Participatory Assessment of Bamboo Resources in Sre Thom and Chiklob CPAs and Sre Huy CCF, Mondulkiri Province

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Summary

A bamboo resource inventory was conducted in Srae Huy Community Conservation Forest (CCF), Srae thom Community Protected Area (CPA) and Chiklob CPA in Mondulkiri Province to identify potential commercial species, assess abundance, identify the annual regeneration rate and annual allowable harvest. This study was to support sustainable harvest of bamboo for livelihood enhancement of the project "Cambodia Supporting Forests and Biodiversity.

A four day training workshop was organized to train community members on bamboo inventory methodology. Output of the training include inventory plan, identification of the study areas, selection the inventory team, identification of the sample plot size and development of data sheets for recording inventory results. Two forms of datasheet were developed – one for recording bamboo density and another for bamboo size. Nine out of the 18 identified bamboo groves along streams within and adjacent the three CPAs and CCFs were selected for inventory using a 50m x 50m sample plots.

A total of 698 hectares of bamboo forests was found in the three study sites – 112 hectares in Srae Huy, 336 hectares in Chiklob and 250 hectares in Srae thom. 125 sample sites were inventoried totaling to 12.5 hectares or 1.79% of the total bamboo area. Four species, namely: Russey Roleak, Russey Prey/Rosorb, Russey Khley and Russey Tronung Moin were identified as potential for commercial use. Russey Roleak and Russey Prey are potential for a variety of products ranging from household utensils to valuable products like paper, pulp and ply wood, whereas Russey Tronung Moin and Russey Khley are good for furniture frame and supportive materials, for instances roof batten, hoe and broom handle, cloth bar and black pepper rail. See table below for population status of these species in the inventory sites.

Species	No. Clumps	No. Culms					Shoots	Total No. Culms
		Dead	Old (5-6 years)	Adult 2-4 years)	Juvenile (1-2 years)	Young (>1 year)		
Russey Roleak	83,726	1,016,878	645,267	550,213	487,614	336,566	140	3,051,716
Russey Prey/ Rosorb	24,108	325,884	197,795	220,256	186,997	173,833	1667	1,369,339
Russey Khley	4,727	48,817	44,940	37,285	31,354	24,410	0	200,853
Russey Tronung Moin	1,629	140,640	13,486	8,781	7,880	7,646	0	54,208
Total	**114,190**	**1,532,219**	**901,488**	**816,535**	**7,880**	**542,455**	**1807**	**4,676,116**

The study showed that there were 4,350 culms/ha of Russey Roleak, 1,585 culms/ha of Russey Prey/Rosorb, 268 culms/ha of Russey Khley and 74 culms/ha of Russey Tronung Moin. This represents fairly high bamboo density in the study area, but the level of harvest for utilization is just about 0.5% of the entire population, which is very low due to absence of bamboo commercialization, and most of bamboos are collected for household uses only.

The harvest schedule for adult culms can be broken down in two phases -– the first phase is the first and second year harvest planning, and second phase is the third and following year harvest planning. The first phase harvest planning can be made based on the availability of the current population. Russey Roleak and Russey Prey/Rosorb have similarity in terms of thickness of culm wall, size and utilization, so the two species can be grouped together in computing the annual allowable harvest volume.

The current population of Russey Roleak and Russey Prey/Rosorb is 737,209 adult culms, and 707,624 juvenile culms; Russey Khley have 37,285 adult culms, and 31,354 juvenile culms, and Russey Tronung Moin have 8,781 adult culms, and 7,884 juvenile culms.

In average, based on analysis of culm regeneration of a clump within 6 years, each bamboo clump of the four species has a capacity to produce 4-6 new culms annually. So, the annual culm regeneration of the entire study area is 339,140 culms of Russey Roleak; 132,860 culms of Russey Prey; 6,675 culms of Russey Tronung Moin, and 23,963 culms of Russey Khley. Hence, the annual allowable harvest of this second phase for each species can be projected using this annual regeneration rate. If care of bamboos is sufficiently undertaken, the level of harvest can be higher by 50% or more than the current projection.

Annual harvest of juvenile culms can be implemented at level of its regeneration rate (4-5 culms annually). Bamboo culms should be cut at ground level to allow growing of healthy bamboo shoots and culms. Bamboo harvest should be carried out in November to April to avoid destroying the bamboo shoots and young culms.

1. Introduction

The four–year project entitled ‘Cambodia Supporting Forests and Biodiversity (SFB)’ is a joint initiative of Winrock International, WWF Cambodia, East-West Management Institute (EWMI), Wildlife Conservation Society (WCS) and the Center for People and Forests (RECOFTC), in partnership with the Forestry Administration (FA) of the Ministry of Agriculture, Forestry and Fisheries (MAFF) and the Ministry of Environment (MoE). The project emphasizes community participation and building capacities of local communities and government officials at national and sub–national level to effectively manage the country’s natural resources. The project aims to improve conservation and governance of the Eastern Plains Landscape (EPL) and Prey Lang Landscape (PLL) to address climate change and conserve biodiversity.

The SFB project is composed of three objectives and objective three focuses on the increase of equitable economic benefits from the sustainable forest management. The objective three works on improvement of income from four identified value chains: ecotourism, NTFPs, agro-biodiversity, and timber. In the EPL, bamboo was considered as a potential NTFP product for enterprise development.

Bamboo resources are considerable in the landscape but currently of limited commercial value to the local communities. Therefore, bamboo forests are being cleared for agriculture purposes every year, which contributing to soil erosion. Bamboo enterprise will help address deforestation and enhance rural livelihoods through value addition to bamboo products and access to markets and if managed properly will not only enhance livelihood but also help mitigate climate change through carbon sequestration and contribute to habitat and wildlife protection in the EPL.

Winrock International recommended that an innovative pro-poor bamboo approach would help address biodiversity conservation and poverty alleviation in Vietnam, Cambodia, Laos and the Greater Mekong Sub-region (GMS). In order for sustainable bamboo management, bamboo resource inventory is needed to assess its current population and estimate annual harvest volume in subsequent years. This inventory aims to:

- Determine commercial species of bamboo for trade (as a raw product and post production potential);
- Estimate density of species specific bamboos and their potential use within the identified pilot CPAs and CCF sites - Sre Thom CPA, Chikob CPA, and Sre Huy CCF;
- Estimate the volume of annual bamboo growth of different species per pilot site, and
- Estimate the approximate volume of bamboo for annual extraction under the scenarios as indicated in the objectives

2. Methodology and Materials

Prior to the bamboo resource inventory, selected community were given a 4-day training workshop in Koh Nhek district to provide them knowledge of the bamboo structure and ecology, to identify bamboo areas and associated information, organize resource inventory team, and develop inventory plan.

Based on the input of community members, the bamboo areas were identified and the areas were calculated by estimating the stream distances and distances of bamboos from the stream banks. For bamboo areas that are 10 hectares or more sampling intensity was 5% based on bamboo abundance. A 50m x 20m (1000m^2) sample plot was used to ensure bamboo clumps were fully covered in each sample plot. Since bamboos were mainly confined along the streams, with a few growing farm from the stream, the longer side (50m) of the plot is laid parallel the stream, whereas shorter side (20m) of the plot is laid perpendicular to the stream.

The plot interval was 470 meters based on calculation of plot number and length of the streams. For example, in Cho Chork stream in Sre Huy village, the stream was about 8km (or 8000m) and 17 sampling plots were set up.

The datasheet for recording bamboo resources was divided into two main sections: one on general information of the plot and the other on bamboo data. The table of bamboo data was designed to record thorough information of clump number, bamboo species, clump circumference, bamboo shoot, young stem (to 1 year old), juveniles (1-2 year old), adults (2-4 year old), old stems (5-6 year old), dead stem, cut stem and additional note if any. This designed was to provide complete information on ages of bamboo different uses. For the abundance, it is classified into three following levels:

- No 3 represents abundant, which means intervals between bamboo clumps are close together and there are usually many culms per clump.
- No 2 represents moderate, which means bamboos occur a bit far apart from one clump to another.
- No 1 represents few, which means bamboos mainly grow along the stream and long intervals between clumps

Materials and equipment used: machete, GPS, measuring tapes (50 meters, 10 meters, 5 meters), datasheet and folder and pen.

Information on bamboo property such as size of the culm, culm thickness, internodes and length of bamboo pole were also recorded as these information were useful in identifying the uses of bamboo at different ages.

3. Team composition

- Srae Thom: 9 people; led by Mr. Yin Chen, WWF Field Facilitator;
- Chi Klob: 9 people led by Mr. Yin Chen, WWF Field Facilitator.
- Sre Huy: 9 people led by Yun Sameth, WWF Field Facilitator.

4. Study Area

Due to limited time, the bamboo resource inventory was conducted only inside the CCF and CPA. Only 9 out of the 18 identified bamboo areas, with approximate size of 698 hectares were inventoried. See table 1 for the sizes of bamboo areas and number of plots.

Table 1: Bamboo locations and sizes in the study sites

CPA/CCF sites	Size of bamboo areas	Specific location and sizes	Plots
Chi Klob CPA	336 ha.	O Cheung Chry: 14 ha O Kralorm: 32 ha Metul Thom: 50 ha O Rohort Thom: 240 ha	Total: 44 O Cheung Chry: 2 O Kralorm: 9 Metul Thom: 17 O Rohort Thom:16
Sre Thom CPA	250 ha.	O Chba: 160 ha O Kachass: 90 ha.	Total: 31 O Chba: 24 O Kachass: 7
Sre Huy CCF:	112 ha.	O Chimeat: 54 ha, O Cho Chork: 34 ha, O Ngovlav: 24 ha	Total: 50 O Chimeat: 21, O Cho Chork: 17 O Ngovlav: 12

5. Results

6.1 Bamboo Taxonomy and Ecology

Ecologically, the four species found growing in the study site are deciduous, which regularly shed their leaves during the dry season (December to April). The four species usually grow together close to the permanent and seasonal streams. *Bambusa bambos* was the most dominant species. They mainly grow along the streams and extend to about 20-40 meters from the stream bank, but sometimes grow in colony along low lying areas where there is interface between small and large streams. These species are sympodial in nature where rhizomes produce new shoots through buds and keep outwardly expanding. The bamboo shoots are edible, and thus collected for household uses by all community members. It was reported that bamboo shoots of *Thyrsostachys* spp. is more delicious than *Bambusa* spp. (Plant Resource of South-East Asia No 7: 1995). Individual stems become old and die after 6 years, and the whole clumps may produce flowers and fruits in 60 years and die afterwards. As a result, bamboos create a large biomass which can easily cause massive forest fires during the dry season. According to field observation, dead bamboo may decay in 5 to 6 years and provide good fertilizer to the soil. Since bamboo is a clump species where young shoots grow annually from the rhizomes, it is considered a quick renewable resources and good potential for sustainable enterprise.

Russey Roleak

The four species belong to two genera – *Bambusa* spp. and *Thyrsostachys* spp. Bamboo, unlike rattan, have poorly been researched and documented, it was not possible to identify the scientific names of the species found in the study sites. The book "Plants used in Cambodia" is not reliable as most have invalid and wrong names of bamboo species. Therefore, this bamboo resource inventory report mainly relied on vernacular names. The four bamboo species are briefly described as follows:

Vernacular name: Russey Roleak
Scientific name: *Bambusa bambos* (l.) Voss
Synonym: *Bambusa spinosa* Roxb., *Bambusa arundianacea* (Retzius) Willd, *Arundo bambos* L.

Description: It is densely tufted bamboos, with average clump diameter of around 4.15 meters. The clump forms thickest at the ground to around 3 meters due to densely spin-like branch development at nodes of the bamboo poles. In average, a bamboo clump is, excluding dead and cut bamboos, composed of 16 poles. The nodes are slightly swollen, and the lower parts usually have aerial roots. The pole is around 20 meter high, up to 10 cm diameters; internodes are variable from very short at the lower part to very long at the middle part; the average ranges of internodes at the middle part are around 30-35 cm. Culm wall is almost solid at the base and gradually thicken to the top; the culm wall thickness at the middle part is around 2-3 centimeter. Culm sheath has moderate brown hair when young and become glabrous when old. This species is very common along lowland stream banks running through deciduous forest throughout the country, and usually confused with Russey Prey/Rosorb because of their identical characters.

Uses: The culms of this species are split into strips for different purposes like house wall and floor, furniture, foundation of light concrete and other products like meat skewers, incense handles and chop stick. It is also used as scaffolding for high building construction.

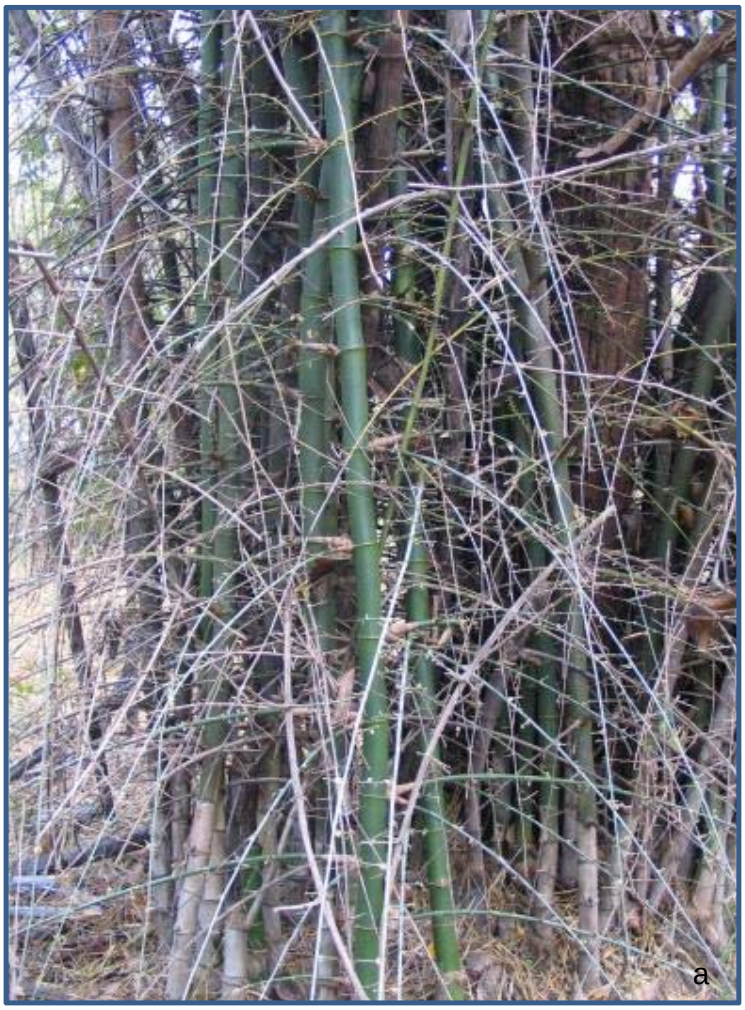


Figure: a) clump of Russey Roleak with thicket spine-like branches at the ground to about 3 meter height; b) Young sheath with absence of hairy; c) mature cum sheath with two auricles.

Russey Prey/Russey Rosorb

Vernacular name: Russey Prey, Russey Rororb in Phnong language
Scientific name: *Bambusa* sp.
Synonym: N/A

Russey Prey/Rosorp is included in the species *Bambusa bambos* by many botanists due to many identical characters. However, this species is distinguished with Russey Roleak by local community or para taxonomists by certain key characters including larger culm and clumps, thick cuticle on young culms, poor culm wall and is easily attacked by insects when young, because of high carbohydrate content, and firmly dense black hair on the back side of the culm sheath. This species is not as common as Russey Roleak in the study sites. An average, excluding dead and cut stem, the clump of this species contains around 32 poles.

The use of this species is the same as Russey Roleak. However, juvenile culms of 1-2 years may still contain weak lignin and high carbohydrate which is preferred by insect. The four to five year old culms are good for being utilized.

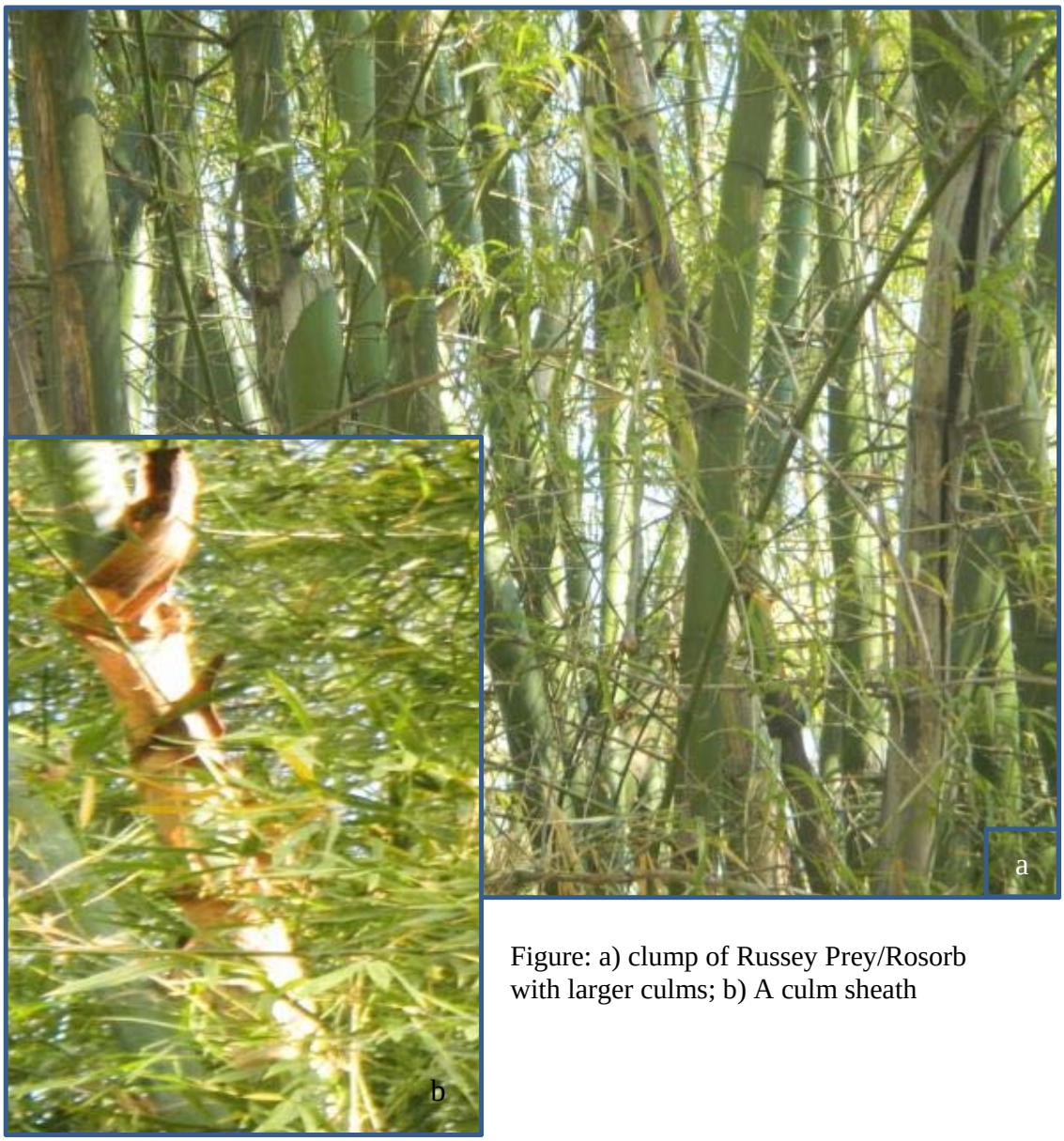


Figure: a) clump of Russey Prey/Rosorb with larger culms; b) A culm sheath

Russey Tronung Moin

Vernacular name: Russey Tronung Moin
Scientific name: *Thyrsostachys* sp.
Synonym: N/A

Description: Russey Tronung Moin is a moderately dense tufted species, and the clump is in average around 1 meter diameter. This species has no spine. Each clump has an average of 41 stems. Culm is erect, with internodes ranging from around 20 cm at base to 30 cm at middle part, 8-10 meters in height and 3-4 centimeters in diameters. The culm wall has small holes and solid at the base. Culm sheath has sparse hair on the back and gradually shed as it ages; the old culm sheath is glabrous. The leave sheath has tiny short hairy auricles, and hairy margin.

Use: Due to its thick culm wall with a very small hole and straight pole, this species is very good for furniture frames and supportive materials of house construction. This species could be potential as ornamental plants.

Figure: a) Habit of Russey Tronung Moin; b) mature culm sheath with absence of hair at the back side, and straight culm, the the major characters being distinguished from Russey Khley; c) thickness of culm wall.

Vernacular name: Russey Khley
Scientific name: *Thyrsostachys* sp.
Synonym: N/A

Description: Russey Khley is identical to Russey Tronung Moin in terms of general characters. However, it can be distinguished by a number of key characters such as smaller clump, smaller stems, shorter internodes at the middle section, somewhat zigzag internodes, vertical strip line on stems in white color, densely black hairy patch at base of the back side of the culm sheath, and curve auricles. The clump of this species is in average about 1.2 meter diameters, composed of around 26 poles.

Use: The uses of this species are similar to Russey Tronung Moin, but its zigzag internodes might be a case that not many people prefer to use for furniture. Its culms are currently used as supporters of black pepper plantation. With smaller clump, white strip in the culm and zigzag internodes, this species might be potential as ornamental plants.

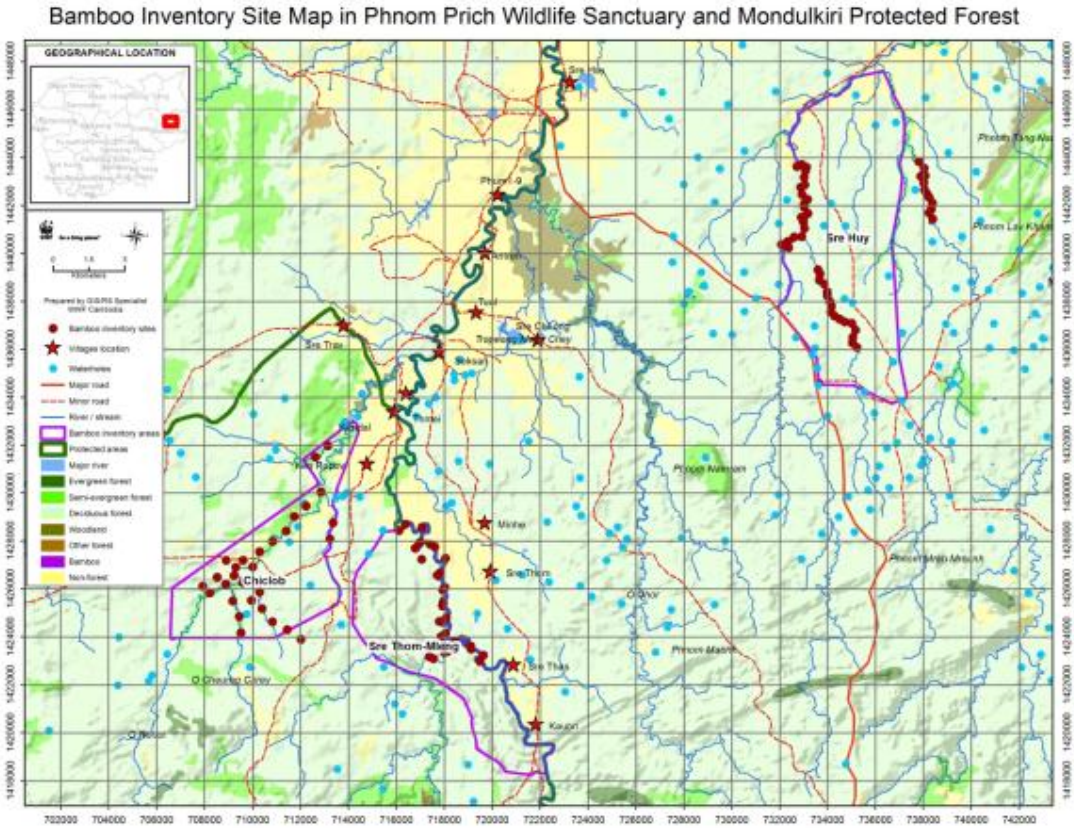
Figures: a) Internodes with culm sheath and vertical line in white color; b) Mature culm sheath with densely hair at the back side, and young culm with short hairy.

6.2 Location of bamboo resources

The four species inhabit only streams banks and low lying areas, but Russey Prey/Rosorb seems to prefer larger and permanent streams, for instance along O Chba and Tonle Sre Pok. Bamboo areas were measured based on the stream distances and the average cross section of bamboo clumps on the stream banks. Bamboo abundance was also qualitatively assess to provide an overall view of the population. There were 18 bamboo areas with total area of 832.5 hectares across the three villages, of which 4 areas (116 hectare) fall outside the CPAs/CCF. Bamboo resources located outside CCF and CPAs were also recorded to prioritize the resource assessment for harvest and management. Distances from villages to the areas and means of transportation were highlighted as important factor in planning harvest throughout the year. The following abbreviations were used in describing the bamboo habitats. DDF denotes Deciduous Dipterocarp Forest;

- SEF denotes Semi-Evergreen Forest, and
- BG denotes Bamboo Grove or bamboo forest.

Map 1: Locations of bamboo resources within and adjacent to the three CCA/CPAs



The followings are bamboo locations by CCF/CPAs:

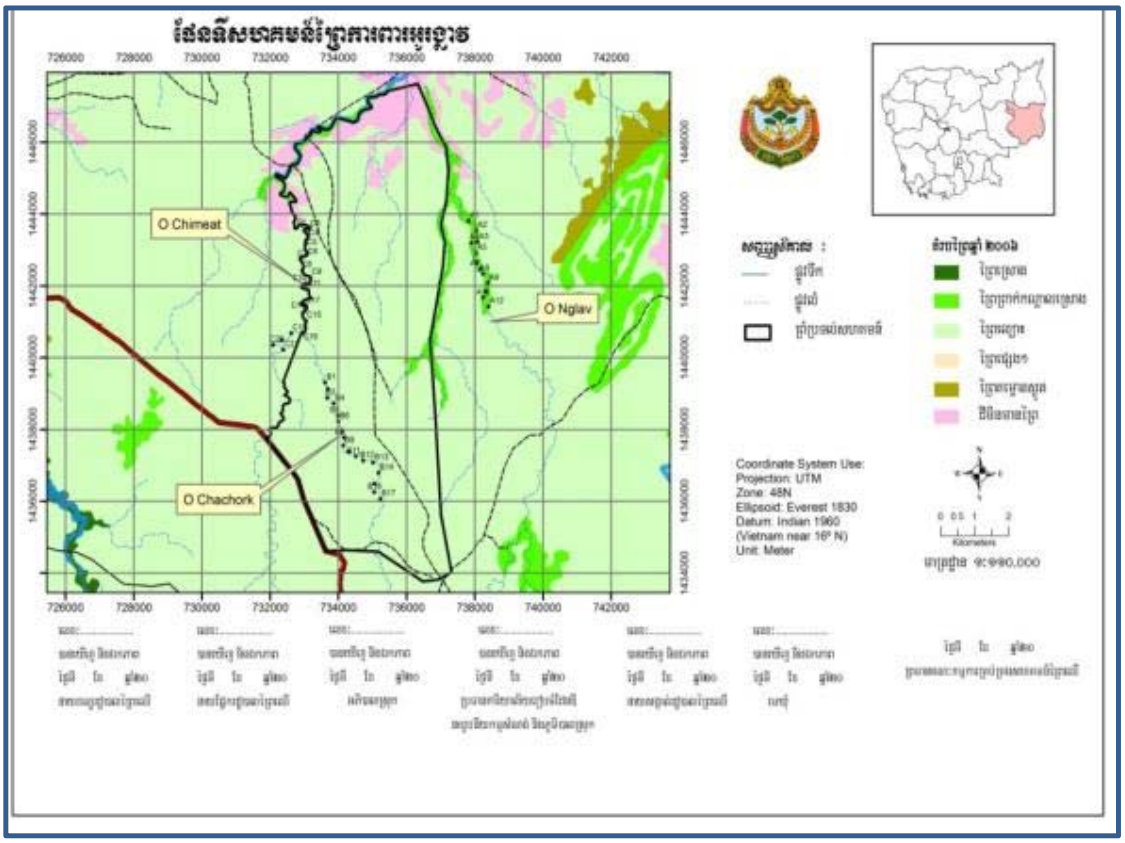
- **Sre Huy CCF**

Bamboos were reported to be present along a number of streams such as O Chimeat, O Cho Chork, O Ngolav and O Sach. In 2013, all bamboos along O Sach produced flowers and fruits, and died afterwards. Bamboo area of the entire CCF was 112 hectares. Sre Huy CCF is located along the main road and is easily accessible all year round.

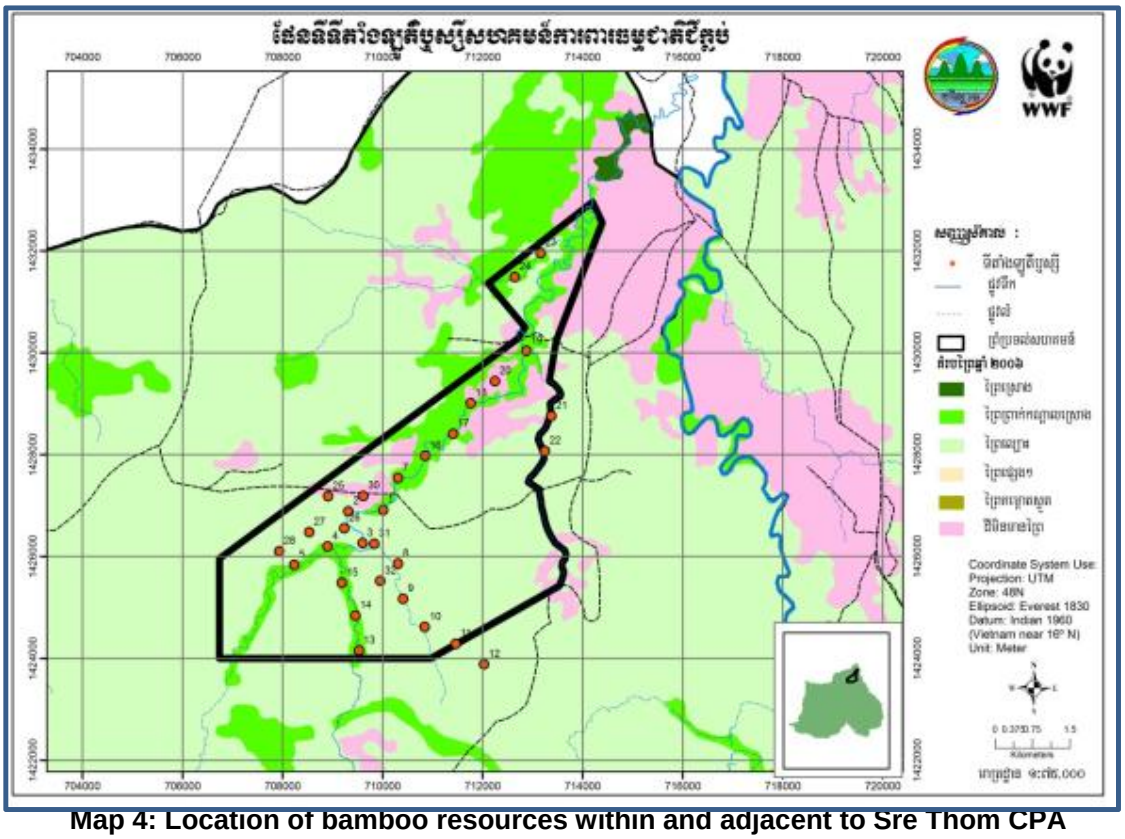
Table 2 Forest type and bamboo abundance

Study Site	Village/ Specific Location	Length of streams	Width on both stream banks	Size	Abundance	In/out CCF/CPA	Distance from village	Mean of transport	Forest type
Srae Huy	Srae Huy O Chimeat	15 km	72 m	54 ha	Abundant	Within CF	18km	Motorbike	DDF
	Srae Huy O Cho Chork	8 km	80 m	34 ha	Abundant	Within CF	25km	Motorbike	DDF
	Srae Huy O Ngolav	6 km	80 m	24 ha	Abundant	Within CF	25km	Motorbike	DDF
	Srae Huy O Sach	10 km	30 m	30 ha	Moderate	Within CF	25km	Motorbike	DDF
Sub Total				112 ha					
Srae Thom	O Kralorm flows to O Rohort	40 km	80 m	32 ha	Abundant	Outside CPA	2.5km	On Foot	BG
	O Chraiv, flow to O Rohort	5.5 km	80 m	44 ha	Abundant	Outside CPA	4km	Motorbike	BG
	Metul Kon	6 km	50 m	30 ha	Abundant	Within CPA	4km	Motorbike	BG
	O Cheung Kha-orl	2 km	40 m	8 ha	Abundant	Within CPA	5km	Motorbike	SEF
	Metul Me (Thom)	3 km	50 m	15 ha	Abundant	Within CPA	15km	Motorbike	SEF
	O Cheung Chry flows to O Rohort	3.5 km	40 m	14 ha	Abundant	Within CPA	16km	Motorbike	SEF
	Rohort Toch flows to O Rohort Thom	2.5 km	50 m	12.5 ha	Moderate	Within CPA	20km	Motorbike	SEF
	O Rohort Thom	40 km	60 m	240 ha	Moderate	Within CPA	6-7km	Motorbike	SEF
Sub-total				250 ha					
Chi Khlorb	O Chba	20 km	80 m	160 ha	Abundant	Within CPA	1.5km	Motorbike	SEF
	O Kachass	15 km	60 m	90 ha	Abundant	Within CPA	2km	Motorbike	SEF
	O Toek Pok	1 km	30 m	3 ha	Few	Within CPA	3km	Motorbike	SEF
	O Cheung Chrey	1 km	20 m	2 ha	Few	Within CPA	1km	On Foot	SEF
	O Ka-uon	2 km	50 m	10 ha	Moderate	Outside CPA	0.5km	On Foot	SEF
	O Vail	5 km	60 m	30 ha	Abundant	Outside CPA	0.5km	On Foot	SEF
Sub total				395.5 ha					

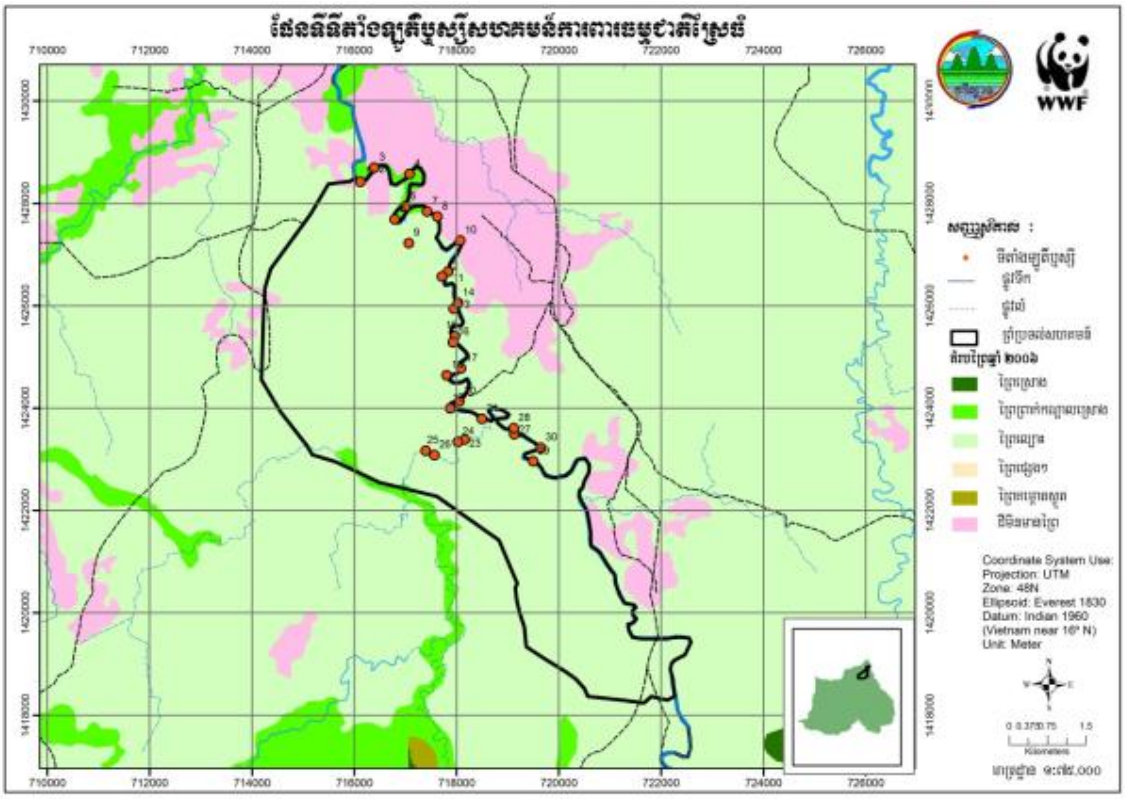
Map 2: Location of bamboo resources within and adjacent to Sre Huy CCA



Map 3: Location of bamboo resources within and adjacent to Chi Khlorb CPA



Map 4: Location of bamboo resources within and adjacent to Sre Thom CPA



6.3 Bamboo density

Based on data analysis of resource inventory in 9 bamboo groves located within the three CCF/CPA sites, Russey Roleak showed the highest density of 4,350 culms (or 120 clumps) per hectare, followed by Russey Prey/Rosorb with 1,585 culms (or 35 clumps) per hectare, then Russey Khley at 268 culms (or 7 clumps) per hectare and last is Russey Tronung Moin with 74 culms (or 2 clumps) per hectare. The number of bamboo shoots was extremely low because it is past the rainy season during the study period. The young culms (less than one year old) were used to represent annual growth of bamboos whereas the cut culms represent the amount of culm harvested by the people. Populations of the four species are shown in table 3.

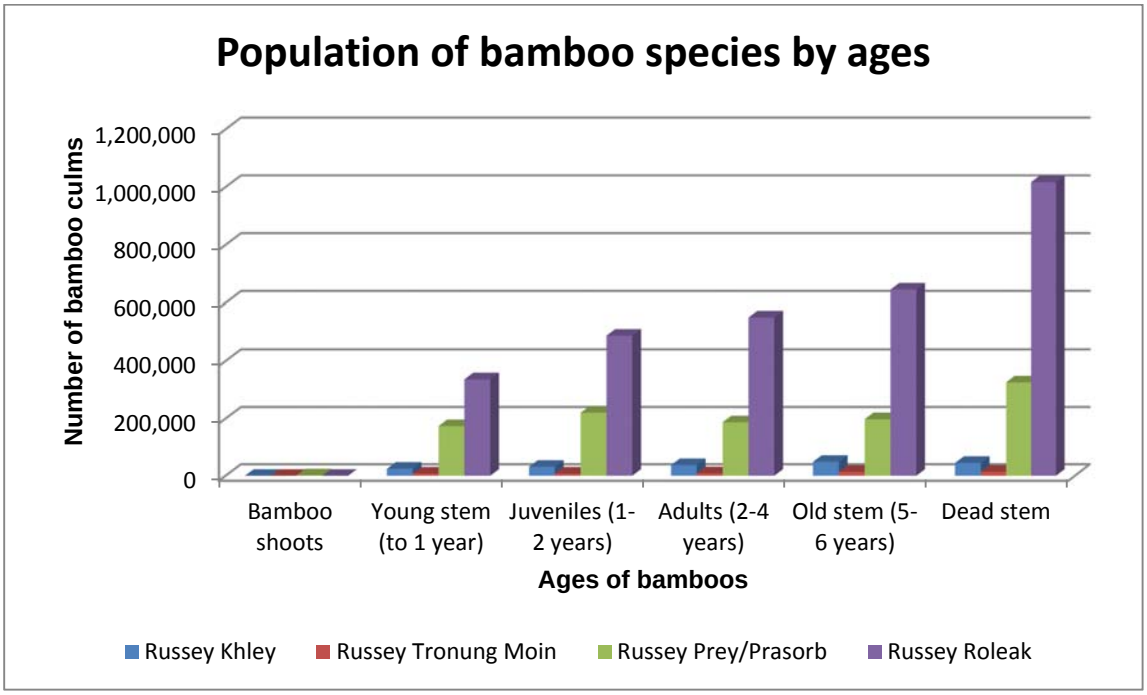
Table 3: Summary of bamboo population by species in the three sites

Bamboo species		Number of culms by ages			
		Russey Roleak	Russey Prey /Prasorb	Russey Khley	Russey Tronung Moin
Bamboo shoots	Number	38	1,667	0	0
	Percentage	0	0	0	0
Young culms (to 1 year)	Number	336,566	173,833	24,410	7,646
	Percentage	11	16	13	15
Juveniles (1-2 years)	Number	487,614	220,256	31,354	7,884
	Percentage	16	20	17	15
Adults (2-4 years)	Number	550,213	186,997	37,285	8,781
	Percentage	18	17	20	17
Old culms (5-6 years)	Number	645,267	197,795	48,817	13,486
	Percentage	21	18	26	26

Dead culms	Number	1,016,878	325,884	44,940	14,064
	Percentage	33	29	24	27
Cut culms*	Number	15,140	16,614	1,910	2,250
	Percentage	0	1	1	4
Total	Total	3,036,576	1,106,431	186,807	51,862
	Percentage	100	100	100	100

**Cut bamboo culms are recorded to demonstrate the scale of bamboo consumption in each site, but they are not included in the data analysis.*

Figure: Graph of culm number by species



In order to facilitate a plan for bamboo harvest and management plan, the analysis is made by site as follows:

6.3.1 Sre Huy Community Conservation Forests (CCF)

Total bamboo study areas of Sre Huy CCF were 112 hectares, of which 5 hectares or 4.46% of the entire area were sampled for inventory. Russey Roleak population was higher than other species, followed by Russey Khley. Russey Prey/Rosorb, and Russey Tronumng Moin had the smallest population respectively. See table for specific record of culms.

Table 4 Summary of bamboo population by species in Sre Huy CCF

Bamboo species		Number of culm by ages			
		Russey Roleak	Russey Prey / Rosorb	Russey Khley	Russey Tronung Moin
Clump no	Number	15,115	2,240	2,555	120
Bamboo shoots	Number	38	1,600	0	0
	Percentage	0	2	0	0
Young stem (to 1 year)	Number	104,536	12,366	14,777	900
	Percentage	11	15	13	9

Juveniles (1-2 years)	Number	152,733	16,520	20,592	960
	Percentage	16	19	18	9
Adults (2-4 years)	Number	197,866	15,742	24,885	1,040
	Percentage	21	18	22	10
Old stem (5-6 years)	Number	276,198	21,040	30,184	5,460
	Percentage	29	25	27	53
Dead stem	Number	226,365	17,943	22,407	1,960
	Percentage	24	21	20	19
Cut stem	Number	9,797	0	0	0
Total	Total number	957,734	85,211	112,845	10,320
Percentage	Percentage	100	100	100	100

6.3.2 Chi Khlorb CPA

The resource inventory was conducted in a 4.4 hectares of the total 230 hectares in Chi Khlorb CPA; representing only 1.9% of the entire areas. Four species were recorded, of which Russey Roleak showed the highest number followed by Russey Prey/Rosorb and Russey Tronung Moin. Russey Khey was not present at the inventory plots.

Table 5 Summary of bamboo population by species in Chiklob CPA

Bamboo species		Number of culms by ages		
		Russey Roleak	Russey Prey/ Rosorb	Russey Tronung Moin
Clump no		50,258	1,263	1,113
Bamboo shoots	Number	0	0	0
	Percentage	0	0	0
Young culm (to 1 year)	Number	138,464	14,591	3,403
	Percentage	9	16	17
Juveniles (1-2 years)	Number	227,376	16,498	3,881
	Percentage	15	18	20
Adults (2-4 years)	Number	260,166	16,754	4,074
	Percentage	18	18	21
Old culm (5-6 years)	Number	282,432	21,854	4,217
	Percentage	19	23	21
Dead culm	Number	572,013	24,227	4,071
	Percentage	39	26	21
Cut culm	Number	2,010	600	2,250
Total	Number	1,480,451	93,924	19,647
	Percentage	100	100	100

6.3.3 Sre Thom CPA

A total 3.1 hectares were inventoried representing 1.24% of the 150 hectares bamboo area in Srae thom CPA. The inventory covers all the four species, and the result shows that the population of Russey Prey/Rosorb was higher than Russey Roleak, Russey Khley and Russey Tronung Moin:

Table 6: Summary of bamboo population in Srae Thom CPA

Bamboo species		Number of culms by ages			
		Russey Roleak	Russey Prey/Rosorb	Russey Khley	Russey Tronung Moin
Clump no	Number	18,352	20,605	2,171	395
Bamboo shoots	Number	0	67	0	0
	Percentage	0	0	0	0
Young culm (to 1 year)	Number	93,567	146,876	9,633	3,343
	Percentage	16	16	13	15
Juveniles (1-2 years)	Number	107,505	187,238	10,762	3,043
	Percentage	18	20	15	14
Adults (2-4 years)	Number	92,181	154,500	12,400	3,667
	Percentage	15	17	17	17
Old culm (5-6 years)	Number	86,638	154,900	18,633	3,810
	Percentage	14	17	25	17
Dead culm	Number	218,500	283,714	22,533	8,033
	Percentage	37	31	30	37
Cut culm	Number	3,333	16,014	1,910	0
Total	Number	598,390	927,295	73,962	21,895
	Percentage	100	100	100	100

7. Discussion

7.1 Commercial bamboo species

Based on property and uses, the four bamboo species were categorized into two main types – thin-walled culm species and thick-walled culm species.

- Thin-walled culm species was composed of Russey Roleak and Russey Prey/Rosorb. Both species have large culms fairly long internodes. These two species are highly potential for housing materials, kitchen utensils, fishing traps and nets, and core of incense sticks. Russey Roleak is more preferred than Russey Prey due to durability of culm wall. Based on anecdotal observation, million culms of the two species have been annually collected along the Mekong River and its tributaries for trade in raw materials and semi-products to Phnom Penh, surrounding flat plain areas, and the Tonle Sap Great Lake. The two species are also extensively utilized by local community. Currently its population has been critically decreased due to land use changes, unsustainable collection practice and over harvest (Hourt et al, 2007)

- Thick-walled culm species is composed of Russey Tronung Moin and Russey Khley. The two species currently have less demand for product processing due to smaller culms and thick wall. Poles of Russey Khley were used as supportive materials for black pepper plantation. Russey Tronung Moin usually has straight culms and small hollow, and so is most suitable for furniture frame. Russey Khley have smaller and shorter internodes than Russey Tronung Moin and not straight, so it is not suitable for product development. However, Russey Khley has small clump, lack spine-like branch and has horizontal strip in white or pale grey color which could be potential species for ornamental bamboos in future.

7.2 Density of bamboo culms and potential use

- The two species of Russey Roleak and Russey Prey/Rosorb were 4,350culms/ha and 1,585 culms/ha, which were higher density in the study areas. Due to similarity of the uses of the two species, these two species can be combined together into one. Based on field data of the two species, the adult culms were 737,209 individuals (1,056 culms/ha) and the juvenile ones were 707,869 individuals (1,014 culms/ha). Young culms and bamboo shoots were only 512,104 individuals, which is only 26% of juvenile and adult culms. However, local use of the two species is less than 2% of the total population. Bamboo culms may only be cut when needed for immediate use.
- The density of Russey Tronung Moin were just 74 culms per hectare, which is very small if compared to other three species, but 4% of its populations were harvested for local consumption. Whereas Russey Khley with density of 278 culms per hectare is higher than Russey Tronung Moin 3 to 4 times, but was little used by local community.

Little harvest of bamboo culms at the study areas doesn't mean people do not use them, but because bamboo resources are still available surrounding their villages. The dead culms were the highest and a major threat to forest fire if dry season is prolonged as a result of climate change. Fire will provide immediate impact to bamboo clumps by burning culms and result to poor culm quality. It also provides impact to nearby ecosystems. It is believed that if bamboo culms are harvested properly, it will minimize hazard of forest fire in the dry season. In addition, good practice of bamboo management will allow bamboo shoots to grow well and developed into high quality culms.

7.3 Annual bamboo growth

With regard to bamboo ecology, bamboos die after six years, so the analysis of annual bamboo growth is made within 6 years only. Hence the dead bamboo culms were not included in this analysis. Cut bamboo culms were included in the analysis because it is still within 6 years. Annual bamboo growth is defined as the accumulation of bamboo shoots and young bamboo culms which are developed from bamboo shoots last rainy season. The total population of

bamboo culms of each species is the sum of annual growth (bamboo shoots and young culms), juvenile culms, adult culms, old culms and cut culms. The average annual growth of bamboo culms of each species being produced per site is a division of the total culms of a clump with six. The percentage of annual growth is a multiplication of annual bamboo growth with 100% and divided by average total annual growth. In average, each clump could regenerate 4 to 6 bamboo shoots dependence on species. As illustrated in the following table, the percentage of annual bamboo growth at the study areas is usually over 100%. So, bamboo harvest would not negatively affect the regeneration if it is well managed.

Table 7: volume of annual bamboo growth of the four species found in the study sites

Bamboo species	Locations	Village	size in hectare	Clump no	Annual growth	Percentage of annual growth	Average annual growth per clump	Juveniles (1-2 years)	Adults (2-4 years)	Old culms (5-6 years)	Cut culms	Total population	Average annual growth
	O Chimeat	Sre Huy	54	2,134	11,957	101	6	16380	18669	23863	0	70,869	11,811
Russey Khley	O Cho Chork	Sre Huy	34	301	1,600	89	6	2,052	3,576	3,501	0	10,729	1,788
	O Ngovlav	Sre Huy	24	120	1,220	83	12	2,160	2,640	2,820	0	8,840	1,473
	O Chba	Sre Thom	160	1,400	6,933	112	4	7933	8800	12333	1267	37,267	6,211
	O Kachass	Sre Thom	90	771	2,700	101	3	2,829	3,600	6,300	643	16,071	2,679
	Total		362	4,727	24,410	486	5	31,354	37,285	48,817	1,910	143,776	23,963
Russey Tronung Moin	O Kralorm	Chi Khlorb	32	213	853	132	3	1,031	924	1,067	0	3,876	646
	O Rohort Thom	Chi Khlorb	240	900	2,550	110	3	2,850	3,150	3,150	2,250	13,950	2,325
	O Ngovlav	Sre Huy	24	120	900	65	12	960	1,040	5,460	0	8,360	1,393
	O Chba	Sre Thom	160	267	1,800	107	6	2,400	3,667	2,267	0	10,133	1,689
	O Kachass	Sre Thom	90	129	1,543	248	5	643	0	1,543	0	3,729	621
	Total		546	1,629	7,646	661	4	7,884	8,781	13,486	2,250	40,047	6,675
Russey Prey/Rosorb	O Kralorm	Chi Khlorb	32	213	1,991	141	7	2,098	2,204	2,204	0	8,498	1,416
	O Rohort	Chi Khlorb	240	1,050	12,600	122	10	14,400	14,550	19,650	600	61,800	10,300
	O Chimeat	Sre Huy	54	386	1,594	87	5	2,391	3,086	3,934	0	11,006	1,834
	O Cho Chork	Sre Huy	34	414	2,692	137	5	3,068	2,296	3,746	0	11,802	1,967
	O Ngovlav	Sre Huy	24	1,440	9,680	131	5	11,060	10,360	13,360	0	44,460	7,410
	O Chba	Sre Thom	160	11,733	91,400	133	6	112,667	101,400	92,800	12,800	411,067	68,511
	O Kachass	Sre Thom	90	8,871	55,543	134	5	74,571	53,100	62,100	3,214	248,529	41,421

	Total		546	24,108	175,500	885	6	220,256	186,997	197,795	16,614	797,161	132,860
Russey Roleak	O Cheung Chrey	Chi Khlorb	14	2,240	9,380	115	4	13,020	13,650	12,670	210	48,930	8,155
	Kralorm	Chi Khlorb	32	3,662	15,004	108	4	18,880	23,360	26,382	0	83,627	13,938
	Metul Thom	Chi Khlorb	50	2,056	5,779	87	3	10,526	10,756	12,679	150	39,891	6,649
	O Rohort	Chi Khlorb	240	42,300	108,300	88	3	184,950	212,400	230,700	1,650	738,000	123,000
	O Chimeat	Sre Huy	54	6,094	47,237	86	9	70,791	82,620	120,780	9,514	330,943	55,157
	O Cho Chork	Sre Huy	34	5,741	41,336	81	9	61,741	86,626	115,558	282	305,544	50,924
	O Ngovlav	Sre Huy	24	3,280	16,000	92	5	20,200	28,620	39,860	0	104,680	17,447
	O Chba	Sre Thom	160	17,067	89,067	149	4	101,333	86,267	78,667	3,333	358,667	59,778
	O Kachass	Sre Thom	90	1,286	4,500	110	3	6,171	5,914	7,971	0	24,557	4,093
	Total		634	83,726	336,604	915	4	487,614	550,213	645,267	15,140	2,034,838	339,140

7.4 Volume of annual bamboo extraction

The bamboo extraction is carried out in accordance to the type of uses. Old bamboos are difficult to be used for product development, especially for bending because of old and crisp lignin, except used as supportive materials and fence bar. For flooring, furniture and core of incense stick, 2-4 year bamboo culms are most suitable, whereas handicraft products, 1-2 years old bamboo culms can be used as lignin is still flexible. Since that bamboo resource at the target areas have not been used, the adult culms can be harvested to its maximum volumes in the first and second years (see table 9). The third year afterward, harvest can be implemented in line with its annual generation rate (see table 10). With current projection of annual generation rate, annual allowable cut (AAC) of bamboo culms is made by species – 339,140 culms of Russey Roleak; 132,960 culms of Russey Prey/Rosorb; 6,675 culms of Russey Tronung Moin, and 23,963 culms of Russey Khley. However, the harvest capacity of these species could be higher than this estimation if bamboo clumps are well managed in future.

Table 8: first year harvest of the adult culms

Bamboo species	Juveniles (1-2 years)	Adults (2-4 years)
Russey Khley	31,354	37,285
Russey Tronung Moin	7,884	8,781
Russey Prey/Prasorb	220,256	186,997
Russey Roleak	487,614	550,213

Table 9: Harvest volume of bamboo culms in the third and following years

Bamboo species	Location	Village	size in hectare	Clump no	Annual growth	Percentage of annual growth	Average annual growth per clump	Harvest projection in third year and afterwards
Russey Khley	O Chimeat	Sre Huy	54	2,134	11,957	101	6	11,811
	O Cho Chork	Sre Huy	34	301	1,600	89	6	1,788
	O Ngovlav	Sre Huy	24	120	1,220	83	12	1,473
	O Chba	Sre Thom	160	1,400	6,933	112	4	6,211
	O Kachass	Sre Thom	90	771	2,700	101	3	2,679
	Total		362	4,727	24,410	486	5	23,963
Russey Tronung Moin	O Kralorm	Chi Khlorb	32	213	853	132	3	646
	O Rohort Thom	Chi Khlorb	240	900	2,550	110	3	2,325
	O Ngovlav	Sre Huy	24	120	900	65	12	1,393
	O Chba	Sre Thom	160	267	1,800	107	6	1,689
	O Kachass	Sre Thom	90	129	1,543	248	5	621

	Total		546	1,629	7,646	661	4	6,675
Russey Prey/Rosorb	O Kralorm	Chi Khlorb	32	213	1,991	141	7	1,416
	O Rohort	Chi Khlorb	240	1,050	12,600	122	10	10,300
	O Chimeat	Sre Huy	54	386	1,594	87	5	1,834
	O Cho Chork	Sre Huy	34	414	2,692	137	5	1,967
	O Ngovlav	Sre Huy	24	1,440	9,680	131	5	7,410
	O Chba	Sre Thom	160	11,733	91,400	133	6	68,511
	O Kachass	Sre Thom	90	8,871	55,543	134	5	41,421
	Total		634	24,108	175,500	885	6	132,860
Russey Roleak	O Cheung Chrey	Chi Khlorb	14	2,240	9,380	115	4	8,155
	Kralorm	Chi Khlorb	32	3,662	15,004	108	4	13,938
	Metul Thom	Chi Khlorb	50	2,056	5,779	87	3	6,649
	O Rohort	Chi Khlorb	240	42,300	108,300	88	3	123,000
	O Chimeat	Sre Huy	54	6,094	47,237	86	9	55,157
	O Cho Chork	Sre Huy	34	5,741	41,336	81	9	50,924
	O Ngovlav	Sre Huy	24	3,280	16,000	92	5	17,447
	O Chba	Sre Thom	160	17,067	89,067	149	4	59,778
	O Kachass	Sre Thom	90	1,286	4,500	110	3	4,093
	Total		698	83,726	336,604	915	4	339,140

8. Recommendations

- The two species Russey Roleak and Russey Prey/Rosorb are most suitable for trade in terms of culm quality and volume. Whereas Russey Tronung Moin and Russey Khley can also be harvest for trade but in limited volume.

- If bamboo resource becomes potential for local livelihood, bamboo clumps should be properly managed. Silviculture like thinning bamboo clumps should be carried out by community, especially primary beneficiaries. Old and dead bamboo culms should be removed in order to provide adequate space to promote bamboo shoot growth.

- Only juvenile and adult culms are harvestable for use or sale. The young bamboo with ages less than one year still has weak lignin and tend to shrink and prone to insect attack after collection. Based on this finding, all adult culms could be harvested, whereas juvenile culms should better be harvested based on its annual generation rate.

- Cutting bamboo should be at base, in order free up space for other clumps that are growing and for production of bamboo shoot. Currently, culms are cut 3 meters above the ground because people want to avoid the thick spines on the ground. This will keep the bamboo clump becoming denser and prevent bamboo from generating new shoots, and bamboo shoots will not develop into good quality.

- Collecting bamboo done at the onset of rainy season, especially between May and July may impact bamboo shoots. So, it would be better to harvest bamboo culms from November to May to minimize impact.

- Under the community-based bamboo management, thick spiny branches on the ground should be cleared to provide easy to access to the clumps for culm collection. If branches on the ground are cleaned in year one, it would not take much labor to clean in subsequent years.

- All stakeholders including government technical agency, NGOs, private sectors and local authority should promote bamboo development for community income generation. This will provide incentive to community in community-based forest ecosystem management.

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Annex

Datasheet for Field Record of Bamboo Density

Date:…….., Group members:……..…… Recorder:……..
Village:…….. Commune:……...…… District:……..……
Province:……..…..…...
Area name/feature:…… Block no:…… Plot no:……., sheet no:……..
Forest type:……. UTM:……..…..….. Elevation:……
Distance from village: Disturbance:…….. Plot size:……

Clump no	Bamboo species	Clump cir (m)	bamboo shoots	Young stem (to 1 year)	Juveniles (1-2 years)	Adults (2-4 years)	Old stem (5-6 years)	Dead stem	Cut stem	Additional note
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										
13										

Datasheet to record size of bamboo culms

Bamboo species: ……..

Recorder..... Area: ……..…… Date……

No	Length of section 1(Length of node interval shorter than 30 cm)								Length of section 2(Length of node interval longer than 30 cm)											Total node intervals	Total length of bamboo culm
	Cir (cm)		Length of node interval (cm)		Culm thickness (mm)		Number of node intervals	Length of section1(m)	Cir (cm)			Length of node interval (cm)			Culm thickness (mm)			Number of node intervals	Length of section1(m)		
	Base	End	Base	End	Base	End			Base	Middle	End	Base	Middle	End	Base	Middle	End				

Activities of the measurement of bamboo size

Figure: a) cutting bamboo wall to measure wall thickness; b) and c) measurement of culm wall; d) counting internodes; e) measurement of the entire length of bamboo culm; f) measurement of culm circumference.