Social Norm of Work and the Optimality of Resource Extinction

Y. Hossein Farzin*

Ken-Ichi Akao**

Abstract

Departing from the standard economics assumption, we assume that people value work not only for earning income to satisfy consumption needs but also as a source of community/social involvement which provides socio-psychological satisfaction. We show that in closed, rural resource-based communities where sharing in the harvest work is a cultural norm, the socio-psychological satisfaction from work and adherence to work norm can induce full-employment harvesting, thus rendering it optimal to harvest a resource to extinction even if a sustainable resource consumption path is feasible. We show that such communities can sustain their natural resources either by using outside-the-community employment opportunities or by economic diversification. However, to be effective, such policies must ensure that the outside wage rate and the initial capital stock are above certain minimum levels, which will be higher the longer these policies are delayed.

* Corresponding author, Professor, Department of Agricultural and Resource Economics, University of California, Davis, CA 95616, U.S.A. farzin@primal.ucdavis.edu.

** Professor, School of Social Sciences, Waseda University, Tokyo, Japan, Akao@waseda.jp

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1. Introduction

Ecologists often argue that the extinction of natural resources is a consequence of our rather selfish behavior and partial view of the ecosystem. In order to satisfy human needs, many people behave as if they are independent of the ecosystem that provides the basic materials to sustain life. As such, in their view, *over-consumption* or materialistic greed is the underlying cause of extinction problem. Economists have in turn identified the circumstances under which resource extinction can be the outcome of a *rational* behavior. For example, when resource markets are well established and the motivation for resource harvesting is to maximize the present discounted value of profits, they have shown that if the harvesters' discount rate is high relative to the species' biological growth rate it may lead to resource extinction in a finite time. They have also shown that when property rights over the resource are not well instituted or can not be effectively implemented (as, for example, in an open-access regime), then strategic behavior of resource users combined with unfavorable economic and biological growth conditions can result in extinction.

Both of these views provide valuable insights into the causes of resource extinction. In this paper, however, we attempt to provide an alternative explanation. We argue that in closed, rural resource-based (RRB) communities, the psychological and sociological benefits of work in general and the desire to follow the communal *norm* of sharing in the harvesting efforts in particular may explain the extinction of natural resources. This can occur if work is both a source of earning income to satisfy materialistic (consumption) needs as well as a principal means of community involvement and a cultural norm. We go beyond the standard neoclassical income-leisure choice, which considers work only as a source of income. Rather, we follow sociologists and psychologists (see, for example, Whelan (1994) and Agerbo et al (1997)), who recognize that, in addition to being a source of income and material satisfaction, work can provide psychological and sociological (nonpecuniary) satisfaction. The socio-psychological benefits of work can be particularly strong in poor RRB communities where sharing of the efforts needed for production is a social norm and an important constituent of one's identity. In such communities, being out of work or choosing not to participate in sharing of the efforts is a deviation from the social norm, which can inflict severe social stigma and considerable loss of utility.

Allowing for the nonpecuniary value of work, whether this arises from an individual's self (psychological) assessment or from a desire to follow the social norm of work, can give rise to "full employment obsession" in such communities. If labor is the principal input (or "effort") that determines the rate of resource harvest, a "full employment obsession" can explain why it may be *optimal* to extinct a resource in *finite* time even if an alternative sustainable path is available: sustainability may require the community to break away with its work norm by laying off some of its workforce for a transitory period to let the resource stock grow. Thus, we offer "full-employment obsession" as an alternative to both the ecologists' "selfish behavior" explanation and the economists' profit maximization and market failure explanations of resource extinction. The point is that, even in the absence of the ecologists' and economists' causes of extinction, that is, even if communities recognize the ecological constraints on regenerative capacity of the resource, and the harvesters do not pursue profit maximization as their principal motive, and the community fully owns the right to the resource so that there is no absence of property rights to lead to open-access harvesting, still the negative socio-psychological effects of unemployment and the disutility associated with violation of the social norm of work may prevent the community from resorting to unemployment to reduce the aggregate level of harvesting effort in order to let the resource stock regenerate itself to a sustainable level. We show that in such situations, employment outside the community or economic diversification can under appropriate conditions achieve both resource sustainability and full employment goals.

Our result alerts us that the persistent of social norms that may have been once beneficial but are no longer in line with the existing physical (ecosystem) realities or with other (economic, technological, demographic, social or political) conditions, rather than helping, can actually become an *obstacle* to resource sustainability. Interestingly, in his illuminating and popularized work, Diamond (2005) attributes to cultural beliefs and norms of resource harvesting, and their persistence, as a principal cause of the resource extinction and consequent collapse of past civilizations such as Easter Islanders, the Mayans, and the Norse Vinlanders in Greenland. However, our argument should not be misconstrued: it does not deny the important role that communal norms of work can, under appropriate conditions, play to bring on cooperation and coordination necessary for sustainable management of common property resources (see, particularly Ostrom (1990)(2000) and Ostrom and Cardenas (2006), among many others).[1]

Economics literature provides few studies of conditions for the optimality of resource extinction in a finite time. Clark (1973) and Spence (1973), the classic papers, showed that when there is a purely economic motivation (i.e., maximization of the present value of the stream of profits from resource sales), if the resource owner's discount rate is higher than the growth potential (intrinsic/biological rate of growth) of the resource, then it is economically optimal to deplete the resource stock to extinction in a finite time. Spence (1973) corroborated this result numerically in the case of the blue whale, which was then an endangered species.[2] Brander and

[1] Diamond's accounts of these collapses are, however, mainly descriptive histories and fall short of providing analytical, let alone economic, explanations. For an insightful review and assessment of the relevance of Diamond's work to modern civilizations, see Page (2005).

Taylor (1998) in an insightful paper analyzed the dynamic interactions of an open-access renewable resource and human population to explain the collapse of the Easter Island civilization, showing that the resource and population dynamics had an oscillatory behavior, and that a change in parameters, reflecting climatic changes on the island, allowed the population or the resource stock to fall below critical levels for regeneration, leading to the extinction of the population or the resource. The main distinctive feature of our paper is the explanation of excessive supply of effort because of the socio-psychological value of work and the desirability of adherence to social norm of work in an RRB community.

The paper proceeds as follows. Section 2 briefly reviews some of the empirical evidence for socio-psychological value of work to individuals in general and discusses why it may be particularly strong in RRB communities. Section 3 uses the standard bioeconomic model of a renewable resource to show the incompatibility of full employment with resource sustainability when nonpecuniary value of work is strong, and identifies the condition under which resource extinction in finite time is optimal. Section 4 explores the possibilities of outside employment and economic diversification as potential policies to achieve both full employment and resource sustainability, and shows that for such policies to be effective the outside wage rate and the initial capital stock should exceed certain minimum levels, and that these critical levels will be higher the longer the adoption of the policies are delayed. Section 5 concludes.

2. Socio-psychological Value of Work

Work is a principal means for people to connect and become involved with communal activities. In turn, community involvement directly and indirectly brings the individual a sense of self-esteem, self-respect, belonging, identity, recognition, reputation, friendship, security, and status, all of which are ingredients of one's quality of life and satisfaction (Jahoda (1988)(1982)(1981)).[3] Being employed is an essential determinant of happiness; the unemployed

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[2] Note that the well-known case of extinction of a population under the open-access regime (sometimes known, incorrectly, also as the "tragedy of the commons") may be viewed as a special case of this result when the discount rate approaches infinity. However, Cropper and Lee (1979) show that this result need not hold when the harvest price is allowed to be inversely related to the harvest rate rather than assumed to be constant, as in Clark (1973). In that case, the result holds only for sufficiently small initial stocks but not for sufficiently large initial stocks even if the discount rate is infinite (see also Farzin (1984) for the role of the initial stock size for the effect of the discount rate on resource depletion). In a related paper, Smith (1975) explains the mass extinctions of mega fauna in America during the late Pleistocene by using an open-access resource (free-access hunting) model. He shows that if the average biological growth rate at zero stock level is low and less than the equilibrium harvest per unit biomass, the extinction of a species will occur due to hunting pressure.

[3] For a general and insightful treatment of the effects of identity on economic behavior and outcomes, see Akerlof (2000). Also, see Akerlof and Kranton (2003)(2005) for an analysis of the effects of workers' identity on incentives to exert effort, wage rate variation, and firms' optimal management strategies. For a survey of the social psychological consequences of unemployment and implications for behavioral macroeconomic model and policy, see Darity and Goldsmith (1996).

have significantly lower well-being scores in the social psychological and labor economics literature (see, for example, Fryer and Payne (1986), Feather (1990) and Argyle (2001)). Further, Lucas, *et al* (2004), find strong statistical evidence that the adverse effect of unemployment on individuals' subjective well-being persists even after they become employed again. More interestingly, empirical work in labor economics literature has established that unemployment is strongly negatively correlated with individual well-being, *even after controlling for income and other individual characteristics.* In other words, the unemployed are generally worse off than the employed, and by more than their lower income would predict (see, for example, Clark and Oswald (1994), Korpi (1997), Winkelmann and Winkelmann (1998), Di Tella, MacCulloch and Oswald (2001)(2003), and Clark (2003) and references cited therein). For example, Winkelmann and Winkelmann (1998) used panel data on life satisfaction from German-Socio-Economic Panel for 1984-1989, where the individual's subjective well-being was measured on an ordinal scale from 0 to 10. After controlling for income and various observed individual characteristics and specific fixed effects, they found that (a) being unemployed has a significant and substantial negative effect on satisfaction, and (b) the pecuniary costs of unemployment, occurring directly through reduced income, are much smaller than the nonpecuniary costs, occurring indirectly through reduced well-being. They estimated that income would have needed to be increased by a factor of seven in order to generate an increase in satisfaction large enough to offset the adverse effect of unemployment. Di Tella, MacCulloch and Oswald (2001) came to similar conclusions. Using the Euro-Barometer data on individual life satisfaction, ordered on a four-point scale for 12 European countries for the period 1975-91, they found that, controlling for the income loss and other indirect effects, being unemployed has a strong negative effect on well-being. Based on Di Tella et. al's estimated happiness function, Frey and Stutzer (2002) calculated the compensation variation for being out of work rather than holding a job and noted that "a move from the lowest income quartile to the highest income quartile would not be enough to offset the adverse effect of unemployment, suggesting that unemployed people suffer high non-pecuniary costs (p.402)". These results suggest that being unemployed significantly reduces people's well-being, even when receiving the same income as when employed. As Di Tella, MacCulloch and Oswald (2003, pp. 819-820) note "Being unemployed is much worse than is implied by the drop in income alone. The economist's standard method of judging the disutility from being laid off focuses on pecuniary losses. According to our calculations, that is a mistake, because it understates the full well-being costs, which according to the data, appear to be predominantly nonpecuniary." The facts that in advanced industrial countries, where social safety nets cushion joblessness, some individuals prefer to work with earnings less than the unemployment benefit or to engage in voluntary work are evidence of nonpecuniary value of work.[4] Furthermore, the

[4] Moffitt (1983) found strong empirical support for the existence of welfare stigma among eligible but non-participants in AFDC-U, the welfare program for which families with an unemployed male were eligible.

presence of nonpecuniary value of work is strongly suggested by Mulligan's (1998) insightful empirical study of the dramatic increase in civilian work in the United States during World War II. Ruling out the changes in workers' budget sets (the after-tax real wages were substantially lower than either before or after the war) or other pecuniary explanations such as wealth effects of government policies, wage-induced intertemporal substitution, and changes in the nonmarket price of time, she concluded that nonpecuniary motives such as patriotism and changing discrimination against women can explain the phenomenon.

Finally, using data from the Alaska salmon fisheries, which have been subject to entry limitations since 1975, Karpoff (1985) tested the hypothesis that fishermen attach a significant nonpecuniary value to their work by estimating the present value of the expected rent stream from fishing and examining whether permit prices reflected a premium above what monetary income alone would suggest. He found that the continued presence of many low-income fishermen in the fisheries was evidence that they derived nonpecuniary benefits from fishing.

The negative socio-psychological effects of unemployment on well-being are likely to be particularly strong in closed RRB communities, when compared, for example, with the effects on working populations in cosmopolitan urban areas. The reason is that in such communities, being productive and sharing in the production efforts is often a community norm which gives the individual a sense of belonging and identity. Not sharing in the work is considered a deviation from the norm, and has significant negative psychological and sociological effects on the deviator's well-being, which every community member tries to avoid. In many RRB communities, especially in less developed countries, full participation in supplying efforts needed for resource harvesting is a norm which in turn stems from the community norm of sharing the harvest. Diverging from the norm of sharing in the efforts can inflict social shame and cause the deviator to be ostracized. This is less true in metropolitan urban areas with diversified economies that are open to trade with outside, and where the role of the individual is less apparent to the rest of society. As noted by Veblen (1899, P.69 and P.75) long ago, in urban areas individuals are often recognized for their *consumption* behavior, so that "distinction in consumption" or "conspicuous consumption" is a means of gaining recognition and identity. It seems therefore plausible to assume that the adherence to the social norm of work can be quite strong in closed RRB communities; that is, rarely community members choose not to fully participate in supplying labor for resource harvesting. Interestingly, in a revealing empirical study of the psychological effect of unemployment on individual well-being, Clark (2003) finds a strong and statistically significant positive correlation between the negative socio-psychological effect of unemployment and the degree of adherence to the social norm of work. Accordingly, given the force of adherence to the norm of work in RRB communities, it seems reasonable to suppose that unemployment can be particularly stigmatic and welfare reducing in such communities.

3. Full-Employment Obsession and Resource Extinction

3.1 Sufficient Condition for Extinction in finite time

Dasgupta and Maler (1995, P. 2373) emphasize that "poor countries are for the most part *biomass-based subsistence economies*, in that their rural folk eke out a living from products obtained directly from plants and animals." Many rural communities in poor countries depend on natural resources, so it may be thought that residents of such communities would have sustainability as a major social and economic goal. However, if the socio-psychological value of work and the force of social norm of work are strong, full employment can also be an important goal. Achieving sustainability and full employment simultaneously is not a problem if the community's initial resource base is sufficiently large and the resource's regenerative capacity is sufficiently high; if not, there may be a conflict between sustainability and full employment. This section identifies the precise conditions that make extinction of the resource in finite time socially optimal.

Economics literature traces sustainable resource allocation to the so-called Ramsey (1928) problem: seeking an optimal path along which the resource stock (in his case, manufactured capital) stock converged to some positive level, (i.e., an interior optimal stationary state) *regardless* of the initial size of the stock. In our case, an interior optimal stationary state is a sustainable stock level. On the other hand, if the optimal policy turns out to be one of full employment, the resource may become extinct. As noted in introduction, in the economic literature an optimal path that leads to resource extinction in finite time requires a marginal productivity of the resource stock that is less than the time discount rate (see, for example, Clark (1973) and Spence (1973)). In this paper, however, we show that under certain conditions full employment until resource extinction is socially optimal and that the optimality of extinction holds regardless of the time discount rate.[5]

Consider an RRB community with a constant population (labor force) size of $\overline{E}$. The community owns and lives off of a stock of a single renewable resource (e.g., a fishery or forest) the size of which is denoted by $S(t) \geq 0$ at time *t*. The change in the resource stock over time is described by

$$\dot{S}(t) = G[S(t)] - H[E(t), S(t)] \qquad \forall t \geq 0, \tag{1}$$

where $G(S)$ is the natural growth function, $H(E,S)$ is the harvest function where $0 \leq E(t) \leq \overline{E}$ is the level of "effort", which we simply assume to consist only of the community labor force at

[5] It has been well known that in the game theoretic framework the resource extraction towards finite time extinction can occur as a result of "individual" rationality under open-access regime. Gordon (1954) and Hardin's (1968) influential paper, "the tragedy of the commons", are among the early works alluding to this, followed by a number of rigorous analyses including Dasgupta (1982), Cornes and Sandler (1983)(1996), and Sorger (1998), among others. It should be emphasized, however, that in our model there is no open access to the resource and no strategic interactions among the community members who

time t. We make the following assumptions:

(A1): $G(S)$ is concave in S (i.e., $G_{SS} \leq 0$) and there is a unique biological carrying capacity $k > 0$ such that $G(k) = 0$, $G(S) > 0$ for all $0 < S < k$, and $G(0) = 0$.

(A2): $H(E,S)$ is an increasing function and strictly concave in E (i.e. $H_E > 0, H_S > 0, H_{EE} < 0$).

(A3): For any given $S_0 \geq 0$, the *full-employment* harvest rate $H(\bar{E},S(t))$ exceeds the population growth $G(S(t))$, so that $\dot{S}(t) = G[S(t)] - H[\bar{E},S(t)] < 0$, thus permitting finite time exhaustion of the resource stock. Notice that this assumption can hold if the resource growth rate is sufficiently low relative to the stock effect on harvest ($H_S(\bar{E},S)$), in which case the curve of harvest function at *full employment,* $H(\bar{E},S)$, may everywhere lie above that of population growth function, $G(S)$.

Assumptions (A1) and (A2) are quite general. On the other hand, assumption (A3) reflects the situation when full employment and sustainable resource use are incompatible. Our objective is to show under what condition resource exhaustion in a finite time is socially optimal.

Furthermore, in a departure from the standard economics assumption, and for the reasons discussed above, we assume that the community's welfare depends not only on its consumption level, but also upon its employment level relative to the community's employment norm. More specifically, denoting by $W(C,E)$ the community's instantaneous social welfare function[6], where $C \geq 0$ and $E \geq 0$ are the aggregate consumption and employment, we assume that:

(A4): $W(C,E)$ is jointly concave in C and E, $W_C > 0$, and $W_E > (<) 0$ if $E < (>) \hat{E}(C)$, where $\hat{E}(C)$ is the critical community's employment level for which $W_E(C,\hat{E}) = 0$ and satisfies $\hat{E}'(C) < 0$. That is, for any consumption level C, $\hat{E}$ is the critical employment level for which the welfare gain due to socio-psychological value of an incremental increase in employment and adherence to social norm of work exactly offset by the welfare loss from disutility of increased work level.

The social welfare postulated in (A4) can be derived consistently from an *extended* individual utility function of the general form $U = U(c,z,m)$, where $c \geq 0$ is consumption,

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are assumed to fully and collectively own the resource.

[6] The time arguments of the functions are omitted whenever no confusion arises.

$z = T - l \geq 0$ is leisure time (equal to the fixed total time endowment T less labor time $l \geq 0$), and $m(l) \geq 0$ captures the socio-psychological effects of work, which is assumed to increase with one's community involvement and hence labor time (i.e. $m'(l) > 0$). The utility function is assumed to satisfy the usual assumptions that it is increasing in each of its arguments (i.e., $U_c > 0, U_z > 0, U_m > 0, U_c \to \infty$ as $c \to 0$) at decreasing rates (i.e., $U_{cc} < 0, U_{zz} < 0, U_{mm} < 0$) and that both leisure and socio-psychological effects are complements with consumption (i.e., $U_{cz} > 0, U_{cm} > 0$)[7]. One can then rewrite U in the reduced form of $u(c,l) \equiv U(c,T - l, m(l))$ so that the overall, or net, marginal utility of labor time is $\partial u/\partial l = dU/dl = -U_z + U_m\, m'(l)$, where the first term on the right-hand side is the marginal *disutility* of labor and the second term is the marginal *utility* of labor that arises from the socio-psychological value of working. We assume, as seems plausible, that, at any given consumption level c, for sufficiently large values of l the first term dominates the second one (implying that at the margin labor becomes a net source of disutility, $u_\ell(c,l) \equiv \partial u / \partial l < 0$) and inversely for sufficiently small l. Therefore, for each $c > 0$, there exists a unique $\hat{l}(c) > 0$ such that $\partial u(c,l)/\partial l = -U_z + U_m\, m'(l) > (\leq) 0$ as $l < (\geq) \hat{l}(c)$.

That is, $\hat{l}(c)$ is the threshold labor time, at consumption level c, so that the marginal disutility of labor exactly offsets its marginal utility. As shown in Farzin and Akao (2006), at sufficiently low wage (and hence consumption) rates, leisure may lose its desirability to such an extent (i.e., U_z becomes so small) that work can even become a source of *utility* (i.e., $\partial u(c,l)/\partial l > 0$), so that one chooses to work as much as possible ($l = T$). The social welfare function $W(C,E)$ postulated in (A4) inherits these properties. Specifically, employment itself enhances the community's well-being if its level is below the critical level $\hat{E}$. In fact, the direct link between the individual utility function and the social welfare function becomes obvious if we adopt the concept of utilitarian social welfare and assume that the community's population $\bar{E}$ consists of identical individuals. In that case, we have $W(C,E) = \bar{E}\ u(C / \bar{E}, E / \bar{E}) = \bar{E}\ u(c,l)$ and $\hat{E}(C) = \bar{E} \cdot \hat{l}(C / \bar{E}) = \bar{E} . \hat{l}(c)$.

To provide an economic interpretation of the postulated social welfare function, one can think that a typical community member derives utility from two separate sources: one from her consumption and leisure in accordance to the utility function of standard economics, represented by $V(c,z)$ and the other from socio-psychological utility of adhering to the community's norm of work. The latter can be represented by the utility function $\Pi(l) = M + v(1 - \frac{l}{l^*})$, where $M > 0$ can be thought of as a constant amount of satisfaction if the individual supplies labor in full

[7] For more details about the properties of the extended individual utility function, see Farzin and Akao (2006).

adherence to the community's norm of work expected from each member, denoted by l^*, and $v(\,)$ as the utility loss from diverging from the norm, where $(1-\frac{l}{l^*})$ indicates the degree of deviation from the norm. The utility loss function is assumed to satisfy the conditions, $v(0)=0$, $v(1)=-\infty$, $v'(0\,)=0$, so that $v<0$ for $l \neq l^*$, and $v''(\,)<0$. In this case, a typical community member's utility function is $U(c,z,l)=V(c,z)+\Pi(l)=V(c,z)+M+v(1-\frac{l}{l^*})$, where $U_c=V_c>0, U_z=V_z>0,$ and $U_{l/l^*}=-v'>(<)0$ if $l<(>)l^*$, and where the last inequality reflects the increasing gain of socio-psychological satisfaction as the individual labor supply becomes closer to the community's norm of work. Rewriting $U(\;)$ in its reduced form of $u(c,l) \equiv V(c,T - l) + M + v(1 - l/l^*)$ and differentiating with respect to l , one has $\partial u(c,l)/\partial l = -V_z - \frac{1}{l^*}v'$. The sign of the first term is negative while that of the second is positive. The utility loss function v is strictly concave and $-v'(1)=+\infty$ (which follows from the assumption of $v(1)=-\infty$). It therefore follows that for any $l^*>0$, there exists a unique $\hat{l}(c) \in (0,l^*)$ such that $\partial u(c,l)/\partial l > (\leq) 0$ as $l < (\geq) \hat{l}(c)$. Thus, the typical community member's preference for consumption and supply of effort gives rise to a community welfare function $W(C,E)$ with the properties assumed in (A4) above.

Denoting by ρ be the time discount rate, the social planner's problem is:

$$\begin{aligned} &\max_{E(t)} \int_0^\infty W[H(E,S),E]e^{-\rho t}dt \\ &\text{subject to} \quad \dot{S}(t) = G[S(t)] - H[E(t),S(t)], \\ &\qquad\qquad\quad 0 \leq E(t) \leq \bar{E}, 0 \leq S(t), \quad \forall t \geq 0; \\ &\qquad\qquad\quad S(0) = S_0 \in [0,k] \text{ given.} \end{aligned} \tag{2}$$

Define $w(E,S) \equiv W[H(E,S),E]$, i.e. w is a reduced form of the social welfare function W, and satisfies $w_{SS} < 0$. Then, the Hamiltonian of problem (2) is:

$$\Psi(E,S,\lambda) = w(E,S) + \lambda[G(S) - H(E,S)], \tag{3}$$

where λ is the co-state variable and measures the shadow price of the resource stock. The necessary conditions for a solution of problem (2), $(E^*(t),S^*(t))$, are that, at each $t \geq 0$:

$$\Psi[E^*(t),S^*(t),\lambda(t)] = \max[\Psi(E(t),S^*(t),\lambda(t)) \mid E(t) \in [0,\bar{E}]], \tag{4}$$

and

$$\dot{\lambda}(t) = \rho\lambda(t) - \partial\Psi[E^*(t), S^*(t), \lambda(t)] / \partial S. \tag{5}$$

Denoting by $\tilde{E}(S,\lambda)$ the implicit function solving $\Psi_E(\tilde{E}(S,\lambda), S, \lambda) = 0$, we refer to $\tilde{E}(S,\lambda)$ as the stationary point of Ψ. It is worth noting that the maximum condition (4) does not necessarily hold at the associated stationary point $E = \tilde{E}(S^*(t), \lambda(t))$, implying that the employment constraint may be binding (i.e., $E(t) = \bar{E}$, or 0, $\forall t \geq 0$) at the optimum. This is because the Hamiltonian as a function of E may not be concave at the stationary point, due to the concavity of the harvest function $H(E,S)$ in E. When the maximum condition holds with $E(t) = \bar{E}$, it indicates that the community gives priority to full employment rather than to sustainability. The following proposition identifies the precise conditions under which this occurs.

Proposition1*: Assuming that problem (2) has a solution, if*

$$\frac{-\tilde{E}H_{EE}(\tilde{E},S)}{H_E(\tilde{E},S)} - \frac{-\tilde{E}w_{EE}(\tilde{E},S)}{w_E(\tilde{E},S)} > 0 \tag{6}$$

the optimal path is the full- employment obsession path.

Proof: See Appendix A1.

The economic interpretation for Proposition 1 is straightforward once we note from (3) that a small increase in employment level E has two beneficial effects on the current social welfare: by increasing the harvest and hence consumption level and through its non-pecuniary effect ($w_E = W_H H_E + W_E$). But, by raising the harvest level, it also lowers the resource stock, which involves a cost amounting to $\lambda H_E(E,S)$ in utility terms. Both the marginal benefit (w_E) and cost (λH_E) of employment *decline* as employment level is increased. Accordingly, Proposition 1 states that full employment obsession, and thus finite time extinction of the resource, occurs when the (employment) elasticity of the marginal cost of employment (the first term of the LHS of (6)) always exceeds the elasticity of its marginal benefit (the second term). In other words, in response to a given percentage increase in employment level, the latter declines proportionally less than the former does, implying that the marginal *net* benefit from employment will always be positive and increasing with employment level. We shall refer to condition (6) as condition for full employment obsession.[8]

Two important points follow from this condition. First, it neither involves the natural growth function $G(S)$ nor the time discount rate ρ: the former because of assumption (A3) and the latter because along the optimal path the harvest rate at any time is at its maximum feasible,

[8] Technically, the condition requires that at the stationary point $\tilde{E}$, the harvest function H be more concave in E than the welfare function w is, implying that $\frac{d}{dE}(\frac{w_E}{H_E}) > 0$ at that point.

i.e. at the full-employment, level, $H(\bar{E}, S)$, so that a change in the discount rate has no effect on the optimal harvest path. Therefore, the mechanism causing the finite time resource extinction in our model differs sharply from those noted in the literature. Here it is the socio-psychological satisfaction from employment and adherence to social norm of work (reflected by E in the social welfare function) that drives the economy to the full-employment path and leads to resource extinction in finite time. Second, we note that condition (6) cannot hold if $W_E(C,E) \le 0$ and $W_{CE}(C,E) \le 0$.[9] But, $W_E(C,E) < 0$ is the basic premise of the standard labor supply theory that regards labor only as source of disutility and ignores the socio-psychological value of work and compliance with social norm of work. On the other hand, since the latter is a distinctive feature of preferences in RRB communities, it is more likely that the condition for full employment obsession holds for these communities, where one expects $W_E(C,E) > 0$[10].

3.2. A Specific Illustration

In this subsection, we present an example illustrating the full-employment obsession path as the optimal path. Let us specify the functions in Problem (2) as follows:

(1) The natural growth function takes the Logistic form:

$$G(S) = rS\left(1 - \frac{S}{k}\right), \quad r > \rho, k > 0 \tag{7}$$

The natural (intrinsic) growth rate, r, is the resource's maximum potential reproductive rate. So, the inequality $r > \rho$ implies that the resource is economically productive, thus further sharpening the distinction between our model and the previous studies of the condition for finite time resource extinction.

(2) The harvest function has a Cobb-Douglas form:

$$H(E,S) = \gamma E^{\alpha} S^{\beta}, \quad \gamma, \alpha, \beta > 0, \quad \alpha + \beta \le 1; \tag{8}$$

Where it is noted that the harvest is bounded above by $\bar{H} = H(\bar{E}, k)$. The necessary condition for

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[9] To see this formally, recall that $w(E,S) \equiv W[H(E,S),E] = W(C,E)$. Differentiate (3) with respect to E to get $W_C H_E = -W_E + \lambda H_E$, and use this to obtain

$$\frac{-EH_{EE}}{H_E} - \frac{-Ew_{EE}}{w_E} = \frac{-EH_{EE}}{H_E} - \frac{-E\left(W_{CC}(H_E)^2 + 2W_{CE}H_E + W_C H_{EE} + W_{EE}\right)}{\lambda H_E}$$

$$= \frac{-EH_{EE}}{H_E}\left(1 - \frac{W_C}{\lambda}\right) - \frac{-E\left(W_{CC}(H_E)^2 + 2W_{CE}H_E + W_{EE}\right)}{\lambda H_E} == \frac{-EH_{EE}}{H_E}\left(\frac{W_E}{\lambda H_E}\right) - \frac{-E\left(W_{CC}(H_E)^2 + 2W_{CE}H_E + W_{EE}\right)}{\lambda H_E} < 0,$$

where all functions are evaluated at $(\tilde{E}(S,\lambda), S, \lambda)$.

[10] It is also worth noting that condition (6) does not hold if the harvest function is convex or linear in E (i.e., if $H_{EE} \ge 0$), although the latter has been commonly assumed in the literature.

finite time extinction of the resource is $\lim_{S\to 0} H_S(\bar{E},S) = \infty$.[11] The Cobb-Douglas harvest technology (8) does have this property. By assuming that the total productivity is high enough to satisfy

$$\gamma > \frac{r[(1-\beta)k]^{1-\beta}}{(\bar{E})^{\alpha}(2-\beta)^{2-\beta}},$$

assumption (A3) holds, implying that the resource is harvested to extinction in a finite time. (See Appendix A2 for the proof.)

(3) The social welfare function also takes a simple Cobb-Douglas form:

$$W(C,E) = C^{\eta_C}E^{\eta_E},\ \ \eta_C,\eta_E > 0,\ \ \eta_C + \eta_E < 1. \qquad (9)$$

It is concave, increasing in consumption and employment, and $W(0,E) = W(C,0) = 0$. Further, it satisfies $W_E > 0$ and $W_{CE} > 0$. Especially because of the latter two properties, the Cobb-Douglas social welfare function suits our purpose particularly well. For, in view of the discussion in Section 3, it can be attributed to preferences of an RRB community so poor that a rise in employment level *always* has a positive effect on the community's well-being and its marginal value of consumption; that is, for *all* feasible paths of resource use (C,E), $W_E > 0$ and $W_{CE} > 0$ never switch signs.[12]

The reduced form of the social welfare function is

$$w(E,S) = W[H(E,S),E] = \gamma^{\eta_C}E^{\alpha\eta_C+\eta_E}S^{\beta\eta_C}. \qquad (10)$$

Since

$$\frac{-EH_{EE}}{H_E} - \frac{-Ew_{EE}}{w_E} = (1-\alpha) - (1-\alpha\eta_C-\eta_E) = \eta_E + \alpha\eta_C - \alpha$$

condition (6) for optimality of full employment obsession, and hence of finite time extinction, simplifies to[13]

$$(\eta_E + \alpha\eta_C) > \alpha \qquad (11)$$

That is, under these specifications, the net marginal welfare effect of employment will always be

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[11] To see this, suppose $\lim_{S\to 0} H_S(\bar{E},S) = \xi < \infty$. Then, we can approximate the harvest function with ξS and the natural growth function with rS in a neighborhood of the origin. Thus, $\dot{S} = G(S) - H(E,S) \approx S(r-\xi)$. With a linear differential equation, it takes infinite time to extinction.

12 Notice that the boundedness condition, $W(0,E) = 0$, is necessary to have an optimal path with finite time extinction. On the other hand, the condition $\lim_{C\to 0} W_C(C,E) = \infty$ defies the optimality of resource extinction in finite time, without non-pecuniary effects of employment.

[13] For the proof of the existence of an optimal path see Appendix A3.

positive if the elasticity of social welfare level with respect to employment $(\eta_E + \alpha\eta_C)$ exceeds the elasticity of the harvest level, α.[14] Parameter η_C measures the importance of material consumption in social well being. As such, it may be interpreted as reflecting the society's degree of consumption fixation or, as ecological economists and social psychologist may call it, "material greed". Parameter η_E reflects the social welfare significance of socio-psychological value of employment and force of adherence to social norm of work. On the other hand, parameter α measures the significance (share) of work effort in resource extraction, which varies directly with the degree of labor-intensity of resource harvesting technology. Thus, for the economy specified with the above functional forms, inequality (11), written also as $\eta_E - \alpha(1-\eta_C) > 0$, provides an empirically testable condition for the optimality of finite-time resource extinction. In particular, it implies that, all else being equal, the finite-time extinction is likelier, (*i*) the greater the consumption fixation of the community, (*ii*) the greater the force of socio-psychological value of work and adherence to the social norm of work, and/or (*iii*) the lower the labor-intensity of the community's harvesting technology.

4. Policy Options for Sustainability

In this section, we explore some economic policies that can induce an RRB community to adopt a sustainable path of resource use. We do this in the context of the specific functional forms (7)-(9) used in the previous section. We assume that before a policy measure is implemented the condition $(\eta_E + \alpha\eta_c) > \alpha$ holds, so that the optimal path is that of full employment obsession with resource exhaustion in finite time.

It is worth noting that this condition consists of two elasticities of the welfare function, η_E and η_C, and one elasticity of the harvest function, α. Thus, to have a potential to prevent the finite time resource extinction, two broad groups of policy measures may be distinguished. One group consists of policies that can affect the community's preferences and/or its harvesting technology in such a way that at least one of the three elasticities is suitably changed so as to defy the condition $(\eta_E + \alpha\eta_c) > \alpha$. By itself, this requirement rules out a number of policy options as ineffective. For example, it is easy to show that any economic assistance to the community in the form of a commodity grant or a subsidy that proportionally augments consumption will not help to prevent resource extinction.[15] Similarly, unless it sufficiently

[14] Notice, again, from (11) and $\eta_C<1$ that the full-employment obsession, and hence the finite time extinction, can occur *only if* employment also directly enhances the individual's utility and therefore the community's welfare, i.e., only if $\eta_E>0$.

[15] It can also be shown that when economic assistance to the community is in the form of a real flow of lump-sum transfers or foreign grants (denoted by $X(t)\geq 0,\ \forall t\geq 0$), one has

reduces α (i.e., making harvesting more labor-intensive), a technological assistance that is confined to resource harvesting may not only fail to induce resource use sustainability, it can even worsen the situation because it could accelerate the pace of resource exhaustion. Examples of such technologies are those of more efficient but "effort-neutral" or "effort-augmenting" harvesting technologies, and, perhaps ironically, may also include the technologies that enhance the resource stock (for example, radar-based fishing vessels capable of locating fish stocks by radar). The other group of policies are those that take the community's preferences and harvesting technology as given, at least in the short run, and resort to formal labor markets as mechanisms to absorb what would otherwise constitute excessive effort (from the sustainability viewpoint) in the resource sector.

In what follows we do not explore potential policies in the first group as they would involve changing consumption habits (preferences)-much in accord with ecologists' advice- with the effect to lower the value of η_C, or changing the community's attitude towards employment (social norm of work), with the effect to lower the value of η_E, or both. Such policies would aim to encourage changes in cultural values. Accordingly, besides involving economic incentives, they involve complex and community-specific social, institutional, and political incentives whose effects may take a long time to evolve, perhaps longer than the resource can survive. Instead, we concentrate on two economic policy options in the second group and derive conditions under which they can lead the community to a full employment and yet sustainable path of resource use. The main difference between the two options is that one of them considers employment opportunities outside the community while the other aims at additional employment opportunities through economic diversification.

4.1 Outside Employment Opportunity

Suppose that an outside labor market is opened to our RRB community. Denote by $\omega > 0$ the constant wage rate in units of harvest.[16] Notice that any optimal path is a full

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$$\frac{-EH_{EE}}{H_E} - \frac{-Ew^X_{EE}}{w_E} = \eta_E - \alpha + \alpha\eta_C\varphi\left(1+\frac{X}{H}\right),$$

where $w^X(E,S,t) = W[H(E,S)+X,E] = [H(E,S)+X]^{\eta_C}E^{\eta_E}$ and the function φ is defined by $\varphi(x) \triangleq \frac{(\alpha+\eta_E)x-\alpha(1-\eta_C)}{x(\alpha\eta_C+\eta_E x)}$, $x = (1+\frac{X}{H}) \geq 1$. Since $\lim_{x\to\infty}\varphi(x)=0$, it follows that such policies can be effective (*i.e.*, $\eta_E - \alpha + \alpha\eta_C\varphi\left(1+\frac{X}{H}\right) \leq 0$) if the rate of transfer relative to harvest rate is at any time sufficiently large *and* if $\eta_E < \alpha$. However, if $\eta_E \geq \alpha,$ the full employment obsession path is optimal and resource extinction occurs in finite time, no matter how large the flow of transfers.

[16] The assumption of constant real wage rate is made for expositional simplicity. The results that follow

employment path because now people can work without necessarily reducing the resource stock. Thus, the social planner's problem is:

$$\max_{E(t)} \int_0^{\infty} W[H(E(t),S(t)) + \omega(\bar{E} - E(t)), \bar{E}]e^{-\rho t}dt,$$
$$\text{subject to } \dot{S}(t) = G[S(t)] - H[E(t),S(t)], \tag{12}$$
$$0 \le E(t) \le \bar{E}, 0 \le S(t), \text{ for each } t \ge 0;$$
$$S(0) = S_0 \ge 0 \text{ given.}$$

The Hamiltonian is

$$\Psi(E,S,\lambda) = w^O(E,S) + \lambda[G(S) - H(E,S)] \tag{13}$$

where $w^O(E,S)$ denotes the welfare function with outside employment opportunity, and is given by

$$w^O(E,S) = [H(E,S) + \omega(\bar{E} - E)]^{\eta_C} \bar{E}^{\eta_E}. \tag{14}$$

Assuming the existence of an optimal path and denoting it by $(E^*(t), S^*(t))$, if $\bar{E} \ge E^*(t) > 0$, we have

$$\Psi_E(E^*,S^*,\lambda) = \eta_C[H(E^*,S^*) + \omega(\bar{E} - E^*)]^{\eta_C - 1}[H_E(E^*,S^*) - \omega]\bar{E}^{\eta_E} - \lambda H_E(E^*,S^*) \ge 0$$

which implies[17]

$$H_E(E^*,S^*) - \omega > 0 \tag{15}$$

or, by substituting for $H_E(E^*,S^*) = \alpha\gamma(E^*)^{\alpha-1}S^{*\beta}$,

$$E^* < \left(\frac{\alpha\gamma(S^*)^{\beta}}{\omega}\right)^{\frac{1}{1-\alpha}}. \tag{15'}$$

This sets an upper bound on employment in the resource sector E^*. Since $\dot{S}^* = G\left(S^*\right) - H(E^*,S^*)$, an optimal path $S^*(t)$ satisfies

$$\dot{S}^* > G\left(S^*\right) - H\left[\left(\alpha\gamma S^{*\beta} / \omega\right)^{\frac{1}{1-\alpha}}, S^*\right] \tag{16}$$

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also hold for time dependent wage rates $\omega(t)$.

[17] Notice that because of the marginal social cost of employment due to the negative stock effect of increased harvest rate (i.e., $-\lambda H_E$), the optimal employment allocation requires that the marginal product of employment in the resource sector to exceed the outside wage rate .

Let $\omega(S)$ be the function that solves $G(S) - H\left[\left(\alpha\gamma S^{\beta} / \omega(S)\right)^{\frac{1}{1-\alpha}}, S\right] = 0$, that is

$$\omega(S) = \left[\frac{\gamma\alpha^{\alpha} S^{\beta}}{G(S)^{1-\alpha}}\right]^{1/\alpha} \quad (17)$$

(Note in particular that for $\omega(S_0)$, $G(S_0) - H\left[\left(\alpha\gamma S_0^{\beta} / \omega(S_0)\right)^{\frac{1}{1-\alpha}}, S\right] = 0$.)

Then, we have

Proposition 2: *If $\omega \geq \omega(S_0)$, then $S^*(t) \geq S_0$, i.e. along an optimal path the resource stock never declines below the initial stock level.*

Proof: By (17) and (16), if $S^*(t) = S_0$, then $\dot{S}^*(t) \geq 0$. ■

Thus, as long as the outside wage rate does not fall below a certain minimum level, given by $\omega(S_0) = \left[\frac{\gamma\alpha^{\alpha} S_0^{\beta}}{G(S_0)^{1-\alpha}}\right]^{1/\alpha}$, the outside employment opportunity absorbs what would otherwise be excessive effort ($\bar{E} - E^*$) in the resource sector, thereby ensuring both full employment and sustainability of resource use. The required minimum outside wage rate depends on the initial resource stock, S_0, the elasticities of the harvest rate with respect to effort and the resource stock, α and β, the efficiency of the harvesting technology, γ, and the resource's biological characteristics as reflected by its natural (intrinsic) growth rate, r, and carrying capacity, k, which influence $G(S)$. Noting that $\lim_{S\to 0} \omega(S) = \infty$ [18], it is clear that when the initial resource stock is very small (for example, because economic measures to encourage resource conservation have been long neglected), then very high outside wage rates are needed to induce the RRB community to move to a sustainable path of resource use. It is also easy to verify that $\partial\omega(S_0)/\partial\gamma > 0$, $\partial\omega(S_0)/\partial r < 0$, and $\partial\omega(S_0)/\partial k < 0$, implying respectively that the required minimum outside wage rate will be higher, the greater is the efficiency of harvesting technology, but the lower are the resource's intrinsic growth rate or carrying capacity.

4.2 Economic Diversification

Next, we consider the option of economic diversification by creating a new economic activity; for example, a formal manufacturing sector. This sector produces a homogenous good

[18] This follows from
$\lim_{S\to 0}\left[\omega(S)^{\alpha/(1-\alpha)} / (\alpha\gamma^{1/\alpha})\right] = \lim_{S\to 0}\left[S^{\beta/(1-\alpha)} / G(S)\right] = \lim_{S\to 0} [\beta/(1-\alpha)] S^{(\alpha+\beta-1)/(1-\alpha)} / r = \infty.$

according to production function $F(K,L)$, and accumulates capital according to

$$\dot{K} = F(K,L) - c \geq 0, \; c \geq 0, \; K(0) = K_0 \geq 0 \text{ given}.^{19} \tag{18}$$

where $K \geq 0$ is capital stock, $L \geq 0$ is labor input, and $c \geq 0$ is the consumption of the good expressed in units of harvest equivalent[20]. Thus, the community's instantaneous welfare can be written as $W(H+c, E+L)$, where, as usual, $H = H(E,S)$ is harvest and E is labor input into the resource extraction sector.

To simplify the analysis and make the results comparable with the case of outside employment opportunity analyzed in the previous subsection, we assume that the production function has a form of $F(K,L) = f(K)L$, where f is an increasing function ($f'(K) > 0$). This implies that the marginal and average products of labor are equal to $f(K)$ and increase over time as capital is accumulated.

By the same argument as in the previous subsection, an optimal path entails full employment, i.e., $E + L = \bar{E}$ for all $t \geq 0$. Thus, the social planner's problem is

$$\begin{aligned} &\max_{c(t),E(t)} \int_0^\infty W[H(E(t),S(t)) + c(t), \bar{E}] e^{-\rho t} dt, \\ &\text{subject to } \dot{S}(t) = G[S(t)] - H[E(t),S(t)], \\ &\qquad \dot{K}(t) = F[K(t), \bar{E} - E(t)] - c(t) \\ &\qquad 0 \leq E(t) \leq \bar{E}, 0 \leq S(t), \quad \forall t \geq 0; \\ &\qquad S(0) = S_0 \geq 0, \; K(0) = K_0 \geq 0 \text{ given.} \end{aligned} \tag{19}$$

Assume that this problem has a solution $(E^*(t), c^*(t), S^*(t), K^*(t))$. Then, let us fix the path of capital stock at its optimal path, $K^*(t)$, and consider the partial problem:

$$\begin{aligned} &\max_{c(t),E(t)} \int_0^\infty W[H(E(t),S(t)) + c(t), \bar{E}] e^{-\rho t} dt, \\ &\text{subject to } \dot{S}(t) = G[S(t)] - H[E(t),S(t)], \\ &\qquad \dot{K}^*(t) = F[K^*(t), \bar{E} - E(t)] - c(t) \\ &\qquad 0 \leq E(t) \leq \bar{E}, 0 \leq S(t), \; \forall t \geq 0; \\ &\qquad S(0) = S_0 \geq 0 \text{ given.} \end{aligned} \tag{19'}$$

Obviously, $(E^*(t), c^*(t), S^*(t))$ is also a solution of this partial problem. We can now reduce the number of state variables in this problem to one by noting from the second constraint in (19') that

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[19] Note that we are implicitly assuming that investment in the industry sector is irreversible. We are also assuming that the initial capital stock, K_0, is given to the community either as a capital grant from the government or as foreign aid.

[20] Alternatively, we can assume the manufactured good and the resource harvest are perfect substitutes in consumption. Farm raised fish and harvested wild fish present an example.

$$c(t) = c(L(t),t) = f[K^*(t)]L(t) - \dot{K}^*(t), \quad L(t) = \bar{E} - E(t) \tag{20}$$

and substituting from (20) in (19') to rewrite (19') as:

$$\begin{aligned}
&\max_{E(t)} \int_0^\infty W[H(E(t),S(t)) + c(\bar{E} - E(t),t),\bar{E}]e^{-\rho t}dt,\\
&\text{subject to } \dot{S}(t) = G[S(t)] - H[E(t),S(t)],\\
&\qquad 0 \le E(t) \le \bar{E}, 0 \le S(t) \text{ each } t \ge 0;\\
&\qquad S(0) = S_0 \ge 0 \text{ given.}
\end{aligned} \tag{21}$$

Define the associated Hamiltonian by

$$\Psi(E,S,\lambda) = w^D(E,S,t) + \lambda[G(S) - H(E,S)],$$

where $w^D(E,S,t) = [H(E,S) + c(\bar{E} - E,t)]^{\eta_C}\,\bar{E}^{\eta_E}$ is the social welfare function under economic diversification. As in the previous case, suppose $E^* > 0$. Then, by the maximum condition we must have $\Psi_E(E^*,S^*,\lambda^*) \ge 0$, which, noting from (20) that $c_L(\bar{E} - E^*,t) = f(K^*(t))$, implies

$$\begin{aligned}
&H_E(E^*,S^*) - c_L(\bar{E} - E^*,t) = H_E(E^*,S^*) - f(K^*(t))\\
&\ge (\eta_C \bar{E}^{\eta_E})^{-1}\lambda H_E(E^*,S^*)(H(E^*,S^*) + c(\bar{E} - E^*,t))^{1-\eta_C} > 0.
\end{aligned} \tag{22}$$

Interestingly, condition (22) is essentially the same as condition (15) of the previous case, with $f(K^*(t))$, the marginal product of labor, now corresponding to ω, the outside wage rate, in (15) and (16). Thus, similar to Proposition 2, we have the following result:

Proposition 3: *If $f(K_0) \ge \omega(S_0)$, then $S^*(t) \ge S_0$, i.e. the resource stock never declines below the initial stock level on an optimal path.*

<u>*Proof*:</u> Since $\dot{K} \ge 0$, $f(K^*(t)) \ge f(K_0) \ge \omega(S_0)$. So, if $S^*(t) = S_0$, then $\dot{S}^*(t) \ge 0$.■

Accordingly, economic diversification can lead the community to a sustainable full employment path as long as the initial grant of capital is not less than a certain minimum level, specifically $K_0 \ge f^{-1}[\omega(S_0)]$ where, as before, $\omega(S_0) = \left[\dfrac{\gamma\alpha^\alpha S_0^{\ \beta}}{G(S_0)^{1-\alpha}}\right]^{1/\alpha}$.

The economic intuition for this result is similar to that of Proposition 2, once we note that in the present case the manufacturing wage rate, which is determined by $\omega(t) = f(K^*(t))$ along the optimal path, plays the same role as the outside wage rate ω in the previous case (see (16)). Since the manufacturing wage rate increases over time as capital stock is accumulated, an initial stock of capital that meets the minimum required level ensures that along the optimal path the manufacturing wage rate is always sufficiently high to (optimally) absorb what would otherwise be excess effort in the resource sector. Since $f'(K) > 0$, the comparative statics results obtained in the previous case for $\omega(S_0)$ apply equally to the minimum required capital stock, $K_0 = f^{-1}(\omega(S_0))$. In particular, if the initial resource stock is very small, then a very large initial capital stock will be required to achieve a full employment sustainable path of resource use. This yields a general lesson for policymakers in the poor, resource-based developing countries; namely, the economic cost of achieving sustainability can significantly rise if appropriate remedial policies are not adopted early on. On the other hand, perhaps ironically, this result also shows that contrary to the view sometimes expressed by radical ecologists, industrialization and accumulation of manmade capital not only need not be at odds with the objective of resource sustainability, it can in fact facilitate it, at least in the context of RRB economies studied here.

5. Conclusion

In this paper we have focused on poor rural communities that depend on a renewable natural resource and provided an alternative explanation why such communities may choose a path of resource extraction that leads to extinction in a finite time. We have argued that in resource-based communities, sharing in the harvest efforts is a communal norm and as such a source of belonging and identity that confers socio-psychological benefits to members, and that the existence of these benefits as an integral part of the community's overall welfare can explain the community's strong desire (or even obsession) for full employment and hence its resistance to curtailing the supply of "effort" (as frequently observed in fishing and forest communities).

Embedding this argument into a standard bioeconomic model of optimal renewable resource extraction, we have shown that the communal norm of work combined with the lack of alternative income sources and the biological constraint on growth of the resource stock can interact to induce the community to choose a resource extraction path that results in resource extinction in finite time. Thus, our analysis offers an example of situations where a social norm can trap the community in a harmful social arrangement and act as an obstacle to resource sustainability. The persistence of a social norm (sharing in harvesting effort) and socio-psychological satisfaction from following it can in the face of changing conditions (declining resource stock) lead to an adverse outcome (continued over-supply of effort and resource extinction in a finite time). The point to be drawn is that, while the communal norm of fully participating and sharing in the harvesting efforts may have been rational during a period of time when the resource stock has been relatively abundant, its persistence when the stock is run down relative to a community's population may well lead to the collapse of the resource and the community dependent on it.

Clearly, expectations of quick changes in the communal norm of work or in the biological resource growth constraint are unrealistic. Therefore, one has to rely on economic policy to induce these communities towards a path of resource extraction that is both sustainable and compatible with the goal of full employment. We have shown that in principle successful economic policies would aim at providing the community with alternative employment sources either through employment opportunities outside the community (including labor migration) or by diversifying the community's economy by creating indigenous capital-based economic activities. In either case, to be successful, the policies must ensure that the outside wage rate or the initial capital stock granted to the community do not fall below a certain minimum level, which depends on the existing size of the resource stock, on the characteristics of the community's harvesting technology, and on the biological growth characteristics of the resource in question.

No doubt the model developed in this paper is highly simplified, thus suggesting several important directions for its extensions and future research. At a technical level, several possible extensions of the present model are noteworthy. For one thing, it would be interesting to relax the assumption of a constant population size and examine how the pressure of a growing population may exacerbate the problem of finite resource extinction and complicate the design of potential policies to avoid it. It would also be interesting to examine how the condition for finite time resource extinction would change if one departed from Cobb-Douglas specifications of the community's preferences and harvesting technology. Would, for example, greater elasticities of substitution between constituents of the community's well-being or between inputs in the harvesting technology lessen the possibility of resource extinction or accentuate it? How would they affect the policies to restore sustainability? Similarly, how would a more general specification of the social welfare function that differentiates the consumption of the resource from that of the manufactured consumption good, or a more general production function in the latter sector, affect our main conclusions? At a policy level, it would be interesting to consider a situation, perhaps not too unrealistic in the poor developing nations, in which no benevolent outside agency (public or private) may concern itself about the plight of possible resource extinction, so that the community has to rely on itself to come up with a remedial policy. One such policy could involve foregoing the full employment objective for some time and reducing the "effort" by a communal agreement to lay off some of the labor force, or shorten the length of individuals' activity period, in order to achieve a full employment sustainable path in the log run. What are the conditions for the community to reach such a binding agreement, given possible intergenerational conflicts of interests between employment and consumption? What would be the optimal shape of such an agreement (i.e., how much to reduce the effort at any time and for how long)? Also, it would be rewarding to explore socio-political and economic-organizational policies that could in the long run alter the underlying community's preferences or harvesting technology so as to avoid resource extinction. Finally, of particular value will be empirical research into the magnitude of the critical parameters constituting the condition for finite time resource extinction.

Appendix

A1. *Proof of Proposition 1*

We first prove the following lemma:

<u>*Lemma 1*</u>: *Assume that problem (2) has a solution for each* $S \in [0,k]$. *If* $\Psi_{EE}(\tilde{E}(S,\lambda),S,\lambda) > 0$ *for all* $S,\lambda > 0$, *the optimal path is full employment obsession path.*

<u>*Proof:*</u> $\Psi_{EE}(\tilde{E}(S,\lambda),S,\lambda) > 0$ implies that the maximum condition is satisfied at the corner; so, $E = 0$ and/or $E = \overline{E}$. Thus, the optimal policy $E^*(S)$ for the problem (2) satisfies $E^*(S) \in \{0,\overline{E}\}$. Notice that this implies there is no optimal interior steady state. Let $\hat{S} \in [0,k]$ be the maximum stock level such that $E^*(S) = \overline{E}$ for all $S \in (\hat{S},k]$. By Assumption (A3), an optimal path from $S_0 \in [\hat{S},k]$ decreases monotonically over time, but by definition of $\hat{S}$ it cannot fall below $\hat{S}$. Therefore $\hat{S}$ should be an optimal steady state. However $\hat{S}$ cannot be interior. $\hat{S} = k$ is obviously suboptimal. Thus, we conclude that $\hat{S} = 0$. That is, $E^*(S) = \overline{E}$ for all $S \in (0,k]$.■

<u>*Proof of Proposition 1*</u> :

Since $\Psi_{EE}(\tilde{E},S,\lambda) = w_{EE}(\tilde{E},S) - (w_E(\tilde{E},S)/H_E(\tilde{E},S))H_{EE}(\tilde{E},S)$,

$\Psi_{EE}(\tilde{E}(S,\lambda),S,\lambda) > 0$ is equivalent to (6). Thus the statement is true by Lemma 1. ■

A2. *Finite Time Exhaustion*

<u>*Proposition A1*</u>: *Let* $\widehat{S}$ *be the supremum such that if* $0 < S < \widehat{S}$, $\dot{S} = G(S) - H(\overline{E},S) < 0$. *When initial stock* S_0 *is in* $(0,\widehat{S})$, *the path* $S(t;S_0)$ *described by*

$$\dot{S} = G(S) - H(\overline{E},S) = rS\left(1 - \frac{S}{k}\right) - \gamma \overline{E}^{\alpha} S^{\beta}, \quad S(0) = S_0,$$

goes to zero within a finite time.

Proof: Notice that $\dot{S} = G(S) - H(\bar{E}, S) < rS - \gamma \bar{E}^{\alpha} S^{\beta}$. Let $\sigma(t, S_0)$ be the solution of $\dot{\sigma} = r\sigma - \gamma \bar{E}^{\alpha} \sigma^{\beta}$, $\sigma(0) = S_0$. This Bernoulli's differential equation is solved as

$\sigma(t;S_0) = \left[\left(S_0^{1-\beta} - \frac{\gamma \bar{E}^{\alpha}}{r} \right) e^{r(1-\beta)t} + \frac{\gamma \bar{E}^{\alpha}}{r} \right]^{\frac{1}{1-\beta}}$. From this, $\sigma(t;S_0)$ goes to zero within a finite time if the initial stock satisfies $S_0^{1-\beta} < \gamma \bar{E}^{\alpha} / r$. By construction, $S(t;S_0) < \sigma(t;S_0)$ and thus $S(t;S_0)$ also goes to zero within a finite time. Note that since $\dot{S}(t;S_0) < 0$, $\lim_{t \to \infty} S(t;S_0) = 0$ is obvious, and we can arbitrarily choose an sufficiently small initial value.■

Proposition A2: *If* $\gamma > \frac{r[(1-\beta)k]^{1-\beta}}{(\bar{E})^{\alpha}(2-\beta)^{2-\beta}}$, then $\dot{S} = G(S) - H(\bar{E}, S) < 0$ *for all* $S \geq 0$.

Proof: Let $g(S;\gamma) = rS(1 - S/k) - \gamma \bar{E}^{\alpha} S^{\beta}$. If there is a unique pair ($\tilde{\gamma}$, $\tilde{S}$) such that $g(\tilde{S};\tilde{\gamma}) = 0$, $g_S(\tilde{S};\tilde{\gamma}) = 0$, and $g_{SS}(\tilde{S};\tilde{\gamma}) < 0$, then $g(S;\gamma) < 0$ for all $S > 0$ and $\gamma > \tilde{\gamma}$. Solve the system of equations $g(\tilde{S};\tilde{\gamma}) = 0$ and $g_S(\tilde{S};\tilde{\gamma}) = 0$ and we have the unique solution

$$\tilde{S} = \frac{1-\beta}{2-\beta} k, \ \tilde{\gamma} = \frac{r[(1-\beta)k]^{1-\beta}}{(\bar{E})^{\alpha}(2-\beta)^{2-\beta}}.$$

It is easily seen that $g_{SS}(\tilde{S};\tilde{\gamma}) = -r(2-\beta)/k < 0$.■

A3. *On the Existence of Optimal Paths*

We apply the Romer's Theorem (Romer, 1986) to prove the existence, because the theorem is applicable to a non-convex problem as in our model.

The reduced form welfare function for our model is written as:

$$\omega(S, \dot{S}) = \begin{cases} \gamma^{-\eta_E/\alpha} [G(S) - \dot{S}]^{\eta_C + \eta_E/\alpha} S^{-\eta_E \beta/\alpha} & \text{if } \dot{S} \in [G(S) - H(\bar{E}, S), G(S)], \\ -\infty & \text{otherwise.} \end{cases}$$

Since we have assumed $\eta_E - \alpha(1 - \eta_C) > 0$, ω is convex in $\dot{S}$. Hence, to apply the theorem, we introduce an "artificial" argument,

$$\ddot{S}(t) \text{ such that } \dot{S}(t) - \dot{S}(s) \equiv \int_s^t \ddot{S}(\tau) d\tau,$$

and rewrite $\omega(S,\dot{S})$ as $\omega(S,\dot{S},\ddot{S})$. Notice that in order for $\ddot{S}$ to exist almost everywhere, $\dot{S}$ must be absolutely continuous. This restriction is a cost of applying the Romer's Theorem. Another restriction is that we have to assume that $\ddot{S}$ is essentially bounded, i.e. there exists a real number M such that $\underset{t \geq 0}{\text{ess.sup}} \mid \ddot{S}(t) \mid < M$. The Romer's Theorem ensures the existence of optimal paths if the following two conditions are met:

(1) $\omega(S,\dot{S},\ddot{S})$ is upper-semi continuous and $\omega(S,\dot{S},\bullet)$ is concave for all $(S,\dot{S}) \in \mathbb{R}^2$,

(2) There is a real number m such that $\omega(S(t),\dot{S}(t),\ddot{S}(t)) \leq m - \mid \ddot{S}(t) \mid$ holds almost everywhere on $[0,\infty)$ and for all $(S(t),\dot{S}(t),\ddot{S}(t))$.

Our model obviously satisfies the first condition. For the second condition, notice that there is an upper bound of $\omega(S,\dot{S},\ddot{S})$, say $\bar{\omega}\,(<\infty)$. Thus, choose $m = M + \bar{\omega}$ and then condition (2) is satisfied. ■

References

Agerbo, E., T. Eriksson, B. Preben, and N. Westergard-Nielsen (1997),"Unemployment and Mental Disorders- an Empirical Analysis" University of Arhus, Arhus, Denmark.

Argyle, M. (2001), *The Psychology of Happiness*, New York: Taylor &Francis.

Akerlof, G. (2000) "Economics and Identity", *Quarterly Journal of Economics*, Vol. CXV, No. 3: 715-753.

Akerlof, G. A. and R. E. Kranton (2005), "Identity and the Economics of Organization", *Journal of Economic Perspectives*, Vol.19, No.1, Winter, 9-32.

Akerlof, G. A. and R. E. Kranton (2003), "Identity and the Economics of Organization", Working Paper, Department of Economics, University of Maryland, http://www.wam.umd.edu/~rkranton/identityandorganizations.pdf

Brander, J. A. and M. S. Taylor (1998)," The Simple Economics of Easter Island: A Ricardo-Malthus Model of Renewable Resource Use", *American Economic Review*, Vol.88, No.1, PP: 119-138.

Clark, A. E. (2003), "Unemployment as a Social Norm: Psychological Evidence from Panel Data", *Journal of Labor Economics*, Vol.21, No. 2, pp. 323-351

Clark, C. W. (1973), "Profit Maximization and the Extinction of Animal Species*", The Journal of Political Economy*", Vol.81, No.4: 950-961

Clark, A. E., and A. J. Oswald (1994), "Unhappiness and Unemployment", *Economic Journal*, Vol. 104, No. 424: 648-659

Cornes, R. and T. Sandler (1983), "On Commons and Tragedies", *American Economic Review*, Vol.73, PP. 787-792

Cornes, R. and T. Sandler (1996), *The Theory of Externalities, Public Goods and Club Goods*, Second Edition, Cambridge University Press.

Cropper, M. L. and D. R. Lee (1979), "The Optimal Extinction of a Renewable Natural Resource", *Journal of Environmental and Resource Economics*, 6, 341-349.

Darity, W. Jr. and A. H. Goldsmith (1996), "Social Psychology, Unemployment and Macroeconomics", *Journal of Economic Perspective*, Vol.10, No.1, winter, 121-140.

Dasgupta, P. (1982), *The Control of Resources*, Basil Blackwell, Oxford.

Dasgupta, P. and K. G. Maler (1995), 'Poverty, Institutions, and the Environmental Resource-Base", chapter 39 in *Handbook of Development Economics,* J. Behrman and T.N. Srinivasan, (eds.), Vol. IIIA, Elsevier Science, The Netherlands.

Diamond, J., (2005), *Collapse: How Societies Choose to Fail or Succeed*, Viking Penguin.
Di Tella, R., MacCulloch, R. J., and A. J. Oswald (2001), “Preferences Over Inflation and Unemployment: Evidence from Surveys of Happiness,” *American Economic Review*, Vol. 91, No. 1, 335-341.
Di Tella, R., MacCulloch, R .J., and A. J. Oswald (2003), “The Macroeconomics of Happiness”, *Review of Economics and Statistics*, 85 (4), 809-827.
Farzin Y. H. (1984), “The Effect of Discount Rate on Depletion of Exhaustible Resources”, *Journal of Political Economy,* Vol. 92, No. 5, 841-851.
Farzin, Y. H. and K. Akao (2006), “Non-pecuniary Value of Employment and Individual Labor Supply”, *Fondazione Eni Enrico Mattei (FEEM) Working Paper* No. 21.2006.
Feather, N. T. (1990), *The Psychological Impact of Unemployment*. New York, Springer.
Fryer, D. and R. Payne (1986), “Being Unemployed: A Review of the Literature on the Psychological Experience of Unemployment.” In *International Review of Industrial and Organizational Psychology, 1986*, C. L. Cooper and I. Robertson (eds.), pp.235-278, London, Wiley, 1986.
Frey, B. S. and A. and Stutzer (2002), “What Can Economists Learn From Happiness Research?” *Journal of Economic Literature*, Vol. XL, June, 402-435.
Gordon, J.R. (1954), “The Economic Theory of a Common Property Resource: The Fishery”, *Journal of Political Economy*, Vol. 62, 1031-1039.
Hardin, G. (1968), "The Tragedy of the Commons", *Science* 162, 1243-1247.
Jahoda, M. (1981), “Work, Employment and Unemployment: Values, Theories, and Approaches in Social Research”, *American Psychologist*, February, 36, 184-1991.
Jahoda, M. (1982), *Employment and Unemployment: A Social Psychological Approach*, Cambridge, Cambridge University Press.
Jahoda, M. (1988), “Economic Recession and Mental Health: Some Conceptual Issues”, *Journal of Social Issues*, Fall, 44, 13-23.
Karpoff, J. M. (1985), “Nonpecuniary Benefits in Commercial Fishing: Empirical Findings from The Alaska Salmon Fisheries”, *Economic Inquiry*, 23 (1),159-174.
Korpi, T. (1997), “Is Well–Being Related to Employment Status? Unemployment, Labor Market Policies and Subjective Well-Being among Swedish Youth”, *Labor Economics*, 4:2, 125-147.
Lucas, R.E., A.E. Clark, Y. Georgellis, and E. Diener, (2004), “Unemployment Alters The Set Point for Life Satisfaction”, *Psychological Science*, Vol. 15, No. 1, PP. 8-13.
Moffitt, R. (1983), “An Economic Model of Welfare Stigma”, *American Economic Review*, Vol. 73, No. 5, 1023-1035
Mulligan, C. B. (1998), “Pecuniary Incentives to Work in the United States During World War II”, *Journal of Political Economy*, Vol.106, No. 5, 1033-1077.

Ostrom, E. (1990), *Governing the Commons: The Evolution of Institutions for Collective Action,* New York: Cambridge University Press, 1990.

Ostrom, E. (2000), "Collective Action and the Evolution of Social Norms", *Journal of Economic Perspectives*, Vol. 13, No. 3, Summer, 137-158.

Ostrom, E. and J .C. Cardenas (2006), "How Norms Help Reduce the Tragedy of the Commons: A Multi-Layer Framework for Analyzing Field Experiments". In *Norms and the Law,* John N. Drobak (ed.), 105-36. New York: Cambridge University Press, 2006.

Page, S.E. (2005), "Are We Collapsing? A Review of Jared Diamond's Collapse: How Societies Choose to Fail or Succeed?", *Journal of Economic Literature*, Vol. XLIII, 1049-1062

Romer, P. (1986), "Cake Eating, Chattering, and Jumps: Existence Results for Variational Problems", *Econometrica* 54, 897-908.

Smith, V. L. (1975), "The Primitive Hunter Culture, Pleistocene Extinction, and the Rise of Agriculture", *American Economic Review*, Vol.83, No.4, 727-756.

Spence, A.M. (1973), "Blue Whales and Applied Control Theory", in *Systems Approaches to Environmental Problems*, Bavarian Academy of Sciences, conference values, June 1973.

Sorger, G. (1998) Markov-perfect Nash Equilibria in a Class of Resource Games, *Journal of Economic Theory* 11, 78-100.

Veblen, T. (1989), *The Theory of the Leisure Class*, New York, A.M. Kelly, 1975

Whelan, C. (1994), "Social Class, Unemployment and Psychological Distress", *European Sociological Review* 10, No.1, PP. 49-61.

Winelmann, L. and R. Winkelmann, (1998), "Why Are the Unemployed So Unhappy? Evidence from Panel Data", *Economica,* 65, No. 257, pp. 1-15.