# Landuse and Landcover Changes in Mount Malindang Range Natural Park, Philippines

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#### Abstract

Mt. Malindang Range Natural Park (MMRNP) is one of the Key Biodiversity Areas (K.B.A.) in the Philippines. One of the major threats facing MMRNP is land-use change and habitat loss. Landuse and landcover changes in the MMRNP were determined from 1992 to 2015 using Geographic Information System (G.I.S.). Human settlements and agricultural land uses were increasing and often directly bordered the protected area boundaries. Results also showed that human settlements in MMRNP are creeping towards the core zone, potentially increasing human activity and threatening the protected area's biodiversity. Urban expansion around MMRNP varied but increasing as much as 10%. Forest cover varied both within the buffer and core zones with possible evidence of deforestation throughout the MMRNP. Comparison of spatial data from 1992 and 2010 survey reveals a reduction of 10,588.80 hectares in forest cover. Spatial analyses of forest cover data between 2010 and 2015 indicated an increase of ~157.2 hectares of forest cover due to the National Greening Program (N.G.P.) of DENR. Increasing human impacts and continued loss and fragmentation of wildlife habitats inside the protected areas strongly affect their effectiveness as conservation sites. Promoting awareness of biodiversity conservation among residents should be one of the major focuses of the management plans. It is essential to continue efforts to protect and manage protected areas such as Mt. Malindang Range Natural Park. The findings of this research provide a valuable contribution to support biodiversity conservation. It is highly recommended that periodic monitoring, both spatial and ground truthing activities of the land cover across the MMRNP is essential to better understand the trends in land use impacts to protected areas.

Keywords: biodiversity, conservation, forest cover, G.I.S., protected area

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## Introduction

Forest fragmentation is one of the major environmental problems the world is currently facing. It threatens the biodiversity and ecological functions of the forest (Harris, 1984). It was estimated that more than 50% of known plant species that grow in tropical forests suffer from rapid landuse changes (Achard *et al.*, 2002). Recent studies (Sala *et al.*, 2000) also suggested that land-use changes are likely to have a greater impact on biodiversity reduction than climate change. However, demographic, economic, and social changes worldwide continue to exert considerable pressure on forest cover and condition.

One reason for forest fragmentation is the conversion of forest areas into agricultural lands (Gibbs *et al.*, 2010). This problem is highly associated with the increase in population. According to FAO (2009), in Asia and the Pacific, population is projected to reach 4.2 billion by 2020, an increase of 600 million from 2006. This increase entails pressure to produce more goods and services, especially food, which eventually highlights agriculture's intensification and ultimately threatens the world's remaining forests. Moreover, commercial logging, plantation development, mining, industry, urbanization, and road building are also causing deforestation in tropical regions (Geist & Lambin 2002).

In the Philippines, one key biodiversity area is Mt. Malindang, located at the province of Misamis Occidental. It houses five major habitats including grassland, dipterocarp forest, lower motane forest, upland wetland, and mossy and associated forests (DENR, 2009). The influx of migrant settlers increased the population of the area, creating a boom in the construction industry resulting in high demand for wood. Thus, illegal logging and timber poaching became rampant (Carandang *et al.*, 2013). It is in this scene that Mt. Malindang was declared as a natural protected area through Republic Act No. 9304 of 2004 establishing it as the Mt. Malindang Range Natural Park (MMRNP). This declaration was supported by the survey conducted in response to Republic Act 7586 (also known as the NIPAS Act) of 1992 that mandated that all protected area in the country conduct a survey and registration of protected area

occupants (SRPAO). The first SRPAO in Mt. Malindang was conducted in the year 1999, which detailed the demographic information, socioeconomic condition, proofs of occupancy, and period of occupancy of PA occupants of Mt. Malindang (DENR, 2013). The second SRPAO was conducted in 2015. Between the two surveys, there was a significant increase in population of MMNRP occupants. This data does not easily tell, however, the impact of increasing population on land use and land cover.

Thus, this study aimed to illustrate the spatio-temporal dynamics of the land use and landcover of MMRNP with emphasis on the change of population living in MMNRP from data obtained in SRPAO 1999 and 2015.

#### Materials and Methods A. Study Area



Figure 1. Map showing the Mount Malindang Range Natural Park.

The study area is the whole Mount Malindang Protected Area located in the province of Misamis Occidental with geographic coordinates of  $123^{0}31'45"$  to  $123^{0}55'30"$  East longitudes and  $8^{0}30'30"$  to  $8^{0}45'55"$  North latitudes. The total land area of Mount Malindang is 52,262 hectares, with 34,464 hectares categorized as Strict Protection Zone (S.P.Z.) and the remaining 18,798 hectares as Multiple Use Zone (M.U.Z.). The Park is surrounded by 65 barangays from fourteen municipalities and three provinces (DENR, 2015).

This study's key data sets were the 1992 and 2010 land cover map from DENR, 2015 digital elevation map, and survey results of the 1999 and 2015 Survey and Registration of Protected Area Occupants (SRPAO) obtained from the Department of Environment and Natural Resources (DENR, 2015). Due to limitation of data, comparisons were made only for 1999 and 2015 population (SRPAO data) and 1999 to 2010 land cover data from DENR.

The data were managed and layered using ArcGIS 10.2. All the datasets were projected into UTM 51 North using the World Geodetic System (WGS) 1984 geographic coordinates system.

## **Results and Discussion**

## a. Demographic Profile of the Park Occupants

Table 1 shows the demographic profile of protected area occupants living within Mount Malindang. In 1999, the SRPAO survey included 12,206 (6,299 respondents 52% male and 5,827 or 48% female), and where 1,921 or 56% of the respondents are *Subanen*. People of the *Subanen* tribe, an indigenous group that resides in the mountainous and riverine areas in Mindanao, who are the only ethnic tribes that took residence in MMNRP. They were considered the first caretakers of Mt. Malindang, and reportedly rely on the resources of the mountain. In 1992, around 92% of the whole population were farmers but there was a noted decrease of farmers in 2015 (66%). and the number of *Subanen* inhabitants increased to 73%. There was no significant difference between

male and female occupants in the two years. The decrease in farmers and households may be due to an unbalanced data collection between the two surveys. However, even with this, there is an evident growth of the entire population living within the Park (1.97% increase).

		% Change			
Profile of Park Occupants	1999		2015		<b>8</b> -
	Number	Percentage	Number	Percentage	
Households	3,425		2,959		-13.61
Population	12,206		12,446		1.97
Farmers*	3,150	92%	1,945	66%	-38.25
Subanen respondents	1,921	56%	9,042	73%	370.69
Male	6,299	52%	6,505	52%	3.27
Female	5,827	48%	5,941	48%	1.96

#### Table 1. Population profile of PA occupants.

\*Can be Subanen or not

Figure 2 shows the 1999 and 2015 SRPAO, respectively which, indicate that in 1999 SRPAO there were a total of 12,201 people living within the Mount Malindang protected area. The survey was conducted in eleven (11) municipalities and three cities, where Don Victoriano ranked as the most populated municipality with 3,614 or 30% of the total population. The survey included 48 out of the 65 barangays covering Mt. Malindang and was a census, regardless of whether the household's location is within or outside the protected area (DENR, 2009).



Figure 2. Population graph of 1999 and 2015 SRPAO.

The second SRPAO was conducted from April 2015 to October 2015 by the DENR-PA Office to households in 50 barangays from the 11 municipalities and three cities within the strict protection zone of the Park. Again, Don Victoriano ranked the most populated municipality within Mt. Malindang, which comprised 4,954 or 40% (Figure 3). The Park had total occupants of 12,446 individuals and 2,959 households in the year 2015. The average household size for the SRAPAO 15 will conform the national average of individuals per household which 5. The population of the P.A. occupants is increasing, and as a consequence may result in forest cover loss in Mount Malindang. It is well known that population growth is one of the factors that threatens loss in forest cover and biodiversity in forested areas (Chipika, 2000)

The spatial distribution of population among the 14 municipalities and cities shows that Don Victoriano is the area with the highest population. All its 11 barangays are within the protected area. There was also a notable increase of occupants in adjacent barangays (e.g. Tangub City, Clarin, and Jimenez). There is also an observable decrease in Lopez Jaena, Oroquita, Aloran, and Bonifacio, which may be attributable to the

transfer of occupants from these barangays to neighboring barangays (e.g. Don Victoriano) (DENR, 2015).



Figure 3. Population distribution of SRPAO 1999 and 2015 by areas.

#### b. Spatial Dispersion of Farms and Home Lots

The 2015 SRPAO has added data collections on households and farm lots and the area occupied by home and farm lots, which was not included in the 1999 survey. It was found out that there were a total of 246.036 hectares that were used for home lots of the 2,959 households included in the survey, and a total of 3,211.09 hectares within the protected area that are utilized for farming.

In terms of farm hectarage, the findings revealed that Don Victoriano's municipality has the most number of farm areas utilized within the Park with a total land farm area of 2,009.03 hectares.

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The spatial dispersion of farms in 2015 SRPAO is consistent with the result of the population survey that the municipality of Don Victoriano has the most number of farm areas in the fourteen municipalities/cities of Mount Malindang but, in terms of home lot area used by the occupants, the municipality of Concepcion has the highest hectarage of land area occupied for home lots with a total of 57.43 has. (**Table 2**). These results indicated only the location of farms and their corresponding land areas. However, the farm area's utilization, whether they are planted or not, was not identified during the survey.

Municipalities /Cities	Total Farm Area (has.)		Total Home Lots Occupied (has.)		
Aloran	14.00	(0.4)	2.17	(0.9)	
Bonifacio	23.22	(0.7)	7.25	(2.9)	
Calamba	25.73	(0.8)	10.15	(4.1)	
Clarin	147.50	(4.6)	21.93	(8.9)	
Concepcion	304.20	(9.5)	57.43	(23.3)	
Don Victoriano	2,009.03	(62.6)	36.40	(14.8)	
Jimenez	61.00	(1.9)	16.67	(6.8)	
Lopez Jaena	3.00	(0.1)	6.25	(2.5)	
Oroquieta City	118.00	(3.7)	19.76	(8.0)	
Ozamiz City	78.00	(2.4)	18.78	(7.6)	
Panaon	7.70	(0.2)	4.21	(1.7)	
Sinacaban	34.70	(1.1)	0.71	(0.3)	
Tangub City	183.50	(5.7)	14.65	(6.0)	
Tudela	201.50	(6.3)	29.69	(12.1)	
Total	3,211.09	(100)	246.04	(100)	

Table 2. Data on Area of Farms and Home Lots Occupied by P.A.Occupants in 2015.

Note: value in close parenthesis signifies % value

Among the 14 municipalities/cities, the municipality of Don Victoriano has the largest number of areas intended for farming activities. The municipality produces crops like cabbage, carrots, spring onions, and other cash crops. Most of the occupants in the municipality are farmers and traders (DENR 2009, 2015).

The spatial distribution of home lots occupied inside the protected area among the 14 municipalities/cities showed that Concepcion is the most occupied municipality because some of the respondents owned two houses, one on their farm and another is located near the barangay center where schools and roads and other services are accessible.

Based on the Geographic Information System (GIS) output, the occupants are already encroaching inside the protected area's core zone (Figure 4). It must be stated that according to the NIPAS law and in RA 9304, there should be no occupants inside the strict protection zone. However, if this trend will continue, it is expected that the population will continue to creep inside the strict protection zone. Thus, there be is an urgent need to reinforce the implementation of the NIPAS law in the area. Another reason for the encroaching is the lack of easily identifiable markers to notify the occupants of the delineation between the strict protection zone and multiple-use zone. This situation also calls for the need to conduct periodics monitoring as occupants will always increase their agricultural coverage since Mt. Malindang's soil is rich (Boniao *et al.*, 2006).



Figure 4. Maps showing the overlay of Home and Farm locations (SRPAO 2015).

The result of this study serves as the basis for policy formulation and implementation for the conservation of Mount Malindang Natural Protected Area. It is worthwhile to mention that there is no definite policy or delineation of the Park areas as to where the occupants should limit their land use. There is also a problem in relocating inhabitants since they already have taken roots in the area before it was declared as a natural protected area (Figure 5).



Figure 5. Date of Occupancy by MMRNP occupants in SRPAO 2015 survey.

#### c. Forest cover 1992 to 2010

Mount Malindang was declared as National Park and Water Reserve in the year 1971 by RA 6266, and over a decade it was resurveyed and formally declared as a protected area and its peripheral areas as Buffer Zones by RA 7586, also known as National Integrated Protected Areas Act of 1992 with a total forest cover of 37,417.08 hectares (DENR, 2015) Moreover, due to the Park's enormous value, it was declared as Mount Malindang Range Natural Park by RA 9304 in 2004. The MMRNP has a total of 53,262 hectares, with 34,464 hectares categorized as Strict Protection Zone (S.P.Z.) and the remaining 18,798 hectares as Multiple Use Zone (DENR, 2009). However, within almost two decades, the forest cover of MMRNP continuously declining of about 63.76% from 37,417.08 hectares in 1992 to 23,858.86 hectares in 2010, based on the G.I.S. analysis. It clearly shows a total loss of forest cover of 10,588.80 hectares for the last 18 years. This loss of the forest cover is alarming in that it directly affects the biodiversity, watershed, and other protective and functional uses of the Park. Forest loss seriously affects biodiversity

(Chapungu *et al.*, 2014). Forest fragmentation and loss are considered major threats to the conservation and biodiversity, and ecological functions of the forests (Harris, 1984).



Figure 6. 1992 and 2010 Landcover Map of Mount Malindang Protected Area.

Land cover and stratified digital elevation model (dem) for 2010 and 2015 were analyzed and compared to assess the forest cover status. Figure 6 & 7 shows a significant increase in forest cover of about ~157.2 hectares for the last five years, which may be attributed to the National Greening Program of the DENR, which started last 2011. This may also indicate that the reforestation program of the DENR has yielded positive results.

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Figure 7. Comparison Map of 2010 Landcover and 2015 Stratified Map (dem) of Mount Malindang.

#### **Conclusions and Recommendations**

Based on the preceding analyses, there is a declining forest cover of 63.76% in Mount Malindang Protected Area from 1992 to 2010 and a slight increase in forest cover of about 157.2 hectares in 2015. The population of the Park is increasing. The farm lots and households of the protected area occupants are already encroaching-in the protected area's strict protection zone. The forest is becoming fragmented and primarily due to agricultural activities. The community has no easily identifiable markers of the entire protected area which delineates where to expand and/or not expand their farming activities due to weak implementation of NIPAS law. Some farmers are already occupying 3,192.93 hectares portions of the protected area's strict protection zone.

Based on the result of the study, the following are being recommended:

Mount Malindang Range Nature Park biodiversity conservation policy must be given priority for implementation to ensure the protection of the natural resources within the protected area.

- 1. Integration of Biodiversity conservation in every agricultural/farming activity.
- 2. The biodiversity conservation and protection program, should there be any, must be implemented and priority be given to the strict protection zone.
- 3. Natural resources management activities shall be directed at enhancing the state of the different forest habitat types and the natural resources and biodiversity within them to provide resource-dependent Subanen tribes and the local community with sustainable livelihoods.
- 4. Further study on the role of the Subanen and the local communities in the protection and conservation of Mount Malindang Natural Range Park is needed.

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