. 2, 2003: 125-133.

[7]. Eastman, J. R., "Guide to GIS and Image Processing," Massachusetts: Clark University, vol. 1, 2009, pp.129 – 150.

[8]. Sanga-Ngoie, K., Kumara K.J.C. & Kobayashi, S., "potential grape - growing sites in the tropics: exploration and zoning using a gis multi-criteria evaluation approach," Asian Conference of Remote Sensing, Hanoi, 2010.

[9]. Shrinivasen, A, "Handbook of Precision Agriculture: Principles and Applications," 1st ed, New York, The Harworth Press Inc.,2006, pp. 3-491

[10]. IPCC: Intergovernmental Panel on Climate Change. 2007. "Climate Change 2007: Impacts, Adaptation, and Vulnerability." Contribution of Working Group II to the Third Assessment Report of the Intergovernmental Panel on Climate Change, (online IPCC)

http://www.ipcc.ch (accessed on 4 April 2009)

[11]. Cassim, M, "Ajimu Project," Ritsumeikan Asia Pacific University, Japan. **www.ajimu-project.org** (accessed on 25.03.2011)

[12]. Chen, S.H., Jakeman, A.J.& Nortan, J.P., "Artificial Intelligence Techniques: An Introduction to their use for modeling environmental system," *Journal of Mathematics and Computer Simulation*. 78, 2008: 379-400.

[13]. Kumara, K.J.C. "Modeling and Simulation of Viticultural growth to response effects of climate change: nonlinear modeling approach using neural networks," *Master thesis*, 2010, University of Applied Sciences, Trier, Germany.

[14]. Oita Prefecture, Japan. http://www.pref.oita .jp/english/(accessed on 4 April 2011)

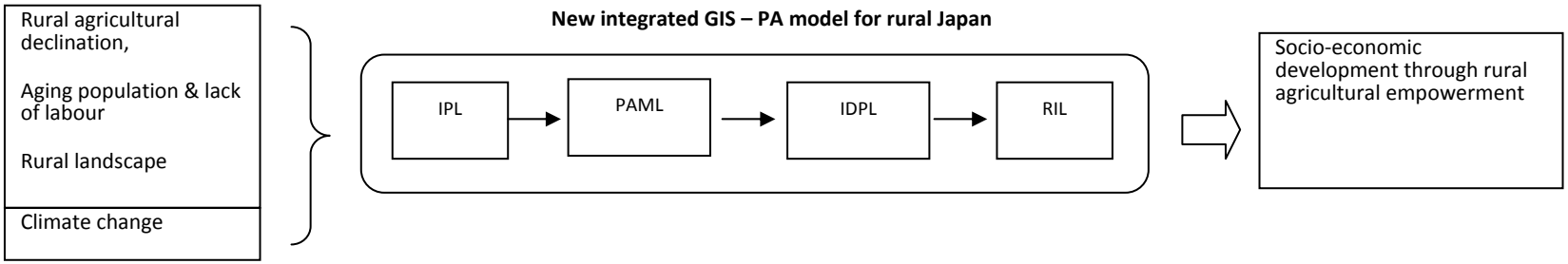


**Figure 1**: Different layers of the proposed system, issues and main outcome of the research

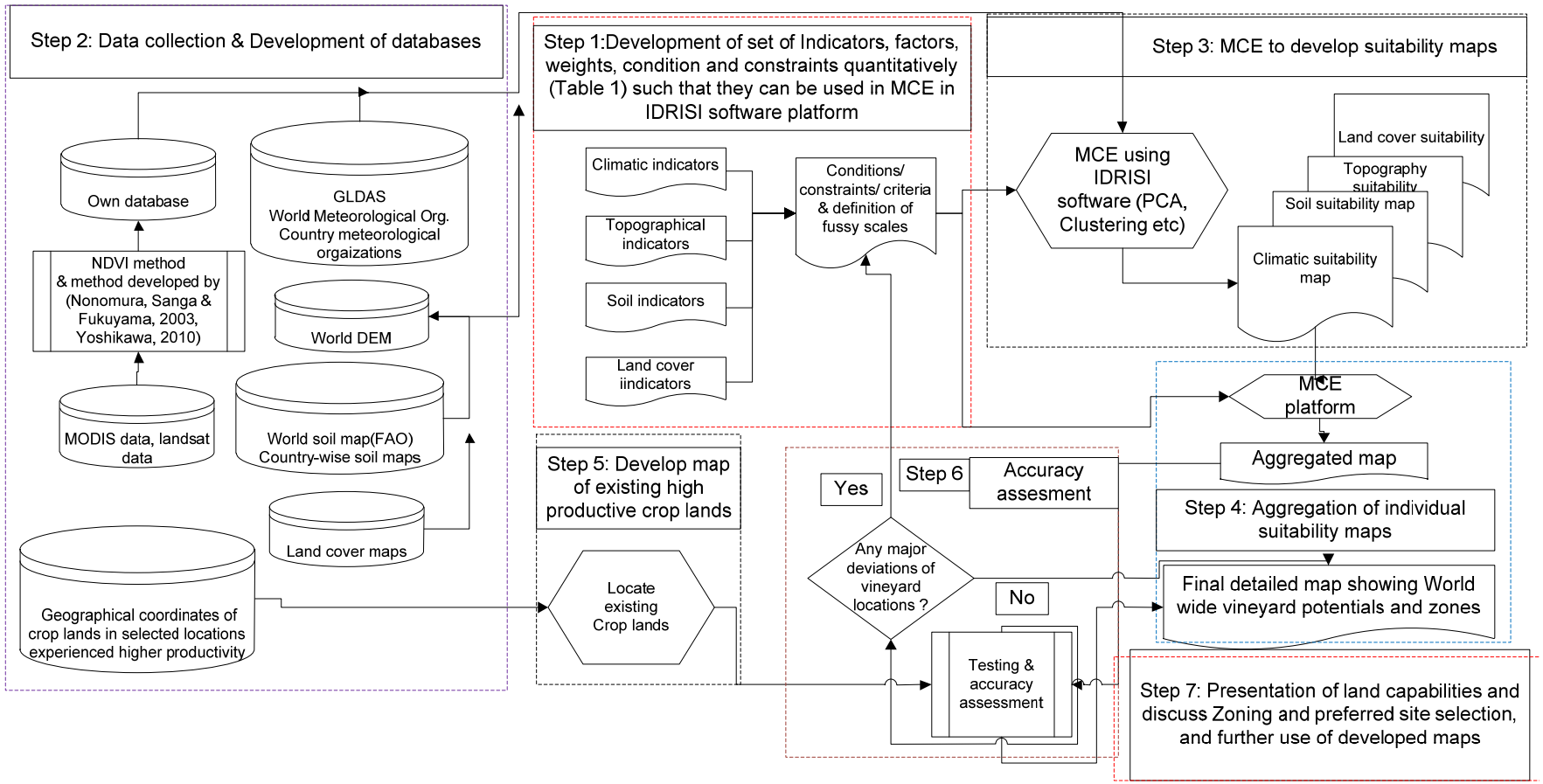


**Fig. 2**: Main steps of the methodology for zoning and potential site exploration to integrate with the Precision Agriculture and Climate Change mode