Journal of Environmental Science and Management Special Issue 1-2016: 83-90 ISSN 0119-1144

Mangrove Palms: Sustainable Feed Source for Swine

RESEARCH NOTES

ABSTRACT

Approximately 15% of global greenhouse gas emissions are from land use change, most of which is for deforestation to make way for agriculture. Around 75% of agricultural land is used for feeding animals rather than humans directly. One solution is to cultivate trees and perennials for livestock feed. Mangrove palms (Nypa fruticans), endemic in the Philippines and most of Southeast Asia, have the potential to be a game-changer in the swine industry. Their calorific yield per hectare is 400% higher than that of maize – the common energy source in swine. Tapping the sugar- rich sap of the palm and feeding it to pigs is an ancient practice that has been overlooked by researchers in the past in favor of industrial field crops. This paper outlines priority areas for research to help redress that imbalance and realize the full potential of the 'climate-smart' nipa palm.

Key words: *feed, nipa, Nypa fruticans, livestock, palm tapping*

Jim Leandro P. Cano[1,2*]
Rheynalyn R. Trivino[1]
Craig B. Jamieson[1]

[1] Next Generation Consultancy, Los Baños, Laguna, 4031, Philippines
[2] Agricultural Systems Cluster, College of Agriculture, University of the Philippines Los Baños (UPLB), College, Laguna, 4031, Philippines
[3] World Agroforestry Centre (ICRAF) Philippines, Los Baños, Laguna, Philippines

E-mail: jpcano@up.edu.ph
(*corresponding author)

INTRODUCTION

Global population is projected to reach 9.6 B by 2050 from just over 7 B today (*FAO 2013*), which has implications for food security and climate change. Urbanization and increased income levels are further increasing the demand for animal protein (*WHO nd*). With the current trends, demand for meat in 2050 is projected to increase by 73% from levels in 2010 (*FAO 2011*).

According to UN World Population Prospects, the Philippine population is expected to reach approximately 157 M by 2050 (*UN 2012*), which will increase the demand for meat in the country, specifically pork. Pork accounts for 60% of the meat produced and consumed in the Philippines (*ACIAR 2014*). Such an increase in the demand for pork will have a corresponding impact on land requirements for swine and feed production.

Over the past years, the Philippine population has grown significantly with its pork consumption steadily increasing as well, which can be seen by the linear trend line in red (**Figure 1**). It shows that at 2014, there was an average of 15 kg of pork meat consumed per capita per year. Recent studies have shown that pork has become an inelastic commodity in the country (*Apolinares et al. n.d.*).

Currently, around 70% (*FAO 2006*) of global agricultural land is used for livestock production, comprising pastureland and cropland for feed. Thus, this study explored possible alternative and sustainable sources of energy feed for swine production based on research done in the past on nipa sap production as swine feed.

Maize as a Staple Feed Crop

Maize is the second most important crop in the Philippines, next to rice, with an average of 3 M ha for its production from 1988–2002 (*Cardenas et.al. 2005*). About 60% of the maize produced in the Philippines is channelled to the livestock and poultry sectors, while the remaining 40% is used as food and other kinds of products (*Padilla 2011*). In the Philippines, two types of maize that are grown are white and yellow. Many Filipinos from two island groups of the Philippines - Visayas and Mindanao - consume white maize as their staple; whereas, yellow maize is mostly used as feeds for the livestock and poultry sector.

An increasing trend in the inventories of swine and poultry from 1988–2002 implies a directly proportional increase in the demand for feed crops (**Figure 2**). The increase of meat consumption can also be attributed to

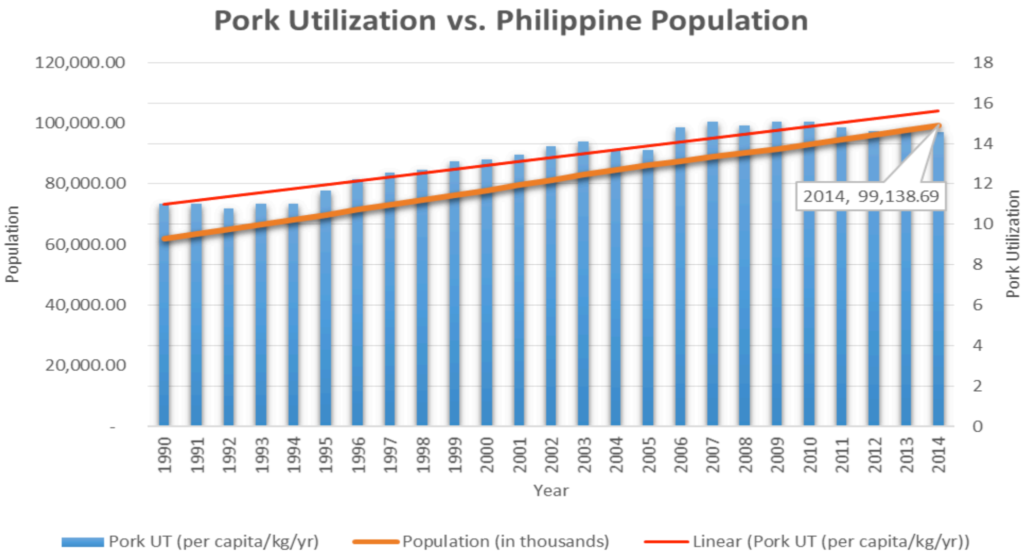

Figure 1. Growing trend of pork consumption with the growing population in the Philippines (*Bureau of Agricultural Statistics 2015*).

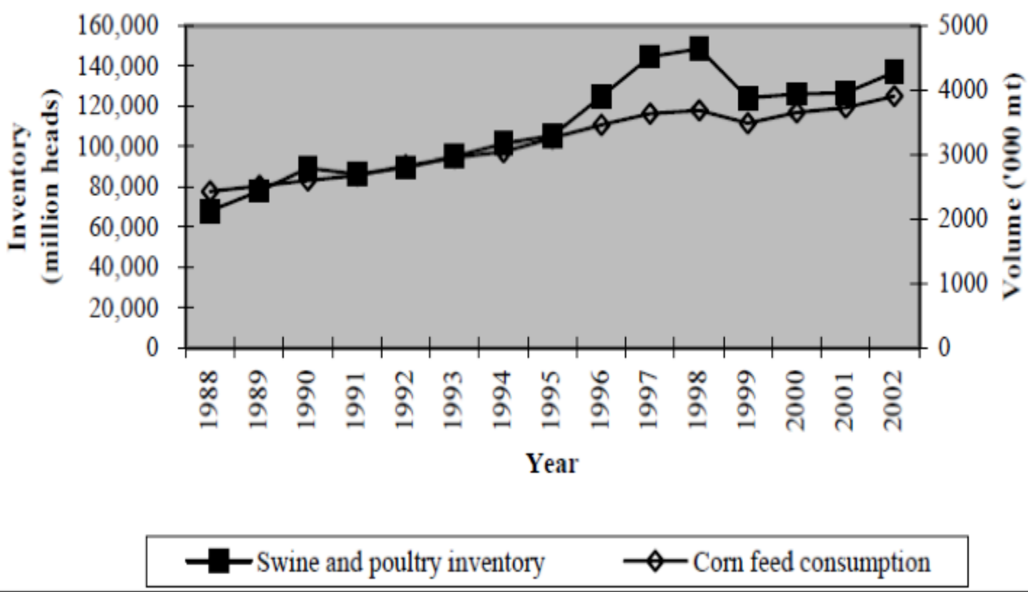

Figure 2. Cross trend of swine and poultry inventory with maize, Philippines, 1988-2002 (*Cardenas et.al. 2005*).

the exponential growth of the population and the rate of urbanization taking place within the country.

Problems Associated with Maize

Unsustainable systems have been defined in the past as those that deplete resources to the point of unavailability for the whole system. However, in recent years, the term 'unsustainable' means more, where it entails any of the following: adverse effects on human health, animal welfare, or that of the environment (*Broom et al. 2013*).

Monocultures may be defined as unsustainable because of their adverse impacts on humans, wildlife, and environment. They have been widely practiced since the Green Revolution and have been sustained by political and economic forces. Large-scale use of agrochemicals, intensive cultivation and land preparation, double cropping, and other resource-pressurising practices have led to various environmental issues. Agricultural expansion has brought about an acceleration of deforestation in developing countries (*Brady and Sohngen 2008*).

Environmental Degradation

Land, water, and ultimately, environmental degradation take place as a result of monocropping. Its practice promotes the heavy use of fertilizers, pesticides, and herbicides, which change the acid levels of the soil. Intensive monocropping changes the soil structure and texture over time, eventually leading to more compact and crusted soils. Aggregates and surface soils are lost in the process, thus leading to low water infiltration rates, higher rates of erosion, and greater run-off (*FAO 1999*). The lack of rich topsoil and necessary nutrients have forced farmers to rely on agrochemicals to fill in the gap, which leads to degradation of the soils.

In the light of climate change, soils play an integral part as they serve as carbon and nitrogen sinks (*Brevik 2013*) which are major components of soil organic matter (*Brady and Weil 2008*). A study on the conversion of a tropical forest to a fertilized crop producing land led to an increase in nitrous oxide (N_2O) emissions (*Hall et al. 2004*). Areas that were once filled with trees have been cleared to give way for the cultivation of more annual crops, such as maize. As these lands are cleared of their natural vegetative cover, the soil is exposed to the battering effects of climate shocks: high rainfall, strong winds, intense heat, and regular typhoons. These soils are then very prone to sheet erosion of surface soils and/or mass movement of soils, such as landslides or mudslides, when they are saturated.

Vulnerability of Maize to Climate Change

In 1996, Smith estimated that climate change will affect maize yields in some regions, whether or not they are irrigated, because the growing season would be shortened as average global temperatures would increase (*Smith 1996*). Developing countries are said to be vulnerable to climate change scenarios in the next 50 years (*Bellon et al. 2011*). However, it should be noted that many developing countries have small-scale farmers who grow maize for their subsistence.

Crop scientists from the International Rice Research Institute (IRRI), based in the Philippines, have confirmed the rule of thumb that every 1-degree Celsius rise in temperature above the status quo leads to a 10% decrease in yields of the world's three major food staples: rice, wheat and maize; of the three, maize is the most vulnerable. For maize to propagate, pollen from the tassel must fall to the silk strands emerging from each corn ear. Kernels are developed once pollen successfully attaches to the silk strands, which begins the process of fertilization. However, if temperatures are unusually high, these silk strands tend to dry out and turn brown, thus making them unable to participate in the crop's fertilization process. Increased temperatures can also cause plants to dry up faster. Leaf curling is a natural response of the plant to reduce its exposure to the sun. On the underside of the leaves, the stomata close to lessen moistureloss, but in the process, the rate of CO_2 intake is reduced, which would also restrict photosynthesis (*Brown 2009*).

Climate change scenarios include increased sea-levels and higher temperatures. Annual crops will have to be cultivated at higher altitudes, which would promote the conversion of forests to arable lands, reducing carbon sinks and contributing to the acceleration of climate change. Higher temperatures are known to increase pest incidences in crop areas. Maize is susceptible to various types of pests under such conditions (e.g., corn stem borer, leafhopper, jassid). *Zulfiqar et al.* (2010) discussed a significant correlation between the increase in temperatures and the increase of pest incidence exists, specifically for the presence of jassid and leafhoppers in maize.

Maize's role as a major source of energy for livestock and poultry feeds can be very uncertain in the future, given its vulnerability towards the changing climate. New sources of energy, which are sustainable and climate-smart, must be researched and/or developed.

Palm-Tapping for Animal Feed

Grain crops tend to have higher productivity in thetemperate countries than in the tropics. In tropical countries, perennials often exceed the productive potential of grain crops (e.g., maize, cassava, African oil palm, sugar cane, sugar palm) (*Preston 2000*). *Khieu and Preston* (*1995*) published a paper detailing the experiment they carried out in testing the potential of tapping sugar palm (*Borassus flabellifer, Khieu and Preston 1995*) for its raw juice and feeding it to pigs. Using sugar palm juice as swine feed was demonstrated with the cooperation of 14 farm households. Fresh juice from the sugar palm with "restricted amounts of boiled whole soya beans (equivalent to 150 g day^{-1} protein)" was fed to the pigs. It resulted into an average growth rate of 400 g day^{-1}. According to their economic analysis, pig feeding showed to be more profitable than making sugar from the juice, if the costs of wood fuel are factored in for juice concentration. From their experiment, juice production ranged from 2.76 kg tree day^{-2} to 6.37 kg tree day^{-1}. With a spacing requirement of approximately 50 m^2 per tree, it can be estimated that the amount of sugar that can be produced per hectare per year would range from 12 to 18 t. Under rain-fed conditions, this would show that sugar palm is "both highly productive and an efficient user of solar energy" (*Khieu and Preston 1995*).

Feeding sugar palm syrup to pigs has long been practiced in Indonesia, particularly in Roti and Savu (*Fox 1977, cited by Dalibard 1999*). *Borassus* is at the center of the economy of Savu for its different ways of utilization;

pig-rearing with the palm's juice is one such component. To the people of Savu, pigs are a prime means of converting palm products into protein. Fresh sap is fed to the pigs almost throughout the tapping season, fattening them compared to a control where the livestock lost weight (*Dalibard 1997*). In the 18th Century, Captain James Cook travelled from New Guinea to the island of Savu during the peak season of tapping. Cook recorded in his book "Voyages" how the locals of Savu used palm syrup as feed for pigs and other animals. *Fox* (*1977 cited by Dalibard 1999*) quotes Cook, "I have already observed that it is given with the husks of rice to the hogs, and that they grow enormously fat without taking any other food: we were told also, that this syrup is used to fatten their dogs and their fowls..."

As palms are mostly concentrated in the equatorial belt and densely in the Southeast Asian region, tapping palms for feed purposes has the potential to change the current practices in livestock production. *Khieu and Preston (1995)* suggests that farming systems using palm as a source for feed could be small-scale but highly productive. Most of the swine producers in the Philippines are small-scale, hence making the most out of the palms in the country can be a key to climate-smart livestock production systems.

Generally, palm trees have advantages over other crops with regard to sustainability. Places where *Arenga pinnata* (*Dalibard 1999*) are found, kin to Nypa, have more stable and productive soils than areas where cassava cultivation is present (*Dransfield 1977 cited by Dalibard 1999*). Conventional agriculture relies heavily on industrial inputs, which are mostly manufactured with the aid of fossil-fuels. The cultivation of maize and other annual crops for animal production drives the need for more fossil fuels, hastening the effects of climate change. Perennials generally do not require intensive cultivation and management compared to annuals; fewer external and industrial inputs are required. However, labor and technical skills development would be the major input for the management of palm tapping. Maximizing the potential of perennials such as palm species in the equatorial belt can be a key to promoting climate-smart livestock production.

Candidate Palm Species

As mentioned, *B. flabellifer* and *A. pinnata* are candidate species. Still more members of the palm family can be explored for animal production; they can be found across countries in the equatorial belt, most of which are in Asia and Africa. *Dalibard* (*1997*) summarized their location and management.

Although there have been studies on different palm species for animal production, there has been no wide acceptance across nations for the idea of using palm juice for swine and poultry feed. *Khieu* (*nd*) stated that there are approximately 8 million sugar palm trees in Cambodia. *B. flabellifer* alone could feed 3–4 million pigs or 14 million ducks in the country. If other palm species were considered, more swine and poultry could be raised sustainably on perennials as a source of energy rather than annuals.

In the Philippines, riverbanks and estuaries are home to another palm tree that is also a mangrove - *Nypa fruticans* (*Rasco 2011*). Nypa, also known as Nipa palms, can thrive in fresh and brackish waters. They propagate sexually with their male and female inflorescences, and asexually through dichotomous branching (*Rasco 2011*). They are spread across Asia-Pacific, Northern Australia, and Africa.

Nypa fruticans as a Promising Species

Nypa fruticans in particular possesses various traits that make it competitive, as well as advantageous, as a replacement for animal production. Among the palms, *Nypa* is the most convenient species for tapping because of its low height even when it reaches its mature stage. Labourers do not have to climb to tap it, unlike other palm species (e.g. *Cocos nucifera*) (*Rasco 2011*).

Meanwhile, nipa is not known to suffer significantly from increased sea levels because of its high adaptability to floods and various environmental conditions. It may have certain pests and diseases as some leaves were seen to have some mechanical damage in his study, which may have been caused by leaf-eating insects, and leaf lesions that may have been due to certain fungal pathogens (*Rasco 2011*) (**Table 1**).

Nypa can be tapped as early as four years of age. As with *Borassus*, *Nypa* can produce sap for as long as 50 years, and it can be tapped throughout the year (*Dalibard 1997*).

For tapping, *Nypa* groves need to be planted at 2,500 plants per hectare because high density is not ideal for flowering. This is in contrast to the ideal planting density of 10,000 plants per hectare if *Nypa* is to be used for leaf shingle production.

Nypa groves have a relatively fast growth rate, making them a highly prolific species even without any human intervention or management. They do not compete with other crops for agricultural land as they are found in places which are deemed to be 'unfit' for any agricultural activity. With their capacity to reproduce both sexually and asexually, they can multiply relatively fast, leading to more *Nypa* groves that can serve as carbon sinks.

Table 1. Summary of comparison between Nypa and Maize.

	Nipa Palm (*Nypa fruticans*)	Maize (*Zea mays*)
Cultivation	Clearing of old leaf fronds as part of management	Conventional practice: intensive cultivation
Inputs required	Labor (for tapping)	Labor, fertilizers, pesticides
Habitat	Riverbanks, Estuaries, freshwater and brackish waters; Can thrive in areas deemed 'unfit' for agricultural activities	(irrigated & cultivated) Upland
Vulnerability to pests/diseases	No records showing serious pests and diseases	High
Resilience to Climate Shocks	Can serve as a buffer for storms; not negatively impacted in the event of typhoons and floods	Shallow root zone making it highly vulnerable to strong winds and rains
Environmental effects	Can be an invasive species	Traditional agricultural practices can lead to physical and chemical degradation of soil, loss of biodiversity, contribute to global GHG emissions

High Yields

Comparison between maize and sugar palm (in energy or cereal grain equivalent tons per hectares) shows that crop yield of the latter are higher at 25 t ha^{-1}, while maize is at 5 t ha^{-1} (*Preston 2000*). *Nypa* has a calorific yield that is 400% higher than that of maize ha yr^{-1}. Although sap production occurs all-year round, it varies from month to month. Drawing on two estimates of *Nypa* sap production, the World Agroforestry Centre (ICRAF, n.d.) had an optimistic estimate of sap yield for the Philippines of 126,000 L ha^{-1} yr^{-1}, whereas *Dennet* (*1927 as cited by Rasco 2011*) gave an estimate of 15,600 L ha^{-1} yr^{-1} of alcohol, which translates to 312,000 L of sap, assuming 100 L of sap yields 5 L of pure alcohol. *DOST* (*1991 as cited by Rasco 2011*) also gave an estimate that with the use of the traditional way of preconditioning of the fruit stalk, *Nypa* sap could yield up to 57,750 L ha^{-1} yr^{-1}, whereas the improved way could yield as much as 101,285 L ha^{-1} yr^{-1}. 100 L of sap contains around 21 kg sugar, according to *Rasco* (*2011*), who also gave the following factors as causes of variation among individual plants' sap yields: wide differences of yield per plant daily; length of sap collection period; plant population per hectare; time of the year; proportion of plants that yield sap; and age of the Nypa plant or branch.

Environmental Benefits

Nypa has the potential to replace an annual crop (maize) for some livestock production, bringing benefits for the environment and climate change. As climate change accelerates, it is of paramount importance that more resilient crops are deployed. Taking into account the exposure of the Philippines to approximately 20 typhoons per year, crops which can withstand climate shocks (e.g., floods, typhoons, storm surges) are key to establishing sustainable livestock production systems. *Nypa* can withstand the increased effects of climate change, while protecting and conserving the coastal ecosystem. Being able to thrive in a wide range of environments, from brackish to fresh and saline waters, *Nypa* acts as a buffer against storm surges, floods, and typhoons at the intertidal zones. A project conducted in 2005 by the Rufford organization in Tra Vinh, Vietnam, reported that the storm or flood impact to local residents was reduced to 40% by *Nypa* (*Le Thi et al 2007*). They are crucial in developing considerable tidal lands and providing a habitat that is suitable to "endemic, rare, and even endangered species of aquatic and terrestrial flora and fauna that breed and thrive in brackish water" (*Cadiao and Espiritu 2012*).

Greater benefits to the environment and biodiversity can be obtained when *Nypa* co-exists with mangrove swamp trees (e.g., *Avicennia, Rhizophora*), mainly because the synergy of their characteristics provide a safe place for flora and fauna. *Primavera* (*2000*) stated that other animals can be gathered (e.g., crabs, lobsters, molluscs, bivalves) aside from harvesting fish and shrimp, which would consequently benefit the farmers. One example is the integration of aqua-silvaculture systems into *Nypa* groves where mudcrabs can be harvested, which can be a source of additional income for farmers who utilize the palm either for sap or leaf shingle production. With the environmental and economic benefits of *Nypa*, mangrove reforestation may take place, given the current state of mangrove swamps, where an estimate of about 149,000 ha of mangroves remain in the Philippines (*WRI 2000*).

Rasco (*2011*) suggested that one possible way to domesticate *Nypa* is to use it to rehabilitate abandoned fishponds. This could bring many benefits to the Philippines and other Southeast Asian countries, as there are many abandoned ponds after the shrimp industry's boom in the 1980s. In the Philippines, half of the 279,000 ha of mangrove swamps were lost from 1951 to 1988 because of the conversion to culture ponds (*Primavera 2000*). Rehabilitating these areas with *Nypa* could once again restore the coastal wetlands to their natural state and bring about a positive multiplier effect to the environment and its stakeholders.

Research Priorities

As with the experiment conducted by *Khieu and Preston* (*1995*), the palm juice was a source of energy for the pigs, a protein source for the animals' nutrient requirements was also required; in their case, soybean. However, soybean can rarely be found at low prices; alternative sources have been suggested by *Dalibard* (*1997*), such as cassava leaves, sweet potato leaves, fodder tree leaves, aquatic plants (e.g., duckweed, *Azolla*), whole soya plant at milky grain stage, and fish wastes.

The use of alternative protein sources whose cultivation does not rely heavily on industrial inputs would be ideal to complement the climate-smart aspect of the *Nypa* sap. *Azolla* is one good candidate because of an initial study investigating its performance as a protein supplement with sugar cane juice in Colombia. *Becerra et al.* (*1990*) conducted trials on *Azolla* with sugar cane juice, showing that the pigs' performance decreased as *Azolla* levels were increased during the growing phase, yet had reversed effects during the finishing phase where the growth rate was faster than those of the control group. Overall, no differences were observed in the growth rates among the treatment groups (0%, 15%, and 30% *Azolla*). Hence, further study should be conducted to test whether it is feasible to feed *Azolla* as a protein source during the finishing phase, in combination with other potential protein source for the growing phase.

Another research priority for *Nypa* is for techniques to make the tapping process more cost-efficient. Traditionally, *Nypa* fruit stalks undergo preconditioning before it is tapped. Preconditioning is necessary to remove the embolism that normally blocks the vascular tissue before fruit abscission (*Bamroongrugsa et al. 2004*). Accordingly, higher plants tend to activate biosynthesis of ethylene as a stress-related response in plant physiology, (*Ievinsh and Ozola 1997*). Ethylene production stimulates sap flow, thus proposing that, theoretically, an exogenous application of ethylene may increase sap flow (*Rasco 2011*), which was tested by *Ranasinghe and Waidyanatha* (*2003, as cited by Rasco 2011*) in coconut. A cotton ball soaked in 3.0 mL of 2.5% commercial Ethrel was applied at the axis of the tapping spadix (base of the outer bract). There was a consistent increase over a period of years in yield per day, per spadix, per palm, and in sugar content of the sap. Their speculation was that Ethrel inhibited callose formation, thus increasing the length of sap flow and overall flow rate (*Rasco 2011*). As this experiment was conducted on coconut, testing it with *Nypa* sap collection for animal production could yield high returns.

CONCLUSION AND RECOMMENDATIONS

Livestock production must intensify if it is to keep pace with growth in demand, specifically for protein-rich food. Current agricultural practices that support the livestock industry rely heavily on industrial inputs and unsustainable production methods. The challenge for the livestock sector is how to produce more with less. Hence, this game-changing concept of utilizing a tree that is naturally found in the equatorial belt – *N. fruticans* – for the purpose of animal production. *Nypa* is a multi-purpose source of livestock feed, climate-shock buffer, and key to the conservation and regeneration of the environment and biodiversity. Research and development is necessary to bring clarity on how the palm could be utilized, specifically in the effort of replacing annual crops in the supply chain of feeds for animal production. As there have been various studies on how to use palm juice for fattening pigs, tapping *Nypa* for the same purpose has yet to be fully developed. Understanding its use and turning potential into a reality could change the current livestock production systems, not only in the Philippines, but also in countries where *Nypa* is endemic. Collaboration between different stakeholders - academe, government, business, and farmers – is important to maximize the use of Nypa in the Philippines.

Academe

Experts in plant breeding can be key to developing *Nypa* varieties that have the best qualities. Unlike other crops, which have benefitted from research and development, no extensive work has been conducted on this palm species despite its potential. Production systems and technology should be developed together with *Nypa* producers for best results. There also has to be clear comparative studies conducted between maize and *Nypa* for swine production: cost-benefit analyses, socio- and techno-economic studies.

Government

Mechanisms are required to implement the existing policies that support the coastal wetlands. This would significantly address the need to conserve, regenerate, afforest, and reforest mangrove areas that have been lost or converted to culture ponds.

Business

Supply and demand in animal production are mostly fuelled by the activities of businesses, which make them crucial in the development of a supply chain that takes the value of *Nypa* into consideration. Businesses willing to become boundary partners for future research can help drive the development of climate-smart livestock feeds from palm trees.

Farmers

There is a need to raise awareness of the potential of *Nypa* among farmers to stimulate interest. Research and business development would be taken up if farmers can see the potential for *Nypa* as animal feed.

REFERENCES

Apolinares, RJVC, Sarmiento, JM., Digal LN. 2011. "Determining the Market Potential of Livestock and Poultry in the Philippines: An Application of the Almost Ideal Demand System", 7th Mindanao Statistics Congress, Davao City, 18-19 August 2011. Australian Centre for International Agricultural Research (ACIAR). Annual Operation Plan 2014-2015: Country Context – Philippines.

Bamroongrugsa N., C Purintavarakul, S Kato, J Stargardt. 2004. Production of sugar-beating sap from nipa palm in Pak Phanang basin, Southern Thailand. Bull. Soc. *Sea Water Sci. Jpn*. 38:304-312.

Becerra M, Murgueitio E, Reyes G and Preston T R. 1990. *Azolla filiculoides* as partial replacement for traditional protein supplements in diets for growing-fattening pigs based on sugar cane juice. Livestock Research for Rural Development. Volume 2, Article #16. Retrieved January 23, 2015, from http://www.lrrd.org/lrrd2/2/maricel.htm

Bellon MR, Hodson D, Hellin J. 2011. Assessing the Vulnerability of Traditional Maize Seed Systems in Mexico to Climate Change. Accessed from http://www.bioversityinternational.org/uploads/tx_news/Assessing_the_vulnerability_of_traditional_maize_seed_systems_in_Mexico_to_climate_change_1471.pdf

Brady M, Sohngen B. July 2008. Agricultural Productivity, Technological Change, and Deforestation: A Global Analysis. Paper presentation at the American Agricultural Economics Association Annual Meeting.

Broom DM, Galindo FA, Murgueitio E. 2013. Sustainable, efficient livestock production with high biodiversity and good welfare for animals. Proc R Soc B 280:20132025. http://dx.doi.org/10.1098/rbsp.2013.2025

Brady, N.C.; Weil, R.R. 2008. The Nature and Properties of Soils, 14th ed.; Pearson Prentice Hall: Upper Saddle River, NJ, USA.

Brevik, E.C. 2013. The Potential Impact of Climate Change onSoil Properties and Processes and Corresponding Influence on Food Security. *Agriculture*, 3, 398-417. doi:10.3390/agriculture3030398

Brown LR. 2009. Plan B 4.0: Mobilizing to Save Civilization. Earth Policy Institute. W.W. Norton & Company.

Bureau of Agricultural Statistics. Accessed on 2015 from http://countrystat.psa.gov.ph/.

Cadiao LV, Espiritu LC. March 2012. Leaf to Uplift Mindoro: Rehabilitation and Propagation Of Nipa (*Nypa fruticans* Wurmb) in Occidental Mindoro.

Cardenas DC, de Villa LMM, Decena FLC. 2005. Status and Prospects of Feed Crops in the Philippines. CAPSA Working Paper 78. UNESCAP-CAPSA. Accessed from http://ageconsearch.umn.edu/bitstream/32662/1/wp050078.pdf

Dalibard C. 1997. The Potential of Tapping Palm Trees for Animal Production. Paper presented at Second FAO Electronic Conference on Tropical Feeds Accessed from http://www.fao.org/ag/aga/agaP/Frg/conf96.htm/dalibard.htm

Department of Science and Technology (DOST). 1991. Increasing nipa sap yield through improved mechanical tapping. PCCARD 8(4): 1-8.

Dennet, J.H. 1927. Final observations on the nipah palm as a source of alcohol. *Malaysia Agric. J*. 15:420-432.

Dransfield, J. 1977. Dryland Sago Palms. In: First International Sago Symposium. The Equatorial Swamp as a Natural Resource. Ed. Tan K. Sarawak, East Malaysia, Kuching, 1976. Kuala Lumpur. pp. 76-83.

FAO. July 1999. Poverty Alleviation and Food Security in Asia: Land Resources. Rome, Italy.

FAO. 2006. Livestock's long shadow: environmental issues and options. Rome, Italy.

FAO. 2011. World Livestock 2011 – Livestock in food security. Rome, Italy.

FAO. 2013. Tackling Climate Change through livestock – a global assessment emissions and mitigation opportunities. Accessed from http://www.fao.org/docrep/018/i3437e/i3437e.pdf on June 20, 2014.

Hall, S.J.; Asner, G.P.; Kitayama, K. 2004. Substrate, climate, and land use controls over soil N dynamics and N-oxide emissions in Borneo. Biogeochemistry, 70, 27–58.

Ievinsh G, Ozola D. 30 April 1997. Ethylene and the Defense against Endogenous Oxidative Stress in Higher Plants. Biology and Biotechnology of the Plant Hormone Ethylene

Khieu B. n.d. The Sugar Palm Tree as the Basis of Integrated Farming Systems in Cambodia. Livestock Feed Resources within Integrated Farming Systems, FAO.

Khieu B, Preston TR. 1995. Conserving Biodiversity and the Environment and Improving the Well-Being of Poor Farmers in Cambodia by Promoting Pig Feeding Systems Using the Juice of the Sugar Palm Tree (Borassus flabellifer). Livestock Research for Rural Development. Volume 7, Article #15. Retrieved January 16, 2015, from http://www.lrrd.org/lrrd7/2/5.htm

Le Thi Thu Ha, Nguyen Xuan Vy, Le Thi Thu Thao. 2007. Taking care, harvesting and processing sugar and alcohol from Nypa Palm's sap. http://www.rufford.org/files/Guidelines%20for%20Nypa%20farmers.pdf

Padilla LDE. October 2011. Bureau Agricultural Research: Research and Development Digest. October-December 2011 Issue (Volume 13 No. 4).

Preston TR. January 2000. Livestock Production from Local Resources in an Integrated Farming System; a Sustainable Alternative for the Benefit of Small Scale Farmers and the Environment. Workshop-seminar "Making better use of local feed resources" SAREC-UAF.

Primavera JH. 2000. Philippine Mangroves: Status, Threats and Sustainable Development. In International Workshop Asia-Pacific Cooperation Research for Conservation of Mangroves. 26-30 March 2000. Okinawa, Japan.

Rasco ET Jr. 2011. The Nypa Palm: Nature's Gift from the Age of Dinosaurs. National Academy of Science and Technology, Bicutan, Taguig, Metro Manila, Philippines.

Smith JB. June 30, 1996. Vulnerability and Adaptation to Climate Change: Interim Results from the U.S. Country Studies Program. Springer Science and Business Media

World Agroforestry Centre (ICRAF). n.d. Nypa fruticans. 20 June 2011. http://www.worldagroforestrycentre.org/sea/Products/AFDbases/AF/asp/SpeciesInfo.asp?SpID=18140.

World Health Organization (WHO). n.d. Global and regional food consumption patterns and trends. Accessed from http://www.who.int/nutrition/topics/3_foodconsumption/en/index4.html on June 20, 2014.

United Nations. 2012. World Population Prospects: The 2012 Revision. Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat. Accessed on December 12, 2014 from http://esa.un.org/unpd/wpp/index.htm

World Resources Institute. 2000. World resources 2000-2001: people and ecosystem—the fraying web of life. Washington, DC., UNDP. 400,

Zulfiqar MA, MA Sabri, MA Raza, A Hamza, A Hayat, A Khan. 2010. Effect of Temperature and Relative Humidity on the Population Dynamics of Some Insect Pests of Maize. *Pak. j. life soc. Sci.,* 8(1): 16-18.