Supplementary Material I: Methods

The variables used in this study were acquired from different sources, reflecting different scales of measurement. This required many data preparation steps. This document is dedicated to clarifying these steps in detail.

A) LULC for Urban Configuration and Nature Conservation indicators

We acquired two Landsat Collection 1 Higher-Level Surface Reflectance images (formerly known as Landsat Climatic Data Record images) distributed by the U.S. Geological Survey (USGS), covering the entire study area (path 76 and path 77, row 220, WRS-2 reference system, https:// earthexplorer.usgs.gov/). To avoid variation caused by vegetation phenology and changes in solar geometry, which could be detected as false cover changes (Kennedy et al., 2010), we favoured images from the dry season of each year (May to August): one image from the Landsat 5 Thematic Mapper (TM) sensor on 2005-05-15, and one image from the Landsat 8 Operational Land Imager (OLI) sensor on 2015-08-15. We collected 100 samples for forest cover, 100 samples for built-up cover and 100 samples for other classes. We then classified these three classes of land cover at each image date using the *Support Vector Machine* (SVM) supervised algorithm (Hsu et al., 2003), using ENVI 5.0 software.

Land-use and land-cover changes from 2005 to 2015 were quantified using map algebra, by mathematically adding them together in pairs (10*LULC2015 + LULC2005). We reclassified the LULC data into forest gain (conversion of any 2005 LULC to forest cover in 2015); forest persistence (2005 forested pixels that remained forested in 2015); new built-up area (conversion of any 2005 LULC to built-up in 2015); and urban maintenance (2005 built-up pixels that remained built-up in 2015).

Land-use land-cover maps were used to classify the observed built-up expansion patterns in the analysed municipalities, following the method of Inostroza et al. (2013). First, we identified the largest patch containing the central business district (CBD) of each municipality as the contiguous urban fabric in the year 2005. Second, each new pixel appearing in the year 2015 was classified as infill, axial or isolated following a set of simple rules:

- New built-up pixels having 2 or more neighbouring built-up pixels in the year 2005 were classified as infill.
- New built-up pixels having one neighbouring built-up pixel in the year 2005 were classified as axial.
- New built-up pixels located 500 m or closer to the main road axes were classified as axial.
- New built-up pixels without neighbouring built-up pixels in the year 2005 were classified as isolated.

New built-up pixel classification and geoprocessing was done using ArcGis10 ©.

To assess the classification accuracy, we used high resolution images available on the GoogleEarthTM platform for the visual classification of validation points relative to the use and cover map produced for 2015. Forty random points for each class were randomly generated to construct the confusion matrix (Congalton, 1991). From the matrix, global accuracy, global and class Kappa Index, and omission and commission errors (Congalton 1991) were calculated. The classification performed for 2015 showed a Kappa coefficient of 0.86 and overall accuracy of 90.8%. The results of Kappa index by class and the errors of omission and commission are shown in Table A. Thus, the performance of the land use and land cover classification presented here was considered satisfactory.

Table A. Producer accuracy, *Kappa* Index and omission and commission errors per class.

Classes	Producer accuracy	*Kappa*	Var (*Kappa*)	Omission error	Commission error
Forest	1,00	0.89	0,00	0,00	0,007
Build-up	0.90	0,78	0,01	0,11	0,15
Others	0.85	0,92	0,01	0,16	0,05

B) Spatial plans and land-use strategies:

The official limits of the Ecological-Economic Zoning (EEZ) were provided in vector format by the Forestry Foundation of São Paulo and by the São Paulo State Environmental Planning Division (CPLA-SP). The official limits of the Ilhabela and Ubatuba master plans were provided by the Ilhabela and Ubatuba municipalities. We generated presence–absence raster files for each strategic zone (30 m resolution) in QGIS 3.10 software. The zones were grouped into common dominant land-use strategies (Figure B), as detailed in Table B.

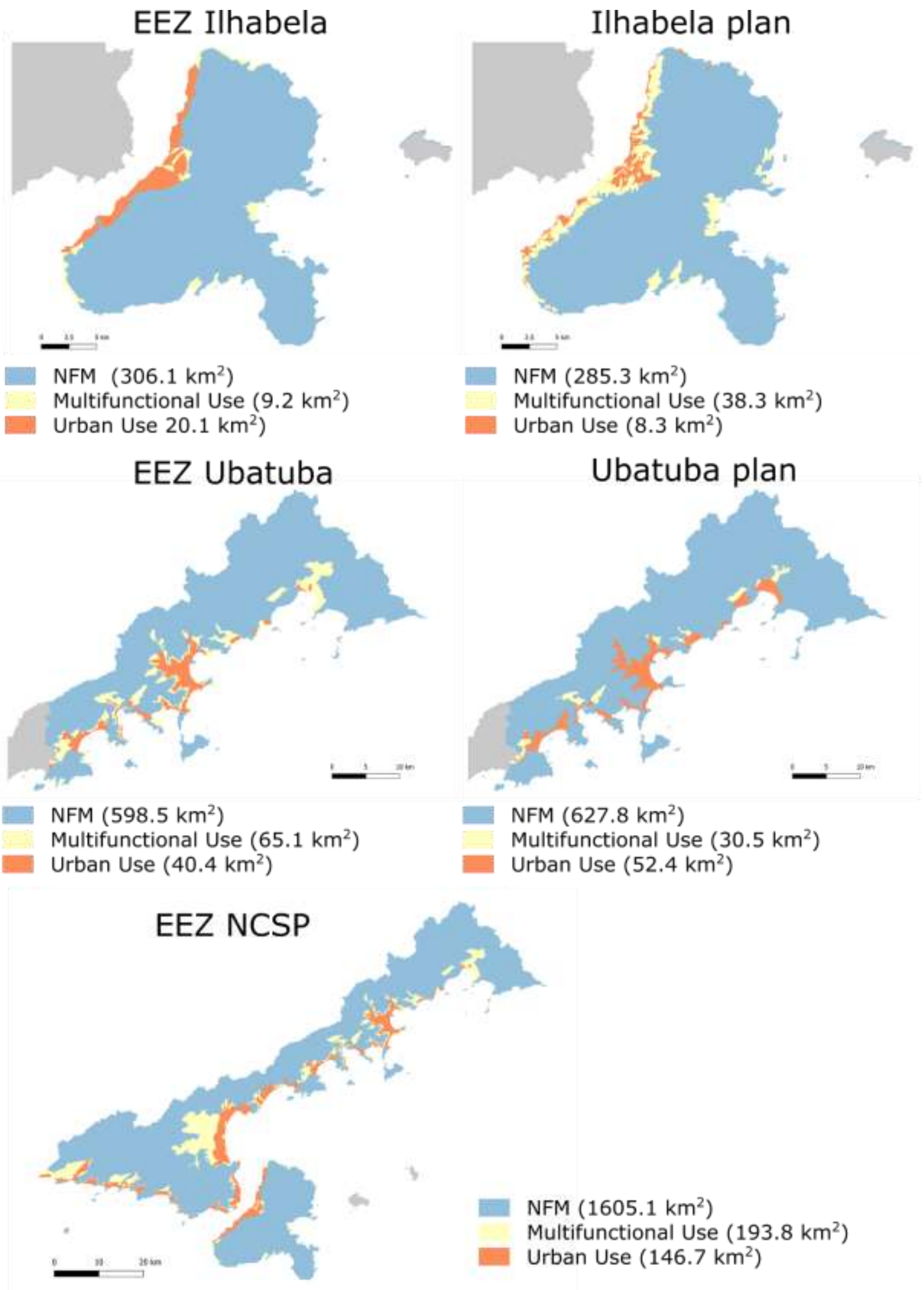

Figure B. Land-use strategies at the regional and municipal scale. Areas are calculated per land-use strategy in both contexts. Abbreviations: EEZ = Ecological-Economic Zoning; NFM = Native Forest Maintenance.

Dominant land-use strategy	Land-use strategy description	Variables and expected correlation	Indicators and expected correlation
Protected areas and native forest maintenance (NFM)	Goal: Zones designated to support forest and ecosystem conservation, ecosystem restoration. Allowed: visiting for educational and research purposes, very restricted changes for the mentioned purposes.	Forest persistence (++) forest gain (+) NDVI increase (+)	Nature Conservation (++)
Multifunctional use	Goal: Zones designated to support multiple land uses; restricted build-up is allowed, but nature conservation and sustainable uses are encouraged: 1) Conservation and/or restoration: natural resources, ecosystem characteristics and water supply. 2) Landscape heritage conservation, traditional territories, residential areas, rural uses and rural villages. Allowed: The same as the NFM strategy + agriculture, aquiculture, and restricted new built-up areas for residence, urban services, rural villages and tourist accommodation. Recommendation: develop tourism, improve connectivity between settlements and locate housing near the transportation network, increase public/basic services.	Forest persistence (+) forest gain (0) NDVI increase (0) Urban persistence (0) Urban infill (0) Urban axial (+) Urban isolated (+) Permanent housing density increase (?) Waste service increase (+) Sanitation service increase (+) Water service increase (+)	Nature Conservation (+) BSH (+) Urban configuration (+)
Urban use	Goal: Zones designated to support efficient urban development, accessibility, urban services, residential housing development, tourism development.	Urban persistence (++) Urban infill (++) Urban axial (++) Urban isolated (+)	BSH (++) Urban configuration (++)

	Recommendations: increase basic services (mandatory), increase housing with social interest near the transportation network, improve connectivity and the development of more compact cities, contain urban sprawl. Priority for 2001 City Statute development	Permanent housing density increase (++) Waste service increase (++) Sanitation service increase (++) Water service increase (++)	

Table B. Land-use strategies and variables used for evaluation. Information from the zones' descriptions for each evaluated plan are summarized. BSH = Basic Service and Housing indicator. The expected correlations are given: (++) = positive and very strong; (+) = positive; (0) = no correlation, (-) negative.

C) Federal Census data organization: Urban Basic Services and Housing indicator, socioeconomic and population:

Regarding Federal Census data, we arranged the information for each sector/area in a table. We added this information to a vector file provided by the Brazilian Institute of Geography and Statistics (IBGE), with the spatial limits of the census sectors for 2000 and 2010. The variables related to numbers per census sector were transformed into density, i.e. population and housing. For each census sector area, we calculate the population and housing density for a pixel size of 30 m, which gave us a value of population/housing number per 30 m pixel. Regarding the percentage data, i.e. alphabetization and basic services provision, we rasterized them to a 30 m pixel raster, and assumed that all pixels inside each census area have the same value. The Federal Census occurred only in 2000 and 2010. Annual rates of change were calculated for 2005–2015 to allow comparability between LULC periods. The Human Develop Index is available at a municipality level. We attributed the HDI for the vector file with the municipality border, and we rasterized (30 m resolution) this file in QGIS and therefore used it only for the EEZ models.

Supplementary Material II: Results

Partial Least Squares Path Modelling (PLS-PM) using the “plspm” package in R generates additional results that might help the reader to better understand the proposed framework and respective results. This section is dedicated to illustrating in detail the Partial Least Squares Path Modelling (PLS-PM) statistics and Bootstrapping validation test results (D). Further, we provide the isolated areas results per strategy in order to enrich the discussion.

D) **Partial Least Squares Path Modelling (PLS-PM) statistics and bootstrapping validation test results:** relationships between land-use strategies and indicators, and drivers and indicators

Relationship	Coefficient	Mean.Boot	Std.Error	Pr(>|t|)
EEZNFM -> nature	0.39031	0.39034	0.000831	0.00e+00***
EEZmult -> nature	-0.10036	-0.10029	0.001183	0.00e+00***
EEZmult -> BSH	0.29072	0.29067	0.000835	0.00e+00***
EEZmult -> urban	0.10399	0.10400	0.000900	0.00e+00***
EEZurb -> BSH	0.39433	0.39435	0.000944	0.00e+00***
EEZurb -> urban	0.64583	0.64588	0.001125	0.00e+00***
Socioeconomic -> nature	-0.06499	-0.06500	0.000678	0.00e+00***
Socioeconomic -> BSH	0.38732	0.38733	0.000512	0.00e+00***
Socioeconomic -> urban	-0.00108	-0.00108	0.000343	0.007
Population -> nature	-0.11789	-0.11791	0.000891	0.00e+00***
Population -> BSH	0.13052	0.13053	0.000849	0.00e+00***
Population -> urban	0.10183	0.10180	0.001331	0.00e+00***
Topography -> nature	0.15569	0.15573	0.000711	0.00e+00***
Topography -> BSH	-0.03744	-0.03745	0.000609	0.00e+00***
Topography -> urban	-0.06409	-0.06410	0.000530	0.00e+00***

Table D1. Partial Least Squares Path Modelling (PLS-PM) statistics for Ecological-Economic Zoning (EEZ). Abbreviations: NFM = Native Forest Maintenance strategy; multi = Multifunctional Use strategy; urb = Urban Use strategy; nature = Nature Conservation indicator; BSH = Basic Services and Housing indicator; urban = Urban Configuration indicator; Coefficient= coefficient of correlation between the evaluated relationships; Mean.Boot = bootstrapping mean with 1000 samples; Std.Error = standard error; Pr(>|t|) = p-value, with p-value <0.05 *; p-value <0.01 **; p-value <0.001 ***.

Relationship	Coefficient	Mean.Boot	Std.Error	Pr(>|t|)
IBNFM -> nature	0.2196	0.2196	0.00479	0.00e+00***
IBmult -> nature	-0.0158	-0.0141	0.00893	3.07e-53***
IBmult -> BSH	0.3709	0.3377	0.15369	0.00e+00***
IBmult -> urban	0.1382	0.1257	0.05766	0.00e+00***
IBurb -> BSH	0.2671	0.2672	0.00279	0.00e+00***
IBurb -> urban	0.4258	0.4259	0.00503	0.00e+00***
Socioeconomic -> nature	0.1982	0.1981	0.00410	0.00e+00***
Socioeconomic -> BSH	-0.4248	-0.4246	0.00254	0.00e+00***
Socioeconomic -> urban	-0.0632	-0.0632	0.00209	3.47e-164***

Population -> nature	-0.2150	-0.2150	0.00270	0.00e+00***
Population -> BSH	0.0557	0.0558	0.00235	7.28e-250***
Population -> urban	0.2206	0.2205	0.00476	0.00e+00***
Topography -> nature	0.0879	0.0878	0.00217	0.00e+00***
Topography -> BSH	-0.0492	-0.0492	0.00142	9.56e-244***
Topography -> urban	-0.0600	-0.0599	0.00173	6.48e-196***

Table D2. Partial Least Squares Path Modelling (PLS-PM) statistics for Ilhabela (IB) Master Plan. Abbreviations: NFM = Native Forest Maintenance strategy; multi = Multifunctional Use strategy; urb = Urban Use strategy; nature = Nature Conservation indicator; BSH = Basic Services and Housing indicator; urban = Urban Configuration indicator; Coefficient = coefficient of correlation between the evaluated relationships; Mean.Boot = bootstrapping mean with 1000 samples; Std.Error = standard error; Pr(>|t|) = p-value, with p-value <0.05*; p-value <0.01**; p-value <0.001***.

Relationship	Coefficient	Mean.Boot	Std.Error	Pr(>|t|)
UBANFM -> nature	0.30140	0.30136	0.001154	0.00e+00***
UBAmult -> nature	0.00358	0.00352	0.001808	0.00101**
UBAmult -> BSH	0.07506	0.07504	0.001321	0.00e+00***
UBAmult -> urban	0.06065	0.06070	0.001462	0.00e+00***
UBAurb -> BSH	0.29706	0.29715	0.001856	0.00e+00***
UBAurb -> urban	0.50590	0.50595	0.002438	0.00e+00***
Socioeconomic -> nature	-0.04938	-0.04935	0.000993	0.00e+00***
Socioeconomic -> BSH	0.37584	0.37588	0.001012	0.00e+00***
Socioeconomic -> urban	0.00124	0.00125	0.000789	0.175
Population -> nature	-0.17908	-0.17899	0.002030	0.00e+00***
Population -> BSH	0.20791	0.20776	0.001900	0.00e+00***
Population -> urban	0.15884	0.15867	0.003043	0.00e+00***
Topography -> nature	0.18659	0.18658	0.001147	0.00e+00***
Topography -> BSH	-0.06211	-0.06214	0.000932	0.00e+00***
Topography -> urban	-0.08139	-0.08139	0.000848	0.00e+00***

Table D3. Partial Least Squares Path Modelling (PLS-PM) statistics for Ubatuba (UBA) Master Plan. Abbreviations: NFM = Native Forest Maintenance strategy; multi = Multifunctional Use strategy; urb = Urban Use strategy; nature = Nature Conservation indicator; BSH = Basic Services and Housing indicator; urban = Urban Configuration indicator; Coefficient = coefficient of correlation between the evaluated relationships; Mean.Boot = bootstrapping mean with 1000 samples, Std.Error = standard error; Pr(>|t|) = p-value, with p-value <0.05*; p-value <0.01**; p-value <0.001***.

E) Urban isolated areas

	Km^2	% of total isolated		Km^2	% of total isolated		Km^2	% of total isolated
EEZurb	4.35	16.00	IBurb	0.4	19.61	UBAurb	1.57	19.15
EEZmult	12.03	44.26	IBmult	1.31	64.22	UBAmult	1.01	12.32
EEZNFM	10.8	39.74	IBNFM	0.33	16.18	UBANFM	5.62	68.54
Total of isolated area	27.18			2.04			8.2	

Table E. Urban isolated area classification. Abbreviations: NFM = Native Forest Maintenance strategy; multi = Multifunctional Use strategy; urb = Urban Use strategy.

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