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Farmers' Perception on the Sustainability of a Rubber-Based Agroforestry System as a Climate Change Adaptation Strategy in Agusan Del Sur and North Cotabato, Philippines

ABSTRACT

This documentation research sought to evaluate the effectiveness of rubber-based agroforestry typologies as a climate change adaptation strategy in the major rubber producing regions in the Philippines, particularly in Agusan del Sur and North Cotabato. It focused on the understanding/perception of the RBAS farmer respondents on climate change and their account of its influence on the production system and their coping mechanisms. Among the farmer respondents, drought (El Niño), typhoon, strong winds, heavy rains/excessive rainfall, flash floods and landslides are among the common evidences of climate change. Generally, most of the adaptation strategies employed is through cultural management practices like minimized usage of inorganic fertilizer and chemical pesticides from Agusan del Sur farmer respondents while some of the farmer respondents in North Cotabato employed organic farming practices to adapt to climate change. For both provinces, farmer respondents particularly identified agroforestry and diversified farming system as an effective adaptation strategy. Results proved the potential of the rubber-based agroforestry system to evolve as a resilient farming practice to adapt to climate change vis-à-vis stable biological and economic productivity, controlled occurrence of pest and diseases and minimized detrimental effects of climate change on the agroforestry farm component as a whole.

Key words: *climate change, resilience, rubber-based agroforestry, typology*

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INTRODUCTION

Smallholder farmers have begun to rehabilitate degraded grassland in many parts of the Philippines through the integration of tree crops on their farming systems (*Bertomeu, 2006; Paelmo et al. 2016; Schroth 2014*). Rubber-based agroforestry system (RBAS) is among the adopted smallholder farming practices, due to its potential to rehabilitate degraded areas while simultaneously providing economic benefits to farmers. The economic significance of Para rubber (*Hevea brasiliensis Muell Argo*) had long been recognized (*Nair 2010; Montefrio 2016; Schroth et al. 2004*) because of its ability to produce latex. Latex regeneration, physiological response to stimulation, and duration of latex flow after tapping spell the resulting rubber yield which is greatly influenced by the rubber clones (*Chao et al. 2015;Pethin et al. 2015; Sanoi et al. 2017*).

Rubber can thrive on a wide range of environment (*Omokhafe and Emuedo 2006*), but it performs well in areas with high temperature, adequate moisture and fertile soil. Beside these factors, the productivity of the crop is also impinged on the type of clone used. *Akpan et al.* (*2007*) and *Akpan* (*2014*) explained that the clones, varieties, tapping date and soil types are major factors that influence both the growth and productivity of rubber trees. Moreover, the importance of improved germplasm of clonal rubber plants is evident on the latex productivity including fertilization and irrigation (*Aoki et al. 2014; Mak et al. 2008*).

Meanwhile, the rubber-based agroforestry systems are providing significant ecosystem services (*van Noordwijk, et al. 2012; Yi et al. 2014 and Villamor et al. 2014*). Trees or woody perennials in particular provide significant ecological value (*Paelmo et al. 2015*). This is possible through well managed smallholder rubber-based agroforestry. They have also proven that rubber-based agroforestry is also more beneficial to the environment and biodiversity compared to monoculture rubber. Engagement in diversified rubber farm production significantly increases household net income per capita by threefold (*Liu et al. 2006*). *Manivong and Cramb* (*2008*) also stated the potential of rubber farming to reduce poverty among poor upland farmers including the attainment of local household food security (*Honrade et al. 2017*). *Fox et al.* (*2014*) and *Nath et al.* (*2013*) reiterated the importance of diversity in rubber farming through agroforestry system to ensure the balance of environmental and economic benefits.

This paper provides evidences on the productivity of rubber-based production systems/typologies and the potential-based production systems in different agroecological zones in the Philippines amidst occurrence of climate change. Specifically, it sought to: characterize the socio-economic and demographic characteristics of rubber smallholders; identify clones of para rubber used in the provinces; determine the institutional and organizational aspects of rubber farming; identify and document/characterize pests and diseases in rubber-based production system; analyze the economic data/information derived from rubber-based agroforestry variants; and determine the influence of climate change on rubber-based production systems.

MATERIALS AND METHODS

The provinces selected for this documentation research conducted from 2013 to 2014 were among the dominant rubber producing niche in the Mindanao region representing two climatic types, namely Agusan del Sur and North Cotabato (**Figure 1**). For each province, the farmer respondents sample size was computed using the Slovin's formula. Participatory data gathering was administered with the aid of structured survey questionnaire. The farmer respondents provided the detailed documentation of the socio-demographic profile, institutional support system, farm-related activities and problems, household income, observed farm level evidences of climate change and coping mechanisms employed among others.

The raw data based on the respondents' interview was analyzed in terms of qualitative measures vis-à-vis frequency count and mean values.In terms of climatic type based on the modified coronas classification, Agusan del Sur: under Type II. Type II climate has no dry season with very pronounced wet season of heavy precipitation. Maximum rainfall generally occurs from December to January although there is no single dry month. Its average monthly rainfall is 355 mm. and average temperature is 27.150C. On the other hand, North Cotabato has Climate Type IV having no pronounced wet and dry season.

RESULTS AND DISCUSSION

Demographic characteristics of rubber-based agroforestry smallholder farmers

From the total 623 farmer respondents, majority (n=343; 55.06%) of them were natural residents of the municipality (**Table 1**). In terms of the age of the farmers for the two provinces, farmer respondents are within the middle age of 50 (**Table 2**). According to Zhengfei and *Oude Lansink* (*2006 as cited by Duesberge et al. 2017*) age influences farm productivity. Particularly they elucidated that productivity increases over the lifetime of a farmer

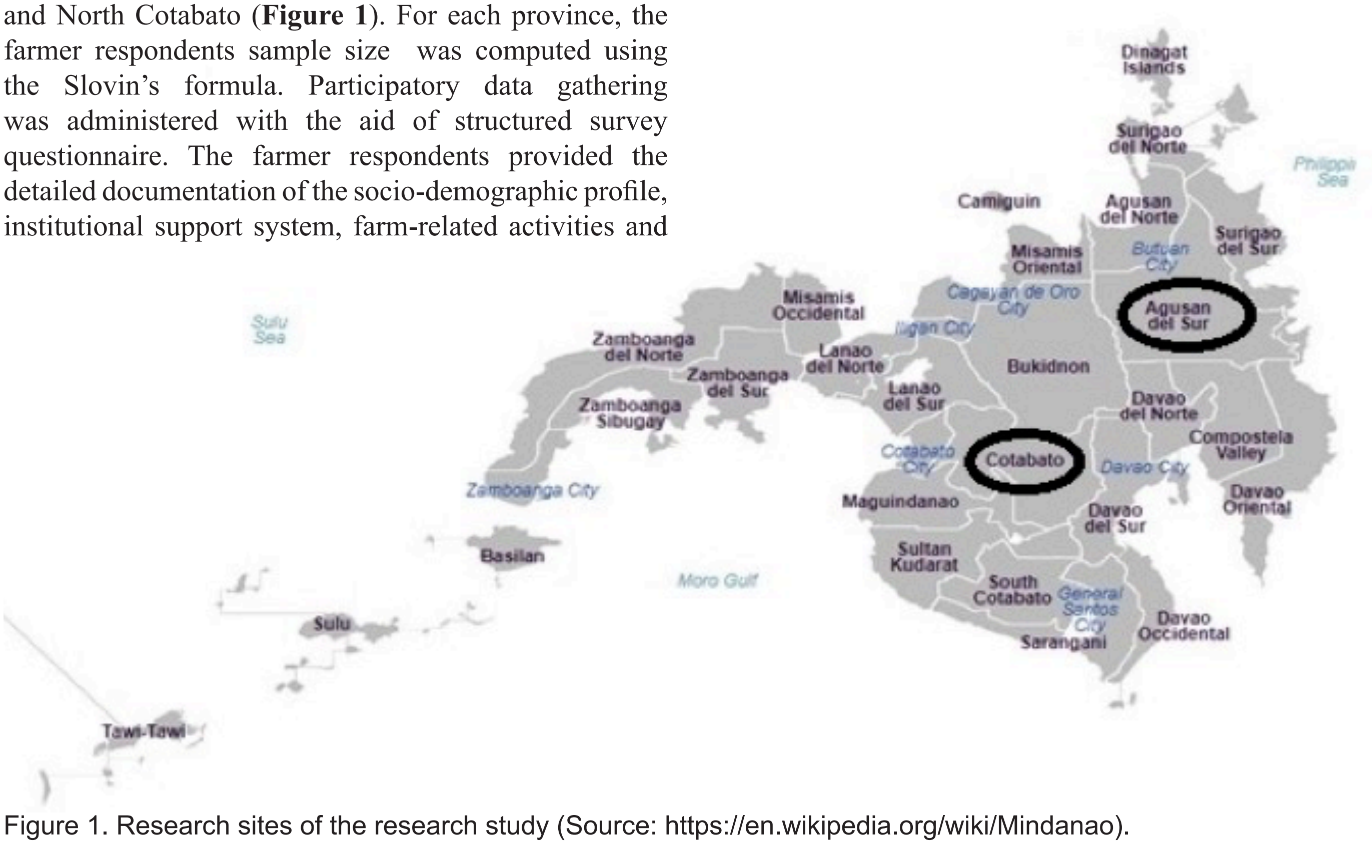

Figure 1. Research sites of the research study (Source: https://en.wikipedia.org/wiki/Mindanao).

Table 1. Summary (count= n) of RBAS farmer respondents from Agusan del Sur and North Cotabato (2014).

Province	Municipality	Number of Respondents	Native in Area (n)	%
Agusan del Sur	Bayugan	112	82	73.21
	La Paz	24	13	54.17
	Prosperidad	73	47	64.38
	San Francisco	51	31	60.78
Subtotal		260	173	65.78
North Cotabato	Kabacan	30	11	36.67
	Kidapawan	156	84	53.85
	Makilala	177	75	42.37
Subtotal		363	170	46.83
TOTAL		623	343	55.06

up until their mid- to late forties and then decreases afterwards. This is in consonance with the findings of *Ajewole* (*2010*) stating that the age and experience of farmers affect their attitudes towards adopting new ideas and practices. Farmers engaged in farming are as young as 19 to 84 years of age and 21 to 87, for Agusan del Sur and North Cotabato, respectively.

Meanwhile, for both provinces, majority of the respondents are male and married farmers. The existence of household provides potential for a successor in continuing the farm enterprise (*Duesberg et al. 2017*) thereby circumventing the retirement farm effect. Fortunately, only a few of them had no formal education and a significant number as well of them have attained high school to undergraduate levels. It is noticeable that majority of the RBAS farmer respondents are elementary graduates with 109 and 185 from Agusan del Sur and North Cotabato, respectively. Moreover, some of them in each of the documentation sites are college graduates (**Table 2**). *Nyantika and Aming* (*2015*) noted in their study that College graduates farmers in Silang, Cavite Philippines had higher tendency to apply pesticides in their pineapple farms. However, fertilization is not influenced by the education attainment.

Varieties of para rubber domesticated in the RBAS of Agusan del Sur and North Cotabato, Philippines

RRIM Series is the dominantly planted variety while our own USM 1 is the least observed planted clone (**Table 2**). *Department of Agriculture* (*2015*) in their publication indicated that USM 1 has a dry rubber yield of 2,498.15 kg ha-1 year-1, which is 18.81% higher than that of the standard RRIM 600 clone from Malaysia. However, the major driving factor according to the farmer respondents is that they are only dependent on the existing planting material from their neighbors or from the supplied variety of the supporting institutions like Department of Agriculture. The performance of the rubber farms heavily relies on the quality of rubber clones (*Gohet et al. 2016; Pethin et al. 2015*). With the advent of our very own clone developed by the University of Southern Mindanao, our farmers can have other options of rubber planting material.

During the interview, some of the farmers also elucidated the information that they prefer the improved clones than seedlings for tapping can be done four years after planting. The trade-off is in the healing of the bark after tapping. Tapped seedlings heal faster than the clones. However, after a year of farmers' interview and exposure of the RBAS farms particularly in Rizal, Agusan del Sur, farmers are changing their minds in preferring the seedlings over the improved rubber clones. Based on their observation, seedlings with their tapering trunk shape can better withstand strong winds during typhoons. The farmer respondents are not always aware of the variety of their planted rubber.

Institutional/organizational aspects of rubber farming

Majority of the farmer respondents including their family members recognized the importance of being a member in organizations (**Table 2**). Majority of the respondents are affiliated with social organizations. Moreover, the entirety of the household members is usually registered as members of the organization. Similarly, rubber farmers were also documented to be dominantly associated with organizational affiliation (*Kromkratoke and Suwanmaneepong 2017*). This could be attributed to the benefits gain in their organizational membership (**Table 2**). This is consonance with the findings of *Alho* (*2015*); *Penunia* (*2011*), indicating membership to organizations or institutions provide social and economic benefits. Indeed, the sense of belongingness is vital in the farming system. Through their membership in the organization/ institution the farmers are able to avail training, loan/ credit, and self-fulfillment, availment of fertilizer, discount on some goods, animal dispersal, insurance,

Table 2. Socio-demographic characteristics, variety of rubber planted and benefits derived (count= n) of RBAS farmer respondents from Agusan del Sur and North Cotabato (2014).

Age, Gender, Civil Status	Agusan Del Sur	North Cotobato	Total	%
Age	**Year**	**Year**		
Age Minimum	19	21		
Age Maximum	84	87		
Age Average	51.5	54		
Gender				
Male	186	285	471	75.6
Female	74	78		
Civil Status				
Single	16	15	31	4.98
Married	215	296	516	82.83
Separated	5	7	12	1.92
Widow/Widower	20	44	64	10.27
Educational Attainment				
No formal education	8	3.08	4	1.10
Elementary graduate	109	41.92	185	50.96
High school graduate	55	21.15	77	21.21
College undergraduate	33	12.69	14	3.86
College graduate	19	7.31	24	6.61
Vocational course	13	5.00	14	3.86
Others	21	8.08	14	3.86
no response	2	0.77	31	8.54
Variety				
PB Series	18	6.92	99	27.27
RRIM Series	173	66.54	179	49.31
USM	1	0.38	2	7.26
GT Series				
RI Series	2	0.77		
Unidentified	66	25.38	83	22.87
Household Member				
Respondent	181	69.62	195	53.72
Spouse	120	46.15	104	28.65
Children	14	5.38	6	1.65
Benefits				
Training	97	37.31	93	25.62
Loan/credit	42	16.15	72	19.83
Self fulfillment	113	43.46	121	33.33
Availment of fertilizer	30	11.54	84	23.14
Discount on some goods	1	0.38	30	8.26
Animal dispersal	22	8.46	24	6.61
Insurance	14	5.38	11	3.03
Employment	18	6.92	2	0.55
Ensured market outlet	3	1.15	34	9.37

employment and assistance in product marketing. Majority of the farmer respondents from Agusan del Sur and North Cotabato had nonmaterial benefits (i.e. self-fulfillment and training) in joining the organization. Meanwhile, farmer respondents from North Cotabato have the highest count of individuals benefitting marketing assistance of their farm produce through the organization. It is also noteworthy that all farmer respondents had no mention that their membership in the social organizations would lead to agricultural productivity or technical efficiency in their farm operation. This validates the findings of *Addai et al.* (*2014*) and *Andre et al.* (*2010*) proving that membership in farmer based organizations has no current significant influence on technical efficiency and yield. Based on the discussion with the farmer respondents their engagements with the organizations are primarily to facilitate the marketing of their produce for the traders usually transact business with the organization and not on individual basis. Moreover, the technical competence which could have been inculcated among the farmers through trainings is only availed by 37.31% and 25.62% only by farmer respondents by Agusan del Sur and North Cotabato, respectively. Instead, the farmer organizations are widely perceived as institutional response to the different economic needs and social constraints confronted by the farmers such as access to credit (*Fischer and Qaim 2011*). In addition, increased in household income due to membership in organization resulted when the farmers market collectively as indicated by the minority of the respondents in the study sites.

Pests and diseases documentation in rubber-based production system

The pest and diseases observed and accounted by the farmer respondents in RBAS particularly those infesting rubber (**Table 3**). Fortunately Bayugan, Agusan del Sur had no observed pest and diseases. Moreover, farmer respondents from Kabacan, North Cotabato, have no pest occurrence noted. Moreover, termites are the only pest observed by 3.03% of the farmer respondents (n=11). Similarly, only 2.31% of the respondents from Agusan del Sur observed termites in their rubber farms. The number of respondents that accounted pest occurrence is very negligible. Consequently, the pest population as well is not causing significant reduction in latex yield and growth and development inhibition among the planted rubber. Seemingly, their occurrence is not causing to drop the latex production beyond/below the economic threshold level. In relation, the farmer respondents have passive action on the infestation. Moreover, during the conduct of the farmers' interview it is also noticeable that indeed the RBAS farms are robust in growth and development. In view of this, the recorded average annual yield of cuplump (kg ha^{-1} yr^{-1}) of 1,012 and 1,463 from Agusan del Sur and North Cotabato are comparable to the published yield of Department of Agriculture of 800 to 1,200 kg ha^{-1} yr^{-1}. This also reflects the inherent stability of the RBAS in a changing climate system wherein the pest and diseases occurrence is controlled, consequently, resulting stable yield. The pest and disease occurrence is controlled in a RBAS for diversity of the crop components limits the food supply for a particular pest and disease consequently limiting as well their population build up. The gene-for-gene theory by Harold Flor in 1942 could be the argument for this RBAS advantage in terms of controlling pest and diseases. A virulent gene cannot infect a resistant host. Consequently, the diverse crop components could have the enhanced resistance to a potential pest and disease. However, the critical climate factor that could adversely affect yield is the higher rainfall intensity which decreases the tapping days and latex yield (*Sdoodee and Rongsawat 2012*).

Economic benefits derived from rubber-based agroforestry variants

The average farm size of RBAS is categorically on small-scale level (1-5 ha). In fact, the minimum size is even less than a hectare for Agusan del Sur and North Cotabato with 0.06 and 0.22 ha, respectively. Meanwhile, private land is the type of land claim having the highest frequency among the farmer respondents with 160 and 236 from Agusan del Sur and North Cotabato, respectively (**Table 4**).

With regard to the kind of tenurial status of farmer respondents, from among the seven classifications, majority of them is owner/cultivator with 209 and 306 from Agusan del Sur and North Cotabato, respectively (**Table 4**). Having the right over the land shapes its investment scheme (*Goldstein and Udry 2008*) in this paper it is the planting of rubber. The "share tenant" is the second most common type of tenurial status for North Cotabato (n=48).

Monocropping of rubber is dominantly the practiced initial production system (**Table 5**). This is in accordance with the documentation noted by *Ahrends et al.* (*2015*) occurring in the Southeast Asia in terms of rubber plantation development. Similarly, rubber (in pure stand) is the climax species observed dominantly among the farms of the farmer respondents. The intercropping with rubber resulting to diversified farming progressing to the evolution of Rubber-based Agroforestry System (RBAS) is hastened by farmers' recognition to increase productivity particularly of smallhold farmers. This in turn increases the economic performance of the farm particularly when intercropped with fruit trees (*Soomboonsuke et al. 2009*). Moreover, this shift from monocropping of rubber to RBAS is in view of ensuring a sustainable farming practice (*Wigboldus et al. 2017*).

In terms of common RBAS practiced, there are four major typologies observed, namely: fruit trees + rubber; plantation crop + rubber; plantation crop + fruit trees + rubber; agricultural crops + plantation crops + fruit trees + rubber; and plantation crop + agricultural crop with rubber. The intercropping with rubber for the said crop combinations or typology has been

Table 3. Count (n) of RBAS farmer respondents from Agusan del Sur and North Cotabato which had accounted the pest and disease occurrence (2014).

Province	Pest Occurence Accounted by Famer Respondents (Count, N)*								
	Aphids	Termites	Unidentified insects	Birds	Borer	Leaf hopper	Ants	Leaf sucker	
Agusan del Sur									
Bayugan									
La Paz	1	1							
Prosperidad		5	3	1	1	7	1	1	
San Francisco			1						
Total	1	6	4	1	1	7	1	1	
%	0.38	2.31	0.77	0.38	0.38	2.69	0.38	0.38	
North Cotabato									
Kabacan		4							
Kidapawan		7							
Makilala		11							
Total		3.03							
%									
	Disease Occurence Accounted by Famer Respondents (Count, N)*								
	bark disease	fungus	pink disease	root rot	phytopthora	canker	bark necrosis	stem rot	die back
Agusan del Sur									
Bayugan									
La Paz	1	1	2						
Prosperidad			7	12	12	3	1	1	1
San Francisco	8		15						
Total	9		24	12	12	3	1	1	1
%	2.48		6.61	3.31	3.31	8.83	0.28	0.28	0.28
North Cotabato									
Kabacan		4							
Kidapawan		2							
Makilala		5							
Total		11							
%		3.03							

*none numerical entry indicates absence of pest and disease occurrence

Table 4. Type of land claim and tenurial status (count=n) of RBAS farmer respondents from Agusan del Sur and North Cotabato (2014).

	Agusan del Sur		North Cotabato	
	n	%	n	%
Type of land claim				
Ancestral	69	26.54	94	25.90
Public	31	11.92	40	11.02
Private	160	61.54	236	65.01
Tenurial status				
Owner/cultivator	209	80.38	306	84.30
Owner/ non-cultivator	18	6.92	17	4.68
Share tenant	13	5.00	48	13.22
Leaseholder	3	1.15	3	0.83
Amortizing owner	6	2.31	2	0.55
Held under certificate of land	7	2.69	1	0.28
Settler	1	0.38	1	0.28

documented to be functionally productive as well by other researchers (*Devendra 2011; Esekhade et al. 2014; Ogwuche et al. 2012; Premakumar et al. 2015; and Worku 2013*). The combination of the different crops elicited more positive beneficial effects vis-vis diversity in income sources (*Snoeck 2013*), improved soil fertility management and better growth performance of intercrops among others. Moreover, diversification through intercropping in the farm reduces risks and enhances adaptive capacity to disturbances (*Reyes and Feutsh 2016; Otene et al. 2015*).

Taungya agroforestry system can either be the initial production system or the observed recent farming system of the farmer respondents. Moreover, rubber in some of the farmer respondents is just integrated after establishment either of plantation crop or fruit trees or from a monocropping system of agricultural crops. It was

Table 5. Evolution of RBAS and livestock raised by farmer respondents (count=n) from Agusan del Sur and North Cotabato (2014).

	Agusan del Sur				North Cotabato			
	Initial Farming System		Recent Farming System		Initial Farming System		Recent Farming System	
	n	%	n	%	n	%	n	%
Farming system	5	1.92			4	1.10		
Agricultural crops alone without rubber			8	3.08	9	2.48	16	4.41
Agricultural crops with rubber	1	0.38					1	0.28
Agricultural crops + fruit trees without rubber			2	0.77			1	0.28
Agricultural crops + fruit trees + rubber	14	5.38	1	0.38	8	2.20		
Fruit trees alone without rubber	4	1.54	8	3.08	6	1.65	7	1.93
Fruit trees + rubber	145	55.77	80	30.77	185	50.96	127	34.99
Pure rubber	41	15.77			104	28.65		
Plantation crop without rubber	27	10.38	77	29.62	30	8.26	138	38.02
Plantation crop + rubber	3	1.15	38	14.62	6	1.65	54	14.88
Plantation crop + fruit trees with rubber			3	1.15			9	2.48
Agricultural crops + plantation crops + fruit trees with rubber					1	0.28	1	0.28
Plantation + agricultural crop without rubber	1	0.38	28	10.77	3	0.83	10	2.75
Plantation + Agricultural crops + rubber	3	1.15			7	1.93	1	0.28
Plantation + fruit trees without rubber								
	n		%		n		%	
Livestock integration by RBAS								
Yes	125		48.08		254		69.97	
No	97		37.31		90		24.79	
Animals raised								
Carabao (*Bubalus bubalis*)	88		33.85		96		26.45	
Goat (*Capra hircus*)	19		7.31		41		11.29	
Pig/swine (*Sus domesticus*)	102		39.23		93		25.62	
Chicken (*Gallus gallus*)	131		50.38		208		57.30	
Cow (*Bos taurus*)	8		3.08		84		23.14	
Horse (*Equus caballus*)	1		0.38		11		3.03	
Ducks (*Anas luzonica*)	20		7.69		24		6.61	
Fish	7[a]		2.69		15[b]		4.13	
Turkey (*Meleagris gallapavo*)	1		0.38		5		1.38	
Goose (*Anser cygnoides domesticus*)					3		0.83	

[a] Tilapia (*Nilotica* sp) is being cultured by farmer respondents from Agusan del Sur
[b] Nilotica sp, milkfish (*Chanos chanos*) and catfish (*Clarias batrachus*) are being cultured by the farmer respondents from North Cotabato

also observed that usually after the productive lifespan of rubber for tapping purposes, a negligible percentage of the rubber respondents (0.28 to 0.38%, n=1) are harvesting the rubber tree for wood or timber purposes. This provides income still for the household maximizing the utility of rubber (*Penot 2004*). Moreover, this implies the recognition of the farmers on the ecosystem services elicited from the rubber which are not only provisioning but also regulating, supporting and cultural. Rubber being a perennial species continuously provided amelioration of the soil and microclimate. Meanwhile, the cultural value could be entwined with the fact that rubber significantly provided source of livelihood for the farmers' households.

In addition to the RBAS, majority of the farmer respondents in each province are engaged in livestock production (**Table 14**). Among the poultry, chicken is dominantly raised with 131 and 208 among the farmer respondents from Agusan del Sur and North Cotabato, respectively (**Table 15**). Animal integration in the farm is a form of mixed farming which is the backbone of Asian agricultural farming system (*Devendara 2007*).

Agusan del Sur farmer respondents indicated higher value of average annual expenditure for their domestic concerns at Php 119,749.32 as compared to that of the North Cotabato with Php 103,595.64 (**Table 6**). Domestic expenditure includes basic needs for food, education,

Table 6. Average monthly and annual expenditures, sources of income mean annual income per hectare (Philippine peso, PhP)* of RBAS from cuplump of RBAS farmer respondents from Agusan del Sur and North Cotabato (2014).

Expenditure and Income	Agusan del Sur	North Cotabato
Expenditure		
Average Monthly Expenditure, Php (USD)	9.979.11 (235.08)	8,632.97 (203.37)
Average Annual Expenditure, Php (USD)	119, 749.32 (2,820.95)	103,595.64 (2,440.42
Sources of Income		
Farming (Ccrop and Livesotck Component), Php (USD)	48,984.24 (1,153.93)	96,996.32 (2,284.95)
Off-farm, Php (USD)	39,157.22 (922.43)	42,610.33 (1,003.78)
Non-farm, Php (USD)	73,127.67 (1,722.68)	85,516.61 (2,014.53)
TOTAL INCOME (Excluding cuplump), Php (USD)	161,269.13 (3,799.04)	225,123.26 (5,303.26)
Mean Annual Income of RBAS (Rubber + Intercrops)		
Cash Crops	20469.18 (482.20)	
Plantation	5781.2 5 (!36.19)	
Fruit Trees	3084.61 (72.66)	
Subtotal Income of Intercrops Php (USD)	29335.04 (691.05)	72433,60 (1706.33)
% Total Income	18.19	32.17
Annual income ha-1 of RBAS from cuplump, Php (USD)	33,564.30 (790.68)	44,020.12 (1,036.99)
% Total Income	17	16

*Exchange rate in 2013: Php 42.45 = 1 USD (Source: nap.psa.gov.ph/stats/persodollar.asp)

shelter, medical needs, communication expense for mobile cellular cards including financing customary social community events such as feast, birthdays and weddings among others. Fortunately, the said expenditures are adequately covered by the availability of the different sources of income (**Table 6**). The opportunity to engage in diverse livelihood of the farmers' household provided stable and sustained income sources year round vis-à-vis on, non and off-farm livelihood. Furthermore, the diversity of farm components provides resiliency of RBAS amidst environmental disturbance. In view of this, the different sources of income particularly from RBAS agroforestry system (**Table 6**) provided significant economic stability (*Wulan et al. 2006*) even with the occurrence of evidences and influence (**Table 8**) of climate change (*Jongrungrot and Thungwa 2014*) as observed by the farmer respondents. The household income complemented from the RBAS, other farm based component like crops and livestock and off-farm income including the non-farm sources are more than sufficient to provide to the declared average annual expenditures for all the documented farmer respondents in the two provinces. Moreover, the integration of other farm components in the RBAS ensures source of income for the household while waiting for the tapping period of rubber (*Rodrigo et al. 2005*). Intercropping yielded 18.19% and 32.17% share on the farm income for Agusan del Sur and North Cotabato, respectively. On the other hand, the cuplump production significantly contributes/ augments 17.00 and 16.00% for Agusan del Sur and North Cotabato, respectively for the household income (**Table 6**). Hence, RBAS income share to the household income is almost 1/3 and ½ for Agusan del Sur and North Cotabato, respectively.

Meanwhile, there were seven rubber-based typologies documented wherein the cuplump production for North Cotabato is almost doubled (fresh weight of 3,718.00 kg ha^{-1} yr^{-1}; dry weight of 2,230.80 kg ha^{-1} yr^{-1}) when rubbers intercropped with fruit trees (**Table 7**). This finding was in inconsonance with the beneficial effect of intercropping on latex yield (*Devendra 2011; Esekhade et al. 2014; Herath and Takeya 2003; Ogwuche et al. 2012; Premakumar et al. 2015; Siju et al. 2012; and Worku 2013*). The increased latex yield in the rubber-based fruit intercropping is attributable to the fertilization management in this crop combination. Farmers usually provide soil amendment to the fruit trees to ensure the harvest of the high value fruit crops. In relation, the rubber would likewise benefit from this cultural management in terms of increase latex production. Meanwhile, the quiet lower cuplump production in Agusan del Sur could be attributed to the younger age of the planted rubber as compared to the tappable rubber planted in North Cotabato. However, it is notable that cuplump from the RBAS variants can significantly augment household income.

Implications of Climate change to Rubber-Based Production Systems

The understanding/perception of the RBAS farmer

Table 7. Cuplump production(kg ha^{-1} yr^{-1}) and derived income from rubber-based typologies observed in Agusan del sur and North Cotabato as described by the farmer respondents (2014).

Production system	Agusan del Sur			North Cotabato		
	Kg cuplump	Cuplump (PhP)	Cuplump USD)	Kg cuplump	Cuplump (PhP)	Cuplump (USD)
Agricultural crops with rubber	285.02	9,268.95	218.35	596.5	23,199.65	546.52
Fruit trees + rubber	866	28,940.00	681.74	3,718.00	64,755.20	1,525.45
Pure rubber	1,562.18	52,525.36	1,237.35	1,619.81	48,615.07	1,145.23
Plantation crops with rubber	843	28,951.07	682.00	1,440.14	44,702.82	1,053.07
Plantation crops, fruit trees with rubber	509.65	16,001.70	376.95	1,440.58	33,272.84	783.81
Agricultural crops, plantation crops, fruit trees with rubber	357.65	12,517.65	294.88	868.5	30,124.80	709.65
Agricultural crops, plantation crops with rubber	667.54	13,846.56	326.19	772.12	30,741.58	724.18

*Exchange rate in 2013: Php 42.45 = 1 USD (Source: nap.psa.gov.ph/stats/persodollar.asp)

respondents on climate change and their account of its influence on the production system (**Table 8**) were generated based on their personal exposure and experiential encounter with these phenomena (*Thomas et al. 2007*). This is founded on the so-called psychological distance theory which is basically egocentric denoting the "self, here and now" including the different ways in which an object might be removed from that point- in time, space, social distance and hypotheticality (*Trope and Liberman 2010*).

Among the farmer respondents for both provinces, drought (El Niño), typhoon, strong winds and heavy rains/excessive rainfall are among the common understanding of climate change. Majority of the farmer respondents from Agusan del Sur and North Cotabato relates typhoon occurrence (92.69%) and drought/el niño (62.26%), respectively to climate change. In fact, farmer respondents from Agusan del Sur even identified the most recent super typhoon they had experienced causing significant devastation. These were Super Typhoon Pablo (international name: Bopha) and Typhoon Sendong (international name: Washi) in December 07, 2012 and December 15, 2011, respectively. Meanwhile, farmer respondents from Agusan del Sur and North Cotabato pinpointed heavy rains/excessive rainfall results to flashfloods/flooding (**Table 8**). The vulnerability of Philippines to typhoons, tropical storms, floods and landslides from 1995 to 2014 had also been reported inthe climate risk index to have ranked 4th among the ten countries adversely affected by climate change (*Kreft et al. 2015; Lasco et al. 2011*). Moreover, the increasing power of wind speed (strong winds) noted by the farmer respondents is consistent with the findings of *Rozynsky et al.* (*2009*). On the other hand, RBAS being on rainfed areas is prone to drier season like drought as indicated by a significant number of respondents from North Cotabato (62.26%).

Farmer respondents attribute the observed climate change in the resulting influence in their production system (**Table 8**). The farm level evidences are translated to the morphological and physiological observation on the domesticated crops in the RBAS. Majority of the farmer respondents observed the influence of climate change specifically as declining yield (*Aydinalp and Cresser 2008; Esteve et al. 2015; Lasco et al. 2011; Mesike and Esekdae 2014*), stunted growth (*Siwar et al. 2013*), aborted flowering, aborted fruiting (*Hatfield and Prueger 2015; Zinn, Tune-Ozdemir, and Harper 2010*), occurrence of pest and disease (*Dinesh et al. 2015; FAO 2008; Sharma and Pande 2013; Palikhe 2007*), wilting (*Barlett et al. 2016*) and increased dosage of farm inputs (*Kumar et al. 2011*). Similarly, these were observed by the farmer respondents from Agusan del Sur together with damage and uprooting of crops. In addition, farmer respondents from North Cotabato had observed increased wintering of rubber in the advent of climate change but some crops grew faster. However, this observation of the faster crop growth amidst farm level evidences of climate change is contradictory to the studies of *Hatfield and Prueger* (2015) and *Mall et al.* (*2017*). This could be attributed to the adaptation strategies employed by the farmer respondents such as enhancing the soil fertility through use of organic practices, sanitation. Contributory to the declining yield particularly of the rubber latex are the adverse effects of aborted flowering and fruiting, plant wilting and occurrence of pest and diseases. In view of these, increased dosage of fertilization and pesticide application are resorted by farmers.

Perceptions and observed adverse effects of climate change on the RBAS prompted the farmer respondents to implement adaptation strategies as their coping mechanism (**Figures 2** and **3**). The behavioral response to mitigate or adapt to the adverse impacts of climate change has been documented in a number of studies

Table 8. Understanding/perceptions of climate change and its impacts on RBAS as observed by the farmer respondents from Agusan del Sur and North Cotabato (2014).

	Agusan del Sur		North Cotabato	
	n	%	n	%
Farm level evidences of climate change*				
Drought/el niño	28	10.77	226	62.26
Floods/flashfloods	17	6.54	28	7.71
Typhoon	241	92.69	17	4.68
Strong winds	1	0.38	44	12.12
Heavy rains/ excessive rainfall	18	6.92	82	22.59
Earthquake	1	0.38		
Landslides			1	0.28
Impacts of climate change on RBAS*				
Declining yield	213	81.92	188	51.79
Stunted growth	101	38.85	128	35.26
Aborted flowering	67	25.77	60	16.53
Aborted fruiting	64	24.62	58	15.98
Occurrence of pest and diseases	11	4.23	32	8.82
Wilting	7	2.69	49	13.50
Increase dosage of farm inputs	2	0.77	9	2.48
Damaged crops	41	15.77		
Uprooted	3	1.15		
Damaged branches	2	0.77	11	3.03
Breaking/falling down of trees			13	3.58
Increased Wintering			3	0.83
Crops died			6	1.65
Fast growth			10	2.75

*Based on multiple answers of farmer-respondents

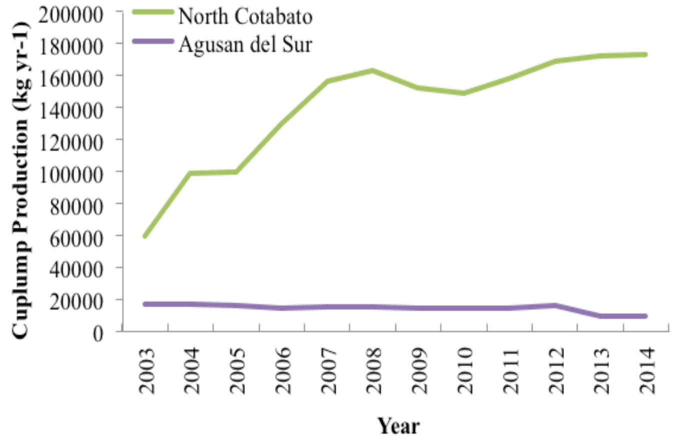

Figure 2. Cuplump production (kg yr^{-1}) in Agusan del Sur and North Cotabato. (PSA website 2015).

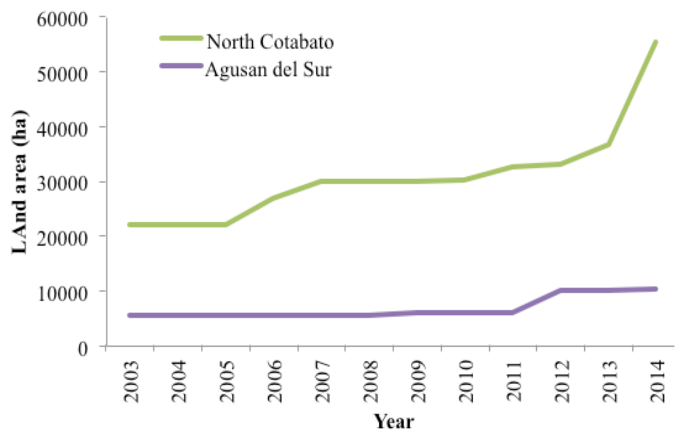

Figure 3. Land area harvested for cuplump production in Agusan del Sur and North Cotabato. (PSA website 2015).

preceding awareness and perception of the changing climate and its impact (*Li, Ting, and Rasaily 2010; Mercado 2016; Niles and Mueller 2016*). These action responses to adapt may be influenced by the magnitude of variability, frequency of event occurrence and rate of change within climate systems (*Hulme 2003*).

To minimize the losses due to climate change, farmers have six approaches of coping mechanisms employed for Agusan and North Cotabato, to wit, production system, soil and water conservation measures, tapping schedule, kind of inputs, culturalmanagement and seeking technical assistance (**Table 9**). Sustainable production schemes are employed through diversification, intercropping and agroforestry, planting of trees such as rubber including contour farming as a major climate change adaptation strategy by farmers from Agusan del Sur (39.99%) and North Cotabato (22.87%). These adaptation strategies coincided with the documented coping mechanisms of agroforestry and trees on farms by a number of studies as well (*Devendra 2012; IFOAM 2009; Brahma et al. 2016*). The woody perennials increase carbon sequestration making it as effective coping strategy to climate change (*Agostini et al. 2015; Rajab et al. 2016*). In fact, majority of the farmer respondents from North Cotabato (19.33%) recognized tree planting in the farm as a coping mechanism to climate change.

Similarly, farmer respondents form both provinces recognized mulching as an effective soil and water conservation measure contributory to adapting to climate change. This could be attributable to the beneficial effect of mulching of decreasing soil and nutrient losses. Moreover, it significantly contributes to increase infiltration rate and lower soil temperature consequently reducing evaporation (*Lalljee 2013*). In terms of the kinds of inputs as a coping strategy to climate change. farmer respondents from Agusan del Sur minimized the

Table 9. Adaptation strategies to climate change implemented by farmer-respondents from Agusan del Sur and North Cotabato.

Adaptation Strategy	Frequency Count (n)	Percentage (%)	
Agusan del Sur			39.99
I. Production System	2	0.76	
adoption of organic farming	18	6.92	
agroforestry or multiple cropping	2	0.77	
contour farming	2	0.77	
crop rotation	4	1.53	
diversified farming system/intercropping	1	0.38	
planting of banana between rubber trees	17	6.54	
utilized/maximized use of the area with plantation crops	1	0.38	
planting of rubber	55	21.15	
planting of trees/reforestation	1	0.38	
planting of vegetables	1	0.38	
replacing the old rubber trees by other crops			14.61
II. Soil and Water Conservation Measures	37	14.23	
applying natural technologies like mulching cover crops and letting shrubs/ small trees, grasses and sedges grow under plantation	1	0.38	
manage water to support the crop			6.92
III. Tapping Schedule	16	6.15	
alternate tapping	1	0.38	
double tapping during good weather	1	0.38	
early morning harvesting			3.46
IV. Kind of Inputs	1	0.38	
application of fertilizer	2	0.77	
applied herbicides	2	0.77	
avoid spraying of herbicides/pesticides	3	1.15	
minimize usage of chemicals	1	0.38	
zero application of herbicide and chemicals pesticide			
V. Technical Assistance	1	0.38	3.85
consult to PCA			
attend training and seminar (organic farming, compost, farming technique, climate change)	9	3.46	13.46
VI. Cultural Management/Practices	4	1.54	
no burning	12	4.62	
avoid burning (grasses, trees, cellophane, garbage)	9	3.46	
not engaged in kaingin/no cutting of trees	3	1.15	
plant crops that can easily adopt to the changing environment	7	2.69	
weeding/slashing			
North Cotobato			
I. Production Scheme			22.87
planting of drought tolerant varieties	1	0.28	
planting of high yielding varieties	2	0.55	
planting of trees/continous planting	72	19.83	
utilized/maximized the vacant area	8	2.20	
II. Soil and Water Conservation Measures			4.96
mulching	18	4.96	
III. Tapping Schedule			0.83
interval tapping	1	0.28	
no tapping during rainy season	2	0.55	
IV. Kind of Inputs			1.65
application of fertilizer	1	0.28	
application of organic fertilizer	4	1.10	
avoid using of chemicals (insecticides,pesticides,herbicides)	1	0.28	
V. Technical Assistance			1.38
attend trainings and seminars	5	1.38	

Table 9. Adaptation strategies to climate change implemented by farmer-respondents from Agusan del Sur and North Cotabato (cont.)

Adaptation Strategy	Frequency Count (n)	Percentage (%)	
VI. Cultural Management/Practices			
adjustment on practices	1	0.28	4.13
zero burning	7	1.93	
regular weeding	3	0.83	
sanitation	3	0.83	
follow proper cultural management practices	1	0.28	

usage of inorganic fertilizer and chemical pesticides while some of the farmer respondents in North Cotabato employed organic farming practices. *IFOAM* (*2009*) also recorded the potential of organic farming practices as an effective approach to adapt to climate change. Sanitation and change in the tapping frequency are practiced by the farmer respondents both for Agusan del Sur and North Cotabato. The modification in the tapping frequency wasin terms of refraining from tapping during onset of high rainfall intensity, Such suspension of tapping activities were also reported by *Zaw et al.* (*2017*) in view of high rainfall intensity. On the other hand, during favorable weather conditions farmers in Agusan del Sur maximize the opportunity by increasing frequency of tapping within the day (double tapping) or conducting it early in the morning. North Cotabato farmer respondents solely recognized the used drought tolerant varieties in their planting scheme. *Liu et al.* (*2013*) likewise noted such adaptive mechanism among farmers in East China.

Nonetheless, even with the farm level evidences of climate change accounted by the farmer respondents, the cuplump production for North Cotabato is continuously increasing generally from 2003 to 2014 (**Figure 2**). Meanwhile, for Agusan del Sur cuplump yield production is stable for the said period. It is also notable that the planted area for Agusan del Sur had slight area expansion (**Figure 3**) by not yet translated to increased yield of cuplump for it is not yet tappable.

CONCLUSION AND RECOMMENDATIONS

The farms cultivated for RBAS are dominantly classified as small-scale with an average of 1 to 5 ha. Majority of the farmer-respondents are owner/cultivator. Dominantly planted rubber clone is RRIM Series. Resiliency of the RBAS to climate change is being established evidently in Agusan del Sur and North Cotabato. The pest and diseases occurrence as testified by the farmers are very minimal not enough to cause significant economic loss. In fact, the famer respondents from Agusan del Sur have the highest value of average annual expenditure for their domestic concerns at PhP 119,749.32 while that from North Cotabato is PhP 103,595. Accordingly, the said expenditures are adequately covered by the availability of the different sources of household incomes. Moreover, the challenges of climate change is adequately buffered by the RBAS through the adaptation strategies documented on the farmers field which the farmers' themselves adopt to cope with the changing climate.

Based on the results of the documentation research it proved the potential of the rubber-based agroforestry system to evolve as a resilient farming practice to adapt to climate change vis-à-vis stable productivity both biological and economic, controlled occurrence of pest and diseases and minimized detrimental effects of climate change on the agroforestry farm component as a whole.

Meanwhile, the non-productive aged rubber trees indeed are logically harvested for its timber. It should be replaced or replanted using our very own developed USM 1 to diversify the planted variety and recorded higher latex yield.

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