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ORIGINAL ARTICLE Socio economical evaluation of Uncaria gambir cultivation systems in West Sumatra, Indonesia David Malik1, 2, Aflizar3, Synthia Ona Guserike Afner3, Akira Fukuda 1 and Tsugiyuki Masunaga1* 1 Faculty Life and Environmental Sciences, Shimane University, Matsue, 690 ô 8504, Japan 2 Faculty of Economy, University of Baiturrahmah, Jl. Raya By Pass km 15, Aie Pacah, Koto Tangah, Padang, West Sumatra 25586, Indonesia 3 Agriculture Polytechnic of Payakumbuh, Jl. Raya Negara KM.

7 Tanjung Pati, Koto Tuo, Harau, Kabupaten Lima Puluh Kota, Sumatera Barat 26271, Indonesia * Corresponding author: masunaga@life.shimane-u.ac.jp Received: March 22, 2020 ?Accepted: July 27, 2020 ?J-STAGE Advance published date: November 1, 2020

ABSTRACT ?? Uncaria gambir (Ug) is the main ingredient for producing Gambir which is an international trading commodity that Indonesia has shared its production of 80 % in the world.

This paper investigates the type of Ug cultivation system in West Sumatra and its contribution to farmers` income security. Rapid rural appraisal was used for collecting data. Economic analysis is carried out consisting of Benefit and Cost ratio (B/C Ratio), net present value (NPV), internal rate of return (IRR), sensitivity test on the discount rate and Gambir production.

Six Ug cultivation systems were found, namely Ug-Mono, Ug-Rubber, and Ug-Areca nut in Lima Puluh Kota regency (LPKR) and in Pesisir Selatan regency (PSR) Ug-Durian, Ug-Durian-Jengkol and Ug-Durian-Petai. In general, The Ug cultivation systems combined with Durian and Jengkol or Petai, that were found valuable additional crops, were more stable in income generation against to the fluctuation of Ug production and Gambir price. Among the six, the highest B/C Ratio was found in Ug-Durian-Jengkol

(2.8) while the lowest was in Ug-Mono and Ug-Rubber (1.9).

Moreover, Ug-Durian-Jengkol show better NPV and IRR in the most conditions of Gambir price from 10,000 to100,000 Rp kg ?1 as well as Gambir production from 2,400 to 4,800 kg y ?1 . On the other hand, NPV and IRR of Ug-Mono, -Rubber or -Areca nut systems sharply decreased with the decrease of Gambir price. These systems relied more on Ug production and Gambir price in the income generation. It exhibited the vulnerability of income structure of these systems.

From the results, to secure farmers` income from volatility of Ug production and Gambir price, this research suggested Ug cultivation systems combining with durian or other profitable cash crops in West Sumatra. Key words: BC Ratio, NPV, IRR, Cultivation systems, Gambir, Uncaria gambir INTRODUCTION ??Gambir is a dried sap extracted from Uncaria gambir (hereafter, Ug) leaves and twigs. This plant has a high con- centration of catechin between 7ô33 % and tannin between 20ô 55 % (Zhalimi 2006).

Local people use Ug leaves as traditional medicine and Gambir for betel mixture. In pharmaceutical industry, Gambir is used as an ingredient for production of medicine such as antioxidants, and piles used for stress regulation and inflammatory bowel diseases (Anggraini et al. 2011; Chobot et al. 2009; Fan et al. 2017).

In the textile industry, Gambir is used for sunlight proof color agent and leather processing (Zhalimi 2006). Cur- rently, developments on the use of Gambir are applied in several other industries such as; the food, beverage and chemical industries (Rauf et al. 2015). Ninety seven percent of Gambir produced in Indonesia is exported to India, Pakistan, and Bangladesh while the rest is exported to Japan, Malaysia, Singapore, Thailand, Brunei Darussalam, Bahrain and United States.

The demand for the Gambir produced has continue to increase yearly with the growth of textile and pharmaceutical industries in India and other im- porting countries. India alone imported Gambir worth US $ 32 million with a volume of 14,312 ton from Indonesia in 2012, which shared 99 % of world trade (Directorate General for National Export Development, 2015). ??Gambir production consists of two steps, i.e.

Ug cultivation-harvest and Gambir production which is the extraction of Gambir composition from the leaves and twigs. The Ug is cultivated by local farmers only, while the extraction is conducted by the Ug cultivating farmers (hereafter, Ug farmers) and sometimes by companies that buy the Ug harvests from local farmers.

Indonesia is the largest Gambir producing country and is the worlds` first 78 Gambir

exporter which owns 80 % of world production (Purwanto et al., 2013). The West Sumatra Province is the main Ug cultivation area in Indonesia, which controls 67 % of Indonesia`s production. In this province, there are two main areas, Lima Puluh Kota Regency (LPKR) and followed by Pesisir Selatan Regency (PSR).

The cultivation field of Ug covers relatively moderate area among all the main cash crops such as palm, rubber, coffee and tea in LPKR and PSR totaling about 39,84 % and 12,44 %, respectively, although Ug field in national average is only 0,19 % in Indonesia (Statistics of Sumatera Barat Province 2015). ??For the last ten years, Ug cultivated area have in- creased by 16 %, about 3,000 ha, with average production of 9,398-ton year ?1 while in PSR is has increased by 68 %, about 10,000 ha, with average production only 4,882-ton year ?1 . The price of Gambir has been fluctuating in the past years as shown in table 1.

Ug farmers in West Sumatra are thought to be very prosperous because they monopolize Gambir market supply. However, in reality, Ug farmers are still struggling to find a better option to increase their income due to the unstable price of Gambir. On the Gambir price, farmers can only capitulate on the prices offered by middlemen.

This is because the number of buyers are limited in Gambir market and the market structure is an Oligopsony which is the main contributor to the unstable Gambir price (Fauza, 2016). Regardless of unstable prices in the present market, Ug can generate tangible income monthly to the farmer with less input compared to other crops in those regions.

Therefore, the local farmers are willing to continue Ug cultivation and to increase their income. ??Besides the effect of the market structure, Ug farmers earn less income due to lack of improved technologies adopted for better Ug cultivation and high quality Gambir to meet export standard (Nasution et al. 2018).

Although a pressing machine used for extracting Gambir from Ug leaf and twig is available in the market, most local farmers cannot afford it, thus leading to production of low quality Gambir, as farmers still rely on conventional and less efficient pressing methods. As an alternative approach to increase Ug farmers income, some farmers in PSR have practiced mixed gardening, which combines Ug and other profitable cash crops such as durian (Durio zibethinus), jengkol (Archidendron pauciflorum) and petai (Parkia speciosa).

This technique seems a realistic option for farmers to generate additional income from other crops in their Ug fields. Moreover, the vulnerability of Gambir price and its profit

that influence farmer income its clearly expose in the study sites. Besides the tradition in producing Gambir has been rooted for generations and it is the main source of income.

??? However, there is no research analyzing economical structure of the Ug mixed cropping systems. In order to decipher these structures, it is necessary to characterize and evaluate the Ug cultivation systems on its variation and efficiency on income generation. Therefore, the present study examines Ug cultivation systems including Ug mono- culture and Ug mixed cropping systems on their variation and income structures and discusses the current movement on Ug mixed cropping systems at the main Ug producing areas in West Sumatra. Table 1. Cultivated area, Gambir production and price.

Year LPKR PSR Price of Gambir (Rp kg ?1) Cultivated area (ha) Production (ton ha ?1) Cultivated area (ha) Production (ton ha ?1) 2008 14,410 11,790 ç4,788 3,503 19,265 2009 14,682 14,601 ç6,314 3,400 27,850 2010 14,577 ç7,924 ç7,070 3,102 28,244 2011 15,470 ç7,743 ç9,869 5,225 28,244 2012 15,308 ç7,833 14,714 5,567 28,900 2013 15,424 ç7,934 15,277 6,005 24,000 2014 15,582 ç8,722 15,277 5,422 16,000 2015 15,659 ç8,814 14,314 5,422 20,000 2016 16,199 ç9,181 14,303 6,794 50,000 2017 17,357 ç9,444 ç8,648 4,383 27,000 Rp: Indonesia Rupiah (1 USD'14,400 Rp in June 2018) Source: Badan Pusat Statistik, 2018 79 MATERIALS AND METHODS Study sites ??In West Sumatra there are two main Gambir producing regencies which are Lima Puluh Kota Regency (LPKR) and Pesisir Selatan Regency (PSR).

These two regencies were selected as representative sites, based on their long history of Ug cultivation and Gambir production (Putri, 2005; Fauza, 2016), at least 100 years according to local farmers. LPKR is located between latitudes 0o 01^ 32.6? S and 0? 10^ 35.4? N and longitudes 100? 15^ 50.7? E and 100? 50^ 51.9? E (see figure 1), covering a total area of about 335,430 hectares.

LPKR is 189 km away from the capital province, Padang, with an altitude of 550ô750 meters above sea level (MASL) and average annual rainfall of 1,800ô3,700 mm. In LPKR, two villages were chosen, Mahat and Katinggian. PSR is located between latitudes 1 ? 03^ 30.2? S and 1? 16^ 51.6? S and longitudes 100? 27^ 18.9? E and 100? 30^ 16.8? E, with a total surface area of 574,988 hectares, and the 62 % of this area is covered by protected forest (Kerinci seblat national park).

PSR is located 33 km away from the capital province, Padang, and located on the land of 10ô115 MASL. In PSR, two villages were chosen, Siguntur tuo and Barungbarung balantai. PSR has an annual rainfall of 1,800ô 3,700 mm. Both regencies have similar equatorial climate with temperatures between 24ô 32 ^(Köppen and Geiger classification).

Variations of Ug mixed cropping systems are existing, in which Ug is commonly mixed with one to three horticulture crop species such as areca nut (Areca cathechu), rubber (Hevea brasiliensis), durian, jengkol and petai. The majority of Ug fields are located on the hillsides, away from local community residence which can only be accessed by foot or use of motorbike.

Data collection on Ug farming system and farmer characteristic ?? According to FAO, Rapid Rural Appraisal (RRA) is one method that uses for bridging between formal surveys and unstructured research methods such as in-depth Fig. 1. Study sites: Lima Puluh Kota regency (LPKR) and Pesisir Selatan regency (PSR). 80 interviews, focus group discussion and observation studies.

At LPKR, head of the village and two key informants participated which is from senior Ug farmer and local middleman. At PSR, two key informants participated from village officer and one Ug farmer representative. They were selected purposefully and interviewed based on their knowledge regarding history on Ug and Gambir, development, local demographics, and infrastructure.

??Focus group discussion (FGD) is one method of gathering people with similarity in terms of gender, ethnicity, social background, experience, and interest (Nyumba et al., 2018). Focus group discussion targeted collecting information on Ug farmers` cultivation system, types of crops, yield and densities, income estimation and Ug farmers ` characteristics by combining questionnaires and in-depth interview.

Purposive sampling was use to collecting data that related directly to the farmer that applied different Ug cultivation system. Respondents are the representative of majority farmer adopt Ug cultivation systems found in the study sites. Price data were collected from farmers and local middlemen. Data were taken from mid-July to end of September 2017 with 56 farmers at LPKR, and from mid-September to early October 2018 with 15 farmers at PSR.

Data and reports obtained from farmers and key informants are reconfirmed to the head of the villages so that the data collected can be accountable. Data analysis ??This study investigated farmer` s income generated from Ug cultivation systems along with crops from mixed gardening within Ug fields. Descriptive statistic was used to analyze the Ug cultivation systems, characteristics of dif- ferent farmers and income structure at the different study sites.

Financial analyses were used such as benefit-cost ratio (B/C Ratio), net present value

(NPV) and internal rate of return (IRR) to analyze the value between different Ug cultivation systems in these sites. For B/C Ratio (see formula 1) greater than 1 implies the project/investment is profitable and expected to deliver a positive net present value.

NPV and IRR are used to determine farmers` investment and cash flow on their Ug and production of other crops using the following formula 2 (Ajijur et al., 2017). According to this financial analysis criteria, when NPV greater than 0 (zero) then it is worth pursuing. IRR is used to estimate profitability of potential projects or investments, calculated by setting up the NPV of all cash flows from the investment equal to zero (formula 3). When the IRR is greater than the discount rate this implies the investment is worth supporting.

By using these three indicators then we could compare all Ug cultivation system differences and justify which system provides best value for the Ug farmer. B/C Ratio = S T t=0 Bt ? 1 ?r? t S n T=0 Ct ? 1 ?r? t (1) Net Present Value = S T t=0 Bt - Ct ? 1 ?r? t (2) Internal Rate of Return = ?Cash flow? ? 1 ?r? t ? initial investment (3) Where: Bt ' benefit of production in year t Ct ' cost of production in year t T'total number of years of production t'year of production r'discount rate ??To perform B/C Ratio, NPV and IRR it is necessary to give estimation in period of time.

In this estimation, all Ug cultivation systems were set within a thirty (30) year time horizon so that data on early and mature stages of Ug and other crops productivity in the Ug field can be generated. Land prices for Ug fields were omitted in the calculations, as all Ug fields were inherited (Dendi et al. 2005), thus the initial investment consists of land preparation and construc- tion of production house.

The operational cost, consists of labor costs, weed control and depreciation costs. Deprecia- tion cost is at 10 % based on 30 years of useful life of the first investment therefore it was applied and categorized as a fixed cost. Most farmers in both LPKR and PSR do not apply chemical fertilizers. Therefore, the fertilizer cost is not included in the calculation.

??Income calculation was based on the average produc- tion of the dried Gambir that farmers sell to middlemen or domestic markets. At LPKR production ranges from 4,680ô 5,400, with an average of 4,800 kg year ?1 , while at PSR production ranges between 2,160ô 2,640 kg year ?1 with an average of 2,400 kg year ?1 .

These values, equivalent to 400 and 200 kg month ?1 for LPKR and PSR respectively, are different from values reported by provincial statistics which have higher average production of 540 and 288 kg month ?1 for LPKR and PSR respectively (Directorate

General of Estate Crops, 2013). Crops other than Ug, the yield was calculated with the unit of kg tree ?1 year ?1 .

Prices of other cash crops such as rubber, areca nut, durian, jengkol and petai were collected from the market in 2018 while Gambir prices were collected from 2014 to 2018 from farmers and local middleman. Crop yield data from Ug and the other 81 crops are reported on annual basis. Our preliminary re- search, indicates no clear relationships between cultivation systems and Ug growth and production.

??In order to evaluate the effect of modification of Ug cultivation systems on farmer`s income, economical simulations on Gambir production were conducted assuming following conditions: firstly, Gambir production was set at 2,400 kg year ?1 which is a condition that farmer might potentially experience at both study sites, secondly, Gambir price was set at (low) 10,000, (medium) 25,000, (medium-high) 50,000 and (high) 100,000 Rp kg ?1 , thirdly, initial investment were modified corresponding to the crops mixed with Ug and fourthly, interest rate were assumed stable within 30 years of the project for 10 %.

Thus, we can analyze which type of cultivation system perform better NPV and IRR after the simulation in both study sites. RESULTS AND DISCUSSION Variation of Ug cultivation systems ??At LPKR a total 56 Ug farmers were recruited for this study out of these 37 farmers practiced Ug monoculture, 8 farmers adopted a combination of Ug and rubber tree and 11 farmers adopted combination of Ug and areca nut.

While at PSR, all 15 Ug farmers recruited adopted a combination of Ug and durian. In addition, out of the 15 farmers, 13 farmers combined Ug durian with jengkol and 1 farmer did with petai (Table 2). Socioeconomic and Ug farmer characteristics ??Table 3 shows the socioeconomic and Ug farmers` characteristics. All of Ug farmers in both regencies were male.

At LPKR, farmers between the ages of 41 to 50 years preferred Ug mixed while farmers less than 40 years preferred to adopt Ug-Mono. Many young and middle-aged Ug farmers in LPKR practice Ug-Mono. This is probably due to the lack of higher educational schools before 2006 in LPKR, as shown in Table 2, seventy-six percent of farmers had not schooled or only finished elementary school while eighty-seven percent of farmers in PSR finished junior or high school.

Thus, relatively higher percentage of youth started working after elementary school and resulted in high availability of labor to work in the Ug field in LPKR. Besides, there is an influence from the philosophy of society that someone is said to be a grown up when

they are able to producing Gambir. So that producing Gambir becomes a means of supporting life and their ==main source of livelihood== or income in LPKR.

??For Ug-Mono, there seems no clear relationships with the number of farmer`s dependents while majority of farmers had the number of dependents from 4 to 6 for Ug- mixed. ==However, we could not== find the reason for this in the present study. In terms of the farm size, farmers with Ug-Mono tend to have wider area. Sixty-two ==percent of the farmers== had fields of more than two hectares while only sixteen and twenty percent of Ug-mixed farmers in LPKR and PSR had the field more than two hectares.

During the interview, it was found that the farmers of Ug-Mono were motivated to expand their field in order to earn more income, but for Ug-mixed farmers. In PSR, Ug farmers had relatively high level of education, which was due to better school infrastructure and locations close to the provincial capital Padang. It may have facilitated the farmers to make better strategy to get higher income.

During the interview at PSR, many farmers raised the reason why they practiced the mixed cropping system was that they could sell the products other than Ug in Padang city markets. This geographical advantage in PSR with higher education was probably the reason why all the farmers in PSR conducted Ug mixed cropping systems. Table 2. Description on Ug cultivation systems found in study sites.

Site Farmer Type of Ug Cultivation Systems Code 37 Uncaria gambir (Ug) monoculture Ug-Mono LPKR ç8 Ug + Rubber (hevea brasiliensis) Ug-Rubber 11 Ug + Areca nut (areca cathechu) Ug-Areca nut ç1 Ug + Durian (durio zibethinus) Ug-Durian PSR 13 Ug + Durian + Jengkol (archidendron pauci?orum) Ug-Durian-Jengkol ç1 Ug + Durian + Petai (parkia speciosa) Ug-Durian-Petai 82 Ug farmer income and Ug preference ??? Table 4 show the estimation of Ug farmer`s annual income generated from Gambir and other crops.

On Gambir production, LPKR farmers obtained yield twice of that in PSR, in relation to low production at PSR, it is due to the short duration of working time which is around 6ô 7 hours day ?1 while in LPKR on average 10ô 12 hours day ?1 . The labor cost was 33.3 % and 40 % of total revenue in LPKR and PSR, respectively. Labor scarcity at PSR might be one of the reasons why the labor cost was relatively high.

Consequently, the net income in LPKR was more than double compared with that in PSR for Gambir. For the additional crops, the crop density ==in the Ug field== was very small compared with that of Ug, especially for durian, jengkol, petai those crumb rubber ratios were less than 1:1250 in the field. Although the crop price was relatively low compared

with that of Ug, except Durian (one durian Table 4.

Income from producing Gambir and from additional crops Crops Crop density (crop ha ?1) Production (kg ha ?1 y ?1) Price (Rp kg ?1) Annual TRa (103 Rp ha ?1 y ?1) Labor cost (103 Rp ha ?1 y ?1) Net Income (103 Rp ha ?1 y ?1) Gambir LPKR 2,700ô3,000 4,800 24,000 115,200 38,400 76,800 Gambir PSR 3,750ô4,000 2,400 24,000 57,600 23,040 34,560 Rubber 28 0.2 ç6,000 çç33.6 ? çç33.6

Areca nut 25 50 ç2,000 ç2,500 ? ç2,500 Durianb ç8 60 40,000 19,200 ? 19,200 Jengkol ç7 200 12,000 16,800 ? 16,800 Petai ç3 360 ç8,000 ç8,640 ? ç8,640 Rp: Indonesia Rupiah (1 USD'14,400 Rp in June 2018) aTR'Total Revenue 'Yield x Price, b: Yield and Price are in piece, Table 3. Socioeconomic and Ug farmer characteristics No Characteristics LPKR n'56 PSR n'15 Ug mono Ug mixed Ug mixed 1. Male 37 19 15 2.

Age 10ô20 years ç4 ? 21ô30 years ç8 ç1 ç2 31ô40 years 24 ç7 ç4 41ô50 years ç1 11 ç9 3. Marital Status Married 32 17 12 Single ç5 ç2 ç3 4. Number of farmer `s dependents 1ôô3 11 ç1 ç3 4ôô6 ç7 16 10 '6 12 ç2 ç2 5. Education No education 10 ç1 ? Elementary 18 14 ç2 Junior High School ç7 ç1 ç1 Senior High School ç2 ç3 12 6. Ug farm size (ha) ?2 14 16 12 2ô3.9 ç9 ç3 ç3 4ô5.9

10 ? '5.9 ç4 ? 83 fruit weighs around 1ô 1.5 kg). In spite of such small crop density, its` provided better additional income compared to cash crops at LPKR Ug field such as rubber and areca nut. Based on the results of interview with the farmers, since rubber had less appreciated from both demand and price by local middleman compared to Gambir then the farmers began to plant Ug in their rubber fields.

Unproductive or old rubber trees were cut down and used as fire wood in the production of Gambir while some productive existing rubber trees in their Ug field were left over aiming to generate additional income from the cram rubber. It is in line with the description of rubber-based agroforestry system or ? jungle rubber? in Indonesia specifically Sumatra where jungle rubber is less productive and in order to diverse sources of income then farmer mixed trees or fruit trees in the field (Penot et al., 2017).

On the areca nut in LPKR, it was clarified that there was a socio-cultural reason why the local famers cultivated it in spite of its very small income compared with Gambir. Areca nut is used for cere- monies, medicines, land boundary and chewing tradition. Refer to Ug field, farmer plant areca nut functioned as a land boundary. Therefore, farmer can receive benefit from selling it as it has a value in the local market and society or use it for farmer own necessity.

?? Harvesting of Ug leaves at LPKR is mainly artisanal where farmers have to move from one plant to another throughout the whole field, thus taking up to two month to harvest over an area of one hectare. The leaves and twigs regenerate after two months from time of harvest, thus providing a long harvest period within a year and the possibility of farmers to make more profit. As a result of multiple harvest periods, farmers at LPKR preferred Gambir production, thus moving towards Ug Mono.

??At PSR, based on the interview results with both farmers and the head of the village, no Ug farmer carried out Ug-Mono. This was because the farmers were aware of unstable Gambir prices, thus diversifying the crops and getting additional income from harvesting other crops such as durian, jengkol, and petai two to three times a year.

Additionally, these Ug farmer (respondents) work on rice fields although the income generated from rice is not reported in this study. This possibly explains the reason why these farmers made less income from Gambir and invested less time in its production process. Benefit-Cost Ratio (B/C Ratio), Net Present Value (NPV) and Internal Rate of Return (IRR) ??Table 5 shows B/C Ratio, NPV and IRR in respective Ug cultivation systems.

The B/C Ratio, NPV and IRR are three related indicators in order to analyze different type of Ug cultivation systems found in the present study. The rule of thumb to this indicator by capturing the value, if NPV' 1, or B/C Ratio'1 or IRR'discount rate then the system is worth to pursue (Philipps and Sanghvi 1996). ??Initial investment mainly varied in regions. It differed about 10 million Rp between LPKR and PSR.

The distance to Ug fields from farmers residence at LPKR were longer compared with those at PSR, resulting in higher transporta- tion costs, thus higher initial cost at LPKR. While in PSR, although labor cost for land preparation slightly more ex- pensive than that in LPKR, it is about 20 % and 11 % respec- tively. However, the difference did not much influence on the initial investment.

In LPKR, 85 % out of the total initial investment goes to construction of produc tion house while 15 % goes to land preparation. In PSR, 68 % out of the total initial investment goes to construction of production house and the remain, 32 %, goes to land preparation. ?? Operational cost consists of depreciation for the produc- tion house, labor, and weed control.

It was 39,735,000 Rp in LPKR and 23,927,000 Rp in PSR, the main contributor for higher operational cost was derived from labor cost (96 %), while weed control and depreciation of production house contribute only a smaller amount (4 %) of operational

cost. At LPKR, farmers carry out harvests three times a year for that reason the operational costs are higher.

In addition, Ug farmer`s operational costs start from the second year up to the project period of 30 years. ??Farmers started generating income from Gambir when the Ug tree is 18 months old. Ug farmers in LPKR had a higher income from Gambir than those in PSR. Ug farmers in LPKR produced Gambir as much as 4,800 kg year ?1 equivalent to Rp 76 million year ?1 whereas Ug farmers in PSR only produced Gambir as much as 2,400 kg year ?1 equivalent to Rp 34 million year ?1 .

In 6 th year to 30 th year, the income varied except for Ug Mono because the mixed crops harvest starts from the 6 th year. Interestingly, durian, jengkol, and petai generated a significant additional income without increase in labor cost. This was because the farmers harvested these crops themselves and also high prices of these mixed crops.

Although rubber and areca nut could also generate additional income without the additional cost in labor, the income was very small, when compared with durian, jengkol, and petai. This might be due to the low prices of rubber and areca nut. ??The B/C Ratio indicates that all types of Ug cultivation systems are positive implying these projects gave farmers a large profit margin for 30 years.

However, the B/C Ratio was high in order of Ug-Durian-Jengkol, Ug-Durian-Petai, 84 Ug-Durian, Ug-Areca nut and Ug-Mono / Ug-Rubber. The higher B/C Ratio of the 3 systems found in PSR was due to low initial investment and operational cost and high contribution from additional crops range from 35 %ô 52 % for farmer income. Whereas, farmers at LPKR who produced mainly Gambir and generated less than 5 % from additional crops perform better NPV and IRR.

IRR is a discount rate that makes the NPV equal to zero. As it showed in Table 6, the sensitivity test of NPV in various discount rates from low of 10 % up to high of 50 % revealed that Ug cultivation systems in LPKR are sustainable at high discount rate (57 %ô58 %).

It has implication if the discount rate increases up to 50 % then the Ug cultivation systems in PSR will result in negative NPV as it can sustain up to 49 % of discount rate. This implies that Ug cultivation systems in LPKR are more profitable and sustainable. ??However, it should be noted that Ug cultivation systems in LPKR require high Gambir production to achieve high NPV and IRR.

Beside the fluctuation of discount rate, factors such as weather, lack of labor and natural disaster which are beyond the capabilities of farmers may affect crop production (Elevitch et al. 2014). From the sensitivity analysis of Gambir production (Table 7), it was found that the Ug cultivation systems in LPKR become less profitable compared to those in PSR as Gambir production is 2,400 kg ha ?1 year ?1 .

It is because the NPV in LPKR decrease about 40,000,000 Rp ha ?1 y ?1 for every decrease in Gambir production by 600 kg from 4,800 kg ha ?1 y ?1 while in PSR it is only about 25,000,000 Rp ha ?1 y ?1 . This means that Ug farmers in LPKR heavily rely on Gambir`s production to increase their income. As discussed above on Table 6 and 7, it was clarified that NPV has strong response to discount rate and production fluctuation of Gambir in LPKR.

??In order to discuss profitability and sustainability when different Ug cultivation systems are adopted in these study sites, a simulation was conducted by modifying the Gambir price in both study sites. Results of the simulation are Table 5. Initial investment, annual cost and benefit, B/C Ratio, NPV and IRR Type of Ug cultivation system Description Year LPKR PSR Ug- Mono Ug- Rubber Ug- Areca nut Ug- Durian Ug-Durian-Jengkol Ug-Durian- Petai Initial investment for starting cultivation Land preparation and construction of production house (103 Rp ha ?1 y ?1) 1 40,500 40,521 40,640 29,192 29,292 29,252 Operational cost: Depreciation cost, labor cost and weed control (103 Rp ha ?1 y ?1) 2ô30 39,735 39,735 39,735 23,927 23,927 23,927 Total cost (103 Rp ha ?1) 1,153,650 1,153,652 1,153,664 694,779 694,789 694,785 Annual net income (103 Rp ha ?1 y ?1) Gambir mono 2ô5 76,800 76,800 76,800 34,560 34,560 34,560 6ô30 76,800 76,800 76,800 34,560 34,560 34,560 Gambir with Rubber 33.6

Gambir with Areca nut 2,500 Gambir with Durian 19,200 Gambir with Durian and Jengkol 36,000 Gambir with Durian and Petai 27,840 Cumulative net income for 30 years (103 Rp ha ?1 y ?1) 2,227,200 2,228,073. 2,292,200 1,501,440 1,938,240 1,726,080 B/C Ratio 1.9 1.9 2.0 2.2 2.8 2.5 NPV (103 Rp ha ?1 y ?1) 273,999 274,188 289,497 180,703 285,718 234,702 IRR 57 % 57 % 58 % 41 % 49 % 45 % B/C Ratio: benefit/cost ratio, NPV: net present value, IRR: internal rate of return 85 shown in Figure 2.

In general, NPV of all Ug cultivation systems are positive with the Gambir price higher than 10,000 Rp kg ?1 in both study sites and it proportionally increases with the increase of Gambir price. Then IRR, which tells sustainability of the system, also become higher with the increase of Gambir price. Judging from the NPV and IRR values, Ug-Durian-Jengkol, Ug-Durian-Petai and Ug-Durian are found to be better Ug cultivation systems in order to secure farmer`s income.

These three Ug cultivation systems are capable of providing some profits from the additional crops even though Gambir price become only 10,000 Rp kg ?1. The Ug-Durian-Jengkol seems to be the most profitable and sustainable Ug cultivation system in West Sumatra. Lin (2011) stated that mono culture system showed less resilience on future extreme climate change scenario compared to crop diversification or mixed cultiva- tion systems, which also showed a benefit to adopt Ug mixed systems.

?? Although Ug-Mono or Ug-Rubber or Areca nut systems are less profitable as shown in Figure 2, Ug farmers in LPKR have tried to shift from Ug mixed system to Ug-Mono system recently. It was because they have simply believed that maximizing Gambir production was the best way to increase their income. In order to extend more profitable Ug cultivation system, ex.

Ug-Durian-Jengkol or mixed with other crops, it is necessary to persuade local farmers by providing quantitative economical information as shown in this study and to demonstrate a model cultivation system in LPKR or other Ug mono system area. CONCLUSION ??This study indicates that income generated from Ug cultivation systems varied depending on Gambir produc- tion, price and types of crops mixed with Ug.

In LPKR, Ug- Mono was the common and some farmers practiced Ug- Rubber and Ug-Areca nut systems while in PSR all the farmers practiced Ug mixed cultivation systems combined with durian and jengkol or petai. Based on the economical analysis referring to the result of NPV and IRR, all Ug cul- tivation systems in LPKR and PSR are positive and worth to pursue the systems.

However, Ug cultivation systems in LPKR looked relied too much on Gambir production, Table 7. The sensitivity of NPV to the change of Gambir production in respective Ug cultivation systems. Gambir production (kg ha ?1 y ?1) NPV (103 Rp ha ?1 y ?1) LPKR PSR Ug-Mono Ug-Rubber Ug-Areca nut Ug-Durian Ug-Durian- Jengkol Ug-Durian- Petai 2,400 110,457 110,645 125,955 180,703 285,718 234,702 3,000 151,342 151,531 166,841 205,234 310,250 259,233 3,600 192,228 192,416 207,726 229,766 334,781 283,765 4,200 233,113 233,302 248,612 254,297 359,312 308,296 4,800 273,999 274,188 289,497 278,828 383,844 332,827 NPV: net present value Table 6.

The sensitivity of NPV to the change of discount rate in respective Ug cultivation systems. Discount rate (r) NPV (103 Rp ha ?1 y ?1) LPKR PSR Ug mono Ug-Rubber Ug-Areca nut Ug-Durian Ug-Durian, Jengkol Ug-Durian, Petai 5 % 492,708 493,083 522,127 350,355 548,935 452,473 10 % 273,999 274,188 289,497 180,703 285,718 234,702 15 % 169,476 169,579 178,611 101,855 164,098 133,857 20 % 112,044 112,103 117,877 ç60,038 100,092 ç80,629 25 % ç76,856 ç76,890 ç80,798 ç35,431 ç62,772 ç49,484

30 % ç53,464 ç53,482 ç56,237 ç19,758 ç39,243 ç29,770 35 % ç36,942 ç36,950 ç38,950 çç9,158 ç23,502 ç16,527 40 % ç24,730 ç24,730 ç26,215 çç1,652 ç12,482 çç7,213 NPV: net present value 86 which made the farmers income structure less stable against to the fluctuations of Ug production and Gambir price.

In order to improve and secure Ug farmer` s income, this research suggested Ug farmers, especially Ug Mono farmers, to shift their Ug cultivation systems combined with other profitable cash crops, ex. durian. ACKNOWLEDGEMENTS ??The authors thank to University of Baiturrahmah for providing funding for this study. The authors also thank the faculty of Life and Environmental Sciences in Shimane University for financial supports in publishing this report.

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