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Marie-Eve Yergeau
&
Dorothée Boccanfuso
&
Jonathan Goyette

UNIVERSITÉ DE SHERBROOKE

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Marie-Eve Yergeau*
Dorothée Boccanfuso†
Jonathan Goyette‡

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Abstract

The establishment of protected areas is a widespread practice designed to curb environmental degradation. However, it is often criticized as limiting the expansion of agriculture and natural resources extraction, especially in poor regions. Others maintain that conservation can increase welfare if the opportunity cost of conservation is less than the benefit generated by alternative uses of the land. In the economic literature, theoretical results on the relation between conservation and welfare are generally pessimistic while recent empirical studies showed a positive relation. The main objective of this paper is to reconcile theoretical and empirical results. We develop and test a theory explaining the relation between conservation, ecotourism and welfare. In our model, conservation allows to develop an ecotouristic sector which generates an alternative source of income at the local level. The theoretical results are tested on Nepalese data. We find that protection associated with ecotourism development affects positively local welfare. Our theoretical results are consistent with the empirical literature.

Keywords: Welfare, environment, conservation, ecotourism, protected areas
JEL classification : I31, Q26; Q56

*GRÉDI et LAMETA - Département d'économique - Faculté d'administration - Université de Sherbrooke et Université Montpellier I - Email: marie-eve.yergeau@usherbrooke.ca.

†GRÉDI - Département d'économique - Faculté d'administration - Université de Sherbrooke - Email: dorothee.boccanfuso@usherbrooke.ca

‡GRÉDI - Département d'économique - Faculté d'administration - Université de Sherbrooke - Email : jonathan.goyette@usherbrooke.ca

1 Introduction

The establishment of protected areas is a widespread practice designed to curb environmental degradation. Between 1990 and 2011, the world's protected areas have increased in number by 155% (WDPA, 2012). However, the approach is often criticized as limiting the expansion of agriculture and natural resources extraction, especially in poor regions where this practice is not negligible (Adams et al., 2004; Ferraro and Hanauer, 2011). Indeed, in Central and South America, more than a quarter of land territory is protected while in South-East Asia and in South and Central Africa, protected areas cover nearly 15% of the territory (IUCN, 2003). Since natural resources exploitation often represents the main source of income for the poorest populations (OCDE, 2009), some authors maintain that goals of conservation and poverty alleviation are conflicting and thus cannot be achieved simultaneously (Sanderson and Redford, 2003 ; Adams et al., 2004). On the other side, empirical studies showed that under certain conditions, the establishment of protected areas rather resulted in an increase of welfare for local populations (Andam et al., 2010; Sims, 2010; Ferraro and Hanauer, 2011). These authors argue that land protection can increase welfare if the opportunity cost of conservation is less than the benefit generated by alternative uses of the land, such as ecotourism (e.g. Sims, 2010 ; Ferraro, Hanauer and Sims, 2011 ; Ferraro and Hanauer, 2011).

With this in prospect, the main objective of this paper is to reconcile theoretical and empirical results found in the literature on the link between conservation and welfare. The theoretical models developed so far are rare. Moreover, they usually exhibit pessimistic results since they assume that conservation is a constraint to the optimal use of land. Conversely, empirical studies have shown that a positive relation between land protection and welfare exists. The authors generally ascribe this result to ecotourism development inside protected areas. Therefore, we develop a theoretical model in which conservation policies allow an alternative sector to develop. This way, even though the natural resources exploitation is constrained, another income-generating sector is developed in parallel. To be consistent with what is suggested in the empirical literature, we assume this alternative sector to be ecotourism. We examine the effect of conservation combined with ecotourism development on welfare.

The few theoretical analysis on the link between conservation and welfare are typically developed from the von Thünen model's basic assumption (1926). This latter assumption is that land is allocated to its optimal use, which is determined by its geographic location, in particular its distance from a city centre (Angelsen, 2007). Thus, authors who study the effect of conservation policies on welfare, basing their analysis on this type of model, generally obtain pessimistic results since protected areas constrain the optimal use of land. Intuitively, assuming that a protected area limits the use of land without generating other local-level benefit, diminishing marginal returns will lead to a decrease in total rent. Moreover, workers will have to relocate to other sectors. Labor supply will increase, which will in turn results in a decrease of real wages (Sims, 2010). It thus seems natural, a priori, to believe that conservation policies will reduce local economic welfare by limiting land use choices. For instance, Robalino (2007) studies the effect of conservation policies on income distribution by developing a two sectors model. He concludes that these policies limit agricultural development which affects the income of farmers in particular. Indeed, the prices raise caused by land use restrictions generates a decrease in real wages which lowers workers' consumption. Robinson et al. (2008) and Robinson and Lokina (2011) integrate in their respective model temporal and spatial components that affect households decision-making. They conclude that conservation policies cause negative effects on welfare, for households located around protected areas. In both cases, the authors ascribe the welfare decrease to distance costs since households have no longer access to resources located nearby their residence.

However, the empirical literature on the relation between conservation and welfare is more mitigated. Lewis, Hunt and Platinga (2002; 2003) as well as Duffy-Deno (1998) find no significant effect of land conservation on employment and wages growth rates in the United States. Badypadhyay and Tembo (2010) rather show that the establishment of protected areas in Zambia had some positive impact on the income of certain households located around the areas. However, it also increased income inequalities. Conversely, other authors conclude that protected areas can improve significantly the situation of the poor. Andam et al. (2010), Sims (2010), Ferraro and Hanauer (2011) and Canavire-Bacarreza and Hanauer (2013) find that protected areas in Thailand, Costa Rica and Bolivia have contributed to economic development. Moreover, when controlling for certain geographic and socio-demographic variables, they conclude that the positive effect is more important in localities where poverty rates are higher. Indeed, since these localities are often associated to a low agricultural potential, the opportunity cost of conservation is lower. These authors suggest that ecotourism development within these areas allowed to generate sufficient income to compensate the loss caused by land use restrictions. To our knowledge, Ferraro and Hanauer (2014) are the only authors who study the channel through which the establishment of protected areas affect welfare. They find that ecotourism is the main channel in Costa Rica.

The World Tourism Organization (WTO) defines ecotourism as: "All nature-based forms of tourism in which the main motivation of the tourists is the observation and appreciation of nature as well as the traditional cultures prevailing in natural areas" (OMT, 2010). Moreover, ecotourism must minimise negative impacts on natural and socio-cultural environment, generate economic benefits for host communities and provide alternative employment and income opportunities for local communities (OMT, 2012). Ecotourism in protected areas thus appears to be this alternative use of the land, concurrently contributing to the goals of reducing poverty and protecting ecosystems (Andam et al., 2010; Sims, 2010, Ferraro and Hanauer, 2011). Furthermore, this industry is increasingly embedded in poverty alleviation strategies (Yunis, 2004 ; Goodwin, 2006 ; Chok, Macbeth and Warren, 2007). To that end, studies show that tourism development contributes to economic growth, more in poor than in developed countries (e.g. Eugenio, Morales and Scarpa, 2004 ; Sequeira and Nunes, 2008). Moreover, there is evidence supporting that tourism in developing countries is one of the main source of export and foreign currency and that it contributes to employment (Neto, 2003; Yunis, 2004). However, tourism development can also harm local population welfare notably because of income inequality increase, local inflation and a reallocation of labour supply toward the tourism sector, causing a lack of labour in the farming sector (Stevens, 1993; Nepal, 2002 ; Goodwin, 2006 ; Simpsons, 2007). The relation between tourism and welfare thus remains ambiguous since very few authors have measured objectively the microeconomic impacts, on welfare and poverty alleviation of local populations (Meng, Li and Uysal, 2010).

Considering the divergence between the theoretical and empirical results, developing a theoretical model based on empirical results appears relevant. We develop a two-sectors model: extractive and ecotouristic, in which natural resources conservation allows an ecotouristic sector to develop. We suppose that production in the extractive sector deteriorates the natural environment which affects negatively the production in the ecotouristic sector. A social planner can constrain the extractive sector in order to favor the ecotouristic one thus limiting the negative externality. Moreover, since empirical studies show that geographic characteristics can affect the link between conservation and welfare, we integrate into the model variables determining the relative propensity of land for a sector compared with the other. We examine the welfare variation with regard to the planner constraint severity and to the relative propensity of land for a sector compared with the other. We test the relevance of the theory on Nepalese data.

The rest of the paper is organized as follows. In the next section, we develop and resolve the theoretical model. Section three details the comparative statics and shows the welfare variation with regard to the planner constraint severity as well as to relative propensity of land. In section four, we use econometrics tools to examine the empirical validity of our model with Nepalese data. We finally conclude and highlight the main findings of this study.

2 The model

We consider a static two-sectors model: extractive and ecotouristic. The extractive sector is composed of all activities whose production alters the natural environment. For instance, agricultural exploitation requires to clear forest in order to cultivate land. The extractive sector also includes activities such as timber and non-timber extraction as well as collection of medicinal plants or firewood and fodder. The sector definition is to be kept general. In order not to add confusion about the different types of environmental damage caused by the different types of activities, any kind of alteration resulting from the production in the extractive sector will be referred to as a resource extraction. Furthermore, since the alteration is required in order to produce, the extracted resource will be considered as a factor of production. The ecotouristic sector represents the alternative sector that develops because of conservation policies. There is one local agent who gets welfare out of the extractive good consumption and the income generated from the ecotouristic sector. He has one unit of time that he allocates between the two sectors. A central planner aims at maximizing social welfare. To do so, he decides of the allocation of labor between the sectors and chooses the quantity of natural resources to be extracted. He can also constrain the production in the extractive sector in order to limit the natural resources extraction.

One of the distinctive feature of the model is that the extractive sector produces a negative externality on the ecotouristic sector. Indeed, the economy is endowed with a certain exogenous environmental quality level. Since the extractive good production requires the extraction of natural resources, it negatively affects the environmental quality. In turn, the ecotouristic good is notably produced from environmental quality. Therefore, the damage caused by the extractive sector on the environmental quality lowers the production in the ecotouristic sector. By imposing restrictions on the extractive good production, the planner limits the damage caused on environmental quality and thus encourage the ecotouristic good production.

The model also captures a result emerging from the empirical literature, that is, the effect of conservation on welfare is affected by certain geographic characteristics. For instance, because of the low opportunity cost of conservation, the establishment of protected areas seems to increase local welfare, more in regions characterized by a weak agricultural potential. Therefore, the model will take into account the relative land propensity towards the production of one good compared with the other.

2.1 The extractive sector

The extractive good is produced by a representative firm, from labor and natural resources extraction. By simplicity, we assume the following production function:

$$
\begin{aligned}
Y_E &= Z L_E^{\beta} R_E^{1-\beta} \qquad (1)\\
\beta &\in [0,1]\\
Z &> 0
\end{aligned}
$$

where Y_E is the production in the extractive sector, L_E is labor, R_E is the extracted resource and Z is a strictly positive term, aggregating the effect of geographic characteristics on the extractive good production. In absolute, the value of Z will only have a level effect on the production. A value of Z contained in the $]0,1[$ interval translates into unfavourable characteristics which affects production adversely. A value above 1 rather translates into favourable characteristics and affects production positively.

2.2 The ecotouristic sector

The ecotouristic good is produced by a representative firm, from labor and environmental quality. Again by simplicity, we assume the following production function:

$$
\begin{aligned}
Y_T &= V L_T^{\alpha} Q(R_E)^{1-\alpha} \qquad (2)\\
\alpha &\in [0,1]\\
V &> 0
\end{aligned}
$$

where Y_T is the production in the ecotouristic sector, L_T is labor, $Q(R_E)$ is environmental quality, which is a function of the extracted resource, and V is a strictly positive term, aggregating the effect of geographic characteristics on the ecotouristic good production. Thereby, the value of V compared with the value of Z will determine the relative propensity of land for the ecotouristic good production compared with the extractive good production.

The environmental quality is defined according to the following function:

$$Q(R_E) = \bar{Q} - R_E^{\gamma} \qquad (3)$$

where $\bar{Q}$ is the highest environmental quality level possible, that is, the environmental quality when no resource has been extracted, and R_E^{γ} is the damage produced by the extractive sector, that is, the negative externality caused by the extractive sector on the ecotouristic good production.

We suppose as well that:

$$
\begin{aligned}
L_E + L_T &= 1 \qquad (4)\\
\bar{Q} &= 1 \qquad (5)\\
\gamma &> 1 \qquad (6)
\end{aligned}
$$

We normalize the labour supply (4) as well as the highest environmental quality level (5) to 1. Equation (6) means that the cost of natural resources extraction on environmental quality is convex. Intuitively, the extraction cost convexity allows taking into account that the less resources remain, the more the marginal extraction alters environmental quality. For instance, cutting a tree on a territory where 1000 trees remain will affect environmental quality less than cutting a tree on the same territory, if only 2 trees remain. Moreover, the value of γ can be considered as a relative indicator of land fragility[1]: The environmental quality in an area where the value of γ is higher will be more damaged by resources extraction and therefore considered as more fragile.

2.3 The society

A central planner chooses the resources allocation that maximizes social welfare. The local representative agent gets welfare from the extractive good consumption and from the income generated by the ecotouristic sector, according to the following function:

$$W = Y_T^{\phi}(C_E - \bar{C_E})^{1-\phi} \tag{7}$$

where W is social welfare, Y_T is the income generated by the ecotouristic sector, C_E is the extractive good consumption and $\bar{C_E}$ is a subsistence constraint for the extractive good consumption, that is, the agent's extractive good consumption will never be less than $\bar{C_E}$. We assume that the ecotouristic good produced is all consumed by a foreign tourist, for whom utility is not accounted for the planner's objective function, on the local market. This hypothesis is more realistic because local people in developing countries do not tend to participate in tourism activities[2]. And since, by definition, ecotourism must create income opportunities for host communities it is coherent to assume that society gets welfare from the income generated by the ecotouristic sector. As for the parameter ϕ, it represents the planner preferences for the ecotouristic good. Implicitly it can also be interpreted as an environmental constraint. Indeed, the higher the value of ϕ, the more the ecotouristic good production must be important and so the less the extracted resources can be high. Generally speaking, the parameter thus represents a (indirect) preference for environmental conservation or, in other words, an environmental constraint. This is how we will interpret the parameter in the rest of the paper: The higher the value of ϕ, the more severe the environmental constraint is considered.

The planner must choose the allocation of factors that solves the following problem:

$$\max_{L_E, R_E} [V(1-L_E)^{\alpha}(1-R_E^{\gamma})^{1-\alpha}]^{\phi}[ZL_E^{\beta}R_E^{1-\beta} - \bar{C_E}]^{1-\phi} \tag{8}$$

Taking the first order conditions, we obtain:

$$\frac{\partial W}{\partial L_E} = \frac{(1-\phi)\beta R_E^{1-\beta}}{L_E^{1-\beta}} - \frac{\phi\alpha[L_E^{\beta}R_E^{1-\beta} - \bar{C_E}]}{1-L_E} = 0 \tag{9}$$

$$\frac{\partial W}{\partial R_E} = \frac{(1-\phi)(1-\beta)L_E^{\beta}}{R_E^{\beta}} - \frac{\phi\gamma(1-\alpha)[L_E^{\beta}R_E^{1-\beta} - \bar{C_E}]}{(1-R_E^{\gamma})R_E^{1-\gamma}} = 0 \tag{10}$$

In order to calculate an analytic solution, we suppose the subsistence constraint, $\bar{C_E}$ to equal 0. This will only cause a level effect on the extractive good production. With this simplification, we obtain the demand for labor in the extractive sector and for the extracted resource:

[1]For instance, an area with lower regeneration capacities would be considered as more fragile. For a discussion about fragile land management, see for instance Lugo (1995) and Jodha (1995).

[2]For instance, in 2012, internal travel and tourism consumption in Sub-Saharan Africa represented less than 50 000 millions US$ (3.8% of GDP with a GDP of 1 290 222 millions US$) while in Europe, it represented nearly 550 000 millions US$ (4,5% of GDP with a GDP of 12 220 717 US$) (World Bank, 2014; WTTC, 2014.)

$$L_E = \frac{(1-\phi)\beta}{\phi\alpha + (1-\phi)\beta} \tag{11}$$

$$L_\alpha^E < 0; L_\beta^E > 0; L_\phi^E < 0$$

$$R_E = \left[\frac{(1-\phi)(1-\beta)}{\phi\gamma(1-\alpha) + (1-\phi)(1-\beta)}\right]^{\frac{1}{\gamma}} \tag{12}$$

$$R_\alpha^E > 0; R_\beta^E > 0; R_\phi^E < 0; R_\gamma^E \lesseqgtr 0$$

The labor demand in the extractive sector depends on the share of labor in the extractive good production (β), the share of labor in the ecotouristic good production (α) and the severity of the environmental constraint (ϕ). The labor demand derivatives with regard to the parameters are quite intuitive. The higher the labor share in the extractive sector, the higher the labor demand will be. Conversely, the higher the labor share in the ecotouristic sector, the lower the labor demand will be. Finally, the more severe the environmental constraint, the lower the labor demand in the extractive sector will be. Since labor demand in the ecotouristic sector $L_T = 1 - L_E$, then it varies positively with the labor share in the ecotouristic good production and with the environmental constraint severity. It varies negatively with the labor share in the extractive good production.

The extracted resource demand depends on the share of labor in the extractive good production (β), the share of labor in the ecotouristic good production (α), the severity of the environmental constraint (ϕ) and the marginal extraction cost γ. Not surprisingly, it varies positively with the labor share in the extractive good production and negatively with the environmental constraint severity. We also observe that it varies positively with the labor share in the ecotouristic sector. As mentioned previously, an increase in the value of α involves an increase of the labor demand in the ecotouristic sector. This raise generates a decrease of the labor demand in the extractive sector (since $L_T + L_E = 1$). To compensate for this reduction of labor, the extracted resource demand thus must increase. The sign of the partial derivative of R_E with respect to γ is uncertain and depends on the value of the parameters. In the comparative statics that follows, the values assigned to the parameters translate into a positive sign which can appear, a priori, counter-intuitive. In fact, an increase of the marginal extraction cost generates an increase of the marginal damage caused by resource extraction, which lowers environmental quality. In the ecotouristic sector, the decrease in environmental quality results in an increase of the labor demand. Once again, this generates a reduction of the labor demand in the extractive sector, and so an increase of the extracted resource demand.

The economy is closed and composed of five markets that we assume to be cleared. First, the labor supply equals the labor demand in both the extractive and ecotouristic sectors. Next, the quantity of extracted resources equals the one used for the extractive good production. Finally, the extractive and ecotouristic good production is entirely consumed on the local market. Therefore, the optimal social welfare depends on the labor share in both sectors production β and α, the marginal cost of extraction γ as well as on the environmental constraint severity ϕ, according to the following:

$$
\begin{aligned}
W^* = & \left[V \left(\frac{\phi\alpha}{\phi\alpha + (1-\phi)\beta} \right)^{\alpha} \left(\frac{\phi(1-\alpha)\gamma}{\phi(1-\alpha)\gamma + (1-\phi)(1-\beta)} \right)^{1-\alpha} \right]^{\phi} \\
& \times \left[Z \left(\frac{(1-\phi)\beta}{\phi\alpha + (1-\phi)\beta} \right)^{\beta} \left(\frac{(1-\phi)(1-\beta)}{\phi(1-\alpha)\gamma + (1-\phi)(1-\beta)} \right)^{\frac{1-\beta}{\gamma}} \right]^{1-\phi}
\end{aligned} \tag{13}
$$

In the next section, we show how the optimal welfare varies according to the environmental constraint severity.

3 Comparative statics

We now turn to the analysis of the relation between the conservation and welfare. We examine how the optimal welfare W^* varies according to the value of the parameter ϕ. We also take geographic characteristics into account by considering three different cases:

1. $V = Z = 1$: Geographic characteristics do not favor a sector compared with the other;
2. $V > Z$: Geographic characteristics favor the ecotouristic sector;
3. $V < Z$: Geographic characteristics favor the extractive sector.

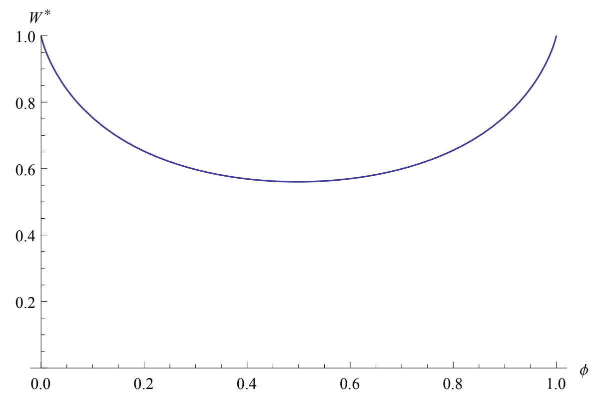
The comparative statics require to assign a value to certain parameters. Since we want the optimal welfare W^* to vary according to the environmental constraint severity ϕ, we need to assign a value to the parameters α, β and γ. The parameter β represents the share of labor in the extractive good production. We assign to this parameter the value of 0.7 which is in fact an historical estimate for labor share in agriculture from Clark (1988)[3]. It was notably used in Gollin, Parente and Rogerson (2007) and Restuccia, Yang and Zhu (2008). The parameter α represents the labor share in the ecotouristic good production. We also assign to this parameter the value of 0.7, as in Nowak et al. (2003). The authors' choice rely on different studies showing that tourism and farming sectors compete for the same labor supply (Bryden, 1973; Latimer, 1985; Telfer and Wall, 1996)[4]. Finally, we assign to the parameter γ the value of 1.2. Since, to our knowledge, the calibration of such a parameter has not been done in the literature, this value is arbitrary. However, we conducted a sensitivity analysis using different values of $\gamma > 1$ contained between 1 and 30 and it turned out it only had a level effect on the optimal welfare[5]. Indeed, for a given value of ϕ, the higher the value of γ, the higher the value of welfare W^* will be. This means that when the marginal cost of extraction is high, then the welfare reduction caused by conservation is lower. The result is intuitive since it shows that a relatively more fragile territory will benefit more from conservation.

We now turn to the variation of optimal welfare according to the environmental constraint severity and considering the effect of geographic characteristics.

3.1 Case 1: $V = Z = 1$

When $V = Z = 1$, geographic characteristics do not affect production in either sector. Furthermore, they do not favor one good production compared with the other.

Figure 1: Optimal welfare versus protection with $V = Z = 1$



As represented in figure 1, when the effect of geographic characteristics on the extractive and the ecotouristic good production is neutral, an increase of the environmental constraint severity first generates a decrease in welfare. Then, from a certain value of ϕ, welfare starts increasing. This returning threshold can thus be interpreted as the point where the opportunity cost of conservation equals the benefit generated by conservation.

To illustrate this idea, imagine a land exclusively agricultural. Then a government enforces environmental policies: a protected areas is established onto 1% of the territory. Since the major part of the land still remains agricultural, very few tourists are likely to be attracted. Therefore, since this hundredth of protected land will not generate significant benefit from ecotourism, the cost in terms of agricultural production will necessarily be higher than the benefit generated by the alternative sector. A decrease in welfare occurs. Suppose now that the government decides to protect 30% of the territory and to make it attractive for tourists. Even though benefits from the ecotouristic sector are still lower than the conservation cost, the marginal welfare loss decreases. The same story is repeated until the share of protected land is sufficiently important for the benefits from ecotourism to equalize and then to exceed the protection opportunity cost. Conservation will then generate an increase in welfare.

This interpretation involves as well that the marginal benefit of ecotourism development is increasing. One could imagine, for instance, that should a larger part of the territory be adapted for ecotouristic activities, it would also be used more intensively. However, proving this point would require a more in-depth empirical analysis that is out of the scope of this study. We thus leave it for future research.

The next two cases considered illustrate situations when geographic characteristics favor one sector compared with the other.

3.2 Case 2: $V > Z$ $(V = 2; Z = 1)$

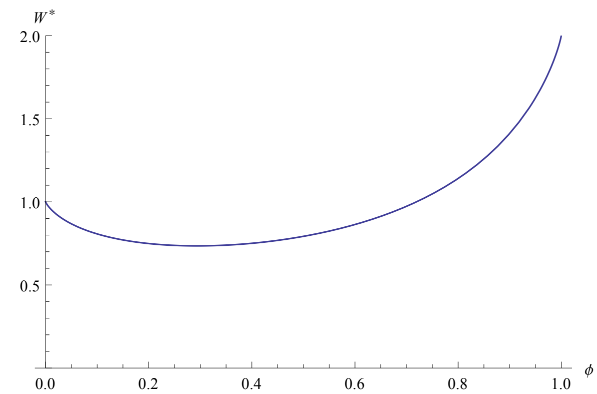
We now examine how the optimal welfare varies with the value of ϕ when geographic characteristics favor the ecotouristic sector rather than the extractive one.

[3] Cited in Gollin, Parente and Rogerson, 2007

[4] Cited in Nowak et al. (2003).

[5] See in appendix the function drawn for different values of γ in figure 8.

Figure 2: Optimal welfare versus protection with $V > Z$

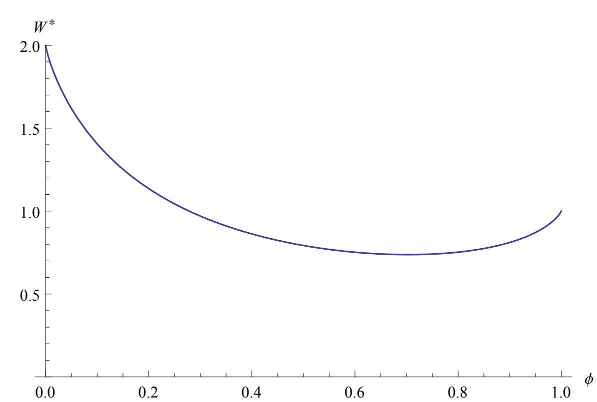


As observed in the empirical litterature, geographic characteristics affect the relation between conservation and welfare. Two main conclusions arise from figure 2. Firstly, the absolute increase in welfare generated by conservation is more important than in the previous case while the absolute decrease is smaller. Secondly, the returning point is located more to the left. That is, the threshold where conservation cost equalizes the benefit generated by the alternative sector occurs for a lower protection level (and consequently for a lower ecotouristic development level). Why? Since geographic characteristics are relatively less suitable for producing the extractive good (for instance, land is less suitable for agriculture), then the opportunity cost of conservation is weaker. A lower ecotouristic development level is thus required to compensate the loss caused by conservation and this effect gets stronger as the difference between V and Z also increases.

3.3 Case 3: $V < Z$ $(V = 1; Z = 2)$

We now examine how the optimal welfare varies with the value of ϕ when geographic characteristics favor the extractive sector rather than the ecotouristic one.

Figure 3: Optimal welfare versus protection with $V < Z$

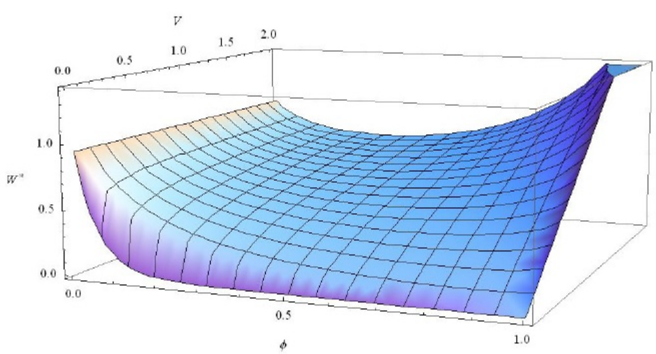


As shown in figure 3, the effect is now opposite to the previous case. Firstly, the absolute welfare decrease generated by protection is more important than in case 1 while the increase is smaller.

Secondly, the threshold is located more to the right. That is, the opportunity cost of conservation is higher. For conservation to generate an increase in welfare, it is required that the ecotouristic sector be much more developed. We observe as well that the optimal welfare will never be as high as when land is not protected at all.

It can be shown that regardless the value of V and Z, a relative increase of V compared with Z generates a shift of the welfare curve to the left and upward in the plane (ϕ, W^*)[6]. That is, for two identical regions, except for the value of V, the one with the highest value of V will always get more benefits out of protection. Indeed, the opportunity cost of conservation will be relatively weaker. Thus, the absolute welfare decrease following the protection will be lower and the threshold where benefits generated by conservation equalize the conservation opportunity cost will occurs for a lower protection level. This is illustrated in figure 4 that shows the evolution of the threshold, according to the value of V.

Figure 4: Threshold variation according to V



In the next section, we examine the empirical relevance of the model.

4 Empirical evidence

We have shown theoretically that, conditionally to the development of an alternative sector, environmental conservation can be associated to an increase of welfare. We observed as well that the link between conservation and welfare will be affected by geographic characteristics. The model that will be estimated is not a structural model. The estimation rather aims at verifying if the two main theoretical conclusions can be replicated with data. These conclusions are: (1) the development of an alternative sector (ecotouristic) positively affects the relation between conservation and welfare and (2) geographic characteristics affect the relation between conservation and welfare.

4.1 The data

The empirical validity of the model is tested on Nepalese data. This is a sound choice owing to the large percentage of the Nepalese territory devoted to protected areas and the rapid growth of its tourism sector. Indeed, since 1973, 20 protected areas including 10 national parks, 6 conservation

[6]Proof in appendix

areas and 4 reserves, as well as 12 buffer zones have been gradually established. These areas cover 34 185.62 km^2 of the territory which represents 23.23% of the country (DNPWC, 2014). In 2002, agriculture was allowed but limited on 55% of the protected land while forbidden on the remaining 45%[7]. Furthermore, Nepal is characterized by natural and cultural diversity and richness which grant to the country a comparative advantage for ecotourism. Since the boundaries opened in the 50s, important and sustained growth of tourism has been observed. In 2012, total income generated by tourism was 356 725 US$; the industry then represented 4.7% of total GDP. It is expected that in 2020, the share of GDP accounted for by tourism will be 8.1%, which represents a growth rate of 4.4% for the 2011-2020 period (WTTC, 2012). Today, ecotourism is one of the main country's development strategy (Governement of Nepal, 2014) and nearly 50% of tourists entering Nepal visit a protected area (NTB, 2011) and participate in ecotourism (Nepal, 2002). Therefore, the study of the link between ecotourism, conservation and welfare in Nepal is relevant to provide guidance to development and conservation policies.

In order to examine the relation between ecotourism, conservation and welfare as described in the theoretical model, ideally one would use data on (1) the income that each household gets from both the ecotouristic and the extractive sectors and (2) restrictions imposed to each household on the extraction and use of natural resources. However, such detailed data are not available and proxies have to be used. We must mention as well that we are not aiming at measuring the causality link but rather at verifying if data can replicate the shape of the relation obtained theoretically. The data used come from different sources and are summarized in table 1. The theoretical variables are associated with four empirical variables in order to measure: (1) household welfare, (2) conservation constraint severity, (3)income generated by the ecotouristic sector and (4) extractive good consumption. To these variables other controls will be added, depending on the estimated model.

As for the welfare measure, we use the annual per household adult equivalent consumption expenses. Data come from the Nepal Living Standard Survey (NLSS) which is a household survey that was conducted in 2010. The methodology of this survey relies on the *Living Standards Measurement Study*[8] (LSMS). The sampling is composed of 5 988 households from 71 out of the 75 districts of the country. Therefore, due to lack of data, the four missing districts are excluded from the estimation[9]. We also exclude of the sampling households from Kathmandu. The capital owns the only international airport of the country. It is a global hub but also a necessary transition for a majority of tourists who visit Nepal. However, we aim at capturing the effect of ecotourism only and no available information allows us to identify the motive for the visit of tourists in Kathmandu. That is why, including the capital in the analysis may bias the results. The sampling is thus composed of 5 268 households. In order to take into account inter-household composition heterogeneity as well as intra-household resources reallocation, we use per household adult equivalent consumption expenses. We use the Oxford equivalence scale, which assigns a weight of 1 consumption unit to the first adult, 0.7 to the other individuals aged 14 years and above and 0.5 to children younger than 14 years. According to Hadji (2010), this equivalence scale is more representative of the consumption structure in developing countries.

The estimation also requires a measure of conservation. In many developing countries, the estab-

[7] Betweeen 2002 and 2010, 4 protected areas have been established: Shivapuri Nagarjun National Park (2002), Banke National Park (2010), Api Nampa Conservation Area (2010) and Gaurishankar Conservation Area (2010). To our knowledge, no information is available regarding the agricultural restriction on these areas.

[8] For more information about the methodology, see http://econ.worldbank.org.

[9] These districts are: Mustang, Dolpa, Manang and Humla.

Table 1: Variables summary

Variables	Description	Source
Dependent variable		
Exp	Per household adult equivalent consumption expenses	Nepal Living Standard Survey (NLSS), 2010
Variables of interest		
Protect	Share of the district belonging to a protected area	Authors calculation from ArcGIS
Tour	Number of tourist arrivals per protected area in 2010	Nepal Tourism Board
Agricultural Income	Per household agricultural income	NLSS 2010
inter	Interaction variable between ecotouristic development and conservation	Protect$\times$Tour
Control variables - household level		
hhsize	Household size	NLSS 2010
ethnicity	Household head ethnicity	NLSS 2010
education	Household head highest education level attained	NLSS 2010
sex	Sex of household head	NLSS 2010
age	Age of household head	NLSS 2010
nonfarmval	Value of non-farm assets owned by household	NLSS 2010
poor	Identify if household lives below the poverty line - dummy variable	NLSS 2010
Control variables - district level		
region	Division of the country from West to East (5 divisions)	NLSS 2010
belt	Division of the country from North to South (3 divisions)	NLSS 2010
ad	Division of the country into subregions (12 divisions)	NLSS 2010
urbrur	Identify if the household lives in urban or rural area	NLSS 2010

lishment of protected areas is a strategy used for both decreasing natural resources degradation and developing an ecotouristic sector as an alternative source of income besides agriculture (Rana et al., 2010). It thus appear as a relevant proxy for the conservation constraint severity so we interpret the parameter ϕ as a measure of land protection. When ϕ is weak, the planner is not very concerned about conservation. All land territory can be used for the extractive good production and no protected area is established. When ϕ is high, the planner has a strong preference for the ecotouristic good and thus for conservation. He protects a large part of the territory. This way he both limits resources extraction and develop the ecotouristic sector. The available data do not distinguish households living inside a protected area from those living outside. For this reason, we calculate a measure of protection for each district and associate households to the measure of their district of residence. This measure is represented by the share of the district that belongs to a protected area. To calculate it, we use the Geographic Information System (ArcGIS) program that allows to analyse geospatial data. First, we select the district surface that belongs to a protected area and obtain the area. Then, we calculate the ratio between this area and the total surface of the district. This way we obtain a measure of protection between 0 and 1, for each of the 70 districts considered in this study.

Next, we measure ecotouristic development by the number of tourists arrival per protected area, in 2010. The data come from the Nepal Tourism Board, that annually compiles a tourism statistics directory. Again, we use a per district measure. We consider that the number of visitors participating to ecotourism in each district corresponds to the number of visitors that accessed a protected area established on the district. We associate households to the ecotouristic development measure of their district of residence.

Finally, as for the extractive good consumption measure, we use the per household farm income[10]. We calculate it using the NLSS (2010) data.

4.2 Results

In the first estimation, we aim at verifying the first theoretical result which is that ecotourism development positively affects the relation between conservation and welfare. Yet, we do not take into account geographic characteristics that are likely to affect the relation between conservation and welfare. We estimate the following model:

$$Exp_i = \beta_1 Tour_j + \beta_2 Farm_i + \beta_3 Protect_j + \beta_4 inter + \beta_5 P_i + \epsilon_i \tag{14}$$

where Exp are the per household adult equivalent consumption expenses, $Tour$ is the number of tourist arrivals in the protected area established on the district, $Farm$ is the per-household farm income, $Protect$ is the protected district share, P is a vector of household-level control variables and ϵ is the random error. In order to verify if the relation between conservation and ecotourism affects the link between conservation and welfare, we add to the model an interaction variable. Therefore, $inter$ represents the interaction between protection and ecotourism. This way, the marginal effect of conservation on welfare becomes $\beta_3 + \beta_4 Tour$. It is thus dependent on the ecotouristic development level. In the theoretical model, the cross partial derivative of welfare with respect to protection and ecotourism development indicates the expected sign of the interaction variable coefficient. The calculation leads to:

$$\frac{\partial^2 W^*}{\partial \phi \partial Y_T} = \frac{W^*}{Y_T} \left[\phi(\ln Y_T - \ln Y_E) + 1\right] \tag{15}$$

which means that the expected sign is uncertain. Protection and ecotourism will be complementary if $\ln Y_E - \ln Y_T < \frac{1}{\phi}$ and substitute if $\ln Y_E - \ln Y_T > \frac{1}{\phi}$. As we see, the nature of the effect depends on the protection level ϕ.

Formally and as shown in appendix[11], (15) represents the effect of the slope variation of the welfare curve following the variation of Y_T, combined with the curve translation in the plane (ϕ, W^*). Because the curve translates laterally, the nature of this total effect becomes dependent on the protection level, i.e. the value of ϕ. For the nature of the effect to be independent of the protection level, one has to isolate and subtract from (15) the part of the effect caused by the lateral translation of the curve. This would allow to observe how each point of the welfare function moves in the plane (ϕ, W^*) following a variation of Y_T, on the left and on the right of the returning threshold, no matter where the threshold is located in the plane. Let $W^*(\phi)$ be the value of W^*

[10] The farm income includes value of total crop production, value of by-product production, net income from renting farm assets, value of sales from non-crop farm production, earning from sale of livestock, value of home-produced non-crop consumption and total cash and in-kind received from tenants on land lease-out.

[11] We show in appendix how the welfare curve varies in the plane (ϕ, W^*) according to the value of V. The same proof applies for a variation of Y_T.

for each value of ϕ on the initial curve and let $W^*(\phi')$ be the value of W^* for each value of ϕ on the translated curve. Then, the lateral translation corresponds to the slope variation with regard to Y_T, assuming $W^*(\phi) = W^*(\phi')$, $\forall\phi$. In other words, we observe how each point of the curve moves with the variation of Y_T, assuming they move neither upward or downward. From the calculation, we obtain:

$$\frac{\partial^2 W^*}{\partial\phi\partial Y_T}|_{W^*(\phi)=W^*(\phi')} = \frac{W^*}{Y_T} \tag{16}$$

The subtraction of (16) to (15) leads to the condition determining the welfare curve returning threshold[12]. This means that, no matter for which value of ϕ the returning threshold occurs, protection and ecotourism will be substitutes when the extractive good production is higher than the ecotouristic good production, i.e. on the left of the returning point while they will be complementary when the ecotouristic good production is higher than the extractive good production, i.e. on the right of the returning point. Therefore, if we obtain for the variable *inter* a coefficient:

1. positive, then protection and ecotourism are complementary. We should observe a returning point located on the left in the plane (ϕ, W^*);
2. negative, then protection and ecotourism are substitutes. We should observe a returning point located on the right in the plane (ϕ, W^*);
3. negative, with a positive quadratic term, then the nature of the relation between ecotourism and welfare depends on the protection level. We should observe a centered returning point in the plane (ϕ, W^*).

The results obtained from the Ordinary least squares estimation for the variables of interest are presented in the first column of table 2.

Ecotourism development as well as farm income are positively linked with welfare. However the number of tourist arrivals is not statistically significant at a 10% level ($pval = 0.14$). Land protection is negatively related to welfare. On the other side, the coefficient associated with the interaction variable shows that ecotourism development within protected areas is positively linked to welfare. This result is consistent with the theoretical one: when the alternative sector is not developed, protection generates a welfare decrease. However, this decrease diminishes with the increase of ecotourism (in the theoretical model, with the increase of ϕ) until ecotourism is sufficiently developed (where $-8373.939+0.238\times Tour = 0$) so that the relation between protection and welfare becomes positive and growing. However, since previous empirical studies showed that geographic characteristics affect the relation between protection and welfare, this estimation is very likely to be affected by an omitted variables bias. This potential bias will be treated in the next model.

In the second estimation we aim at verifying if geographic characteristics affect the relation between conservation and welfare. To do so, we include in the model control variables related to geographic location. If these variables interfere in the relation between protection and welfare, we should observe a variation in the value of the coefficients compared with the ones obtained in the first estimation. The information on the relevant geographic characteristics[13] is not available at a

[12] $\ln Y_T - \ln Y_E = 0$. See equations 18-20 in the appendix for the condition calculation.

[13] These variables include: slope, elevation, distance to major city, average temperature, average rainfall, condition of watershed, distance to road, forest cover (Sims, 2010; Ferraro and Hanauer, 2011; Canavire-Bacarreza and Hanauer, 2013).

Table 2: OLS regression results on welfare

	Per household adult equivalent consumption expenses	
	(1)	**(2)**
Tourists arrivals	0.041	0.066**
	(0.028)	(0.028)
Protected share of district	-8373.939***	-9190.297***
	(3173.202)	(3093.529)
Agricultural income	0.050***	0.065***
	(0.019)	(0.020)
Interaction	0.238***	0.126**
	(0.053)	(0.052)
R^2	0.31	0.36
Observations	5268	5268

Robust standard errors. *** 1% significance ** 5% significance. Standard errors in brackets. Regression (1) includes controls for household size, sex of household head, age of household head, level of education of household head, ethnicity of household head, value of non-farm asset owned by household and a dummy variable indicating if the household is below the poverty line. Regression (2) includes regression (1) controls and geographic controls. All controls are 1% significant.

sufficiently disaggregated level to be used in this estimation. Therefore in order to control for the effect of geographic characteristics, we add to the model the following variables:

1. region: The country is divided into 5 regions, from West to East as shown in figure 5 (from Far Western on the left to Eastern on the right). The variable takes a value between 1 and 5 and indicates in which region the household lives;

2. belt: The country is divided into 3 geographic belt, from North to South as shown in figure 5 (Mountains, Hills and Terai). The variable takes a value between 1 and 3 and indicates in which belt the household lives;

3. ad: The country is divided into 12 subregions. These subregions separate the country from West to East and from North to South. The variable takes a value between 1 and 12 and indicates in which subregion the household lives;

4. urbrur: This variable distinguishes urban and rural households. The variable takes a value of 1 or 2 and indicates if the household is urban or rural.

Although these variables do not specifically identify geographic characteristics that significantly affect welfare, they do control for characteristics that are common to populations localized on a defined share of land. Including the geographic controls, we obtain the following model:

$$Exp_i = \beta_1 Tour_j + \beta_2 Farm_i + \beta_3 Protect_j + \beta_4 inter + \beta 5 P_i + \beta 6 G_j + \epsilon_i \quad (17)$$

where G is a vector of geographic controls.

According to the Bayesian information criterion (BIC) and the Akaike's information criterion (AIC), the second model gives a more accurate estimation. The BIC for the first estimation equals 125 974.6 while the one for the second estimation is of 125 625.2. The AIC for the first model

Figure 5: Map of ecological belt and region of Nepal

Source: Government of Nepal

equals 125 895.7 and the one for the second model is of 125 520.1. Thus, the two criteria are lower in the second estimation.

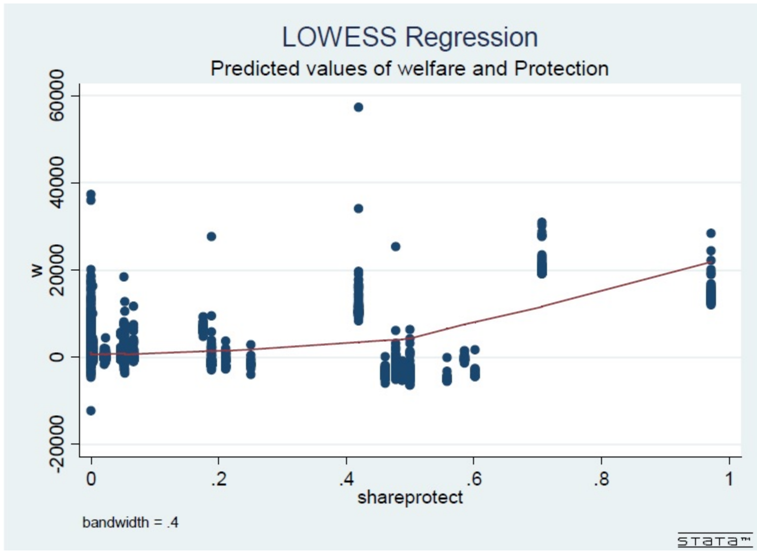
Comparing the results obtained for the two estimations, one can indeed notice that the coefficient values of the variables of interest have changed. The coefficient associated with the ecotouristic development variable increases and becomes significant. The value of the coefficient associated with the protection variable decreases (increases in absolute value) and the one associated with the agricultural income increases. Finally the value of the interaction variable coefficient decreases. Not taking the geographic characteristics into account thus underestimates the strength of the relation of land protection and ecotouristic development with welfare. However it overestimates the link between the interaction variable and welfare.

The coefficient associated with the interaction variable is positive[14]. As discussed previously, if we graphically represent the relation between welfare and land protection, for a protection level between 0 and 1, we should observe a quadratic relation with a returning point located on the left. In order to verify this, we calculate the predicted values of welfare using the tourist arrivals, the farm income, the protection variable and the interaction term along with their respective coefficients. This way, we only keep the predicted value of welfare associated with the variables that determined the theoretical relation. From this predicted welfare variable (W) and the protection variable (shareprotect), we run a non-parametric regression using the locally weighted scatterplot smoothing (LOWESS) method.

We observe in figure 6 that the result generated by the non-parametric regression is consistent with the one expected. Indeed, as expected from the positive sign of the interaction variable

[14] We also estimated a model including a quadratic interaction term. The variable was non-significant.

Figure 6: LOWESS results on predicted values of welfare



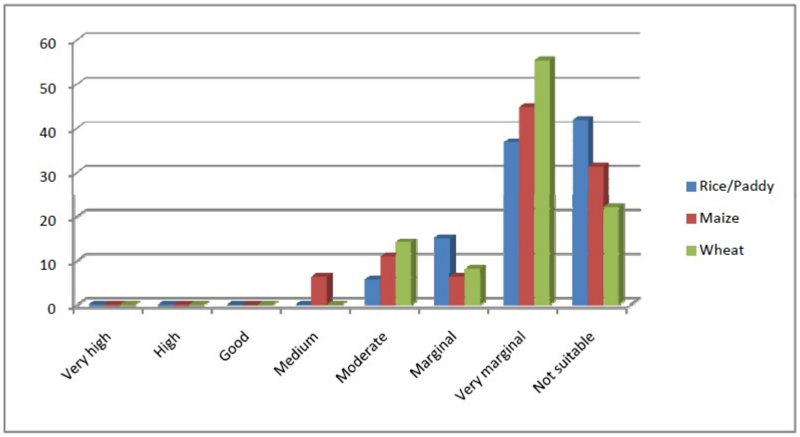
Source: Authors calculation from NLSS 2010

coefficient, the slope is very weak for a low protection level but increases with the protection level. Furthermore, the shape of the curve is similar to the theoretical result obtained when geographic characteristics favor the ecotouristic sector rather than the extractive one. In Nepal, agriculture depends largely on geographic characteristics and climate. Indeed, 17% of territory is plain and the remaining 83% is hills and mountains. Moreover, 15% is covered with snow. In the Himalayan region, only 1% of territory is suitable for farming due to poor soil quality and rigorous climate. In the hills region, land is cultivated intensively but still cannot produce sufficient quantities of food. Finally, the Terai region located in the south of the country is fertile and intensively cultivated. However, it only represents 14.4% of the territory (Pariyar, 2008). According to data published by the FAO, the three crops covering the largest cultivated land surface of Nepal in 2012 were rice/paddy (1 531 493 ha.), maize (871 387 ha.) and wheat (765 317 ha.)[15]. The FAO Global AgroEcological Zones (2002) is a database including a *suitability for cultivating individual crops* measure. Soil suitability classifications are based on knowledge of crop requirements, of prevailing soil conditions, and of applied soil management[16]. Figure 7 shows the suitability index of the territory of Nepal, for the three main crops. We observe that the share of territory having a suitability index between good and very high is zero. Moreover only a marginal part of the territory is considered as medium for rice and wheat cultivation. Thus, the three crops occupying the largest surface are mainly produced on a land categorized as moderate to very marginal. In the light of these results, it appears that Nepal is not endowed with geographic characteristics that are suitable for generating high agricultural returns. This reinforce the link between the empirical and the theoretical results of this paper.

[15] http://faostat3.fao.org/faostat-gateway/go/to/download/Q/QC/E

[16] For more information on the index, see http://gaez.fao.org/Main.html#

Figure 7: Crop suitability index



Source: FAO, 2002

5 Conclusion

In the literature on the relation between environmental conservation and welfare, empirical and theoretical results diverge. Indeed, theoretical models developed so far usually show pessimistic results while recent empirical studies showed a positive relation between conservation and welfare. In most cases, authors ascribe this result to ecotourism development inside protected areas. Moreover, they observe that land protection contributes more to the increase of welfare in areas where the poverty levels are higher. According to them, this can be explained by a low agricultural potential, translating in a weak opportunity cost of conservation. Therefore, the main goal of this paper was to reconcile theoretical and empirical results found in the literature on the relation between conservation and welfare. We argued that this gap can notably be explained by the fact that in theoretical models, authors consider conservation policies as a constraint to the optimal use of land. They do not include in their model an alternative sector that can be developed because of conservation. Thus, we developed a two-sectors model: extractive and ecotouristic, based on two results emerging from the empirical literature. First, environmental conservation allows to develop an alternative sector, which represents a source of income for local communities. Second, geographic characteristics affect propensity of land to produce one good compared with the other.

The theoretical result shows a quadratic relationship between conservation and welfare, provided that protection is associated with ecotourism development. Moreover, geographic characteristics affecting the relative land propensity for a good production interfere with the relation between conservation and welfare. When geographic characteristics favor the ecotouristic good production rather than the extractive good production, the welfare decrease caused by conservation is weaker and the returning threshold occurs for a lower protection level. The opportunity cost of conservation is thus weaker. Conversely, when geographic characteristics favor the extractive sector rather than the ecotouristic one, then the welfare decrease caused by protection is more important and the returning point is located more to the right. The opportunity cost of conservation is therefore higher. These results are consistent with the empirical literature.

We also tested the empirical validity of the model using Nepalese data. Estimations support the theoretical result. Indeed, land protection associated with ecotouristic development is positively related to welfare. Moreover, geographic variables affect the nature and the strength of the relation between conservation and welfare. A non-parametric regression between predicted values of welfare and the protection level shows a relation similar to the theoretical one. The empirical evidence confirm the relevance of the model.

This result is important in a context where the interrelation between environmental conservation and poverty alleviation objectives are considered as a challenge, particularly in developing countries. Indeed, environmental conservation can potentially generate positive benefits for local populations, provided it is associated with the development of an alternative sector. Our model thus contributes to the theoretical literature which did not include this alternative sector. At the empirical level, the estimation results are consistent with recent studies on the link between protected areas and welfare. An in-depth study would be necessary to conclude on policies recommendations. A causality analysis that would take into account the potential endogeneity between the variables of interest and welfare should notably be conducted. Moreover, the use of household-level data to measure the ecotouristic income as well as the protection level would allow a more precise analysis.

In spite of its simplicity, the theoretical result is consistent with data. In future work, extensions can be considered. First, the functional forms were selected for their mathematical simplicity. It would be relevant to verify the results with other types of function. For instance, a CES welfare function would allow to take into account the substitutability level between the two sectors. Next, the model could be dynamic. Such a model would allow to include resources regeneration, as frequently seen in the literature. Finally, the model assumes that ecotourism does not produce any environmental damage. However, there exists studies showing the opposite. It would thus be relevant to integrate in the model damages caused by the extractive as well as the ecotouristic sector.

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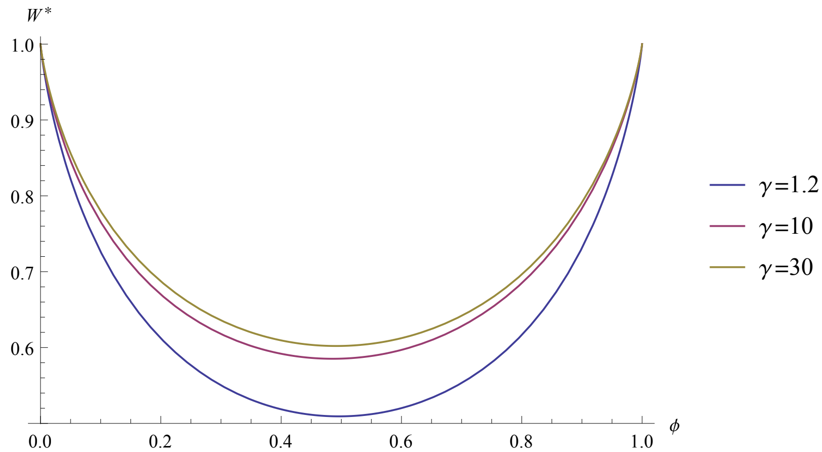
Appendix

Figure 8: Optimal welfare versus protection for different values of γ



Proof of the variation of W^* with regard to V

We show that if the characteristics of a region become more suitable for ecotourism (increase of V with regard to Z), then the welfare decrease generated by protection will be smaller and the returning point where the relation between welfare and protection becomes positive will occur for a lower protection level (it will be located more on the left in the plane (ϕ, W^*).

In this section, we show how the optimal welfare curve varies following an increase of V. We answer 3 questions:

1. How does welfare W^* vary with regard to V;
2. How does the returning threshold in the plane (ϕ, W^*) vary with regard to V;
3. How does the slope of the curve in the plane (ϕ, W^*) vary with regard to V, on the right and on the left of the returning threshold.

How does welfare W^* vary with regard to V

In order to verify how optimal welfare W^* varies with regard to V, we calculate:

$$\frac{\partial W^*}{\partial V} = \frac{\phi W^*}{V} > 0$$

An increase of V will cause a level effect on welfare, which will generate a translation of the welfare curve upward (figure 9).

How does the returning threshold in the plane (ϕ, W^*) vary with regard to V

The returning threshold in the plane (ϕ, W^*) is located where the slope of the welfare curve equals 0. Therefore, we calculate the slope:

$$\frac{\partial W^*}{\partial \phi} = W^*[\ln Y_T - \ln Y_E] \tag{18}$$

By equalizing (18) to 0, we find the condition for the slope to equal 0:

$$0 = W^*[\ln Y_T - \ln Y_E] \tag{19}$$

$$\ln Y_T = \ln Y_E \tag{20}$$

Therefore, the slope will equal 0 when $\ln Y_T = \ln Y_E$.

We now turn to how the returning threshold varies with V. We calculate the partial derivative of (18) with regard to V, assuming $W^*_\phi = 0$:

$$\frac{\partial^2 W^*}{\partial \phi \partial V} |_{W^*_\phi=0} = \frac{1}{V} > 0 \tag{21}$$

Equation 21 shows that the slope at the point where $W^*_\phi = 0$ on the initial curve becomes positive after an increase of V. Thus the curve necessarily translates towards the left (figure 10).

How does the slope of the curve in the plane (ϕ, W^*) vary with regard to V, on the right and on the left of the returning threshold

We calculate the variation of the slope with regard to V:

$$\frac{\partial^2 W^*}{\partial \phi \partial V} = \frac{\phi W^*}{V}[\ln Y_T - \ln Y_E] + \frac{W^*}{V} \tag{22}$$

Let ϕ_{min} be the ϕ value corresponding to the returning threshold, i.e. ϕ_{min} is the protection level yielding to th lowest optimal welfare level. It is noteworthy that the welfare curve is decreasing if $\phi < \phi_{min}$ and is increasing if $\phi > \phi_{min}$. Equation (22) is a partial derivative of (18). We have seen that (18) exhibits a lateral translation of the welfare curve due to an increase of V. Thus, the slope variation with regard to V can be the result of a lateral translation of W^* and/or the result of an evolution of the slope of W^*. In order to capture the second effect only, we have to isolate the lateral translation effect. To do so, one must consider the slope variation, assuming that the returning threshold always occurs for the same value of ϕ. Formally, we must subtract to (22) the effect caused by the lateral translation of the curve. This way, we will see how each point of the curve varies on the left and on the right of the threshold, independently of the value of ϕ for which the returning threshold occurs.

Let $W^*(\phi)$ be the value of W^* for each value of ϕ on the initial curve and let $W^*(\phi')$ be the value of W^* for each value of ϕ on the translated curve. Then, the lateral translation corresponds to the slope variation with regard to V, assuming $W^*(\phi) = W^*(\phi')$, $\forall \phi$. In other words, we observe how each point of the curve moves with the variation of V, assuming they move neither upward or downward. From the calculation, we obtain:

$$\frac{\partial^2 W^*}{\partial \phi \partial v} |_{W^*(\phi)=W^*(\phi)} = \frac{W^*}{V} \tag{23}$$

We subtract this effect to (22):

$$\frac{\phi W^*}{V}[\ln Y_T - \ln Y_E] + \frac{W^*}{V} - \frac{W^*}{V} = \frac{\phi W^*}{V}[\ln Y_T - \ln Y_E] \tag{24}$$

This way and as shown in figure 11, the slope variation following an increase of V, no matter where the returning threshold is located in the plane (ϕ, W^*) will be:

1. positive, if $\ln Y_T > \ln Y_E$, so on the right of the returning threshold;
2. negative, if $\ln Y_E > \ln Y_T$, so on the left of the returning threshold.

Therefore, for 2 identical regions except for the value of V, protection will generate a smaller decrease of welfare in the region where V is higher. The relation between welfare and conservation will also become positive for a lower protection level.

The opposite result would be observed if considering an increase of Z compared with V. We leave the proof to the reader.

Figure 9: How does welfare W^* vary with regard to V

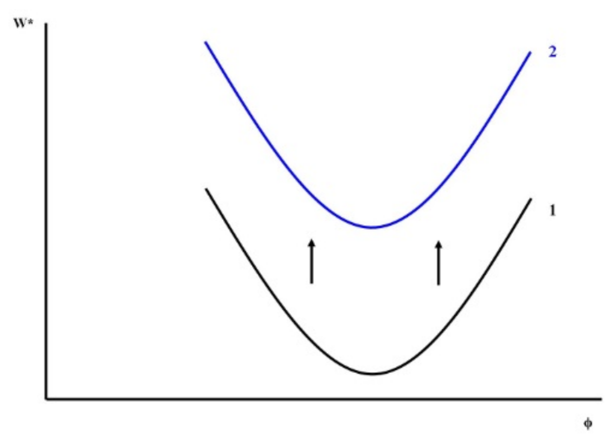


Figure 10: How does the returning threshold in the plane (ϕ, W^*) vary with regard to V

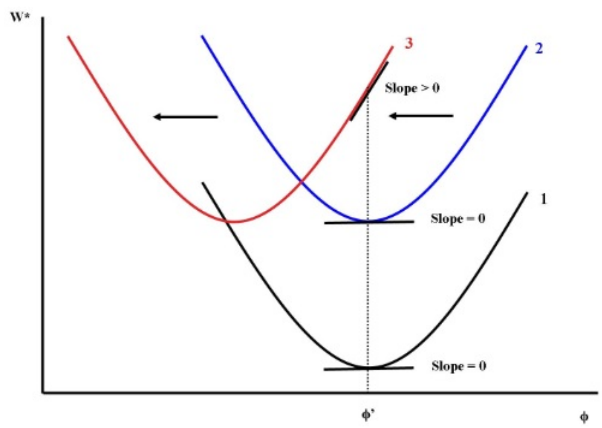


Figure 11: How does the slope of the curve in the plane (ϕ, W^*) vary with regard to V, on the right and on the left of the returning threshold