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Omura, Makiko

(Citation)
Kobe University Economic Review,52:63-78

(Issue Date)
2006

(Resource Type)
departmental bulletin paper

(Version)
Version of Record

(JaLCDOI)
https://doi.org/10.24546/00518348

(URL)
https://hdl.handle.net/20.500.14094/00518348

THE BREAKDOWN OF COOPERATION AND ENVIRONMENTAL DEGRADATION: AN ANALYTICAL FRAMEWORK

By MAKIKO OMURA

This paper considers an analytical framework looking into the phenomena of cooperative institutional breakdown and the consequent environmental degradation. Such phenomena are seen in many developing countries. The analysis utilises a game theoretic approach to explain how an internal cooperative framework degenerates into the original one-shot Prisoner's Dilemma model due to changes in the payoffs, trust and discount factors, brought by outsiders. We provide an illustrative case description of upland migration in the Philippines. To the extent that the underling assumptions approximate the actual conditions, the theoretical framework is expected to explain and/or predict the processes of real phenomena that may not be precisely observable.

1. Introduction

Transformations of traditional agricultural systems due to a changing environment have been suggested as one of the main causes of deforestation and environmental degradation in various developing countries. For instance, swidden or shifting-cultivation practiced by the uplanders has been deemed to be one of the major causes of deforestation and associated environmental degradation in the Philippines, besides logging activities. The expansion of land area under swidden farming and the intensification of land use have occurred due to a dramatic increase in the population pressure in the uplands, which is mainly brought by the migrants from the lowlands. Such increasing stresses on the upland environment cause slope instability, serious soil erosion and other environmental deterioration including damaged ecosystems, loss of biodiversity, siltation of rivers, damaging irrigation systems and hydroelectric power facilities, as well as soil productivity decline.

Similar phenomena of deforestation due to influx of migrants are experienced by Brazil, Cameroon, Costa Rica, Guatemala, Peru, Sudan, Thailand and many other developing countries. Such problems of migration can be directly encouraged by misplaced government policies such as construction of roads into forests, cheap logging fees, improper property rights enforcement, etc. There are also cases reported that the privatisation or nationalisation has transformed locally well managed resources to open access resources, creating tragedy of the commons problems in Niger, Thailand, Nepal, India and other countries, as suggested by Ostrom (1990), Stevenson (1991), Bromley and Cernea (1989), Jodha (1986).

While the direct environmental effects brought by the immigrants, such as additional population pressure, expansion of farming areas, and environment-damaging farming methods, are considered to be serious, our interests here are on their indirect effects. This paper

considers and analyses the impact of immigration on the marginal lands through indirect effects, in particular, the effects on the existing cooperative resource management of the original communities. With the arrival of new immigrants, there can be an introduction of new farming methods and consumption patterns that are not suited to the local environment. In addition, the local traditional practices themselves can become unsustainable. For instance, it may not longer be feasible to retain a proper cycle for shifting-cultivation that is within the carry capacity of the environment. Concerning such claims that the traditional agricultural practice has become as environmentally destructive as those of new immigrants, or that the forestlands has become virtually open access resources, our interest is to see how such phenomena occur.

Hence our main purpose is to analyse the breakdown of a traditional resource management system that is considered to be sustainable due to the various changes in the state of the community brought by a stream of immigrants.[1)] Our purpose is to consider an analytical framework which may explain the phenomena. It is not our purpose to investigate particular cases or to grasp the exact reality. Nevertheless, in order to consider the framework concretely, we provide a representative case description of upland migration in the Philippines.

In the following section, we describe the phenomenon of upland migration and environmental deterioration in the Philippines, with special attention to the quantitative and qualitative impacts brought by the lowlanders. We then consider the framework for the breakdown of traditional, cooperative institution.[2)] We view the indigenous farming system as having been sustainable due to their cooperation. Our analytical approach is based on the game theoretic framework concerning cooperative behaviours. We analyse how changes in factors such as payoffs, trust, and discount factor of the indigenous farmers being affected by the lowland migrants can lead to the breakdown of their institution. Following the analysis, concluding remarks are given, with a caveat on the vulnerability of cooperative institutions.

2. A Descriptive Case: The Phenomena in the Philippines

In the Philippines where lowlanders have migrated to the uplands, the upland population growth has been rapid with an annual rate of 3.2 percent in 1950-1985 (Cruz et al. 1992). Especially during 1980-1985, migrants to the uplands dramatically increased inducing about four percent annual population growth in the uplands (see Table.1 and Table.2). In 1985, about 18 million people (more than 30 percent of the total population) resided in the uplands, of which 11 million (5.7 million were migrants, 5.3 million were indigenous people) resided in

1) Note that such a description as “traditional environmentally sustainable system” is itself an arguable statement, since there is a number of different traditional methods varying in their impacts on environment, and since there is no definite way of measuring such impacts. However, these issues are not of our concern here.

2) There is a vast impact of lowlanders on the indigenous community besides those considered in this paper. The most notable would be commercialisation and modernisation which are briefly mentioned in Concluding Remarks. Those effects generally seem to adversely affect people’s attitude toward cooperative management, as noted in Jodha (1990, pp. A-71).

the forestlands within the upland areas. In the overall uplands, an estimated 70 percent of the upland population consisted of lowland migrants and their descendants, the other 30 percent consisted of at least 60 indigenous ethnic groups (ibid., pp. 19-20).

TABLE 1. Total Upland Population in the Philippines, 1950-1985 (in thousands)

Year	1950	1960	1970	1975	1980	1985
Total Population	5,868	8,192	11,169	12,702	14,440	17,513
Annual Growth Rate (%)	3.39	3.15	2.61	2.60	3.39	

Sources: National Census and Statistics Office, *Population Census, various years; Barangay Census*, 1985; adjusted for uplands using Cruz, Zosa-Feranil, and Goce (1986).

*This table is adopted from the tables in Cruz et al. (1992, pp. 21).

TABLE 2. Net Upland Migrant Population in the Philippines, 1960-1985

Year	1960-1970	1970-1975	1975-1980	1980-1985
Upland Rural	384,225	275,293	788,513	1,760,280
Upland Urban	83,402	152,101	575,039	785,330
Total Upland	467,627	427,394	1,363,552	2,545,610
Migration Rate (%)	4.2	3.4	9.4	14.5

Notes:

1. Net migrants as a percentage of the total upland population in the census year.
2. Migrants defined as persons 10 years old and over changing residence during a specified time period.
3. Birth-to-1960 information incomplete; migration figures for this period adapted from Smith (1977).
4. Census-defined classification of urban and rural based on national Population Census (1960-1980) and national Barangay Census (1985).
5. Upland areas defined as lands with 18% slope or higher as officially classified; includes municipalities with 75% or more of their land area classified as upland.

Sources: National Census and Statistics Office, Population Census, various years; Barangay Census, 1985; adjusted for uplands using Cruz, Zosa-Feranil, and Goce (1986).

*This table is adopted from the tables in Cruz et al. (1992, pp. 8,9).

A majority of those uplanders engage in swidden cultivation which requires cutting, drying and burning of forest vegetation, then alternatively cropping upland rice, maize, or root crops, generally with little or no input of fertilizer (World Bank 1989, pp. 23; Porter et. al. 1988, pp. 28-29). In the early 1990s, an estimated seven million hectares, roughly 23 percent of the total land area of the Philippines are put under this practice, and it is said to have annually destroyed 50,000 to 100,000 hectares of forest lands which consequently became seriously degraded.[3)] It is reported that, some 80,000 to 120,000 families have cleared an estimated 2.3 million hectares of forestlands (Repetto 1988, pp. 59). Since most of them are legally considered as squatters without stable tenurial rights, their incentives for conservation of local resources are said to be undermined (Lynch & Talbott 1988, pp. 688-689).

Contrary to popular beliefs about destructive swidden farming, it is argued that some traditional swidden cultivation methods practiced by indigenous tribes have been

3) Cruz et al. (1992, pp. 22-23) reports that a 30 degree slope is used as an upper limit for upland cultivation beyond which excessive soil erosion is inevitable. Nevertheless, farming on moderately sloped lands also requires protection measures as the topsoil gets washed away by seasonal rains.

environmentally sustainable. They are reported to employ various protective measures, recognising the delicate balance between the forest resources and their own survival (Gibson 1986, pp. 34; Aguilar 1982, pp. 180). Such arguments are supported by a number of case surveys on different tribes, and also evidenced by the actual preserved forest cover in their communities. Their protection measures are taken at every point of swidden cycle starting from site selection to the fallow stage. Such measures include: a general avoidance of pioneering new areas of virgin forest; fireline construction to prevent fire spreading; use of fertilizer and various measures for soil maintenance; practicing crop rotation; tree and crop cover-planting to prevent soil erosion and landslides; construction of buffers; planting trees before entering the fallow stage, and so forth (see Aguilar 1982, Cruz et al. 1992, pp. 22, Gibson 1986, Lopez-Gonzaga 1983, World Bank 1989). They apply different swidden cycles according to the environment and allow a sufficient fallow period to recover soil fertility.

2.1 The Effects of Lowland Migrants

The effects of lowland immigrants on upland community can be broadly categorised by quantitative and qualitative effects. The quantitative effects are mainly due to population pressure.[4)] The average population density on the uplands with 18 to 30 degree slopes has reached 260 persons per square kilometre (Cruz et al. 1992, pp.4), which is argued to be well above the critical limit of swidden farming.[5)] Such population pressure has led to a decline in available cultivation areas, and typical farm sizes in the uplands have become as low as one hectare in overcrowded areas such as Cebu, and 2-3 hectares in less densely populated areas (World Bank 1989, pp. 22-23).

Cultivated upland forestlands increased from less than 10 percent to over 30 percent of total cultivated area during 1960 and 1987. Facing the closure of the lowland agricultural frontier already in the mid-1970s, most of agricultural expansion took places in the uplands where lands are generally fragile and ill-suited for agriculture (Cruz et al. 1992, pp. 4, 23). Besides the expansion of farming in the less favourable lands, the obvious result has been the intensification of land use by a shortening of the swidden cycle and fallow period, more frequent cropping, change in cultivation methods and so on. While such intensified farming methods can be regarded as favourable in terms of improved land use efficiency in an appropriate setting, the situation we are concerned with would be different. Considering the fragile land base unsuitable for farming, poverty of immigrants, insecure tenure status and invadable nature of upland forests, it seems to be improbable to expect an efficient use of upland resources, not to mention a sustainable use.

Indeed, the transformation of uplands into farms and the intensification of farming are claimed to have led to substantial soil erosion and degraded soil quality (ibid.). Soil erosion reduces the fertility and water-holding capacity of soil, thus reducing its future productive

4) The population growth rates have been much higher in the uplands than the country as a whole with increasingly higher rates of net in-migration since the 1970s. See Table1 and Table2.

5) The critical limit depends on the particular environment, see Gibson (1986), Porter et al. (1988, pp. 29), World Bank (1989, pp. 23).

value (Cruz and Repetto 1992, pp. 19). The annual average depreciation of upland agricultural soil is estimated to be 242 million pesos in 1972 prices, and since this represents a continuing loss of productivity, the loss associated with soil depreciation for the year is deemed to be considerable (ibid.).[6] From the figures in Table 3, it is clear that upland agricultural soil has continuously depreciated throughout the period of 1970-1987. Some traditional farmers have given up swidden cultivation altogether, while some others have been pushed further back onto the steeper sloped, less fertile forests that are more prone to damage. World Bank (1989, pp. 23) reports that swidden farming is now often practiced in degraded areas long denuded of trees, and even the indigenous farmers are said to engage in destructive practices causing as much soil erosion as those lowland migrants (also see, Cruz et. al. 1992, pp. 21-22; Aguilar 1983, pp. 421; Lopez-Gonzaga 1983, pp. 126). Soil erosion impair irrigation facilities, thereby further deteriorating land quality.[7]

TABLE 3. Upland Agricultural Soil Depreciation, 1970-1987 (in million 1972 pesos)

1970	1971	1972	1973	1974	1975
-139	-151	-163	-176	-188	-200
1976	1977	1978	1979	1980	1981
-212	-224	-236	-249	-261	-273
1982	1983	1984	1985	1986	1987
-285	-297	-309	-322	-334	-346

*This table is adopted from the table in Cruz and Repetto (1992, pp. 18).

The qualitative effects of migrating lowlanders on the upland communities reflect the heterogeneity between them and indigenes. These effects cannot be precisely determined since there are various indigenous tribes and lowlanders. Yet they seem to have affected the state of indigenous people in many ways. A short list of lowlanders' heterogeneity concerning resource management would be: their farming knowledge and techniques, available resources, notion of production, economic concept, type of corps to plant, incentives for environmental protection, affiliation to the land, norms of sharing and cooperation, consumption patterns, and so forth (Lopez-Gonzaga 1983; Cruz 1985; Gibson 1986; World Bank 1989; Concepcion 1991). Lowlanders generally have little knowledge about the ecological and environmental constraints of farming in the uplands with the high risk of soil erosion. Most of the recent migrants are reported to be impoverished landless people being pushed from the lowlands where unequal distribution of wealth and unemployment prevail (Cruz et al. 1992; Cruz and Repetto 1992). They therefore lack the resources to practice any conservation measures. Adding to their poverty, the fact that most of them are squatters may well suggest their high discount rates and low incentive to invest in any conservation or protection measures to which the returns accrue

6) They also provide estimates of timber and coastal fishery depreciation, both of which also exhibit net depreciation throughout the same period. In addition, they provide a crude assessment of the externality effects of soil erosion in watersheds on three off-site sectors: irrigated agriculture, coastal fishing, and hydropower generation. The losses of these three sectors together are estimated to be 4.9 billion pesos for 1988 alone. However, note that these assessments are crude both in terms of availability of data and estimating methods.

7) Although we are not discussing other damaging effects on the uplands, we should note that commercial logging and mining companies often pioneered the opening of frontier forestlands, constructing roads and offering the follower migrants easy accesses to the logged-over lands and promoting further illegal cutting.

in the long-term future. They employ swidden cultivation simply because it requires the minimum input of labour and capital, using land as a substitute. In such a situation, those migrants are rather expected to extract as much as possible regardless of long-term efficiency or sustainability of resource use.

One of the most serious effects, the fundamental change brought by the lowlanders is increasing land insecurity. It stems from the legislative and administrative confusion. The upland forests in the Philippines, which designate those areas with the slopes of at least 18 degree, are state property under the jurisdiction of the Department of Environment and Natural Resources. While the constitution recognises the property rights of indigenous tribes, neither their traditional rights nor state property rights are generally protected or enforced over those lowlanders illegally migrating and squattering in the forest areas (Cruz et al. 1992, pp. 5, 28; Cruz and Repetto 1992, pp. 42).[8] Such legislative confusion has become detrimental to the indigenous communities, especially due to a recent rapid increase in migrants who regard the uplands virtually as open access resources.[9]

Increasing land insecurity may hamper indigenes' incentive to sustain their protective measures and to restrict their use of resources, as the acquisition of the future benefit from such investment will not be assured. Moreover, the new entrants have reduced the availability of land areas for indigenes to the extent that it has become increasingly difficult for them to sustain their traditional swidden farming allowing a sufficient fallow period for the soil to recover its fertility. Such population pressure may increase the necessary resource use exceeding the sustainable limit, i.e. carry capacity, of the environment. If one cannot get sufficient returns, there is no reason to expect the original equilibrium state to be sustained, and the traditional swidden farmers are now also regarded to degrade the upland environment. Thus, unclear property rights and increasing population pressure together seem to have converted some upland forests from tribal lands to de facto open access resources, generating a situation characterised by a well-known Hardin's Tragedy of the Commons.[10]

3. The Framework for the Breakdown of Cooperative Institutions

Like the case of the Philippines described above, there are many cases reported around the world where resources which were sustainably managed by traditional local communities have become seriously depleted as such institutions have broken down. Concerning the community-level resource management system, the main theoretical interests rest on the explanation of the cooperative behaviour of individuals. There is a vast literature attempting to explain such

8) For especially legislative issues concerning the Philippine forest lands, see Lynch and Talbott (1988).

9) The World Bank (1989, pp. x) admits that most upland areas are now *de facto* open access, and stresses that such lack of secure tenure or titling provides no incentive for land maintenance, resulting in a high rate of soil erosion.

10) Lee (1991, pp. 316) points out that many common property resources (CPR) management problems today, representing Hardin's problem, arise primarily through weakening of traditional management due to modernisation, increasing intensity of use, population growth, etc. Larson and Bromley (1990, pp. 238) regard the unclear property rights or/and the breakdown of enforcement authority as possibly the basic cause of environmental degradation in many developing countries.

cooperative behaviour of people.[11] Anthropologists and sociologists view cooperation to be induced by the norms and conventions. Some stress the importance of biological factors, focusing on the evolutionary process. Economists, retaining the fundamental assumption of rational self-interested individuals, analyse cooperation from the point of view of individuals' incentives. They utilise the game theoretic framework setting different assumptions. There are also a number of case studies of so-called 'common property resource (CPR) management' analysing the cooperative structure of the society (for instance, see Wade 1987; Ostrom 1990; White and Runge 1994a,b; Seabright 1990).[12]

The breakdown of cooperative institutions can be due to the changes in the external and/or internal conditions that are beyond their capacity to deal with. In this part, we first consider various reasons for the institutional breakdown in the light of the literature on CPR management. Then referring to our case, the process of the breakdown of the traditional cooperative system is analysed in a game theoretic framework to see how the various factor changes affect individuals' incentives for cooperation. We consider the possible impacts of lowland immigrants on cooperation among the traditional upland farmers. It may illustrate the vulnerability of such cooperative institutions in developing countries, leading to some remarks in the Conclusion.

3.1 Factors of Institutional Breakdown

The cooperative institutions managing common property resources are subject to various conditions.[13] Although the effects can vary from place to place, we assume that the indigenous farming system has been sustainable due to their cooperation. In our case, a stream of upland migrants are considered to have affected most of these conditions in general. Bromley and Cernea (1989) maintain that in many cases, incentive schemes have become inoperative due to external pressures or forces beyond the control of the community, or due to internal processes that the community was unable to master. The institutional breakdown can occur because of a shift in natural environment, property regime, population, technology, public policy, income distribution within the community, and so forth. Similarly, Jodha (1990) states that degradation of CPR can come about due to a change in dynamics such as population growth, market forces, technological changes and environmental stress, which affect the informal or formal norms of people. Such external shocks may sufficiently affect internal factors such as homogeneity among the members. Also, some severe external shocks may endanger long-term cooperation by making it too costly strategy.

The effectiveness of CPR management is said to especially rest on the following factors:

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11) See Bardhan (1993a,b) for a review of various theories of cooperation including game theory and evolutionary biology. Also, see Seabright (1990, 1993), Stevenson (1991), Runge (1986), White and Runge (1994a,b), Hirshleifer (1987), Ostrom (1990).

12) Although the usage of the term 'common property resource management' is controversial, we simply regard it here as signifying 'resources managed under a communal management system.'

13) For the factors enforcing and discouraging cooperation, and for the conditions for successful CPR management, see Bromley (1989), Bromley and Cernea (1989), Jodha (1990), McKean (1992), Singleton and Taylor (1992), White and Runge (1994a), Dasgupta and Maler (1990), Wade (1987), Runge (1986).

well-defined user-managers, a clear definition of CPR, clear and easily enforced rules, effective monitoring, and balanced distribution of rights and shares. Besides such institutional arrangements, the importance of the nature, an internal element of society, is also stressed. Communities where members retain continuing and close interrelationships, homogeneous interests and shared beliefs are seen to be more capable of achieving cooperation. For such communities, collective action and internalisation of cooperative norms are regarded to be relatively easy. Internalisation of norms by the members then is deemed to reduce transaction costs and facilitate monitoring, which would enforce cooperation. Besides those factors, White and Runge (1994a) notify the significance of shared knowledge about the benefit generated through their collective action. On the contrary, cooperative institutions are said to be weakened by a sufficient degree of heterogeneity where coordination would become increasingly difficult.[14] In fact, even if the society is originally homogeneous, it is nevertheless not sufficient for cooperation, and homogeneity itself is subject to the influence of various factor changes.

3.2 The Theoretical Structure of Cooperation

Adopting a game theoretic framework, we analyse the process of the breakdown of traditional system to clarify how individuals' incentives are affected. The Prisoner's Dilemma (PD) game has been widely utilised to explain the free-rider behaviours of self-interested individuals.[15] It has been providing the theoretical justification for Garrett Hardin's *Tragedy of the Commons* (1968) or Mancur Olson's *Logic of Collective Action* (1956). By putting several assumptions, the repeated Prisoner's Dilemma (RPD) game can be shown to produce spontaneously sustainable cooperative equilibria by making cooperation a rational choice.[16] Such assumptions include: future payoff not heavily discounted (not too high short-term reward from defection); sufficient probability of credible punishment over time to overweigh the benefit from defection; game repeated infinitely or finitely but expected to be continued sufficiently long, and so forth. Hence we are assuming foresighted rational individuals.[17] While some argue that the Assurance game better resembles the real CPR situation,[18] it depends on each empirical situation, and the case we are concerned here seems to be better

14) It seems to be that the more heterogeneous the group is, the more the group has to depend on the outside enforcement scheme. For instance, see Johnson and Libecap (1982). Note that there is an "infinite set of homogeneity/heterogeneity distinctions" (White and Runge 1994a, pp. 12).

15) The one-shot PD game always results in an inferior outcome because of the dominance of a free-rider strategy. Hence rational individuals do not cooperate unless there is a compulsory outside enforcement.

16) As Seabright (1993) states, in the repeated games, cooperative behaviour can grow out of self-interest as future concerns get incorporated. See Seabright (1993) for various conditions. For the formal proofs, see Abreu (1988), and Fudenberg and Maskin (1986).

17) Cooperative behaviour can be viewed as an outcome of a rational individual's choice, being consistent with self-interested behaviour. For instance, Runge (1986, pp. 632) argues that "the tenacity of traditional institutions cannot be explained simply as the manifestation of backwardness or irrationality," but "a more logical explanation is that rational individuals are not inclined to relinquish institutional arrangements that have apparently acted as survival-promoting strategies even if survival has not been especially comfortable." Yet, note that such cooperation with an 'uncomfortable outcome' may be fragile and 'evolutionary unstable,' in the sense that commercialisation or modernisation may put a voluntary end to such traditional institutions. On the other hand, if such institution is efficient, they can be 'evolutionary sustainable.'

explained by the RPD model.

Now, let us consider a simple theoretical framework based on the PD model.[19)]

		Player 2	
		Cooperate	Defect
Player 1	Cooperate	*X X*	*Y Z*
	Defect	*Z Y*	*0 0*

FIGURE.1

Here, the assumptions are $Y > X > 0$ and $Z < 0$. If this is a one-shot PD game, then the outcome becomes both defecting as it is the dominant strategy for both players. If the game is repeated with a discount factor of δ and if $Y - X < \delta X/(1-\delta)$ holds, then there exists a retaliation strategy of one playing defect for at least T periods ($t > T$), making the other who has broken the agreement of cooperation worse off:

$$Y\text{-}X \leq \delta X + \delta^2 X + \ldots + \delta^T X \tag{1}$$

Assume there exists a certain amount of uncertainty about other's strategies.[20)] Letting p ($0 \leq p \leq 1$) be the probability of a player believing the other's cooperative behaviour (i.e. a "trusting" cooperation equilibrium) in the current period, then the expected payoff to each player from cooperation is:

$$\pi_c = p\frac{X}{1-\delta} + (1-p)\left(-Z + \frac{\delta^{t+1}X}{1-\delta}\right). \tag{2}$$

The expected payoff is the sum of the payoff from cooperating forever with probability p, and the payoff of playing defect forever once being defected by another, with probability (1-p). Similarly, the expected payoff to each player from playing defect is:

$$\pi_D = p\left(Y + \frac{\delta^{t+1}X}{1-\delta}\right) + (1-p)\left(\frac{\delta^{t+1}X}{1-\delta}\right). \tag{3}$$

Thus the net expected benefit from playing cooperate is:

$$\pi_C - \pi_D = p\frac{X(1-\delta^{t+1})}{1-\delta} + pY - (1-p)Z, \tag{4}$$

18) In the Assurance game, it is in players' interests to cooperate provided that they are assured of others' cooperation. For instance, see Runge (1986) for the use of this model in the analysis of community-level resource management. He also refers to the concept of "critical mass" and Sugden (1982, 1984)'s "principle of reciprocity."

19) The basic framework is adopted from Seabright (1990).

20) A certain amount of uncertainty about others' strategies can lead to cooperation. Particularly, if a player assigns any probability to "the possibility that others will view cooperation as being in their long-term interest, they may experiment with the cooperation strategy, in turn inducing others to follow suit" (Stevenson 1991, pp. 75, referring to Kreps, Milgrom, Roberts and Wilson 1992). One example for ensuring such an outcome in the RPD game is to play tit-for-tat strategy in which players begin with cooperation and one mimics the strategy of the other in the previous period.

which is increasing in p, given other parameters. For a sufficiently high or low value of p, it becomes either positive or negative, respectively. For a given value of net expected benefit, the probability of cooperation p is an increasing function in Y and Z, while it is an decreasing function in X. Letting $\pi_C = \pi_D$ (or $\pi_C - \pi_D = 0$), the critical value of p is

$$p^*(X,Y,Z) = Z(1- \delta)/\{X(1- \delta^{t+1}) + (Z - Y)(1- \delta)\}. \quad (5)$$

Thus assuming the other will cooperate (sufficiently high p), it is beneficial for one to cooperate provided a sufficient benefit from cooperation. The average payoff in each period in the RPD game resembles the one-shot Assurance game where one is better off cooperating when the other cooperates (i.e. $\pi_C > \pi_D$), but defecting when the other defects (i.e. $\pi_C < \pi_D$).[21] Thus, cooperate-cooperate strategies become Pareto efficient, joint-welfare-maximising cooperative equilibria.

This framework can also be treated as the Multiperson Prisoner's Dilemma (MPD) game with n individuals, assuming random matching, where the probability of cooperation now becomes the proportion of population playing cooperation.[22] Thus the critical value of p (i.e. p^*), now becomes the critical mass of cooperative population. If a sufficient proportion of the population cooperates, optimal outcomes can be achieved. In the case of the indigenous tribes of our interest, p is considered to be sufficiently large, provided that their institutions have been sustained over time, they are interdependent, and their cooperative behaviours seem to be governed by social conventions and norms.[23] Thus the sustained cooperation-cooperation equilibria in their society may be regarded to represent the focal points determined by their past, cultural experiences and the like.[24]

3.3 The Breakdown of Cooperation

While the game theoretic analysis on cooperation assumes no dynamic change in the

21) In the Assurance game, the new restrictions, parallel to the game in Figure1, become $X > Z > 0$ and $Y < 0$. It differs from the RPD game in the sense that once cooperation-cooperation is reached, there is no incentive for one to deviate in the Assurance game. The RPD game discussed here may achieve cooperative outcomes by incorporating the expectation about other's strategies, while allowing the room for a defect strategy.

22) Runge (1986) discusses the MPD game but not in a sequential game context. He discards the uniform MPD game as it cannot reach cooperative outcomes, and considers the extended MPD game incorporating the interdependence in decision which leads to multiple equilibria without the dominance of free-rider strategies. By coordinating the expectation of a "critical mass" of agents, the game reduces to the Assurance game. In this sense, the more homogeneous community is likely to achieve optimal outcomes. Also, he stresses the importance of village norms and conventions for such coordination.

23) According to Tirole, using the sociological definition, "a convention refers to the coordination on a particular Nash equilibrium in a situation of multiple Nash equilibria," and a norm is something generated so as to be approved by others and "need not be in one's self-interest" (1993, pp. 6). However, we do not make any detailed distinction between them and use them as some internalised customs or rules which one naturally follows. Bardhan (1993a, pp. 635-636) notes that social norms, morals, and social empathy inducing reciprocal behaviour, provide rules of thumb and focal points in the game, allowing the player to go beyond the self-interest. As aforementioned, norms and conventions are said to be cost effective, yet can be regarded as sustainable only if the background environment remains basically the same. See Dasgupta and Maler (1990, pp. 115), Runge (1986, pp. 630-31).

24) A simple definition of focal point is "the equilibria that people sometimes just naturally focus upon" (Kreps 1990b, pp. 415). Within a game theoretic framework, this issue leads to an interesting discussion on retrospection, and also on bounded rationality. See Kreps (1990a,b).

environment, the situation we are concerned with, or any situation in reality, experiences various fundamental changes. As Bardhan (1993a, pp. 635) stresses, real-world cooperation is continuously affected by on-going interactions among agents, modifications of the rules of the game, changes in the payoff matrix, possible evolution of strategy sets, change of preferences and values in a community, and so forth. Ostrom (1990, pp. 50) points out that the physical and technological constraints also change, being affected by the players' actions in every period (e.g., resource units being withdrawn each period). Although we are not able to construct a sophisticated model wholly incorporating such dynamic aspects, here we consider some of the factor changes in our game structure. We attempt to clarify how changes in each factor affect individuals' incentives to cooperate, leading to the breakdown of cooperation.

Referring to the Philippine case, cooperative behaviour would designate a sustainable use of forest with protective farming methods, while the defect strategy would be to extract as much as possible with little or no consideration for others nor for the future. As aforementioned, lowlanders' discount rates are likely to be much higher, reflecting their poverty and tenure insecurity. Thus there is little reason to expect mutual trust or voluntary cooperation among the immigrants, or between them and traditional farmers. Their overall heterogeneity including cultural background and languages may well hamper the realisation of any binding agreement to engage in cooperative activity, unless such strategies happen to be the dominant strategies for all of them, which is evidently not the case. Nevertheless, note that we are more interested in looking at the changes in the incentive scheme among the original upland people, rather than the relationship between them and migrating lowlanders.

3.3.1 Changes in the Payoffs: X

Even if the immigrants do not explicitly enter into the game as players, they would affect the payoff matrix which is set above. The return to each individual would be reduced, supposing the whole pie is fixed. In other words, the carry capacity of the environment has been reached. Given the environmental constraints in the forestlands, the traditional farmers would experience a decline in output per hectare. Not only the decline in farming areas per se, as the result of population pressure, would make output decline. Due to insecure property rights, the more fertile and favourable farming areas might be taken away. Also, the quality of soil would be degraded due to intensified use without appropriate protection measures. As stated earlier, the upland environment is fragile and unless handled properly, swidden cultivation can cause severe soil erosion, over-burning of forest trees, and other environmental degradation.

Even if the original value of p (the degree of trust, or the probability of an individual believing the other's cooperative behaviour) is unaffected, if the benefit from cooperation is reduced to below a certain threshold level $\underline{X}^*$ to keep cooperative behaviour, the cooperation-cooperation outcome will be hampered, since a lower value of $\underline{X}$, where $\underline{X} < \underline{X}^* \leq X$, now requires a higher value of p^*. One such case is that even if they have the established trust, norms and conventions, if the returns are reduced so as to make a family's life difficult to sustain, cooperation may disappear.

Indeed in such a case, one would expect an increase in the discount rate, resulting from the reduction in the absolute value of the benefit from cooperation, i.e. $\partial\delta / \partial X < 0$. For instance, even if the value of X relative to that of Y remains unchanged, the changes in their absolute values due to the shrinkage of the whole pie would affect the players' calculation in deriving their strategies. If the players experience a considerable reduction in the payoffs due to population pressure or serious environmental deterioration, defection may become the only viable choice. Since there has been an increasing inflow of lowland migrants, and since the stresses on environment are likely to increase over time, the players may anticipate a continuous reduction in the absolute value (hence also the discounted value) of future payoffs. This would further decrease the prospect of cooperation.

It would be hard to expect cooperation, even in a society characterised by a cooperative nature, if one's own survival is at stake.[25] As such, there is a 'threshold' or 'critical payoff' in terms of absolute values, which enable their subsistence, especially if their living highly depends on the activities incorporated in the game. If this critical payoff can no longer be assured, one would immediately expect an increase in the discount rate, and eventually, a decrease in the degree of trust. Thus this change in a situational, external factor would induce changes in internal factors, δ as well as p, leading to a breakdown of cooperation and environmental degradation. Note also that even if the defect choice falls below the critical payoff, the only strategy is to take the exit option by quitting swidden activities altogether or moving somewhere else.

3.3.2 Changes in the Trust: *p*

From the analysis on cooperative framework, it is clear that p, the degree of trust, has to be sufficiently large in order to bring a cooperative outcome. From equation (5), it is clear that if X is reduced, p has to become even larger in order to enable cooperation. Thus the original value of p would no longer be sufficiently large to sustain cooperation. Nevertheless, following a sufficient reduction in X as mentioned above, the value of p would not increase but would decline, i.e. $\partial p / \partial X > 0$, thus making cooperation impossible.

Now consider a game where the lowland migrants are explicitly incorporated as players. Heterogeneity is introduced. Such heterogeneity would contain a different time horizon, different (higher) discount rate, possibly different cost and utility functions, and so forth (see the previous discussion on the lowlanders' qualitative impacts). The immigrants would have various probability distributions of the beliefs about other's behaviours. Due to their lack of secure property claims and poverty, their concern about the upland environment and their incentives to practice any protective farming methods are perceived to be negligible, if not inexistent. Since they have no prospect for any sort of long-term future benefit, their expectation about the behaviour of indigenous farmers would be irrelevant, having no influence on those migrants' behaviour. Assuming such a scenario, the indigenes' expectation

25) As McKean (1992, pp. 248) puts it, "the need to cooperate even in the interest of survival is woefully inadequate motivation to cooperate."

on cooperation, the original value of p would undoubtedly decline when the indigenous community faces these different players.

3.3.3 Changes in the Discount Factor: δ

One of the fundamental problems brought by the immigrants are that their lands and the peripheries have now become subject to encroachment. If the upland forests virtually become open access resources, their future payoffs are no longer guaranteed. Such take over threats would significantly increase their discount rate, hence their discount factor δ would be considerably reduced so as to hinder cooperation among the traditional community. If the environment can be destroyed by new immigrants no matter what they do, the traditional farmers' incentives to invest in lands, to apply protective measures, or to use the resources sustainably, would not function. Also as discussed in the previous section, with smaller returns from their activities, one would discount the future more heavily as the survival today becomes the priority matter. Moreover, immigrants' destructive practices resting on their shorter time horizons would produce negative externality effects on the traditional practice to a certain extent.

As we have seen, we may expect the migrants from lowlands to affect the traditional cooperative community in all these aspects, and if it is the case, there is no reason to expect cooperation among the indigenes to be sustained.[26] If their land is exploited by new entrants whose interests are to reap all the benefits today, one's rational strategy becomes to do the same and get as much as possible in the first period, especially if the returns are significantly reduced. The rules of the game change, and the RPD game is reduced to the original one-shot PD game with its original predicted outcomes. The *Tragedy of the Commons* is triggered by the external forces.[27] The conditional cooperation collapses in every respect that the pie becomes too small so that cooperation can never be in the interest of the players, the future is highly discounted, and the prospect for repeating the game is significantly limited. No credible threats or retaliation would exist if everyone is facing such a severe environment. Thus changes in dynamic environment, i.e. external variables, induce changes in individuals' incentives, i.e. internal variables, from resource conserving to resource mining. Cooperation, together with social norms and degree of trust, are eroded within the indigenes, and consequently environmental degradation occurs.

As such, conversion of the upland forests to open access resources may result, where labour inputs expand on the available land until the average products equals their opportunity costs,

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26) The resulting shift in their strategies may designate that the original cooperative behaviour was not a John Maynard Smith's notion of evolutionary stable equilibrium, in the sense that the defect strategy was never driven out. According to Bardhan (1993, pp. 635), evolutionary stable strategy is a pattern of behaviour generally followed in the population, such that "no mutant strategy can invade." For interesting analysis on the evolutionary models of cooperation, see Hirshleifer (1987), Boyd and Richerson (1985).

27) Repetto and Holmes (1983) provide an interesting work concerning the resource depletion problems in developing countries. They conduct simulations looking at the effects of population growth, commercialisation, breakdown of traditional management system and creation of open-access situation (change in discount rate), and so forth. Their simulation exhibits considerable effects on environment caused by the breakdown of traditional systems of resource management and the creation of virtual open access situation, as well as those of commercialisation.

with all profit being dissipated. If the effects of immigration are limited, there is a possibility for one to achieve Pareto optimal outcome provided that a biding agreement is reached. Otherwise, every farmer may turn to be myopic trying to maximise present profits. Such over-exploitation of resources at the open access equilibrium would result in serious environmental degradation.

4. Concluding Remarks

In this paper, we have analysed how the traditional sustainable resource management system breaks down with negative consequences for the environment, referring to the upland migration problems in the Philippines as a representative case. For the breakdown of traditional institution, we have considered factors leading to such a situation, describing how the cooperative framework among the upland indigenous people degenerates into the original one-shot Prisoner's Dilemma model due to the adverse impacts brought by lowland migrants. To the extent that the underling assumptions approximate the actual conditions, the theoretical framework is expected to explain and/or predict the processes of the real phenomena that may not be precisely observable. Further works assessing the phenomena empirically are expected in this respect.

Throughout the paper, we have been viewing the traditional farming methods practiced by indigenous people as environmentally sustainable practice resting on their cooperation. While much of the recent literature maintains the effectiveness of such local, traditional institutions for resource management, their tenacity and sustainability seem to require abundant conditions. As we analysed in this paper, such institutions seem to be highly vulnerable to the changes in dynamics. For one to sustain such institutions already existent or to have resilient institutions that can induce appropriate technology in response to the changing environment, one of the most important conditions would be the adequate issuance and enforcement of property rights. This is also essential in order to avoid the open access situation.

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