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What Factors can Influence the Expansion of Protected Areas around the World in the Context of International Environmental and Development Goals?

Jakie czynniki mogą wpływać na poszerzanie obszarów chronionych na świecie w kontekście międzynarodowych celów środowiskowych oraz rozwojowych

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Abstract
The protection of biodiversity is an integral part of sustainable development. All the major international environmental and development programs – Aichi Biodiversity Targets, Millennium Development Goals and Sustainable Development Goals – have committed countries to conserving valuable ecosystems by ensuring that a certain proportion of their terrestrial and marine areas are protected. While many countries have registered improvements in their coverage of protected areas, a significant number are behind in their targets. This paper attempts to shed light on the role of various factors in nature conservation which go beyond the performances of individual countries. Regression analyses were performed on variables that could influence the coverage of protected areas. The main findings point to the significance of economic development, whereas other factors remain less relevant. Although the level of economic development corresponds to the protected areas on an individual country level, it does not automatically ensure a slowdown in biodiversity loss.

Key words: protected area, biodiversity, environmental indicator, sustainable development, Millennium Development Goals, Sustainable Development Goals, Aichi Biodiversity Targets

Streszczenie
Ochrona bioróżnorodności jest nieodłączną częścią zrównoważonego rozwoju. Wszystkie znaczące międzynarodowe programy ekologii i rozwoju – Cele Aichi (Aichi Biodiversity Targets), Milenijne Cele Rozwoju (Millennium Development Goals) oraz Cele Zrównoważonego Rozwoju (Sustainable Development Goals) – zobowiązały kraje do ochrony cennych ekosystemów poprzez zapewnienie, że pewne części ich lądowych oraz morskich obszarów będą podlegały ochronie. Wiele krajów zanotowało wzrost zasięgu ich obszarów chronionych, jednak wiele innych nie osiąga zamierzonych celów. Niniejszy artykuł koncentruje się na ogólnej próbie analizy różnych czynników wpływających na ochronę środowiska związanych z ochroną środowiska. Wykorzystano analizę regresji zastosowaną wobec zmiennych, które mogą wpływać na przyjmowaną powierzchnię obszarów chronionych. Przeprowadzone badania wskazują na znaczącą rolę rozwoju ekonomicznego, podczas gdy inne czynniki wydają się mniej znaczące. Chociaż stopień rozwoju ekonomicznego odpowiada wielkości chronionych obszarów na poziomie poszczególnych krajów, nie oznacza to automatycznie spowolnienie tempa ubytku bioróżnorodności.

Słowa kluczowe: obszar chroniony, bioróżnorodność, wskaźnik środowiskowy, Milenijne Cele Rozwoju, Cele Zrównoważonego Rozwoju, Cele Aichi

Introduction

This paper focuses on using the coverage of protected areas as an environmental indicator in the context of sustainable development. Biodiversity conservation is an important part of the environmental component of the concept of sustainable development (UN, 1992), and it interacts with the economic and social dimensions of sustainable development (Giddings et al., 2002). Protected areas are seen by many conservationists as a key tool in biodiversity conservation (Saout et al, 2004; Naughton-Treves et al., 2005), moreover they may help to maintain food security and water supplies, strengthen climate resilience and improve human health and well-being (IUCN, 2015). Despite this, the socio-economic benefits generated by protected areas remain controversial and under debate (Adams et al., 2004; Naughton-Treves et al., 2005, Brockington, Wilkie, 2015). Because the loss of biodiversity is recognized by the international community as one of the most serious global environmental threats (the United Nations General Assembly declared 2011-2020 the *United Nations Decade on Biodiversity* (CBD, 2010), it is not surprising that the coverage of protected areas is a widely used indicator of sustainable development (Chape et al., 2005, IUCN, 2010). Probably the most recognized definition of a protected area is provided by the International Union for the Conservation of Nature – an international organization working in the field of nature conservation and sustainable use of natural resources. According to this organization, a protected area is a *clearly defined geographical space, recognised, dedicated and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values* (Dudlay, 2008:8).

The Millennium Development Goals and the *Sustainable Development Goals* include the coverage of protected areas indicators. *The Millennium Development Goals* contain indicator no. 7.6, *Proportion of terrestrial and marine areas protected* within Target 7.B. (UN, 2015a). The indicator focuses on changes in the proportion of protected areas – however, because it does not set any measurable goals, the rate of change is non-essential. *The Millennium Development Goals Report* is largely positive concerning the performance within the 7.6 indicator. Indeed, many regions have significantly increased their terrestrial protected areas since 1990. Globally, 15.2 per cent of terrestrial and inland water areas, and 8.4 per cent of coastal marine areas (up to 200 nautical miles from shore) were protected in 2014 (UN, 2015a).

Sustainable Development Goals (officially known as *Transforming our World: the 2030 Agenda for Sustainable Development*) only use the *coverage of protected area* indicator for marine areas within Goal 14. Target 14.5 commits countries to, *By 2020, conserve at least 10 per cent of coastal and marine areas, consistent with national and international law, and based on the best available scientific information* (UN, 2015b). Apart from quantitative aspects, the SDGs put more emphasis on the quality of biodiversity conservation in this target, and it is done through the standardization of rules and science-based management. While Goal 14 deals with *life below water*, Goal 15 is focused on *life on land*. The first Target, 15.1 states that countries will, *By 2020, ensure the conservation, restoration and sustainable use of terrestrial and inland freshwater ecosystems and their services, in particular, forests, wetlands, mountains and drylands, in line with their obligations under international agreements* (UN, 2015b). Therefore the target does not come with a measurable indicator for terrestrial ecosystems; instead it commits countries to fulfil their obligations under international agreements.

The Strategic Plan for Biodiversity is an important international agreement in relation to nature conservation and protected areas. The plan was adopted by Parties to the United Nations *Convention on Biological Diversity* (CBD) in Japan in 2010 (Pereira et al., 2013) and it contains 20 *Aichi Biodiversity Targets* organized under five strategic goals. Target 11 postulates that *By 2020, at least 17 per cent of terrestrial and inland water, and 10 per cent of coastal and marine areas, especially areas of particular importance for biodiversity and ecosystem services, will be conserved. This is to be done through a number of effectively and equitably managed, ecologically representative and well connected systems in protected areas, along with other effective and area-based conservation measures, all integrated into the wider landscapes and seascapes* (CBD, 2010). Therefore Target 11 of the *Aichi Biodiversity Targets* can be used as a benchmark for the SDGs Target 15.1, which is, in itself, an important international commitment.

In order to structure and analyse indicator sets, many organizations now use the driving force-pressure-state-impact-response (DPSIR) framework (Mace, Baillie, 2007). The indicator *coverage of protected areas* can be classified, according to its place in the DPSIR framework, as a response indicator (Butchart et al., 2010), measuring the effectiveness and impact of policy and management responses (Walpole, 2009). In other words, it measures political commitment to biodiversity conservation and does not provide information on *effectiveness* in conserving biodiversity (Chape et al, 2005). Although the actual performance of and future trends regarding the indicator *coverage of protected areas* have been described (UN, 2005a; Butchart et al, 2010), there is little knowledge of the factors which influence changes (either positive or negative) in the coverage of protected areas. In the literature, more attention is paid to the factors that affect the success of biodiversity conservation in national parks and other protected areas (Bruner et al., 2001; Leverington, 2010). Knowledge concerning the actual performance of

Table 1. Frequency distributions of protected areas in 1990 and 2012 (source: own elaboration)

PAcoverage (%)	Number of countries in 1990	Relative distribution in 1990 (%)	Number of countries in 2012	Relative distribution in 2012 (%)
0-1	46	23.00	23	11.39
1-5	59	29.50	41	20.30
5-10	37	18.50	29	14.36
10-15	28	14.00	27	13.37
15-20	15	7.50	29	14.36
20-30	7	3.50	33	16.34
30-40	6	3.00	12	5.94
over 40	2	1.00	8	3.94
Total	200	100.00	202	100.00

Table 2. Regional aspect of terrestrial protected areas in 1990 and 2014 (source: own elaboration)

Region	1990	2014	Difference	Growth Rate
Caucasus and Central Asia	2.70	4.60	1.90	170%
Oceania	2.00	5.00	3.00	250%
Southern Asia	5,40	6.80	1.40	126%
Northern Africa	2.70	7.70	5.00	285%
South-Eastern Asia	8.40	14.00	5.60	167%
Sub-Saharan Africa	10.60	15.30	4.70	144%
Western Asia	3.70	15.40	11.70	416%
Eastern Asia	12.00	16.80	4.80	140%
Latin America and the Caribbean	8.80	23.40	14.60	266%

Table 3. Terrestrial and marine protected areas in 2012 and achievement of SDGs and Aichi Biodiversity targets (source: own elaboration)

	Terrestrial protected areas (17 % target[1])		Marine and coastal protected areas (10 % target[1,2])	
PAcoverage (%)	Number of countries	Cumulative distribution	Number of countries	Cumulative distribution
0-1	13	6.50	38	24.68
1-5	35	24.00	48	55.84
5-10	26	37.00	17	66.88
10-17	47	60.50	19	79.22
17-30	52	86.50	13	87.66
30-50	24	98.50	10	94.16
50-75	3	100.00	5	97.40
over 75	0	100.00	4	100.00
Total	200		154[3]	

[1] Aichi target, [2] SDGs target, [3] There are 46 landlocked countries in the world

protected areas in biodiversity conservation at a local level is undoubtedly important, but it does not provide useful information about factors critical to the success or failure of achieving an increase the coverage of protected areas worldwide. This paper attempts to shed light on the role of various factors behind the performance of individual countries in establishing or enlarging their protected areas. To address the issue, we performed a regression analysis on variables that could influence the coverage of protected areas.

Protected areas in the world: statistical overview

The following section provides a basic statistical overview of the performance of countries in fulfilling the three international development and environmental goals – *Millennium Development Goals*, *Sustainable Development Goals* and *Aichi Biodiversity Targets*. Starting with *Millennium Development Goals*, the average value of protected area coverage in 1990 (the baseline) was 7.51%. The performance of the investigated countries had changed considerably by 2012, by which time the coverage had almost doubled to an average value of 13.92%. At the same time, differences among countries increased. The worst performers (Sao Tome and Prince Island) had a rate of protected area on their territories lower than 0.01%, four countries' protected areas were below 0.1% (Aruba, Barbados, Jordan and the Federal States of Micronesia) and twenty three countries' had less than 1%. In contrast, twenty countries achieved the threshold of 40% and the eight best performing countries (Germany, Greenland, Hong Kong, Lichtenstein, Monaco, Namibia, Slovenia and Venezuela) protected more than 50% of their territory. The detailed distribution from 1990 and 2012 is displayed in Table 1.

In rare cases, a decrease in the proportion of protected areas has been documented; the biggest drop occurred in the case of Jordan. All other countries witnessed either stagnation or a rise in their protected area network. In 47 countries the number of protected areas increased by more than 10 percentage points. Additionally, 13 of those countries increased their protected areas by 20 percentage points and 4 (Bulgaria, Monaco, Namibia and Slovenia) increased theirs by 30 percentage points or more.

From a regional perspective, progress in the protection of terrestrial protected areas can be found in every region of the world, but some regions performed better than others. In Latin America and the Caribbean, the protected areas grew from 8.8% in 1990 to 23.4% in 2012. Similarly, Western Asia's protected areas quadrupled from 3.7% to 15.4%. The protection of marine and coastal areas increased the most in Oceania, where there were no protected areas in 1990 and by 2012 that had changed to 7.4% of marine and coastal areas being protected. The performances of various regions are listed in table 2.

In September 2015 the UN member states adopted 17 *Sustainable Development Goals* after the expiration of the MDGs. SDGs are part of a wider 2030 Agenda for Sustainable Development and form an integrated framework of linked and mutually reinforcing goals. Moreover, SDGs can also be seen as a paradigm shift (Lebeda, 2015). Although the environmental dimension to SDGs has been significantly strengthened compared to the previous MDGs agenda (Hajer et al., 2015). It sets measurable targets only for marine areas (Target 14.5 commits countries to conserve at least 10 per cent of coastal and marine areas by 2020) (UN, 2015b). This deficiency however, can be overcome by the inclusion of Aichi Biodiversity Targets, which set the tangible threshold at 17% of terrestrial and inland water, and 10% of coastal and marine areas (CBD, 2010). In 2012, some 79 countries (39.5%) achieved the Aichi target for terrestrial areas, and 51 countries (33.12%) complied with the targets for marine and coastal areas (see Table 3).

When comparing the average size of terrestrial and marine protected areas, it is not surprising that the latter (marine and coastal areas) are larger. The best performing countries protect almost all of their marine and coastal areas; Slovenia (98.42%), Bosnia and Herzegovina (99.21%) and Monaco (99.99%). However, we should recognise that their marine and coastal areas are small in absolute terms. Nevertheless, there are also examples of good performers whose marine and coastal areas are relatively large, but they are still able to provide protection to a significant part of them, i.e. the Netherlands (61.82%), Germany (64.46%) and Ecuador (75.66%).

Regression analyses: data, variables and results

In this section we attempt to find whether economic, social, environmental or institutional factors are associated with the proportion of protected areas in the countries of the World. Therefore we have performed two regression analyses. The cross-sectional regression analysis should explain which factors influence the proportion of protected areas in a cross-section of countries (from 2012; the most up-to-date data). The panel regression will allow us to analyze not only the variability of protected areas among countries, but also their variability over time in the period under study (i.e. 1990-2012).

Data and variables

Our dependent variable is the proportion of protected areas (terrestrial and marine combined) in the total area of countries. Since it is a proportion that varies between zero and one, we have transformed this variable through a logit transformation to take its bounded nature into account. The data for countries for the period 1990-2012 were obtained from the World Bank's database *World Development Indicators* (World Bank, 2016a).

We are interested in a possible association between various indicators of development and the proportion of protected areas. Therefore our main explanatory variables measure the level of development in different dimensions. Dietz and Adger (2003) show in their analysis that the extent of government environmental policy increases with economic development. Because nature conservation and the establishment of protected area networks are part of a state's environmental policies, we should expect the wealthier countries to have the higher share of protected areas. The level of economic development is measured by gross national income (GNI) in per capita terms (atlas method, current USD). The data were acquired from the *World Development Indicators* database (World Bank, 2016a).

The level of social development is approximated by two indicators – the mean years of education and the *Human Development Index* (HDI). HDI is a composite indicator that consists of two sub-indices of education (expected years of education and mean years of education), one sub-index of health (life expectancy at birth) and one sub-index of standard of living (gross national income per capita). Although HDI measures the level of human development, it is evident from its composition that it can also be used as an approximation of social development. Data for both indicators were obtained from the *United Nations Development Programme* (UNDP) *Human Development Report Database* (UNDP, 2016). Due to data unavailability it was not possible to include other explanatory variables that the authors were interested in, such as indicators of poverty (poverty headcounts) and income inequality (Gini coefficient).

In the development and environmental literature the quality of institutions is considered to be one of the determinants of successful biodiversity conservation processes (Smith et al., 2003). We approximate the level of institutional development by three indicators. First, we used the average of six indices from the *Worldwide Governance Indicators* (WGI) that measure institutional quality in six dimensions: voice and accountability, political stability and absence of violence, government effectiveness, regulatory quality, rule of law, and absence of corruption. Each of the six indices has values from –2.5 to 2.5, with higher values indicating better performances. Data for these indicators were acquired from the WGI World Bank's website (World Bank, 2016b). Second, we used the Index of Freedom calculated by the organization Freedom House as the average of two indicators that measure the level of civil liberties and political rights in a country. The index can have values from 1 to 7 and the lower the index, the better the quality of a country's institutions (Freedom House, 2016). Third, we used the Heritage Foundation´s Index of Economic Freedom (IEF) as an approximation of institutional quality. The index can have values from 1 to 100 with higher values indicating a better quality of institutions (Heritage Foundation, 2016).

Our control variables include the total area, total population and population density of countries, the proportion of people living in urban areas and the proportion of forest areas in the total area of the countries. Data for all these variables were obtained from the World Development Indicators database (World Bank, 2015). As for the proportion of forest variable, the literature suggests (see, for instance Joppa and Pfaff, 2009; Jenkins et al., 2015) that countries tend to protect forested territories in remote areas, unsuitable for agriculture and other human activities. For instance, the USA protects very large areas of its dry, mountainous west – and very little else (Joppa, Pfaff, 2009). It is therefore reasonable to expect that countries with a higher proportion of forests will also have a higher percentage of protected areas.

Apart from the proportion of forest areas, we have decided to incorporate other variables that roughly approximate the differences in land use structure among countries. This is because some types of habitats might constitute a significant factor for biodiversity conservation (Hoekstra, Boucher, 2005). To control this influence in our regressions, we have included variables of land use acquired from the FAO GeoNetwork database (FAO, 2016). Through a series of geospatial analysis operations conducted in ArcGIS 10.3., we have determined the proportion of main land use types for each country. These types were further aggregated into the following four groups of land use/land cover (LULC), partly according to EPI categories (Yale University, 2016) and partly arbitrarily: grassland and shrubs (as those with a higher chance of being protected); wetlands (as a special type of land use); cropland and urban land (land use types directly shaped by human economic activity) and other types of land use (aggregation of sparsely vegetated areas, bare areas and open water areas). With the latter type of land use – sparsely vegetated areas, bare areas – we can expect a similar pattern to the forests. According to Joppa and Pfaff (2009), the common phrase *rock and ice* summarizes the perception that protected area locations are biased towards marginal (arid, rocky, icy) lands. It may be financially expedient and politically pragmatic to protect such land that has a low financial value (Ando et al, 1998). After these adjustments, we have a total of five land use variables (including the proportion of forest areas). The aggregation has been done to reduce the number of variables entering the regressions.

We have also included a dummy variable to control for any form of a country's membership in IUCN (IUCN, 2010). Protected areas should benefit from their countries' IUCN membership because the organization is committed to the protection of biodiversity and supports the expansion of protected areas among its members (IUCN, 2017).We have also identified other variables that could potentially have an impact on the dependent variable (such as the GEF index for biodiversity and the IUCN Red List Index). However, the problem with these variables was the unavailability of data, therefore we decided not to include them in our regression models.

Cross-sectional regression

We transformed the dependent variable as described above and applied logarithmic transformations to some of the regressors (GNI, population and area). We included the (logged) average of GNI per capita to smooth the fluctuation of this variable in time, and to increase the number of observations available. We used the standard OLS estimation technique for cross-sectional data. It is possible to summarize the model of our interest in terms of a general equation as

$$E(\textit{proportion of protected areas}) = \alpha + \beta_1(\textit{economic/institutional/social development}) + \beta_2(\textit{population/area/density}) + \beta_3(\textit{forest area}) + \beta_4(\textit{grassland and shrubs}) + \beta_5(\textit{cropland and urban land}) + \beta_6(\textit{wetland}) + \beta_7(\textit{other land use variables}) + \beta_8(\textit{IUCN membership}) + \varepsilon. \quad (1)$$

We are especially interested in coefficients that estimate the effects of economic, institutional and social development variables on the proportion of protected areas. The applied models and results are summarized in table 4.

Based on the results of the eight models presented (and also some others not presented), it is possible to conclude that when other influences are controlled (i.e. land use, total population or area and IUCN membership), the level of development plays a somewhat significant role in explaining the proportion of protected areas. However, when there are more (than one) indicators of development present in the model, they all tend to lose their statistical significance (see model 1, for example). We believe

Table 4. Cross-sectional regression models and results(source: own elaboration)

dependent variable: lprotect								
variables	models							
	1	2	3	4	5	6	7	8
ln_avg_gni	0.038 (0.124)	0.184*** (0.057)	–	–	–	–	–	–
wgi	0.314 (0.214)	–	0.415*** (0.094)	0.416*** (0.093)	–	–	–	–
ln_popul	0.128* (0.066)	0.110 (0.067)	0.136** (0.068)	–	0.136* (0.068)	–	–	–
ln_area	–	–	–	0.171** (0.067)	–	0.134* (0.068)	0.134** (0.068)	0.139** (0.066)
forarea	0.018*** (0.006)	0.021*** (0.007)	0.020*** (0.007)	0.015** (0.007)	0.022*** (0.007)	0.018** (0.007)	0.018** (0.007)	0.017** (0.007)
grabs	0.009 (0.008)	0.012* (0.007)	0.009 (0.007)	0.004 (0.007)	0.010 (0.007)	0.006 (0.007)	0.008 (0.008)	0.008 (0.007)
antrop	0.004 (0.003)	0.005* (0.002)	0.004* (0.002)	0.005** (0.002)	0.005** (0.002)	0.007*** (0.002)	0.006*** (0.002)	0.005** (0.002)
wetland	–	–0.050 (0.052)	–0.034 (0.055)	–0.039 (0.053)	–0.049 (0.053)	–0.043 (0.053)	–0.045 (0.050)	–0.045 (0.050)
others	–0.003 (0.006)	–0.004 (0.006)	–0.004 (0.006)	–0.009 (0.006)	–0.003 (0.006)	–0.006 (0.006)	–0.008 (0.007)	–0.010 (0.006)
ief	–	–	–	–	0.023*** (0.009)	–	–	–
free	–	–	–	–	–	–0.134*** (0.045)	–	–
iucn	0.356 (0.226)	0.363 (0.231)	0.431** (0.215)	0.425** (0.214)	0.452** (0.212)	0.552** (0.222)	0.552** (0.219)	0.496*** (0.221)
school	–	–	–	–	–	–	0.059** (0.028)	–
hdi	–	–	–	–	–	–	–	1.610*** (0.558)
_cons	–5.526*** (1.720)	–6.558*** (1.410)	–5.404*** (1.214)	–4.998*** (0.830)	–6.875*** (1.472)	–4.437*** (0.857)	–5.335*** (0.888)	–5.900*** (0.959)
R^2	0.253	0.249	0.313	0.326	0.275	0.293	0.276	0.292
Obs.	157	157	162	162	158	162	160	160

Note: White's robust standard errors of regression coefficients in parentheses. ***Significant at 1% significance level. ** Significant at 5% significance level. * Significant at 10% significance level. One regression outlier has been identified in the regression models (Jordan). Exclusion of this observation has not changed the results significantly therefore all the presented models include Jordan.

that this occurs due to a high collinearity (correlation) among the variables, which approximates the level of economic, social and institutional development. It is also apparent that WGI (variable *wgi*) is the strongest of the development variables: it is the least statistically insignificant development variable when the others are included in the regression (see model 1), and it is the most significant when only one development variable is included (see models 3 and 4 compared to the rest of the models).

The other development variables are also significant when included in the regressions separately. This is true for the variables that approximate the level of economic development (GNI per capita, variable *ln_avg_gni*), the level of social development (mean years of education, variable *school*, and HDI, variable *hdi*), and the level of institutional development (index of economic freedom, variable *ief*, and index of freedom, variable *free*). It is possible to conclude in all instances that a higher level of development (economic, social or institutional) is associated with a higher proportion of protected areas.

Total population (variable *ln_popul*) is a positive but weak determinant of our dependent variable: countries with a larger population tend to have a higher proportion of protected areas. If we include total area (variable *ln_area*) as another control variable in our regression, both variables lose their significance. We believe that, once again, this is caused by a high collinearity between these two regressors. If we replace the total population variable by the total area variable, the latter is always significant, while other regression results only change slightly. The only exception is a slight decline in significance of the proportion of forest areas (variable *forarea*). Nevertheless, this always remains significant with at least a 5% significance level.

The other land use variables (*grabs* as an aggregation of grasslands and shrubs, *wetland* for wetlands, and *others* as an aggregation of sparsely vegetated areas, bare areas and open water areas), are not statistically significant, except for the variable *antrop* (an aggregation of cropland and urban land), which is significant in most of the models. Originally we would have expected a negative (if any) relationship between this variable and our dependent variable. On the other hand, the variable may also approximate the level of economic development (more developed countries will tend to use a higher proportion of land for agricultural and urban economic activities). This may be a plausible explanation because the significance of the *antrop* variable particularly increases in models where the variable does not directly measure the level of economic development (i.e. models without GNI per capita).

The IUCN dummy variable (*iucn*) is significant, with no less than a 5% significance level, except for models 1 and 2, where it is not significant at all. This is because of the presence of the economic development variable: if we control for level of economic development, the IUCN membership is not a statistically significant determinant of our dependent variable. At this point it is appropriate to concede that there may an endogeneity issue related to the IUCN explanatory variable. The higher proportion of protected areas may be a consequence of IUCN membership and, at the same time, IUCN membership may be a consequence of a higher level of environmental protection, leading to a higher proportion of protected areas. However, due to the unavailability of time data for IUCN membership, and having performed the cross-sectional regression analysis, it is practically impossible to fully account for this kind of problem.

Moreover, it is necessary to stress that our regression models explain only a third of the total variability of the dependent variable. So some other important factors must exist that influence the proportion of protected areas. Our regression may therefore suffer from an omitted variable bias. To account for these issues, we have decided to perform a panel regression. The next sub-section deals with the panel regression approach.

Panel regression

Similar to the cross-sectional regression, we have transformed our dependent variable (proportion of protected areas in countries' total areas) using a logit transformation to account for its bounded nature. The explanatory variables have also remained the same. Despite using the same variables, a panel data analysis may lead to better estimates as it considerably increases the number of observations available. Moreover, it enables an analysis of the variability among countries and the changes over time. On the other hand, time is a serious issue in our panel regression because many of our explanatory variables are time-invariant.

This is the case with almost all land use variables in this category, the only exception being the proportion of forest areas, the data for which were obtained from the *World Development Indicators* database (World Bank, 2016a). The other land use variables were acquired from the FAO GeoNetwork database (FAO, 2016) by means of the GIS analysis described above. The data were available only for one time period as no historical records exist (this, however, may reflect reality well because land use changes little over time). There are also other variables in our analysis that do not change over time. This is true for the IUCN dummy variable and for the total areas of countries.

This issue is a challenge for our analysis because it is not possible to estimate the impact of time-invariant variables on a dependent variable using the fixed-effects (FE) method (due to the nature of the method; it excludes all time-invariant variables from the regression). However, these impacts can be estimated using the random-effects (RE) approach. It is appropriate to use the RE method if no variables are omitted from the regression, or if the omitted variables do not depend on the variables already included in the model (i.e. if there is no correlation between the two groups of variables). If these assumptions do not hold, the application of the RE approach leads to inconsistency in the estimated regression coefficients.

When omitted variables correlate with the variables already included in the model, the FE method is the correct one to use; it leads to unbiased and consistent estimates. This approach enables to control for an omitted variable bias because it assumes that the omitted variables are time-invariant, i.e. they have time-invariant values and time-invariant effects. However, the FE approach does not allow one to estimate the effects of time-invariant observable variables in the model: all time-invariant influences (whether observable or not, i.e. omitted) are estimated together as (time-invariant) individual-specific effects.

There are statistical tests available to determine whether the RE or FE method should be used. First, we performed the Breusch-Pagan test and it showed that the pooled OLS approach is not appropriate for our data. In other words, the test confirmed that we should choose either the FE method or the RE method. Therefore, we applied both the Hausman and the Mundlak tests and they showed that the FE method is the correct one to use. However, in that case we would not have been able to estimate the effects of the time-invariant variables (they would be combined with the time-invariant individual-specific effects along with the unobserved omitted variables, also assumed to be time-invariant).

Because a significant number of our variables do not change over time we decided to use both the FE and the RE methods. However, it must be stressed that only the FE approach will lead to unbiased and consistent estimates, while the RE method will provide inconsistent estimates. Table 5 summarizes the regression models and the results. Once again, we are especially interested in coefficients that estimate the effects of economic, institutional and social development variables on the proportion of protected areas.

In the first set of models (1a and 1b), we included all the development variables in the regression at the same time. When the RE method (model 1a) is used, the variable measuring economic development (*ln_gni*) and one of the variables that approximates social development (*school*, mean years of education) are positively statistically significant, while the institutional development variables and the other social variable (*hdi*) are not. This is true no matter how the institutional development is measured: whether WGI (variable *wgi*) is replaced by the index of economic freedom (variable *ief*), or by the index of freedom (variable *free*), nothing changes substantially (it is only when *free* is included, that the *iucn* dummy variable loses its marginal statistical significance). When we use the FE method to estimate the same model (1b), but without the time-invariant variables, only the social development variable *school* remains significant; other development variables are no longer significant. Again, nothing really changes when we alternate the way we measure the level of institutional development – the model is slightly better when we use the index of economic freedom instead of the WGI.

Therefore, in the second set of models, we used *ief* to measure institutional development and we approximated the level of social development only by using *hdi*. In model 2a (when RE is used), none of these variables are statistically significant, while the economic development variable is marginally significant. The results did not change when we used *wgi* to measure institutional development. However, if we measure the level of institutional development by *free* instead of *ief*(or *wgi*), then *hdi* becomes statistically significant at a 1% significance level, while *free* is not significant and the model is slightly worse. When the FE are used (model 2b), the economic development variable loses its marginal statistical significance but other results from the RE model remained valid.

In the third set of models, we replaced the social variable *hdi* with the variable *school* and we measured the level of institutional development using *wgi*. While the institutional variable in the RE model (3a) is once again not significant, the social variable *school* is statistically significant at a 1% significance level. The economic variable is also significant (at 5% significance level). These results persist no matter how the level of institutional development is measured. The FE model (3b) shows similar results. The social variable *school* is always significant to no less than a 5% significance level, while the economic and institutional variables are not. Nothing changed when we replaced *wgi* by *ief*. But an interesting situation occurs if we substitute *wgi* for *free*: the economic variable is significant once again but the population variable is not.

In the fourth set of models we excluded the variables measuring social development in order to find whether some of the other development variables gained significance. In RE model 4a, this is true for the economic variable and its significance greatly increases, while the institutional variables remain insignificant (although *wgi* is, surprisingly, *negatively* significant at a 10% level). The same results are obtained when the FE method is applied (model 4b). When we replaced *free* with *wgi*, the *wgi* variable was once again negatively statistically significant, this time even at a 5% level. Although this is a surprising result, this model is generally very poor.

In the last (presented) set of models we did not control for the level of institutional development but we did control for social and economic development. When the RE model is used (5a) both variables (*ln_gni* and *school*) are statistically significant. If we substitute *school* with *hdi*, the economic variable is only marginally statistically significant at a 10% level. If both social variables are included at the same time, then *hdi* loses its significance, while *school* and *ln_gni* remain significant. When the FE model is used (5b), the significance of the economic variable declines substantially, and is only marginally statistically significant (at a 10% level). Interestingly, some of the control variables also lose their significance. This is true for the population variable and the proportion of forest areas. On the other hand, the social variable *school* is highly significant at a 1% level. Similar results are obtained when the *school* variable is replaced by *hdi*, which becomes significant at a 5% level. But if we include both social variables in the model at the same time, then once again the economic variable and the control variables (population, proportion of forest areas) regain their significance. The *school* variable is also significant at a 1% level, while *hdi* is not significant.

We have also excluded all development variables other than the institutional ones from the models (not presented in table 5). The results show that it is only in this case and when the RE method is used, that the institutional variables are statistically significant.

Table 5. Panel regression models and results(source: own elaboration)

variables	dependent variable: lprotect									
	models									
	1a (RE)	1b (FE)	2a (RE)	2b (FE)	3a (RE)	3b (FE)	4a (RE)	4b (FE)	5a (RE)	5b (FE)
ln_gni	0.169** (0.077)	0.053 (0.103)	0.138* (0.073)	0.005 (0.106)	0.111** (0.044)	0.011 (0.059)	0.284*** (0.337)	0.229*** (0.043)	0.122*** (0.044)	0.119* (0.062)
Wgi	–0.142 (0.110)	–0.173 (0.158)	–	–	–0.138 (0.105)	–0.158 (0.139)	–	–	–	–
ln_popul	0.208*** (0.064)	1.077*** (0.370)	0.216*** (0.062)	1.099*** (0.415)	0.244*** (0.064)	1.062*** (0.290)	0.479*** (0.092)	1.193*** (0.269)	0.260*** (0.061)	0.389 (0.335)
forarea	0.027*** (0.007)	0.044** (0.019)	0.026*** (0.007)	0.056*** (0.020)	0.027*** (0.007)	0.039** (0.018)	0.014** (0.007)	0.021** (0.010)	0.016** (0.007)	0.007 (0.014)
Grabs	0.016** (0.007)	–	0.016** (0.007)	–	0.016** (0.008)	–	0.007 (0.009)	–	0.012 (0.008)	–
Antrop	0.003 (0.003)	–	0.003 (0.003)	–	0.002 (0.003)	–	–0.004 (0.005)	–	–0.002 (0.004)	–
wetland	–0.042 (0.050)	–	–0.060 (0.048)	–	–0.035 (0.050)	–	–0.010 (0.050)	–	–0.014 (0.055)	–
Others	–0.003 (0.005)	–	–0.002 (0.005)	–	–0.003 (0.005)	–	–0.014** (0,006)	–	–0.008 (0.006)	–
Ief	–	–	0.003 (0.006)	–0.008 (0.006)	–	–	–	–	–	–
Free	–	–	–	–	–	–	0.001 (0.023)	0.024 (0.026)	–	–
Iucn	0.373* (0.219)	–	0,320 (0,207)	–	0.338 (0.230)	–	0.015 (0.238)	–	0.232 (0.229)	–
school	0.098** (0.049)	0.176*** (0.064)	–	–	0.104*** (0.035)	0.138** (0.060)	–	–	0.141*** (0.031)	0.180*** (0.049)
Hdi	–0.403 (1.447)	–0.606 (2.100)	0.911 (0.973)	2.565 (2.160)	–	–	–	–	–	–
_cons	–8.984*** (1.260)	–22.36*** (5.491)	–8.642*** (1.246)	–23.01*** (6.281)	–9.387*** (1,280)	–21.85*** (4.557)	–12.72*** (1.730)	–23.99*** (4.279)	–9.33*** (1.171)	–11.36*** (5.023)
R^2	0.215	0.183	0.220	0.190	0.205	0.176	0.167	0.183	0.178	0.135
Obs.	753	830	719	775	1220	1339	3216	3686	1325	1456

Note: White's robust standard errors of regression coefficients in parentheses. ***Significant at 1% significance level. **Significant at 5% significance level. *Significant at 10% significance level.

nd discussion of results

This is particularly true for the *ief* variable, which is significant at a 1% level, while *free* is only marginally statistically significant and *wgi* is insignificant. When the FE method is used, none of the institutional variables are significant.

Summary and discussion of results

The results of the cross-sectional and panel regressions point to the same conclusion. They show that there is a significant relationship between the level of development and the proportion of protected areas. Generally, we can conclude that a higher level of development is associated with a higher proportion of protected areas, no matter how the level of development is approximated.

First, we performed cross-sectional regressions. Bearing in mind the possible limitations of this approach (as already discussed), we found statistically significant relationships between indicators that approximate levels of development and the proportion of protected areas. However, in the cross-sectional settings this is only true when the development indicators enter the regression separately. When more development variables are included in models at the same time, they all lose their statistical significance.

This may be caused by the collinearity (high correlation) between the development variables (ceteris paribus).

The results of the cross-sectional regression models can be summarized as follows (ceteris paribus):

- A higher proportion of protected areas is associated with a higher level of development (economic, social or institutional).
- Larger countries (in terms of land size) tend to have higher proportions of protected areas.
- More populated countries tend to have higher proportions of protected areas.
- A higher proportion of protected areas is associated with a higher proportion of forest areas.
- A higher proportion of protected areas is associated with a higher proportion of cropland and urban areas (combined).
- No other land use variable is significant.
- A higher proportion of protected areas is associated with IUCN membership.

Secondly, we performed panel regressions. Because a considerable number of our explanatory variables are time-invariant, we faced a difficult choice when selecting the optimal model. It is possible to estimate the impacts of the time-invariant variables when the random-effects method (RE) is used. However, these estimates may be inconsistent if our data favours the fixed-effects method (FE). That it is indeed the case, as has been shown in the results of the Hausman and Mundlak tests. Nevertheless, the application of the FE approach does not allow one to estimate the impact of the time-invariant variables. Therefore, we applied both approaches to the same models, bearing in mind that the estimates of the RE method (with the time-invariant variables included) are probably inconsistent. In contrast, the estimates of the FE method (with the time-invariant variables excluded) should be unbiased and consistent.

The RE models indicate that there are statistically significant relationships between variables which measure levels of development and the proportions of protected areas. The results of these models can be summarized as follows (ceteris paribus):

- The social development variable *school* is highly significant in all models where it was included, while the other social development variable, *hdi* is mostly insignificant (collinearity is a probable cause; it is a composite index of some other variables in most of the models). This means that a higher proportion of protected areas is associated with a higher level of social development (approximated by mean years of education).
- The economic development variable (*ln_gni*) is also statistically significant (at least at a 10% level) in all models. This means that a higher proportion of protected areas is associated with a higher level of economic development.
- Institutional development variables are almost always insignificant. The only exceptions are *ief* and *free* in models where no other development variable is included.
- More populated countries tend to have higher proportions of protected areas.
- A higher proportion of protected areas is associated with a higher proportion of forest areas.
- Most of the time-invariant land use variables are insignificant. The only exception is the variable *grabs* (the aggregation of grasslands and shrubs) in models where all development variables are included.
- The IUCN dummy variable is mostly insignificant.

However, the results of the RE models are probably inconsistent. Therefore, better evidence is provided by the FE models, which should yield consistent estimates. In accordance with the approaches used previously, the FE models also indicate statistically significant relationships between variables approximating the level of development and the proportion of protected areas.

The results of the FE models can be summarized as follows (ceteris paribus):

- The social development variable *school* is statistically significant (at least at a 5% level) in all models it enters, while the other social development variable *hdi* is mostly insignificant. So a higher level of social development (approximated by mean years of education) is associated with a higher proportion of protected areas.
- The economic development variable *ln_gni* is highly significant (at a 1% level) in models where institutional development variables are included and social development variables are excluded. It is also marginally statistically significant in models where we control for social development and do not control for institutional development. Generally we may conclude that a higher level of economic development is associated with a higher proportion of protected areas.
- The institutional development variables are not significant no matter how we measure them.
- More populated countries tend to have higher proportions of protected areas, and this is proved by every model except the one where we do not control for the influence of institutions.
- A higher proportion of forest areas is associated with a higher proportion of protected areas. This is not only true for the model in which we do not control for the influence of institutions.

To conclude, it is obvious from the summaries above that a significant relationship exists between the level of development and the proportion of protected areas. All other things being equal, the more developed countries tend to have a higher proportion of protected areas. This assertion is true no matter how the level of development is approximated. However, we should take into account the findings of some studies (for instance Rees (2003), which highlight the fact that beyond a certain point, there is unavoidable conflict between economic development and environmental protection. The proportion of protected areas is only one of many environmental indicators (OECD, 2008; Syrovátka, Hák, 2015); therefore we cannot simply generalize that a higher level of development automatically means better protection for the environment.

The majority of development variables are significant in most of the models, the only exception being the institutional variables, which are not significant once the levels of social or economic development are controlled for. This is indicated by the cross-sectional and the panel approach and by the findings. The conclusion isn't consistent with the findings of Smith et al. (2003), who found correlation between governance scores and environmental performance (although not in terms of protected area coverage). In our analyzes, we have also found that a higher proportion of forest areas and a larger population size are associated with a higher proportion of protected areas. The relationship between the proportion of forests and protected areas was also confirmed by (Joppa, Pfaff, 2009); forests often occupied remote areas with environmental conditions less suitable for agriculture (Opršal et al., 2016; Dytrtová et al., 2016) and these can be set aside for protection. In contrast with our original expectations, the other land use variables proved to be insignificant in most cases. This may be surprising, especially in the case of bare land and sparsely vegetated areas(deserts) – in our research, the countries' proportions of protection areas were not biased towards these two categories of land cover as the literature suggests (Ando et al., 1998; Joppa, Pfaff, 2009). Also, our regression models have only explained a limited amount of the total variability of the dependent variable (approximately one third in the cross-sectional approach and one quarter in the panel regression approach), so there remains some room for further improvements in the regression models and methods.

The findings mentioned so far represent rather positive trends and important steps towards nature conservation, as well as the widely accepted role of the protected area coverage indicator, which reflects the importance of protected areas in biodiversity conservation. However, the use of the indicator naturally has certain limits. First of all, measuring the extent of protected areas provides only partial information concerning political commitment to biodiversity conservation. Therefore, measurements of extent should be combined with assessments of conservation effectiveness within protected areas. Without sound and effective management based on scientific knowledge, protected areas may fail to meet their main objective of biodiversity conservation (Leverington et al., 2010). Moreover, the mission of protected areas has expanded in recent years and encompasses not only biodiversity conservation, but also the socioeconomic development of local communities (Naughton-Treves et al., 2005). Given the fact that further economic growth will most likely create more pressure on Earth's ecosystems, and may undermine sustainable human development (Rockström et al, 2009), the integration of biodiversity conservation and socioeconomic development goals remains a serious challenge.

Our paper focuses on various factors behind the performance of individual countries in nature conservation, in terms of the coverage of protected areas. Yet, we recognize that protection across the world is geographically very uneven, both at a national level and at the ecosystem level. Despite the expansion of global terrestrial protected area systems, many biomes still have less than 10% of their area within formally protected areas (Jenkins, Joppa, 2009). Protection area networks are biased towards places that are unlikely to face land conversion, such as higher elevations, steeper slopes and places that are a greater distance from roads and cities(Joppa, Pfaff, 2009).Taking these facts into consideration we may assume that setting conservation agendas such as the Aichi Biodiversity Targets, Millennium Development Goals and Sustainable Development Goals might raise the coverage of protected areas at a national level, but at the same time it may not adequately cover countries' unique species and ecosystems (Scott et al. 2001; Maiorano et al, 2006; Jenkins et al. 2015). The relationship between biodiversity targets and the actual needs of nature conservation remains a challenge for future research.

Conclusion

The world's system of protected areas has grown substantially over the past 23 years, covering over 14.0% of countries' total area. Considering the magnitude of the changes that have occurred in nature conservation since 1990, an increase in the proportion of protected areas has been recorded in almost every country in the world. Nevertheless, the scale of this progress varies considerably among countries, and the disparities between best and worst performing countries are enormous. Since nature conservation and socioeconomic development represent the backbone of the *Millennium Development Goals* and the *Sustainable Development Goals*, the links between these two phenomena have been investigated. Therefore, we applied methods of regression analysis to find whether a relationship exists between the level of development and the proportion of protected areas. We have approximated the level of development using various economic, social and institutional variables. After controlling for some other influences and performing both cross-sectional and panel regressions, we have concluded that the more developed countries tend to have higher proportions of protected areas. Although the coverage of protected areas is well-established and a useful indicator of environmental performance of individual countries, it does not ensure adequate cover of a country's valuable species and ecosystems as well as sound environmental management of existing protected areas.

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