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Integration of GPS and GIS in Establishing Land Information System of CTU-Barili Parcels of Lands

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ABSTRACT

Establishing land information system is a valuable resource in managing vast area of lands. In this study, GIS and GPS are integrated as a modern method of generating relatively spatially accurate and operationally effective cadastral and other related information database. CTU-Barili Campus lots are about 100 hectare. Since its transfer from its former location (Lahug, Cebu City) to its recent location (Cagay, Barili, Cebu), the administration and the faculty of agricultural engineering have no sufficient knowledge on its land boundaries or property lines. This paper focuses on establishing its land information system in terms of property lines, land-use and topography to a projected real world coordinate system (PRWCS). Due to the availability of geospatial data and tools, it is now easier to establish, link and combine land information in a bigger spatial setting. As a result, useable relatively accurate GIS and GPS based digital land information of CTU-Barili Campus can serve as a decision support system for the school's property management and sustainable development.

Keywords: GIS and GPS mapping, cadastral, land information system

INTRODUCTION

Geographic Information System (GIS) is a computer-based tool (Barreca, Bonforte & Neri, 2013) capable of capturing, storing, analyzing and managing spatial data and associated attributes that can be used to manage land resources (Yilmaz, 2008). In the last three decades, both GIS and GPS address a broad range of applications in mapping (Ali et al., 2012; Yilmaz, 2008), disaster and hazard evaluation (Barreca, Bonforte, & Neri, 2013) and mitigation, monitoring urban growth (Tayyebi, Pijanowski & Tayyebi, 2011), urban planning and sustainable development (Z. Xu & Coors, 2012), watershed delineation, natural resources inventory, surveying land property lines. In the advent of geographical information system (GIS) and global positioning system (GPS), the quality of establishing land information system (LIS) particularly on its spatial data can be improved in a better way (Ali, Tuladhar & Zevenbergen, 2012) compared to the traditional land surveying. Such practical GIS and GPS technologies advanced land information and management. Knowing property or boundary lines is an important aspect for sustainable land development and management. Traditional land surveying is no longer enough to monitor boundaries of vast land areas in establishing geospatial data of parcels of lands. Geospatial mapping of CTU-Barili Campus requires the integration of GIS and GPS in order to obtain the significant advantages of establishing its land information to a projected real world

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coordinate system (PRWCS). The need to adapt advanced technologies in mapping like GIS and GPS is to accurately map locations and information of lands. GIS mapping facilitates decision making as it promotes ease of storing, retrieving, and updating spatial data (Labib & Nashed, 2013).

This study focuses on spatial data particularly on mapping and surveying specific boundaries, shape and location of the estimated 103-hectare lands of CTU-Barili Campus. One of its aims was to visualize its land information in GIS platform like Google Earth. The paper focused on establishing land information system of CTU-Barili in terms of property lines, land-use and topography to a projected real world coordinate system (PRWCS). The following specific objectives were to: (1) digitize property points and boundary lines of CTU-Barili in AutoCAD and determine their global positions by a hand-held GPS; (2) integrate and store these boundaries in a GIS tool (Quantum-GIS); (3) visualize land information by integrating Google Earth images of CTU-Barili; (4) develop topographic map; (6) digitize several land uses of CTU-Barili parcels of lands.

Study Area

The area of interest is in the province of Cebu (Figure 1)focused on Cebu Technological University-Barili Campus parcels of lands that are about 103 hectares. The campus is located on the mountain range at the mid-section of south-western part of Cebu Province with longitude from 123.542° to 123.556° and latitude from 10.121° to 10.140°. About 55 km from Cebu City, the campus is situated in the southern limit of barangay Cagay, western limit of barangay Cabcaban and eastern limit of barangay Kalubihan of the Municipality of Barili. Its elevation ranges from 82 to 162 meters above mean sea level based on the World Geodetic System of 1984 (WGS84) datum. Mainly agricultural lands, it suits to the flagship program of the campus of which is formerly known as Cebu State College of Science and Technology – College of Agriculture. Since its transfer from its former location (Lahug, Cebu City) to its recent location (Cagay, Barili, Cebu), the administration and the faculty of agricultural engineering have no sufficient knowledge on its land boundaries or property lines. CTU-Barili Campus is located in a remote area where there is such a need to establish its land information to a projected real world coordinate system (PRWCS).

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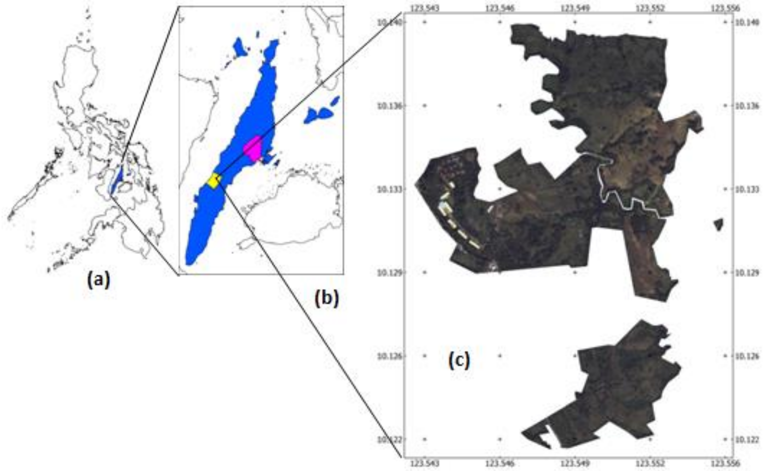

Figure 1. The Study Area. (a) Map of the Philippines; (b) Cebu Province, Cebu City (pink), Barili (yellow); (c) CTU-Barili Campus (in google earth image)

MATERIALS AND METHODS

Digitizing CTU-Barili Boundary Points and Property Lines

CTU-Barili owns 11 (eleven) titled parcels of lands of varying shapes and sizes (Figure 2).Each parcel of land was digitized in AutoCAD in order to visualize shapes and calculate sizes of these lands relatively accurate as possible. The specified Barangay Boundary Monuments (BBM) in the Land Titles determined the relative locations of every parcel of land with respect to each other. By acquiring copies of lot descriptions from DENR-Bureau of Lands, Cebu City verified description of points with questionable bearings and distances.

Georeferencing CTU-Barili Campus

Global locations of boundary points were determined using hand-held GPS adapting Universal Transverse Mercator (UTM) projection. Likewise, global positions of some campus landmarks (like fence corners, school buildings, faculty houses, animal and crop production projects, etc.) were determined establishing their real world coordinates where these became GPS waypoints. Likewise, established fences, road networks, and different land-use areas of the school were tracked by a hand-held GPS establishing a set of real world coordinates where these became GPS tracks. Eventually, waypoints and tracks data were transferred from the GPS device to the computer using a Garmin Map Source interface to view them as maps. Waypoints and tracks were viewed in Google Earth verifying there global positions.

Waypoints and track data saved as GPS Database (gdb) files were also saved as drawing exchange format (dxf) files in Map Source. Such waypoints and track data in drawing exchange format files were viewed in AutoCAD where digitized CTU-Barili boundary points and property lines were integrated. Placing the digitized campus boundary lines was done manually by looking into minimal gap among points with waypoints data. Converting the georeferenced dxf files into

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keyhole markup language (kml), using KML tools, results by manual adjustment were verified, checked and viewed repeatedly in google earth. Thus, this manual process was done repeatedly until relative accurate results were achieved. Finally, georeferenced dxf files were then integrated or added as vector layers in Quantum-GIS generating GIS layouts of land information in terms of property lines, land-use and topography of CTU-Barili campus projected to WGS 84-UTM zone 51N for the Philippines.

Generating CTU-Barili Campus Contour Lines

Generation of CTU-Barili Campus contour lines was done by the use of the free version SketchUp and the Google Earth's terrain of the campus. Note that adding location from Google Earth's image requires internet connection. The detailed procedure in extracting contour lines from Google Earth's terrain was adapted as presented in wikiHow (n.d.) from the topic "create contour lines usingSketchUp". Once contour lines model was created, still at SketcUp, a cross line was drawn at the origin of the model. This facilitates locating center of the model when viewed in AutoCAD. The contour model was then exported to AutoCAD as 3D model. Note, however, that geo-location in SketchUp is in degrees, thus, it was converted to UTM. When the model is opened in AutoCAD, its origin is at the center of the model and this is its geo-location. The entire model was selected and copied with its origin as base point. A new blank CAD file is opened with units in meter where the copied contour model is pasted specifying its geo-location in UTM as its insertion point. The contour model is now geo-referenced. Before adding the model as vector data in QGIS, contour lines were edited and joined.

RESULTS AND DISCUSSION

The integration of GPS and GIS mapping led to the generation of school's cadastral map, topography map and land-use map.

Cadastral Map

Concerning establishing of CTU-Barili cadastral map (Figure 2), using Quantum-GIS, 11 parcels of lands were plotted and geographically projected to real world coordinate system. Plotting and closing of each parcel of land according to lot descriptions specified in the Land Title were done not without problems since some of the boundary point descriptions are with questionable bearing and distance. Nevertheless, acquiring copies of lot descriptions from DENR-Bureau of Lands, Cebu City overcame most of the questionable descriptions.

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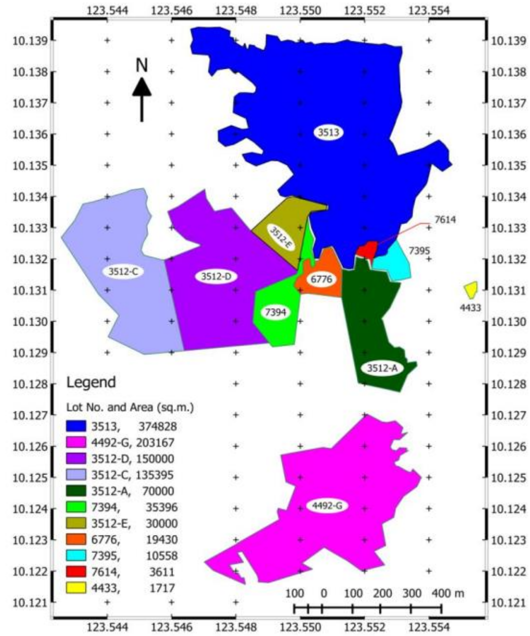

Figure 2: CTU-Barili Campus Parcels of Lands to a projected real world coordinate system

AutoCAD functionality of calculating area of any closed polygon implemented checking of land areas of the different parcels of lands. As specified in the Land Title, CTU-Barili possesses a total of 1034102 m2 (103.4102 hectare) of land (Table 1).However, from AutoCAD area calculation, significant differences were observed on subdivided lots due to questionable descriptions in bearings and distances. Consequently, farther verification of unsolved questionable descriptions are needed by acquiring copies of lot descriptions from a surveyor or firm who conducted boundary surveying of the lands especially those from subdivided lots since DENR-Bureau of Lands, Cebu City does not possess copies of lot descriptions of subdivided lots.

An interesting result of CTU-Barili cadastral map revealed that a particular parcel of land with lot number 4433 with an area of 1717 m2is separated from a larger parcel of land in Barangay Cabcaban. This particular lot is not utilized as of the moment.

Table 1. Land Area of CTU-Barili Parcels of Lands

Lot Number	Land Area, m^2		Difference, m^2
	Tile	By AutoCAD	
3513	374828	374849.98	21.98
4433	1717	1713.73	-3.271
6776	19430	19432.46	2.46
7394	35396	35401.23	5.23
7395	10558	10560.13	2.13
7614	3611	3610.99	-0.0106
3512-A *	70000	69420.17	-579.8262
3512-C *	135395	135553.77	158.7708
3512-D *	150000	150000.64	0.6409
3512-E *	30000	30001.69	1.69

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4492-G *	203167	203718.89	551.8922
Total m^2	**1034102.00**	**1034263.69**	**161.6861**
Area hectare	**103.41**	**103.43**	**0.01616861**

Topography Map

CTU-Barili topography map is represented using contour lines generated from Google Earth's image using open source SketchUpMake 2014. Google Earth elevation is based on the World Geodetic System of 1984 (WGS84) datum where altitude or elevation can simply be thought of as meters above local mean sea level. Figure 3portrays the shape and elevation of CTU-Barili lands which is generally rolling down towards the creek. Thus, peaks of elevation are found on extreme west and east boundaries of the biggest group of lands with latitudes from 10.129^0 to 10.139^0.The peaks of this area achieves elevation about 155 m at the west and 135 m on the east, whereas the lowest elevation towards the creek is about 90 m above mean sea level.

Likewise, peak of elevation at Kalubihan area is about 165 m and which is rolling down towards north-east to a lowest elevation about 110 m above mean sea level.

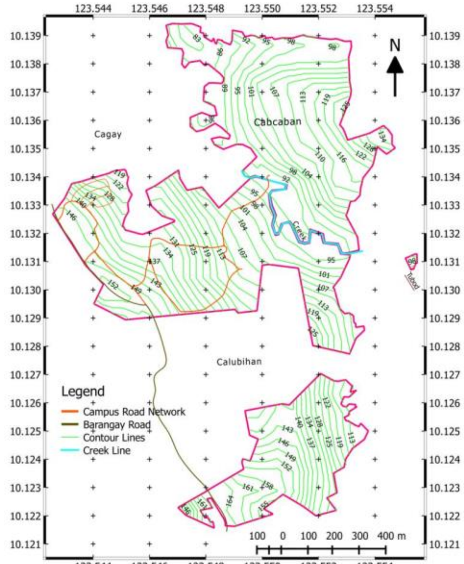

Figure 3. CTU-Barili Campus Topography Map to a projected real world coordinate system

Land use Map

CTU-Barili Campus comprises mainly of agricultural land having agriculture as its flagship program. Land-use and land management at CTU-Barili has a major impact in terms of its agricultural production. A great challenge lies on a sustainable and long-term development plan. Figure 4 represents these several agricultural land-use of which trees and shrubs occupies the highest percentage about 23% distributed throughout CTU-Barili parcels of lands. This is followed by the area intended for cattle production about 18%. An interesting area about 15% (16 hectare,

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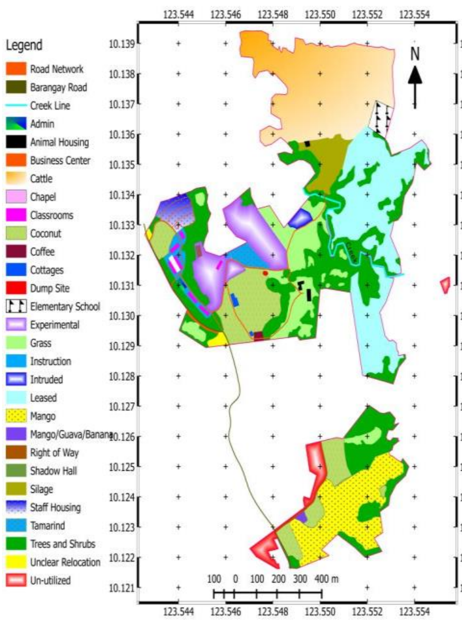
to be verified in the contract) is under the contract of lease. Development of areas for coconut and mango production is on-going and still increasing comprising to 9.4% and 8.4%, respectively. Nevertheless, noticeable areas of grassland about 7% (7.4 ha) is considered under-developed. From time to time areas for experimental research available both for faculty and students is about 6.4% (6.6 ha).

On the other hand, a considerable un-utilize area about 2.3% (2.4 ha) at Barangay Cabcaban and the separated parcel of land with the lot number 4433.Another important land-use of about a hectare which is not known to the researcher until this research is the Elementary School of Cabcaban, which is still included inside the specified lot descriptions of lot number 3513, was donated by the previous owner according to some information.



Landuse	Area, m^2	Percent
Animal Housing	2037	0.20%
Business Center	1308	0.13%
Cattle	190144	18.39%
Coconut	97583	9.44%
Coffee	1498	0.14%
Cottages	1360	0.13%
Dump Site	317	0.03%
Elementary School	9851	0.95%
Experimental	65949	6.38%
Grass	73863	7.14%
Instruction	17601	1.70%
Intruded	5114	0.49%
Leased	156226	15.11%
Mango	87195	8.43%
Mango/Guava/Banana	1396	0.14%
Silage	26008	2.52%
Staff Housing	16228	1.57%
Tamarind	9273	0.90%
Trees and Shrubs	234046	22.63%
Unclear Relocation	3880	0.38%
Un-utilized	24011	2.32%

Figure 4. CTU-Barili Campus Landuse Map with a table of land area in m^2 and in percent to the total land area.

CONCLUSIONS

The land information system in terms of cadastral, topography and land-use maps of CTU-Barilli Campus were brought together on a framework of global position. GIS outputs present an opportunity of visualizing, retrieving, and updating large amounts of spatial information projected to a real world coordinate system. Such GIS outputs in this study provide administrators, faculty members, students, and other decision makers a quick, relevant and integrated tool for judging accurately and rapidly its land information system. Evaluation of its land information is now manageable by a click of the mouse. Further investigations are required particularly to those points with questionable lot descriptions in order to obtain relatively more accurate results. Further studies on spatial land information in terms of detailed soil characteristics and suitability mapping are recommended.

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LITERATURE CITED

Ali, Z., Tuladhar, A., & Zevenbergen, J. 2012. An integrated approach for updating cadastral maps in Pakistan using satellite remote sensing data. International Journal of Applied Earth Observation and Geoinformation, 18, 386–398. doi:10.1016/j.jag.2012.03.008

Barreca, G., Bonforte, A., & Neri, M. 2013. A pilot GIS database of active faults of Mt. Etna (Sicily): A tool for integrated hazard evaluation. Journal of Volcanology and Geothermal Research, 251, 170–186. doi:10.1016/j.jvolgeores.2012.08.013

Labib, M., & Nashed, A. 2013.GIS and geotechnical mapping of expansive soil in Toshka region. Ain Shams Engineering Journal, 4(3), 423–433. doi:10.1016/j.asej.2012.11.005.

Tayyebi, A., Pijanowski, B. C., &Tayyebi, A. H. 2011.An urban growth boundary model using neural networks, GIS and radial parameterization: An application to Tehran, Iran. Landscape and Urban Planning, 100(1-2), 35–44. doi:10.1016/j.landurbplan.2010.10.007

Wheaton, J. M., Garrard, C., Whitehead, K., & Volk, C. J. 2012. A simple, interactive GIS tool for transforming assumed total station surveys to real world coordinates – the CHaMP transformation tool. Computers & Geosciences, 42, 28–36. doi:10.1016/j.cageo.2012.02.003

Xu, H. 2012. Application of GPS-RTK Technology in the Land Change Survey. Procedia Engineering, 29, 3454–3459. doi:10.1016/j.proeng.2012.01.511

Xu, Z., & Coors, V. 2012.Combining system dynamics model, GIS and 3D visualization in sustainability assessment of urban residential development. Building and Environment, 47, 272–287. doi:10.1016/j.buildenv.2011.07.012

Yilmaz, I. 2008. A case study for mapping of spatial distribution of free surface heave in alluvial soils (Yalova, Turkey) by using GIS software. Computers & Geosciences, 34(8), 993–1004. doi:10.1016/j.cageo.2007.06.008