

Land Cover Change Analysis of Maasin Watershed Forest Reserve, Iloilo, Philippines

Emelyn A. S. Peñaranda^{1*},
Juan M. Pulhin², Enrique P. Pacardo²,
Leonardo M. Florece², and Leni D. Camacho²

INTRODUCTION

The Philippines has a land area of 30 million ha. In 1934, 57% or 17 million ha of these are still covered with forests. However, in 1980, the forest cover was reduced to 7.4 million ha. Recent estimates indicate that there are only about 5.33 million ha, roughly 18% of the total land area, still covered with forests. These figures show the gravity of watershed degradation. If allowed to continue, this situation will have great repercussions on economic activities, and the health and social well being of communities within and beyond the watershed (Philippine-Canada LGSP 2003). Watershed degradation which takes on several forms or combination of soil, vegetation, biodiversity, water, climate, and landscape degradation including land conversion, is caused by several factors but mainly due to uncontrolled and destructive human activities for basic survival, to continuous economic and industrial gain.

The degraded condition of the watersheds also rendered these ecosystems more vulnerable to increased frequency and intensity of extreme weather events. It was already observed that the ecological pressures of climate change in some of the country's critical watershed areas have already been reported to contribute to water shortages in the dry season, food security issues, increased flooding in the rainy season and salt water intrusion in the water table. This critical condition of the watershed necessitates the analysis of its state, particularly the land cover and land use at the local level, because watershed issues are geographically bound and assessment of any sector's interest on watershed must be taken on locality-by-locality basis (FAO and Forest Trends 2007).

Land cover is defined as the physical characteristics of earth's surface, captured in the distribution of vegetation, water, soil and and/or artificial structures. Land use refers to the way in which

ABSTRACT

The paper analyzed the land cover condition of Maasin Watershed Forest Reserve (MWFR) through remote sensing and time change analysis. Remote sensing, the measurement of object properties on Earth's surface using data acquired from aircraft and satellites, has revolutionized understanding of dynamic environment. Researchers use remote sensing satellites to provide repetitive coverage of the earth for studying landscape dynamics, phenological variations of vegetation and change detection analysis. By using land satellite imageries generated from remote sensing, the extent of change in land cover of Maasin Watershed Forest Reserve from 1993, 2001, and 2009 was analyzed.

Land cover in MWFR was classified into forest, brush, grass, and bare areas. Results of the analysis revealed that land cover of the said watershed has not been very stable from 1993 to 2009. Time change detection analysis through cross tabulation showed evident changes from one class to another over the years. The results of the study showed slight improvement in the state of the forest of MWFR as evidenced by a net gain of 10.19% in the forest cover for 16 years. Net increase in the total forest area was gained from the conversion of brush and grassland areas. The study also concluded that with limited primary and corroborating secondary data, remote sensing technology and time change analysis proved to be effective in presenting valuable information about the land cover conditions over time.

Keywords: land cover, land satellite image, land use, Maasin Watershed

land has been used by humans and their habitat, usually with accent on the functional role of land for economic activities. Land cover/land use is a composite term, which includes both categories of land cover and land use. Land cover/land use change information has an important role to play at local and regional as well as at macro level planning and management. Most of the time, the planning and management tasks of the environment are troubled due to insufficient information on rates of land cover/land use changes. The land cover changes occur naturally in a progressive and gradual way. However sometimes it may be rapid and sudden due to anthropogenic activities (Butenuth *et al.* 2007 in Meliadis 2011).

The land cover pattern of a region is an outcome of natural and socio-economic factors and their utilization by man in time and space. Land is becoming a scarce resource due to immense agricultural and demographic pressure. Hence, information on land use/land cover and possibilities for their optimal use is essential for the selection, planning and implementation of land use schemes to meet the increasing demands for basic human

¹Senior Science Research Specialist,
Ecosystems Research & Development Service,
Department of Environment & Natural Resources,
Region 6, Port Area, Iloilo City

²Professors, University of the Philippines Los Baños, College, Laguna

*Corresponding author: emelyn_penaranda@yahoo.com

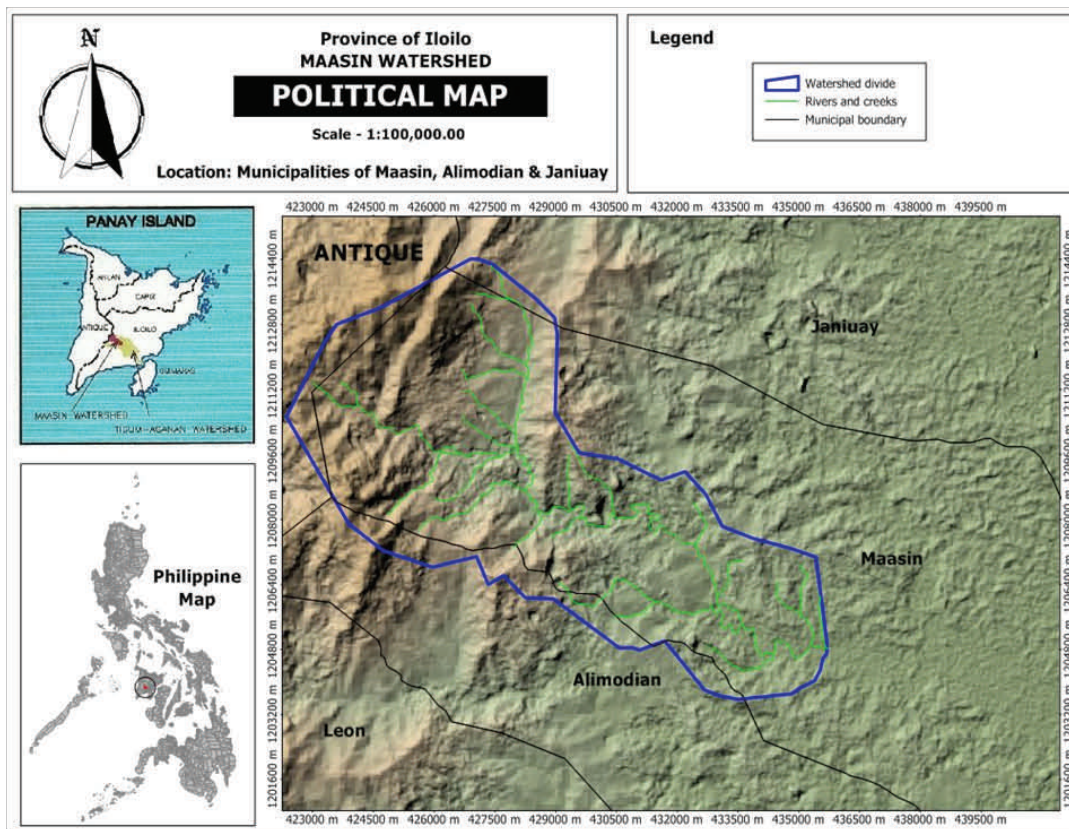


Figure 1. Political map of Maasin Watershed Forest Reserve, Iloilo, Philippines.
(Source: Ecosystems Research and Development Service, DENR, Region 6)

needs and welfare. This information also assists in monitoring the dynamics of land use as a result of the changing demands of increasing population. Land use and land cover change has become a central component in current strategies for managing natural resources and monitoring environmental changes. The advancement in the concept of vegetation mapping has greatly increased research on land use and land cover change. Thus, providing an accurate evaluation of the spread and health of the world's forest, grassland, and agricultural resources has become an important priority (Zubair 2006). Imagery in the form of aerial photographs and satellite images has been demonstrated to be the most cost effective method for land cover mapping throughout the world (Trisurat *et al.* 2000 in Meliadis 2011).

Remote sensing, the measurement of object properties on Earth's surface using data acquired from aircraft and satellites, has revolutionized one's understanding of dynamic environment. Presently, remote sensing has covered wide range of applications in different fields of agriculture and environment. A great number of researches using this approach focused on land use to study adverse effects on the ecology of the area and vegetation. Land use and land cover change have become a central component in current strategies for managing natural resources and monitoring environmental changes. Researchers use remote sensing satellites to provide repetitive coverage of the earth for studying landscape dynamics, phenological variations of vegetation and change detection analysis.

With the foregoing discussion, this paper assessed the state of Maasin Watershed Forest Reserve (MWFR) land cover using remote sensing and time change analysis.

MATERIALS AND METHODS

Study Site

The study was conducted in Maasin Watershed Forest Reserve situated in the central portion of Iloilo Province, Western Visayas covering a total area of 6,738.52 ha within the municipalities of Maasin, Alimodian, and Janiway with 16 barangays. The watershed was chosen because of the critical role of the watershed in providing environmental services particularly domestic water to over 500,000 residents of Iloilo City and adjacent municipalities, namely Maasin, Cabatuan, Sta. Barbara, Pavia, Oton and San Miguel. The watershed is also a major source of irrigation water to agricultural lands in the central portion of Iloilo province. Maasin Watershed Forest Reserve is situated at UTM Coordinates from 423000 to 435000 North and 1203000 to 1215000 East (Figure 1).

Land Satellite Imageries Processing

The Maasin Watershed Forest Reserve was characterized in terms of land cover and land use through land satellite imaging technology. The remote sensing software ENVI was used to

carry out all image processing and analysis while QGIS was used for post processing and overlay analysis. The land satellite imageries processing procedures are shown in Figure 2 and discussed in detail in the succeeding section.

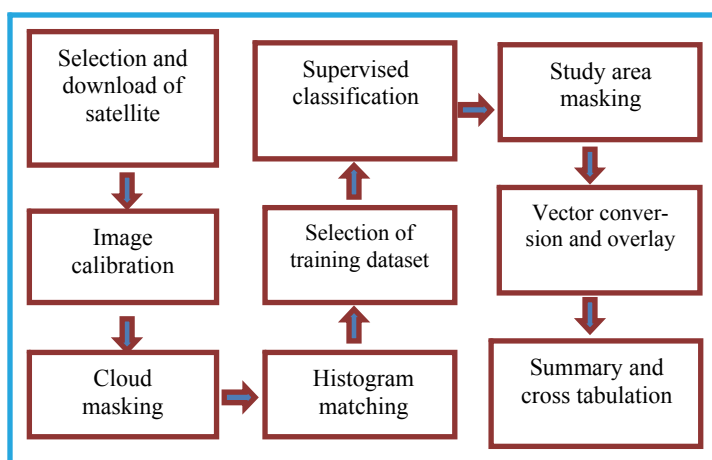


Figure 2. Work flow for land satellite image processing over Maasin Watershed Forest Reserve.

Selection and Download of Satellite Imagery

Satellite imagery was obtained through the Earth Explorer webpage. The website provides an easy-to-use interface from which users can select imagery over a wide range of remote sensing products. For this study, images obtained by Landsat 5 were used over the years 1993, 2001, and 2009. Landsat multispectral images offer six optical and one thermal band. For the purpose of this study, optical bands were used.

Image Calibration

To aid data transfer via the web, LandSat images were compressed as 8-bit integers with each band stored as separate files. In order to make meaningful results from succeeding analyses, images must be calibrated to show reflectance values. To do such, LandSat offers all necessary information and formulae in its metadata and guidebook, respectively. For this study, the remote sensing software ENVI was used to carry out all image processing and analysis. QGIS was used for post processing and overlay analysis.

Cloud Masking

Optical sensors' greatest enemy are clouds and their corresponding shadows. These sensors operate within wavelength bands which can be impeded by the aforementioned obstructions. Clouds appear opaque in images; hence, there is no way to know for sure the reflectance value of the ground directly below it. For the purpose of this study, clouds and shadows were masked out, excluding pixels with clouds from analyses. Since the analysis aimed to compare land cover distribution in a time series, clouds from all input images were

combined into one mask and applied to all such that the number of valid pixels in all images was the same.

Pixels with clouds were identified using density slicing, a technique wherein pixels containing a specific range of values can be isolated from one of the image's bands. For clouds, the blue band (band 1) was used. In this band, clouds appeared very bright thus occupying upper limit values.

Histogram Matching

Images taken in different times and places also differed in visual quality. Factors including actual land cover, time of day, sensor condition, sun angle, and topography affect the differences of the captured images' quality. In order to isolate land cover, other factors should be minimized. A general method for equalizing the images for comparison is histogram matching. This procedure aims to modify a band's histogram to match the quality of the histogram of the image deemed to be of good quality.

For this study, histogram matching was attempted but did not perform well. Since presence of masked pixels affect an image's histogram, it became very difficult to match histograms. Very thin sheets of unmasked clouds were also present in the images, thus, further degrading the quality of image. This step was ultimately skipped.

Selection of Training Dataset and Supervised Classification

The selected method of analysis was supervised classification. Supervised classification is a method of clustering pixels into user-defined training classes which, in this case, are land cover classes. Since land cover has greatly changed in the area since the 1990s, it would be virtually impossible to acquire ground-verifiable control points. For this study, land cover was determined using the image's visual quality.

Points and areas within the image were selected to represent general land cover types which included forests, brush lands, grass, and bare/non-vegetated. Expert judgment was used in identifying control points. Determination of land cover types was done visually using various false color composites of the images' bands. False color composites revealed features that cannot be differentiated with the normal "natural look" of the imagery. Near-infrared composites showed vegetation distribution better, while Short wave infrared composites revealed bare soil better. Below are images showing (1) natural-look; (2) near-infrared (NIR); and (3) shortwave infrared (SWIR) (Figure 3).

In the natural-look, vegetation is shown as green, and bare as yellow-white. While this provides the natural feel, it does not offer very good visual analytic depth. With the NIR image, density of vegetation can be easily determined since it is shown in varying brightness of red. Bare and non-vegetated areas are shown in blue but do not offer visually compelling variations.

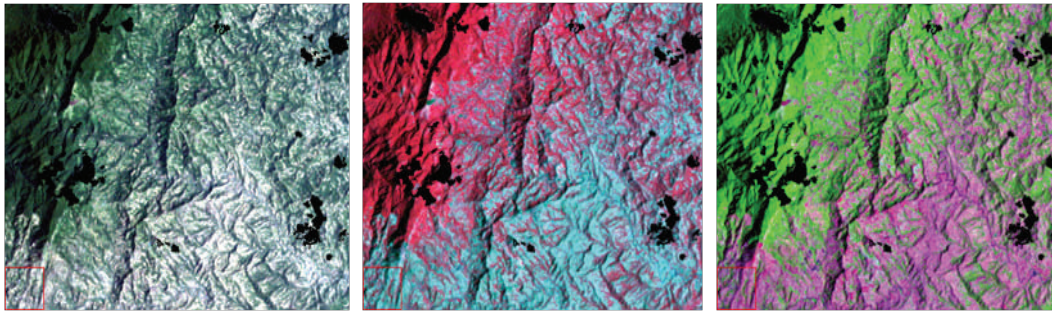


Figure 3. Sample natural look, near-infrared and shortwave infrared images.

In the SWIR image, vegetation is shown in bright green while bare areas are shown in varying shades of pink. Using these three views, land cover types for the training classes were determined. Forests are highly dense vegetation in the mountainous areas (seen from NIR image); grass are pink areas with hints of light green (seen from SWIR image); brush are areas with moderate vegetation on the mid and eastern section of the image (seen from NIR image); and bare areas are bright blue or bright pink in the NIR and SWIR images.

At least 15 control points per land cover type were identified and was computed for separability. Separability is a measure in remote sensing to determine how well each paired land cover types could be differentiated from each other, thus indicating good clustering and ultimately the quality of the resulting classification. The training classes used for this study fell within the acceptable range of separability values.

The supervised method maximum likelihood was used in this study. As per ENVI guidebook, maximum likelihood classification assumes that the statistics for each class in each band are normally distributed and calculates the probability that a given pixel belongs to a specific class. Unless a probability threshold was selected, all pixels were classified. Each pixel was assigned to the class that had the highest probability (that is, the maximum likelihood). If the highest probability is smaller than the threshold specified, the pixel remains unclassified.

Study Area Masking

The Maasin watershed is generally moderately elongated whose outlet drain towards the southeast direction. A preliminary minimum bounding rectangle selected from the Landsat scene to capture the watershed area was selected to optimize the classification scheme. Since the computations should be within the watershed, the image was further masked to exclude areas within the MBR but outside the watershed.

Vector Conversion and Overlay

Image data are stored as pixels containing only the classification assignments. In order to generate area computations, pixels were converted into vectors, file types which could accommodate multiple attribute values and thus

include area information. The classified and masked images were converted to vectors and were overlaid. The output of this procedure is a single GIS file which contains the land cover type distribution for the three selected time periods.

Summary and Cross Tabulation

Since the land cover data were contained in a single tabular form from the previous procedure, it would only be a matter of opening the table in MS Excel to generate the cross tabulations. Year pairs populated with land cover area summations reveal important insights such as land cover distribution changes.

Accuracy and Reliability Assessment of the Classified Image

In order to determine the level of accuracy of the classified images for MWFR, a confusion matrix operation was performed and generated (Appendix Table 1). The accuracy assessment compares the resulting classified images to identified points on the ground and sees whether the assigned class is really the observed class defined by the points on the ground. The assessment performed for three temporal data showed that most of the land cover types were classified with acceptable level of accuracies. The levels of accuracy for the images for 1993, 2001, and 2009 were 74.10%, 72.90%, and 87.40%, respectively (Appendix Table 1). Lower accuracy levels on older images were generated because of limited control points considering that ground truth points came from the image itself, with expert knowledge in identifying “truth” points. The accuracy for 2009 was highest because in addition to the image itself, additional points were generated using historical Google earth imagery.

Change Detection Analysis through Cross Tabulation

Change detection analysis of the land cover of MWFR was also done using cross tabulation. Cross tabulation matrix is a quantitative output that shows how much of a given land-cover type has changed into specific categories (Thiam nd). The categories at date 1 were displayed on the X axis while the Y axis displayed the same categories at date 2. The cells corresponding to stable areas were in the diagonal entries of the matrix.

Off-diagonal entries indicated areas that have changed to new classes. If no change has occurred, all cells for each category would be on the diagonal entries and the off-diagonal entries would have zeros. In case of change, pixels move from one category to another. Sometimes the change affects the majority of the pixels in a given class. As a result, the diagonal entry of the category affected would be much lower than the off-diagonal entry of the category that gained most of its cells.

Land Cover Analysis Using Indigenous Knowledge

The local knowledge of people on the land cover change in Maasin Watershed was also integrated in the analysis through participatory analysis. Three Participatory Rural Appraisal workshops were conducted with the upland farmers residing inside the watershed and with the farmer leaders of the federation of the upland farmers associations, the *Katilingban sang Pumuluyo nga naga Atipan sa Watershed* (KAPAWA). One of the major information collected during the appraisal is their knowledge of the land cover changes and the causes of such changes.

RESULTS AND DISCUSSIONS

Land Cover of Maasin Watershed

By using land satellite imageries generated, the extent of MWFR cover and land use change from 1993, 2001, and 2009 was analyzed (Figure 4). Table 1 presents the land cover classification in Maasin Watershed for each study year as derived from the images. Bare areas in 1993 comprised 29.37% of the total area of the watershed. This was followed by the forest (23.08%), grass (22.04%) and brush (19.88%). The data generated from the images seemed to confirm the findings of an earlier study (Salas 2004), citing that Maasin Watershed in 1991 is 93% denuded.

In 2001 and 2009, forest cover increased to 24.44% and 33.27%, respectively. The grassland evidently increased to 34.38% in 2001 and then declined by 9.88% in 2009. The brush and bare areas decreased in 2001 but showed increases in 2009 (Figure 5).

Land cover change in MWFR was also influenced by a number of factors such as property rights, tenure system, governance, and even by the high demand of agricultural products (Pailagao *et al.* 2010).

Change Detection Analysis

Table 2 shows that the forest cover of MWFR slightly improved from 1993 to 2009. This was evidenced by an increase of 656.48 ha from 1993 in 2009. The computed annual change was 41.03 ha or 10.19% improvement in the forest areas for a period 16 years. The brush lands had an increase of 104.39 ha (6.52 ha^{-1}) or an equivalent improvement of 1.62%. On the other hand, grasslands diminished by 784.03 ha or net decline of 12.16% for 16 years. Bare areas also slightly increased by 23.16 ha. This was equivalent to 0.36% improvement.

Change detection analyses in the land cover of MWFR was also done using the cross tabulation. Results showed that the land cover in MWFR had not been very stable from 1993 to 2009. The cross tabulation showed evident changes from one class to another over the years. From 1,487.71 ha of forest in 1993, only 1,254.10 ha were actually retained in 2009. The other 233.61 ha became brush, grass and bare lands. The net increase in the total forest area for 16 years was gained from the conversion of brush and grass land areas to forest (Table 3). For the grass land which constituted 1,420.85 ha in 1993, only 217.88 ha remained in 2009 while the rest became bare (502.36 ha), forest (218.36 ha), and brush (481.95 ha).

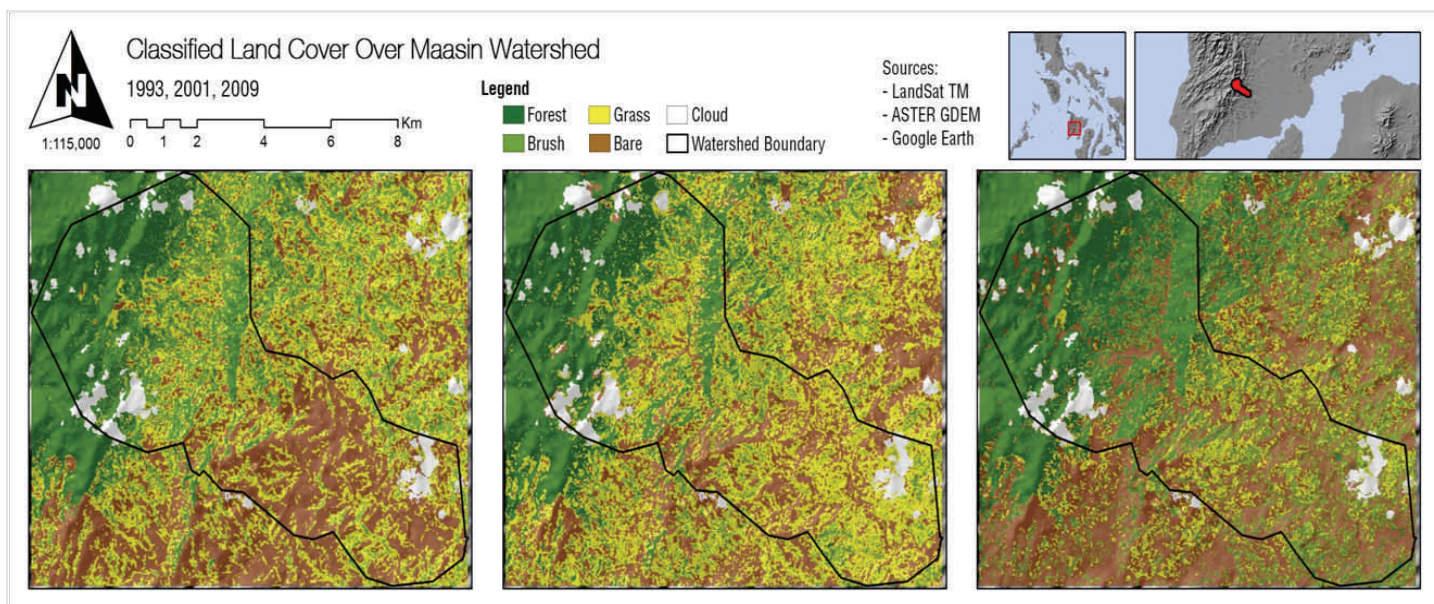
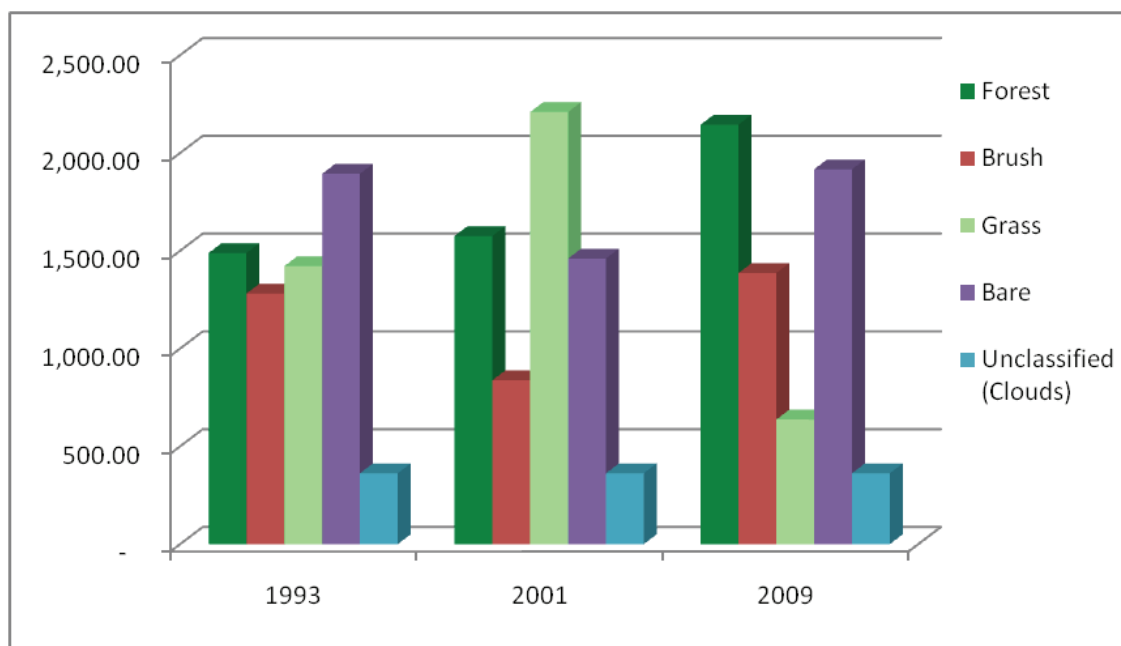


Figure 4. Classified land cover over Maasin Watershed Forest Reserve, 1993, 2001, and 2009.

Table 1. Classification and area of land cover of Maasin Watershed Forest Reserve, 1993, 2001, and 2009

Classification	1993		2001		2009	
	Area (ha)	% of Total Area	Area (ha)	% of Total Area	Area (ha)	% of Total Area
Forest	1,487.71	23.08	1,575.47	24.44	2,144.19	33.27
Brush	1,281.27	19.88	838.17	13.00	1,385.66	21.50
Grass	1,420.85	22.04	2,209.31	34.28	636.82	9.88
Bare	1,893.27	29.37	1,460.15	22.65	1,916.43	29.73
Unclassified (clouds or rivers)	362.20	5.62	362.20	5.62	362.20	5.62
Total	6,445.30	100.00	6,445.30	100.00	6,445.30	100.00

**Figure 5.** Graphical presentation of the land cover of Maasin Watershed Forest Reserve, 1993, 2001, and 2009.

Bare areas could probably be a result of the continuous harvesting of bamboo poles since the majority of the farmers relied primarily on bamboo as a major source of livelihood. The gain in the brush land could be attributed to the increase and growing plantation of coffee and abaca as part of the Community-Based Resources Management Program in the area. Some studies also revealed that relative increase in the vegetative cover of watersheds and other protected areas was observed as an outcome of environmental policies, interventions from government and non-government organizations, foreign assisted projects and the shift to community-based conservations (Palao *et al.* 2010, Rondeau 2010).

Local Knowledge of People about Land Cover of Maasin Watershed

The local knowledge of people regarding the changes in the land cover of MWFR was also integrated in the analysis through the conduct of participatory appraisal. The results of participatory assessment presented in Figure 6 were in agreement with the data generated from remote sensing.

The PRA participants in Barangay Trangka recalled that other than the area of the old growth forest, the vegetative cover of Maasin Watershed after the Second World War was dominated by endemic forest species, abaca and *tigbao* (*Saccharum spontaneum*). During the economic reconstruction after the war, the people who sought refuge in the watershed remained in the

Table 2. Change in the land cover of Maasin Watershed Forest Reserve, Iloilo, Philippines, 1993, 2001, and 2009

Classification	1993 - 2001	2001 - 2009	1993 - 2009	% Change
Forest	87.75	568.72	656.48	10.19
Brush	(443.10)	547.49	104.39	1.62
Grass	788.46	(1,572.49)	(784.03)	-12.16
Bare	(433.12)	456.28	23.16	0.36

Table 3. Cross tabulation of the land cover changes in Maasin Watershed Forest Reserve, Iloilo, Philippines, 1993, 2001, and 2009

2001							
1993	Forest	Brush	Grass	Bare	Total		
Forest	1,188.36	130.70	100.06	68.59	1,487.71	Increase	1,612.94
Brush	325.19	349.64	439.75	166.69	1,281.27	Retain	3,243.90
Grass	53.85	245.03	801.50	320.47	1,420.85	Decrease	1,226.26
Bare	8.07	112.80	867.99	904.40	1,893.27		
Total	1,575.47	838.17	2,209.31	1,460.15			

2009							
2001	Forest	Brush	Grass	Bare	Total		
Forest	1,318.36	113.52	17.22	126.37	1,575.47	Increase	1,955.68
Brush	321.51	257.86	111.44	147.36	838.17	Retain	2,864.59
Grass	331.86	737.94	392.58	746.93	2,209.31	Decrease	1,262.84
Bare	172.46	276.33	115.58	895.78	1,460.15		
Total	2,144.19	1,385.66	636.82	1,916.43			

2009							
1993	Forest	Brush	Grass	Bare	Total		
Forest	1,254.10	103.27	9.36	120.99	1,487.71	Increase	2,194.89
Brush	607.43	326.29	60.87	286.67	1,281.27	Retain	2,804.69
Grass	218.66	481.95	217.88	502.36	1,420.85	Decrease	1,083.52
Bare	64.00	474.15	348.70	1,006.42	1,893.27		
Total	2,144.19	1,385.66	636.82	1,916.43			

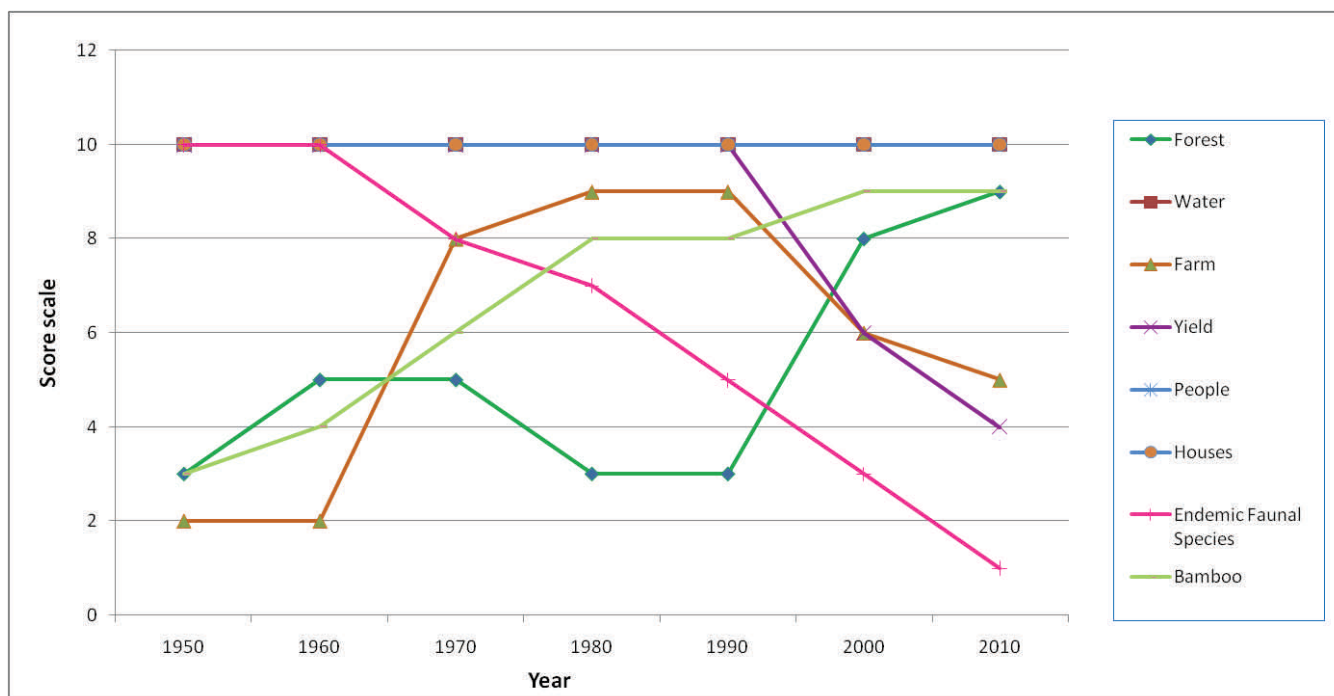


Figure 6. PRA participants' assessment of the condition of the watershed in terms of forest cover, bamboo area, agricultural farms and yield level, human population and endemic faunal species.

area and engaged in *kaingin* making or slash and burn cultivation. They burned the *tigbao* grasses and converted them to agricultural farms and grazing areas for their livestock. Timber poaching also became rampant. These high impact agriculture activities persisted until the 1990s.

The next decade saw intensive rehabilitation efforts such as reforestation, planting of fruit trees, coffee and abaca. This contributed to the increase in forest area as well as brush lands and an observable decline in grasslands and bare areas. In 2002, the federation of farmer's association in MWFR, the KAPAWA was awarded the Community-Based Forest Management Agreement (CBFMA). The agreement provided the KAPAWA a stewardship contract to manage 2,685 ha in the watershed that contributed to increases in both forest and brush lands in the succeeding years. The population of endemic species was reduced to very low levels due to continued deforestation and later on degradation of the watershed.

The FGD (focus group discussion) participants claimed that the level of population in the watershed was just maintained through the natural process of birth and death and by restricting new farmers to live in the watershed. Farms also increased when *kaingin* making was apparent but reduced to lower levels when laws were enforced.

One very important implication of the findings on land cover change analysis in MWFR is the effort of concerned stakeholders to include the DENR, the Provincial Government of Iloilo, Local Government of Maasin, Maasin Water District

(MIWD), National Irrigation Agency (NIA) and some civil society groups. The programs of the government over the years had only contributed to a minimum to the joint efforts and pooled resources from the different agencies to rehabilitate and improve the state of the watershed, most specifically its forest cover. This is despite the condition of the watershed. In monetary terms, the rehabilitation was valued at about PhP 65,177,768.00 (Table 4).

In the light of this analysis, one challenge that may be posed is that: can a paradigm shift from the "command and control" regulations and other conservation approaches to market-based measures like the Payment for Environmental Services, be worth trying and experimenting and possibly effect much bigger changes in the management of the Maasin Watershed?

CONCLUSION AND RECOMMENDATIONS

The paper analyzed the land cover condition of MWFR through remote sensing and employing time change analysis. Remote sensing, the measurement of object properties on Earth's surface using data acquired from aircraft and satellites, has revolutionized one's understanding of dynamic environment. Researchers use remote sensing satellites to provide repetitive coverage of the earth in studying landscape dynamics, phenological variations of vegetation and change detection analysis. By using land satellite imageries generated from remote sensing, the land cover change of Maasin Watershed Forest Reserve from 1993, 2001, and 2009 was analyzed.

Table 4. Documented projects implemented in Maasin Watershed Forest Reserve, Iloilo, Philippines

Project	Area (ha)	Funds used	Source of Funds
River bank rehabilitation	270	3,284,000.00	DENR
Assisted natural regeneration	300	1,905,562.00	DENR
Agroforestry project in Sta. Rita and Daja, Maasin, Iloilo	300	1,665,373.00	DENR
Contract reforestation project by Municipal Environment and Development Council	200	2,448,000.00	DENR
Reforestation project (Let people co-exist with the trees)	500	500,000.00	Province of Iloilo
Reforestation project (FSP Loan II, OECF)	2,685	46,874,833.00	JBIC
Survey Mapping and planning		1,800,000.00	ADB
MIWD watershed protection project		1,000,000.00	DENR
Construction of structural and vegetative measures	2,850 m ³	3,700,000.00	NEDA
Establishment of vegetative measures	5.39	600,000.00	NEDA
Research and Development		1,400,000.00	NEDA
Total	4,260.39	65,177,768.00	

Sources: DENR reports; Alli 2000; Salas 2004; Buric et al. 2011

Land cover in MWFR was classified into forest, brush, grass, and bare areas. Results of the analysis revealed that land cover of the said watershed has not been very stable from 1993 to 2009. Time change detection analysis showed the evident variation from one class to another over the years. In the case of forest areas, from 1,487.71 ha in 1993, only 1,254.10 ha were actually retained in 2009. The other 233.61 ha became brush, grass or bare lands. Overall, the remote sensing and time change analysis of the land cover of Maasin Watershed Forest Reserve revealed a slight improvement in the state of its forest as evidenced by a net gain of 10.19% in terms of vegetated forest area over a period of 16 years.

This is despite the joint efforts and pooled resources of the concerned stakeholders to rehabilitate the watershed. The minimal improvement of rehabilitation efforts implies the need for a new management level for Maasin Watershed toward a more sustainable watershed.

The study also concludes that with limited primary and corroborating secondary data, remote sensing technology and time change analysis proved to be effective in presenting valuable information about the land cover conditions over time.

Based on the results of the study and considering the critical function of Maasin Watershed in the provision of water

services in Iloilo City and the adjacent municipalities, it is recommended that a research on the relationship of land cover and water yield be conducted. With the massive replanting efforts of the government like the National Greening Program, there is a need to document the effects of these reforestation activities on watersheds at multiple spatial and temporal scales. Paired watershed experimentation can be one of the approaches to consider. The adoption of conservation approaches using market-based measures like Payment for Environmental Services, should be studied in detail to determine the possible effect of change in the management in the land cover and vegetative state of Maasin Watershed Forest Reserve.

Other researches like species suitability, given the geomorphological and hydrological characteristics of the watershed, should also be explored. The establishment of physical structures and enhancement of vengeneering measures to minimize soil erosion especially in the steep slopes where gullies were observed is also recommended.

REFERENCES CITED

FAO and Forest Trends. 2007. Investing in the future: an assessment of private sector demand for engaging in markets & payments for ecosystem services, by S. Waage, with contributions from I. Mulder, K. ten Kate, S. Scherr, J.

- P. Roberts, A. Hawn, K. Hamilton, R. Bayon and N. Carroll, Forest Trends. Payments for Environmental Services from Agricultural Landscapes- PESAL Papers Series No.2 Rome, Italy, FAO and Washington, D.C., Forest Trends.
- Meliadis, I. and Meliadis, M. 2011. Multi-temporal Landsat image classification and change analysis of land cover/use in the Prefecture of Thessaloiniki, Greece. Proceedings of the International Academy of Ecology and Environmental Sciences, 1(1): 15-25.
- Pailago, C.T., Espaldon, M.V.O, Dorado, M.A., Catacutan, D. C. and Rebancos, C. M. 2010. Drivers of land use change in Lantapan, Bukidnon, Philippines. UPLB, College, Laguna. Journal of Environmental Science and Management 13(1):1-11 (June 2010).
- Palao, Lk. M., Dressler, W.H., Cruz, R.V.O., Pulhin, J. M., Bantayan, N. C., Florece, L. M. 2010. Land cover change in Cabayugan Puerto Princesa Subterranean River National Park, Palawan, Philippines. UPLB, College, Laguna. Journal of Environmental Science and Management 13(2):1-13 (December 2010).
- Philippines-Canada Local Government Support Program (Lgsp). 2003. Watershed management: Saving forests, storing water for the future. Service delivery with impact: Resource Books for Local Government. Philippines-Canada Local Government Support Program <http://www.dilgxi.org/KPs/EnvironmentalManagement/watershed.pdf>. [Date accessed 27 September 2011].
- Rondeau, J. 2010. Tigum-Aganan Watershed Stakeholder Mapping and Analysis. CUI-UPP Philippines Metro Iloilo Guimaras Sustainable Bioregion Initiative. Canadian Urban Institute.
- Salas, J. C. 2005. Environmental service payments for Maasin Watershed. In Padilla, J.E., Tongson, E. and Lasco, R. (eds), PES: Sustainable Financing for Conservation and Development: Proceedings from the National Workshop on Payments for Environmental Services: Direct Incentives for Biodiversity Conservation and Poverty Alleviation, Manila, March 1-2, 2005, WWF, ICRAF, REECS, UP-CIDS, UIPLB-ENFOR, CARE. pp. 103-115.
- _____. 2004. Case Study of the Maasin Watershed: Analyzing the Role of Institutions in a Watershed-Used Conflict. World Agroforestry Centre (ICRAF) Southeast Asia Regional office, Indonesia.
- Thiam, A. K. n.d. Change Detection Exercise: Cross classification. Graduate School of Geography, Clark University. http://www.uriit.ru/japan/Our_Resources/Books/RSTutor/Volume3/mod9/exercises/CROSSCLASS.HTM, [Date accessed: 13 Sept. 2013].
- Zubair, A. O. 2006. Change Detection on Land use and Land Cover.
- Using Remote Sensing Data and GIS: A case study of Ilorin and its environ in Kawara State. MS Thesis in Geographic Information Systems (GIS), Department of Geography, University of Ibadan, Ibadan.

ACKNOWLEDGMENT

The author is grateful to the Department of Environment and Natural Resources (DENR), the Department of Science and Technology-Accelerated Science and Technology Human Resource Development Program (DOST-ASTHRDP) through the National Science Consortium and the Southeast Asian Regional Center for Graduate Study and Research in Agriculture (SEARCA) for the scholarship and thesis grants. Sincere gratitude is also conveyed to the chair and members of her guidance and advisory committee namely Dr. Juan M. Pulhin, Dr. Enrique P. Pacardo, Dr. Leonardo M. Florece, and Dr. Leni D. Camacho for their support, valuable comments, new ideas and suggestions to complete this research. The author is also indebted to Mr. Leonardo Barua, Ms. Angela Limpiada, Ozzy Nicopior, and RD Altarez for their expertise and reference materials on remote sensing and land satellite imaging. The untiring support and love of all her colleagues, classmates, friends and families are highly acknowledged and served as inspiration for the author to finish this piece of work. To God be the glory!

Appendix Table 1. Confusion matrix of land satellite imageries of Maasin Watershed Forest Reserve, Maasin, Iloilo, Philippines

1993		Ground Truth Class (in %)				Total	Overall Accuracy
		Forest	Brush	Grass	Bare		
Assigned Class	Forest	63.0	0.0	0.0	0.0	15.7	
	Brush	25.9	72.0	9.7	0.0	25.9	
	Grass	7.4	28.0	64.5	0.0	26.9	
	Bare	3.7	0.0	25.8	100.0	31.5	
Total		100.0	100.0	100.0	100.0	100.0	74.07

2001		Ground Truth Class (in %)				Total	Overall Accuracy
		Grass	Bare	Brush	Forest		
Assigned Class	Grass	76.5	14.3	46.9	10.7	38.0	
	Bare	11.8	85.7	0.0	0.0	26.4	
	Brush	2.9	0.0	46.9	7.1	14.0	
	Forest	8.8	0.0	6.3	82.1	21.7	
Total		100.0	100.0	100.0	100.0	100.0	72.90

2009		Ground Truth Class (in %)				Total	Overall Accuracy
		Bare	Brush	Forest	Grass		
Assigned Class	Bare	100.0	3.7	3.8	16.0	30.1	
	Brush	0.0	85.2	11.5	0.0	25.2	
	Forest	0.0	7.4	80.8	0.0	22.3	
	Grass	0.0	3.7	3.8	84.0	22.3	
Total		100.0	100.0	100.0	100.0	100.0	87.40