EXECUTIVE SUMMARY

Synopsis

In your run […]

Results

Bar/flower chart and Table with each scenario x main model output, to deal with different unit ranges potentially have these normalized?

Table Z. Normalized output values for all scenarios across each evaluated ecosystem services

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Scenario | Total Stored C | Water Yield | Avoid Sedimentation | Nutrient inputs | Pollination |
| […] Current |  |  |  |  |  |
| BUA |  |  |  |  |  |
| Scenario 1 |  |  |  |  |  |
| Scenario 2 |  |  |  |  |  |

Figure Z. Bar of all indicators-scenarios or flower chart by scenario?

A detailed description and map of the outputs from each model and indicator are provided below in the detailed summary.

DETAILED SUMMARY

[INTRO PARAGRAPH?]

*CARBON STORAGE & SEQUESTRATION*

Rationale: Land use and Land Cover (LULC) change is a leading source of global carbon emissions. Conversion of carbon-rich natural habitats to agricultural and other human land-uses releases large quantities of carbon into the atmosphere. Protection and restoration of carbon-rich habitats helps to retain and sequester carbon in both the living plant matter and in belowground carbon pools (e.g. peat bogs, soil carbon).

Indicator Description: *Total Landscape Stored Carbon* *(Mt)*

This indicator estimates the current amount of carbon stored in a landscape across all land cover types based on the biophysical amount of stored in four carbon pools (aboveground, belowground, soil and dead matter) and areas under-going land use transitions. Changes in stored carbon with land-use change in the evaluated scenarios were estimated using IPCC carbon stock and conversion values for different land-use types in conjunction with each LULC change scenarios. The results for each evaluated scenario by the relevant carbon pool are presented in Table A.

*\*Note: The model assumes that none of the LULC types in the landscape are gaining or losing carbon over time, and it does not account for variation in carbon storage within each LULC type resulting from species composition or abiotic factors. Finally there the model does not account for movement of carbon between the carbon pools with time.*

Results: Of the evaluated scenarios, [scenario A] had the highest total stored carbon with [XX MT] stored across the four carbon pools, and [scenario B] had the lowest with only [XX MT] stored.

Table A. Carbon storage across evaluated scenarios in Megatons of C

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Scenario | Total Stored C | Above Ground | Below Ground | Soil Carbon | Dead Matter |
| […] Current |  |  |  |  |  |
| BUA |  |  |  |  |  |
| Scenario 1 |  |  |  |  |  |
| Scenario 2 |  |  |  |  |  |

Land use and land cover maps can be contrasted to estimate the gross change (sequestration/emissions) in stored carbon that results from re-vegetation of degraded lands and/or conversion of carbon-rich habitats releasing large quantities of carbon in the form of CO2 between scenarios. Estimated emissions and sequestration between the evaluated scenarios is presented in Table B calculated as the difference in estimated total stored carbon between scenarios given in Table A. Where values are positive, this implies additionally sequestered carbon, while negative values imply additional carbon emissions as you switch from the first scenario (Row) to the second scenario (Column).

Table B. Carbon of Emissions (positive values) and Sequestration (negative values) between contrasted scenarios in Megatons of C across the 4 evaluated carbon pools

|  |  |  |  |
| --- | --- | --- | --- |
| Scenario | Scenario 1 | Scenario 2 | Scenario 3 |
| Scenario 1 |  | Difference in Emissions | Difference in Emissions |
| Scenario 2 | Difference in Emissions |  | Difference in Emissions |
| Scenario 3 | Difference in Emissions | Difference in Emissions |  |

Default Maps:

Carbon intensity(storage) per pixel for each scenario

If baseline defined - Difference in carbon intensity between scenario and baseline

User Selected Maps:

Difference in carbon intensity/storage between selected scenarios

*For further details on this indicator and model please see the User Guide:*

[*http://data.naturalcapitalproject.org/invest-releases/documentation/current\_release/carbonstorage.html*](http://data.naturalcapitalproject.org/invest-releases/documentation/current_release/carbonstorage.html)

*HYDROPOWER WATER YIELD*

Rationale: In many parts of the world, water is a scarce resource in high demand by multiple sectors. Its availability is likely to become more erratic with potential shifts in precipitation with climate change. Understanding how watershed composition and configuration can affect the supply of water under changing climate scenarios can help policy makers coordinate multiple water-use demands from domestic, agriculture, industry, hydropower, conservation sectors. Using spatially explicit models of land use, cover types, soils and climate projections this model will calculate the amount of water that is produced and used from a watershed over a year time-frame and the amount available for local populations and downstream users.

Indicator Description: *Water Yield (cubic meters)*

This indicator estimates the annual average quantity of water produced by a watershed as measured as a single outflow point. The quantity of water produced by watersheds in each scenario is estimated from topographic data precipitation data, on average annual precipitation, annual reference evapotranspiration and a correction factor for vegetation type, root restricting layer depth, plant available water content, land use and land cover, root depth, elevation, saturated hydraulic conductivity, and consumptive water use.If a sub-watershed shapefile is provided, the quantity of water produced by each sub-watershed is calculated separately at their respective outflow points as well as at the entire watershed level. Results from each evaluated scenario are presented in Table C.

*\*Note: This model is based on annual precipitation averages, which neglect extremes and do not consider the temporal dimensions of water supply and hydropower production. Furthermore, the model does not consider the spatial distribution of land use land cover and complex land use patterns or underlying geology, which may induce complex water balances, may not be well captured by the model. Finally water transfers for irrigation, either between subbasins or between seasons, are not well captured by the model.*

Results: Of the evaluated scenarios, [scenario A] had the highest total water yield with [XX m3] provided across the evaluated watershed, and [scenario B] had the lowest total water yield with only [XX m3] of water produced on an annual basis.

Table C. Estimated Water Yield (m3) from watershed and sub-watersheds for evaluated scenarios

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Scenario | Total WatershedWater Yield | Sub-watershed [x] yield | Sub-watershed [x] yield | Sub-watershed [x] yield | Sub-watershed [x] yield |
| […] Current |  |  |  |  |  |
| BUA |  |  |  |  |  |
| Scenario 1 |  |  |  |  |  |
| Scenario 2 |  |  |  |  |  |

Secondary Indicator: *Potential Hydropower Capacity (kW/timespan)*

This secondary indicator estimates the value of the water yield for reservoir hydropower production using market value and production costs, the remaining lifetime of the reservoir, and a discount rate.It calculates the relative contribution of each land parcel to annual average water yield and production of hydropower, values this contribution in terms of energy production, and calculates the net present value of hydropower production over the life of the reservoir. The valuation model assumes that energy pricing is static over time.

Results:

Table D presents the amount of energy produced by the hydropower station and the value of this energy in economic terms over a specified timespan that is attributable to each watershed based on the water yield contribution for each scenario. Of the evaluated scenarios, [scenario A] had the highest energy [XX] and value [XX] produced across the watershed, and [scenario B] had the lowest energy [XX] and value [XX] produced over the XX year timespan evaluated.

Table D. Estimated total energy produced by the watershed and its economic value over the lifespan of the hydropower dam across evaluated scenarios

|  |  |  |
| --- | --- | --- |
| Scenario | Total energy produced (kW/timespan) | Value of energy produced (currency/timespan) |
| […] Current |  |  |
| BUA |  |  |
| Scenario 1 |  |  |
| Scenario 2 |  |  |

Default Maps:

*Spatially-explicit outputs of relative water yields can identify areas contributing the most to hydropower value and inform how changes in the landscape will alter that contribution. (From NatCap Website) - what are these?*

*For further details on this indicator and model please see the User Guide:* [*http://data.naturalcapitalproject.org/invest-releases/documentation/current\_release/reservoirhydropowerproduction.html#limitations-and-simplifications*](http://data.naturalcapitalproject.org/invest-releases/documentation/current_release/reservoirhydropowerproduction.html#limitations-and-simplifications)

*SEDIMENT RETENTION*

*Rationale:* Although point-sources of pollution (e.g. sewage, mine, or industry effluents) can be a major cause of water quality deterioration, non-point source pollution from agriculture, roads and land-use represents a very important contributor to water quality impairment, siltation, as well as loss of soil fertility. This is particularly true of agricultural landscapes where erosion sediments are a major input into aquatic ecosystems. Management of in-field agricultural practices and landscape configuration (vegetation buffers, riparian buffers, contour cropping) can reduce sediment loads in downslope water systems.

Indicator Description: *Avoided Sediment Inputs into Waterways (tn or %)*

This indicator estimates the amount of sediment entering waterways in comparison to bare soil values or relative to other evaluated scenarios. The indicator can also be modified to value the landscape in terms of water quality maintenance or avoided reservoir sedimentation, and determines how land use changes may impact the cost of sediment removal. Relative differences in avoided sedimentation between evaluated scenarios were estimated using the USLE equation for soil loss considering landscape topography, land cover and in-field management practices and are provided in Table E.

*\*Note: This model only accounts for sheet erosion, but does not consider other significant sources of sediment input such as rill or gully erosion. The model also depends on the USLE equation which might not be appropriate in all landscapes or soil types.*

Results: Of the evaluated scenarios, [scenario X] had the highest avoided sedimentation compared to bare soils with [XX Tn] of sediment retained on the landscape, and [scenario X] had the lowest avoided sedimentation with only [XX Tn] retained on the landscape.

Table E. Relative difference (%?) in avoided sedimentation for scenarios against bare soil and each other scenario evaluated

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Scenario | Bare Soil | Scenario 1 | Scenario 2 | Scenario 3 |
| […] Current |  |  |  |  |
| BUA |  |  |  |  |
| Scenario 1 |  |  |  |  |
| Scenario 2 |  |  |  |  |

Default Maps:

Difference in avoided sedimentation of each scenario to bare soil

User Selected Maps:

Difference in avoided sedimentation between user selected scenarios

*For further details on this indicator and model please see the User Guide:* [*http://data.naturalcapitalproject.org/invest-releases/documentation/current\_release/sdr.html*](http://data.naturalcapitalproject.org/invest-releases/documentation/current_release/sdr.html)

*NUTRIENT RETENTION CAPACITY*

Rationale: Water purification and removal of nutrients from overland flows of water by vegetation is an essential service provided by ecosystems. This is particularly important in agricultural landscapes where leaching of nutrients are a major input into aquatic ecosystems. High-levels of livestock manure and/or inorganic fertilizer application to farmed fields can cause leaching of nutrients from soils, contributing to elevated levels of nitrogen and phosphorus in nearby and downstream waterways. In some cases these inputs can impair water quality and cause eutrophication of these aquatic ecosystems. Use of riparian buffers, vegetation stips and ditching can help reduce excess nutrient inputs into waterways.

Indicator: *Nitrogen and Phosphorus export from / retention on Landscapes (kg)*

This indicator estimates the contribution of vegetation and soil to purifying water through the removal of nutrient pollutants from runoff. The model calculates the amount of nutrient retained on each pixel through filtration by the described terrestrial vegetation and sums nutrient export and retention per watershed. The pixel-scale calculations allows representation the heterogeneity of key driving factors in water yield such as soil type, precipitation, and vegetation type. Results from each evaluated scenario are presented in Table F.

*\*Note: This model does not address any chemical or biological interactions or instream processes that may occur from the point of loading to the point of interest besides filtration by terrestrial vegetation. The model was developed for watersheds and landscapes dominated by saturation excess runoff hydrology, it may be less applicable to locations where the hydrology is determined by rainfall intensity.*

Results: Of the evaluated scenarios, [scenario X] had the lowest nutrient export from the landscape with only [XX kg] exported into waterways across the landscape, and [scenario X] had the highest nutrient export with [XX kg] reaching waterways within the landscape.

Table E. Total amount of Nitrogen and Phosphorus (kg) retained on landscapes by vegetation and amount exported into landscape waterways in evaluated scenarios

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Scenario | Exported Nitrogen (kg) | Export Phosphorus (kg) | Nitrogen Retention (kg) | Phosphorus Retention (kg) |
| […] Current |  |  |  |  |
| BUA |  |  |  |  |
| Scenario 1 |  |  |  |  |
| Scenario 2 |  |  |  |  |

Default Maps:

*Maps of N and P export for each scenario (as compared to a baseline)*

User Selected Maps:

*For further details on this indicator and model please see the User Guide:* [*http://data.naturalcapitalproject.org/invest-releases/documentation/current\_release/waterpurification.html*](http://data.naturalcapitalproject.org/invest-releases/documentation/current_release/waterpurification.html)

*POLLINATION*

Rationale: Seventy-five percent of globally important crops rely either in part or completely on animal pollination, in particular most high economic and nutritional-value fruit and vegetable crops. Much of this pollination is supplied by wild bees (in addition to other wild insects, bats and birds) and can constitute a significant economic contribution to farmer livelihoods. These crops are important not only from a yield perspective, but also from a food security lens as vegetables and fruits supply the bulk of the vitamins (A, C, D, E) and minerals needed for a healthy diet. However, habitat loss (in addition to chemical use) can be a major contributing factor to loss of pollinator species in landscapes resulting in lowered crop yields at the farm level as distance from natural habitat types to crops increases. Where natural pollinations are already falling off or insufficient to meet crop demands, farmers are paying to rent reared bee colonies to improve yields. However, good land management practices which provide nesting and foraging habitats throughout the year for bees (forest, grasslands, etc) which are intermixed with croplands can help maintain a robust population of pollinators and pollination services.

Indicator: *Index of wild bee abundance and crop visitation (per pixel)*

This indicator estimates the likely abundance of pollinator (summed across all guilds) species nesting across each pixel of the landscape on each cell in the landscape, given the availability of nesting sites and of flower (food) resources nearby; and the likely abundance of pollinators on each agricultural cell in the landscape, based on the average of all bee species or guilds. It represents the likely average abundance of pollinators visiting each farm site. The model uses information on the availability of nesting sites and flower resources defined by the LULC map and species preferences, as well as flight ranges of bees, to map an index of bee abundance across the landscape. The model uses this map and bee flight ranges again to predict an index of the number of pollinators likely visiting crops in each agricultural cell on the landscape.

*\*Note: The model’s limitations include exclusion of non-farm habitats that may determine pollinator abundance and of the effects of land parcel size. The model also does not account for managed pollinators, pollinators other than bees nor pollinator persistence over time.*

Results: Maps

*Default Maps:*

*Pollinator visitation abundance on agricultural cells for each scenario*

*Pollinator nesting abundances on all cells for each scenario*

*User Selected Maps:*

*Difference in visitation abundance on agricultural cells for selected scenarios*

*Difference in nesting abundance on agricultural cells for selected scenarios*

*For further details on this indicator and model please see the User Guide:*

<http://data.naturalcapitalproject.org/invest-releases/documentation/current_release/croppollination.html>