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Carbon Storage of the Trees and Roots of the Different Forest Communities of Kalahan Forest Reserve, Philippines

Florencia B. Pulhin[a*], Rodel D. Lasco[b], Alfie M. Torres[c], & Nelson M. Pampolina[d]

ABSTRACT

Climate change has caught much attention globally because of its adverse impacts. It has been recognized that tropical forests have the greatest potential for mitigating climate change due to its high capacity to absorb carbon dioxide (CO_2) from the atmosphere. In the Philippines, Kalahan Forest Reserve (KFR), located in cluster 1 of Ikalahan– Kalanguya Ancestral Domain, provinces of Nueva Vizcaya and Pangasinan is one of the areas that can serve as sink of carbon. To determine the amount of carbon that can be potentially stored in the forestlands of KFR, eight transects (two transects each in mossy and Pinus kesiya forests; four transects in secondary forests) were established. In each transect, 10 sample plots measuring 100 m^2 were established. Trees with diameter at breast height (DBH) ≥ 5 cm inside the sample plots were measured and their species name noted. Biomass of trees and roots were determined using appropriate allometric equations. Biomass densities were converted to equivalent carbon by multiplying them by 45% average value for the Philippines. Results of the assessment show that biomass and carbon densities of the three forest communities are in the following order: Pinus kesiya > secondary > mossy. More than 80% of the biomass is contributed by the trees while the remaining portion comes from the roots. Using the carbon density values derived, forestlands of KFR with an area of 5,087 ha holds a total of 457,698.79 mg of carbon. The results imply that KFR has great potential to serve as sink of carbon.

Keywords: biomass, carbon, forestlands, Kalahan Forest Reserve

INTRODUCTION

Recent evidences show that indeed climate change is happening. In Asia/Southeast Asia, the following changes are observed: number of warm days and nights increased; temperature increased by about 0.14^0C to 0.20^0C; from 1955 to 2005 the ratio of rainfall in the wet and dry seasons increased; occurrence of extreme events increased; increased occurrence of disasters such as fires, landslides, floods and droughts increased (IPCC 2014; ADB 2010).

In the Philippines, observed changes during the period 1951–2010 include an increase in temperature of 0.65°C, significant increase in the number of hot days and warm nights, decrease in number of cold days and cool nights and more intense and frequent occurrence of extreme daily rainfall (Cinco *et al*. 2013).

Climate change has been a major concern globally because of the adverse impacts to both human and the environment. Rising sea level will result to saltwater intrusion into estuaries and aquifers, coastal erosion, displacement of wetlands and lowlands, degradation of coastal agricultural areas, and increased susceptibility to coastal storms; lower rice yields due to shor ter growing periods; loss in income associated with degradation of agricultural areas and loss of housing associated with coastal inundation; decrease in water availability due to increased evapotranspiration in water bodies; and degradation of water quality (ADB 2010).

[a]Scientist II, Forestry Development Center, College of Forestry and Natural Resources, University of the Philippines Los Baños (CFNR, UPLB)
[b]Coordinator, World Agroforestry Centre, IRRI, Los Baños
[c]Asst. Professor, Dept. of Forest Products and Paper Science, CFNR, UPLB
[d]Professor, Department of Forest Biological Sciences, CFNR, UPLB
*Corresponding author: yaybpulhin@yahoo.com

Thus, the global community resolved to mitigate greenhouse gas (GHG) emissions through various means. One of the most effective ways to absorb carbon dioxide from the atmosphere is through forest protection and reforestation. Forests absorb carbon dioxide from the atmosphere and serve as a natural reservoir of carbon. Studies conducted show that different restoration/rehabilitation efforts lead to increase in carbon storage of the forestlands where interventions are undertaken (Budiharta *et al.* 2014; Locatelli 2015; Ilyas 2012). This is particularly true to tropical countries like the Philippines where growth of trees are fast because sunlight is available all throughout the year and rainfall is abundant. Shively (2004) reported that the Philippines ranks seventh among the tropical countries in terms of its ability to sequester carbon. For instance, Brown *et al.* (1996) mentioned that between 1995 and 2050 reforestation and agroforestry store 7.50 and 2.03 Pg carbon, respectively. Regeneration on the other hand stores 3.8 – 7.7 Pg C while avoided deforestation activities absorb 3.3 –5.8 Pg of carbon during the same period. Among these rehabilitation strategies, reforestation and agroforestry are popular for the economic return and environmental benefits they provide.

While forests are huge reservoirs of carbon dioxide, they are likewise sources of carbon because of the many anthropogenic activities. Drivers to deforestation include shifting cultivation, unorganized encroachment on forest lands, squatting, migration of landless lowlanders to forested areas, illegal logging and conversion of native forests to other land uses such as agricultural area, settlement etc. (Carandang *et al.* 2012; Jayagoda 2015). In addition, natural phenomenon such as wildfires, pest outbreaks and storms result to scattered but huge emissions of carbon to the atmosphere (Valentini *et al*. 2000).

Globally, forest and land use accounts for about 1/3 of anthropogenic carbon emissions from 1750 to 2011 and 12% of emissions in 2000 to 2009 (IPCC 2014). In Southeast Asia, carbon emission from forest and land use peaked in the 1980s (Calle *et al.* 2016). However, from 2001 to 2015, emissions from forest and land use decreased due to a reduction in deforestation (FAO 2017; FAOSTAT 2013).

The Philippines offers such areas that can serve as carbon sinks, among which is KFR in northern Philippines. Existing dense and sparse forests of KFR can be protected to avoid CO_2 emissions. The global carbon market recognized the importance of forest in mitigating the GHG emissions and has included forest and soil C sequestration in the list of acceptable offsets (UNFCCC 1997).

The study generally aims to determine the potential of the KFR in mitigating climate change. Specifically, it seeks to: (1) determine the biomass and carbon densities of the trees and roots of the three forest communities in KFR; (2) estimate the amount of carbon that can be stored in KFR; and (3) recommend measures that can enhance the role of KFR in climate change mitigation.

METHODOLOGY

Description of the Study Area

KFR is located in cluster 1 of Ikalahan–Kalanguya Ancestral Domain in the provinces of Nueva Vizcaya and Pangasinan (Figure 1). It covers 14,730 ha of mountainous land with elevation ranging from 600–1717 masl. Average annual rainfall recorded is over 4000 mm while temperature ranges between 8–24°C (KEF 2010).

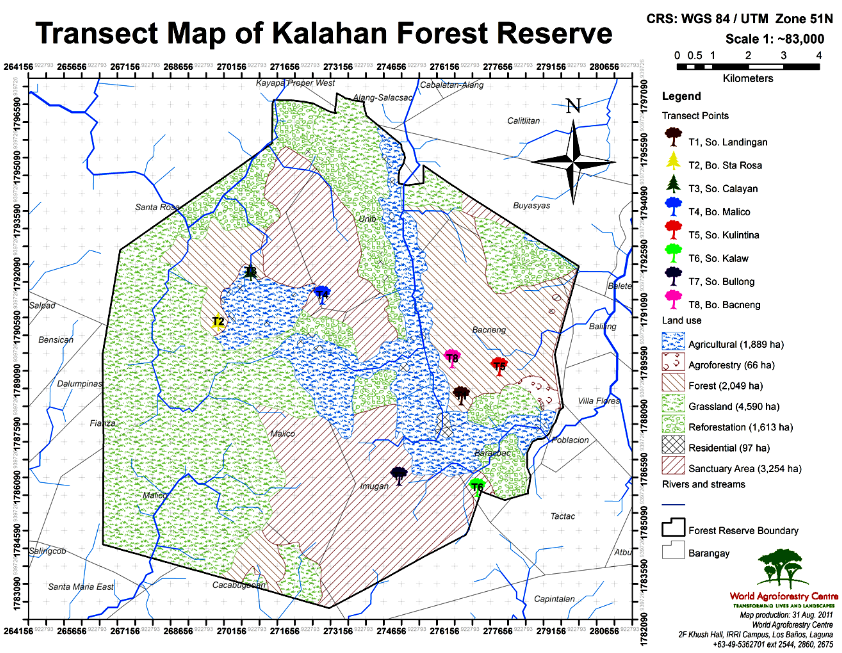

Figure 1. Location of transects established in the assessment

KFR is a host to diverse floral and faunal species. Studies conducted in the reserve shows that there are 286 species of vascular plants belonging to 75 families, eight species of which are critically endangered based on the IUCN Red lists (KEF 2010). Aside from flora, KFR is rich in wildlife species such as birds. It is also the home of the Ikalahans, a cultural minority group characterized by a unique culture practicing sustainable agroforestry systems. To protect the communities from being evicted by land grabbers, Ikalahan tribal elders organized a people's organization called Kalahan Educational Foundation (KEF). The Ikalahans got their rights over the area on 13 May 1974 through a Memorandum of Agreement (MOA) between the KEF and the Bureau of Forest Development (currently the Forest Management Bureau). The MOA provided an opportunity for the KEF to establish the KFR which provided protection to the ancestral lands and culture of the indigenous people. Furthermore, the MOA also gave them complete control and authority to manage the natural resources within the reserve (Dolom & Serrano 2006).

KFR contains three major types of forest – (1) *Pinus kesiya* forest on the western side, (2) dipterocarp forest on the eastern portion and (3) mossy forest on the central part. Within the reserve, sanctuary forests were set aside for watershed and wildlife protection. Other portions were composed of agroforestry farm, agricultural and grassland areas.

Pine community is a grassland area dominated by *Pinus kesiya* trees. Species diversity and evenness are relatively low in this type of forest. Dipterocarp community or lowland evergreen forest has high species diversity and abundance but home of some threatened forest tree species. Fagaceous–myrtaceous community or mossy forest is part of the sanctuary forest where human intervention is little or totally none (Pampolina 2013).

Sampling Method Used

A total of eight transects (two transects each in mossy and *Pinus kesiya* forests and four transects in secondary forest) were established inside the forestlands of KFR to assess the amount of carbon stored. In each transect, 10 sample plots measuring $100m^2$ were established (Figure 2). In each sample plot, diameter at breast height (DBH), total height and species of every tree with DBH of ≥ 5 cm were determined.

The field team while taking DBH of a tree.

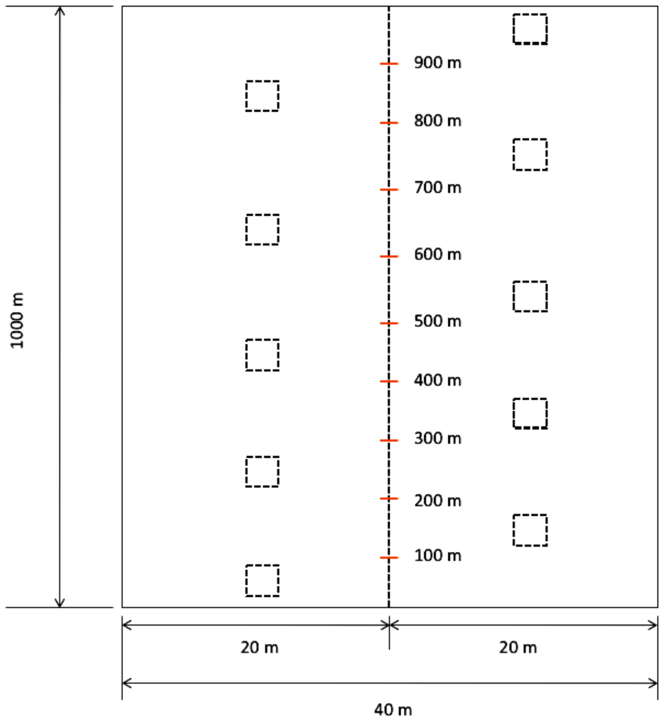

Figure 2. 4000m^2 transect with 10 plots measured 100m^2 for tree inventory

Samples of trees that cannot be identified by the survey team were collected and labelled using their local names. Local names were verified based on the morphological and vegetative characters of the specimens in KEF and UPLB CFNR herbaria. The 1999 Revised Lexicon of Philippine Trees was also used for further verification of species' identity. The location of eight transects established is shown in Figure 1.

Biomass and Carbon Storage Determination

Biomass of each tree was calculated using the allometric equations developed by Brown (1997). These equations were recommended by the IPCC guidelines for tropical forests (IPCC 2003; 2006).

For broad leaves:

for trees with 5 cm ≤ DBH < 60 cm:

$$Y = \exp(-2.134 + 2.53 * \ln(DBH))$$

The field team while laying the transect.

for trees with DBH > 60 cm:

$$Y=42.69-12.8\ (DBH)+1.242\ (DBH)^{\wedge}2$$

For conifers: $Y = \exp(-1.17 + 2.119 * lnD)$

where:
Y = biomass, kg
exp = e to the power of
LN= natural log
D = diameter at breast height (DBH), cm

Tree biomass was converted to equivalent amount of carbon by multiplying by 45%, which is the average C content of wood samples collected from secondary forests from several locations in the Philippines (Lasco & Pulhin 2000).

For the roots, biomass was estimated using the formula by Cairns *et al*. (1997):

Root biomass = $exp(-1.0587+0.8836*LN(AGB))$

where:
exp = e to the power of
LN= natural log
AGB= above ground biomass

The biomass and carbon estimates presented in the paper are focused on the trees and roots only due to budget and time constraints. Since bulk of the biomass present in the forest ecosystem is present in the trees, the results presented here provide important information on carbon storage of an ecosystem.

RESULTS AND DISCUSSION

Profile of the Ecosystems

There are three forest communities assessed in this study: secondary forest, *Pinus kesiya* forest and mossy forest. Of these communities, secondary forest is found to be the most diverse, containing a total of 93 different tree species. Mossy forest ranks second in terms of the number of species present since it hosts 48 tree species. Pine forest, occupying the 3rd rank, hosts 30 other species of trees (Figure 3). The presence of other species of trees is likely attributed to the seeds dispersed by wind and birds through time.

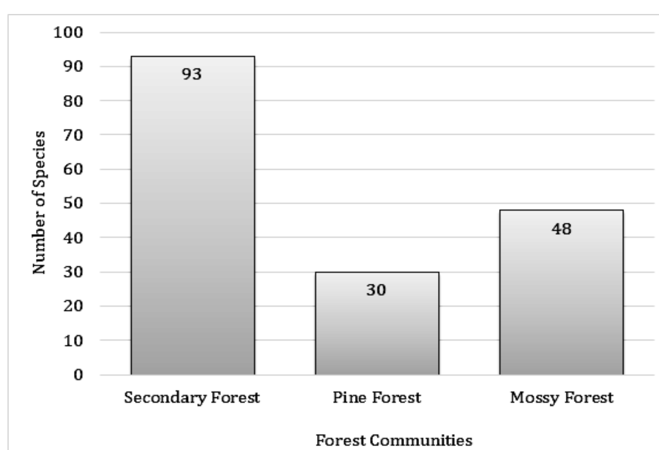

Figure 3. Number of species in the three forest communities.

DBH of trees in the secondary forest ranged from 5–54.3 cm with an average of 13.1 cm. Large percentage of the trees present in this type of forest community fall under DBH class 5–15 cm and only around 8% of the trees have DBH of more than 25 cm. This clearly indicates that this ecosystem is dominated relatively small trees (Figure 4).

In the *Pinus kesiya* forest, trees are relatively large compared with those of the secondary forest. Around 30% of the trees sampled fall under diameter class of 5–5 cm and about 23% are under 15.1–25 cm in DBH. About 20% of the trees fall under the DBH class of 25.1–35 cm while the remaining 27% have DBH of more than 35 cm. It is worthy to note that this forest community has huge trees. Overall, trees inside this ecosystem have DBH ranging from 4.5 cm to 90.7 cm with an average of 25.6 cm (Figure 4).

Similar to the secondary forest, mossy forest contains trees that are of small DBH. DBH of trees range from 5–45.4 cm with an average of 11.9 cm. About 73% of the total trees present in this type of forest community are under DBH class of 5–15 cm and around 22% belong to DBH class of 15.1–25 cm. A mere 4% of the trees sampled have DBH greater than 25 cm (Figure 4).

As regards total height, secondary forest hosts trees that are 3–50 m high with an average height of 15.69 m. *Pinus kesiya* forest, on the other hand, contains trees that have a height range of 2–25 m while mossy forest hosts trees with total height of 5–45 m. Average total height of the trees in the pine and mossy forests is 10.31 m and 14.33 m, respectively.

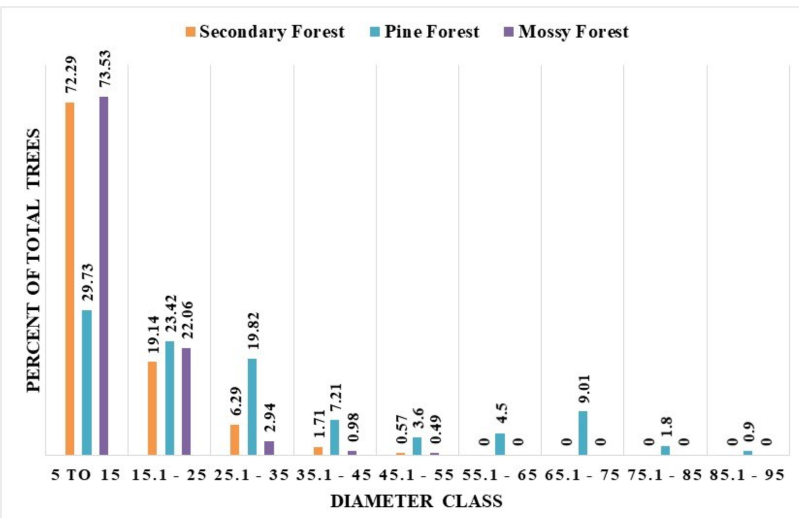

Figure 4. Distribution of trees in the three forest communities of KFR per diameter class.

Biomass and Carbon Densities of the Different Forest Communities

Figures 5 and 6 show the total biomass and carbon densities of the three forest communities. Of the three communities, *Pinus kesiya* forest stores the largest amount of biomass and carbon. This forest community has biomass densities of 324.82 Mg ha^{-1} (Brown 1997). About 88% of the biomass is contributed by the trees while the remaining 13% comes from the roots. This is consistent with previous carbon stocks assessment studies conducted where bulk of the biomass of a forest ecosystem is contributed by the trees.

Compared with other studies conducted in the Philippines, the value derived from this study is higher than the ones derived by Lasco and Pulhin (2009), and Patricio and Tulod (2010). Lasco and Pulhin reported that biomass densities of *Pinus kesiya* in Baguio City and Nueva Ecija are 200 Mg ha^{-1} and 107.83 Mg ha^{-1}, respectively. Patricio & Tulod in their study of *Pinus kesiya* in Bukidnon found a biomass density value of 219.31 Mg ha^{-1} .

In terms of carbon density, the *Pinus kesiya* forest of KFR has 146.17Mg ha^{-1} (Brown 1997). The high amount of carbon present in the *Pinus kesiya* forest is attributed to the large trees present in the ecosystem. As mentioned earlier, about 27% of the trees present in the *Pinus kesiya* forest have DBH greater than 35 cm. Biomass and carbon of a forest ecosystem is highly influenced by the DBH of trees present in the said ecosystem (Paoli *et al*. 2008; Rutishauser *et al*. 2010).

The secondary forest of KFR ranks second in terms of biomass density value derived. Biomass density derived for secondary forest is 146.17 Mg ha^{-1} (Brown 1997) (Figure 5). These values are lower than the biomass estimates derived for secondary forest in the Philippines. Mature secondary forest at Mt. Makiling in Luzon island was reported to have 576 Mg ha^{-1} (Lasco *et al.* 2004). In Musuan, Bukidnon, Tulod (2015) found that secondary forests have biomass density of 489.08 Mg ha^{-1} while in Malaybalay and Impasug–ong, Bukidnon, Patricio and Tulod (2010) reported that the same type of ecosystem has biomass density of 1,019.22 Mg ha^{-1}. A possible reason for the lower value reported in this study compared with the previous studies is the absence of large trees. Big chunks of the aboveground biomass are contained in the large diameter trees (Paoli *et al*. 2008; Rutishauser *et al.* 2010). In terms of percentage contribution of the trees and roots to the total biomass, results show that about 85% of the total biomass is shared by the trees while the remaining 15% comes from the roots.

As regards carbon density of the secondary forest, results of the assessment show that it contains 65.78 Mg ha^{-1} (Brown 1997). Again these values are lower than the carbon density values derived from secondary forests in Mt. Makiling (Lasco *et al*. 2004), Musuan (Tulod 2015) and Malaybalay, Bukidnon (Patricio & Tulod 2010).

Among the three forest communities, mossy forest of KFR has the lowest biomass density. Biomass densities of mossy forests are 128.84 Mg ha^{-1} (Brown 1997) (Figure 5). Typical to mossy forests in the Philippines, trees inside the mossy forests of KFR are relatively small, hence, it is expected that the biomass values derived are low. As mentioned in the previous section, DBH of trees inside the mossy forests of KFR has an average value of 11.9 cm only. Majority of the total trees belong to DBH class of 5–15 cm. Similar to *Pinus kesiya* and secondary forests, large percentage of the total biomass is provided by the trees (84%). In terms of carbon, the mossy forest has densities of 57.98 Mg ha^{-1}.

Compared with the mossy forest in Mt. Makiling, biomass and carbon density values derived from this study are a lot lower. In Mt. Makiling, mossy forest has biomass density of 408.5 Mg ha^{-1} and carbon density of 183.8 Mg ha^{-1} (Lasco & Pulhin 2003).

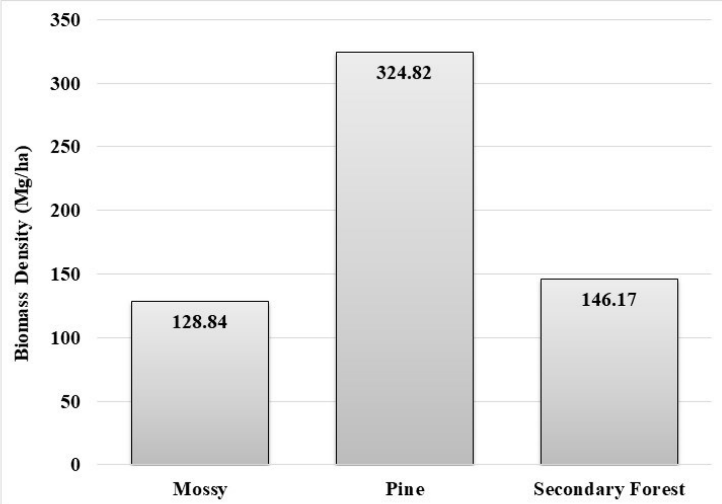

Figure 5. Biomass densities of the three forest communities in KFR

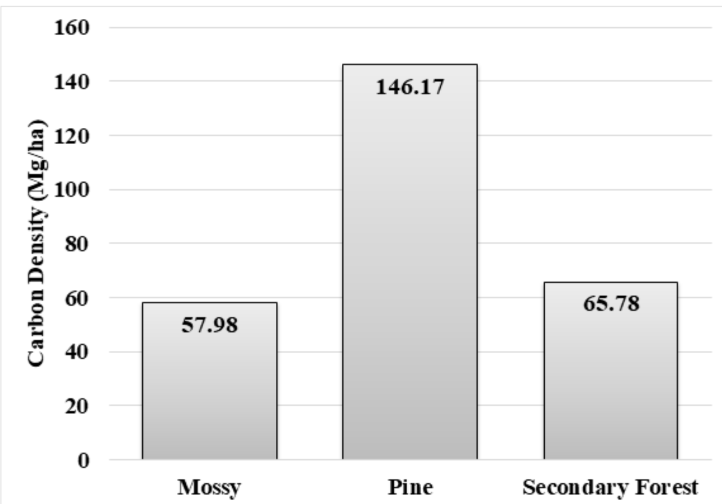

Figure 6. Carbon densities of the three forest communities in KFR

Using the carbon density values derived, the total forestlands of KFR, with an area of 5,087 ha holds a total carbon of 457,698.79 Mg (Brown 1997). Carbon storage in the area will significantly increase if forest protection and rehabilitation efforts will be undertaken. Aside from climate mitigation , protecting and rehabilitating the forestlands of KFR will also provide other environmental services such as biodiversity, water regulation, landscape beauty and soil conservation. Likewise, it will promote climate change adaptation (Lasco *et al*. 2013).

Factors Affecting Carbon Storage of the Kalahan Forest Reserve

Some portions of KFR has been converted to other land uses such as cultivated areas through time. An image analysis of the area between two periods (1989 and 2010) showed an on–going deforestation rate of 0.03%. The decrease in forest cover is attributed largely to conversion of forest to brush lands and cultivated lands. Other studies found a decrease of forest cover (natural and secondary) from 23 to 22% and agriculture from 39 to 33% from 1989 and 2001. At the same time, old *Pinus kesiya* forest increased from 7 to 10% (ICRAF 2013).

On the average, each household has 3 ha. of land, one–third of which is being cultivated while the rest is left forested. Community access is only allowed in production forest and prohibited in the watersheds and sanctuaries. Majority of the local people in the area are swidden farmers with sweet potato, cassava, beans, sayote, corn, taro, okra and upland rice being their staple crop. Off–farm activities consist of fruit processing and quality soft broom production (tiger grass) (ICRAF 2013).

The key players that could contribute to change of the landscapes of mountainous and forest vegetated ecosystem, either positive or negative, comprised of households, the KEF, key political leaders and groups of conservationists. The households include all the family members residing in the ancestral domain. The KEF refers to the foundation responsible in the implementation of policies regarding the overall use and management of natural resources. The key political leaders oversee the political needs of the community as the legal owner of the ancestral domain. Lastly, conservationists include bird watchers, tourists, researchers and academe conducting research towards conservation.

Climate Change Mitigation Potential of the Kalahan Forest Reserve

Forests have a very important role because of its high potential in absorbing carbon and the many environmental and social benefits associated with it (Brown *et al.* 1996, 2000; Moura–Costa 1996). Among the forests in the world, tropical forests have the largest potential to mitigate climate change. Role of forests in climate change mitigation can be enhanced through forest protection or conservation of existing carbon pools, reforestation, agroforestry and bioenergy.

Strict implementation of existing policies to protect the forests in KFR should be given priority. Kalahan Educational Foundation (KEF) as the umbrella program for all the activities and projects within the KFR should take this action in place. One of its programs is agroforestry which is in–charge of the natural resources protection and development including issuance of permits, research and reforestation programs.

Proper forest management activities have a great potential to mitigate climate change (Nabuurs *et al*. 2007). Majority of the areas are forested mostly dipterocarp species although the western edge is dominated by *Pinus kesiya* trees with scattered species of oak. There are some primary forests but majority are secondary forests. Meanwhile, the eastern portions are barren because of the logging which the outsiders did several decades ago. Sanctuaries are also set aside within the KFR which are devoted for wildlife protection and people interventions are not allowed inside. Small swidden farms up to 3 ha can be found interspersed with the forest stands. Roshetko *et al.* (2007) claimed that conversion of grassland, agricultural fallow and permanent shrublands to tree based systems promotes considerable increase in carbon storage. IPCC (2000) set an example in a global level that converting unproductive grasslands and croplands to agroforestry can sequester 586 MtC yr^{-1} by 2040 or 29% of the USA emissions. Aside from mitigation, the integration of timber producing species, industrial crops and other agricultural crops also enhances the economic returns that can be derived from the forest while reducing the pressure on the forest ecosystem.

Indigenous knowledge practice systems which are environmentally sustainable are known to the Ikalahans. Thus, it should be transferred, protected and maintained from one generation to the next. One of the promising practices is the Forest Improvement Technology (FIT) that aims to expedite growth rate of indigenous trees within the forest to improve carbon sequestration. The growth rate presently expected in the Philippine forests is about 4.5 m^3 ha^{-1} yr^{-1} Under proper management using FIT, the forest can produce as much as 15 to 20 m^3 ha^{-1} yr^{-1} (Rice 2000).

CONCLUSION

KFR has great potential in mitigating climate change because of its capacity to store substantial amount of carbon. A large percentage of the total carbon of the forest ecosystem of KFR is contributed by the trees and only a small portion is given by the roots. Aside from carbon, other environmental services such as biodiversity, water and aesthetic beauty can also be reaped if this area is protected and further enriched. There are still many open areas that could be further developed by the introduction of trees, thereby increasing carbon sequestration. Using this carbon density value, the total forestlands of KFR with an area of 5,087 ha holds a total of 457,698.79 Mg of carbon. The reserve's potential to serve as C sink can be enhanced through several protection and rehabilitation activities, including the provision of alternative livelihood to the local communities to reduce pressure in the forest resources and lessen the practice of shifting cultivation in the area.

LITERATURE CITED

Asian Development Bank. 2010. Climate Change in Southeast Asia: Focused Actions on the Frontlines of Climate Change. © Asian Development Bank. Retrieved from http://hdl.handle.net/11540/720. License: CC BY 3.0 IGO. 32pp.

Brown, S., J. Sathaye, M. Cannel, & P. Kauppi. 1996. 'Management of forests for mitigation of greenhouse gas emissions', Chapter 24. In R.T. Watson & M.C. Zinyowera, & R.H. Moss (Eds), Climate Change 1995: Impacts, Adaptations, and Mitigation of Climate Change: Scientific–Technical Analyses, Contribution of Working Group II to the Second Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge and New York, Cambridge University Press, pp. 775–797.

Brown, S. 1997. Estimating Biomass and Biomass Change of Tropical Forest. A Primer. FAO Forestry Paper 134. United Nations Food and Agriculture Organization, Rome.

Budiharta, S., E. Meijaard,' P. D Erskine, C. Rondinini, M. Pacifici & K. A Wilson.' 2014. Restoring Degraded Tropical Forests for Carbon and Biodiversity. Environmental Research Letters, Volume 9, Number 11.

Cairns, M. A., S. Brown, E. Helmer & G. A. Baumgardner. 1997. Root Biomass Allocation in the World's Upland Forests. *Oecologia* (1997) 111:1±11

Carandang, A. P., L. A. Bugayong, P. C. Dolom, L. N. Garcia, M. M. B. Villanueva & N. O. Espiritu. 2013. Analysis of Key Drivers of Deforestation and Forest Degradation in the Philippines. Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH. Manila, Philippines. 128pp.

Calle, L., J. G. Canadell, P. Patra, P. Ciais, K. Ichii, H. Tian, M. Kondo, S. Piao, A. Arneth, A. B. Harper, A. Ito, E. Kato, C. Koven, S. Sitch, B. D Stocker, N. Vivoy, A. Wiltshire, S. Zaehle & B. Poulter. 2016. Regional Carbon Fluxes from Land Use and Land Cover Change In Asia, 1980–2009. Environ. Res. Lett. 11 074011 doi:10.1088/1748–9326/11/7/074011.

Cinco, T. A., F. D. Hilario, R. G. de Guzman & E. D. Ares. 2013. Climate Trends and Projections in the Philippines. Paper presented during the 12th National Convention on Statistics (NCS) held on October 1–2, 2013 at EDSA Shangri–La Hotel, Mandaluyong City.

Dolom, B. L. & R. C. Serrano. 2006. The Ikalahan: Traditions Bearing Fruit. In search of excellence: exemplary forest management in Asia and the Pacific. FAO, Rome.

FAO. 2017. Carbon Emissions from Forests Down by 25% Between 2001–2015. News Article. Rome, Italy.

FAO Statistical Yearbook. 2013. Rome, Italy.

ICRAF (World Agroforestry Centre). 2013. Linking Communities to Voluntary Forest – Related Carbon Market: The Case of Kalahan, Nueva Vizcaya, Philippines. Project Report.

Ilyas, S. 2012. Carbon Sequestration Through Reforestation in Reclaimed Coal Mine Sites in East Kalimantan, Indonesia. *Journal of Environment and Earth Science*. Vol 2, No.10

IPCC (Intergovernmental Panel on Climate Change). 2000. The Carbon Cycle and Atmospheric Carbon Dioxide. In: Watson, R. T., I. R. Noble, B. Bolin, N. H. Ravindranath, D. Verardo, D. Dokken. Land Use, Land Use Change and Forestry: A Report of the International Panel on Climate Change. Cambridge University Press, Cambridge.

IPCC (Intergovernmental Panel on Climate Change). 2003. Good practice guidance for land use, land–use change and forestry (GPGLULUCF). PCC–IGES, Kanagawa.

IPCC 2006. Guidelines for National Greenhouse Gas Inventories, vol. 4. In S. Eggelstons, L. Buendia, K. Miwa, N. Todd & K. Tanabe (Eds.). Hayama, Japan: Institute for Global Environmental Strategies (IGES).

IPCC 2014. Summary for Policymakers. In Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Edenhofer, O., R. Pichs–Madruga, Y. Sokona, E. Farahani, S. Kadner, K. Seyboth, A. Adler, I. Baum, S. Brunner, P. Eickemeier, B. Kriemann, J. Savolainen, S. Schlömer, C. von Stechow, T. Zwickel and J.C. Minx (Eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Jayagoda, D.D. 2015. A Unique Case Study of Tree Plantation Bringing Increased Forest Cover to Puerto Princesa, Philippines. *Journal of Sustainable Development*, Vol. 8, No. 1.

Kalahan Educational Foundation. 2010. Rapid Agro–Biodiversity Appraisal (RABA): Kalahan, Nueva Vizcaya, Philippines. Project Report. Imugan, Nueva Vizcaya, Philippines. 52 pp.

Lasco, R.D., F.B. Pulhin, & P. Pulhin. 2013. Guidebook on Mainstreaming Climate Change in Biodiversity Planning and Management in the Philippines. World Agroforestry Centre and United States Agency for International Development, Philippines.

Lasco, R.D. & F.B. Pulhin. 2009. Carbon Budgets of Forest Ecosystems in the Philippines. *Journal of Environmental Science and Management*. 12(1):1–13.

Lasco, R. D. & F. B. Pulhin. 2000. Forest Land–Use Change in the Philippines and Climate Change Mitigation. *Mitigation and Adaptation Strategies to Global Change Journal* 5(1):81–97.

Lasco, R. D., I. Q. Guillermo, R. V. O. Cruz, N. C. Bantayan & F. B. Pulhin. 2004. Carbon Stocks Assessment of a Secondary Forest in Mount Makiling Forest Reserve, Philippines. *Journal of Tropical Forest Science* 16(1):35–45.

Locatelli, B., C. P. Catterall, P.I. M_bach, C. Kumar, R. Lasco, E. Marín–Spiotta, B. Mercer, J. S. Powers, N. Schwartz, & M. Uriarte. 2015, Tropical reforestation and climate change: beyond carbon. *Restor Ecol*, 23: 337–343. doi:10.1111/rec.12209.

Moura–Costa, P. 1996. Tropical Forestry Practices for Carbon Storage in Forestry and Agroforestry Projects. Winrock International Institute for Agricultural Development. Virginia, USA. 87pp.

Nabuurs, G.J., O. Masera, K. Andrasko, P. Benitez– Ponce, R. Boer, M. Dutschke, E. Elsiddig, J. Ford–Robertson, P . Frumhoff, T . Karjalainen, O. Krankina, W.A. Kurz, M. Matsumoto, W. Oyhantcabal, N.H. Ravindranath, M.J. Sanz Sanchez, & X. Zhang. 2007: Forestry. In Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [B. Metz, O.R. Davidson, P.R. Bosch, R. Dave, L.A. Meyer (Eds)], Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Pampolina, N. M., A. M. Torres & F. B. Pulhin. 2013. Biodiversity Assessment of the Kalahan Forest Reserve (KFR). Final report. World Agroforestry Center, 2nd Floor Khush Hall, IRRI, College, Laguna.

Paoli, G., L. Curran, & J. Slik. 2008. Soil Nutrients Affect Spatial Patterns of Aboveground Biomass and Emergent Tree Density in Southwestern Borneo. *Oecologia* 155, 287–299.

Patricio, J. H. P & A. M. Tulod. 2010. Carbon Sequestration Potential of Benguet Pine (*Pinus Kesiya*) Plantations in Bukidnon, Philippines. *Journal of Nature Studies* 9(1).

Rice, D. 2000. The Kalahan Forests and Carbon: A Philippines Case Study. Indigenous Affairs. Pp 60–67.

Roshetko, J. M., R. D. Lasco & M. S. de los Angeles. 2007. Smallholder Agroforestry Systems for Carbon Storage. *Mitigation Adaptation Strategies to Global Change Journal* 12(2):219–242.

Rutishauser, E., F. Wagner, B. Herault, E.A. Nicolini, & L. Blanc. 2010. Contrasting above–ground biomass balance in a Neotropical rain forest. *Journal of Vegetation Science* 21, 672–682.

Shively, G.E. C.A. Zelek, D.J. Midmore & T.M. Nissen. 2004. Carbon Sequestration in A Tropical Landscape: An Economic Model To Measure Its Incremental Cost. *Agroforestry Systems* 60: 189–197.

Tulod, A. M. 2015. Carbon Stocks of Second Growth Forest and Reforestation Stands in Southern Philippines: Baseline for Carbon Sequestration Monitoring. Advances in Environmental Sciences– *International Journal of the Bioflux Society*. Volume 7, Issue 3. pp.422–431.

UNFCCC. 1997. The Kyoto Protocol. UNFCCC, Geneva, Switzerland.

Valentini, R., H. Dolman, P. Ciais, D. Schulze, A. Freibauer, D. Schimel, & M. Heimann. 2000. Accounting for Carbon Sinks in the Biosphere – European Perspective. CARBOEUROPE Cluster. EU DG Research, Bruxelles.