Tourism, Natural Resource Use and Livelihoods in Developing Countries: A Bioeconomic General Equilibrium Approach

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Abstract

Protecting degraded open-access natural resources while maintaining or improving individuals' livelihoods is a major challenge, particularly in developing countries. Tourism is often viewed as a win-win solution that can shift natural resource users away from resource extraction and increase local incomes. Existing studies examining the impacts of tourism on natural resource use and livelihoods fail to account for the full suite of effects tourism has on local economies. We offer a new method for assessing the impacts of tourism growth by combining local economy-wide impact evaluation (LEWIE) techniques from development economics with bioeconomic modeling techniques from natural resource economics. We construct our "Bio-LEWIE" model using a novel data set of microeconomic and biological data from the western Philippines. We simulate the impact of a 10 percent increase in tourism expenditures on fishing pressure and local incomes for different socioeconomic groups (e.g., poor households versus nonpoor households). We find that if fish cannot be traded with outside markets, fishing pressure increases and the fish stock declines. The growth in tourism causes households' real incomes to increase, however they decrease slightly over time due to the decline in the fish stock. In contrast, if fish can be imported, fishing pressure decreases and the fish stock recovers. Real incomes also increase in this scenario, including a small growth in real incomes over time as the fish stock recovers. However importing fish results in smaller overall gains in real incomes (particularly for fishing households), which is due to a leakage of money out of the local economy via fish imports. This model predicts the costs and benefits of tourism growth, when they will occur, and for whom. This framework can help policy-makers in the developing world find synergies between natural resource protection, sustainable livelihoods, and economic growth.

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1. Introduction:

Protecting degraded open-access natural resources while maintaining or improving individuals' livelihoods is a major challenge, particularly in developing countries (FAO, 2004; World Bank and FAO, 2009; Tallis et al. 2009). Resource management schemes that seek to rationalize open-access resource sectors (e.g., through privatization, access rights, etc.) in theory can be used to reach economically efficient harvest levels (Scott, 1957; Cunningham et al., 2009; Wilen, 2013). However there is a general consensus that open-access resources in developing-world contexts present additional challenges for management (Ostrom, 1990; Cinner et al., 2009; Wilen, 2013). These challenges include issues such as weak institutions for monitoring and enforcement as well as concerns about excluding resource users who depend on the resource for their livelihoods.

In light of these challenges, an alternative to resource management policies such as privatization is the provision of alternative livelihoods for natural resource users. In developing countries, tourism is often promoted as a way to decrease pressure on natural resources and alleviate poverty by providing alternative livelihoods to natural resource users (Kiss, 2004). The hope is that by creating opportunities in the tourism sector, fishermen will shift to new livelihood activities while maintaining or even increasing local incomes. For example, the Philippine Government is heavily promoting tourism as an alternative livelihood to fishing in order to combat problems of overfishing in artisanal fisheries (Fabinyi, 2010).

In this paper we explore the implications of an increase in tourism expenditures for an open-access fishery in El Nido, a municipality on the island of Palawan in the western Philippines. The municipality of El Nido has a population of approximately 36,000 people and the main industries are fishing, tourism and farming. This location is an ideal case study for assessing the impact of tourism growth on the use of natural resources because it is experiencing marked growth in tourist visits and simultaneously suffering from significant overfishing in its near-shore artisanal fishery.

While tourism in El Nido has the potential to alleviate fishing pressure and improve local incomes, whether tourism will actually achieve this is unclear. For example, an increase in tourist expenditures may create tourism jobs that draw fishermen out of fishing; however tourists also demand fish (e.g., in local restaurants), which could cause an increase in the profitability of local fishing operations. Also if tourism raises local incomes, this may increase the demand for higher protein foods like fish and meat. It is also possible that the effect of tourism growth in the economy will change over time because fish stocks take time to adjust to new harvesting pressures resulting from tourism.[2]

The ambiguous effect on a natural resource of growth in another sector was noted by Manning et al. (2013). In a northern Honduran fishery, they showed that in theory, an increase in the price of a locally produced agricultural good (palm oil) has an ambiguous effect on fishing pressure and natural resource stock size. They noted that higher profitability in the agricultural sector may draw labor out of the fishing sector; however, higher local incomes created additional demand for fish.

[2] In the case of ecotoursim, recovering marine ecosystems may draw more tourists, though this relationship is not estimated in this work.

The goal of this paper is to simulate the impact of an increase in tourism on fishing pressure and local incomes in El Nido, including how these variables change over time and how different socioeconomic groups are affected. To do this requires a model that maps tourists expenditures into a model of the local economy, accounting for the multiple economic channels (e.g., labor markets, inputs markets, consumption demand) through which tourism can affect fishing pressure and local incomes. In addition, the model must account for how new harvesting pressures will change fish stocks levels over time, resulting in feedbacks to the local economy. The model must also disaggregate the impacts to show the effects on different socioeconomic groups over time. Currently no existing work in development economics or natural resource satisfies these needs.

Research in development economics has produced sophisticated economy-wide models that account for ways that tourism affects local economies. Economy-wide models capture the way that producers and consumers in an economy are connected (due to interactions through labor markets, input markets, and markets for goods). These models show how changes in one sector can have impacts throughout the entire local economy. Local Economy-Wide Impact Evaluation (LEWIE) models are a type of economy-wide model that use microeconomic data from businesses and households to build a model of a local economy. A study on tourism in the Galapagos Islands using a LEWIE model shows that ecotourism in the Galapagos has a marked impact on natural resource use and incomes, and that these impacts vary depending on how well-connected a local economy is to outside markets (Taylor et al., 2003; Taylor et al. 2009). Economy-wide models have also been used to show the disaggregated impacts of tourism on different income groups. Blake et al. (2008) use a computable general equilibrium model of the

Brazilian economy to show that lower income groups benefit less than higher income groups from tourism. While these studies model the economy-wide impacts of tourism, they do not account for how natural resource stocks will respond to new levels of harvesting pressure. This means they fail to account for how changes in natural resource availability will feedback into the local economy to affect harvesting pressure and local incomes.

Bioeconomic models of fisheries account for how changes in fish stock levels feedback to decisions about fishing effort and profitability in the fishery; however, these models typically focus narrowly on the fishing sector (Conrad and Smith, 2012). An exception is Smith et al. (2010) in which they include an outside wage labor market (with a fixed wage rate) to account for the fact that fishermen choose between fishing and alternative wage-earning opportunities. While an outside wage rate allows for one channel through which tourism could impact the fishing sector (the labor market), tourism is likely to affect fishing pressure through several other channels (e.g., input markets, changes in consumer demand), meaning that a richer model is needed to account for the full suite of economy-wide impacts of tourism.

There are recent efforts to examine fisheries in a multi-sector setting. For example, Finnoff and Tschirhart (2008) join a general equilibrium ecosystem model with a regoinal computable general equilibrium model to assess impacts of different quota policies in Alaska’s Pollock fishery. This work represents an important methodological advancement, however it does not include the disaggregated impacts that are of particular policy-relevance in a developing world setting. Manning et al. (2013) examine the impact of a price change in the agricultural sector on fishing pressure in the case of a Northern Honduran village. This work establishes that fishing and fishing communities are affected by economic activities in other sectors; however they do not provide an explicit empirical model of the fish stock, which precludes an assessment of the temporal distribution of impacts on fishing pressure and incomes. Furthermore, there is still a need to build on these multi-sector modeling efforts to examine the case of tourism growth and its impacts on resource use and local incomes.

In summary, currently there is no satisfactory framework for assessing the impacts of tourism growth on natural resource use and local incomes in developing countries. To address this gap in the literature, we couple recent advances in static Local Economy-Wide Impact Evaluation (LEWIE) models (Taylor and Filipski, 2014) with dynamic bioeconomic tools applied by natural resource economists (Conrad and Smith, 2012; Smith et al., 2010). This model, which we call a Bioeconomic Local Economy-Wide Impact Evaluation (Bio-LEWIE) model, is used to simulate temporally explicit impacts of an increase in tourism expenditures on fishing pressure and local incomes for different socioeconomic groups in El Nido. The Bio-LEWIE model structure is described in detail in the next section. In Section 3, we discuss the unique dataset of microeconomic and biological data collected at the field site to parameterize the model. In the results section (Section 4) we simulate a 10 percent increase in tourism expenditures under different assumptions about whether or not fish can be imported and exported from El Nido. Finally, in Section 5 we discuss policy implications of our results.

2. The Model

Assessing the impacts of tourism growth on fishing pressure and local incomes requires a model that maps how tourism spending affects the fishing sector through multiple channels (e.g., labor markets, inputs markets, consumption demand). In addition the fish stock levels must adjust to new fishing pressure levels. We accomplish this by coupling a LEWIE model of the El Nido economy with a dynamic fish population model. Figure 1 gives a schematic of the Bio-LEWIE model, which involves two sub-models that iterate over time. Each of these two model components and the way they are integrated is discussed in detail below.

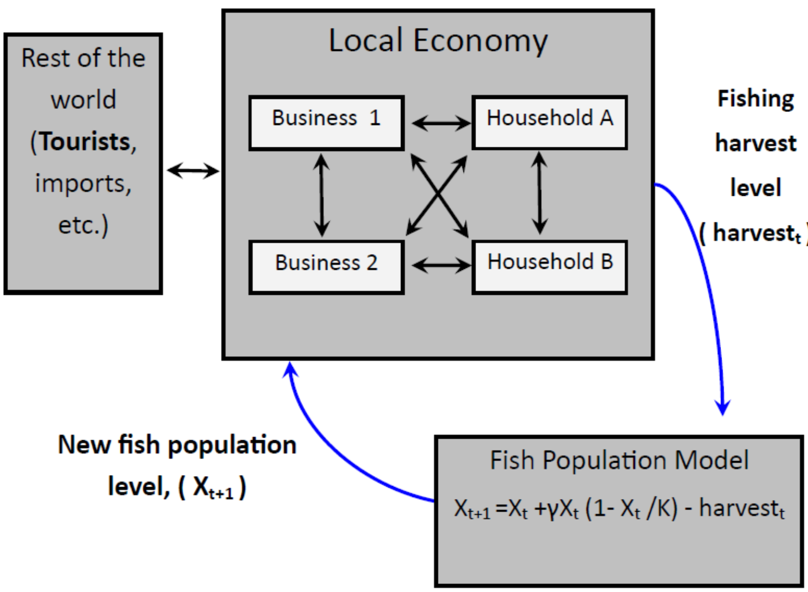

Figure 1: Schematic of the Bio-LEWIE model.

2.1 A LEWIE model of the El Nido local economy

LEWIE models are designed to capture the direct and indirect effects of shocks to economies such as a growth in tourism expenditures at the local scale (Taylor and Adelman, 1996). The building blocks of the LEWIE model of El Nido are a series of models of firms and households engaged in a variety of economic activities. The core economic equations and associated variable names for the model are listed in Tables 1 and 2.

TABLE 1
Index, Variable, and Parameter Definitions

Index, Variable, or Parameter	*Definition*
i	Production sector
f	Factor
h	Household type
t	Time step
$Q_{i,t}$	Output in sector *i* at time *t*
$FD_{i,f,t}$	Factor demand for factor *f* in production of good *i*
$FVA_{f,t}$	Factor value added for factor *f*
$TFY_{h,t}$	Total factor income
$P_{i,t}$	Equilibrium price for good *i*
$W_{i,t}$	Wage for factor *f*
$Y_{h,t}$	Income for household *h*
$YBAR_{\ h}$	Exogenous income for household *h*
$CD_{h,i,t}$	Consumption demand by household *h* for good *i*
$ED_{i,t}$	Aggregate demand in El Nido for good *i*
$MS_{i,t}$	Marketed surplus for good *i*
$IN_{i,t}$	Intermediate demand for good *i*
$FS_{f,t}$	Total factor supply for factor *f*
A_i	Cobb-Douglas shift parameter
$\beta_{i,f}$	Output elasticity for factor *f* for good *i*
$\alpha_{h,i}$	Expenditure Share for household *h* for good *i*
$g_{h,i,t}$	Consumption of good *i* by household *h*
γ	Intrinsic growth rate for fish stock
K	Carrying capacity for fish population

TABLE 2
Core Economic Equations of the Bio-LEWIE Model for El Nido

Relation	*Equation*
Production functions	$Q_{i,t} = Q_i(FD_{i,f,t})\ i = 1, \dots, I; f = 1, \dots, F$
Intermediate demands	$IN_{i,t} = IN_i(Q_{i,t})\ i = 1, \dots, I$
Factor demand	$FD_{i,f,t} = FD_{i,f}(Q_{i,f,}, P_{i,t}, W_{i,t})\ i = 1, \dots, I; f = 1, \dots, F$
Total factor demand	$TFD_{f,t} = \sum_i (FD_{i,f,t})\ i = 1, \dots, I; f = 1, \dots, F$
Factor value added	$FVA_{f,t} = \sum_i (FD_{i,f,t} W_{i,t})\ i = 1, \dots, I; f = 1, \dots, F$
Total Factor Income	$TFY_{h,t} = TFY_h(FVA_{f,t})\ h = 1, \dots, H$
Household total income	$Y_{h,t} = TFY_{h,t} + YBAR_{\ h}\ \ h = 1, \dots, H$
Household consumption demand	$CD_{h,i,t} = CD_{h,i}(P_{i,t}, Y_{h,t}) i = 1, \dots, I; h = 1, \dots, H$
El Nido demand	$ED_{i,t} = IN_{i,t} + \sum_h (CD_{h,i})\ i = 1, \dots, I; h = 1, \dots, H$
Product market equilibrium	$MS_{i,t} = Q_{i,t} - ED_{i,t}\ i = 1, \dots, I;$
Factor market equilibrium	$TFD_{f,t} = FS_{f,t}\ ; f = 1, \dots, F$

There are six production activities included in the model, which represent the primary economic activities in El Nido. They are hotels and restaurants, tours, retail, agriculture and livestock, fishing, and other services (see Table 3). Hotels and restaurants are frequently joint businesses in El Nido and so are combined. Tours include a variety of activities directed at tourists in El Nido, the most common of which are boat tours to local islands and snorkeling/diving sites. Retail includes include a wide range of stores from local corner stores to larger grocery stores and hardware stores. Agriculture and livestock include the production of crops (the most common being rice) and livestock products. Fresh fish products are aggregated into one good[3]. Other services include businesses such as mechanics, barbers, photocopy shops, etc.

TABLE 3

Endogenous Accounts
Production activities:
Hotels and restaurants
Tours
Retail
Agriculture and livestock
Fishing
Other services
Household groups:
Poor fishing households
Nonpoor fishing households
Poor nonfishing households
Nonpoor nonfishing households
Factors:
Family Labor
Hired Labor
Capital
Land
Purchased inputs
Exogenous Accounts
Tourism expenditures
Government
Municipal
National
Rest of World

[3] In future versions it will be possible to break this into separate activities (e.g., pelagic fishing versus fishing on coral reefs).

For the nonfishing sectors, each production activity's technology in a given year, t, is specified as Cobb-Douglas

$$Q_{i,t} = A_i \prod_f FD_{i,f,t}^{\beta_{i,f}} \tag{1}$$

where $Q_{i,t}$ is quantity produced in sector i in time period t, which is a function of the factor demands ($FD_{i,f,t}, f = 1, \dots, F$). Index and parameter names can be found in Table 1. Constant returns to scale are assumed in each sector (i.e., $\sum_f \beta_{i,f} = 1 \; \forall \; i$). Intermediate inputs used in production are modeled as Leontief processes, meaning that intermediate demands are a constant fraction of output. More complicated functional forms for production functions are possible. However, others have found that with micro economy-wide models, little is gained with the use of alternative functional forms, which derives primarily from the fact that models are calibrated at the same point (i.e., using the same survey data) and most policy simulations involve marginal changes in exogenous variables (Taylor et al., 2003; Taylor et al. 1999).

In the fishing sector, the fish stock level is an additional factor of production. That is, the number of fish in the water is an important determinant of the number of fish on the dock. For this reason the production function in the fishing sector is

$$Q_{fish,t} = A_{fish} \prod_f FD_{fish,f,t}^{\beta_{fish,f}} * X_t^{\beta_{fish,stock}} \tag{2}$$

where X_t, is the fish stock level in time period t. This assumes that within a given time period, the fish stock level is fixed. Constant returns to scale are also assumed in the fishing sector, meaning that $\sum_{f \neq stock} \beta_{fish,f} + \beta_{fish,stock} = 1$.

In addition, we assume that individuals in the fishery are not forward-looking or strategic in their decisions about how much labor to dedicate to fishing. That is, they do not take into account how their actions may affect the fish stock and profitability in the future or how the actions of others will impact their ability to catch fish in the current period. These assumptions are consistent with a fishery best approximated by an open-access setting with many fishing agents acting independently with little information sharing.

The production activities listed above purchase factors of production explicitly or implicitly from households to produce output in various sectors. The factors of production in the economy include family labor, hired labor, capital, and land.[4] We assume the amount of labor in the economy is fixed, meaning that the model does not currently account for the possibility of migration. However we assume that there is unemployment or underemployment, and that the local labor supply responds to wage increases.[5] Arable land in El Nido is relatively scarce due to steep terrain, and so the amount of land in agriculture is considered fixed. The model also assumes that the amount of capital in each economic activity is fixed[6]. In cases where factor levels are fixed, the level of that factor used in the analysis is derived from survey data.

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[4] An F-test rejects the null that family labor and hired labor have the same productivity in three out of the six sectors (fishing, agriculture and retail). This formed the basis of our decision to separate family and hired labor in the model.

[5] The elasticity of labor supply is not known. We start by assuming that labor supply is nearly perfectly elastic, which reflects high unemployment rates in Palawan. Excess labor supply reduces inflationary pressures, however it does not remove inflationary pressure because land and capital are fixed, which limit the supply response.

[6] This constraint will be relaxed in future versions of the model.

Payments made to these factors of production (in the form of wages and rent) channel money to households in the economy.

Households are aggregated into four representative households that represent different socioeconomic groups in El Nido using two criteria (see Table 3). First, those households that are engaged in any fishing activity are designated as fishing households. Those that are not engaged in fishing are designated as nonfishing households. Second, those households that are below the per capita poverty line[7] are designated as poor households. This categorization of households allows the model to disaggregate the impacts of tourism growth based on socioeconomic characteristics.

Households' incomes are calculated as the sum of payments to factors owned by the household (e.g., wage payments to labor) plus any exogenous forms of income (such as remittances). Consumption demands are modeled using a linear expenditure system (without minimum consumption constraints), which means that households spend a fixed share of their income on a given good. Representative household utility functions are

$$U_{h,t} = \prod_i g_{h,i,t}^{\alpha_{h,i}} \tag{3}$$

where $g_{h,i,t}$ is the amount of good i consumed by household h at time t. In addition to these endogenous accounts, there are several exogenous accounts in the El Nido economy. We assume that the amount of tourism expenditures entering the El Nido economy is exogenous to changes

[7] We use the Philippines Government's official per capita poverty line (approximately 427USD per year) for the island of Palawan.

in the local economy. Tourism demand is assumed to flow in fixed proportions to the various sectors in the economy that tourists patronize. This tourism spending creates additional local demand that must be satisfied either by local production or, if the good is tradable with other regions, by imports. Municipal and national governments tax local business activities and channel revenue into local public expenditures or expenditures outside of the local economy. Finally an account denoted “Rest of World” includes the municipality’s commerce with outside economies (e.g., imports and exports).

The factor demands, intermediate input demands, production levels, consumption demands, and factor supply levels are combined together to generate market clearing conditions that determine the equilibrium quantities and prices for the economy in a given time period. In any economy-wide model, results tend to be sensitive to whether or not goods and factors can be traded with outside regions because this affects equilibrium prices and quantities in the local economy. The Bio-LEWIE model is flexible in that goods and factors can be made tradable or nontradable, allowing for the examination of different trade scenarios. This allows for an assessment in the results section of how tourism might affect fishing pressure and local livelihoods differently depending on whether or not fish can be traded with outside regions.

2.2 Coupling the Local Economy-Wide Impact Evaluation model with a dynamic fish population model

In order to assess the impacts of tourism growth on fishing pressure one must allow the fish stock to adjust over time in response to fishing pressure. To account for this we couple the LEWIE model described above with a dynamic fish population model. For simplicity, we assume that growth of the stock is logistic with γ and K representing the intrinsic growth rate and carrying capacity for the fish population, respectively. The population dynamics for the fish stock take the following form

$$X_{t+1} = X_t + \gamma X_t \left(1 - \frac{X_t}{K}\right) - harvest_t \ . \qquad (4)$$

To understand how these two models are integrated, first consider the LEWIE model of the local economy. In year t, the LEWIE model solves for equilibrium prices and quantities in the economy *conditional* on a fixed fish stock level for that year (X_t). This means that within year t, the fish stock does not adjust in response to fishing pressure. The solution to the LEWIE model determines the total fishing output in time t, denoted $Q_{fish,t}$. From $Q_{fish,t}$, the level of biomass harvested in time *t* is derived, which is then used to calculate the stock level size in the next year $(t + 1)$ according to Equation 4. This assumes that harvest happens after recruitment.

In year $(t + 1)$, the LEWIE model solves for a new set of equilibrium prices and quantities, but this time conditional on the new stock level, X_{t+1}. That is, the local economy adjusts to the new productivity level in the fishing sector resulting from the change in the stock level. If the model is in bioeconomic equilibrium (where the amount harvested in the local economy is equal to the growth in the fish population in that time period), then X_{t+1} equals X_t, and the biological and economic systems are not changing over time. Alternatively if the model is perturbed away from the bioeconomic equilibrium, then the model will iterate forward in time until a new bioeconomic equilibrium is reached.

2.3 Using the Bio-LEWIE model to simulate the effects of an increase in tourism expenditures on fishing pressure and local livelihoods

The Bio-LEWIE model is ideally suited for simulating the effects of increased tourism expenditures on fishing pressure and local incomes. Starting from a bioeconomic equilibrium, we simulate a persistent 10 percent increase in tourism expenditures. Higher tourism spending increases local demand in the sectors that tourists patronize. In an effort to meet this demand, local production activities adjust their demand for labor and other factors of production and intermediate inputs. This affects local prices for factors and goods. The combination of these direct and indirect effects change fishing pressure and ultimately the fish stock size. This change in stock size alters productivity in the fishing sector, which creates a feedback to the local economy. As the model iterates forward in time it records the impact of the increase in tourism expenditures on key variables such as fishing pressure and local incomes for different socioeconomic groups over time.

3. Data and Parameter Values:

The field site used in this study is the municipality of El Nido on the island of Palawan in the western Philippines. The municipality of El Nido has a population of approximately 36,000 people and the primary livelihood activities are fishing, tourism and farming.

The artisanal fishery in El Nido is best approximated by an open-access setting with many resource users and no clearly defined property rights. Large vessels (greater than three gross tons) are prohibited from fishing within 15km of the shoreline, however there are few restrictions on the large number of artisanal fishermen. There are no restrictions on the number of fishing days or the number of boats, and registering one's fishing boat is free. There are some gear restrictions (such as net gauge); however with the exception of cyanide and bombs, enforcement of regulations is relatively minimal. As a result, we assume that the fishery is open-access. The most common gear-types used in El Nido are hook-and-line and bottom-set gillnet, though some households also use driftnets and go spearfishing. The most commonly caught fish groups in El Nido (by weights) are tunas, mackerels, squid and groupers.

In El Nido, tourists come to see sheer limestone cliffs, white sand beaches and the diverse marine life. Most tourist activities involve taking boat trips to beaches, islands and snorkeling/diving sites in the area. Tourism is growing rapidly in El Nido (a 54 percent increase in tourist arrivals between 2010 and 2014), and many former fishermen have begun working in the tourism sector, particularly given that some boat-related skills are transferable between the two sectors.

The economic data used to parameterize this model are from a 2015 survey of households, businesses, and tourists in El Nido, Palawan. This series of surveys was carried out by the lead author and a team of researchers from the University of California, Davis, and Palawan State University. We implemented three surveys: household surveys, business surveys, and tourist surveys.

The household surveys gathered detailed data on assets, time use, net income from all production activities, salaries, transfers, expenditures and basic sociodemographic data. A total of 463 households were surveyed (approx. 6.2 percent of households in El Nido). This covered all 18 sub-municipal districts (barangays) within the Municipality of El Nido. The number of households surveyed in each barangay was weighted by population size, but also stratified to focus on areas where fishing and tourist-related activities are more common, since these are two key sectors in the El Nido Economy. Within a barangay, households were randomly sampled. When data on sitios (sub-barangay units) were available, sitios were chosen randomly to be surveyed. Within a sitio, households were selected by walking randomly selected transects and surveying every fifth household.

Households in El Nido are involved in a variety of livelihood activities, including agriculture, livestock, fishing, household enterprises (e.g., small stores), and wage labor. Agricultural households grew a variety of crops, including rice, fresh vegetables, cashew, and fruit trees. Rice is by far the most common crop. Fishermen harvested multiple species of fish, the most important groups being tunas, mackerels, groupers, snappers, and squids.

The business surveys collected detailed information on inputs, outputs and incomes for establishments in El Nido.. This was used to complement data collected from households for estimating parameters for the production activities in the model. A total of 282 businesses in El Nido were surveyed. Businesses were chosen at random from a list of registered businesses obtained from local government officials.

The tourists surveys were designed to assess how much tourists in El Nido spend and at what establishments. In total 433 tourists were surveyed. All tourists were surveyed at points of departure (the waiting areas of the small private airport and the bus terminal) in order to obtain data for tourists who had completed their stay in El Nido.

We used the economic data from these three surveys to estimate the parameters of the Bio-LEWIE model. Using data from the household surveys and business surveys, each production activity's output elasticities for factors of production ($\beta_{i,j}$) (found in Table 4) were estimated using

$$\ln(\mathrm{Q}_i) = \ln(A_i) + \sum_f \beta_{i,f} \ln(FD_{i,f}) + \varepsilon_i. \quad i = 1, \dots, I \tag{5}$$

where Q_i is output of good i, A_i is a shift parameter, $FD_{i,f}$ is factor demand for factor f in the production of good i, and $\beta_{i,f}$ is the elasticity of output with respect to factor f. In instances where it was difficult to obtain reliable measures of factor usage, the assumption of constant returns to scale was used to impute the output elasticity for that factor. This is the case for the output elasticity for the stock in the fisheries production function. Because it is not possible to estimate the output elasticity for the fish stock in the fishing sector, we calculate this elasticity by setting $\beta_{fish,stock} = 1 - \sum_{f \neq stock} \beta_{fish,f}$.

TABLE 4

Output Elasticities for Production Activities in El Nido

	Agriculture & livestock	Fishing	Hotels & restaurants	Retail	Tours	Other services
Family Labor	0.17^{**}	0.52^{***}	0.29^{***}	0.34^{***}	0.14^{**}	0.15^{*}
	(0.076)	(0.110)	(0.108)	(0.052)	(0.070)	(0.084)
Hired Labor	0.10^{***}	0.08^{***}	0.20^{***}	0.17^{***}	0.14^{***}	0.17^{***}
	(0.029)	(0.037)	(0.030)	(0.025)	(0.023)	(0.028)
Capital	0.16^{***}	0.26^{**}	$0.51^{\dagger}$	$0.49^{\dagger}$	$0.72^{\dagger}$	$0.68^{\dagger}$
	(0.046)	(0.089)				
Land	$0.53^{\dagger}$					
Purchased inputs	0.03					
	(0.038)					
Fish stock		$0.14^{\dagger}$				
A (shift param.)	7.48^{***}	5.19^{***}	9.50^{***}	8.66^{***}	11.3^{***}	10.10^{***}
	(0.449)	(0.869)	(0.903)	(0.350)	(0.509)	(0.593)
Observations	144	132	88	155	73	95

Standard errors in parentheses. †These elasticities are imputed and not estimated.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

In order to simulate the disaggregated effects of tourism growth on different socioeconomic categories, we used data on livelihood activities and consumption expenditures to divide households into four groups. The groups are poor fishing households, nonpoor fishing households, poor nonfishing households, and nonpoor nonfishing households. These household groups' demands for goods in the economy are determined by the expenditure share parameters ($\alpha_{h,i}$) from their linear expenditure system. Using the household survey data, we estimate these expenditure shares for the household groups (found in Table 5) using

$$E_{h,i} = \alpha_{h,i} TE_h + \mu_{h,i}, \quad i = 1, \ldots, I; h = 1, \ldots, H \tag{6}$$

where $E_{h,i}$ is the expenditure on good i by household h, and TE_h is total consumption expenditures for household h.

TABLE 5
Expenditure Share Estimates for Household Groups in El Nido

Household type (observations)	Fish	Agr/live	Retail	Hotel/rest.	Other services
Poor, fishing	0.20***	0.037**	0.60***	0.0017	0.16***
(68)	(0.04)	(0.02)	(0.03)	(0.00)	(0.02)
Nonpoor, fishing	0.14***	0.039***	0.49***	0.0046**	0.33***
(56)	(0.02)	(0.01)	(0.06)	(0.00)	(0.07)
Poor, nonfishing	0.074***	0.098***	0.61***	0.0066*	0.21***
(143)	(0.01)	(0.02)	(0.03)	(0.00)	(0.02)
Nonpoor, nonfishing	0.038***	0.043***	0.55***	0.0078***	0.36***
(155)	(0.01)	(0.01)	(0.03)	(0.00)	(0.03)

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

In the Bio-LEWIE model, tourism demand is assumed to flow in fixed proportions to the various sectors in the economy that tourists patronize. The expenditures shares for tourists (found in Table 6) were estimated using

$$TourE_i = \pi_i TourTE + \eta_i, \quad i = 1, \ldots, I \tag{7}$$

where $TourE_i$ is a tourist's expenditures on good i, $TourTE_i$ is the total expenditures by the tourist, and π_i is the share of expenditures dedicated to good i. Note that these represent the shares for those tourists who did not have all-inclusive tour packages. The fractions of tour packages' total price that flows to various sectors were obtained through informal interviews with tour operators. We find that the majority of tourist spending goes to hotels, restaurants and tours.

TABLE 6
Expenditure Share Estimates for Tourists in El Nido

	Fish	Tours	Retail	Hotel/Rest.	Other services
Expenditure share	0.00053*	0.13***	0.018***	0.82***	0.026***
	(0.00)	(0.03)	(0.01)	(0.04)	(0.01)

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

The biological data for parametrizing the Bio-LEWIE model will be derived from ongoing ecological surveys in the El Nido region. Because these surveys are still in process, currently we run the model with placeholder biological parameter values which will be replaced with site-specific values when they become available. The current placeholder values used in the model have been chosen to align with the scale of output in the fishery sector given the baseline data from the economic surveys.

4. Results:

We use the Bio-LEWIE model to simulate the impact of a persistent 10 percent increase in tourism expenditures to examine the effects of tourism growth on fishing pressure and local incomes in El Nido. Because local economies are strongly affected by the extent to which they are able to trade (through exports and imports) with outside markets, we simulated how growth in tourism affects fishing pressure and local incomes in two different trade scenarios. First we examine the case where fish are not tradable with outside regions (Case 1); second we examine the case where fish are tradable with outside regions (Case 2). This provides a picture of how the impacts of tourism would change if a location where to gain access to trade with outside markets for fish (i.e., market integration).

Both of these two cases are salient to El Nido. Currently there is some trade in fish products between El Nido and outside regions. However, fishermen in these regions complain of a lack of resources needed to facilitate trade. For example, they note that the ice available in the region is of low quality (it contains many air bubbles) and so does not last long; this causes the danger of fish spoiling before it makes it to its intended destination. In addition, a road between El Nido and other regions exists, but in places it is poorly maintained. While these challenges create barriers to trade currently, the main road is in the process of being paved and local growth on the island of Palawan (in part due to tourism) means that better resources for fish transport (such as better ice) may become be available in the near future. As a result, examining both cases provides a picture of how the transition currently taking place in El Nido may affect the way that fishing pressure and local incomes are impacted by tourism growth in the region.

In each case we assume that labor cannot migrate in from outside regions. The services in the hotel/restaurant sector, tours sectors, and other services sectors are not tradable with other regions (because in general these goods must be consumed and operated locally) and so have endogenously determined prices. Also, we assume that it is possible to trade agricultural goods with outside regions because rice and other key agricultural goods that do not spoil quickly are commonly imported into El Nido. The only difference between the two cases presented here is whether or not fish can be traded with outside markets. Because these simulations are not run with a full set of biological parameters specific to the field site yet, the results here should be viewed as illustrative of how this model can be used to assess the impacts of tourism growth rather than as accurate predictions of impacts.

Case 1: The impacts of growth in tourism when fish cannot be traded with outside markets

The short-run and long-run impacts of the 10 percent increase in tourism expenditures are summarized in Table 7. Initially, the increase in tourism expenditures stimulates production in sectors directly patronized by tourists (e.g., the hotel/restaurant sector and tourism sector). Because these sectors use fish as an input, this causes an increase in local demand for fish. There is also higher local demand for fish from households whose incomes have increase due to tourism growth. Together this increase in demand for fish puts upward pressure on the price of fish and increases the amount of labor in the fishing sector, which increases fishing pressure (Figure 2A). Also, the influx of tourism spending into the local economy causes real incomes to increase for households.

Now consider how these changes in the local economy affect the biological system and how this feeds into the entire local economy through time. In response to increased fishing pressure (Figure 2A), the fish stock level declines over time (Figure 2B). This reduces productivity in the fishery and causes the local price of fish to increase (Figure 2C). As a result of the decline in the fish stock and the impacts this has on prices and on all sectors of the economy, real incomes for households decrease slightly over time.

TABLE 7

Initial and long-run impacts of a 10 percent increase in tourism expenditures
(No fish imports or exports possible)

	Percent change in the first year	*Percent change after 30 years*
Fish Stock	-0.28	-4.18
Real Income (poor, fishing)	12.67	12.63
Real Income (nonpoor, fishing)	5.91	5.88
Real Income (poor, nonfishing)	8.29	8.22
Real Income (nonpoor, nonfishing)	12.18	12.14
Price of fish	5.84	6.49
Price of agriculture	0.00	0.00
Price of retail	4.19	4.25
Price of hotel and restaurants	7.68	7.71
Price of tourism	22.97	22.99
Price of other services	9.01	9.05
Quantity produced (fish)	9.50	9.20
Quantity produced (agriculture)	-0.22	-0.22
Quantity produced (retail)	10.39	10.38
Quantity produced (hotel and restaurants)	9.97	9.97
Quantity produced (tourism)	10.00	10.00
Quantity produced (other services)	7.38	7.39
Family labor demand (fish)	16.03	16.55
Family labor demand (agriculture)	-0.71	-0.72
Family labor demand (retail)	21.51	21.49
Family labor demand (hotel and restaurants)	21.37	21.37
Family labor demand (tourism)	41.09	41.08
Family labor demand (other services)	25.27	25.29
Hired labor demand (fish)	16.01	16.53
Hired labor demand (agriculture)	-0.73	-0.74
Hired labor demand (retail)	21.49	21.47
Hired labor demand (hotel and restaurants)	21.35	21.35
Hired labor demand (tourism)	41.06	41.06
Hired labor demand (other services)	25.25	25.27
Wage (family labor)	0.18	0.18
Wage (hired labor)	0.20	0.20

Figure 2A: Percent Change in Fish Harvest
(No fish imports or exports)

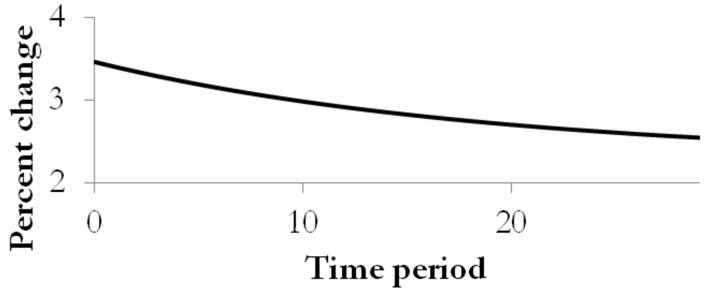


Figure 2B: Percent Change in Fish Stock
(No fish imports or exports)

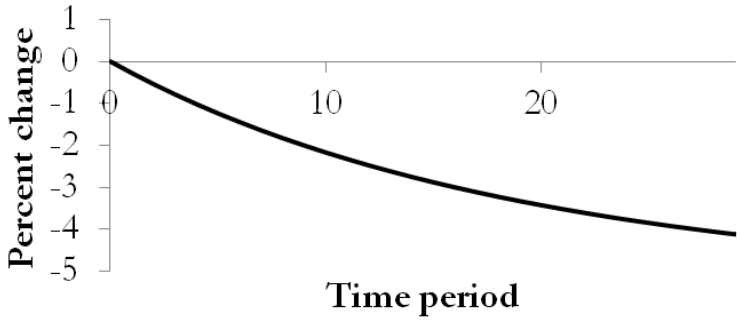
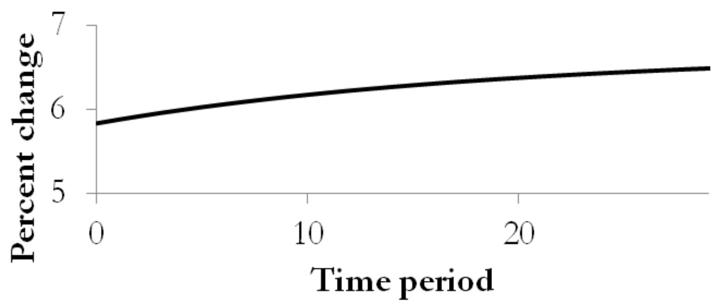


Figure 2C: Percent Change in Price of Fish
(No fish imports or exports)



Case 2: The impacts of growth in tourism when fish are traded with outside markets

In case 2, we simulate the same 10 percent increase in tourism expenditures except allow fish to be traded with outside regions. The short-run and long-run impacts of tourism growth in this case are summarized in Table 8. The higher demand in sectors directly patronized by tourists (e.g., hotel/restaurant sector and tours sector) stimulates production in these sectors and results in a higher intermediate demand for fish. However, since fish can be traded with outside regions, this does not cause an increase in the price of fish because by assumption any shortage in local supply is met by importing fish. As a result, fishing is now less profitable relative to other sectors, which causes a decrease in fishing labor and smaller harvesting pressure. Real incomes increase as a result of higher tourist expenditures, but gains in real income are smaller than when fish cannot be traded (particularly for fishing households), which is due to a leakage of money out of the local economy via imports of fish.

Now consider how the impacts on the biological system feed into the entire local economy through time. The decrease in fishing harvest (Figure 3A) results in a small recovery in the fish stock over time (Figure 3B). This increases productivity in the fishing sector and attracts some of the labor that left fishing (for other sectors) back into fishing, increasing the level of harvest slightly (Figure 3A). The increase in productivity in the fishing sector also causes real incomes to grow slightly over time.

TABLE 8

Initial and long-run impacts of a 10 percent increase in tourism expenditures
(Fish imports and exports possible)

	Percent change in the first year	*Percent change after 30 years*
Fish Stock	0.10	1.35
Real Income (poor, fishing)	9.04	9.18
Real Income (nonpoor, fishing)	3.55	3.62
Real Income (poor, nonfishing)	7.18	7.23
Real Income (nonpoor, nonfishing)	11.25	11.29
Price of fish	0.00	0.00
Price of agriculture	0.00	0.00
Price of retail	3.03	3.05
Price of hotel and restaurants	7.20	7.20
Price of tourism	22.80	22.80
Price of other services	7.28	7.32
Quantity produced (fish)	-1.30	-0.87
Quantity produced (agriculture)	-0.16	-0.16
Quantity produced (retail)	8.70	8.76
Quantity produced (hotel and restaurants)	9.92	9.92
Quantity produced (tourism)	10.00	10.00
Quantity produced (other services)	6.36	6.39
Family labor demand (fish)	-2.11	-1.69
Family labor demand (agriculture)	-0.52	-0.52
Family labor demand (retail)	17.88	18.00
Family labor demand (hotel and restaurants)	21.26	21.27
Family labor demand (tourism)	41.10	41.10
Family labor demand (other services)	21.55	21.66
Hired labor demand (fish)	-2.15	-1.72
Hired labor demand (agriculture)	-0.55	-0.56
Hired labor demand (retail)	17.84	17.96
Hired labor demand (hotel and restaurants)	21.22	21.22
Hired labor demand (tourism)	41.05	41.05
Hired labor demand (other services)	21.51	21.62
Wage (family labor)	0.14	0.14
Wage (hired labor)	0.17	0.17

Figure 3A: Percent Change in Fish Harvest
(Fish imports and exports possible)

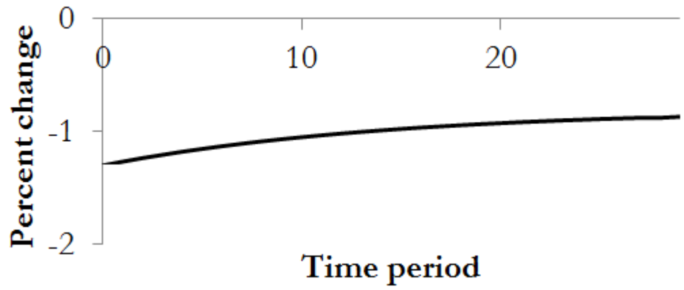
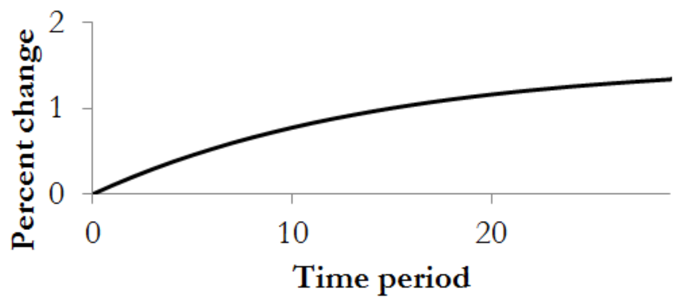


Figure 3B: Percent Change in Fish Stock
(Fish imports and exports possible)



5. Conclusions:

This model illustrates that in order to assess how promoting alternative livelihoods in another sector will affect natural resource use and local incomes over time, one must use a combination of local economy-wide modeling and bioeconomic modeling. Using the Bio-LEWIE model we showed that growth in tourism affects fishing pressure through multiple channels (e.g., labor markets, input markets, and household demand) and that resultant changes in fishing pressure and stock levels create feedbacks to the entire local economy.

We show that in general tourism can be expected to impact both local fishing pressure and local incomes over time; however the nature of these effects depend on the degree to which the local economy is connected to outside markets. When fish cannot be traded, higher local demand increases fish prices and fishing pressure, causing the fish stock to decline over time. Overall real incomes increase, but decline slightly over time due to the decline in the fish stock. When fish can be traded, higher local demand for fish is met by imports and the price of fish remains constant. Some labor shifts out of fishing, permitting a small recovery in the fish stock. Overall real incomes increase, and further increase slightly over time due to the recovery of the stock. However, compared to when fish are tradeable, the overall increase in real incomes is smaller (particulary for fishing households) due to the leakage of money out of the local economy via fish imports.

These results suggest that policy-makers seeking to promote alternative livelihoods as a way to reduce pressure on local natural resources should use an approach like that embodied in the Bio-LEWIE model. Understanding the impacts of tourism growth over time requires accounting for local economy-wide effects of tourism, how changes in natural resource availability feed back into the local economy over time, and how these effects vary depending on the market integration context. The Bio-LEWIE model predicts the costs and benefits of tourism growth, when they will occur, and for whom. This framework can help policy-makers in the developing world find synergies between natural resource protection, sustainable livelihoods, and economic growth.

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