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An Optimal Allocation of Forestland between Conservation and Community Forestry in the Preah Sihanouk National Park, Cambodia

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Competing interests over the park's land use between conservation and forest use result in many conflicts. The conservation group is interested in seeing more land be allocated for conservation, while the community forestry–working group is interested in seeing more land be allocated for community forestry, but both view that their utilities would be maximized if they consume some of the other's good. The conservation group values the land based on zone because of conservation value, while the community forestry values the land based on habitat because of productivity. This study optimizing preferences of both groups attempts to propose the optimal allocation of the park's forestland between the two interests. The result suggests that the total evergreen forest land in the general conservation zone could be allocated 2,742 ha for conservation and 1,871 ha for community forestry and the total evergreen forest land in the managed resource zone could be allocated 237 ha for conservation and 475 ha for community forestry. And the total mangrove forestland in the general conservation zone could be allocated 608 ha for conservation and 352 ha for community forestry and the total mangrove forestland in the managed resource zone could be allocated 585 ha for conservation and 1,079 ha for community forestry. For better management, it is recommended that all community forestry land should be confined in the managed resource zone only rather than in both zones. This requires some of the land in the general conservation zone be added into the managed resource zone.

INTRODUCTION

The competing interests over the park's land use result in many conflicts at present. The locals, who have assessed to the park's forest, as it was an open forest, complain about their opportunity loss when the area was established as a national park in 1993. The conflicts become intensified when law enforcement is implemented. This establishment, primarily focused on conservation, lacks an appropriate compensation or an alternative for the locals, whose livelihoods depend on daily collection of forest resources. This discourages local participation in conservation. All of these make the conservation and the management in the park becomes arduous. Thus, an alternative should be sought if the government wishes to assuage the conflict intensity, to reduce cost of law enforcement, to achieve the long run conservation, and to alleviate the penury

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of the locals. A possible option is to restore their opportunities by reallocating some of the park's forestland for their use, which is more environment concerned.

Thus, community forestry being attempted in various forms, under various names such as joint forest management or collaborative forest management, social forestry, etc., and at various scales in many Asian countries, is believed to be environmental concern and biodiversity restoring. It has three common attributes: i). *Locals have access to the land and its resources.* ii). *Locals participate in decisions concerning the forest.* iii). *The community begins by protecting and restoring the forest* (Blanders and Carey, 1998). These three attributes recognize local participation as an intrinsic component in forest management and concern about environmental degradation, rise of civic institutions, equitable access to resources and benefit distribution. Community forestry is not only believed to be environmental concerned, but also to be advantage comparative. Hill and Shields (1998) comparing the benefits between the joint forest management and the non joint forest resource management in local communities in India showed that the locals made more profits in the joint forest resource management than those in the non–joint forest resources management scenario. Now many CF projects are being introduced in many places in Cambodia including some protected areas, which are trying as pilot projects. Because of its potential income generating for the locals and less environmental impact, the Ministry of Environment has recently issued a declaration on the Development of Community Forestry and Fishery in the protected areas of Cambodia. But how much forest area should be allocated for community forestry so that an optimum is achieved?

There are various ways to analyze optimal allocation of land use problem. Barbier and Burgress (1997) developed a cost benefit rule for allocating land use between agriculture and timber at the stand and forest level in tropical countries and a demand relationship for the optimal conversion of forest land that could be estimated at the country or regional level. Burton (1996) designed a mechanism for the allocation of environmental resources for competing uses, intensive, non–intensive and wilderness between industry forestry and environmentalists in the case, some of uses of the environment may result externalities for other group by using the mechanism that was designed in the literature of the optimal provision of public goods in order to elicit each group's truth preferences. Lopez *et al.* (1994) developed a simple supply–demand model to derive an optimal allocation of land uses between agriculture and urban activities in the U.S by including amenity benefits of farmland that the market fails to capture into their model so that the aggregate social returns from various uses are maximized. In the case that one agent is more interested in community forestry while the other is more interested in conservation, but both agents view that their utility will be maximized if they consume some of the other's goods. Thus, it is important that each group reports their preferences over an allocation of the land use between conservation and community forestry.

Therefore, the objective of this study is to develop a model that could propose the optimal allocation of the park's forestland between these two interests.

CONCEPTUAL FRAMEWORK

There are two competing interests over the land use in the park. The community forestry working group, who provide technical supports to the local communities in managing community forestry, is interested in more land to be allocated for community forestry so that the livelihood of the local communities is improved and the poverty is reduced. On other hand, the conservation group is interested in more land to be allocated for conservation, since the park harbors high biodiversity, high conservation values, its suitable for the development of ecologically sensitive recreational facilities and its value as an area, where scientific research and environmental education will contribute to conservation in Cambodia.

The community forestry working group value the land use based on habitat because of its productivity; whereas the conservation group values the land use based on zone because of conservation value. Thus, the available forestland can be partitioned into an $n \times m$ matrix as follows:

$$L = \begin{bmatrix} L_{11} & L_{12} & . & L_{1n} \\ L_{21} & L_{22} & . & L_{2n} \\ . & . & . & . \\ . & . & . & . \\ L_{m1} & L_{m2} & . & L_{mn} \end{bmatrix},$$

where each entry of the matrix L_{ij} represents the amount of land in category's i (habitat) of the community forestry working group and in the category's j (zone) of the conservation group. But only two habitats (evergreen forest and mangrove forest) are considered in this model because they are dominant habitats. There are five zones in this park. They are Core Conservation Zone, General Conservation Zone, Managed Resource Zone, Park Development Zone, and Community Development Zone. But only two zones, general conservation zone and managed resource zone are considered in this model since other zones are either strictly protected or lacked of habitats. Thus, the general $n \times m$ matrix above is reduced to a 2×2 matrix. But since a land in the category of both groups (L_{ij}) must be reallocated between community forestry and conservation, then L_{ij} can be represented as

$$L_{ij} = F_{ij} + C_{ij} \quad (1)$$

where F_{ij} denotes community forestry land in the i^{th} habitat and the j^{th} zone. And C_{ij}, denotes conservation land in the i^{th} habitat and the j^{th} zone.

In this model, it is assumed that if F_{ij} is held constant and C_{ij} is allowed to increase, the marginal utility of the community forestry–working group should increase, but at diminishing return. This is because conservation yields amenity benefits to the locals as well in terms of recreations, environmental benefits, and possibly indirect income generation through ecotourism in the future, particularly whenever the income overwhelms the income from community forestry. There are two reasons for this. First as more lands are added to community forestry, the size of the area increase and therefore the cost and the management difficulty should also increase. The distance and travel time to collect resources would increase as well. As a result the opportunity cost may increase. Second, the areas for recreations and amenity benefits might also diminish. Nonetheless, conservation might not be assumed to be a perfect substitute for community forestry because the locals' livelihoods at present depend mainly on the forest products and non–forest products, but not on conservation. Thus, it is assumed that the group views that its utility would be maximized if it chooses to have a certain amount of conservation land. Therefore, the preferences of the group at each of its category might be expressed by a utility function as

$$U_i\,(F, C) = F_{ij}^{a_i}\, C_{ij}^{b_i} \tag{2}$$

Where a_i and b_i are constants.

It is also assumed that if C_{ij} is held constant and F_{ij} is permitted to increase, the marginal utility of the conservation group should increase, but at diminishing return. This is because community forestry would restore the environment and the biodiversity in the general conservation zone and in the managed resource zone, where habitats are relatively degraded. This implies that community forestry should provide positive externalities to the conservation group. There are two reasons for the diminishing return: First, if more lands are added to conservation, the size of the area increases. As the area becomes lager, more efforts in managing the park are required such as the recruitment of more rangers to protect the park from human disturbance and the ecosystem management. And therefore the cost should increase. All protected areas in Cambodia are disturbed by human activities such as logging, hunting of wildlife and encroachment for settlement and agriculture. Second, species diversity diminishes as area increases (Barret, 1993). However, community forestry might not be assumed to be a perfect substitute for conservation although community forestry has characteristics of sustainable use of resources, there are still many challenges remaining in community forestry (Warner, 1997; Lindyati, 2000; Luukkanen and Kappi, 2002). Those include the task of integrating conservation and development, participation by locals, resource management conflict, equity and decentralization (Warner, 1997). In addition, if community forestry is aimed at less conserving as Warner (1997) argues, community forestry would contribute less to restoring biodiveristy and environment. Then, community forestry may yield negative externalities to the conversation group if it is introduced in pristine habitats such as in the core conservation zone. Thus, it is assumed that the group views that its utility would be maximized if it chooses to have a certain amount of community forestry land in the conservation area, where habitat is degraded at some degree. Therefore, a preference of the group at each of its category might be expressed by a utility function as

$$U_j\,(F, C) = F_{ij}^{\alpha_j}\, C_{ij}^{\beta_j} \tag{3}$$

Where α_j and β_j are constants.

In addition, the evergreen forest is assumed to provide more profits than the mangrove forest in terms of forest products and non–forest products (NTFPs) given all habitats are in the same conditions (Nophea *et al.*, 2001; Kim *et al.*, 2001; De Lopez *et al.*, 2001; Rose *et al.*, 2002). The environmental benefits of each habitat are relaxed. Similarly, the general conservation zone should have higher conservation values than the managed resource zone. Because according to the management plan of the park, the general conservation zone has moderate conservation values, high biodiversity values, moderately disturbed habitats and relative accessibility. This zone encompasses mostly evergreen habitat and some mangrove forest; whereas the managed resource zone has highly disturbed natural habitats, high accessibility and high levels of existing use by locals and a potential for joint conservation management with the local communities. Moreover, the general conservation zone is more restricted than in the managed resource zone. For instance, subsistence gathering of NTFPs are allowed, but not for commercial purposes in the general conservation zone; while these are permitted in the managed resource zone. Although the managed resource zone might have less conservation value in overall, most of habitat is the mangrove forest and some of this might still harbors important sits for large waterbird conservation and shoreline protections from storms and soil erosion.

METHODS

The Vickery Bidding Method

Each group was asked to report their true preferences through an artificial bidding adapted from this method, a technique in which the highest bidder wins auction and pays only the second highest bid. In this bidding each person in each group was given artificial values of land with different sizes in the category of the other group as artificial money to pay when he bid for the land in his category (see Appendixes I and II). Each person was asked to bid competitively within his group in two successive rounds. The second highest bid in the first round was shown to the top bidder, while the third highest bid was shown to other lower bidders (Vickery, 1961). In this round, no land was transferred to any person's account no matter what he loss or won. In the second round, each bidder was informed that if his bid was the highest, he won and $[1-(b_i-b_{-i}^{\frac{1}{8}})/b_{-i}]$ was transferred into his account. Where b_i and b_{-i} were the person i's bid and the second highest bid respectively. Each bidder was required to bid for his category. Since each person was informed that if his account was largest within his group, his preferences would be used in the allocation, each bidder's optimal strategy was to bid equal to his true preferences or truth revealing. Bidding less or higher than his true preferences will not result in increasing his account (see Appendix III for details). Although each individual is required to bid within his group, this will not affect individual's revealing his true preferences if he is rational because each somehow wishes to win within his group so that the allocation truly represents his preferences. Moreover, showing the third highest bid to other lower bidders would not affect his preferences since the third highest bid is below his true preferences. Thus in the second round, each bidder would still bid to his true preferences in hope that he could win and enjoy surplus or net gain.

At this point, the social planner should be able to allocate the land since the planner knows both groups have an incentive to report their true preferences. The optimization problem is then to maximize the utilities of both groups, but is subjected to a limited land as shown in the equation (1).

$$\begin{aligned} L(F, C) &= U_i(F, C) + U_j(F, C) - \lambda_k [F_{ij} + C_{ij} - L_{ij}],\ i=1,2\,;\ j=1,2 \\ &= F_{ij}^{a_i} C_{ij}^{b_i} + F_{ij}^{a_j} C_{ij}^{\beta_j} - \lambda_{ij} [F_{ij} + C_{ij} - L_{ij}] \end{aligned} \tag{4}$$

And the first order conditions are:

$$\partial L./\partial F_{ij}. = a_i F_{ij}^{a_i - 1} C_{ij}^{b_i} + \alpha_j F_{ij}^{\alpha_j - 1} C_{ij}^{\beta_j} - \lambda_{ij} = 0$$

$$\partial L./\partial C_{ij.}=b_i F_{ij}^{a_i} C_{ij}^{b_i-1}+\beta_{ij} F_{ij}^{\alpha_j} C_{ij}^{\beta_j-1}-\lambda_{ij}=0$$

Moving the term λ_{ij} to the right side of these equations and setting to equal gives

$$a_i F_{ij}^{a_i-1} C_{ij}^{b_i}+\alpha_j F_{ij}^{\alpha_j-1} C_{ij}^{\beta_j}=b_i F_{ij}^{a_i} C_{ij}^{b_i-1}+\beta_{ij} F_{ij}^{\alpha_j} C_{ij}^{\beta_j-1}$$

$$a_i \left(\frac{C_{ij}}{F_{ij}}\right)^{b_i}+\alpha_j \left(\frac{C_{ij}}{F_{ij}}\right)^{\beta_j}=b_i \left[\left(\frac{C_{ij}}{F_{ij}}\right)^{-a_i}\right]+\beta_j \left[\left(\frac{C_{ij}}{F_{ij}}\right)^{-\alpha_j}\right] \quad \text{(A)}$$

Because it is assumed that $a+b=1$, and $\alpha+\beta=1$

Parameter Estimation

Before the equation (A) can be solved, it is necessary that the constants be estimated. Here we show how the constants α_j and β_j of equation (3) might be estimated:

If $\alpha_j+\beta_j=1$ (5)

$$MRS=U'_{Cj}/U'_{Fj}=\beta_j/\alpha_j\, F_{ij}/C_{ij} \quad (6)$$

But $e_{Cj,Fj}=U'_{Fj}/U'_{Cj}\, F_{ij}/C_{ij}$ or $U'_{Cj}/U'_{Fj}=(1/e_{Cj,Fj})\, C_{ij}/F_{ij}$ (7)

(6)=(7) then, $1/e_{Cj,Fj}=\beta_j/\alpha_j$ (8)

Because $e_{Cj,Fj}=Q_j$, where $C_{ij}=K F_{ij}^{Q_j}$ (K is a constant), (9)

Then (5) and (8) gives

$\beta_j=1/(1+e_{Cj,Fj})$ or $=1/(1+Q_j)$ and

$\alpha_j=e_{Cj,Fj}/(1+e_{Cj,Fj})=Q_j/(1+Q_j)$

The constants a_i and b_i of the equation (2) were derived as similar procedure as shown above,

$a_i+b_i=1$ and $F_{ij}=\eta C_{ij}^{P_i}$ (η is a constant) (10)

$a_i=1/(1+e_{Fi,Ci})$ or $=1/(1+P_i)$ and

$b_i=e_{Fi,Ci}/(1+e_{Fi,Ci}) = P_i/(1+P_i)$

The equation (9) has been estimated as follows: A person in the conservation group was asked to report his preferences by filling out the questionnaire II (see Appendix II). This questionnaire is a table of artificial values of the community forestry lands (F_{ij}) with different sizes given as artificial money to pay when he bids for the conservation lands (C_{ij}). For instance, having 7,870 ha of community forestry land the person prefers to bid (exchange) 7.5 ha of his given community forestry land for 1 ha of the land in the general conservation zone. Given this exchange rate and his available artificial money 7,870 ha, the person prefers to buy 1,000 ha from this zone and left the remained land, 370 ha for community forestry land. This means that the conservation value of 1,000 ha in the general conservation zone requires 7,500 ha (7.5×1000) of community forestry land. This was recorded as C_{ij} and 370 ha (370=7,870–7,500) was recorded as F_{ij}. The person was asked to complete the rest values for the general conservation zone. Given the entire the conservation group reports their preferences; the elasticity Q_j for general conservation zone could be estimated from the equation (9). This process is repeated for the managed resource zone.

Similarly the equation (10) has been derived the same process as the equation (9) has, but the people were from the community forestry working group. For instance, having 7,870 ha of conservation land, a community forestry worker prefers to bid 6.4 ha of conservation land for 1 ha of community forestry land in the evergreen forest. Given this exchange rate and his available money 7,870 ha, the person prefers to buy 1,000 ha from this forest and left the remained land, 370 ha for community forestry land. This means that the person valued 1,000 ha of community forestry land equal to 6,400 ha (6.4×1000) of conservation land in the evergreen forest. This was recorded as F_{ij} and 370 ha (370= 7,870−7,500) was recorded as C_{ij}. The person was asked to complete the rest values for the evergreen forest. Given the entire the community forestry group reports their preferences; the equation (10) could be used to estimate the elasticity P_i for the evergreen forest. This process is repeated for MF.

Questionnaire Design

Choosing values for the questionnaire I and II were arbitrarily and were based on random numbers generated by a computer using function RANDBEWTEEN (,) in EXCEL. The lower bound value and the upper bound value were predetermined. The smallest size of the protected areas of Cambodia is 5,000 ha and the size of the park is 21,000 ha. Therefore, 5,000 and 22,000 were the lower bound value and the upper bound value respectively. The number 22,000 was included to capture the size of the park. The number 7,870 and 21,500 were selected as the lower bound and the upper bound values since they were the first smallest and the largest numbers among the random numbers that were generated by the computer at that time. A range of values 7,870, 8,370 ... 21,500 were generated and were indicated in the top row in the questionnaire as artificial money for each bidder (see Appendixes I and II). These values appear in hectare. They were used to elicit preferences of each bidder i.e. how would each bidder prefer to give value for the land in his category as artificial money is more available to him.

The brief information about each zone, its conservation values and the socio–economic context of the park was provided for each bidder's update information although some of those have been aware of. The information was given so that each bidder could use to incorporate into their preferences when opting their bidding strategy. Some researchers use population and income as variables in studies of land use allocations. Barbier and Burgress (1997) included population and real GNP as variables in their model in the analysis of deforestation across the tropics and Lopez *et al.* (1994) included population and income per capita in their model in land use allocation for the preservation of agricultural land. However, Cropper and Griffiths (1992) who studied on the effect of population growth on deforestation in the tropical countries concluded that it was inappropriate to include population as a main cause of deforestation, but rather from other factors such as poverty and a problem of market failure. Owing to Barbier and Burgress (1997) and Lopez *et al.* (1992), as population increases the demand for forestland, as a source of income generation should increases and as livelihood improves, the demand for recreation and preservation of nature should increase and therefore the demand for forestland should decreases.

The formula $[1-(b_i-(b_{-i})^{\frac{1}{8}})/b_{-i}]$ was designed to transfer accounts of successful bidders and was used to distinguish the true bids and untrue bids. For example, a successful conservationist bidder submitted a bid of 11 ha of community forestry land for 1 ha of land in the general conservation zone and the second highest bid was 7.4 ha. Thus his net gain is $1-(10-(7.4)^{\frac{1}{8}})/7.4=-0.18$. Therefore, 1.80 (10×0.18) per hectare is subtracted from his account for the general conservation zone. Since he decided to buy 1,000 ha from this zone, the total subtraction was 1,800 ha. Therefore, his bid was not used to estimate the elasticity Q of the general conservation zone, but the second highest bid was since it is assumed to be the true bid (see Appendix Ⅲ). Tie bids or bids that have positive or zero net gains were assumed to bid equal to their true preferences (see Appendix Ⅲ) and were used to estimate the parameters. $(b_{-i})^{\frac{1}{8}}$ was used to stabilize bidding value. That is as b_{-i} grows larger, $(b_{-i})^{\frac{1}{8}}$ stays constant as Figure 1 shown. Adding one more square root would not create a very significant difference for the values as indicated in the horizontal axe in Figure 1.

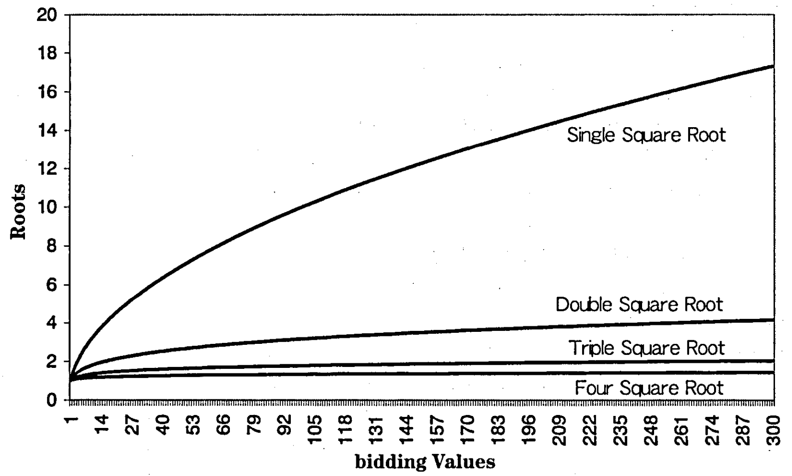

Fig. 1. Graph shows roots of bidding values given different square roots.

Data Collection

Data was collected during the survey in October 2003 in Cambodia. The target groups were the community forestry working group and the conservation group. The community forestry–working group was those who worked for local NGOs, the government institutions such as the community forestry unit within the Department of Nature Conservation and Protection of MoE and individuals who are interested in community development and advocacy. Most of these people have at least two–year experiences and are currently working for community forestry in Cambodia. Most of them know about the situation and the livelihoods of the local communities in the park. The conservation group was those who were mainly from the Department of Nature Conservation and Protection of the Ministry of Environment, the local conservation NGOs and interested individuals. Most of them are field ecologists or field biologists and are currently working for the above institutions.

Individuals in each group were explained the purpose of the study and the procedures in the bidding i.e. the instructions written in the questionnaire were step by step clarified and examples were demonstrated as explained in the equation (9)'s and the equation (10)'s until bidders were clear. Each person in each group was asked to fill a questionnaire twice, the first and the second rounds. When understood the instructions, each bidder was allowed to start bidding. For convenience in filling the questionnaire those, who do not have or have a limited knowledge about Excel, were also instructed. In addition, each was also informed about potential bidders involving in the bidding. The allocated time for each bidder to fill out a questionnaire was one week in the first round. Questionnaires were collected according to the deadline. Allowing 2 days to sort for the highest bid, the second highest bid and the third highest bid, the results of the first round i.e. the second highest bid and the third highest bid (the effective price) were shown to the top bidder and to other low bidders respectively. In the second round, each bidder was asked to fill the second questionnaire and to return it to the surveyor within a week. There were 25 bidders in each group. Bids of those whose accounts have a positive net gain were assumed to be the true bids and were used in estimating the parameters.

RESULTS AND DISCUSSION

The results of the estimated constants a_i , b_i and the elasticity P_i of the community forestry working group and the estimated constants α_j, β_j and the elasticity Q_j of the conservation group are shown in Table 1.

Table 1. The Results of Estimated Parameters.

Habitat	a	b	P	Zone	α	β	Q
Evergreen Forest	0.65	0.35	0.54	General Conservation Zone	0.20	0.80	0.25
Mangrove Forest	0.57	0.43	0.75	Managed Resource Zone	0.72	0.28	2.57

This table shows the preference intensities of each group over the allocation of the lands within their category that are habitats and zone between conservation and community forestry. And the available areas in the park, L_{ij} that are in the community forestry working group's the category and in the conservation group's the category calculated from the Cambodia Forest Cover data of 1997 produced by MRC using ArcView 3.1 software are shown in table 2(L_{ij}). And the optimal allocations of land use between conservation and community forestry in the category of the conservation group and in the category of the community forestry–working group are shown in Table 2. They were obtained from the equation (A), where the total utility of the conservation group and the community forestry–working group at the category of both groups is maximized. Although other point is feasible, the total utility of both groups is neither maximized nor the land is used up.

Interestingly, the results in Table 1 reveal the preferences of both groups over the

Table 2. The Results of the Optimal Allocation Between Community Forestry and Conservation (ha).

		Habitat			
		Evergreen Forest		Mangrove Forest	
		$L_{11}=4{,}613$		$L_{12}=960$	
Zone	General Conservation Zone	$C_{11}=2{,}742$	$F_{11}=1{,}871$	$C_{12}=608$	$F_{12}=352$
		$L_{21}=712$		$L_{22}=1664$	
	Managed Resource Zone	$C_{21}=237$	$F_{21}=475$	$C_{22}=1{,}079$	$F_{22}=585$

Note: $L_{ij}=C_{ij}+F_{ij}$, where F_{ij} denotes community forestry land in the i^{th} habitat and the j^{th} zone. And C_{ij}, denotes conservation land in the i^{th} habitat and the j^{th} zone.

land allocations between conservation and community forestry in their category. The conservation group prefers to have more land to be allocated for community forestry in the managed resource zone, while less in the general conservation zone. This implies that areas that do not have high conservation values are of their less interest. This could be because they believe that given more land is allocated for community forestry in the managed resource zone, where the significant conservation values have already gone, the degraded habitats and the natural environment in this zone would be restored according to the characteristics of community forestry as mentioned somewhere in the introduction part and this would otherwise increase their utility. The conservation group's preferences over community forestry are consistent to the previous assumption that community forestry has positive externalities to them. Whereas the community forestry working group's revelation of its preference intensity in the evergreen forest was a little bit higher than in the mangrove forest, but was not as extremely as that of the conservation group, who valued the general conservation zone much higher than the managed resource zone. The revelation of the community forestry working group's preferences shows that the group does advocate for the conservation although less than community forestry is. This is consistent to the assumption made earlier conservation may also provide utility to the community forestry working group.

Table 2 suggests the optimal allocations between conservation and community forestry within zones and habitats. For instance, among 4,613 ha of the evergreen forest in the general conservation zone, 1,871 ha of which could be allocated for community forestry and 2,742 of which could be allocated for conservation. Similarly among 712 ha of the evergreen forest in the managed resource zone, 475 ha of which could be allocated for community forestry and 237 ha of which could be allocated for conservation. Among 960 ha of the mangrove forest in the general conservation zone, 352 ha of which could be allocated for community forestry and 608 ha of which could be allocated for conservation. And similarly among 1,664 ha of the mangrove forest in the managed resource zone, 1,079 ha of which could be allocated for community forestry and 585 ha of which could be allocated for conservation.

Using the results of Table 2, the rate of substitution between zones is 2.94 ha. It tells that the conservation group is willing to exchange 2.94 ha of forest land in the managed resource zone for 1 ha of forest land in the general conservation zone. And the rate of substitution between habitats is 1.18 ha. This means that the conservation group is willing to exchange 1.18 ha of forest land in the evergreen forest for 1 ha of forest land in the mangrove forest. These are consistent to our hierarchical value assumptions for the category of both groups i.e. the conservation group values the general conservation almost 3 times higher than the managed resource zone, while the community forestry working group values the evergreen forest 1.18 times more than the mangrove forest in terms of profit generation from forest products and NTFPs, given all habitats are in the same conditions. If population and income of the local residents were important variables to have relationship with this allocation preferences as Lopez *et al.* (1994) included population and income per capita in their model in land use allocation agriculture and urban. Barbier and Burgress (1997) included population and real GNP as variables in their model in the analysis of deforestation across the tropics, then provided these in the questionnaires would have changed their preferences in this allocation. In other words, respondents would adjust their preferences accordingly at different levels of information.

Nevertheless, the limitation in Table 2 is that areas, L_{ij} in the community forestry working group's of the category and in the conservation group's the category were calculated based on the data produced by Mekong River Commission in 1997. Some habitats could have been changed since then. Unfortunately, a ground check was not done due to time constraint in this study plus other difficulties. Therefore, other factors such as conservation values in each locality that is critically important habitats for wildlife or endangered species of plants should be subject to scrutiny before a land is delineated and distributed to the locals although optimal allocations have been suggested. Furthermore, location and accessibility, which are convenient for users and habitat conditions, should also be considered before allocation is made. In this case, detail filed assessment might be necessary so that a decision is appropriately made before any area is allocated for community forestry whether should be in the general conservation zone or in the managed resource zone. Thus delineating highly depends upon the degree of conservation significance of each locality and the resource availability in each habitat for the potential income generation for the locals' livelihood.

POLICY IMPLICATIONS AND CONCLUSIONS

The results in Table 2 suggest the optimal allocations between conservation and community forestry in the general conservation zone and in the managed resource zone within both habitats. In accordance to the management prescription of the park, the general conservation zone can be allowed to access for the sustainable gathering of non–timber forest products (NTFPs) only, while harvesting trees, poles for construction or commercial purposes are prohibited. The harvesting of NTFPs is permitted in a defined season or period and in some locations, where habitats are vulnerable and NTFP collection is phased out. Given these restrictions, it implies that harvesting of timber would not be permitted if community forestry were the only possible to be in the general conservation zone. This is contrary to the purpose of community forestry, which harvesting of timber is possible. Therefore, the following options are evaluated for considerations:

Option 1: community forestry should be confined in managed resource zone

Evergreen Forest

Table 2 shows that 1,871 ha of the evergreen forest in the general conservation zone could be allocated for community forestry, but there are 237 ha of conservation land in the managed resource zone. But this land has approximately equivalent conservation value to 81 ha (237/2.94) in the general conservation zone because the rate of substitution between zones is 2.94 per hectare. Then additional evergreen forestland of 1,790 ha (1,871–81) in the general conservation zone should be added to the managed resource zone if this option is chosen and if necessary. If some of the managed resource zone harbors important habitats for conservation and could not be transferred to community forestry, then it is simply that the area be reallocated to the general conservation zone and 1,871 ha of the general consecration zone be added to the managed resource zone directly.

Mangrove Forest

Table 2 also suggests that 352 ha of mangrove forest in the general conservation zone could be used for community forestry, but there are 585 ha of conservation land in the managed resource zone. But this land has approximately equivalent conservation value to 199 ha in the general conservation zone because the rate of substitution between zones is 2.94 per hectare. Then additional mangrove forestland of 153 ha (352–199) in the general conservation zone should be added to the managed resource zone if this option is chosen and if necessary.

Option 2: community forestry could be permitted in both zones

If some of the evergreen forest in the general conservation zone is not delineated and added to the managed resource zone, but restrictions are applied in the general conservation zone than in the managed resource zone owing to the management prescription of the park, some issues might happen because the benefit flow from timber, which are more available in the general conservation zone than that in the managed resource zone will be forgone. Provided that this opportunity is forgone, the locals would have little incentive in participating the rehabilitation of the degraded habitats in the managed resource zone because potential gains from community forestry that the locals could benefit from community forestry could fluctuate widely over time and this would create little incentive for the locals, especially the poor to see and commit themselves for secure ownership of the scheme (Kumar, 2002). This is true because most habitats in the managed resource zone are considerably degraded and should the degraded habitats in the managed resource zone are promoted to rehabilitate, then incentives should be considered. Therefore, Option 1 should be considered when the allocation is made for community forestry, but field assessment must be done before deciding a site for community forestry in order to avoid allocating important sits that are particularly important for conservation. Although the managed resource zone in general has less conservation value than in the general conservation zone, some of it are still important habitats for protections and conservation. This option is also might be preferred by the conservation group as the results in Table 1 show the preferences of the conservation group over the land allocation between conservation and community forestry in the managed resource zone.

Appendix I. Questionnaire for Community Forestry Working Group

Dear Sir/ Madam,

My name is Net Neath, a graduate student majoring in Agricultural Resource Economics at Kyushu University, Japan. Currently, I am conducting research on land use allocation between Community Forestry (CF) and Conservation/ wilderness (CA) in the Ream National park, Cambodia. Two groups, CA group and your group are invited to involve in expressing opinions this allocation through constructing artificial bidding. However before bidding below, I would like to give you the brief information about the park for your update information your responses will be used in writing a thesis only and will be remained confidential. Please, feel free to answer the questions.

Brief Background

Ream was declared as a national park in 1993 and law enforcement was begun in 1996. Those, who have engaged in logging, hunting, extracting specific plants in the core zone either for subsistence and commercial purposes, were no longer allowed. Since then the conflicts between the conservation and the resource use in park has arisen. Before this, people could access freely to the resources. Conflicts and environmental degradation may still continue. A lack of local participation in conservation and management may posit a constraint in the long term conservation; and the enforcement may intensify conflicts. And law enforcement is costly, which currently the Ministry of Environment can not afford adequately. If a substitute provided with an effective property rights regime might orchestrate the competing interests between the resource utilization and the conservation in the park. At present, only few villages has recently been granted CF land as a polite project demonstration; however, many do not have CF and there is a demand for others. This study attempts to propose an optimal allocation of forest land between CF and CA when there is a desire for reconsideration of restoring the local community's welfare.

There are two types of habitats considered in this study: evergreen forest (EF) and mangrove forest (MF). The evergreen forest covers on the mainland and the islands at elevation up to 240 msl. This forest can attain a height more than 30 meters. The dominant species are Dipterocarpus costa (neang deng), Anisopter oblinga (pdiek), Shorea hypochra (Koki phonong), Heritiera sp. (dong chem), Dipterocarpus dyeri (chhoeuteal) and Irvingia olivieri (jumbok); the stocking rate of the primary forest (diameter > 10 cm) is 73.7 m^3/ha (fuelwood is 20.7 m^3/ha and all other stocks, diameter > 30 cm is 53.0 m^3/ha). The density of stocks, diameter > 45 cm is 30.60 m^3/ha, of which the commercial species is 14 m^3/ha. However, this forest is generally substantially degraded due to the commercial species extraction and is assumed to remain about 7 m^3/ha. While the mangrove forests remain some relatively intact habitat. The mean height diameter at breast is 8.7 cm and the standing volume is 62.1 cm^3/ha. Rihzophora apiculata is particularly common through the habitat, while Rihzophora mucronata is found along the waterways and channels. Rear mangrove dominated by Melaleuca leucodendron species (smach).

About 4,640 households (26,600 people), living in five communes around the park depend on the resources. Almost 84% of households gather firewood totally 44,788 m^3

each year or 11.5 m^3 is consumed per household a year. About 3% of households collect construction materials, with a total of annual demand of 4,192 m^3 or 30 m^3 is demanded by a household. About 18% of households collect wild plants for food, medicines and handicrafts. The total quantity collected is 47,240 kg per year or 56.56 kg is collected by a household a year. The annual population growth in the area is approximately 1%. The poverty line in these local communities is between 25–50%, a very high rate. The average annual income of households is about $233 (Ros Seilava *et al.,* 2001); income of 32% households is less than $200, less than a dollar a day. The livelihoods of the majority lack basic amenities such as clean water, food, adequate housing, and clothing. Forest resources serve as the main domestic energy, wild foods, construction materials, and materials for handicrafts. Basic health care, infrastructure, and education are still poor, especially in villages lying further away from the main road, and nearer to the park.

Bidding Rules

i) – suppose you are given CA lands appearing from row CA1 through row CA6 in the table below. In each row are CA land categories 7,870 ha, 8,370 ha... 21,500 ha. You are given each land category as artificial money to pay when bidding the CF land for each habitat in that land category so that you can increase your account (preference). There are two successive rounds of bidding within your group: the first round and the second round. After the first round is completed, the result of the second highest bid will be shown to you. In this round, no land is transferred to any person no matter you or others lose. ii) – in the second round, it requires that if your bid in a land category is the highest, you win and $[1-(b_i-(b_{-i})^{\frac{1}{8}})/b_{-i}]$ is transferred into your account. Where b_i is your bid, the number of CA land you prefer to exchange for 1 ha of CF land for each habitat and b_{-i} is the second highest bid. iii) – you are required to bid each habitat and to indicate your preferences in column A. Whether your land account is increased, decreased or remained the same depends on how you bid in the second round i.e. $[1-(b_i-(b_{-i})^{\frac{1}{8}})/b_{-i}]$ could be positive, zero or negative. If it is negative, of course your account is decreased, but if is positive your account is increased. If your account is the largest within your group, then your preference is selected.

Now in column A, how many hectares of CA land would you like to exchange for 1 ha of CF land in each habitat? And in column B please, indicate the amount of CF land that you prefer to buy.

For example, imagine you have a value of 7,870 as you have 7,870 ha of CA land and if you think that you prefer to exchange 6 ha of CA for 1 ha of CF in EF, then indicate this in column A, row EF. Repeat this for MF. Next if you prefer to have 1,000 ha for CF, it costs value of 6,000 (1,000×6), then you should indicate 1,000 in column B, row EF. This means that of 7,870 ha of CA in EF 6,000 ha is allocated for the use of CF and 1,870ha (7,870–6,000) is left for CA.

I would like to thank you very much for filling the questionnaire. Once, I can gather all answers from the first round, I will send you the outcome of the first bid and I would like to you to fill the second one.

Note: There are 30 potential participants in CA group randomly invited in this bidding

(local and international NGOs, individuals and governmental institutes)

CA1	7,870 ha		8,370 ha		8,875 ha		9,380 ha		9,886 ha	
	A	B	A	B	A	B	A	B	A	B
EF										
MF										
CA2	10,390 ha		10,895 ha		11,400 ha		11,905 ha		12,400 ha	
	A	B	A	B	A	B	A	B	A	B
EF										
MF										
CA3	12,900 ha		13,430 ha		13,920 ha		14,422 ha		14,925 ha	
	A	B	A	B	A	B	A	B	A	B
EF										
MF										
CA4	15,429 ha		15,932 ha		16,436 ha		16,940 ha		17,460 ha	
	A	B	A	B	A	B	A	B	A	B
EF										
MF										
CA5	17,945 ha		18,448ha		18,900 ha		19,453 ha		20,460 ha	
	A	B	A	B	A	B	A	B	A	B
EF										
MF										
CA6	21,500 ha									
	A	B								
EF										
MF										

Appendix II. Questionnaire for Conservationist Group

Dear Sir/ Madam,

My name is Net Neath, a graduate student majoring in Agricultural Resource Economics at Kyushu University, Japan. Currently, I am conducting research on land use allocation between Community Forestry (CF) and Conservation/ wilderness (CA) in the Ream National park, Cambodia. Two groups, CA group and your group are invited to involve in expressing opinions this allocation through constructing artificial bidding. However before bidding below, I would like to give you the brief information about the park for your update information your responses will be used in writing a thesis only and will be remained confidential. Please, feel free to answer the questions.

Brief Background

Ream was declared as a national park in 1993 and law enforcement was begun in 1996. Those, who have engaged in logging, hunting, extracting specific plants in the core zone either for subsistence and commercial purposes, were no longer allowed. Since then the conflicts between the conservation and the resource use in park has arisen. Before this, people could access freely to the resources. Conflicts and environmental degradation may still continue. A lack of local participation in conservation and management may posit a constraint in the long term conservation; and the enforcement may intensify conflicts. And law enforcement is costly, which currently the Ministry of Environment can not afford adequately. If a substitute provided with an effective property rights regime might orchestrate the competing interests between the resource utilization and the conservation in the park. At present, only few villages has recently been granted CF land as a polite project demonstration; however, many do not have CF and there is a demand for others. This study attempts to propose an optimal allocation of forest land between CF and CA when there is a desire for reconsideration of restoring the local community's welfare.

Based on the Management Plan of the park prepared by MoE and IUCN (1996), there are Core Conservation Zone (CCZ), General Conservation Zone (GCZ), Park Development Zone (PDZ), Managed Resource Zone (MRZ), and Community Development Zone (CDZ). Only GCZ and MRZ are of interested in this study because CCZ is strictly protected. While PDZ is areas for tourism development sites such as headquarter, recreations and hiking areas. And CDZ is areas of human settlements, economic activities and a concentration of infrastructure and lacks of habitats. GCZ has moderate conservation values, high biodiversity values, moderately undisturbed habitats and relative accessibility. This zone may be allowed to access to NTFP only, but not for conversion to agricultural land or logging. MRZ has highly disturbed natural habitats, high accessibility and high levels of existing use by locals and a potential for joint conservation management with local community. Locals can access to resources in this zone either for commercial or domestic purposes.

About 4,640 households (26,600 people), living in five communes around the park depend on the resources. Almost 84% of households gather firewood totally 44,788 m^3 each year or 11.5 m^3 is consumed per household a year. About 3% of households collect construction materials, with a total of annual demand of 4,192 m^3 or 30 m^3 is demanded by a household. About 18% of households collect wild plants for food, medicines and handicrafts. The total quantity collected is 47,240 kg per year or 56.56 kg is collected by a household a year. The annual population growth in the area is approximately 1%. The poverty line in these local communities is between 25–50%, a very high rate. The average annual income of households is about \$233 (Ros *et al.*, 2001); income of 32% households is less than \$200, less than a dollar a day. The livelihoods of the majority lack basic amenities such as clean water, food, adequate housing, and clothing. Forest resources serve as the main domestic energy, wild foods, construction materials, and materials for handicrafts. Basic health care, infrastructure, and education are still poor, especially in villages lying further away from the main road, and nearer to the park.

Bidding Rules

i) – suppose you are given CF lands appearing from row CF1 through row CF6 in the table below. In each row are CF land categories 7,870 ha, 8,370 ha ... 21,500 ha. You are given each land category as artificial money to pay when bidding the CA land for each zone in that land category so that you can increase your account (preference). There are two successive rounds of bidding within your group: the first round and the second round.

After the first round is completed, the result of the second highest bid will be shown to you. In this round, no land is transferred to any person no matter you or others lose. ii) – in the second round, it requires that if your bid in a land category is the highest, you win and $[1-(b_i-(b_{-i})^{\frac{1}{8}})/b_{-i}]$ is transferred into your account. Where b_i is your bid, the number of CF land you prefer to exchange for 1 ha of CA land for each zone and b_{-i} is the second highest bid. iii) – you are required to bid each zone and indicate your preferences in column A. Whether your land account is increased, decreased or remained the same depends on how you bid in the second round i.e. $[1-(b_i-(b_{-i})^{\frac{1}{8}})/b_{-i}]$ could be positive, zero or negative. If it is negative, of course your account is decreased, but if positive your account is increased. If your account is the largest within your group, then your preference is selected.

Now in column A, how many hectares of CF land would you like to exchange for 1 ha of the CA land in each zone? In column B please, indicate the amount of CA land you prefer to buy.

For example, imagine you have a value of 7,870 as you have 7,870 ha of CF and if you think you prefer to exchange 6 ha of CF for 1 ha of GCZ for conservation, then indicate it in column A, row GCZ. Repeat this for MRZ. Next if you prefer to have 1,000 ha for conservation in GCZ, it costs value of 6,000 (1,000 × 6) or other words its equivalent CA is 6,000 ha, then you should indicate this in column A in row GCZ. This means that of 7,870 ha of CF in GCZ 6,000 ha is allocated for CA and 1,870ha (7,870–6,000) is left for CF.

CF1	7,870 ha		8,370 ha		8,875 ha		9,380 ha		9,886 ha	
	A	B	A	B	A	B	A	B	A	B
GCZ										
MRZ										
CF2	10,390 ha		10,895 ha		11,400 ha		11,905 ha		12,400 ha	
	A	B	A	B	A	B	A	B	A	B
GCZ										
MRZ										
CF3	12,900 ha		13,430 ha		13,920 ha		14,422 ha		14,925 ha	
	A	B	A	B	A	B	A	B	A	B
GCZ										
MRZ										
CF4	15,429 ha		15,932 ha		16,436 ha		16,940 ha		17,460 ha	
	A	B	A	B	A	B	A	B	A	B
GCZ										
MRZ										
CF5	17,945 ha		18,448 ha		18,900 ha		19,453 ha		20,460 ha	
	A	B	A	B	A	B	A	B	A	B
GCZ										
MRZ										
CF6	21,500 ha									
	A	B								
GCZ										
MR										

I would like to thank you very much for filling the questionnaire. Once, I can gather all answers from the first round, I will send you the outcome of the first bid and I would like to you to fill the second one.

Note: There are 30 potential participants in CA group randomly invited in this bidding (local and international NGOs, individuals and governmental institutes)

Appendix III

a- Explanation for bidding strategy

In the first round the person i would not bid truthfully since he speculates that the social planner will use this technique to allocate land use as informed in the instructions i.e. the person i would bid $b_i > U_i$, in hope that he could claim more land, where b_i is the untrue bid of the person i and U_i is his true bid, which is unobservable. However, since the person i is informed that there is another round of bidding and that if his bid is the highest, he wins and $[1-(b_i-(b_{-i})^{\frac{1}{8}})/b_{-i}]$ is transferred into his account, the person i's optimal strategy is to bid equal to his true revealing. Let's suppose that there are following possibilities in the second round:

1- If the person i bids $b_i^{(1)} > b_{-i} > U_i$, the net gain of the person i might be $[1-(b_i-(b_{-i})^{\frac{1}{8}})^{(1)}/b_{-i}] > 0$ and if $(b_i^{(1)}-b_{-i})$ is approximately close to zero, where b_{-i} is the second highest bid.
2- If $b_i^{(2)} >> U_i = b_{-i}$. The net gain of the person i might be $[1-(b_i-(b_{-i})^{\frac{1}{8}})^{(2)}/b_{-i}] < 0$
3- If $b^{(3)}_{-i} > U_i = b_i$, the person i loses the auction and will get zero net gain.
4- If $b_{-i} < U_i = b_i^{(4)}$, the person i wins the auction and enjoys the net gain $[1-(b_i-(b_{-i})^{\frac{1}{8}})^{(4)}/b_{-i}] > 0$

If the person i bids such that $b_i^{(1)} > b_{-i} > U_i$, thus we might argue that the net gain of the person i might be $[1-(b_i-(b_{-i})^{\frac{1}{8}})^{(1)}/b_{-i}] > 0$ in the case that $(b_i^{(1)}-(b_{-i})^{\frac{1}{8}})$ is approximately close to zero or $[1-(b_i-(b_{-i})^{\frac{1}{8}})^{(2)}/b_{-i}] < 0$ in the case of argument that the bid of the person i deviates far away from the second highest bid i.e. $b_i^{(2)} >> U_i = b_{-i}$. But in order to win the auction and to increase his account, the person i must bid somehow such that

$$[1-(b_i-(b_{-i})^{\frac{1}{8}})^{(1)}/b_{-i}] > 0 \quad \text{or} \quad 1 > (b_i-(b_{-i})^{\frac{1}{8}})^{(1)}/b_{-i}$$

$$\text{or} \quad 1+(b_{-i})^{\frac{1}{8}}/b_{-i} > b_i/b_{-i} > (b_{-i})^{\frac{1}{8}}/b_{-i} \qquad \text{(B)}$$

This implies that b_i is larger than $b_{-i}(b_i/b_{-i} > 1)$ because person i could win the auction only if his bid $b_i > b_{-i})$, then equation (B) reduces to $1+(b_{-i})^{\frac{1}{8}}/b_{-i} > b_i/b_{-i} > 1$ or $[1-(b_i-(b_{-i})^{\frac{1}{8}})^{(1)}/b_{-i}] > 0$ is assumed to be the same case as $[1-(b_i-(b_{-i})^{\frac{1}{8}})^{(4)}/b_{-i}] > 0$ because by symmetric information, each opts a strategy such that $b_i(v) = [(n-1)/n]\ v$ (Vickery, 1961). If each opts such a strategy, it must be true that $b_i - b_{-i}$ comes close to zero or zero if true bid because each bidder opts a bidding strategy $b_i(v) = [(n-1)/n]\ v$ and if valuations are uniformly distributed over the interval [0, 1] then the expected value of the highest bid is $E_i(v^*)=\int_0^1 vf(v)\ dv$, where $f(v)=nv^{n-1}$ is the probability density function of the probability that any particular v is the maximum among n bidders (See Vickery (1961) for details). Then $E_i\ (v^*)=n/(n+1)$. The expected value of the second highest bid is $E_{-i}\ (v^*)=\int_0^1 v\ g\ (v)\ dv$, where $g\ (v)=(n-1)\ (1-v)\ n\ v^{n-2}$, the probability given by the probability that any of n bidders will have a valuation exceeding that of n -2. Then $E_{-i}\ (v^*)=(n-1)/(n+1)$. $[b_i-b_{-i}]=[(n-1)/n]\ [n/(n+1)]-[(n-1)/n]\ [(n-1)/(n+1)]=(1-1/n)/(n+1)$. As n gets larger, $[b_i-b_{-i}]$ approaches zero. This is the case 4. Vickery (1961) found that bid usually stopped approximately at a level equal to the 2nd highest bid (the true value, U_i). Therefore, it must be the case that

$[1-(b_i-(b_{-i})^{\frac{1}{8}})^{(1)}/b_{-i}]=[1-(b_i-(b_{-i})^{\frac{1}{8}})^{(4)}/b_{-i}]>0$. The only case is then person i bids b_i such that b_i and b_{-i} are further apart from his true preference resulting in $[1-(b_i-(b_{-i})^{\frac{1}{8}})^{(2)}/b_{-i}]<0$.

The latter is created by the 2nd highest bidder in the second round that the top bidder will not know what the 2nd highest bidder will opt a strategy in the second round after the first result is shown. This creates uncertainty for each bidder. But if the person i bids equal to his or her true preference (indifference preference), then the person i will have a better chance to get a net gain $[1-(b_i-(b_{-i})^{\frac{1}{8}})^{(4)}/b_{-i}]>0$ and will have a negative net gain if he or she is still perverse to bid untruthfully. Therefore, in summary there are only three possible cases:

1– If the person i bids higher than the true value such that $b_i>b_{-i}>U_i$, the person i might have a net gain$=[1-(b_i-(b_{-i})^{\frac{1}{8}})/b_{-i}]<0$
2– If the person i bids such that $b_i=U_i<b_{-i}$, the person i loses the auction and will get a net gain$=0$
3– If the person i bids such that $b_i=U_i>b_{-i}$, the person i wins the auction and enjoys a net gain$=[1-(b_i-(b_{-i})^{\frac{1}{8}})/b_{-i}]>0$

The formula, $(b_i-(b_{-i})^{\frac{1}{8}})/b_{-i}$ and with the urging for the winning within the group, and getting a positive net gain, an optimal strategy of each bidder is to bid equal to his true preference or truth revealing. As a result, this could lead to tie bids.

b– Explanation of the transferring formula:

$[1-(b_i-(b_{-i})^{\frac{1}{8}})/b_{-i}]$ is chosen favoring to $[1-(b_i-b_{-i})/b_{-i}]$, $[1-(b_i-(b_{-i})^{\frac{1}{2}})/b_{-i}]$ or $[1-(b_i-(b_{-i})^{\frac{1}{4}})/b_{-i}]$ because as shown above, $[b_i-b_{-i}]$ should come close to 0 or 0 as the number of bidders is getting larger. However, the formula $[1-(b_i-b_{-i})/b_{-i}]$, $[1-(b_i-(b_{-i})^{\frac{1}{2}})/b_{-i}]$ or $[1-(b_i-(b_{-i})^{\frac{1}{4}})/b_{-i}]$ would give an incentive to the highest bidders to bid higher than his true valuation because $(b_i-b_{-i})/b_{-i}$ could still generate a value that is smaller than 1 and therefore, $[b_i-b_{-i}]$ may not be necessary close to 0 as long as $[b_i-b_{-i}]<b_{-i}$. This can be explained for $(b_i-(b_{-i})^{\frac{1}{2}})/b_{-i}$, or $(b_i-(b_{-i})^{\frac{1}{4}})/b_{-i}$, since as b_{-i} gets larger $(b_{-i})^{\frac{1}{2}}$ or $(b_{-i})^{\frac{1}{4}}$ also increases (see the graph). Only would $(b_{-i})^{\frac{1}{8}}$ stay approximately stable as b_{-i} gets larger across any real number. Therefore, $[1-(b_i-(b_{-i})^{\frac{1}{8}})/b_{-i}]$ would discourage the highest

bidders to adopt the untrue bidding strategy.

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