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Religious and secular ethics offer complementary strategies to achieve environmental sustainability

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By applying a single dataset (i.e., panel data at a national level) and a single analytical framework (i.e., a dynamic mathematical model), I compared religious (REL) and secular (SEC) ethics in two ways: as feasible strategies (i.e., with realistic parameter values such that a strategy can achieve its goal) and as reliable strategies (i.e., with a tight statistical relationship between a strategy and its goal). In both cases, the goal is to achieve environmental sustainability, but with different precepts and principles applied within different perspectives: global vs. local sustainability, individual feelings vs. social pressures as determinants of pro-environmental behavior, and long-run vs. short-run sustainability. *Analytical* results (feasibility) showed that REL are overall more feasible than SEC and, specifically, REL are more likely to affect the many pro-environmental behaviors required to achieve global sustainability, whereas SEC to affect some pro-environmental behaviors required to achieve local sustainability; REL are more likely to affect pro-environmental behaviors based on individual feelings and social pressures from small communities, whereas SEC to affect pro-environmental behaviors based on social pressures from large communities; REL are more likely to solve collective-action problems to achieve short-run sustainability, whereas SEC to solve collective-action problems to achieve long-run sustainability. *Statistical* results (reliability) based on 32 random- and between-effects regressions support these results and, particularly, REL and SEC were complementary in time (e.g., for REL, short-run sustainability is more reliable than long-run sustainability; for SEC, long-run sustainability is more reliable than short-run sustainability), in space (e.g., for SEC, local sustainability is more reliable than global sustainability), and in society (e.g., for REL, individual feelings are more reliable than social pressures).

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Introduction

Zagonari (2020a) showed that sustainability is an ethical issue. The literature has recently begun to emphasize the role of ethics in achieving environmental sustainability (e.g., Menning, 2016; Lenzi, 2017; Spahn, 2018; Whiting and Konstantakos, 2019; Batavia et al., 2020). In particular, two main groups of environmental ethics can be identified: secular ethics (SEC) and religious ethics (REL) (Zagonari, 2019a). *Secular* ethics (e.g., Snyder, 2017; Knauss, 2018; Lowe, 2019) focus on our responsibility to nature, responsibility to future generations, perceptions of the rights of human and non-humans, and beliefs in inter- and intra-generational equity (Zagonari, 2019b). *Religious* ethics (e.g., Imanaka, 2018; Schmidt, 2019; Christie et al., 2020) have a different focus in each religion. For example, Buddhism focuses on maintaining equilibrium, Christianity on love of neighbors, Hinduism on equal dignity of humans and non-humans, Islam on trusteeship and parsimony, and Judaism on stewardship (Zagonari, 2020b).

However, the observed failures of international agreements on climate change suggest that the unsustainability of global society is a *practical* problem (i.e., one related to actual practice rather than to beliefs; www.sdgindex.org/overview). In other words, it is not enough for an ethical principle or precept to be consistent and to be intended to move the world away from unsustainable practices; the principle or precept must also provide feasible (i.e., effective and practical) and reliable (i.e., unfailing and trustworthy) incentives to achieve sustainability through the application of consistent ethical concepts to achieve realistic equilibrium conditions. This can potentially be achieved using empirical models that predict the consequences of applying these ethical concepts and incentives.

The *empirical* literature on the role of ethics in achieving environmental sustainability based on actual behavior (instead of self-stated behavior, intentions, attitudes, concerns) is still in its infancy. For example, studies based on REL ethics include Peifer et al. (2016), Arli and Tjiptono (2017), and Yang and Huang (2018), whereas studies based on SEC ethics include Yuan et al. (2017), Sorkun (2018), and Khan et al. (2019). In particular, there is a limited literature based on a multiple-country analyses instead of single-culture analyses such as studies of Christian or Muslim communities and a limited literature based on the overall population instead of sub-populations such as students or rural households. For example, Zagonari (2020a) found that the world's five main majority religions can have beneficial impacts on the feasibility and reliability of efforts to achieve global sustainability. Note that in that study, global sustainability was measured in terms of the ecological footprint. Zagonari (2019a) found that three main SEC (beliefs in intra-generational equity, responsibility to nature, and responsibility to future generations) can have beneficial impacts on the feasibility and reliability of global sustainability. Note that in that study, SEC principles were measured in terms of inequality and based on percentages of GDP spent on environmental conservation and green R&D. Zagonari (2020c) found that the five main majority religions and three main SEC principles can have beneficial impacts on the feasibility and reliability of local sustainability. Note that in that study, local sustainability was measured by household waste management, organic food purchases, and household energy conservation. However, Zagonari (2019b) showed that environmental ethics affects actual pro-environmental behaviors by relying on individual feelings and social pressures.

The purpose of the *present* study was to obtain theoretical insights into the feasibility of REL and SEC ethics to achieve environmental sustainability. To do so, I developed a mathematical model based on an evolutionary game with replicator dynamics, then tested the model using statistical results from 32 random- and between-effects regressions to explain the levels and changes for each pro-environmental behavior. The regressions used an original panel dataset that comprised 23 religions and denominations (Baha'is, Buddhists (Lamaists, Mahayanists, Theravadins), Christians (Catholics, Independents, Orthodox, Protestants), Confucianists, Daoists, Ethnic religionists, Hindus (Saktists, Shaivites, Vaishnavites), Jains, Jews, Muslims (Schismatics, Shias, Sunnis), Shintoists, Sikhs, Spiritists, Zoroastrians) and 3 secular ethics related to the reliability of REL and SEC to achieve global and local sustainability in 181 and 183 countries, respectively.

In particular, I empirically tested 12 hypotheses related to the following three theoretical insights:

1. REL is more likely to affect the many pro-environmental behaviors required to achieve global sustainability, whereas SEC is more likely to affect some pro-environmental behaviors to achieve local sustainability.
2. REL is more likely to affect pro-environmental behaviors by relying on individual feelings and social pressures from small communities, whereas SEC is more likely to affect individual feelings and social pressures from the whole society.
3. REL is more likely to promptly solve the collective-action problems in small communities in the short-run, whereas SEC is more likely to stably increase pro-environmental behaviors in the whole society in the long-run.

These hypotheses will be tested within a single theoretical and empirical framework by distinguishing individual determinants (i.e., religious precepts and secular principles) and social determinants (i.e., reciprocity to depict social pressures from the whole society, religion majorities in a country to depict social pressures from large communities, religion percentages in any country to depict social pressures from small communities). This will be done for the main representative pro-environmental behaviors (i.e., involving time in household waste management, money in organic food purchases, both time and money in household energy conservation, and the overall approach to the environment as measured by the ecological footprint).

Methods

The theoretical framework for feasibility. The purpose of this paper is to provide a theoretical framework sustained by empirical evidence to support the reference to religious or secular ethics in fostering pro-environmental behaviors. In particular, the focus on ethical improvements over time requires a dynamic framework to characterize interactions among individual behaviors.

Table 1 summarizes the main features of the collective-action problems in the set of environmental situations under consideration (Zagonari, 2020b). These problems represent situations in which an individual's action (e.g., conserving energy, recycling wastes, purchasing organic food) leads to a clearly better collective status but has such a low potential benefit that its consciously or unconsciously expected utility cannot explain any obligation to perform this action (Talbot, 2018).

The literature on solving environmental collective-action problems by relying on ethics is still in its infancy. For example, Bolis et al. (2017) found that only 3 out of 151 papers in their review supported a deep, disruptive transition based on value-oriented rational action (i.e., substantive rationality, which focuses on the ethics of an action, rather than instrumental rationality, which focuses on whether the means can achieve the desired end, irrespective of the ethics of that means), in which the

Table 1 Main characteristics of sample collective-action problems in environmental contexts, in which an individual action (i.e., to do or refrain from doing something) that is characterized by an opportunity cost (e.g., in terms of time, money, or both) produces benefits for others and for the individual.

	Energy conservation	Waste recycling	Purchasing organic food
Benefits to others only	Y/N	N	N
Repeated actions	Y	Y	Y
Lack of governmental rules	Y	Y	Y
Lack of social sanctions	Y	Y	Y
Lack of alternative technologies	Y	Y/N	Y
Overdetermined benefits	N	N	N
International benefits	Y	Y/N	N

"Overdetermined benefits" refers to an individual expected benefit of 0. Y = yes, N = no, Y/N = sometimes yes, sometimes no.

Table 2 Possible interactions between individual pro- and anti-environmental behaviors in a game theory context.

	Player 2	
	Pro-environmental behavior	**Anti-environmental behavior**
Player 1		
Pro-environmental behavior	R, R	S, T
Anti-environmental behavior	T, S	P, P

Categories of response: T = temptation, R = reward, S = sucker, P = punishment. Couples are presented as actions chosen by Player 1 and Player 2 (first and second responses, respectively).

resulting collective or individual decisions tend to be aligned with personal values and beliefs. Thus, I consider the two main approaches for explaining ethical behavior (i.e., teleological and deontological approaches) to determine which interventions could favor the determinants of ethical behavior (Supplemental Tables S1 and S2, respectively, summarize these approaches). Note that environmental pragmatism can be both teleological (e.g., Norton, 1991) and deontological (e.g., Minteer, 2012), whereas environmental virtue ethics is often considered to be complementary to teleological and deontological approaches (Dzwonkowska, 2018). However, eudemonic virtue ethics (e.g., Hill, 1983) is closer to a teleological approach (i.e., it is included in Table S1), whereas non-eudemonic virtue ethics (e.g., Sandler, 2007) is closer to a deontological approach (i.e., it is included in Table S2).

The *teleological* approach suggests that people behave ethically when the subjective expected utility is positive, whether consciously or unconsciously (Hirsh et al., 2018). Here, I define this utility as the expected benefit of the individual action and the social reward minus the individual opportunity cost and the social sanction. Note that the teleological approach is consistent with both instrumental rationality (i.e., choices are optimal in terms of their usefulness) and bounded rationality (i.e., cognitive constraints, limited time, and lack or disregard of information by decision-makers could lead to satisfactory rather than optimal choices). The *deontological* approach suggests that people behave ethically when they judge whether actions are right or wrong based on universal principles (Budolfson, 2019). Note that this approach is consistent with substantive rationality and with communicative rationality (i.e., accepted choices are based on reasoned arguments, with consensus and cooperation resulting from inter-actor communication).

I will use an evolutionary approach for collective-action problems related to environmental actions for two reasons: first, because the equilibrium does not depend on how many people follow a given rule, since individual feelings and the social identity of each individual depend on their opponents, and second, because coordination to achieve a given equilibrium could be irrelevant, so that deviation from the given equilibrium can be assumed to be random.

Table 2 presents individual pay-offs for four alternative couples of decisions in terms of all permutations of pro- and anti-environmental behavior, where individual feelings and social pressures are the main determinants of pro-environmental behaviors (Zagonari, 2019b). In this table, the couples can be defined in terms of game theory: reward (R), in which individuals cooperate to achieve a greater reward at the cost of some mutual sacrifice; temptation (T), in which one individual makes a selfish choice to improve their reward; sucker (S), in which an individual who chooses a pro-social response suffers for that choice; and punishment (P), in which both individuals suffer from their selfish choices. Of course, these choices also depend on religious and secular values. In terms of SEC, responsibility to nature is depicted by a larger R; distributive justice towards current and future generations is depicted by a smaller T and a larger S, respectively; and responsibility to future generations is depicted by a smaller P. In terms of REL, the sacredness of nature (e.g., maintaining equilibrium in Buddhism and equal dignity of human and non-humans in Hinduism) is depicted by a larger R; concern for one's current community is depicted by a smaller T (e.g., brotherhood in Christianity); concern for one's future community is depicted by a larger S (e.g., stewardship in Judaism and trusteeship in Islam); and concerns for the future environment (e.g., parsimony in Islam) is depicted by a smaller P.

In other words, the pay-offs in Table 2 (i.e., P, R, S and T) represent both religious and secular principles. Consequently, the following phenomena can be *theoretically* depicted by Table 2:

- pro-environmental behaviors driven by ethical principles that are labeled as religious rather than secular ethics (e.g., Confucianism, Taoism, and Buddhism) (Meinertsen, 2017; Shan, 2018)
- secularization, in which some religious ethics are replaced by some secular ethics (Li and Wang, 2018; Shapiro, 2018; McAndrew and Richards, 2020)
- secular ethics, depending on previous religious ethics, in which individuals behave according to their religious principles, even though they are not affiliated with any religion (Zhang and Lu, 2020)

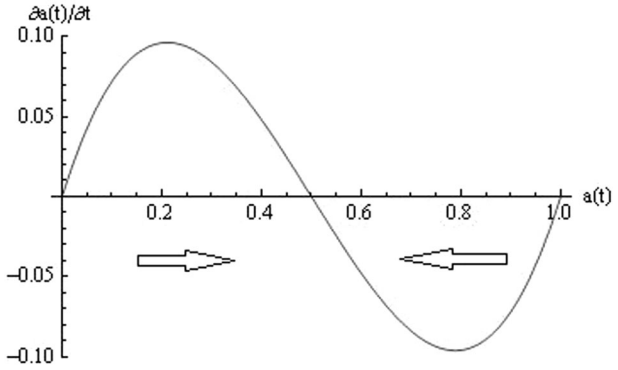

Fig. 1 The probability of selecting pro-environmental behaviors (*a*) over time (*t*) if reward (*R*) = 5, sucker (*S*) = 2, temptation (*T*) = 3, and punishment (*P*) = 4 (i.e., condition c_2 applies with 4–5 = *P* – *R* < *T* – *S* = 3–2 and 3 = *T* > *S* = 2); these values theoretically represent the utility levels that an individual achieves and they are chosen to qualitatively depict the dynamics of *a*(*t*). This figure represents a long-run scenario based on secular ethics (i.e., larger *R* and smaller *P*); $a(t) = 0$ identifies a_1, a_2 is identified by the intersection of the decreasing dynamics of $a(t)$ and the axis $a(t)$, $a(t) = 1$ identifies a_3.

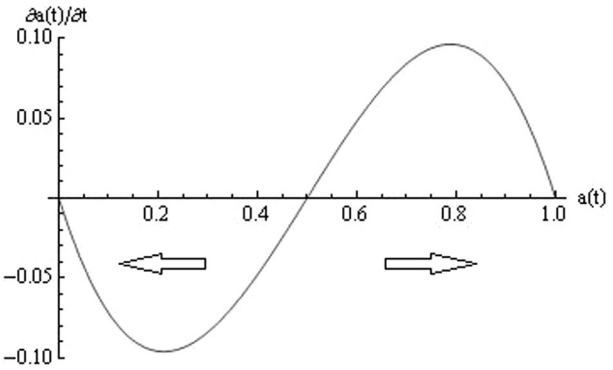

Fig. 2 The probability of selecting pro-environmental behaviors (*a*) over time (*t*) if reward (*R*) = 4, sucker (*S*) = 3, temptation (*T*) = 2, and punishment (*P*) = 5 (i.e., condition c_1 applies with 5–4 = *P* – *R* > *T* – *S* = 2–3 and 2 = *T* < *S* = 3); these values theoretically represent the utility levels that an individual achieves and they are chosen to qualitatively depict the dynamics of *a*(*t*). This figure represents a short-run scenario based on religious ethics (i.e., smaller *T* and larger *S*); $a(t) = 0$ identifies a_1, a_2 is identified by the intersection of the increasing dynamics of $a(t)$ and the axis $a(t)$, $a(t) = 1$ identifies a_3.

- denomination, in which individuals behave according to secular principles, although they are denominational affiliated to a religion (Berger, 1967; Hjelm, 2018)
- pro-environmental behaviors driven by ethical principles that are shared with secular and religious ethics (e.g., concern for future generations in Islam and Judaism, concern for the environment in Buddhism and Hinduism) (Riley and Brauman, 2017; Kollar, 2019; Ikeke, 2020)

Note that the actions described in Table 2 (i.e., pro-environmental and anti-environmental behaviors), regardless of the rewards, represent a deontological approach for both religious and secular ethics (i.e., actions are not chosen because of consequences, but because of individual ethical principles that can have a religious or a secular source). However, social pressures in small or large communities, represented by rewards or punishments, could also be relevant in encouraging pro-environmental behaviors or discouraging anti-environmental behaviors.

If we apply the basic principle rule of replicator dynamics (i.e., a strategy better than the average level will be adopted in a game group with bounded rationality), then the expected utility when adopting a pro-environmental behavior (U_E) and an anti-environmental behavior (U_A) can be calculated as follows:

$$U_E = (1-a)R + a\,S \text{ and } U_A = (1-a)\,P + a\,T$$

Where a and $(1 - a)$ are the probabilities of selecting a "transform strategy" (in which the individual chooses an action that will change society) and "conform strategy" (in which the individual conforms with the status quo), respectively, and *R*, *P*, *S*, and *T*, represent the utility level that an individual achieves under certainty in the four couples of actions presented in Table 2. Moreover, the average expected benefit if a pro-environmental behavior is adopted in an environmentally unsustainable society is given by:

$$\overline{U} = a\,U_E + (1-\mathrm{a})U_A$$

Finally, the replication dynamics equation can be calculated as follows:

$$\frac{\partial a(t)}{\partial t} = a\left(U_E - \overline{U}\right) = a(1-a)[(R-P)(1-a) + a(S-T)]$$

Consequently, the three equilibrium points (i.e., a_1, a_2, and a_3 such that $\partial a(t)/\partial t = 0$ are given by:

$$a_1 = 0$$

$$a_2 = \frac{P-R}{P-R+S-T} < 1$$

$$a_3 = 1$$

where $a_2 < 1$ can be met if the following alternative conditions apply:

$$c_1 : P - R > T - S \text{ and } T < S$$

$$c_2 : P - R < T - S \text{ and } T > S$$

$T > S$ is more likely to apply in an environmentally unsustainable society. That is, people feel cunning, implying a large *T*, if they choose anti-environmental actions while others choose pro-environmental actions, and people feel foolish, implying a small *S*, if they choose pro-environmental actions while others choose anti-environmental actions. On this basis, I will assume that the condition c_2 prevails initially.

Moreover, the dynamics of $a(t)$ in the three equilibria, where *t* represents time, can be calculated as follows:

$$\frac{\partial\left[\frac{\partial a(t)}{\partial t}\right]}{\partial a(t)}(a_1) = R - P$$

$$\frac{\partial\left[\frac{\partial a(t)}{\partial t}\right]}{\partial a(t)}(a_2) = \frac{(P-R)(S-T)}{P-R+S-T}$$

$$\frac{\partial\left[\partial a(t)/\partial t\right]}{\partial a(t)}(a_3) = T - S$$

Figure 1 represents the scenario in which a_1 and a_3 are unstable equilibria, whereas a_2 is stable. Figure 2 represents the scenario in which a_1 and a_3 are stable equilibria, whereas a_2 is unstable. If condition c_2 applies (i.e., $T > S$), then the dynamics of Fig. 1 prevail initially.

Finally, the basin of attraction for the pro-environmental behavior is given by a such that $U_E > U_A$:

$$a > \frac{P-R}{P-R+S-T} \text{ if } P-R > T-S$$

$$a < \frac{P-R}{P-R+S-T} \text{ if } P-R < T-S$$

Thus, if $T > S$ (i.e., a society is environmentally unsustainable), the basin of attraction is decreasing in P ($\partial a_2/\partial P = (S–T)/a_2^2$) and increasing in R ($\partial a_2/\partial R = (T–S)/a_2^2$), whereas if $R > P$ (i.e., environmental sustainability is perceived by everybody to be better than environmental unsustainability), the basin is increasing in S ($\partial a_2/\partial S = (R–P)/a_2^2$) and decreasing in T ($\partial a_2/\partial T = (P–R)/a_2^2$).

Note that both REL and SEC can increase the basin of attraction for pro-environmental behaviors. That is, they can increase a_2 by increasing R and S and by reducing P and T movement towards equilibrium ($\partial a(t)/\partial t$) is slower if the society is closer to equilibrium. Moreover, since REL is more likely to modify S and T such that $S > T$ (i.e., the collective-action problem is solved at a community level), then the prevailing dynamics for religious people is depicted by Fig. 2: short-run impacts on pro-environmental behaviors are more likely and everybody will adopt a pro-environmental behavior at the end. Finally, since SEC is more likely to affect R and P than to affect S and T (i.e., the collective-action problem is not solved for the society as a whole), then the prevailing dynamics for non-religious people is depicted by Fig. 1: long-run impacts on pro-environmental behaviors are more likely (i.e., a_2 increases with increasing R and decreasing P to a greater extent than with increasing S and decreasing T if $T > S$ and $R > P$) and some individuals will *not* adopt a pro-environmental behavior at the end.

Therefore, short-run feasibility means values of P, R, S, and T such that $\partial a/\partial t$ is positive and large. This is the case when a sufficiently large proportion of religious people adopt pro-environmental behaviors (i.e., $a > a_2$ in Fig. 2). In contrast, long-run feasibility means values of P, R, S, and T such that a_2 is large and close to 1. This is the case when a sufficiently small proportion of non-religious people adopt pro-environmental behaviors (i.e., $a < a_2$ in Fig. 1).

The application of these theoretical results to REL and SEC leads to the following insights:

Insight 1: REL is more likely to affect many pro-environmental behaviors, although to a different extent in different religions, by increasing S and R and by decreasing T and P, which are all required to achieve global sustainability. In contrast, SEC is more likely to affect some pro-environmental behaviors by increasing R and decreasing P, which are important to achieve local sustainability.

Insight 2: REL is more likely to affect pro-environmental behaviors by relying on religious precepts (i.e., larger R and smaller P) and social enforcements (i.e., larger S and smaller T) from all communities, regardless of their size. In contrast, SEC is more likely to affect pro-environmental behaviors by relying on secular principles and social enforcements from the whole society. In other words, individual feelings are likely to be more important for REL than for SEC, whereas social pressures are likely to be more important for SEC than for REL.

Insight 3: REL in all communities, regardless of their size is more likely to decrease T and increase S (i.e., $T < S$), by making Fig. 2 depict the relevant dynamics (i.e., a short-run increase in pro-environmental behaviors). In contrast, SEC, with reference to the whole society, is more likely to increase R and decrease P, without significantly affecting T and S, by making Fig. 1 depict the relevant dynamics (i.e., a long-run increase in pro-environmental behaviors).

Note that environmental education and informational campaigns could increase R and decrease P, by enlarging the proportion of non-religious people adopting pro-environmental behaviors. See Zagonari (2020c) for a summary of the empirical literature. In contrast, theological changes and sermons about environmental principles can increase S and decrease T, thereby increasing the proportion of religious people who adopt pro-environmental behaviors. See Zagonari (2020a) for a summary of the empirical literature.

In summary, REL is likely to be *statically* feasible (i.e., there are sets of parameter values such that movement towards equilibrium is represented by pro-environmental behaviors), with impacts on levels of a(t) (i.e., $\partial a(t)/\partial t$). In contrast, SEC is likely to be *dynamically* feasible (i.e., there are sets of parameter values such that the stable equilibrium is represented by pro-environmental behaviors), with impacts on trends of a(t) (i.e., a_2). Since some individuals will not adopt a pro-environmental behavior at the end if SEC prevail, whereas everybody will adopt a pro-environmental behavior at the end if REL prevail, then REL > SEC in terms of overall feasibility. However, REL and SEC might not be statically or dynamically reliable (i.e., there are weak relationships between ethical precepts or principles and the movement towards a stable equilibrium represented by pro-environmental behaviors). In the first sub-section of Results, I will test for static and dynamic reliability at a national level for some REL and SEC based on the three insights introduced in this section.

The panel data. In this section, I will focus on the household determinants of some environmental behaviors (i.e., household waste management (WM), organic food purchases (OF), and household energy conservation (EC) for local sustainability; the ecological footprint (EF) for global sustainability) based on empirically observed values at a national level to depict the individual and social determinants of pro-environmental behaviors from the theoretical perspective defined in the previous section (i.e., P, R, S, and T). To do so, I will link the REL to the characteristics of majority and minority religions (Zagonari, 2020a), and I will consider SEC in terms of reciprocity and concerns for current and future environments (Zagonari, 2019a). Here, I defined the world's majority and minority religions as religions that are based on one or more canonical texts shared by all sects of that religion and that function as the majority religion (i.e., >50% of the citizens) in at least one country and in no countries, respectively. Specifically (Zagonari, 2020c), the determinants of household waste management suggest a need for the following data at a national level: income, education, concern for the environment, age, occupation, and religion. The determinants of organic food purchases suggest a need for the following data at a national level: income and concern for the environment. The determinants of household energy conservation suggest a need for the following data at a national level: income, education, concern for the environment, and age. However, to facilitate comparisons between statistical estimates, I will use the same determinants for all three behaviors (WM, OF, EC), as well as for the individual overall use of Earth's resources as measured by EF.

Zagonari (2020c, 2019a) summarizes the dependent and independent variables for data from 1995 to 2017 that reflect local environmental behaviors (i.e., WM, OF, and EC) and global environmental behavior (i.e., EF), with the main descriptive statistics obtained for a sample of 181 and 183 countries for local sustainability (LOC) and global sustainability (GLO), respectively (i.e., the main nations in the World Development Indicators

database). Referring to the set of countries common to both groups would decrease the sample to 169 countries (i.e., by eliminating Bermuda, Brunei Darussalam, Cabo Verde, Cayman Islands, Comoros, Eswatini, French Polynesia, Samoa, Sao Tome and Principe, Timor-Leste, and Tonga for local environmental behaviors; and eliminating Curacao, Gibraltar, Greenland, Hong Kong SAR, Iceland, Kosovo, Liechtenstein, Macao SAR, Maldives, Monaco, Puerto Rico, San Marino, Seychelles, and Tuvalu for global environmental behaviors). However, I preferred to use the largest possible samples in both contexts. Note that the use of data at a country level rather than at a household level can avoid the gap between belief and action that results from a reliance on self-reported values and behaviors; it also elicits persistent rather than situational influences on behavior and avoids the gap between reality and simulation that results from contexts that differ from daily life (Zagonari, 2020a). Moreover, the use of panel data let me test for endogeneity issues (i.e., the direction of influences can be predicted) and test for spurious correlations (i.e., historical, geo-political or geographical factors can be eliminated). Finally, the use of a "representative individual" at a country level can be supported theoretically (Zagonari, 2019b).

For the *dependent variables* (i.e., the levels for the short-run (SHO) and changes for the long-run (LON) for each pro-environmental behavior), I found inconsistencies between data sources for the same country. In these cases, for WM, I first referred to the EU data, then to the OECD data, and finally to the World Bank data. For OF, I first referred to the EU data, then to the OECD data, and finally to the FAO data. For EC, I referred to the World Bank data. When no data were available, I fixed the value at 0 to depict no WM, OF, or EC. For EF, I referred to http://www.footprintnetwork.org. For the *independent variables*, I represented SEC using the Gini coefficient (*ine*) as a measure of trust and reciprocity in terms of income inequality (Barone and Mocetti, 2016). I used the proportions of GDP spent on environmental protection (*cur*) and environmental R&D (*fut*) to depict the concern for current and future environments, respectively, in terms of the present generation's willingness to pay. Indeed, since data was unavailable for most countries on the proportions of GDP accounted for by private and public debt, which can be used to represent the concern for future generations, I preferred to omit this variable and focus on the concern for the future environment. Note that I did not distinguish between developed and developing countries (i.e., OECD and non-OECD countries), since I focused on environmental ethics. However, I tested for possible interactions between pro-environmental behaviors and economic or social development by using income (*inc*), education (*edu*), unemployment (*une*), and the proportions of citizens older than 65 years (*old*) as independent variables.

I represented REL at a national and individual level as based on the majority religions (i.e., a dummy variable set to 1 if a religion was followed by >50% of the citizens) and minority religion (i.e., the percentage of the citizens following a specified religion if a religion was followed by <50% of the citizens). For both majority and minority religions, I referred to www.worldreligions.org. Note that data on religions and denominations can be affected by the bias imposed by a specific denomination; that is, some individuals are affiliated with a specific denomination of a given religion, even though they are characterized by a low level of religiosity in terms of their beliefs, participation, and behavior (Suh and Russel, 2015). To solve this bias, Zhang and Lu (2020) recently suggested changing the denomination-based scheme in survey responses into a deity-based scheme (i.e., the question "What is your religion?" should be replaced with "What do you believe in?" or, in other words, the question "Are you Buddhist, Taoist, Muslim, …?" should be replaced with "Do you believe in Buddha, Taoist Gods, Allah, …?"). Consequently, the relationships between religious ethics and pro-environmental behaviors could be empirically overestimated, since some pro-environmental behaviors could be implemented by non-religious individuals. However, an underestimation of the same relationships could result from two factors. First, some individuals could behave according to religious principles despite having been recorded as being non-religious, since their past religious precepts became their current secular principles. Second, some religious precepts shared by secular principles could be implemented by non-religious people who see them as secular principles. This may be important where pro-environmental behaviors for secular ethics (i.e., *cur*, *fut*, *ine*) are measured at national level by including both religious and non-religious individuals. The use of panel data mitigates both over- and underestimation by accounting for unobservable heterogeneity (Sequeira et al., 2017; Meon and Tojerow, 2019), although the elimination of estimation errors due to errors in measurements of religious variables would require instrumental variables for the religious variables, which are unfortunately unavailable. In contrast, secularization (i.e., a reduction of religious ethics and institutions and an increase in secular ethics and institutions) does not affect these empirically estimated relationships, since they measure, for each year, the extent to which religious and secular ethics affect pro-environmental behaviors. Similarly, the interpretation of a religion as a philosophy (i.e., attaching labels to ethics) does not affect these empirically estimated relationships, since there is no mismatch between individuals and behaviors.

Moreover, I measured SEC at a national level ex-post (i.e., as outcomes), but measured REL ex-ante with respect to behavior. This was based on the assumption that in a democratic country where the majority of the population is unsatisfied with a given situation (e.g., environmental protection, social inequality, environmental R&D), new political parties with a different platform will be elected to achieve the desired situation.

Finally, for SEC, an increase in *cur* and *fut* represent an increase in R and a decrease in P, respectively, whereas an increase in *ine* represents an increase in T and a decrease in S. In contrast, for REL, beneficial impacts on global and local sustainability from religions and denominations are depicted by significant negative coefficients for EF and significant positive coefficients for WM, OF, and EC, respectively, without linkages to specific parameters (i.e., majority and minority religions are assumed to affect both individual and social determinants of pro-environmental behavior). In particular, the translation of the theoretical framework at an individual level (based on individual feelings and social pressures as determinants for both REL and SEC) into an empirical framework at a national level (based on *cur* and *fut* for individual feelings in SEC, *ine* for social pressures from the whole society in SEC, with REL having intermediate values, representing both individual feelings and social pressures from small communities for minority religions and social pressures from large communities for majority religions) leads to the following conjectures:

i. Minority religions are more likely to be relevant if the focus is on individual feelings whereas majority religions are more likely to be relevant if the focus is on social pressures. Indeed, small religious communities (minority religions) better represent individual feelings than large religious communities (majority religions) represent the whole society.
ii. If the focus is on individual feelings, minority religions are more likely to be relevant if the reference is to many religions than to few religions. Indeed, smaller religious communities tend to develop when a country has many minority religions.

Note that I will ex-post identify specific religious precepts that could justify significant and beneficial impacts.

Results

In the first sub-section of Methods, I combined the main determinants of pro-environmental behaviors at the household level (i.e., individual feelings (IND) and social pressures (SOC)) in a dynamic model by presenting three main insights about the expected impacts of REL and SEC (i.e., global vs. local sustainability; individual feelings vs. social pressures; short-run vs. long-run). In the second sub-section of Methods, I described a dataset at a national level that could be used to measure those determinants by requiring the use of the same set of independent variables to explain the levels and changes of each dependent variable. In this section, I will test the three insights by providing additional insights into the impacts of specific REL and SEC on specific pro-environmental behaviors. In particular, Table 3 expands the three insights into 12 hypotheses (i.e., all possible combinations).

Note that I will not test general vs. specific precepts or principles, since SEC ethics is always based on the same three principles (i.e., *cur* and *fut* depict individual feelings, *ine* represents social pressures). Moreover, I will speak of reliability, which I define as REL and SEC showing statistically significant beneficial impacts at a 90% probability level. Finally, I will use between-effects regressions for majority religions to evaluate the social pressures from large communities and random-effect regressions for minority religions to evaluate the social pressures from small communities, where the random-effect estimations for SEC emphasize individual over the social determinants of behaviors.

Table 3 The 12 hypotheses representing the 3 insights.

Hypothesis 1	Hypothesis 2	Hypothesis 3
a. REL > SEC for GLO	a. REL > SEC for IND	a. REL > SEC for SHO
b. SEC > REL for LOC	b. SEC > REL for SOC	b. SEC > REL for LON
c. For REL, GLO > LOC	c. For REL, IND > SOC	c. For REL, SHO > LON
d. For SEC, LOC > GLO	d. For SEC, SOC > IND	d. For SEC, LON > SHO

GLO global sustainability, *IND* individual feelings, *LOC* local sustainability, *LON* long-term, *REL* religious ethics, *SEC* secular ethics, *SHO* short-term, *SOC* social pressures.

Statistical analysis of absolute reliability. Tables 4 to 7 summarize the results, and Supplementary Materials II provides details.

Note that I considered four contexts for religions:

1. a context with 23 religions and denominations, where all available data are applied: Baha'is, Buddhists (Lamaists, Mahayanists, Theravadins), Christians (Catholics, Independents, Orthodox, Protestants), Confucianists, Daoists, Ethnic religionists, Hindus (Saktists, Shaivites, Vaishnavites), Jains, Jews, Muslims (Schismatics, Shias, Sunnis), Shintoists, Sikhs, Spiritists, Zoroastrians
2. a context with 14 religions and denominations, where I did not consider specific traditions within Buddhism, Christianity, Hinduism and Islam: Baha'is, Buddhists, Christians, Confucianists, Daoists, Ethnic religionists, Hindus, Jains, Jews, Muslims, Shintoists, Sikhs, Spiritists, Zoroastrians
3. a context where I considered the 9 (out of the 23) religions and denominations followed by >50% of the population in at least one country in one year;
4. a context where I considered the 5 (out of the 14) religions and denominations followed by >50% of the population in at least one country in one year.

I will refer to contexts 2 and 4 as general (GEN), and contexts 1 and 3 as specific (SPE).

Note that the ranking of the regressions for global and local sustainability in terms of overall fit goodness (i.e., χ^2 or F) is WM > OF > EF > EC. This is easily accounted for by stressing the fact that if the focus is on pro-environmental behaviors that depend on ethics (i.e., *not* household energy conservation), it is easier to statistically identify the determinants of specific pro-environmental behaviors when they depend on two (i.e., individual feelings and social pressures for household waste management) rather than one (i.e., individual feelings for organic food purchases) determinants. In contrast, it is harder to statistically identify the determinants of generic pro-environmental behaviors (i.e., the ecological footprint). Moreover, *ine* might be interpreted differently in different contexts. In particular, where social pressures are crucial for pro-environmental behavior (e.g., household waste management), then *ine* measures reciprocity and a beneficial impact; where social pressures are *not* crucial for pro-environmental behavior (e.g., organic food purchases), then *ine* represents inequality and a detrimental impact. Finally, most of the variation in pro-

Table 4 Significant impacts ($P < 0.10$) of religious (REL) and secular (SEC) ethics on ecological footprint (EF) and yearly changes in EF (ΔEF) at individual (random-effects regression, based on percentages of people following a specified religion for minority religions) and social (between-effects regression, based on dummy variables at 1 for majority religions) levels.

	Individual feelings (IND)	Social pressures (SOC)
EF	14 REL: bud, chr, **-con**, dao, eth, hin, mus, **-sik**	5 REL
	3 SEC: -ine, cur, fut	3 SEC
	23 REL: budlam, budthe, chrcat, chrind, chrort, chrpro, **-con**, dao, hinsak, hinsha, -**hinvai**, mussch, musshi, mussun, **-sik**	9 REL: budlam
	3 SEC: -ine, cur, fut	3 SEC
ΔEF	14 REL	5 REL: **-chr**
	3 SEC	3 SEC
	23 REL: hinsak, **-hinvai**, mussch	9 REL: **-chrcat**
	3 SEC	3 SEC

As for IND, bud, chr, con, dao, eth, hin, mus, sik are percentages for Buddhism, Christianity, Confucianism, Daoism, Ethnic religions, Hinduism, Islam, Sikhism; budlam, budthe, chrcat, chrind, chrort, chrpro, hinsak, hinsha, hinvai, mussch, musshi, mussun are percentages for Buddhists (Lamaists, Theravadins), Christians (Catholics, Independents, Orthodox, Protestants), Hindus (Saktists, Shaivites, Vaishnavites), Muslims (Schismatic, Shias, Sunnis). As for SOC, chr, chrcat are dummy variables for Christianity, Christians (Catholics). For both IND and SOC, cur and fut are the proportions of GDP spent on environmental protection and on environmental R&D, ine is the Gini coefficient.
Bold = beneficial impacts.

Table 5 Significant impacts ($P < 0.10$) of religious (REL) and secular (SEC) ethics on waste management (WM) and yearly changes in WM (ΔWM) at individual (random-effects regression, based on percentages of people following a specified religion for minority religions) and social (between-effects regression, based on dummy variables at 1 for majority religions) levels.

	Individual feelings (IND)	Social pressures (SOC)
WM	14 REL: **bah**, **bud**, **chr**, **con**, **eth**, -jew, **mus**, -shi, **sik**, -zor	5 REL: -jew
	3 SEC: ine**, fut**	3 SEC: **fut**
	23 REL: **budmah**, **budthe**, **chrcat**, **chrind**, -chrort, **chrpro**, -hinsak, -jew, -mussch, **musshi**, **mussun**, -shi, **sik**, -zor	9 REL: -budmah, -chrort, **chrpro**, -jew
	3 SEC: **fut**	3 SEC: **fut**
ΔWM	14 REL: **con**, -jew	5 REL: -jew
	3 SEC: **cur, fut**	3 SEC: **-ine, cur, fut**
	23 REL: **chrcat**, -chrort, **chrpro**, **con**, **eth**, -jew	9 REL: -budmah, **chrcat**, -chrort, -jew
	3 SEC: **-ine, cur, fut**	3 SEC: **-ine, cur, fut**

As for IND, bah, bud, chr, con, eth, jew, mus, shi, sik, zor are percentages for Baha'is, Buddhism, Christianity, Confucianism, Ethnic religions, Judaism, Islam, Shintoism, Sikhism, Zoroastrians; budmah, budthe, chrcat, chrind, chrort, chrpro, hinsak, mussch, musshi, mussun are percentages for Buddhists (Mahayanists, Theravadins), Christians (Catholics, Independents, Orthodox, Protestants), Hindus (Saktists), Muslims (Schismatic, Shias, Sunnis). As for SOC, budmah, chrcat, chrort, chrpro, jew are dummy variables for Buddhists (Mahayanists), Christians (Catholics, Orthodox, Protestants), Jews. For both IND and SOC, cur and fut are the proportions of GDP spent on environmental protection and on environmental R&D, respectively; ine is the Gini coefficient.
Bold = beneficial impacts.

Table 6 Significant impacts ($P < 0.10$) of religious (REL) and secular (SEC) ethics on organic food purchases (OF) and yearly changes in OF (ΔOF) at individual (random-effects regression, based on percentages of people following a specified religion for minority religions) and social (between-effects regression, based on dummy variables at 1 for majority religions) levels.

	Individual feelings (IND)	Social pressures (SOC)
OF	14 REL: **bah**, -chr, **eth**, -shi; 3 SEC: ine	5 REL: -jew; 3 SEC: **cur**, **fut**
	23 REL: **bah**, -budmah, -chrcat, -chrort, **eth**, -hinsak, -shi	9 REL: -budmah, -chrort, **chrpro**, -jew
	3 SEC: ine, -fut	3 SEC: **cur**, **fut**
ΔOF	14 REL: -shi; 3 SEC: **cur**	5 REL; 3 SEC: **cur**
	23 REL: -chrort; 3 SEC: **cur**, -fut	9 REL: -budmah, -chrort; 3 SEC: **cur**

As for IND, bah, chr, eth, shi are percentages for Baha'is, Christianity, Ethnic religions, Shintoism; budmah, chrcat, chrort, hinsak are percentages for Buddhists (Mahayanists), Christians (Catholics, Orthodox), Hindus (Saktists). As for SOC, budmah, chrort, chrpro, jew are dummy variables for Buddhists (Mahayanists), Christians (Orthodox, Protestants), Jews. For both IND and SOC, cur and fut are the proportions of GDP spent on environmental protection and on environmental R&D, respectively; ine is the Gini coefficient.
Bold = beneficial impacts.

Table 7 Significant impacts ($P < 0.10$) of religious (REL) and secular (SEC) ethics on energy conservation (EC) and yearly changes in EC (ΔEC) at individual (random-effects regression, based on percentages of people following a specified religion for minority religions) and social (between-effects regression, based on dummy variables at 1 for majority religions) levels.There were no significant impacts of SEC on EC and no significant impacts of REL and SEC on ΔEC.

	Individual feelings (IND)	Social pressures (SOC)
EC	14 REL; 3 SEC	5 REL; 3 SEC
	23 REL: -chrind; 3 SEC	9 REL: -chrcat, -chrort; 3 SEC
ΔEC	14 REL; 3 SEC	5 REL; 3 SEC
	23 REL; 3 SEC	9 REL; 3 SEC

As for IND, chrind is the percentage for Christians (independents). As for SOC, chrcat, chrort are dummy variables for Christians (Catholics, Orthodox).
There were no significant impacts of SEC on EC and no significant impacts of REL and SEC on ΔEC.
No Bold = no beneficial impacts.

environmental behaviors can be explained by differences among countries. This is easily accounted for by the different institutional contexts in which the same REL and SEC are implemented.

The following remarks can be obtained if we *separately* examine individual REL with respect to the four contexts considered in Tables 4 to 7:

1. Only Confucianism and Sikhism (both in contexts with 14 and 23 religions and denominations) affect the many aspects of pro-environmental behaviors required to achieve global sustainability based on the ecological footprint. This seems to be consistent with the stated life purposes of Confucians (i.e., contemplate the order of creation and its extension to family and society to form a harmonious and trusting community) and of Sikhs (i.e., to be in harmony with the Earth and all God's creation).
2. Only Vaishnavism within the Hindu tradition affects the many aspects of pro-environmental behaviors required to achieve global sustainability based on the ecological footprint. This seems to be consistent with it being the only Hindu tradition that believes in the immanence of God (i.e., the only way to ensure an intrinsic value to nature).
3. Only Christianity (in the 5 religions context) and Catholicism (in the 9 religions and denominations context) produced sufficient changes in pro-environmental behaviors to move towards global sustainability based on the ecological footprint. This seems to be consistent with the new attitude to nature observed in the Catholic Church, the most popular of Christian denominations. For example, consider Pope John Paul II in *Message for the World Day of*

Peace (1990), Pope Benedict XVI in *Caritas in Veritate* (2009), and Pope Francis in *Laudato Si'* (2015).

4. The significance of the Baha'i Faith and Ethnic denominations in both household waste management and organic food purchases seems to be consistent with the reciprocity principle, which is embedded in "the oneness of the entire human race" in the former and in "the tight communitarian feeling" in the latter.
5. Muslim denominations are significant for household waste management both in the 9 religions and denominations contexts and in the 23 religions and denominations contexts, with both Shia and Sunni, the most popular of Muslim denominations. This seems to be consistent with the Qur'an (7:31): "O Children of Adam! Look to your adornment at every place of worship, and eat and drink, but be not wasteful. Lo! He loves not the wasteful".
6. Buddhist denominations are significant for household waste management both in the 9 religions and denominations contexts and in the 23 religions and denominations contexts, with both Mahayana and Theravada, the most popular of Buddhist denominations. This seems to be consistent with the Adhammika Sutta: "If people err (i.e., greed, hate, ignorance) in their ways, the richness of the Earth declines, whereas moral virtues (i.e., generosity, compassion, wisdom) are able to reverse the environmental decline". Specifically, nobody should put human waste into or spit into the water.
7. Hinduism had no significant effect on household waste management and organic food purchases. This seems to be consistent with the religion's greater focus on equal dignity of human and non-human beings (i.e., resources) than on the conservation of a healthy environment (i.e., pollution).
8. Buddhism and Hinduism had no significant effect on organic food purchases. This seems to be consistent with the absence of mandatory vegetarianism in most traditions of Buddhism and Hinduism.
9. Christian denominations were significantly related to household waste management in the 14 religions and denominations context, in the 9 religions and denominations context with Protestants, and in the 23 religions and denominations context with Catholics, Independents, and Protestants. This might be related to the communitarian feature of Christian denominations rather than to specific religious precepts on waste recycling.
10. No religions and denominations had significant positive impacts on household energy conservation. This is consistent with household energy conservation and the yearly change in household energy conservation being more related to environmental expenditures than to environmental ethics.

Note that the Baha'i Faith and Ethnic denominations had no significant effects in the 23 religions and denominations context, possibly due to their relative ranking within the 14 vs. 23 religions and denominations contexts. This seems to be confirmed by the smaller significance of the positive coefficients (see Supplementary Materials III). Moreover, only Catholics for the yearly change in household waste management and Protestants for household waste management had significant effects for both individual feelings and social pressures. This seems to confirm the communitarian characteristics of these denominations. Of course, the coefficients are smaller in the case of dummy variables that depicted a 50% or larger majority (i.e., 0.049 for Protestants and 0.001 for Catholics) than they are based on percentages, which depict any presence (i.e., 0.126 for Protestants and 0.003 for Catholics). Finally, religions and denominations are more significant in fostering pro-environmental behaviors if both social pressures and individual feelings are involved (i.e., household waste management) than if only individual feelings are relevant (i.e., organic food purchases), and religions and denominations that are significant for the latter are also significant for the former pro-environmental behaviors (i.e., Baha'i Faith and Ethnic denominations in organic food purchases are also significant in household waste management). This seems to confirm that religions and denominations affect both individual feelings and social pressures.

The following remarks can be obtained if we *separately* examine individual SEC with respect to the eight cells presented in Tables 4 to 7:

1. There are no SEC that can affect or change the pro-environmental behaviors required to achieve or move towards global sustainability.
2. As expected, *cur* positively affects organic food purchases and the yearly change in organic food purchases (i.e., 6 out of 8 cells) more than household waste management and the yearly change in household waste management (i.e., 4 out of 8 contexts).
3. As expected, *fut* positively affects household waste management and the yearly change in household waste management (i.e., 8 out of 8 cells) more than organic food purchases and the yearly change in organic food purchases (i.e., 2 out of 8 contexts).
4. As expected, *ine* positively affects household waste management and the yearly change in household waste management (i.e., 3 out of 8 cells) and negatively affects organic food purchases and the yearly change in organic food purchases (i.e., 2 out of 8 cells). In other words, household waste management requires social reciprocity, whereas organic food purchases is a luxury good.
5. As expected, no SEC positively affected household energy conservation or the yearly change in household energy conservation.

Note that SEC have larger impacts if the focus is on social pressures rather than on individual feelings (14 out of 16 cells vs. 9 out of 16 cells for WM and OF). Moreover, SEC requires a larger majority (i.e., 9 out of 24 cells = 0.375 for IND < 14 out of 24 cells = 0.583 for SOC) than for REL (i.e., 24 out of 148 cells = 0.162 for IND > 3 out of 56 = 0.053 cells for SOC). Finally, *ine* had a larger impact if the focus was is on social pressures than on individual feelings (i.e., 2 out of 24 cells = 0.083 for SOC > 1 out of 24 cells = 0.042 for IND).

Statistical analysis of relative reliability. Figure 3 summarizes the relative success percentages of REL and SEC in significantly promoting pro-environmental behaviors. Here, I define the relative success percentages as the number of REL and SEC with statistically significant beneficial impacts over the number of REL and SEC under consideration in each context (e.g., as for GEN, 7 out of 14 and 0 out of 5 for REL in WM for IND and SOC, respectively; 1 over 3 and 1 out of 3 for SEC in WM for IND and SOC, respectively).

Note that both conjectures in the second sub-section of Methods seem to be supported:

i. Minority religions are more relevant if the focus is on individual feelings ($30/222 = 0.135$ where $222 = (14 + 23) \times 6$) than majority religions if the focus is on social pressures ($5/84 = 0.060$ where $84 = (5 + 9) \times 6$).
ii. Minority religions are more relevant if the reference is to many religions ($18/138 = 0.130$ where $138 = 23 \times 6$) than to few religions ($10/84 = 0.119$ where $84 = 14 \times 6$).

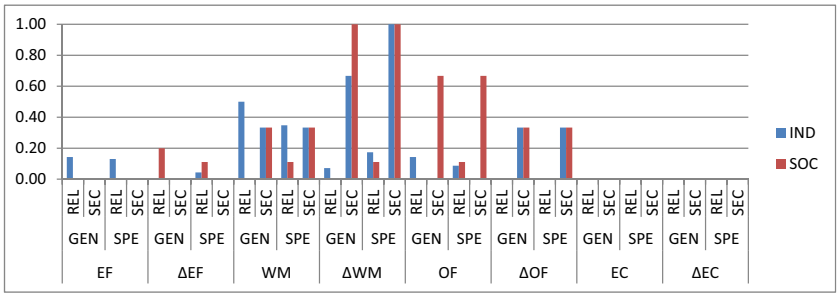

Fig. 3 The relative success rates of religious (REL) and secular (SEC) ethics (i.e., the number of REL and SEC with statistically significant beneficial impacts over the number of REL and SEC under consideration in each context). GEN general context, SPE specific context, IND individual feelings, SOC social pressures, EF ecological footprint, ΔEF yearly change in EF, WM waste management, ΔWM yearly change in WM, OF organic food purchases, ΔOF yearly change in OF, EC energy conservation, ΔEC change in EC.

Table 8 The Bernoulli test results for the 12 hypotheses in Table 3.

Hypothesis 1	Hypothesis 2	Hypothesis 3
a. REL > SEC for GLO (1.42)	a. REL > SEC for IND (−0.72)	a. REL > SEC for SHO (−0.67)
b. SEC > REL for LOC (5.21)	b. SEC > REL for SOC (5.70)	b. SEC > REL for LON (6.18)
c. For REL, GLO > LOC (−0.31)	c. For REL, IND > SOC (3.01)	c. For REL, SHO > LON (4.32)
d. For SEC, LOC > GLO (3.18)	d. For SEC, SOC > IND (1.67)	d. For SEC, LON > SHO (1.11)

Numbers in brackets represent the value of the test statistic. The reference value for significance at $P < 0.10$ is |1.64 | . *GLO* global sustainability, *IND* individual feelings, *LOC*, local sustainability, *LON*, long-term, *REL*, religious ethics, *SEC*, secular ethics, *SHO*, short-term, *SOC*, social pressures.

The number of successes over the number of possible cases are assumed to follow a Bernoulli distribution. Consequently, it is possible to compare the average frequencies by relying on a proxy standardized normal distribution. Table 8 presents the probability that each single hypothesis in Table 3 is significantly supported (i.e., at 90%).

Thus, hypothesis 1 was supported in 2 of 4 cases, although 1a was (slightly) not significant (i.e., 1.42 < 1.64) and 1c had the opposite (non-significant) sign. Hypothesis 2 was supported in 3 of 4 cases, although 2a had the opposite (non-significant) sign. Hypothesis 3 was supported in 2 of 4 cases, although 3a had the opposite (non-significant) sign and 3d was (slightly) not significant (1.11 < 1.64).

Note that the focus on singular impacts suggests that (GLO, IND, SHO) for REL > (GLO, IND, SHO) for SEC (a relative success rate of 0.14 > 0). Moreover, for REL, GEN > SPE (a relative success rate of 0.42), but it was not possible to compare REL and SEC on this aspect, since SEC includes three ethics in all estimates (i.e., GEN cannot be distinguished from SPE for SEC). In other words, the general precepts significantly affecting pro-environmental behaviors are included in the five main religions. Finally, the focus on singular impacts suggests that (LOC, SOC, LON) for SEC > (LOC, SOC, LON) for REL (a relative success rate of 1 > 0.12 for WM and a relative success rate of 0.33 > 0 for OF).

Some methodological remarks are worth noting. Excluding household energy conservation and the yearly change in household energy conservation from the estimates does not significantly affect comparisons between REL and SEC (see Supplementary Materials III). Indeed, all significance levels are unchanged, apart from SEC, where SOC > IND becomes insignificant and LON > SHO becomes significant. Moreover, additional insights can be obtained from coefficients with the expected signs, but statistically significant at <70%. For example, the mandatory vegetarianism for Jainism is confirmed by its positive coefficient. Similarly, within Buddhist traditions, the signs of coefficients support the recommended vegetarianism in the Budlam tradition but not in other traditions. Similarly, within the Hindu traditions, the signs of the coefficients support the ranking of vegetarianism as Hinvai (compulsory) > Hinsha (recommended) > Hinsak (optional). Similarly, within the Islamic traditions, the signs of coefficients support the recommended vegetarianism in Sunni but not in other traditions. Finally, a few additional REL or SEC appear important if 70% significance is used instead of 90% significance (see Supplementary Materials III). Indeed, all significance levels are unchanged, apart from REL > SEC, which becomes significant for global sustainability.

Discussion

The present study is the first attempt to compare religious and secular ethics as feasible and reliable strategies to achieve global and local environmental sustainability in the short- and long-run, by combining analytical and statistical results within a single dynamic framework based on individual and social determinants of pro-environmental behaviors. Thus, it is not possible to compare my results with previous results and look for confirmation or contradiction of my research in previous research. However, the present study complements the research by Zagonari (2020c) by considering more religions and by considering both global and local sustainability. Moreover, it complements the work by Zagonari (2020a) by considering more religions and by considering both global and local sustainability in the short- and long-run. Finally, it complements the work by Zagonari (2019a) by considering both REL and SEC principles and by considering both global and local sustainability in the short- and long-run.

The study has two main weaknesses:

1. The number of religions and denominations (i.e., 5, 9, 14, or 23 in different contexts) does not meet the condition of large numbers that is required to apply the asymptotic property of Bernoulli distributions to my analysis of the differences of success frequencies. However, more detailed data (e.g., using religious sects to depict communities that tightly influence pro-environmental behavior) are not available at a global level.

2. The number of secular ethics (i.e., 3 in all contexts) is small. However, additional national data (e.g., percentages of GDP accounted for by public and private debt to represent the concern for future generations) are not consistent at a global level.

The study has four main strengths:

1. I assumed a representative individual at a country level to use data on *actual* pro-environmental behaviors for up to 23 religions and denominations. Indeed, to achieve the same level of detail, it would have been necessary to perform at least 23 sufficiently large surveys in 23 different countries characterized by different religious traditions.
2. I analyzed actual pro-environmental behaviors which involve time (i.e., household waste management), money (i.e., organic food purchases), and a combination of time and money (i.e., household energy conservation). Other pro-environmental behaviors are included implicitly (e.g., water footprint and carbon footprint in the ecological footprint) or could be analyzed by consulting suitable datasets (e.g., per capita water consumption).
3. I referred to individual feelings and social pressures as determinants, by highlighting generic and specific precepts and principles.
4. I analyzed global and local sustainability as well as short-run and long-run sustainability.

The main results achieved in this paper can be summarized as follows: REL and SEC were complementary in time (e.g., for REL, short-run sustainability is more reliable than long-run sustainability; for SEC, long-run sustainability is more reliable than short-run sustainability), in space (e.g., for SEC, local sustainability is more reliable than global sustainability), and in society (e.g., for REL, individual feelings are more reliable than social pressures).

In terms of strategy suggestions, this implies that secular ethics should be fostered by environmental education and information campaigns for the whole society to achieve local sustainability in the long-run, whereas religious ethics should be fostered at the leaders level (e.g., Gray (2020) on the Catholic theological discontinuity; Hearlson (2020) on the Catholic ecological conversion; joint document on Human Fraternity (2019) by Pope Francis and the Grand Imam of Al-Azhar Ahmad Al-Tayyeb; Campos (2020) on the Catholic and Hindus interreligious dialog in India; Mongrain (2017) on Pope Francis and Patriarch Bartholomew sharing a spiritual revival based on simpler lifestyles) and at the grassroots level (e.g., environmental sermons; Pepper and Leonard (2016) on the impacts of Christian church traditions on water and energy consumption behaviors in Australia; study groups; Intahphuak et al. (2017) on Buddhist monks' effects on recycled garbage in Thailand; outreach groups; Lakhan (2018) on Christian leaders' impacts on recycling behaviors in Canada; religious communities; Gutsche (2019) on the effects of Catholic and Protestant religiosity on environmental consumptions in Germany; charitable agencies; Fang et al. (2020) on the impacts of Christian religiosity on private and public environmental behaviors in Taiwan; religious artists; Purnomo (2020) on an interreligious eco-theological movement comprising the community of Sedulur Sikep, Islam and Catholics for local reforestation in Indonesia) for communities of all sizes to achieve local sustainability in the short-run. Note that the present global sustainability results for religions in the short-run are consistent with Zagonari (2020d), where five main majority religions (i.e., Buddhism, Christianity, Hinduism, Islam, and Judaism) and five main secular principles (i.e., concerns for current and future environments, concerns for current and future generations, and rights of future generations) are compared in terms of their beneficial impacts for the feasibility and reliability of global sustainability (i.e., levels of the ecological footprint) in developed and developing countries.

The main direction for future development of the present study could come from considering additional secular ethics (e.g., concern for future generations, attitudes towards consumption goods), introducing more control variables (e.g., gender, although this is a sensitive issue in comparing both religious and secular ethics), and identifying additional religious precepts (e.g., pursuing parsimony in Islam and Christianity, maintaining equilibrium in Buddhism and Hinduism).

Conclusions

Solving environmental sustainability as a practical problem entails an empirical approach. However, the requirement for data on alternative ethics that affect actual pro-environmental behaviors in many countries under alternative contexts suggests the need to use statistical estimations to support theoretical insights, but also the need to use mathematical models to interpret the empirical results.

The first novelty of the present study is that it *methodologically* provides a dynamic model that can be supported by panel data, and finds tight relationships between the theoretical insights and empirical results. In particular, religious ethics affect the many individual pro-environmental behaviors required to achieve global sustainability in the short-run by relying on specific precepts and social pressures from small communities, whereas secular ethics affects some individual pro-environmental behaviors to achieve local sustainability in the long-run by relying on general principles and social pressures from the whole society. Note that some insights could not be obtained by relying only on the theoretical model (e.g., the relevant environmental precepts are included in the five main religions), whereas some explanations could not be obtained by relying only on a statistical estimate (e.g., *ine* depicts reciprocity in estimations for the ecological footprint and household waste management, but depicts inequality in estimations for organic food purchases).

The second novelty is that this paper *operationally* suggests a complementarity between environmental education or information campaigns for secular ethics and theological changes or environmental sermons for religious ethics to foster pro-environmental behaviors. In particular, religious ethics are more effective in affecting *levels* of pro-environmental behaviors, whereas secular ethics are more effective in affecting *changes* of pro-environmental behaviors. Note that these operational suggestions could not be obtained by considering only some religious or secular ethics within a single country. For example, think of the positive relationship between *ine* and the number of religions and denominations in a country (i.e., reciprocity is more important if many religions are present) and of the positive interaction between *ine* and some significant communitarian denominations (i.e., reciprocity is fostered by Protestant values).

However, environmental sustainability is *also* an urgent problem that requires effective short-run solutions. Unusually, my results suggest that religious ethics are overall more effective than secular ethics, where the former ethics affect many pro-environmental behaviors in a shorter time by relying on smaller communities.

Note that the present study agrees with the literature on global citizenship (e.g., Whiting et al., 2018), which does not require a single global ideology or a homogeneous world culture (e.g., a set of environmental ethics shared and implemented throughout the world), since it supports specific environmental religious or secular ethics, which differ among cultures, societies, and

economies, and which may be enforced by small or large communities to achieve global sustainability as the sum of many local sustainability initiatives.

Data availability

The datasets analyzed during this study come from free and paid sources, as detailed in text: they are available from the corresponding author on reasonable request.

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References

Arli D, Tjiptono, F (2017) God and green: investigating the impact of religiousness on green marketing. Int J Nonprofit Volunt Sect Mark 22. https://doi.org/10.1002/nvsm.1578
Barone G, Mocetti S (2016) Inequality and trust: new evidence from panel data. Econ Inq 54:794–809
Batavia C et al. (2020) Pathways from environmental ethics to pro-environmental behaviours? Insights from psychology. Environ Values 29:317–337
Berger PL (1967) The sacred canopy: elements of a sociological theory of religion. Anchor Books, Garden City, NY
Bolis I et al. (2017) Are we making decisions in a sustainable way? A comprehensive literature review about rationalities for sustainable development. J Clean Prod 145:310–322
Budolfson MB (2019) The inefficacy objection to consequentialism and the problem with expected consequences response. Philos Stud 176:1171–1724
Campos C (2020) Laudato Si': an Indian perspective Theol Stud 79:213–225
Christie I et al. (2020) Sustainability and the common good: catholic social teaching and 'integral ecology' as contributions to a framework of social values for sustainability transitions. Sustain Sci 14:1343–1354
Dzwonkowska D (2018) Is environmental virtue ethics anthropocentric? J Agric Environ Ethic 31:723–738
Fang WT et al. (2020) Is religiosity related to environmentally-protective behaviors among Taiwanese Christians? A structural equation modeling study. Sustainability 12:art. no. 8999
Grey CTS (2020) "The only creature God willed for its own sake": anthropocentrism in Laudato Si' and Gaudium et Spes. Mod Theol 36:865–883
Gutsche G (2019) Individual and regional Christian religion and the consideration of sustainable criteria in consumption and investment decisions: an exploratory econometric analysis. J Bus Ethics 157:1155–1182
Hearlson CL (2020) Ecological conversion as conversion to the child: becoming caregivers, becoming childlike. Horizons 47:232–255
Hill T (1983) Ideals of human excellence and preserving natural environment. Environ Ethics 5:211–224
Hirsh JB et al. (2018) Moral utility theory: understanding the motivation to behave (un)ethically. Res Organ Behav 38:43–59
Hjelm T (2018) Peter L. Berger and the sociology of religion. J Class Sociol 18:231–248
Ikeke MO (2020) The role of philosophy of ecology and religion in the face of the environmental crisis. J Stud Relig Ideol 19:81–95
Imanaka JL (2018) Laudato Si', technologies of power and environmental justice; toward an eco-politics guided by contemplation. J Agric Environ Ethics 31:677–701
Intahphuak S et al. (2017) Religion role on community movement for solid waste management. J Solid Waste Technol Manage 43:321–327
Khan F et al. (2019) Understanding consumers' behavior intentions towards dealing with the plastic waste: perspective of a developing country. Resour Conserv Recycl 142:49–58
Knauss S (2018) Conceptualizing human stewardships in the Anthropocene: the rights of nature in Ecuador, New Zealand and India. J Agric Environ Ethics 31:703–722
Kollar NR (2019) Religions' future in the anthropocene, worldviews: environment. Cult Relig 23:1–32
Lakhan C (2018) The garbage gospel: using the theory of planned behavior to explain the role of religious institutions in affecting pro-environmental behavior among ethnic minorities. J Environ Educ 49:43–58
Lenzi D (2017) Relativism, ambiguity and environmental virtues. Environ Values 26:91–109
Li YJ, Wang Q (2018) The intellectual features and cultural backgrounds of modern environmental ethics in China. Environ Ethics 40:5–20
Lowe BS (2019) Ethics in the Anthropocene: moral responses to the climate crisis. J Agric Environ Ethics 32:479–485
McAndrew S, Richards L (2020) Religiosity, secular participation, and cultural socialization: a case study of the 1933-1942 English urban cohort. J Sci Stud Relig 59:247–268
Meinertsen BR (2017) Towards gratitude to nature: global environmental ethics for China and the world. Front Philos China 12:207–223
Menning N (2016) Reading nature religiously, worldviews: environment. Cult Relig 20:169–188
Meon PG, Tojerow I (2019) The minority ethic: rethinking religious denominations, minority status, and educational achievement across the globe. J Comp Econ 47:196–214
Minteer BA (2012) Refounding environmental ethics: pragmatism, principle and practice. Temple University Press, Philadelphia
Mongrain K (2017) The burden of guilt and the imperative of reform: Pope Francis and Patriarch Bartholomew take up the challenge of re-spiritualizing Christianity in the Anthropocene age. Horizons 44:80–107
Norton B (1991) Toward unity among environmentalists. OUP, Oxford
Peifer JL, Khalsa S, Howard Ecklund E (2016) Political conservatism, religion, and the environmental consumption in the United States. Environ Polit 25:661–689
Pepper M, Leonard R (2016) How eco-theological beliefs vary among Australian churchgoers and consequences for environmental attitudes and behaviors. Rev Relig Res 58:101–124
Purnomo AB (2020) A model of interreligious eco-theological leadership to care for the Earth in the Indonesian context. Eur J Sci Theol 16:15–25
Riley MT, Brauman WA (2017) Wicked problems in a warming worlds: religion and environmental ethics. Worldviews: Environ Cult Relig 21:1–5
Sandler R (2007) Character and environment: a virtue-oriented approach to environmental ethics. Columbia University Press, New York
Schmidt J (2019) Climate virtues ethics: a proposal for future research. Relig Inq 8:29–36
Sequeira TN et al. (2017) Income and religion: a heterogeneous panel data analysis. Rev Soc Econ 75:139–158
Shan G (2018) From intrinsic value to the emotion of wonder. Environ Ethics 40:81–91
Shapiro MR (2018) "It's a game everyone is already playing": the creating-our-morality motif between secularization and spiritualization in contemporary western popular spirituality. J Stud Relig Ideol 17:115–133
Snyder BF (2017) A Darwinian nihilist critique of environmental ethics. Ethics Environ 22:59–78
Sorkun MF (2018) How do social norms influence recycling behavior in a collectivistic society? A case study from Turkey. Waste Manage 80:359–370
Spahn A (2018) "The first generation to end poverty and the last to save the planet"? Western individualism, human rights and the value of nature in the ethics of global sustainable development. Sustainability 10:art. no. 1853
Suh D, Russel R (2015) Non-affiliation, non-denominationalism, religious switching and denominational switching: longitudinal analysis of the effects on religiosity. Rev Relig Res 57:25–41
Talbot B (2018) Collective action problems with conflicting obligations. Philos Stud 175:2239–2261
Whiting K et al. (2018) Education for the sustainable global citizen: what can we learn from Stoic philosophy and Freirean environmental pedagogies? Educ Sci 8:art. no 204
Whiting K, Konstantakos L (2019) Stoic theology: revealing or redundant? Religions 10:art. no 193
Yang Y, Huang S (2018) Religious beliefs and environmental behaviours in China. Religions 9:art no. 9030072
Yuan Y et al. (2017) Model of Chinese household kitchen waste separation behavior: a case study in Beijing City. Sustainability (Switzerland) 8:art. no. 1083
Zagonari F (2019a) Moral philosophy and (moral) theology can function as (behavioural) science: a methodological framework for interdisciplinary research. Qual Quant 53:3131–3158
Zagonari F (2019b) Responsibility, inequality, efficiency, and equity in four sustainability paradigms: insights for the global environment from a cross-development analytical model. Environ Dev Sustain 21:2733–2772
Zagonari F (2020a) Environmental sustainability is not worth pursuing unless it is achieved for ethical reasons. Nat–Palgrave Commun 6:art. no. 108
Zagonari F (2020b) Comparing religious environmental ethics to support efforts to achieve local and global sustainability: empirical insights based on a theoretical framework. Sustainability 12:art. no. 2590
Zagonari F (2020c) Foreign direct investment vs. cross-border trade in environmental services with ethical spillovers: a theoretical model based on panel data, J Environ Econ Policy https://doi.org/10.1080/21606544.2020.1799868
Zagonari F (2020d) Only religious ethics can help achieve global environmental sustainability, Environment, Development and Sustainability (under review) and AMSActa https://doi.org/10.6092/unibo/amsacta/6214
Zhang C, Lu Y (2020) The measure of Chinese religions: denomination-based or deity-based? Chinese J Sociol 6:410–426

Competing interests
The author declares no competing interests.

Additional information
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