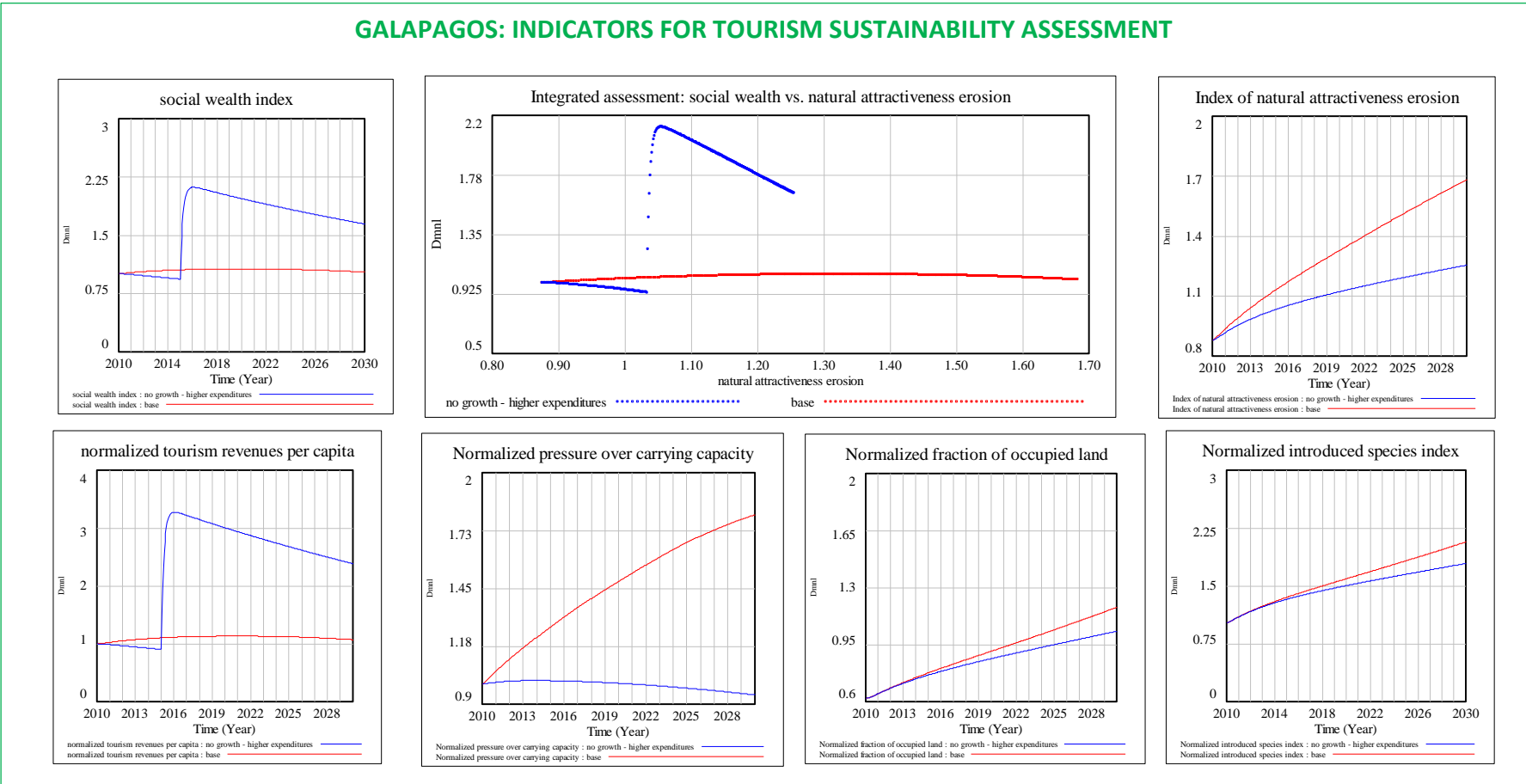


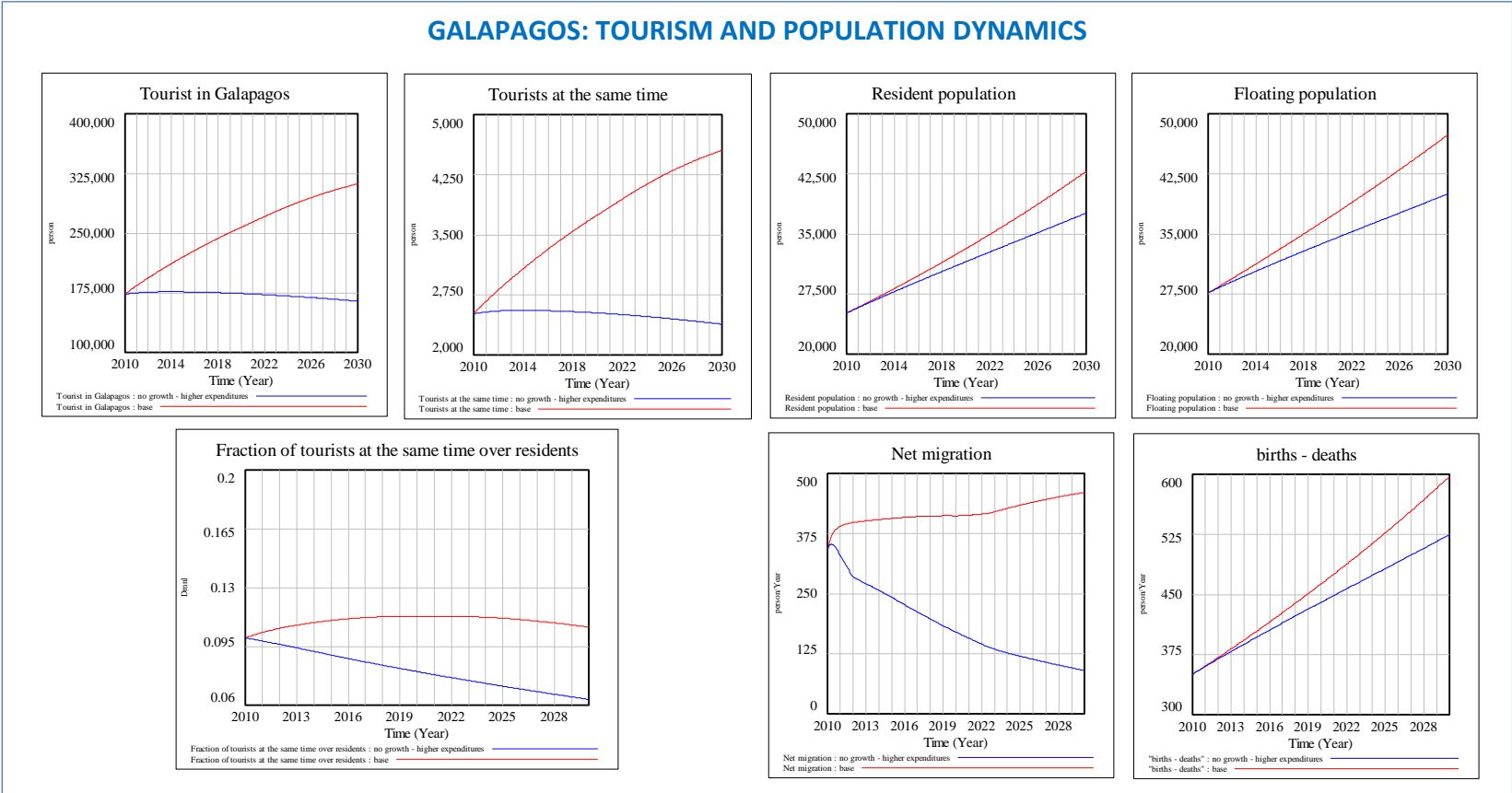
ANNEXES

Annex A: Dashboard views – Vensim model

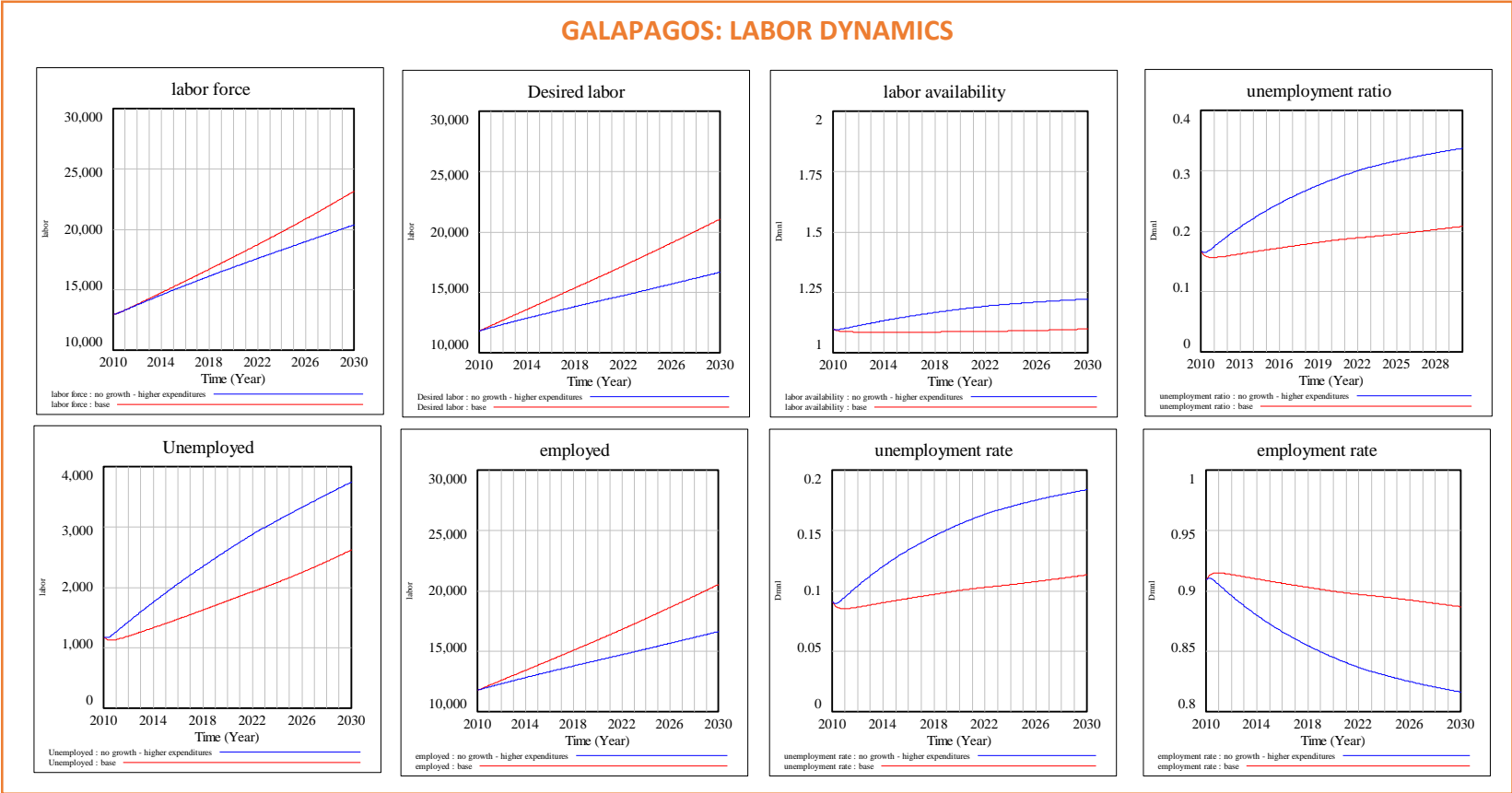
A1. Dashboard – Indicators for tourism sustainability assessment



A2. Dashboard – Population dynamics



A3. Dashboard – Labor dynamics



ANNEX B: Model Documentation

B1. Population & Employment Module

Formulation and comments	Units
<p>Pop 0 to 9 (t) = Pop 0 to 9 (2010) +</p> $\int_{2010}^t \text{births} + \text{immigration } 0:9 - \text{deaths } 0:9 - \text{emigration } 0:9 - \text{maturing } ds$	Person
<p>Pop 0 to 9 (2010) = 4,607</p> <p>The stock of population 0 to 9 years old increases with births and immigration, and decreases with deaths, emigration and maturing. Maturing moves people from population 0 to 9 stock to working age population. The initial number of people in the stock by 2010 is 4,607. Data source: Galapagos data from National Census INEC 2010.</p>	
<p>Working age population (t) = Working age population (2010) +</p> $\int_{2010}^t \text{immigration } 10 \text{ plus} + \text{maturing} - \text{deaths } 10 \text{ plus} - \text{emigration } 10 \text{ plus } ds$	Person
<p>Working age population (2010) = 20,517</p> <p>The stock of working age population increases with immigration and maturing, and decreases with deaths and emigration. Working age population is defined as all people aged 10 years or older according to Ecuador National Institute of Statistics and Census (INEC). This initial value by 2010 is 20,517 persons. Data source: Galapagos data from National Census INEC 2010.</p>	
<p>Accumulated immigration (t) = accumulated immigration (2010) +</p> $\int_{2010}^t \text{annual immigration } ds$	Person
<p>Accumulated immigration (2010) = 0</p> <p>This stock accumulates the annual immigration to keep a track of the number of immigrants arriving to Galapagos during the simulation period. The initial value is 0 assuming that no immigrants are accumulated at the beginning of the simulation period.</p>	
<p>Labor force (t) = Labor force (2010) +</p> $\int_{2010}^t \text{change in labor force } ds$	Labor
<p>Labor force (2010) = working age population (t) * labor force participation rate</p> <p>Equals to the economically active population defined as people aged 10 and older who are employed or those who are unemployed but are available for working and seeking employment (INEC 2010). The stock changes when the working age population or the labor force participation rate change. The initial value is calculated from the multiplication of the working age population stock and the labor force participation fraction.</p>	
<p>Unemployed (t) = Unemployed (2010) +</p>	Labor

Formulation and comments	Units
$\int_{2010}^t \text{labor additions + labor turnover and firing – change in fishing and agriculture labor – hiring other sectors – hiring public – hiring tourism } ds$ <p>Unemployed (2010) = labor force (t)-Public sector labor (t) -fishing and agriculture labor (t)- tourism labor (t) -Other sectors labor (t)</p> <p>People aged 10 and older who do not have a job and are available to be employed (INEC 2010). The unemployed stock increases with labor additions and labor turnover and firing, and decreases with hiring other sectors, hiring public and hiring tourism. Change in fishing and agriculture can increase or decrease the stock depending on the direction of the change. The initial value is calculated by subtracting the labor stocks of all employment sectors from the labor force stock.</p>	
<p>Fishing and agriculture labor (t) = Fishing and agriculture labor (2010) +</p> $\int_{2010}^t \text{change in fishing and agriculture } ds$ <p>Fishing and agriculture labor (2010) = Desired fishing and agriculture labor</p> <p>Number of people working in the fishing and agriculture sector. The stock changes to adjust to the desired fishing and agriculture labor and to capture the effect of labor moving from fishing and agriculture to tourism sector. The initial value equals the desired fishing and agriculture labor.</p>	Labor
<p>Tourism labor (t) = Tourism labor (2010) +</p> $\int_{2010}^t \text{hiring tourism – firing tourism – labor turnover tourism } ds$ <p>Tourism labor (2010) = Desired tourism labor</p> <p>Number of employees working in the tourism sector. The stock increases with hiring tourism, and decreases with firing tourism and labor turnover tourism. The initial value equals the desired tourism labor.</p>	Labor
<p>Other sectors labor (t) = Other sectors labor (2010) +</p> $\int_{2010}^t \text{hiring other sectors – firing other sectors – labor turnover other } ds$ <p>Other sectors labor (2010) = Desired labor other</p> <p>Number of employees working in other sectors of the economy. The stock increases with hiring other sectors, and decreases with firing other sectors and labor turnover other sectors. The initial value equals the desired labor other.</p>	Labor
<p>Public sector labor (t) = Public sector labor (2010) +</p> $\int_{2010}^t \text{hiring public – firing public – labor turnover public } ds$ <p>Public sector labor (2010) = Desired labor public</p> <p>Number of employees working in the public sector. The stock increases with hiring public, and decreases with firing public and labor turnover public. The initial value equals the desired labor public.</p>	Labor
<p>FA moving to tourism (t) = FA moving to tourism (2010) +</p>	Labor

Formulation and comments	Units
$\int_{2010}^t \text{change in FA due to tourism } ds$	
<p>FA moving to tourism (2010) = Desired tourism labor - tourism labor</p>	
<p>Number of people moving from the fishing and agriculture sector to the tourism sector. The stock changes when there is a discrepancy between the desired tourism labor and the tourism labor that could be filled in with fishing and agriculture labor. The initial value equals to the tourism labor discrepancy calculated as desired tourism labor less tourism labor.</p>	
<p>Births (t)= Resident population*birth rate</p>	<p>Person/ Year</p>
<p>Births is the annual rate at which people in Galapagos are born and added to the population 0 to 9 stock. Calculated by multiplying the resident population with the birth rate that assumes number of births per inhabitant.</p>	
<p>Maturing (t)= Pop 0 to 9 (t) / time to mature</p>	<p>Person/ Year</p>
<p>Flow of inhabitants moving from the 0 to 9 years old population stock into the working age population stock. Calculated by dividing the population 0 to 9 stock by the time it takes to mature.</p>	
<p>Deaths 0:9 (t)= Pop 0 to 9 (t) * mortality rate</p>	<p>Person/ Year</p>
<p>Flow of annual deaths deducted from the population 0 to 9 stock. It is calculated by multiplying population 0 to 9 stock with the mortality rate.</p>	
<p>Immigration 0:9 (t)= annual immigration * fraction 0:9</p>	<p>Person/ Year</p>
<p>Additions to Galapagos population 0 to 9 due to immigration. It is calculated by multiplying the annual immigration with the fraction of population from 0 to 9. Assumes that annual immigration keeps the same age composition as the resident population in Galapagos.</p>	
<p>Emigration 0:9 (t)= Pop 0 to 9 (t) * emigration rate</p>	<p>Person/ Year</p>
<p>Flow of residents emigrating outside Galapagos, reduces the stock of population 0 to 9. It is calculated by multiplying the stock of population from 0 to 9 with the emigration rate.</p>	
<p>Deaths 10 plus (t)= working age population (t) * mortality rate</p>	<p>Person/ Year</p>
<p>Flow of annual deaths deducted from the working age population stock. It is calculated by multiplying working age population stock with the mortality rate.</p>	
<p>Immigration 10 plus (t)= annual immigration * (1-fraction 0:9)</p>	<p>Person/ Year</p>
<p>Additions to Galapagos working age population due to immigration. It is calculated by multiplying the annual immigration with one less the fraction of population from 0 to 9, which equals the fraction of working age population. Assumes that annual immigration keeps the same age composition as the resident population in Galapagos.</p>	
<p>Emigration 10 plus (t)= working age population (t) * emigration rate</p>	<p>Person/ Year</p>
<p>Flow of residents emigrating outside Galapagos, reduces the stock of working age population. It is calculated by multiplying the stock of working age population with the emigration rate.</p>	
<p>Annual immigration (t)= other immigration + immigration high skilled</p>	<p>Person/ Year</p>

Formulation and comments	Units
Flow of annual people immigrating to Galapagos. It is calculated by adding other immigration with immigration high skilled.	
Change in labor force (t)= (working age population (t)*labor force participation rate- labor force (t))/time to adjust labor force	Labor/ Year
Change in labor force due to population dynamics -births, deaths, net migration- that modify the working age population. Calculated by multiplying the working age population with the labor force participation rate and then subtracting the current labor force stock to get the discrepancy. This is then divided by the time to adjust labor force to get the rate of change.	
Labor additions (t)= change in labor force (t)	Labor/ Year
Changes in labor force adding up to the unemployed pool due to population dynamics. This flow of labor equals to the change in labor force flow.	
Labor turnover and firing (t) = labor turnover tourism (t) + labor turnover public (t)+ labor turnover other (t)+ firing other sectors (t)+ firing public (t)+ firing tourism (t)	Labor/ Year
Flow of fired and quit labor from all economic sectors returning to the unemployed pool. It is calculated by adding the flow of labor turnover from tourism, public and other sectors and firing of tourism, public and other sectors.	
Change in fishing and agriculture= (Desired fishing and agriculture labor-fishing and agriculture labor (t) + FA moving to tourism (t))/ time to adjust FA labor	Labor/ Year
Flow of labor that moves in or out of the fishing and agriculture stock. Adjusts the stock to the desired fishing and agriculture labor and capture the effect of labor moving from fishing and agriculture to tourism sector. Calculated by subtracting the fishing and agriculture labor and the fishing and agriculture moving to tourism from the desired fishing and agriculture labor to get the discrepancy. This value is divided by the time to adjust fishing and agriculture labor to get the rate of change.	
Hiring tourism (t)= MIN((Desired tourism labor- tourism labor (t))/ time to hire tourism+ labor turnover tourism (t), Unemployed (t)/time to hire tourism)	Labor/ Year
Flow of people that are hired from the unemployed stock to be employed in the tourism sector. The hiring rate closes the discrepancy between the current tourism labor stock and the desired tourism labor over the time it takes to hire tourism labor. It also accounts for the labor turnover tourism that is added up to be rehired. The MIN function prevents the unemployed stock to go negative by allowing to only hire as much people as it is left in the unemployed stock over the time it takes to hire tourism labor.	
Firing tourism (t)= IF THEN ELSE (Desired tourism labor< tourism labor (t), (tourism labor (t)- Desired tourism labor)/ time to fire tourism,0)	Labor/ Year
Flow of people that are fired from the tourism sector when the desired tourism labor is lower than the current tourism labor. It is calculated by subtracting the desired tourism labor from the tourism labor stock, the discrepancy is divided by the time to fire tourism to get the rate of change over time. The IF THEN ELSE function activates the firing tourism only when there is the need to fire, this is when the desired tourism is lower than the tourism labor stock.	
Labor turnover tourism (t)= tourism labor (t)/avg duration employment tourism	Labor/ Year

Formulation and comments	Units
<p>The number of labor that leaves the tourism sector due to attrition or resignation. It is calculated by dividing the tourism labor stock by the average duration of employment in the tourism sector.</p>	
<p>Hiring public (t)= $\text{MIN}((\text{Desired labor public}-\text{Public sector labor (t)})/\text{time to hire public}+\text{labor turnover public, Unemployed (t)}/\text{time to hire public})$</p>	Labor/ Year
<p>Flow of people that are hired from the unemployed stock to be employed in the public sector. The hiring rate closes the discrepancy between the current public labor stock and the desired public labor over the time it takes to hire public labor. It also accounts for the labor turnover public that is added up to be rehired. The MIN function prevents the unemployed stock to go negative by allowing to only hire as much people as it is left in the unemployed stock over the time it takes to hire public labor.</p>	
<p>Firing public (t)= $\text{IF THEN ELSE}(\text{Desired labor public}<\text{Public sector labor (t)}, (\text{Public sector labor (t)}-\text{Desired labor public})/\text{time to fire public}, 0)$</p>	Labor/ Year
<p>Flow of people that are fired from the public sector when the desired public labor is lower than the current public labor. It is calculated by subtracting the desired public labor from the public labor stock, the discrepancy is divided by the time to fire public to get the rate of change. The IF THEN ELSE function activates the firing public only when there is the need to fire, this is when the desired public is lower than the public labor stock.</p>	
<p>Labor turnover public (t)= $\text{Public sector labor (t)}/\text{avg duration of employment public}$</p>	Labor/ Year
<p>The number of labor that leaves the public sector due to attrition or resignation. It is calculated by dividing the public labor stock by the average duration of employment in the public sector.</p>	
<p>Hiring other sectors (t)= $\text{MIN}((\text{Desired labor other}-\text{Other sectors labor (t)})/\text{time to hire other}+\text{labor turnover other, Unemployed (t)}/\text{time to hire other})$</p>	Labor/ Year
<p>Flow of people that are hired from the unemployed stock to be employed in other sectors of the economy. The hiring rate closes the discrepancy between the current other sectors labor stock and the desired labor other over the time it takes to hire labor in others sector. It also accounts for the labor turnover other that is added up to be rehired. The MIN function prevents the unemployed stock to go negative by allowing to only hire as much people as it is left in the unemployed stock over the time it takes to hire other labor.</p>	
<p>Firing other sectors (t)= $\text{IF THEN ELSE}(\text{Desired labor other}<\text{Other sectors labor (t)}, (\text{Other sectors labor (t)}-\text{Desired labor other (t)})/\text{time to fire other}, 0)$</p>	Labor/ Year
<p>Flow of people that are fired from the other sectors of the economy when the desired labor other is lower than the current other sectors labor stock. It is calculated by subtracting the desired labor other from the other sectors labor, the discrepancy is divided by the time to fire other to get the rate of change. The IF THEN ELSE function activates the firing other only when there is the need to fire, this is when the desired labor other is lower than the other sectors labor stock.</p>	
<p>Labor turnover other (t)= $\text{Other sectors labor (t)}/\text{avg duration of employment other}$</p>	Labor/ Year
<p>The number of labor that leaves other sectors of the economy due to attrition or resignation. It is calculated by dividing the other sectors labor stock by the average duration of employment in other sectors.</p>	
<p>Change in FA due to tourism (t)= $(\text{Desired tourism labor}-\text{tourism labor (t)})*\text{sensitivity ratio fa labor to tourism labor}/\text{time to perceive change in tourism labor}$</p>	Labor/ Year
<p>Flow of labor that moves in or out of the fishing and agriculture sector to the tourism sector. It is calculated by the discrepancy between the desired tourism labor and the tourism labor -which is the required labor to be moved to</p>	

Formulation and comments	Units
tourism sector- multiplied by the sensitivity ratio of fishing and agriculture labor to tourism labor. This is divided by the time to perceive change in tourism labor to get the rate of change.	
Resident population= Pop 0 to 9 (t)+ working age population (t)	Person
Represents the number of people living in the Galapagos Islands. Calculated by adding the population 0 to 9 years old stock and the working age population stock.	
Births - deaths= Births- deaths 0:9- deaths 10 plus	Person/ Year
Corresponds to the annual net change in population due to births and deaths. Calculated by subtracting the number of annual deaths 0 to 9 and 10 plus from the annual births.	
Fraction 0:9= Pop 0 to 9 (t)/ Resident population	Dimensionless
Fraction of the resident population that has 0 to 9 years old. It is calculated by dividing the stock of population from 0 to 9 by the resident population.	
Annual emigration= emigration 0:9 (t) + emigration 10 plus (t)	Person/ Year
Number of people emigrating outside Galapagos. It is calculated by adding emigration from 0 to 9 and emigration 10 plus.	
Net migration= annual immigration- annual emigration	Person/ Year
Net number of people migrating in and out of Galapagos. It is calculated as the difference between the annual immigration and the annual emigration.	
Emigration rate= 0.02* Effect of relative unemployment on emigration	Dimensionless/ Year
Annual rate at which people emigrate outside Galapagos. It is calculated by multiplying a normal emigration rate that equals 2% by the effect of relative unemployment on emigration. Data source: normal emigration rate according to Galapagos data from the National Census INEC 1990, 2001, 2010.	
Immigration high skilled= Floating population* high skilled labor fraction	Person/ Year
Corresponds to the people immigrating to Galapagos as high skilled labor. Calculated as the floating population multiplied by the high skilled labor fraction.	
Other immigration= Floating population * normal immigration rate * Effect of relative unemployment on immigration * Job attractiveness multiplier	Person/ Year
Corresponds to the people immigrating to Galapagos based on normal immigration adjusted by the effect of the internal and the external labor market conditions. Calculated as the floating population multiplied by the normal immigration rate and the effect of relative unemployment on immigration and the job attractiveness multiplier.	
Desired labor= Desired fishing and agriculture labor+ Desired labor public+ Desired tourism labor+ Desired labor other	Labor
Desired number of people required by all economic sectors to produce goods or provide services in exchange of remuneration or benefits. Represents the labor demand from all the sectors. It is calculated by aggregating the desired labor from fishing and agriculture, public, tourism and others sectors.	

Formulation and comments	Units
<p>Labor availability= labor force (t)/ Desired labor</p> <p>Ratio that reflects the internal conditions of the labor market in Galapagos. It compares the labor force (labor supply) with the desired labor of all economic sectors (labor demand). A ratio lower than 1 means that demand exceeds supply. Calculated by dividing the labor force stock by the desired labor.</p>	Dimensionless
<p>Unemployment rate= Unemployed (t)/ Labor force (t)</p> <p>Corresponds to the number of unemployed people as a fraction of the labor force stock. Calculated by dividing the unemployed stock by the labor force stock.</p>	Dimensionless
<p>Unemployment ratio= unemployment rate/ unemployment underemployment mainland EC</p> <p>Ratio that reflects the external conditions of the labor market by comparing unemployment in Galapagos vs. unemployment and underemployment in Ecuador. A ratio lower than 1 means that unemployment in Galapagos is lower than in the continent. Calculated by dividing the unemployed rate by the unemployment and underemployment in Ecuador.</p>	Dimensionless
<p>Employed= tourism labor (t)+ fishing and agriculture labor (t)+ public sector labor (t)+ other sectors labor (t)</p> <p>People aged 10 and older who are engaged in any activity to produce goods or provide services in exchange of remuneration or benefits. Calculated by adding the people currently employed in all economic sectors: tourism, fishing and agriculture, public and other sectors labor.</p>	Labor
<p>Employment rate= employed/ labor force (t)</p> <p>Corresponds to the ratio of the number of employed people as a fraction of the labor force stock. Calculated by dividing the employed labor by the labor force stock.</p>	Dimensionless
<p>Normalized employment rate= employment rate/ minimum employment rate</p> <p>Normalizes the employment rate by dividing it to the minimum employment rate. This normalized ratio is aggregated in the social wealth index.</p>	Dimensionless
<p>Desired tourism labor= Tourists at the same time* desired tourism labor per tourist</p> <p>Desired number of employees demanded in the tourism sector. The desired tourism labor depends on the tourists at the same time in Galapagos and the desired tourism labor per tourist.</p>	Labor
<p>Desired fishing and agriculture labor= Floating population* desired FA labor per floating pop</p> <p>Desired number of people demanded in the fishing and agriculture sector. The desired fishing and agriculture labor depends on the floating population in Galapagos and the desired fishing and agriculture labor per floating inhabitant.</p>	Labor
<p>Desired labor other= desired other labor per floating pop* Floating population</p> <p>Desired number of employees demanded in other sectors of the economy. It depends on the floating population in Galapagos and the desired other labor per floating inhabitant.</p>	Labor

Formulation and comments	Units
<p>Desired labor public= Floating population* desired public labor per floating pop</p> <p>Desired number of employees demanded in the public sector. It depends on the floating population in Galapagos and the desired public labor per floating inhabitant.</p>	Labor
<p>EC unemployment effect on emigration= WITH LOOKUP (unemployment ratio)</p> <p>(0,0.55), (0.05,0.6), (0.12,0.75), (0.19,1), (0.42,1.31), (0.62,1.45), (1,1.5), (1.5,1.55)</p> <p>Effect that the external conditions of the labor market have in emigration from Galapagos. Higher unemployment in Galapagos in comparison to Ecuador mainland means more incentives for people to emigrate from Galapagos. Data source: estimated based on Galapagos data from the National Census INEC 1990, 2001, 2010.</p>	Dimensionless/ Year
<p>Job attractiveness multiplier= WITH LOOKUP (labor availability)</p> <p>(0,1.17), (0.6,1.15), (0.8,1.12), (1,1.08), (1.085,1.0288), (1.117,1), (1.14,0.9809), (1.2,0.9), (1.3,0.84), (1.5,0.8)</p> <p>Effect that the internal conditions of the labor market have in immigration to Galapagos. Excess of labor demand in comparison with labor supply (labor availability below 1) means more incentives for people to immigrate to Galapagos. Data source: estimated based on Galapagos data from the National Census INEC 1990, 2001, 2010.</p>	Dimensionless
<p>Effect of relative unemployment on immigration= WITH LOOKUP (unemployment ratio)</p> <p>(0,1.32), (0.02,1.3), (0.05,1.25), (0.12,1.103), (0.19,1), (0.28,0.971), (0.42,0.932), (0.63,0.9), (1,0.85)</p> <p>Effect that the external conditions of the labor market have in immigration to Galapagos. Lower unemployment in Galapagos in comparison to Ecuador mainland means more incentives for people to immigrate to Galapagos. Data source: estimated based on Galapagos data from the National Census INEC 1990, 2001, 2010.</p>	Dimensionless
<p>Desired tourism labor per tourist= WITH LOOKUP (Tourists at the same time)</p> <p>(500,1.601), (1100,1.571), (2500,0.891), (5000,0.766), (7500,0.766), (10000,0.766), (15000,0.766)</p> <p>Number of employees demanded per tourist in the tourism sector. Varies according to the number of tourist reflecting productivity due to economies of scale. Data source: estimated based on Galapagos data from the National Census INEC 1990, 2001, 2010.</p>	Labor/ Person
<p>Desired FA labor per floating pop= WITH LOOKUP (Floating population)</p> <p>(10000,0.0853), (18500,0.0756), (25000,0.0408), (50000,0.032), (100000,0.032), (150000,0.032)</p> <p>Number of fishing and agriculture labor needed per person -considers residents and tourist at the time in Galapagos-. Varies according to the number of floating inhabitants reflecting productivity due to economies of scale. Data source: estimated based on Galapagos data from the National Census INEC 1990, 2001, 2010.</p>	Labor/ Person
<p>Desired other labor per floating pop= WITH LOOKUP (Floating population)</p>	Labor/ Person

Formulation and comments	Units
(10000,0.2019), (18000,0.2156), (25000,0.2534), (50000,0.2914), (100000,0.3058), (150000,0.3058)	
Number of employees demanded per person in other sectors of Galapagos economy -considers residents and tourist at the time in Galapagos-. Varies according to the number of floating inhabitants to reflect higher economic activity in other sectors when floating population increases. Data source: estimated based on Galapagos data from the National Census INEC 1990, 2001, 2010.	
Desired public labor per floating pop= WITH LOOKUP (Floating population)	
(10000,0.0753), (18500,0.0541), (25000,0.0486), (50000,0.0486), (100000,0.0486), (150000,0.0486)	Labor/ Person
Number of public labor needed per person -considers residents and tourist at the time in Galapagos-. Varies according to the number of floating inhabitants reflecting productivity due to economies of scale in the number of public servants required per person. Data source: estimated based on Galapagos data from the National Census INEC 1990, 2001, 2010.	
Birth rate= 15.61/1000	Dimensionless/ Year
Number of annual births per 1000 inhabitants in Galapagos. Data source: Annual statistics of births and deaths Civil Register & INEC 2001, 2010.	
Mortality rate= 1.66/1000	Dimensionless/ Year
Number of annual deaths per 1000 inhabitants in Galapagos. Data source: Annual statistics of births and deaths Civil Register & INEC 2001, 2010.	
Time to mature= 10	Year
Time that takes for people with 0 years to move to the working age population stock (10 plus)	
Labor force participation rate= 0.6324	Labor/ Person
Fraction of the working age population who is willing to be employed. Data source: Galapagos data from the National Census INEC 2010 (PEA/PET).	
Time to adjust labor force= 0.25	Year
Time that takes for working age population to adjust its willingness to be employed and become part of the labor force. Data source: estimated.	
High skilled labor fraction= 0.007	Dimensionless/ Year
Fraction of workers which annually immigrate to Galapagos due to a deficit of local high skilled profiles. Data source: estimated based on Galapagos data from the National Census INEC 1990, 2001, 2010.	
Normal immigration rate= 0.021	Dimensionless/ Year

Formulation and comments	Units
Average fraction of people which immigrate to Galapagos per year. Data source: estimated based on Galapagos data from the National Census INEC 1990, 2001, 2010.	
Unemployment underemployment mainland EC= 0.545	Dimensionless
Ecuador unemployment and underemployment rate. Data source: National Survey of Employment, Unemployment, and Underemployment INEC 2010.	
Minimum employment rate= 0.9	Dimensionless
Assumes that the minimum desired employment rate is the value for 2010. Data source: estimated based on Galapagos data from the National Census INEC 2010.	
Avg duration employment tourism= 5	Year
Average time that an employee remains in its job in the tourism sector. Data source: National Survey of Employment, Unemployment, and Underemployment INEC 2010.	
Avg duration employment other= 5	Year
Average time that an employee remains in its job in other sectors of the economy. Data source: National Survey of Employment, Unemployment, and Underemployment INEC 2010.	
Avg duration employment public= 5	Year
Average time that an employee remains in its job in the public sector. Data source: National Survey of Employment, Unemployment, and Underemployment INEC 2010.	
Time to adjust FA labor= 1	Year
Average time that takes for a person to move in or out of the fishing and agriculture sector. Data source: estimated based on best judgments on the time it takes for a person to fully give up or retake fishing and agriculture activities.	
Time to fire other= 0.5	Year
Average time that takes for an employee to be fired from other sectors in the economy. Data source: based on best judgment estimations on the time needed to formally process a firing request.	
Time to fire public= 0.5	Year
Average time that takes for an employee to be fired from the public sector. Data source: based on best judgment estimations on the time needed to formally process a firing request.	
Time to fire tourism= 0.5	Year
Average time that takes for an employee to be fired from the tourism sector. Data source: based on best judgment estimations on the time needed to formally process a firing request.	
Time to hire other= 0.08	Year
Average time that takes for an employee to be hired in other sectors of the economy. Data source: based on best judgment estimations on the time needed to find and hire an employee.	
Time to hire tourism= 0.08	Year

Formulation and comments	Units
Average time that takes for an employee to be hired in the tourism sector. Data source: based on best judgment estimations on the time needed to find and hire an employee.	
Time to hire public= 0.08	Year
Average time that takes for an employee to be hired in the public sector. Data source: based on best judgment estimations on the time needed to find and hire an employee.	
Time to perceive change in tourism labor= 0.167	Year
Average time that takes for the labor market to perceive a change in the tourism labor and impact the fishing and agriculture labor stock. Data source: estimated.	
Sensitivity ratio FA labor to tourism labor= -0.7684	Dimensionless
Sensitivity of the fishing and agriculture labor to changes in tourism labor. Is the rate at which fishing and agriculture changes per unit of change in tourism labor. Data source: estimated based on Galapagos data from the National Census INEC 1990, 2001, 2010, by applying the next formula: $\text{ratio} = \frac{\text{Labor FA}_1 - \text{Labor FA}_0}{\text{Labor tourism}_1 - \text{Labor tourism}_0}$	

B2. Tourist Arrivals Module

Formulation and comments	Units
Domestic tourists (t) = Domestic tourists (2010) +	
$\int_{2010}^t \text{change in domestic tourists } ds$	Person
Domestic tourists (2010) = 61,574	
The stock of domestic tourists changes to adjust to the expected domestic tourists and to capture the effect of natural attractiveness erosion in tourism. The initial number of tourists in the stock is 61,574 that correspond to the number of tourist arrivals in 2010. Data source: Transit Control Card. Consejo de Gobierno de Galápagos. 2010	
Foreign tourists (t) = Foreign tourists (2010) +	
$\int_{2010}^t \text{change in foreign tourists } ds$	Person
Foreign tourists (2010) = 111,723	
The stock of foreign tourists changes to adjust to the expected foreign tourists and to capture the effect of natural attractiveness erosion in tourism. The initial number of tourists in the stock is 111,723 that correspond to the number of tourist arrivals in 2010. Data source: Transit Control Card. Consejo de Gobierno de Galápagos. 2010	
Change in domestic tourists (t)= (Expected domestic tourists*Effect of natural attractiveness erosion in tourism-Domestic tourists)/time to adjust domestic tourism	Person/ Year

Formulation and comments	Units
<p>Flow of domestic tourist to Galapagos that are added to the domestic tourists stock. Calculated by multiplying the expected domestic tourists with the effect of natural attractiveness erosion and then subtracting the domestic tourists stock to get the discrepancy. This is then divided by the time to adjust domestic tourism to get the rate of change.</p>	
<p>Change in foreign tourists (t)= (Expected foreign tourists*Effect of natural attractiveness erosion in tourism-Foreign tourists)/time to adjust foreign tourism</p>	Person/ Year
<p>Flow of foreign tourist to Galapagos that are added to the foreign tourists stock. Calculated by multiplying the expected foreign tourists with the effect of natural attractiveness erosion and then subtracting the foreign tourists stock to get the discrepancy. This is then divided by the time to adjust foreign tourism to get the rate of change.</p>	
<p>Expected domestic tourists = IF THEN ELSE (Type of scenario of tourism growth=1, Domestic tourists (t) +linear increase domestic tourists *pressure of revenues per capita on tourist growth, IF THEN ELSE (Type of scenario of tourism growth = 2, Domestic tourists (t)*(1+exponential increase rate domestic tourist*pressure of revenues per capita on tourist growth), Domestic tourists (t)))</p>	Person
<p>Expected number of domestic tourist arrivals according to the scenario of tourism growth selected. The IF THEN ELSE function determines the calculation for scenario 1, 2, 3. For scenario 1 of moderate growth, equals to the domestic tourists stock plus the linear increase in domestic tourists and multiplied by the pressure of revenues per capita on tourist growth. For scenario 2 of accelerated growth, equals to the domestic tourists stock multiplied by the exponential increase rate of domestic tourist and the pressure of revenues per capita on tourist growth. For scenario 3 of no growth, equals to the domestic tourists stock.</p>	
<p>Expected foreign tourists = IF THEN ELSE (Type of scenario of tourism growth = 1, Foreign tourists (t)+linear increase foreign tourists*pressure of revenues per capita on tourist growth, IF THEN ELSE (Type of scenario of tourism growth = 2, Foreign tourists (t)*(1+exponential increase rate foreign tourist*pressure of revenues per capita on tourist growth), Foreign tourists (t)))</p>	Person
<p>Expected number of foreign tourist arrivals according to the scenario of tourism growth selected. The IF THEN ELSE function determines the calculation for scenario 1, 2, 3. For scenario 1 of moderate growth, equals to the foreign tourists stock plus the linear increase in foreign tourists and multiplied by the pressure of revenues per capita on tourist growth. For scenario 2 of accelerated growth, equals to the foreign tourists stock multiplied by the exponential increase rate of foreign tourist and the pressure of revenues per capita on tourist growth. For scenario 3 of no growth, equals to the foreign tourists stock.</p>	
<p>Index of natural attractiveness erosion= (Normalized fraction of occupied land +Normalized introduced species index +Normalized pressure over carrying capacity)/3</p>	Dimensionless
<p>Aggregated index of the impacts affecting the attractiveness of the natural capital of the Islands. Calculated by adding the normalized fraction of occupied land with the normalized introduced species index and the normalized pressure over carrying capacity. This is then divided by 3 to give equal weights to the three normalized indicators that are aggregated.</p>	

Formulation and comments	Units
<p>Normalized change in tourist revenues per capita= IF THEN ELSE (change in tourism revenues per capita=0, 0, change in tourism revenues per capita /abs (change in tourism revenues per capita))</p> <p>Normalizes the rate of change in tourism revenues per capita by dividing it to its absolute number. The IF THEN ELSE function avoids division by zero value.</p>	Dimensionless
<p>Tourist in Galapagos= Domestic tourists (t) +Foreign tourists (t)</p> <p>Annual tourist arrival to Galapagos. Calculated by adding the domestic tourists stock and the foreign tourists stock</p>	Person
<p>Domestic tourists on land= Domestic tourists (t) * Fraction of domestic tourist on land</p> <p>Annual arrival of domestic tourists that accommodate on land facilities. Calculated by multiplying the domestic tourists stock with the fraction of domestic tourists on land.</p>	Person
<p>Domestic tourists on board= Domestic tourists (t) *(1 - Fraction of domestic tourist on land)</p> <p>Annual arrival of domestic tourists that choose cruise accommodation. Calculated by multiplying the domestic tourists stock with 1 minus the fraction of domestic tourists on land, that equals to the fraction of domestic tourists on board.</p>	Person
<p>Foreign tourists on land= Foreign tourists (t) * Fraction of foreign tourist on land</p> <p>Annual arrival of foreign tourists that accommodate on land facilities. Calculated by multiplying the foreign tourists stock with the fraction of foreign tourists on land.</p>	Person
<p>Foreign tourists on board= Foreign tourists (t) *(1 - Fraction of foreign tourist on land)</p> <p>Annual arrival of foreign tourists that choose cruise accommodation. Calculated by multiplying the foreign tourists stock with 1 minus the fraction of foreign tourists on land, that equals to the fraction of foreign tourists on board.</p>	Person
<p>Tourists on board= Foreign tourists on board +Domestic tourists on board</p> <p>Total tourists that choose the cruise accommodation. Calculated by adding the foreign tourists on board and the domestic tourists on board.</p>	Person
<p>Tourists on land= Foreign tourists on land +Domestic tourists on land</p> <p>Total tourists that accommodate on land facilities. Calculated by adding the foreign tourists on land and the domestic tourists on land.</p>	Person
<p>Effect of natural attractiveness erosion in tourism= WITH LOOKUP (Index of natural attractiveness erosion)</p> <p>(0,1.08), (1,1), (2,0.97), (3,0.95), (4,0.9)</p> <p>Impact of the erosion of natural capital on the number of tourists visiting Galapagos. The higher the index of natural attractiveness erosion, the higher the effect reducing the number of tourists that visit Galapagos.</p>	Dimensionless
<p>Pressure of revenues per capita on tourist growth= WITH LOOKUP (Normalized change in tourist revenues per capita)</p>	Dimensionless

Formulation and comments	Units
$(-1,1.1), (0,1), (1,1)$	
Represents the pressure to increase tourism driven by lower revenues per capita as a result of population growth. When tourism revenues per capita decrease, tourist arrivals will increase. If tourism revenues per capita increase, this pressure does not affect tourist arrivals.	
Fraction of domestic tourist on land= 0.9437	Dimensionless
Fraction of domestic tourist arriving to Galapagos which choose to accommodate on land facilities. Data source: Transit Control Card. Consejo de Gobierno de Galápagos. 2010	
Fraction of foreign tourist on land= 0.4319	Dimensionless
Fraction of foreign tourist arriving to Galapagos which choose to accommodate on land facilities. Data source: Transit Control Card. Consejo de Gobierno de Galápagos. 2010	
Time to adjust domestic tourism= 1	Year
Time that takes to adjust annual number of domestic tourist arrivals to the expected value considering the effect of natural attractiveness erosion in tourism. Data source: estimated based on the time constant between actual and reported data of tourist arrivals. Transit Control Card. Consejo de Gobierno de Galápagos. 2010	
Time to adjust foreign tourism= 1	Year
Time that takes to adjust annual number of foreign tourist arrivals to the expected value considering the effect of natural attractiveness erosion in tourism. Data source: estimated based on the time constant between actual and reported data of tourist arrivals. Transit Control Card. Consejo de Gobierno de Galápagos. 2010	
Type of scenario of tourism growth= 1, 2, or 3	Dimensionless
Value that works as a switch to choose between the type of scenarios of tourism growth: 1=Moderate tourism growth (lineal), 2=Accelerated tourism growth (exponential), 3=Tourism moratorium (no tourism growth)	
Exponential increase rate domestic tourist= 0.0761361	Dimensionless
Exponential rate of increase of domestic tourists according to projections, applied when the scenario of accelerated growth is selected as the type of scenario of tourism growth. Data source: estimated based on historical values of domestic tourists arrivals. Observatorio de Galápagos 2015.	
Exponential increase rate foreign tourist= 0.0803558	Dimensionless
Exponential rate of increase of foreign tourists according to projections, applied when the scenario of accelerated growth is selected as the type of scenario of tourism growth. Data source: estimated based on historical values of foreign tourists arrivals. Observatorio de Galápagos 2015.	
Linear increase domestic tourists= 2,790	Person
Linear increase of domestic tourists according to projections, applied when the scenario of moderate growth is selected as the type of scenario of tourism growth. Data source: estimated based on historical values of domestic tourists arrivals. Observatorio de Galápagos 2015.	
Linear increase foreign tourists= 6,396	Person

Formulation and comments	Units
Linear increase of foreign tourists according to projections, applied when the scenario of moderate growth is selected as the type of scenario of tourism growth. Data source: estimated based on historical values of foreign tourists arrivals. Observatorio de Galápagos 2015.	

B3. Floating Population Module

Formulation and comments	Units
Domestic tourists at the same time on board= Domestic tourists on board * Average stay of domestic tourists on board / Days per year	Person
Average number of domestic tourists staying at the same time on board accommodation in Galapagos. Calculated by multiplying the annual domestic tourist on board with the average days of stay of domestic tourists on board as a fraction of the number of days per year.	
Domestic tourists at the same time on land= Domestic tourists on land * Average stay of domestic tourists on land / Days per year	Person
Average number of domestic tourists staying at the same time on land accommodation in Galapagos. Calculated by multiplying the annual domestic tourist on land with the average days of stay of domestic tourists on land as a fraction of the number of days per year.	
Foreign tourists at the same time on board= Foreign tourists on board * Average stay of foreign tourists on board / Days per year	Person
Average number of foreign tourists staying at the same time on board accommodation in Galapagos. Calculated by multiplying the annual foreign tourist on board with the average days of stay of foreign tourists on board as a fraction of the number of days per year.	
Foreign tourists at the same time on land= Foreign tourists on land * Average stay of foreign tourists on land / Days per year	Person
Average number of foreign tourists staying at the same time on land accommodation in Galapagos. Calculated by multiplying the annual foreign tourist on land with the average days of stay of foreign tourists on land as a fraction of the number of days per year.	
Tourists at the same time on board= Foreign tourists at the same time on board + Domestic tourists at the same time on board	Person
Average number of tourist at the same time on board accommodation in Galapagos. Calculated by adding the foreign tourists at the same time on board and the domestic tourists at the same time on board.	
Tourists at the same time on land= Foreign tourists at the same time on land + Domestic tourists at the same time on land	Person
Average number of tourist at the same time on land accommodation in Galapagos. Calculated by adding the foreign tourists at the same time on land and the domestic tourists at the same time on land.	

Formulation and comments	Units
<p>Tourists at the same time= Tourists at the same time on board + Tourists at the same time on land)</p> <p>Average number of tourist at the same time in Galapagos. Calculated by adding the tourists at the same time on board and the tourists at the same time on land.</p>	Person
<p>Fraction of tourists at the same time over residents= Tourists at the same time/ Resident population</p> <p>Corresponds to the number of tourists staying at the same time in Galapagos as a fraction of the resident population. An increase indicates that the number of tourists are growing at a faster pace than the local residents</p>	Dimensionless
<p>Residents in urban areas= Resident population* fraction of urban population</p> <p>Corresponds to the number of people living in the urban areas in Galapagos. Calculated by multiplying the resident population with the fraction of urban population.</p>	Person
<p>Floating population= Resident population + Tourists at the same time</p> <p>Accounts for all people living and staying in Galapagos, this is the resident population plus the tourists at the same time.</p>	Person
<p>Floating population on land= Resident population + Tourists at the same time on land</p> <p>Accounts for all people living and staying in any of the islands in Galapagos. This is resident population plus tourist at the same time on land accommodation.</p>	Person
<p>Floating population urban= Residents in urban areas + Tourists at the same time on land</p> <p>Accounts for all people living and staying in the urban areas of any of the islands in Galapagos. This is resident population in urban areas plus tourist at the same time on land.</p>	Person
<p>Average stay on board= Average stay of domestic tourists on board* Domestic tourists at the same time on board/ Tourists at the same time on board+ Average stay of foreign tourists on board* Foreign tourists at the same time on board/ Tourists at the same time on board</p> <p>Number of days that tourists stay in average when visiting on board accommodation. Calculated as a weighted average of the days of stay of domestic and foreign tourists on board.</p>	Day
<p>Average stay on land= Average stay of domestic tourists on land* Domestic tourists at the same time on land/ Tourists at the same time on land+ Average stay of foreign tourists on land* Foreign tourists at the same time on land/ Tourists at the same time on land</p> <p>Number of days that tourists stay in average when visiting on land accommodation. Calculated as a weighted average of the days of stay of domestic and foreign tourists on land.</p>	Day
<p>Days per year= 365</p> <p>Number of days in a standard calendar year.</p>	Day

Formulation and comments	Units
Average stay of domestic tourists on board= 4.5684	Day
Number of days that domestic tourists stay on average when visiting on board accommodation. Data source: estimated from Transit Control Card. Consejo de Gobierno de Galápagos 2010.	
Average stay of domestic tourists on land= 4.4197	Day
Number of days that domestic tourists stay on average when visiting on land accommodation. Data source: estimated from Transit Control Card. Consejo de Gobierno de Galápagos 2010.	
Average stay of foreign tourists on land= 5.5627	Day
Number of days that foreign tourists stay on average when visiting on land accommodation. Data source: estimated from Transit Control Card. Consejo de Gobierno de Galápagos 2010.	
Average stay of foreign tourists on board= 5.932	Day
Number of days that foreign tourists stay on average when visiting on board accommodation. Data source: estimated from Transit Control Card. Consejo de Gobierno de Galápagos 2010.	
Fraction of urban population= 0.825426	Dimensionless
Fraction of the population of Galapagos living in urban areas. Data source: Galapagos data from National Census INEC 2010	

B4. Carrying Capacity of The Galapagos National Park Module

Formulation and comments	Units
ANNUAL Carrying Capacity of the visiting sites by CRUISE tourism mode= DAILY Installed Capacity visiting sites by CRUISE tourism mode *Days per year/ average stay on board	Person
Number of annual visitors that can be received in the visiting sites that are reached by CRUISE mode given the daily installed capacity of the sites to assure a good quality visit to the tourists. Calculated by multiplying the Daily installed capacity of the visiting sites by cruise tourism mode with a ratio of the days per year divided by the average stay on board.	
ANNUAL Carrying Capacity of the visiting sites on LAND tourism mode= DAILY Installed Capacity visiting sites on LAND tourism mode *Days per year/ average stay on land	Person
Number of annual visitors that can be received in the visiting sites that are reached by on LAND tourism mode given the daily installed capacity of the sites to assure a good quality visit to the tourists. Calculated by multiplying the Daily installed capacity of the visiting sites on land tourism mode with a ratio of the days per year divided by the average stay on land.	

Formulation and comments	Units
<p>Annual Carrying Capacity of the Protected Area= ANNUAL Carrying Capacity of the visiting sites on LAND tourism mode + ANNUAL Carrying Capacity of the visiting sites by CRUISE tourism mode</p>	Person
<p>Number of annual visitors that can be received in all the visiting sites of the Galapagos Protected Area given the daily installed capacity of the sites to assure a good quality visit to the tourists. Calculated adding the annual carrying capacity of the visiting sites on land and by cruise tourism mode.</p>	
<p>Daily Occupation of installed capacity CRUISE= Tourists at the same time on board/ DAILY Installed Capacity visiting sites by CRUISE tourism mode</p>	Dimensionless
<p>Ratio that defines the occupation of the daily capacity of the visiting sites that are reached by cruise tourism mode. Ratio above 1 means that the number of on board visitors exceeds the daily capacity. Calculated by dividing the number of tourists at the same time on board by the daily installed capacity of the visiting sited by cruise tourism mode.</p>	
<p>Daily Occupation of installed capacity LAND= Tourists at the same time on land/ DAILY Installed Capacity visiting sites on LAND tourism mode</p>	Dimensionless
<p>Ratio that defines the occupation of the daily capacity of the visiting sites that are reached by on land tourism mode. Ratio above 1 means that the number of on land visitors exceeds the daily capacity. Calculated by dividing the number of tourists at the same time on land by the daily installed capacity of the visiting sited on land tourism mode.</p>	
<p>Annual Occupation of carrying capacity CRUISE= Tourists on board/ ANNUAL Carrying Capacity of the visiting sites by CRUISE tourism mode</p>	Dimensionless
<p>Ratio that defines the occupation of the annual carrying capacity of the visiting sites that are reached by cruise tourism mode. Ratio above 1 means that the number on board visitors exceeds the annual carrying capacity. Calculated by dividing the number of annual tourists on board by the annual carrying capacity of the visiting sites by cruise tourism mode.</p>	
<p>Annual Occupation of carrying capacity LAND= Tourists on land/ ANNUAL Carrying Capacity of the visiting sites on LAND tourism mode</p>	Dimensionless
<p>Ratio that defines the occupation of the annual carrying capacity of the visiting sites that are reached by on land tourism mode. Ratio above 1 means that the number of on land visitors exceeds the annual carrying capacity. Calculated by dividing the number of annual tourists on land by the annual carrying capacity of the visiting sites on land tourism mode.</p>	
<p>Annual pressure over carrying capacity of the Protected Area= Tourist in Galapagos/ Annual Carrying Capacity of the Protected Area</p>	Dimensionless
<p>Ratio that defines the occupation of the annual carrying capacity of all the visiting sites in the Galapagos Protected Area. Ratio above 1 means that the number of annual visitors exceeds the annual carrying capacity. Calculated by dividing the number of annual tourists in Galapagos by the annual carrying capacity of the protected area.</p>	
<p>Normalized pressure over carrying capacity= Annual pressure over carrying capacity of the Protected Area/ Maximum desired pressure over carrying capacity</p>	Dimensionless
<p>Normalizes the annual pressure over carrying capacity of the Protected Area by dividing it to the maximum desired pressure over carrying capacity. This normalized ratio is aggregated in the index of natural attractiveness erosion.</p>	

Formulation and comments	Units
Maximum desired pressure over carrying capacity= 0.7 Assumes that the maximum desired pressure over carrying capacity is the value for 2010. Data source: estimated based on the daily installed capacity provided by Dirección del Parque Nacional Galápagos 2012 and tourist arrivals data from the Observatorio de Galápagos 2010.	Dimensionless
DAILY Installed Capacity visiting sites by CRUISE tourism mode= 1,702 Number of visitors that can be received in the visiting sites that are reached by cruise tourism mode in a day to assure a good quality visit to the tourists. Data source: Dirección del Parque Nacional Galápagos 2012	Person
DAILY Installed Capacity visiting sites on LAND tourism mode= 1,960 Number of visitors that can be received in the visiting sites that are reached by on land tourism mode in a day to assure a good quality visit to the tourists. Data source: Dirección del Parque Nacional Galápagos 2012	Person

B5. Introduced Species Module

Formulation and comments	Units
Endemic species index (t) = Endemic species index (2010) + $\int_{2010}^t \text{change in introduced species index } ds$	Dimensionless
Endemic species index (2010) = 0.77668 The stock of endemic species index changes to adjust to higher dispersion of introduced species within Galapagos ecosystems. The initial value of the index is 0.77668 and is estimated based on the number of reported endemic species as a fraction of the total reported species in Galapagos. Data source: Charles Darwin Foundation 2010.	
Introduced species index (t) = Introduced species index (2010) + $\int_{2010}^t \text{change in introduced species index } ds$	Dimensionless
Introduced species index (2010) = 0.22251 The stock of introduced species index changes to adjust to higher dispersion of introduced species within Galapagos ecosystems. The initial value of the index is 0.22251 and is estimated based on the number of reported introduced species as a fraction of the total reported species in Galapagos. Data source: Charles Darwin Foundation 2010.	
Change in introduced species index (t)= (expected introduced species index driven by population- introduced species index (t))/ time to adjust introduced species	Dimensionless/ Year
Rate of change of the introduced species index to adjust the stocks of endemic species index and introduced species index to changes in the dispersion of introduced species within Galapagos ecosystems. Calculated by subtracting the current introduced species index stock from the expected introduced species index driven by population. This value is then divided by the time to adjust introduced species index to get the rate of change.	

Formulation and comments	Units
Expected introduced species index driven by population= Floating population* introduced species factor per person	Dimensionless
Expected index of introduced species that considers the influence of residents and tourists in the dispersion of introduced species. Calculated by multiplying the total floating population (residents + tourist at the same time) with the introduced species factor per person.	
Normalized introduced species index= introduced species index (t)/ Maximum desired introduced species index	Dimensionless
Normalizes the introduced species index by dividing it to the maximum desired introduced species index. This normalized ratio is aggregated in the index of natural attractiveness erosion.	
Maximum desired introduced species index= 0.22	Dimensionless
Assumes that the maximum desired introduced species index is the value for 2010. Data source: Charles Darwin Foundation 2010.	
Time to adjust introduced species index= 3	Year
Time that takes for new introduced species to be detected and reported. Data source: estimated based on the experience of Galapagos field researchers.	
Introduced species factor per person= 1.03088e-05	Dimensionless/ Person
Fraction of the index of introduced species per floating inhabitant in Galapagos. Data source: estimated based on data from the Charles Darwin Foundation 1990-2010 and calculations of floating inhabitants from the reported data of the Observatorio de Galápagos 2010 and from the National Census INEC 1990, 2001, 2010.	

B6. Urbanization and Land Use Module

Formulation and comments	Units
Urbanized area (t) = Urbanized area (2010) +	
$\int_{2010}^t \text{urbanization completion } ds$	Hectare
Urbanized area (2010) = 396.99	
The stock of urbanized area accumulates the urban area as the urbanization process is completed. The initial number of urbanized hectares in the stock is 396.99 corresponding to the 2010 estimation. Data source: estimated based on spatial data analysis of satellite images of urban areas in Galapagos. Galapagos Science Center.	
Urbanizing area (t) = Urbanizing area (2010) +	
$\int_{2010}^t \text{urbanization rate} - \text{urbanization completion } ds$	Hectare
Urbanizing area (2010) = 0	

Formulation and comments	Units
<p>The stock of urbanizing area corresponds to the land that is in process of urbanization before the process is completed. The stock increases with the urbanization rate, and decreases with the urbanization completion rate. Data source: model assumes that no land is in process of being urbanized at the beginning of the simulation period.</p>	
<p>Road network (t) = Road network (2010) +</p>	
$\int_{2010}^t \text{construction of new roads } ds$	Meter
<p>Road network (2010) = 402,943</p>	
<p>The stock of road network accumulates the meters of road that are constructed in Galapagos. The stock increases with the construction of new roads. The initial value of the stock is 402,943 meters that correspond to the 2010 data on road network. Data source: Ecuadorian Association of Municipalities AME 2012</p>	
<p>Urbanization rate (t)= IF THEN ELSE ((required urbanized area- urbanized area (t)- urbanizing area (t))<0, 0, IF THEN ELSE (required urbanized area> Land outside Galapagos National Park, (Land outside Galapagos National Park- urbanized area (t) -urbanizing area (t))/time to start urbanizing, (required urbanized area- urbanized area (t) -urbanizing area (t))/time to start urbanizing))</p>	Hectare/ Year
<p>Annual rate at which land in Galapagos starts being transformed in urban land and added to the urbanizing area. Calculated as the difference between the required urbanized area and the current urbanized area stock. This discrepancy is divided by the time to start urbanizing to get the rate of change over time. The first IF THEN ELSE function controls that urbanization is irreversible by restricting the urbanization rate to not get values below zero. The other IF THEN ELSE function restricts the urbanization only to the area outside the Galapagos National Park with the condition that if the required urbanized land is bigger than the Land outside the protected area, only the portion that corresponds to not protected land can be urbanized.</p>	
<p>Urbanization completion= urbanizing area (t)/ urbanizing time</p>	Hectare/ Year
<p>Annual rate at which the urbanization process is completed and land is moved from the urbanizing stock into the urbanized stock. Calculated as the urbanizing area stock divided by the urbanizing time.</p>	
<p>Construction of new roads= MAX((required road network length- Road network (t))/ time to build roads, 0)</p>	Meter/ Year
<p>Annual rate at which roads are being built in Galapagos to reach the required road network length. Calculated as the difference between the required road network length and the current road network stock. This discrepancy is divided by the time to build roads to get the rate of change. The MAX function prevents that the construction of new roads become negative capturing the element that construction of new roads is an irreversible process.</p>	
<p>Required urbanized area= Floating population urban* desired urbanized area per person</p>	Hectare
<p>Corresponds to the required land that needs to be urbanized to accommodate the floating population of Galapagos living in urban areas. Calculated by multiplying the number of urban floating inhabitants with the desired urbanized area per person.</p>	
<p>Required road network length= Floating population on land*road length per person</p>	Meter

Formulation and comments	Units
Corresponds to the required road length that is needed to maintain an adequate road connection for the population using the roads network (residents and tourists at the same time on land). Calculated by multiplying the floating population on land with the road length per person.	
Area occupied by road network= Road network (t)* fraction of rural roads* area occupied by meter of road/ m ² per hectare	Hectare
Represents the area of land that is occupied by the road network outside the urbanized area (considering that urban roads are included as part of the urbanized area). Calculated by multiplying the road network stock with the fraction of rural roads. This value is multiplied by the area occupied by meter of road and divided by square meters per hectare to get the area expressed in hectare units.	
Total land occupied= urbanized area (t) + area occupied by road network	Hectare
Refers to the total land that is transformed and occupied by human settlements outside the Galapagos National Park. Calculated by adding the urbanized area and the area occupied by road network.	
Natural ecosystems area= Land outside Galapagos National Park- Total land occupied	Hectare
Refers to the land that remains in its natural state outside the Galapagos National Park. Calculated by subtracting the total land occupied from the land outside Galapagos National Park.	
Fraction of natural land= Natural ecosystems area/ Land outside Galapagos National Park	Dimensionless
Portion of the land that remains in its natural state outside the Galapagos National Park. Calculated by dividing the natural ecosystems area by the land outside the Galapagos National Park.	
Fraction of land occupied = Total land occupied/ Land outside Galapagos National Park	Dimensionless
Portion of the land that is occupied by human settlements outside the Galapagos National Park. Calculated by dividing the total land occupied by the land outside the Galapagos National Park.	
Normalized fraction of occupied land= Fraction of land occupied/ Maximum desired fraction of occupied land	Dimensionless
Normalizes the fraction of land occupied by dividing it to the maximum desired fraction of occupied land. This normalized ratio is aggregated in the index of natural attractiveness erosion.	
Desired urbanized area per person= 227.27/10000	Hectare/ Person
Corresponds to the desired area of urban land needed per inhabitant. Data source: estimated based on the spatial data analysis of satellite images of urban areas in Galapagos between the years 1985 and 2013 and population data from the National Census INEC 1990, 2001, 2010.	
Time to start urbanizing= 0.25	Year
Time that takes to start transforming a plot of natural land into urban land, corresponds to the formal approval process to get the urbanization permits. Data source: based on best judgment estimations on the time required to process and approve urbanization permits.	
Urbanizing time= 3	Year

Formulation and comments	Units
Corresponds to the time that takes to urbanized a plot of land, includes sewerage, water supply, electricity, roads, sidewalks, street lighting. Data source: based on best judgment estimations on the time required to build the urbanization infrastructure.	
Time to build roads= 1	Year
Corresponds to the time that takes to build a road section including permits approval, land clearing and construction. Data source: based on best judgment estimations on the time required to approve and build a road section.	
Road length per person= 15.1482	Meter/ Person
Represents the length of road that is needed per person to facilitate the mobility within each island. Data source: estimated based on the total length of the roads network in Galapagos provided by the Ecuadorian Association of Municipalities AME 2012 and the floating population on land.	
Area occupied by meter of road= 6	Sq. Meter/ Meter
Area surface occupied by each meter of road. Data source: Ecuadorian Association of Municipalities AME 2012	
Fraction of rural roads= 0.74177	Dimensionless
Portion of the road network that corresponds to rural roads. Data source: Ecuadorian Association of Municipalities AME 2012	
m ² per hectare= 10000	Sq. Meter/ Hectare
Number of square meters in a hectare.	
Maximum desired fraction of occupied land= 0.03	Dimensionless
Desired fraction according to local government maximum target. Data source: Consejo de Gobierno de Galápagos. 2010	
Land outside Galapagos National Park= 30,980	Hectare
Correspond to the non-protected area of land from Galapagos that is outside the Galapagos National Park. Data source: Parque Nacional Galapagos, 2016	

B7. Tourism Revenues Module

Formulation and comments	Units
Tourism revenues per capita (t) = Tourism revenues per capita (2010) +	
$\int_{2010}^t \text{change in tourism revenues per capita } ds$	Dollar/ Person

Formulation and comments	Units
Tourism revenues per capita (2010) = indicated tourism revenues per capita	
The stock of tourism revenues per capita corresponds to the revenues from tourists expenditures perceived per local resident. It changes to adjust to the indicated tourism revenues per capita; therefore the value of indicated tourism revenues per capita is the initial value for the stock.	
Change in tourism revenues per capita (t)= (indicated tourism revenues per capita- tourism revenues per capita (t))/ time to perceive change in tourism revenues per capita	Dollar/ Person-Year
Annual rate at which the perceived tourism revenues per capita is adjusted to the indicated value. Calculated by subtracting the tourism revenues per capita stock from the indicated tourism revenues per capita to obtain the discrepancy. This value is then divided by the time to perceive change in tourism revenues per capita to get the rate of change.	
Revenues from domestic tourist= Average expenditures per domestic tourist* Domestic tourists	Dollar
Corresponds to the revenues coming from domestic tourists' expenditures in the Galapagos Islands. Calculated by multiplying the average expenditures per domestic tourist with the annual domestic tourists.	
Revenues from foreign tourist= Average expenditures per foreign tourist* Foreign tourists	Dollar
Corresponds to the revenues coming from foreign tourists' expenditures in the Galapagos Islands. Calculated by multiplying the average expenditures per foreign tourist with the annual foreign tourists.	
Tourism revenues= revenues from domestic tourist+ revenues from foreign tourist	Dollar
Corresponds to the total revenues coming from all tourists' expenditures in the Galapagos Islands. Calculated by adding the revenues from domestic tourist with the revenues from foreign tourist.	
Indicated tourism revenues per capita= Tourism revenues/ Resident population	Dollar/ Person
Represents the average amount of money from tourism expenditures that is being earned per inhabitant. Calculated by dividing the tourism revenues by the resident population of Galapagos.	
Normalized tourism revenues per capita= tourism revenues per capita/ Minimum tourism revenues per capita	Dimensionless
Normalizes the tourism revenues per capita by dividing it to the minimum desired tourism revenues per capita. This normalized ratio is aggregated in the social wealth index.	
Social wealth index= (normalized tourism revenues per capita+ normalized employment rate)/ 2	Dimensionless
Aggregated index of the impacts affecting the social wealth of the people living in the Islands. Represents the capacity of inhabitants to be employed and perform and economic activity that allows them to generate incomes to sustain themselves. Calculated by adding the normalized tourism revenues per capita and the normalized employment rate. This is then divided by 2 to give equal weights to the two normalized indicators that are aggregated.	

Formulation and comments	Units
<p>Average expenditures per domestic tourist= 240.89</p> <p>Corresponds to the average amount of money expend per domestic tourist. Considers only expenditures made by tourist on the islands. This value is 35% of total expenditures made by domestic tourist visiting Galapagos. Data source: Original surveys of Galapagos visitors 2005 (Taylor, Hardner, and Stewart; 2006)</p>	Dollar/ person
<p>Average expenditures per foreign tourist= 355.24</p> <p>Corresponds to the average amount of money expend per foreign tourist. Considers only expenditures made by tourist on the islands. This value is 8.5% of total expenditures made by foreign tourist visiting Galapagos. Data source: Original surveys of Galapagos visitors 2005 (Taylor, Hardner, and Stewart; 2006)</p>	Dollar/ person
<p>Time to perceive change in tourism revenues per capita= 0.25</p> <p>Time that takes for the resident population to perceive a change in the tourism revenues received per inhabitant. Data source: estimated</p>	Year
<p>Minimum tourism revenues per capita= 2,170</p> <p>Assumes that the minimum desired tourism revenues per capita are at least as much as the amount perceived in 2010. Data source: estimated based on average expenditures per tourist from Taylor, Hardner, and Stewart (2006), tourist arrivals from the Observatorio de Galapagos, and population from INEC 2010.</p>	Dollar/ person