

Measuring poverty and income inequality under negative incomes: A case study from Myanmar¹

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Abstract

The purpose of this research article is to explore and discuss some possible methodological corrections to data from income and well-being surveys conducted in fragile eco-marketing systems. We seek to answer the question: "How can inequality best be portrayed so that corrective policies, programs, and projects can be put into place that will help to equalize economic opportunities and outcomes?" The data were collected in 2008 from 100 households each in Bagan, Central Myanmar and Kyaintali, Rakhine State on the Western coast of Myanmar. We challenge the use of traditional monetary welfare measures in two ways. Firstly, we demonstrate that negative income values pose significant problems to use of traditional equality measures, like the Gini coefficient. Secondly, the ranking between Bagan and Kyaintali regions provided by traditional monetary welfare measures reverses for some specific indicators such as land access. We argue that the latter more adequately reflect the situation of the poor rural population in Myanmar. Based on these results, we make policy recommendations for the two areas.

Keywords: Welfare distribution negative income, poverty, Lorenz curves, Gini Coefficient, Myanmar.

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01. **Introduction**

When economists measure income distribution or inequality in society, they typically use the yardstick of gross income or gross expenditure per household. Subtracting the latter from the former not only gives a more realistic indicator of net well-being, it also opens the mathematical possibility of observing negative incomes. Because household size differs and rural households are both consumers and producers of food, welfare should further be estimated both per capita and in terms of accrual, rather than cash, accounting. But the common practice in tracing daily income in farming households is to count income as annual sales of output in a certain season. Unavoidable estimation errors clearly result.

In theory, income is equal to expenditure plus savings but in a developing country where financial markets are frequently neither accessible nor mature, income and expenditures plus savings can be unbalanced at some times for many households, and most of the time for the chronically poor. By definition, negative savings are equivalent to negative incomes. But other non-definitional factors exacerbate negative income. These include:

- 1.1 Seasonal effects where farmers need to spend more than usual when they cannot get food supply from nature or their own farms
- 1.2 Periods where they have to invest for the next season
- 1.3 Unexpected shocks in certain years
- 1.4 Marriages and funeral ceremonies which are ritually costly in many cultures
- 1.5 Purchase of real estate and
- 1.6 Neglecting income sources from the informal economy, illegal markets and illegal lotteries.

Negative income is therefore unavoidable for some people at certain times, even in advanced industrial economies. The serious researcher cannot in good faith reject an observation with negative income from a primary dataset, set it to a missing value, or assume it to be zero; since so doing will distort or camouflage key dimensions of economic structure and go against the very spirit of welfare economic analysis. Moreover, informal or illicit economy data are by nature inaccessible because of legal or social prohibitions, elaborate measures to protect clandestine activities, or even danger to the research team.

Although negative incomes can be portrayed on a Lorenz curve, the calculation of Gini coefficients in this case gives erroneous results (Thant, 2009). To make matters more complicated, the complementary quintile measures of inequality⁴ may yield negative results when net incomes are used. In extreme cases of negative savings throughout the entire lowest economic class, even gross incomes will give negative values. Such negative values make it impossible to use or compare quantile ratios targeting corrective policies. Moreover, such naïve approaches as converting all negative incomes to 1 (since zero would also be incalculable) both are arbitrary and falsify the true distribution of income. These problems have pushed economists to seek other ways to detect the poorest of the poor for program targeting.

For example, a poor person's income does not necessarily equal what he would value. As early as in the **Wealth of Nations** (1776), Smith introduced the Diamond Paradox by differentiating the value in use from the value in exchange. His well-known example compares water, valued principally in use (utility), and diamonds, valued principally in exchange. Quite apart from the relative nature of income distribution, the poor depend much more upon goods and services they can use (like firewood, water, food, health care) than upon goods and commodities with high market value (jewelry, nominal income in a highly inflationary setting, etc.).

This is why measures of the "incidence of poverty"⁵ (percentage head-count of the poor in the total population) must be calibrated not just relatively, but against some real and objective measure such as one's purchasing power parity, PPP in USD\$ per

⁴ Typically the "decile" ratio between the average income of the highest 10 percent and the lowest ten percent or the "quintile" ratio between the highest 20 percent and the lowest 20 percent.

⁵ The terms incidence, depth and intensity of poverty were initially defined by Foster, Greer, Thorbecke (1984) and popularized by Ravallion (1998, 2008). They will be applied empirically later in this article.

person per day that ensures secure access to food and or calories. Among those who are below such a standard, one may then use the average "depth of absolute poverty" of the destitute in one community or social class as a key criterion for the targeting of the policy implication for government or NGO's social programs. Finally, the poorest of the poor may be further pinpointed by calculating the "intensity" of poverty (the average sum of the squares of the average depth) to isolate those geographical and social settings in the most precarious well-being.

The purpose of this research is to explore possible methodological corrections to standard Gini analysis and to show how they may be used for poverty intervention policies. We seek to determine the conditions that define different ecosystems in terms of productivity, sustainability, and overall welfare in order to render government welfare programs both more fiscally efficient and more socially effective. Based upon primary data from income and well-being surveys conducted in two fragile eco-marketing systems in Myanmar, we seek to answer the question: How can inequality best be portrayed so that corrective policies, programs, and projects can be put into place that will help to equalize economic opportunities and outcomes? Nutritional status, access to land and net income are viewed as proxy indicators of comparative wellbeing in the use value of environmental resources of households in different regions.

The data were collected in 2008 from a total of 200 households: 100 each in Bagan, Central Myanmar and Kyaintali, Rakhine State on the West coast of Myanmar. Monetary income and the use of natural resources for food differ markedly between the Bagan and Kyaintali regions due to the natural endowments of forest and common property resources, as well as the remote nature of Kyaintali as compared to Bagan, where transportation and communication are much better developed. Partly as a result, income inequality according to Smith's value in exchange is lower in Central Myanmar, while nutritional status (Smith's value in use) is higher in central Myanmar.

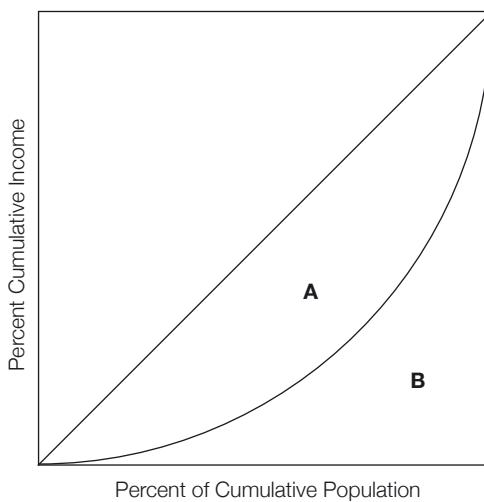
02. Concepts of the Lorenz curve and Gini coefficient

Put simply, the Lorenz curve offers a visual comparison between the actual and a perfectly equal distribution of land, credit, income, expenditures, food availability, health and other possible indicators of well-being. It shows how far away from perfect equality the actual distribution in society lies. A perfectly equal distribution would mean that each quantile — typically a centile, decile or quintile -- of the population has received an identical portion of a welfare input or output. When we speak of land or credit, we speak of equality in *ex ante opportunity*, what Sen Terms the "right to access" well-being, and what philosophers call "commutative justice." Most people would agree that perfect equality in opportunity, without discrimination or reverse discrimination, is a good thing. However, when we speak of food, income or its expenditure, we are normally referring to equality in the *ex post results* of the pursuit of such economic opportunities, in other words "distributive justice." Perfect equality in final incomes or physical welfare is not necessarily equitable because it gives equal rewards to unequal investments of effort, entrepreneurship, human capital, or inborn talent.

In the case of either commutative for an input or distributive justice for an output, perfect equality means that each proportion of the cumulative population will add an equal proportionate increase in the cumulative welfare-good. The line of perfect equality, the 45 degree line in Figure 1, means that the abscissa (cumulative percentage of population) and the ordinate (cumulative proportion of welfare-input or output) move in lock-step. If the distribution of a good tends to be absolutely unequal, the Lorenz curve asymptotically approaches the lower right-hand corner and the area between the absolute equality line and the actual distribution approach is maximized. If on the other hand, the distribution tends to be equal, the Lorenz Curve will asymptotically lie everywhere contingent

with the perfect equality line and the area between them will approach zero. The slope of separate Lorenz curves can then be analyzed for population or regional subgroups to determine which lies farthest away from the perfect distribution. It is those subgroups upon which we normally focus our policy and programmatic interventions to restore greater equality in the aggregate population.

Figure 1. Lorenz Curve and Gini Coefficient.



On the basis of the Lorenz curve for each subgroup, Gini coefficients may be calculated to numerically summarize the distribution of resource opportunities, physical welfare, or economic welfare. The Gini coefficient is calculated as the proportion from 0 to 1 of area A over the entire area (A+B) in Figure 1. Since the Gini calculation yields a single index for each subpopulation, it is particularly helpful when Lorenz curves for two subpopulations cross one or more times.

03. Empirical Evidence and interpretation of the Lorenz and Gini results

Gross income, net income per capita, and other welfare measures that may be potentially studied through the Lorenz-Gini approach are reported in Table 1. The two study regions differ significantly not only in the levels of welfare observed but also in some of the proximate causes of poverty and deprivation suggested by theory. While traditional welfare measures seem to indicate that Bagan is significantly better off than Kyaintali, this relation reverses for some specific indicators such as land access.

3.1. Procedures

Our Myanmar case study used land area per capita as a measure of ex ante commutative justice, i.e. Sen's access to opportunity, in Bagan and Kyaintali. Meanwhile, income, nutritional status, nutritional cost per day, and net income in exchange value (net income per capita – nutritional cost per capita)⁶ were used to compare welfare in terms of ex post distributive justice. For each of these indicators, Gini coefficients were calculated to indicate the degree of inequality of the welfare distribution in the populations of the two study eco-marketing zones.

Since the time series data and secondary data for the previous time period were not accessible in this study and the prices and income of a base year were unknown, real income and expenditures could not be calculated. Nominal income and expenditures were therefore used to indicate the state of distribution.

⁶ Income, food expenditure and net income (after deducting consumption of food, the most necessary and regular consumption good) were calculated per capita per day in US dollars.

04. Empirical Evidence and interpretation of the Lorenz and Gini results

4.1 Procedures

In our case study of Myanmar, the amount of land per capita and nutritional status (necessary for a healthy labour force) were used as a measure of *ex ante* commutative justice, or Sen's access to opportunity in Bagan and Kyaintali. Meanwhile, income, nutritional cost per day, and net income in exchange value (net income per capita — nutritional cost per capita) were used to compare welfare in terms of *ex post* distributive justice. Gini coefficients were therefore calculated to indicate the degree of inequality of the welfare distribution in the populations of the two study eco-marketing zones.

Since time series data and secondary data for the previous time period were not accessible in this study and the prices and income of a base year were unknown, real income and expenditures could not be calculated. Nominal income and expenditures were therefore used to indicate the state of distribution. Our estimation of nutritional status also demanded some methodological innovations. It was derived from a "food pyramid" constructed endogenously from the patterns of local consumption recorded in the survey questionnaire.

Table 1. Descriptive and comparative statistics on the two eco-marketing study zones

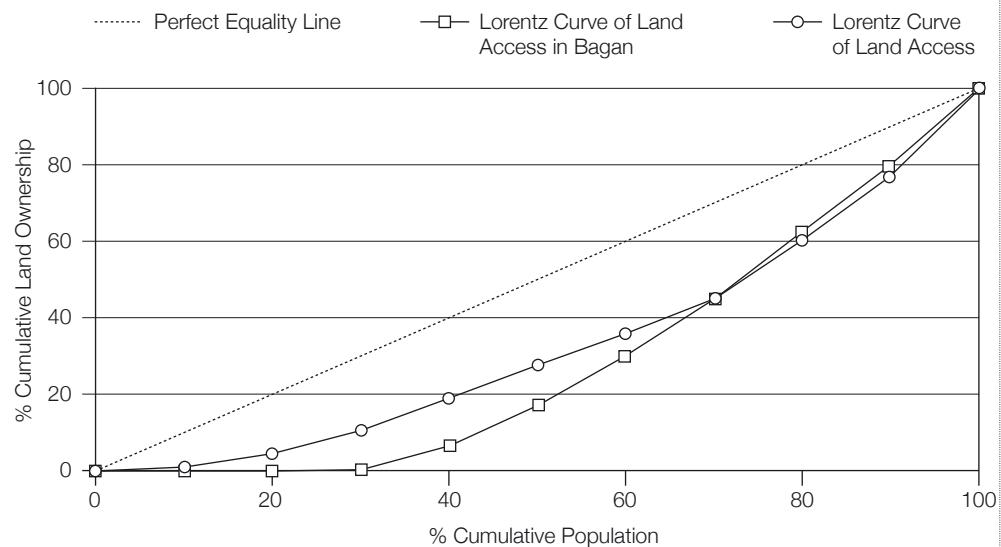
	Bagan, Central Burma (CB)				Kyaintali, Rakhine State (RS)				Tests of means	
	N	Mean	Std. Dev.	Coeff. Var.	N	Mean	Std. Dev.	Coeff. Var.	CB-AS	Sig. (2-tail)
Commutative justice										
How many acres of land do you have?	97	10.50	10.23	0.97	98	4.91	4.00	0.81	5.59	0.000 ***
Access to inputs score	100	-0.46	0.56	-1.22	100	-0.28	0.49	-1.80	-0.18	0.016 **
Distributive justice										
Gross income per capita	97	208346	216992	1.04	88	141235	129592	0.92	67111	0.013 **
Gross income - production costs	84	994015	989441	1.00	82	530726	456619	0.86	463290	0.000 ***
Net income per capita	83	181126	205744	1.14	82	120081	124030	1.03	61045	0.022 **
Nutritional cost per capita	100	486.15	271.98	0.56	94	435.86	332.22	0.76	50.29	0.249 n.s.
Nutritional Status	100	15.03	11.62	0.77	100	16.06	8.38	0.52	-1.02	0.476 n.s.
Rice consumption per capita	100	1.81	0.69	0.38	99	2.50	0.52	0.21	-0.69	0.000 ***
Dietary diversity	100	2.64	1.44	0.55	100	3.06	1.07	0.35	-0.42	0.020 **
Well-being determinants										
Age of household head	100	52.03	13.56	0.26	100	46.47	11.99	0.26	5.56	0.002 ***
Attachment to land	100	0.25	0.37	1.48	100	0.39	0.42	1.09	-0.14	0.013 **
Attitude to community management	97	0.55	0.60	1.10	100	0.31	0.44	1.42	0.24	0.002 ***
Attitude to conservation of species	97	0.86	0.53	0.62	100	0.63	0.47	0.75	0.23	0.002 ***
Attitude toward ecotourism	72	22.08	183.20	8.30	93	0.26	0.55	2.07	21.81	0.252 n.s.
Awareness of forestry	86	1.07	0.61	0.57	99	0.95	0.32	0.34	0.12	0.091 *
Awareness of sustainability	100	-0.32	0.46	-1.42	100	0.45	0.27	0.60	-0.77	0.000 ***
Behaviour toward the environment	100	0.29	0.59	2.02	100	0.03	0.60	20.08	0.26	0.002 ***
Behavioural footprint	100	-0.27	0.35	-1.29	100	-0.39	0.23	-0.58	0.12	0.004 ***
Distance to main road (miles)	81	1.00	1.34	1.34	92	3.04	0.73	0.24	-2.03	0.000 ***
Education of household head	100	3.76	2.23	0.59	100	4.16	1.82	0.44	-0.40	0.166 n.s.
Gender of household head (male=1)	100	0.82	0.39	0.47	100	0.90	0.30	0.34	-0.08	0.104 n.s.
Household size	100	5.52	2.05	0.37	100	4.20	1.91	0.45	1.32	0.000 ***
Time to main road (min)	84	29.70	11.28	0.38	92	67.77	19.85	0.29	-38.07	0.000 ***

The concept of food pyramid is that food categories that people include in their diets rise upwardly as a function of income from basic necessities (rice and other grains) to the greatest luxury goods. To compare the welfare of food consumption in the two study areas, the topmost food categories consumed only by a small social elite were assigned the highest utility weights, and the lowest categories the lowest weights. For a given household or individual, weights were summed to yield a single score.

4.2 Results

Figure 2 shows the Lorenz curves for the commutative justice index access to land, as measured in acres, in Kyaintali and Bagan.

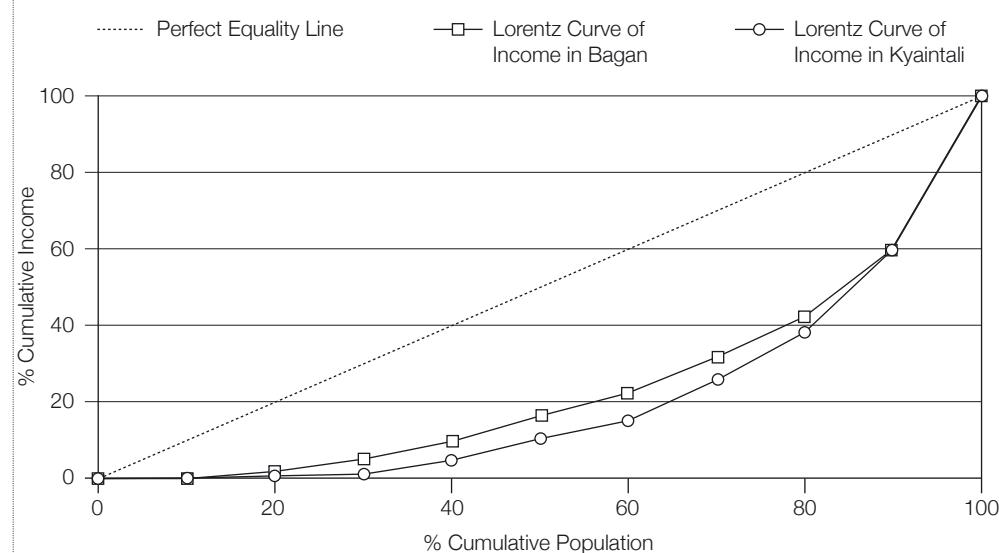
Figure 2. Comparative Lorenz curves of access to land in Bagan and Kyaintali



The Lorenz curve of land distribution in Kyaintali lies almost consistently above, and thus dominates, the curve of Bagan. Furthermore, farmers in Bagan own on average twice as much land as farmers in Kyaintali. This implies that both the relative and absolute inequality of natural resources may be much higher in Bagan, particularly among the middle class (defined as the second and third quintiles). Commutative justice is better in Kyaintali.

In terms of the distributive justice of economic outcomes, however, there is very little difference between the Gini coefficients of gross income for the two regions. Bagan (0.523) enjoys only a slight edge in inter-household equality over Kyaintali (0.55).

Figure 3. Lorenz curves of gross income for Kyaintali and Bagan



But close inspection of the Lorenz curve shows that these similarities are not uniform along the curve. The Lorenz curve of income in Kyaintali sags nearer to the origin, showing that poor people have severely lower income than the poor in Bagan. That is the source of higher Gini coefficient since the rank of the poor is weighted more heavily in the normalization of the Gini coefficient. Amongst the middle class, the Lorenz Curve of Bagan is closer to the equality line than in Kyaintali. This suggests that middle class people who lie above the lowest quintile and below the highest quintile enjoy better equality in Bagan than their counterparts in Kyaintali. Furthermore, according to personal observation, 10 percent of the poor in Bagan live on zero cash income and depend directly upon the environment for food products from forest and common property resources. In Kyaintali, which lies closer to the forest and further away from the infrastructure of the market economy, such dependency upon nature reaches a full 16 percent. Kyaintali is in a situation of worse distributional justice in terms of gross incomes.

The question then arises: Does dependency on the market also bring more equal physical welfare (nutritional status) than dependency upon nature in Myanmar? The answer is, surprisingly, no: the rank of the Gini coefficients for nutritional status (use value) in these two areas is the reverse of that for gross income (exchange value). Specifically, the Gini coefficient of nutritional status is 0.41 in Bagan vs. only Kyaintali in 0.28.

To form an idea of the distribution of nutrition in the population of these two regions, comparative Lorenz curves were drawn for both nutritional status (Figure 4) and nutritional expenditure per capita (Figure 5) for the two eco-marketing zones.

Figure 4. Comparative Lorenz curves for nutritional status in Bagan and Kyaintali

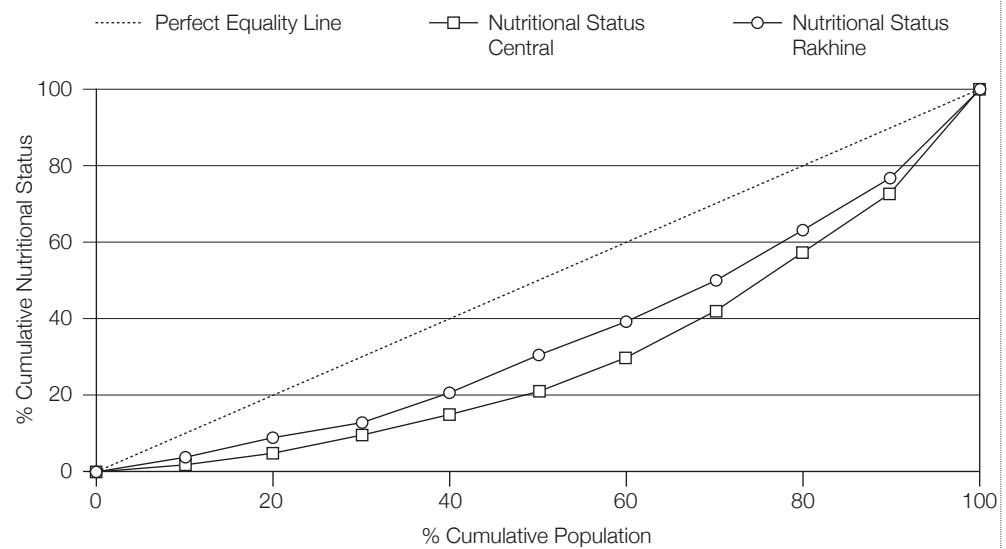
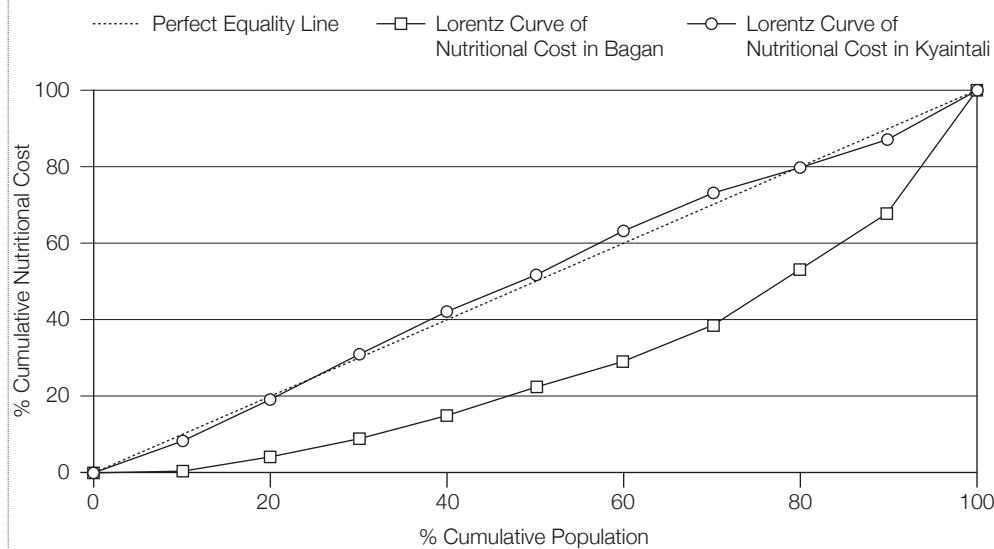
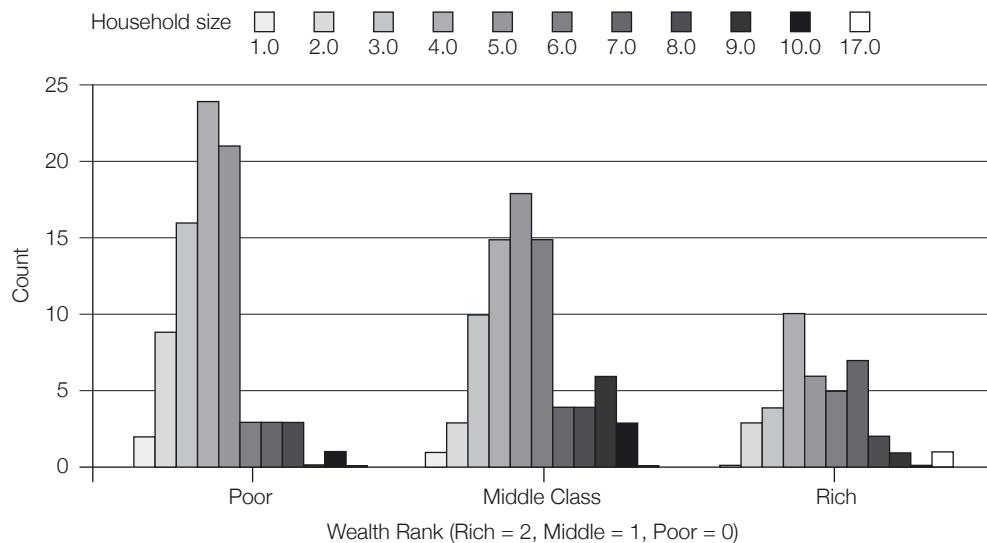


Figure 5. Comparative Lorenz Curves of Nutritional Cost Equality in Bagan and Kyaintali



Nutritional cost from household to household was nearly equal in Bagan even though nutritional status was much more unequal than in Kyaintali. These opposite findings in the two eco-marketing zones indicate that food security in Kyaintali is much more unpredictable. Differential access to natural resources such as land ownership, forest entry and other ecosystem services are the main factors (rather than income or expenditures) that contribute to physical welfare. The inequality of nutritional expenditure in Kyaintali is explained by the households' unequal dependency upon nature.

Nutritional comparisons of this type are essential because two significant problems undermine the usefulness of gross income of the household as a measure of well-being. The first is that families with larger household size tend to have more aggregate income, but not necessarily more income per capita (Figure 6). The second is the quite variable patterns of expenditure and savings that may result in negative incomes, as discussed above. We therefore return our attention to the welfare measure of net income per capita (Table 1). The reason that net income in exchange value was calculated was that some poor households are landless. While they have more nominal income from their random jobs, they have to spend a greater proportion of their income on food since they lack access to land for food production.

Figure 6. Bar chart relating income class to household size

This introduces a great bias in calculating the Gini coefficient for income and nutritional cost per day of the poor households. Furthermore, the Gini coefficient for nutritional status, net income for exchange and land ownership was calculated to portray more accurately the multidimensionality of the welfare situation of poor families. Although mean measures of income are positive, the frequency of negative incomes can be observed in both Figures 7 (Central Burma) and 8 (Kyaintali).

Figure 7. The frequency distribution of negative and positive incomes in Central Burma

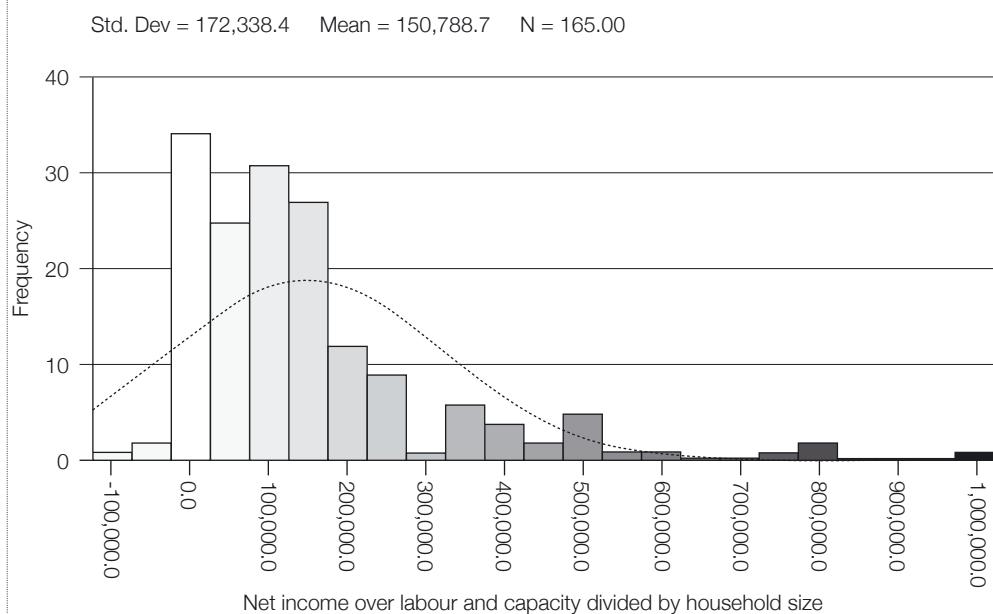
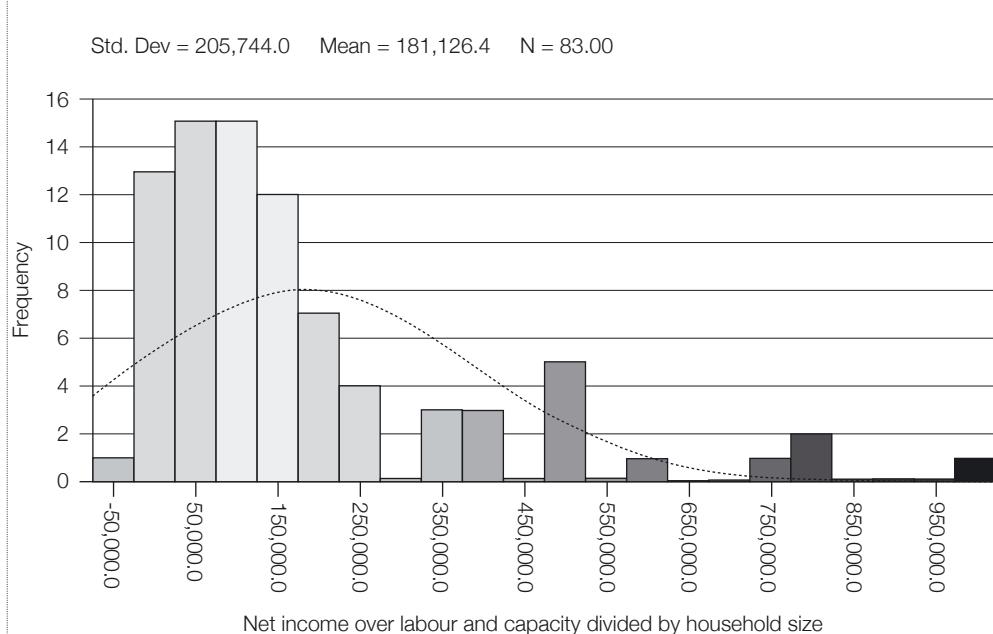
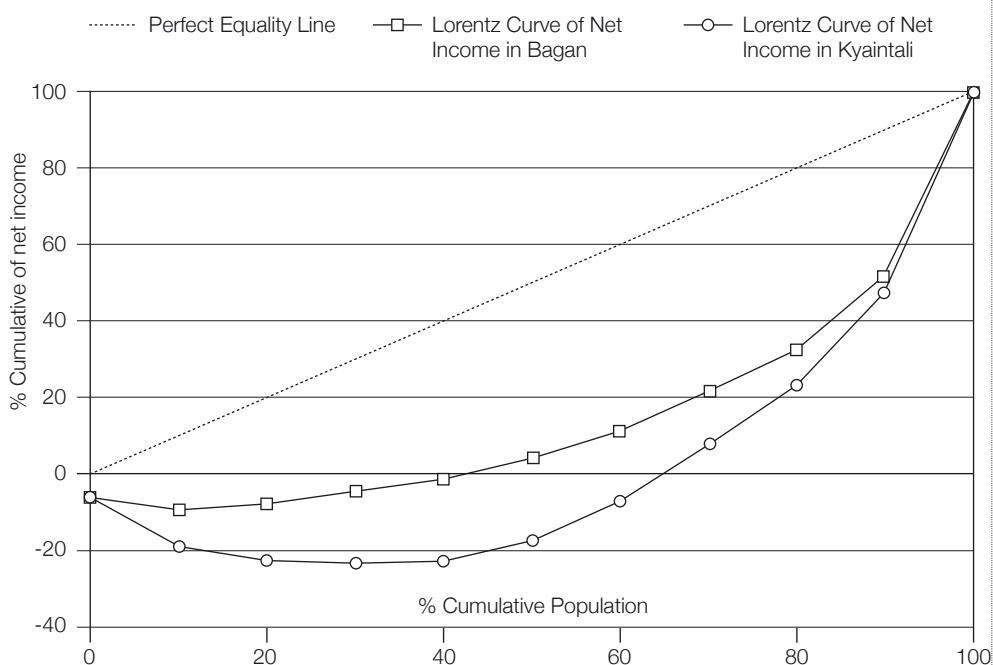


Figure 8. The frequency distribution of negative and positive incomes in Kyaintali



The Lorenz curves for net income per capita (Figure 9) should in principle give a truer picture of the equity and hence sustainability of current levels of welfare. But once drawn, the Lorenz curves sag under the origin with negative values, expressing the severity of the situation of negative incomes in the target population. This means that the study of Gini coefficients will not be reliable; even though we may still make graphical comparisons of points of corresponding levels of net income between the two populations. From comparing the two Lorenz Curves, we may predict that net income per capita inequality in Kyaintali is much greater than in Bagan, and that people have less income in terms of the use value of their nominal income other than food expenditure. About 40 percent of the population in Bagan and 65 percent of population in Kyaintali must subsist on negative income. From this point alone, we may reach a preliminary conclusion; assuming other things equal, government investment in sustainable poverty reduction programs should favor Kyaintali over Bagan. These negative values calculated for net income also suggest the possibility that we may have neglected the environmental services that people extract for their survival. Income from forest products is already included in gross income.

Figure 9. Comparative Lorenz curves for net income per capita in Central Burma and Kyaintali



What remains to be added, however, is the value of services that we exploit from nature such as wood, bamboo, housing materials and firewood from forest, water from lakes and ponds, vegetables from forest, and the land we clear and use freely for rotational cropping etc.

The value of such ecosystem services is frequently enormous, but it is important to calculate it. In subsistence farming communities of Myanmar, the highest priority for natural exploitation is basic survival in terms of food, fuel, water, shelter and income.

For the land, farmers do cropping freely in the buffer area; forest area is a kind of welfare service that is provided by nature for the least well-off families without any rent or tax although according to the land regulation it is technically illegal. It is difficult to accurately internalize the external value of land that people use for shifting cultivation in ecosystem services because people hesitate to answer the question of how much they are degrading the forest for free access to land. The number of families who are exploiting the rent-free agricultural land is 8 and 7 percent of the households in Kyaintali and Bagan, respectively. These values must be added to other types of income through the following internalization of ecosystem services:

Ecosystem services included in gross income

- = Gross Income per capita per day in US \$ + (no. of Bamboo poles * value of bamboo poles/365) + (wood use in ton* value of wood/365) + (value of water * water use per day) + (firewood stored*value of firewood/365) + (vegetables taken from forest*value of vegetables taken from forest) + (vegetables grown in garden + vegetables grown in garden) + (price of rice per cup* rice consumption per day* produce rice in my field)

Equation (1)

Ecosystem services included in net income

- = Gross Income per capita per day in US \$ + (no. of Bamboo poles * value of bamboo poles/365) + (wood use in ton* value of wood/365) + (value of water * water use per day) + (firewood stored*value of firewood/365) + (vegetables taken from forest*value of vegetables taken from forest) + (vegetables grown in garden + vegetables grown in garden) + (price of rice per cup* rice consumption per day* produce rice in my field) – nutritional expenditure per day

Equation (2)

Since the time series data and secondary data for the previous time period were not accessible in this study and the prices and income of a base year were unknown, real income and expenditures could not be calculated. Nominal income and expenditures were therefore used to indicate the state of distribution.

Value of vegetables taken from forest

$$= \frac{\text{Total Nutritional cost}^* \text{ Number of people who extract vegetables from forest}}{(\text{no.of households}^*(\text{no.of households who exploit vegetables from forest} + \text{no.of households who grow vegetables for self consumption}))}$$

Equation (3)

Value of vegetables grown in garden

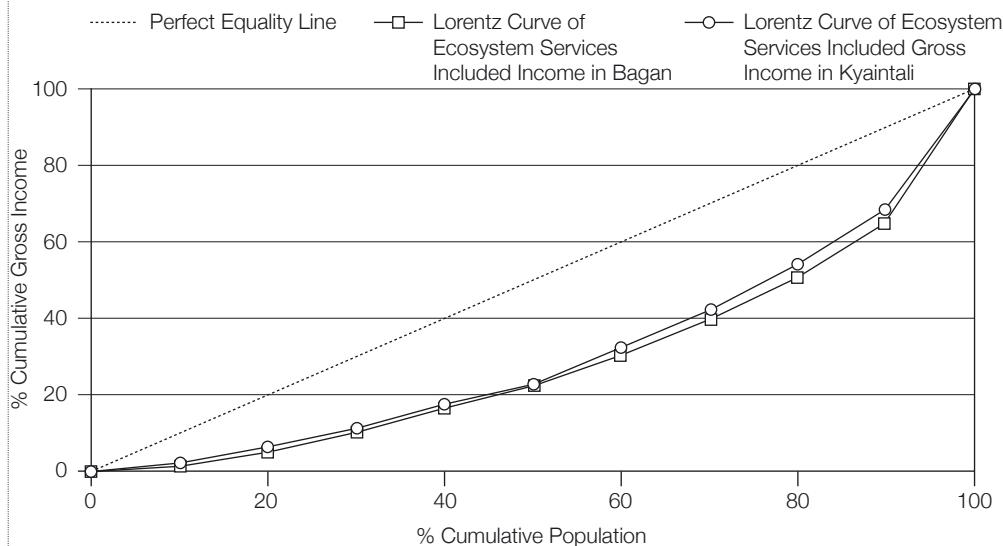
$$= \frac{\text{Total Nutritional cost}^* \text{ Number of people who grow vegetables in garden}}{(\text{no. of households}^*(\text{no. of households who grow vegetables in the garden} + \text{no. of households who grow vegetables for self consumption}))}$$

Equation (4)

When ecosystem services are internalized into gross income, the inequality of income distribution declines to 0.38 and 0.31 in Bagan and Kyaintali, respectively. The mean value of ecosystem-inclusive gross income is US\$ 0.95 and US\$ 0.88 in Bagan and Kyaintal, respectively. The natural resources from the Kyaintali area have clearly mitigated the inequality in the community to some extent and compensated for the poor market and road infrastructure in the area. A comparison of figures 3 and 10 confirms that the exploitation of nature serves as a kind of welfare redistribution mechanism in these two communities.

The Gini coefficient of net income that internalized ecosystem services is also improved to 0.56 and 0.66 in Bagan and in Kyaintali respectively. The mean of net income per capita in Bagan and Kyaintali are US\$ 0.07 and US\$ -0.07, respectively, but the mean net income is improved greatly in Kyaintali when ecosystem services are included in income. The mean ecosystem services inclusive net incomes per capita in Bagan and Kyaintali are US\$ 0.29 and US\$ 0.47 respectively. The mean of daily environmental income in Bagan and Kyaintali differ greatly with US\$ 0.07 per capita in Bagan and US\$ 0.54 per capita Kyaintali. The difference is significant because of the prosperity and fertility of the environment, which is relatively untouched in Kyaintali.

Figure 10. The comparative Lorenz Curves of ecosystem services inclusive gross income of Kyaintali and Bagan.



With the internalization of ecosystem services, the Gini coefficient and Lorenz curves improve (figure 11) in both areas but a negative income problem still exists in the data set that still maintains net income inequality at a high level. Clearly, then, despite the potential interest of such innovative applications of the Gini approach, it becomes virtually useless when such negative values in the data arise for one or more of the reasons noted above. Since the poorest of the poor typically live in remote, mountainous areas with poor infrastructure access,⁷ it is inadequate to check only the inequality to compare the income of the two places. One must clearly go beyond the Gini coefficient⁸.

⁷ Indeed, such remoteness is often the principal cause of the poverty in monetary term because of the lack of facility to participate in the main stream economy.

⁸ One way to inquire about the true welfare of a local community is Sen's Welfare Coefficient, which may be calculated with the following equation:

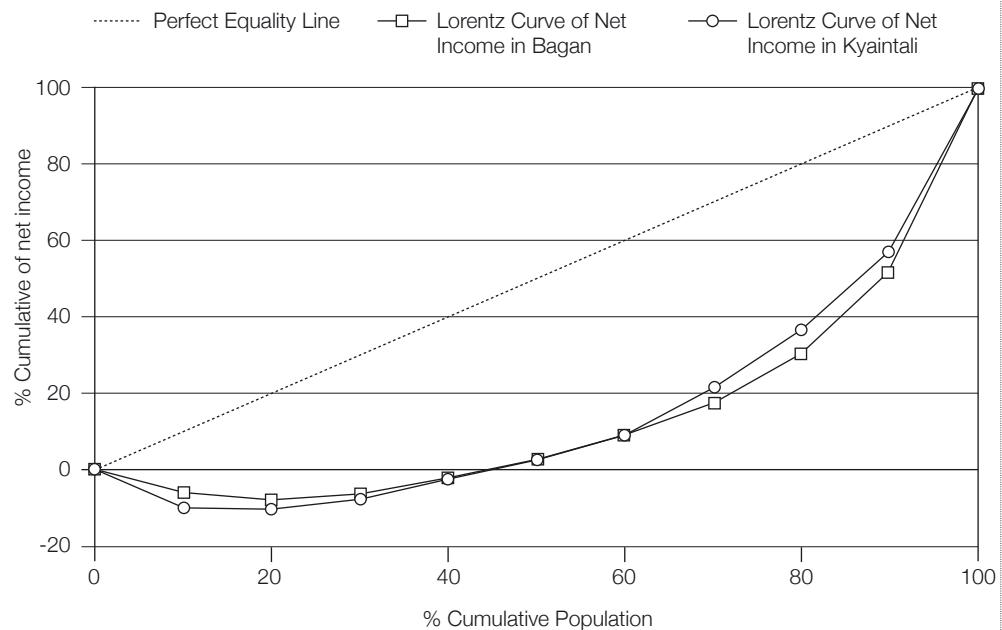
$$W = I * (1 - G)$$

where, W = the Welfare Coefficient

I = Income

G = Gini coefficient.

Figure 11. Comparative Lorenz Curves of Ecosystem Services Inclusive Net Income in Kyaintali and Bagan.



05. Concepts of the incidence, depth, and intensity of poverty as unbiased measures in the presence of negative incomes

Since the Gini coefficient is calculated by arranging household incomes in ascending order, it gives no measure of exactly how deprived people are in monetary or physical terms. Such standards as one US dollar of purchasing power parity, PPP, income or 2000 calories per capita per day are used in the calibration of absolute poverty. These standards may then be analyzed in three successive ways (the incidence, depth and intensity of destitution), as initially defined by Foster, Greer, Thorbecke (1984) and popularized by Ravallion (1998, 2008).

The incidence of poverty or headcount index shows the percentage of households in the population that receive less income or welfare than a given poverty threshold. For example, if we assume the international standard of one dollar per capita per day, we find the proportion of all households under that line out of the entire target population. Households with daily per capita income of less than one dollar per day are then defined as poor. The formula of poverty incidence is as follows:

$$\text{Poverty incidence} = \text{per capita income per day in } \$ < 1$$

Equation (5)

Building on this basis, the depth of poverty or income gap is an indicator that measures how far on average people lie away from the standard income in average. If we are interested in poverty reduction, the income gap tells that, which population will need how much per capita to be lifted out of poverty.

$$\text{Poverty gap} = \Sigma (\text{Poverty line} - \text{income}) / \text{Incidence}$$

Equation (6)

But the poverty gap is still incomplete in that all of the poor are not equally poor; some are living more intense poverty than others. Distributing an equal amount to all villagers would therefore be ineffective within the community. Moreover, two different communities may have the same depth of poverty but very different distributions around that mean. We therefore go on to calculate the intensity of poverty, which gives more weight to people who are further away from the poverty line. The intensity of poverty of a population is calculated by squaring the gap and taking the average of it over all poor households.

$$\text{Intensity of poverty} = \sum (\text{Poverty line} - \text{income})^2 / \text{Incidence}$$

Equation (7)

The three Foster-Greer-Thorbecke measures defined in equations 5 through 7 provide the further advantage over the Gini and quantile approaches in that they can be subjected to pair-wise or multiple one-way ANOVA tests of significant differences of means. Conducting such tests is vital because policy-makers may otherwise target geographical or social group "1" and completely neglect group "2" based on nominal differences in welfare, even though their true levels of deprivation may not differ significantly.

06. Empirical applications of the incidence, depth, and severity of poverty

When we set the poverty line of one dollar per day in per capita income, the incidence of poverty in Bagan at 82 percent seems significantly less than the 95 percent in Kyaintali. The income is calculated in nominal value converted into US dollars with the price of (US\$ 1.00 = Kyat⁹ 1000). The table of Gini coefficients, incidence, depth or income gap and intensity of poverty in per capita income is shown in Table 2.

Table 2: Summary of inequality measures in the two eco-marketing zones.

Eco-marketing zone:	Bagan	Kyaintali
Gini coefficient of income	0.52	0.55
Incidence of poverty	82	95
Income gap	-0.68	-0.71
Intensity	0.52	0.58
Gini coefficient of net income per capita	0.87	0.98
Average net income per capita	0.43	0.21
Gini coefficient of nutritional cost	0.1	0.37
Gini coefficient of nutritional status	0.41	0.28
Gini coefficient of land ownership	0.52	0.43
Gini coefficient of ecosystem service inclusive gross income	0.38	0.31
Gini coefficient of ecosystem service inclusive net income	0.56	0.66

⁹ Unit of Myanmar currency. This exchange rate is close to the true rate observed in the (black) market that households deal with in order to improve their incomes.

The figures highlighted in bold point to the disfavored region in terms of inequality measures that appear substantially different. In terms of commutative justice (access to land and food), Bagan suffers from greater relative inequality. However, in terms of distributive justice (income inequality, poverty, and nutritional cost), there is more inequality in Kyaintali. These results suggest different strategies of well-being equalization in each region.

One-way ANOVA (Analysis of Variance)

Table 1 has shown that virtually all the measures and determinants of commutative and distributive justice differ significantly between Bagan and Kyaintali. But policy makers need to know more specifically, which of the villages within each zone is in special need of poverty-reduction expenditures from the government's limited budget. This is the only way to assure both social effectiveness and fiscal efficiency. One-way ANOVA post hoc comparisons of means were therefore performed to detect significant differences among all seven villages of the study. The two villages from Central Myanmar were Taungphattan and Latpantal. Latpantal is situated on the Bagan-Kyaupadaung Road about 3.8 miles from the main road. Taungphattan separated from Bagan-Nyaung Oo Township in 2007 due to its rapid development. It lies on the railway from Bagan-Nyaung Oo to Myingyun, is 7 miles from Pakhokku by boat and 14 miles from Bagan.

Meanwhile, the villages selected for study in the Kyaintali area were Yaesankwin, Cisonekone, Supotekone, Doetan and Taungpatlel. Demographically, Taungpatlel is a Chin Village 4.5 miles from the nearest city and surrounded by mountains. Yaesankwin is also a Chin Village nearest to the road, lies three miles from the nearest city, and has the lowest population. Cisonekone, Supotekone and Doetan are native Rakhine villages with medium population density. They lie 3, 3.5 and 4 miles, respectively, from the main road. Taungpatlel believe in Christianity and the other four villages are traditional Buddhists. The other two villages in Bagan area also believes in Buddhism.

Table 3 reports only the significant differences in means among villages in order to highly any necessary divergences in strategic approach according to geographical location and specific forms of assistance. In Yaesankwin, the mean of amount of land ownership, access to inputs, which is also called technical efficiency, gross income, community management, average attitude toward conservation and awareness of the forest are the lowest among the seven sample villages. The mean of type of soil or quality of soil is highest in Yaesankwin that means they have good yield per unit acre in input

ratio even though they have lowest gross income and lowest amount of land in average. The lowest community management indicates that there would be lowest level of motivation to conserve the forest and environment. Secondly, the lowest attitude in conservation could be because of no awareness of degradation problems as well. Moreover, this village possesses more fertile soil than other villages and has the lowest opportunity to access agricultural inputs from the outside. Average attitude towards conservation is less in Yaesankwin, where the language barrier prevents people from communicating with strangers, and where institutions are the least developed despite its greatest proximity to the road in the Kyaintali region.

Taungpatlel, despite sharing the same ethnic group with Yaesankwin, is located furthest away from road in Kyaintali, which is the remote area for access of information and services to improve living status, enjoys the most developed community institutions. Taungpatlel also has the highest average attitude towards conservation, environmental behavior, nutritional cost per day and average community management, average financial viability, and is most likely not be in debt with lowest rice consumption per day (or physical wellbeing). Most of all, Taungpatlel has the highest opportunity to access new inputs to their agriculture. Apart from facing the most difficulty in transportation and distance to the road, strong institutions such as churches facilitate to get information for their livelihood and support with new inputs in agriculture. Despite living in a forested area in the middle of mountains, Taungpatlel dwellers take the longest time to fetch firewood. This may be the result of proximity to the National Park and the edge of the buffer zone of the forest area.

As the leader of a ten village group around that mountainous area including the four other Kyaintali villages of the study, Cisonekone is the strongest native Rakhine village in terms of community leadership. Cisonekone enjoys the highest in attachment to land, which means that the location and fertility of the land are good, and there is a high level of tenure security. The environmental footprint is lowest because tree cutting is low, and there less dependency upon the forest for food, shelter and income. Nutritional cost per day in Cisonekone is significantly lower than any other villages because self-sufficient agricultural production supports people with low-cost food without depending on the forest. Gross income in Cisonekone is lowest among all the villages and time taken to fetch the firewood is lowest in Cisonekone too. In overall observation, Cisonekone seems to have a good management and fundamentals.

Doetan is a famous large village with a large poor population and shifting cultivation. Flooding comes more frequently than any other villages among the samples. According to the post hoc test of means, Doetan is lowest in average environmental footprint. However, with the experience of natural disasters and environmental educational meetings, people in Doetan understand more about environmental sustainability than other villages among all the sample villages. Because of the greater distance from the main road and inadequate income to buy vehicles, it takes the longest time for people from Doetan to get to the road. Still, knowledge and experience are better than other villagers are. The since the commuting time is longest from Doetan, we could have denoted that the villagers from Doetan have low capacity to contact with outside world and participate even in the local market.

About Latpantal and Taungphattan in Bagan area, Central Myanmar, Latpantal has a greening project that is trying to help people to get more livelihood from non-timber forest products and the latter has much more variety of transportation routes to connect to the market and have telephone line to have more access to information and much accessible to the market. Latpantal enjoys the highest income and highest rice consumption. They are highest in unsustainable behavior too. This can explain the lowest awareness toward sustainability in this village. The awareness of the sustainability is actually a good thing since awareness toward sustainability in this study is provoked when environmental problems and degradation impact negatively on people's livelihoods. The lowest time taken to road shows that the people in this place have more capacity provided by the empowerment of dry zone greening project to connect to the nearest market and participate in the commodity market than any other study areas to get highest income among seven villages. And water cost is as high as Taungphattan even though location is the same water scarcity as the former because of the arrangement of the local community managing for the reforestation gardens.

Diet diversity is lowest in Taungphattan, which means people cannot afford to consume higher level of dietary combination than other places while people in Latpantal consume highest rice consumption per day. People in Taungphattan are most in debt among all the villages as well as lowest financial viability. There is a microcredit project in Taungphattan and Latpantal, called PACT Myanmar, helping with rural credit.

Table 4. Post Hoc ANOVA (Analysis of Variance) tests for significant differences in means

Welfare concept	One-way ANOVA	Code: White = inter-village differences within the same zone					
	Post-hoc comparisons	Cream = Rakhine state villages sig. greater than central Burma villages					
	LSD	Grey = Central Burma villages sig. greater than Rakhine State villages					
	Dependent Variable	(I) Village	(J) Village	Mean Difference (I-J)		Std. Error	Sig.
Community justice	Diet diversity	Cisonekone	Doetan	0.73	*	0.4	0.070
			Taungphattan	0.86	**	0.37	0.020
			Latpantal	0.66	*	0.37	0.080
	Nutritional cost per day	Cisonekone	Supotekone	-995.42	***	308	0.000
			Taungpatlel	-1984.61	***	613	0.000
			Taungphattan	-1456.62	***	298	0.000
			Latpantal	-1426.62	***	298	0.000
	Rice consumption per day	Latpantal	Taungpatlel	-15.03	***	2.91	0.000
	How many acres of land do you have	Yaesankwin	Taungphattan	-5.68	**	2.28	0.010
	Average access to inputs	Yaesankwin	Cisonekone	-0.367	*	0.19	0.060
			Doetan	-0.33	**	0.165	0.040
			Taungpatlel	-0.67	**	0.329	0.040
Time to the main road	Doetan	Yaesankwin	15.42	***	5.105	0.000	
		Cisonekone	18.27	***	5.216	0.000	
		Supotekone	17.50	***	4.087	0.000	
		Taungphattan	48.42	***	3.92	0.000	
		Latpantal	53.37	***	4.02	0.000	
Soil type	Yaesankwin	Cisonekone	0.53	*	0.275	0.050	
		Taungphattan	1	***	0.23	0.000	
		Latpantal	0.44	*	0.23	0.060	
Water cost	Taungphattan	Yaesankwin	114.50	***	12.89	0.000	
		Cisonekone	101.17	***	12.89	0.000	
		Supotekone	114.47	***	9.493	0.000	
		Doetan	114.50	***	10.11	0.000	
		Taungpatlel	114.50	***	26	0.000	
		Latpantal	44.12	***	8.76	0.000	

Sustainable behaviour	Sustainable attitude	Time to fetch wood	Taungpatlel	Yaesankwin	17430	***	2000	0.000	
				Cisonekone	19088	***	2000	0.000	
				Supotekone	15492.04	***	1924	0.000	
				Doetan	19070.48	***	1952	0.000	
				Taungphattan	19094.14	***	1900	0.000	
				Latpantal	18732.15	***	1893	0.000	
Unsustainable behaviour	Distributive justice	Last year's income	Latpantal	Yaesankwin	803559.5	***	249409	0.000	
				Cisonekone	972950	***	242888	0.000	
				Supotekone	854295.5	***	185680	0.000	
				Doetan	824916.7	***	208231	0.000	
				Taungphattan	518947.28	***	488685	0.000	
				Yaesankwin	Supotekone	-0.33	**	0.152	0.030
Sustainable behaviour	Sustainable attitude	Average attitude toward conservation	Yaesankwin	Doetan	-0.32	**	0.157	0.040	
				Taungpatlel	-0.65	**	0.314	0.040	
				Taungphattan	-0.53	***	0.15	0.000	
				Latpantal	-0.48083	***	0.15	0.000	
			Cisonekone	Doetan	0.30	**	0.124	0.010	
				Taungpatlel	0.43	*	0.248	0.090	
Unsustainable behaviour	Distributive justice	Average attachment to the land		Taungphattan	0.34	***	0.12	0.000	
				Latpantal	0.29	**	0.12	0.010	
		Doetan	Yaesankwin	-0.32	*	0.186	0.090		
			Taungpatlel	-0.82	**	0.356	0.020		
			Taungphattan	-0.35	**	0.14	0.010		
			Latpantal	-0.53	***	0.14	0.000		
Sustainable behaviour	Sustainable attitude	Average environmental behaviour	Cisonekone	Taungphattan	-0.2768	***	0.09	0.000	
				Latpantal	-0.192	**	0.09	0.030	
				Latpantal	-8.1225	***	2.28	0.000	
				Doetan	Yaesankwin	-0.32	*	0.186	0.090

Financial sufficiency	Not in debt	Taungpatlel	Doetan	1.17	*	0.622	0.060
			Taungphattan	1.73	***	0.61	0.010
			Latpantal	1.46	**	0.61	0.020
	Average financial_viability	Taungphattan	Cisonekone	-0.35	***	0.12	0.000
			Supotekone	-0.17	**	0.09	0.050
			Taungpatlel	-0.63	***	0.23	0.010
Belief in community	Average belief in community management	Yaesankwin	Taungpatlel	-0.742	**	0.329	0.030
			Taungphattan	-0.48	***	0.15	0.000
			Latpantal	-0.34	**	0.15	0.030
Ecological awareness	Average awareness of sustainability	Latpantal	Yaesankwin	-0.75	***	0.11	0.000
			Cisonekone	-0.89	***	0.11	0.000
			Supotekone	-0.84	***	0.08	0.000
			Doetan	-0.95	***	0.09	0.000
			Taungpatlel	-1.13	***	0.22	0.000
	Average awareness of forest	Yaesankwin	Taungphattan	-0.21	***	0.074	0.010
				-0.34	**	0.14	0.010

Water cost in Taungphattan is highest among all the sample villages that is contradictory to the government water supply project and agricultural extension projects in dry season. That implies there is a threshold in the system or leakages in the project.

Summary and conclusion

The Gini coefficient results reflect significant income inequality in both communities. Material welfare, defined as the net income of the people when nutritional cost is deducted from nominal income, shows great negativity in both places, invalidating the use of Gini coefficients of net income as a guide to policy intervention. Physical welfare, a Senian *ex ante* measure of opportunity defined as household nutritional status, is much more equally distributed than *ex post* income or nutritional cost in both Bagan and Kyaintali. Of even greater policy interest is that Kyaintali enjoys a much more egalitarian

distribution of physical welfare than Bagan, even though income and material welfare are less well distributed. The net income adjusted for natural environmental resource services shows a highly equal relative distribution in both places, even though households from Kyaintali derive significantly higher absolute livelihood support from their dependency upon nature. We conclude that environmental resources such as forest and land ownership supplement meager nominal income and land access, giving people in Kyaintali better physical welfare.

Average land access for each household farm is 4.91 acres and 10.5 acres in Kyaintali and Bagan, respectively. The distribution of land in Kyaintali is much more even than in Bagan according to the Gini indices and there is less landlessness among the farmers in Kyaintali. Dependency on the forest resources acts as a buffer for poor rural farms in Kyaintali. We deduce as a hypothesis to be confirmed by future researchers that commutative justice in access to land serves to maintain essential elements of welfare ("basic needs") in rural off-market areas. In places where people can depend upon natural environmental resources freely, natural resources substantially even severe inequality in income and materials.

Policy recommendations

At the risk of oversimplification, Bagan suffers principally from a problem in commutative justice (relative access to land, natural resource services, and nutritional status; absolute food insecurity), while Kyaintali suffers from a problem in distributive justice (relative distribution of net income, ecosystem-service inclusive net income, and nutritional expenditures; absolute gross incomes, negative net incomes and incidence of poverty). As a result, the policies should be tailored to each fragile eco-marketing region.

Bagan enjoys higher income but lower provision of environmental resources for households than in Kyaintali. Bagan is already more highly developed in terms of road and transportation access than Kyaintali, but there is higher inequality in both land use and sustainable behavior. Bagan needs to consider land redistribution, collective farming, group ownership of forest lands, nutritional education and food distribution programs. A policy to promote information exchange and networking with "greener" communities could be used to stimulate awareness toward sustainability and better provide for the use environmental resources for the livelihood of all people. Dietary improvement should be given to this community for the health of villagers.

In the Kyaintali area, places like Yaesankwin with high fertility on small plots should receive help in accessing appropriate farming technology and inputs to raise the income of local people to reduce income imparity. Villages like Cisonekone in the Kyaintali group should be improved to have better awareness of the environment and forests, and stronger community management to be a good example to lead the other villages in the local area. Kyaintali area and Rakhine State policy makers therefore need to consider programs to generate more income both directly and indirectly through the improvement in the communication and transport infrastructure. The region also needs a progressive income tax or household welfare system that provides income-deficit households with the purchasing power necessary to allow them to buy food and pay off their debts on time. Positive conditionalities, such as appropriate land, land security and balanced diets of the villagers among the Kyaintali group could lead to a positive chain reaction of change in neighboring villages in a short time.

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